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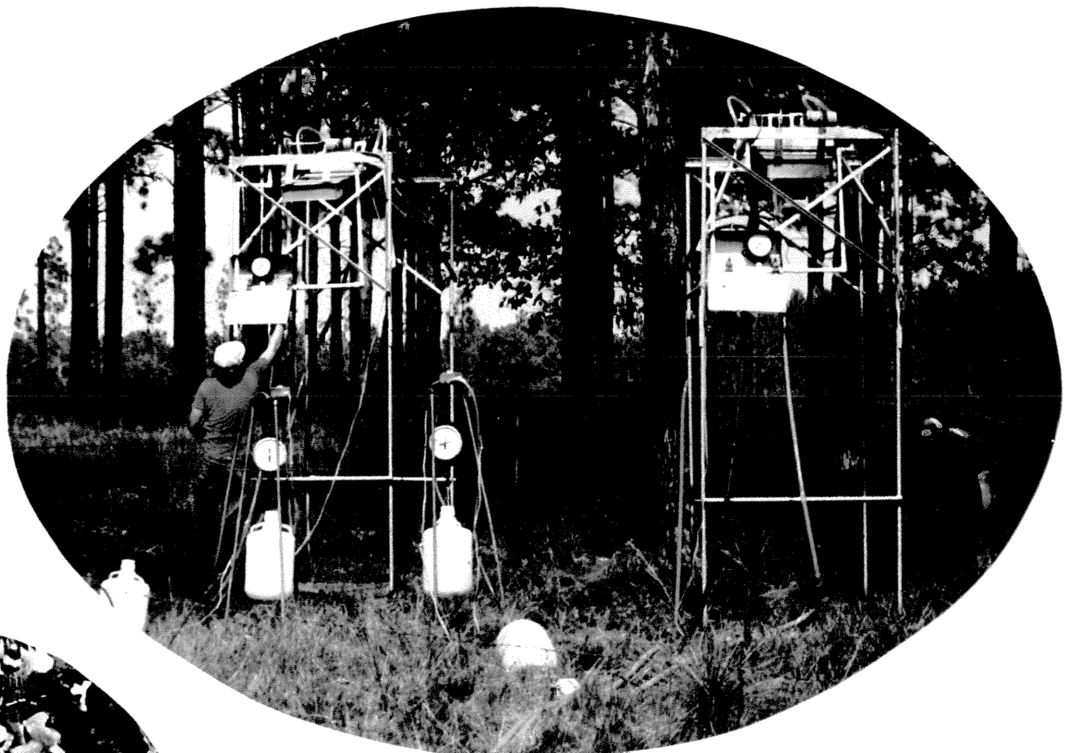
Ecological, Physical, and Socioeconomic Relationships Within Southern National Forests

Proceedings of the Southern Evaluation Project Workshop



U.S. Man and the Biosphere Program

Ecological, Physical, and Socioeconomic Relationships Within Southern National Forests

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PREFACE

There are about 182 million acres of forest land in the southeastern United States that provide great potential for multiple use. These lands are intermixed in federal (10%), forest industry (23%), and other private (67%) ownerships. More than 60 million acres are covered by pine types, mainly loblolly-shortleaf pine but also a large amount of longleaf-slash pine.

The National Forests comprise most of the federally owned land in the Southeast. The forest resources are diverse and intertwined but are integrated into a multiple-use forest management program. Wildlife indicator species are given in Forest Management Plans; these plans establish and describe management direction and monitoring and evaluation requirements needed to ensure compliance.

Since multiple-use or multi-purpose forest management has been practiced and discussed, both practitioners and researchers have asked about interactions between timber, range, wildlife, and other forest management practices. In 1978, forest managers and researchers had their first opportunity to examine these interrelationships by major pine types over a broad area when the Southern Evaluation Project was approved. Five areas, were delineated for study in the longleaf-slash pine and loblolly-shortleaf pine-hardwood types of the National Forests in four southeastern states (Texas, Louisiana, Mississippi, and Florida). Soil, watershed, vegetation, wildlife, and socioeconomic aspects were measured on the areas to provide a data base regarding current management, soil, vegetation, and wildlife diversity.

On May 26-27, 1987, a workshop was held in Long Beach, Mississippi, to discuss results obtained from the Project. The workshop served as a forum in which researchers, resource specialists, managers, and administrators discussed management and ecological relationships on the Southern Region's National Forests. The results of 43 research projects were presented and discussed. The workshop presentations, discussion following the presentations, an executive summary, and appendixes with lists of attendees and of prior publications, presentations, and reports generated from this project are published in these proceedings.

The project and workshop were primarily sponsored and supported by the USDA Forest Service, but also supported by the USDA Soil Conservation Service, USDI Fish and Wildlife Service, several universities, and the Southeastern Association of Fish and Wildlife Agencies. University support was provided from Texas A & M University, Stephen F. Austin State University (Texas), Louisiana State University, Northwestern State University (Louisiana), Mississippi State University, University of Florida, Virginia Polytechnic Institute and State University, Utah State University, and Colorado State University. The project was endorsed by the U. S. Man and the Biosphere Program (MAB-3) on grazing lands, which was developed through the United Nations Education, Scientific, and Cultural Organization (UNESCO) and is sponsored by the U. S. Department of State.

Special thanks are extended to the contributors who prepared and presented papers, to the six moderators (Kent T. Adair, Stephen F. Austin State University, Nacogdoches, TX; Thomas H. Ellis, Southern Forest Experiment Station, New Orleans, LA; Douglas P. Richards, Mississippi State University, Mississippi State, MS; Robert T. Jacobs, Florida National Forest, Tallahassee, FL; Robert C. Joslin, Kisatchie National Forest, Pineville, LA; Dan W. Speake, Fish and Wildlife Service, Auburn, AL) who guided the sessions and follow-up discussion, and to the two wrap-up convenors (Robert G. Merrifield, Texas A & M University, College Station, TX, and Clifford E. Lewis, Southeastern Forest Experiment Station, Gainesville, FL) who synthesized and summarized general impressions and pertinent points from the entire workshop plus leading in the final discussion. The Gulf Park Campus, University of Southern Mississippi, Long Beach, Mississippi, and local arrangements by Mary Tullos and Henry D'Aquilla were excellent and greatly appreciated. The Workshop Steering Committee consisted of Bruce L. Baldwin (Southern Region, USDA Forest Service, Atlanta, GA), Fred E. Smeins (Texas A & M University, College Station, TX), and Henry A. Pearson (Southern Forest Experiment Station, USDA Forest Service, Pineville, LA).

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Henry A. Pearson, Fred E. Smeins, and Ronald E. Thill

CONTENTS

The Southern Evaluation Project--An Executive Summary

Henry A. Pearson, Fred E. Smeins, and Ronald E. Thill

Abstract.--The results of 43 projects, which evaluated the flora, fauna, watersheds, socioeconomics, and forest pests located on southern National Forests were presented and discussed in 4 major categories: Management Outlook and Evaluation, Loblolly-Shortleaf Pine Type, Longleaf-Slash Pine Type, and Watersheds, Socioeconomics, and Forest Pests.

National Forests, as well as private forests, across the South will experience greater demands for their resources in the future. Greater emphasis will be placed on integrated resource management with increased attention toward maintenance of biotic diversity and multipurpose management. This will require increased interaction between various resource managers and scientists as well as greater attention to the needs and desires of the various forest users.

Broader-based ecosystem management approaches on the National Forests are an indication of this trend. National Forest Management Plans, that have recently been developed or are near completion, are proposing improved mechanisms for multipurpose management. The Forest Service is mandated by Congress to produce and monitor timber, wildlife, recreation, forage, and clean water on a sustained yield basis.

The Forest-Range Environmental Study in the early 1970's was designed to assemble information on the Nation's forests and rangelands. A result of this effort was creation of the Accelerated Range Program. This program was designed to provide an integrated, multiresource evaluation of our forest-range ecosystems. Three locations were selected, including the Southern Evaluation Project area, to serve as test sites.

A collaborative effort of several federal, state, and private groups across the South was initiated to evaluate the soil, water, flora, fauna, and socioeconomic parameters of National Forests in Florida, Mississippi, Louisiana, and Texas. Only pretreatment measurements were accomplished because funding was withdrawn prior to treatment application. The loss of funds resulted from National budget problems and priorities, rather than a lack of interest. Findings of initial studies are summarized in this proceedings.

FLORA

Two major upland forest types were evaluated: the loblolly-shortleaf pine (*Pinus taeda-P. echinata*)-upland hardwood type (LSH) in Texas and Louisiana, and the longleaf-slash pine (*P. palustris-P. elliottii*) type (LS) in Louisiana, Mississippi and Florida (Figure 1). Primary objectives of the investigations were to (1) quantitatively characterize the overstory and understory vegetation, (2) relate overstory vegetation parameters to understory browse and herbage production, and (3) relate plant communities and production to soil types. Each study area occurred on National Forest lands and varied between 7,000 and 13,000 acres. All areas included considerable soil-topographic variation as well as variable past silvicultural, burning, and grazing impacts; plant communities were correspondingly variable. The LSH type in Texas and Louisiana was predominantly covered by sawtimber and pole size classes (97% in Texas, 80% in Louisiana). The LS type in Louisiana was 68% sawtimber, 9% pole, 14% seedling and sapling, and 9% regeneration. Most of the LS type in Mississippi was open-grown sawtimber and pole stands, while in Florida about 55% of the area was open-grown sawtimber and pole stands with 23% in titi (*Cyrilla racemiflora* and *Cliftonia monophylla*) and pondcypress (*Taxodium distichum*) swamps.

Upland soils across all study areas were generally sandy, acidic, and low in fertility. Landscape position, slope, drainage regime, depth of surface soil, and permeability of the subsoil are major features that influence vegetation composition, structure, and forage yield. Complexity of soils varied from 5 soil series identified in the LS type in Louisiana to 17 in the LS type in Florida. Most series were classified as Ultisols, with Alfisols the second most common soil order. Alfisols were more common in the western study areas (Texas, Louisiana); Spodosols were found only in the Florida study area. Vertisols were identified only for the Texas site where they covered one-third of

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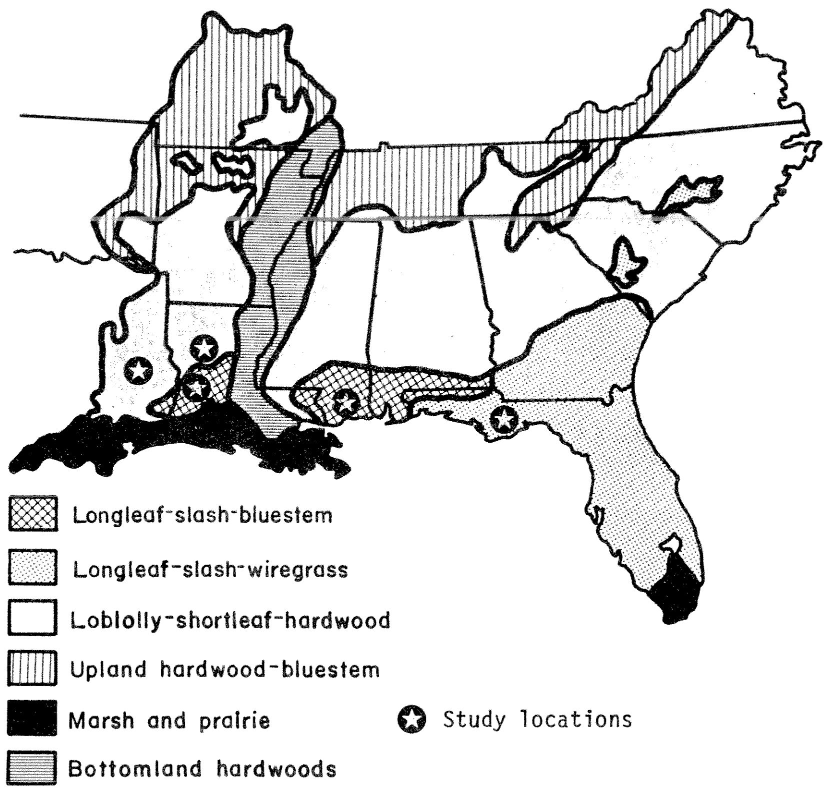

Figure 1.--Forest-range types of the South.

the area. Bottomland soils were primarily Inceptisols and Entisols.

Pine species contributed more than 70 percent of the canopy cover and basal area of most stands across all study areas. Most overstory dominants on all study areas were less than 60 years of age due to one or more timber harvests prior to or subsequent to their incorporation into the National Forest System. Hardwood dominated stands covered only small acreages of each study area, but hardwoods dominated the developing, successional understory and middlestory of most stands unless controlled by prescribed burning or silvicultural practices.

Plant species diversity tended to be fairly high across all study areas. Degree of soil-topographic variability and past disturbance greatly influenced the richness and composition of the communities. Most areas had a total of over 200 species, but up to 300 species were recorded on some areas.

Generally more than 50 woody species occurred with up to slightly more than 100 species in the Texas LSH type. Overstory species were characterized by the four major pine species (Pinus taeda, P. echinata, P. palustris and P. elliottii), several species of oaks (Quercus spp.) were the major and most diverse hardwood group on any given study site. Sweetgum (Liquidambar styraciflua), sweetbay (Magnolia virginiana), and blackgum (Nyssa sylvatica) were other commonly encountered hardwoods. Shrubs were diverse with greater than 40 species on most areas. Holly (Ilex spp.), especially yaupon (I. vomitoria), gallberry (I. glabra), and baygall holly (I. coriacea), were universally encountered. Blackberries (Rubus spp.), blueberries (Vaccinium spp.), and waxmyrtle (Myrica cerifera) were widespread. Nine (9) to 24 species of vines were encountered, with greenbriers (Smilax spp.), jessamine (Gelsemium sempervirens), grapes (Vitus spp.) and poison ivy (Toxicodendron radicans) being widespread.

Grasses and grasslikes contributed between 40 and 50 species. Significant grass genera across all areas were the bluestems (Andropogon spp. and Schizachyrium spp.), panicum grasses (Dicanthelium spp. and Panicum spp.), and threeawns (Aristida spp.). Pinehill bluestem (Schizachyrium scoparium) was widespread and often abundant in the relatively open upland stands. Wiregrass (Aristida stricta) was the most ubiquitous grass on Florida longleaf-slash sites, while uniolas (Chasmanthium spp.) were important in partially open to nearly closed-canopied LSH stands.

Forbs were the most diverse species group and varied from 90 to 150 species across the study areas. Legumes varied between 12 and 26 species. Tephrosias (Tephrosia spp.), pencilflowers (Stylosanthes biflora) and tickclovers (Desmodium spp.) were the most ubiquitous genera. The biomass of legumes was relatively low on all areas but more so on the LS type as compared to the LSH type. Composites were generally the most diverse group of forbs with 50 or more species recorded for each area. Composite genera with several species included Aster, Solidago, Liatris, and Eupatorium. The most widely distributed and abundant fern was bracken fern (Pteridium aquilinum).

Herbage and browse yield varied by stand type, stand size class, and in relation to yearly precipitation variation. Herbage yield ranged from less than 100 lb/acre for closed-canopied stands to as high as 2500 for open pine savannahs, while browse varied from approximately 100 to 300 lb/acre. An inverse relationship existed between herbage and browse yield and overstory features such as canopy cover and basal area. Since most areas consisted of closed to nearly closed-canopied forest, forage yields were generally low across all study areas. Precipitation across all study areas exceeded the average by 15 to 27 inches in 1979. In 1980 the Texas site received 10 inches less than average precipitation while Florida received 7 inches less and the other areas were near their averages. Consequently, understory yields were reduced from 1979 to 1980--particularly in Texas and Florida. This was especially evident for the vine, forb, grass, and fern categories. In their current state, most areas have limited carrying capacity for livestock or deer.

FAUNA

Pretreatment baseline wildlife data were collected on each of the five SEP study areas. Animal groups sampled on all areas included birds, small mammals, and herpetofauna (amphibians and reptiles). Sampling efforts were concentrated on these vertebrate groups, but relative abundance of mid- and large-size mammals was also estimated at several sites. Fish populations were sampled only on the Mississippi study area.

As initially planned, each investigator was to sample seedling (regeneration sites), sapling, pole, and sawtimber stands and comparisons across stand size classes and vegetation types (LSH and LS) were to be derived. On four of the study areas investigators were able to locate at least some acreage in each of these four forest stand size classes. Representative younger stands were not available on the Florida site. There, the investigators compared wildlife abundance and diversity in natural longleaf pine stands with that found in planted slash pine stands. Unfortunately, there was virtually no standardization of techniques or sampling designs among investigators. Sampling seasons, duration, and intensity also varied among areas. Results were also confounded by such factors as differences in extent and recency of prescribed burning and unplanned presence of cattle. To further complicate matters, rainfall substantially exceeded long-term averages on all sites in 1979, but was well below average on the Florida and Texas sites in 1980 and again in Florida in 1981. Drought conditions dramatically reduced some small mammal and bird populations, and toad and frog vocalizations were depressed. Consequently, few specific comparisons or generalizations can be derived across study areas or forest types. Despite differences in methodology, it should be indicated that sampling procedures that were employed would have been adequate (in most cases) to detect within-site treatment effects on some wildlife species had the treatments been imposed and monitored. In the following brief summaries, we have only attempted to make some very general observations regarding relative abundance (and in some cases species diversity) for each animal group. Comparisons of the Florida data with other sites are not included below because they were not obtained for comparable stand size classes. However, birds, herpetofauna, and small mammals generally favored longleaf pine habitats over slash pine habitats, which, in light of the substantive diminishment (>80%) of longleaf pine in Florida during the past 3 decades, raises concern for the future of these vertebrate groups in the pinelands of north Florida.

HERPETOFAUNA

Loblolly-Shortleaf Pine Sites

Amphibian populations and number of species were more closely tied to availability of streams and ponds than to differences in stand size classes. Sawtimber stands in Louisiana contained more water sources than other stands and amphibians were more abundant. Water was more available in seedling stands in Texas and species richness and abundance were greater there than in other stand size classes. A total of 11 amphibian taxa were encountered in Louisiana compared with 15 for Texas.

Reptiles are generally less dependent on water availability and appeared to be more related to differences in stand size classes. Twenty-three (23) taxa were encountered in Texas and 20 in Louisiana. Green anoles (Anolis carolinensis), northern fence lizards (Sceloporus undulatus), and ground skinks (Scincella lateralis) were relatively abundant at both locations. Green anoles and ground skinks showed similar patterns of abundance at both sites, being most abundant in sawtimber and least abundant in seedling areas. In Louisiana, northern fence lizards were most abundant in sawtimber and least abundant on seedling sites. In Texas, the reverse was true, with none found in sawtimber.

Longleaf-Slash Pine Sites

Thirteen (13) amphibian taxa were encountered on Louisiana sites compared with 17 (excluding bayheads) in Mississippi. Twenty-one (21) reptiles were encountered in Louisiana compared with 36 in Mississippi. Higher taxa numbers in Mississippi were likely related to greater sampling efforts and a greater diversity of censusing methods. Mississippi sites also had an abundance of wet bayheads that served as population reservoirs for many herpetofauna. In Mississippi, species diversity was similar among stand size classes, varying from 33 herpetofauna taxa in seedling to 38 in sapling stands.

SMALL MAMMALS

Loblolly-Shortleaf Pine Sites

Fulvous harvest mice (Reithrodontomys fulvescens), cotton mice (Peromyscus gossypinus), and golden mice (P. nuttalli) were abundant small mammals at both LSH sites. Additionally, rice rats (Oryzomys palustris), hispid cotton rats (Sigmodon hispidus), and eastern woodrats (Neotoma floridana) were abundant on the Texas site, while shorttail shrews (Blarina brevicauda) and white-footed mice (P. leucopus) were common in Louisiana. Total catches of small mammals were highest in early successional stages at both sites. Methods employed for monitoring large and mid-size mammals were generally unsatisfactory at both locations. Track counts yielded the most data for deer in Louisiana relative to night spotlight surveys and scent stations.

Longleaf-Slash Pine Sites

Species richness of small mammals was similar at both longleaf-slash pine sites despite differences in methods and sampling effort. Trapping with Sherman live traps and snap traps yielded about seven taxa over all stand size classes at both locations. Shrews (Cryptotis spp. and Blarina spp.) and mice (primarily Peromyscus gossypinus in Mississippi along with P. leucopus in Louisiana) were the most abundant small mammals trapped at both sites. In Louisiana, shrews were caught more successfully in drift fence-pitfall traps than in Sherman live traps and snap traps. Total numbers of small mammals tended to be higher in older stands, but differences were more related to microhabitat differences than timber size classes.

BIRDS

Loblolly-Shortleaf Pine Sites

The number of bird species encountered was comparable for both the sites, with 106 recorded in Louisiana and 115 in Texas. Principal spring birds on the Texas site included northern cardinals (Cardinalis cardinalis), red-eyed vireos (Vireo olivaceus), pine warblers (Dendroica pinus), Carolina chickadees (Parus carolinensis), tufted titmice (Parus bicolor), yellow-breasted chats (Icteria virens), and Carolina wrens (Thryothorus ludovicianus). The most common species in Louisiana included northern cardinals, blue jays (Cyanocitta cristata), Carolina wrens, white-eyed vireos (Vireo griseus), and tufted titmice. Drought conditions in Texas caused slight declines in numbers of species and drastic reductions in numbers of individuals during winter, especially within seedling and sapling stands.

Longleaf-Slash Pine Sites

Avian species richness was comparable on both LS sites during summer, with 54 species encountered in Louisiana and 55 in Mississippi. The most common summer birds on the Mississippi site were American crows (Corvus brachyrhychos), blue jays, northern cardinals, and rufous-sided towhees (Pipilo erythrophthalmus). Highest summer densities in Louisiana were recorded for blue jays, northern cardinals, brown-headed nuthatches (Sitta pusilla), pine warblers, and Bachman's sparrow (Aimophila aestivalis). Bachman's sparrow, a species thought to be rare, had the highest average density of any of the Louisiana summer birds. In Mississippi, eastern wood pewees (Contopus virens) and Kentucky warblers (Oporornis formosus) were both relatively common; both had been thought to be rare in that part of the state. At least one pair each of Louisiana waterthrushes (Seiurus motacilla) and Swainson's warblers (Limnothlypis swansonii) were thought to have nested on the Mississippi site. Prior to this study, neither were known to nest so far south in the state. Differences in bird abundance and diversity were generally predictable based on differences in habitat diversity and structural complexity.

FISH

Longleaf-Slash Pine Sites

In October 1981, two days of electrofishing (along with a limited seining effort) on streams within the Mississippi study site yielded 26 fish species which represented 11 families and 16 genera. Streams sampled differed widely in water and substrate characteristics and fish composition varied accordingly in a predictable fashion. Minnows or shiners (Notropis spp.), chubsuckers (Erimyzon spp.), madtoms (Noturus spp.), darters (Etheostoma spp. and Percina spp.) and topminnows (Fundulus spp.) were considered to be good indicators of habitat changes. Many of these fish have been identified as indicator species in National Forest Management Plans.

WATERSHEDS, SOCIOECONOMICS, AND PESTS

Influences of regeneration/harvest method, site preparation, and cattle grazing on storm flow and sediment loss were evaluated on five small experimental watersheds on the Texas LSH study area. While harvest method and mechanical site preparation all increased storm flow, peak discharge rates, and sediment loss compared with undisturbed watershed, they were not of an order of magnitude that was considered detrimental to long-term site stability. Grazing was only evaluated for one year but results suggested that grazing impacts were negligible at proper stocking rates.

On the Louisiana LS site, silvicultural and grazing combinations were evaluated for their influences on infiltration and runoff water quality. Results indicated that these practices had minimal impacts on the soil and water resources. Infiltration rates and sediment production from longterm burning plots in the Louisiana LS type were not greatly affected compared to unburned controls. Timing of burning to coincide with periods of rapid vegetation regrowth (late spring) minimizes burning impacts. When considered in relation to the positive benefits of fire as a vegetation management tool, its influences on soil and water parameters would fall within acceptable limits.

Grazing by livestock has been practiced on the southern forests since the late 1700's and has continued as a major agricultural enterprise. A preliminary evaluation of contemporary forest grazing and associated sociological and demographic phenomena was conducted on the Mississippi LS study area where livestock grazing is widely practiced. However, conflicts with ever-increasing demands for other uses and a growing rural population makes potential for conflict great. Greater management inputs and educational programs will be required to allow multiple uses, including grazing, to co-exist on the forests.

Economic analyses for beef cattle production in conjunction with pulp and sawtimber rotations on the the southern forest suggest that the potential exists for much greater production with a concomitant increase in total welfare. Individual producers might, however, expect a real decrease in net returns for their products.

The interaction of grazing with tree pests (insects and diseases) has not been adequately evaluated, nor have these interactions been related to other forest management practices. Surveys indicated that root rot fungus (Heterobasidion annosum) was the most widespread potential disease problem related to grazing. While livestock can potentially be expected to create some problems, in terms of increasing the spread and abundance of some diseases and insects, careful management of stocking rates and timing of grazing would be expected to minimize these impacts.

MANAGEMENT OUTLOOK and EVALUATION

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Forest land in the South exceeds 180 million acres extending from Virginia into eastern Oklahoma and Texas. About 18 million acres of these lands are owned by the public, while about 164 million acres belong to farmers, forest industry, and other private owners. The 12.5 million acres of National Forest in the South are managed to sustain yields of high quality forest resources, while protecting the environment and providing for other desired uses of the forests. Federal budgets are declining and the work force shrinking; consequently, management efficiency must increase.

National Outlook for National Forest System Lands and Resource Management in the Southeast

Robert M. Williamson

I am very pleased to be here with you today representing the Chief of the USDA Forest Service, Dale Robertson. Dale sends his regrets at not being here in person. I am going to preface my remarks with some now all too familiar statements that you hear every day when the future of the Forest Service is discussed. In today's economic climate it is highly unlikely that there will be any increase in budget or manpower in the foreseeable future. Our budgets are in fact declining and our work force shrinking. This means we have to increase our efficiency in management of the National Forests.

National Forest lands are the largest blocks of public land dedicated to multiple use purposes in the South. Most private forest lands are committed to single purpose development with some consideration given to other uses if they can be made to produce a monetary return. National Forest lands on the other hand, are multi-purpose lands which meet diverse public needs. As such they have value to the public quite different from the private lands that surround them. The opportunities are great to satisfy both commodity and non-commodity uses. Some of these opportunities have already been discussed today by the various speakers, and I am sure, will be discussed further tomorrow.

Demand for timber, wildlife and fish, and minerals from the National Forests is increasing. Low demand for livestock grazing combined with increased demand for wildlife, dispersed recreation and wilderness continue to be issues in the South.

We will continue to emphasize multiple use benefits of timber, range, recreation, water, wildlife, and wilderness where designed by Congress on the National Forests in an effort to demonstrate the economic and resource management opportunities that can be applied on forested lands under multiple use management. The economics of timber production on Southern National Forests is good, but the economics of timber production, livestock grazing and wildlife production in combination can be even greater if carefully planned and managed. If it is done with sensitivity and creativity, we can provide for special habitat needs of threatened and endangered species, produce quality water flows and maintain a high level of quality recreation.

We are committed to balance in dealing with commodity and non-commodity production of National Forest resources. National Forest represent this commitment. In every Forest Plan we have attempted to achieve this balance in defining a preferred alternative based on public issues and management concerns, the needs of the local communities dependent upon National Forest System land, and our mission of "caring for the land and serving the people." In a large number of cases (a number larger than I would like), the public has disagreed with us. We recognize that this nation has changed greatly since 1905, the founding of the Forest Service, and we are changing just as the South is changing to meet new problems and opportunities in this changing world of ours.

But as great as the opportunities are, it is a complex business. Careful planning must occur. In every Forest Plan, modifications and revisions have been extensive as a result of public input over what was proposed as a preferred alternative in the draft plan. Virtually all changes made were in the direction of more fully accommodating non-commodity user needs and modifying the amount, kind or timing of commodity production, mainly timber.

The public want the National Forests of the South to be something more than three farms, but still be responsive to public demand for wood products and other market items.

The recently completed Southern Timber Supply Study shows an increasing demand for a shrinking supply of wood from all ownerships by the year 2000 in the South. The National Forests will continue to supply a fair share of the wood needed to meet the demand in the future, but that fair share will be determined through our multiple use program. The Southern Timber Supply Study serves to emphasize the importance of the small residual islands of National Forest System lands relative to other ownerships as multiple use enclaves where wildlife and fish, including non-game, recreation and water quality share equal importance with timber production.

The integrated multiple use management prescriptions in our Forest Plans have identified a desired future condition of the vegetation. Our management is being designed to make those changes in the vegetation that are necessary to achieve multiple use goals. Those goals include both game and non-game wildlife and fish, threatened and endangered species, quality water and our traditional commodities of timber, forage for livestock production, and minerals. Admittedly this is a tall order. There are numerous examples throughout the South where we didn't get the prescription quite right. But then, too, there are many success stories.

Robert M. Williamson, Director, Range Management Staff, USDA Forest Service, Washington, D.C. 20250.

Throughout the South we have numerous examples of multiple use prescription which accommodate or even emphasize wildlife. The classic example is the red cockaded woodpecker, where rotation age and timing of harvest has been altered to accommodate the special habitat needs of this species. Notice I said rotation age and timing of harvest. Wood will still be produced. We must demonstrate that we can integrate and jointly achieve our goals.

Even more compelling is the use of prescribed fire to modify habitats for wildlife and produce forage for livestock and reduce forest pests without modifying rotation age or the basic timber production. We are turning demands for consumptive uses into tools to achieve resource objectives. As an example, livestock are used as a tool to maintain clearings in the forest to benefit wildlife and provide for ecological diversity. Tomorrow at one of the sessions, we will be discussing more of these kinds of opportunities.

The Southeast is climatically well suited for agroforestry. Some examples of success stories are the establishments of walnut plantations with tree spacings to accommodate mechanized equipment--fertilizer application equipment and hay processing equipment. Plantations are producing a quality forage resource (hay) and the walnut trees are benefiting from the fertilizer applied to produce a forage crop. As trees reach the size that tree spacing will not accommodate hay processing equipment, livestock grazing is introduced to consume excess forage. Have we looked at the opportunities for PECAN/HAY/GRAZING system in the South. Another example is where we are breaking down large expanses of cool season grasses (Kentucky Tall Fescue) and establishing native warm season prairie species for the benefit of wildlife, especially quail and small mammals (rabbits). Livestock grazing and haying are the tools of management used to maintain the native bluestems in a vegetation condition to maximize quail habitat.

Private industry is beginning to evaluate some of the practices in use on the National Forests and using these and similar techniques to improve game habitat. This improved habitat can be leased at higher fees for hunting than nonmodified or unimproved habitat. In many cases the benefits are complementary providing both increased lease revenues and increased timber revenues. I recently read where Robert O. Anderson, who at one time was the world's largest landowner, is systematical converting some of his ranchers over to primary wildlife production and is marketing the hunting rights.

This is not to say that we know it all. There is still much to be learned, tried and put to use in the management of both the National Forests and private forest lands. We have improved our management to integrate the many public needs and demands into our multiple use programs on the National Forests. Yet some of our data and information are less reliable than we would like. This is why I am particularly pleased that this Southern Evaluation Workshop is taking place at this time. We have taken our best shot at producing Forest Plans that meet our mission of caring for the land and serving the people. The findings of this workshop will help us evaluate what we have done, identify data gaps, missed opportunities, and yes, oversights and mistakes that might require corrections and modifications to our plans. As these findings are identified, I challenge you to continue to think vegetation management and not just in terms of the traditional aspects of range, timber, wildlife, and water production. More importantly, it will help us set priorities and focus research in areas of highest priority.

Just a little where we see livestock grazing in the Southeast. There may be more questions than answers. There never was a large demand for livestock grazing on the National Forests in the South. It is becoming more obvious that grazing on the National Forest lands cannot be justified on the basis of "red meat" production only. First, there is a large acreage of marginal cropland available for grazing as crop acreage is reduced. These acres absorb most of the demand for livestock grazing. Nine years from now as cropland begins to come out of the conservation reserve program, it is anyone's guess as to what will happen. Will CRP be extended, will grazing begin to occur on these lands to provide a cash flow, or will they be plowed up and put into crops. I have seen some estimates that predict larger acreages of surplus cropland by the year 2000. This land cannot and will not stay idle. More private landowners are turning to "agro" forestry to improve cash flows.

Second, we are learning more about the use of livestock grazing as a means to meet vegetation management objectives. Thus, livestock on the National Forests will be considered more of a tool than a use. Livestock will be preferable in many areas to the use of herbicides in manipulating vegetation. In fact we may see the time when livestock cattle, sheep, or goats are paid to graze on NFS lands. It is occurring now.

Third, the basic grazing program on the National Forests in the Southeast will be to meet the needs of the small local livestock producers. These will be reduced over time. The peaks and the valleys in livestock numbers grazing on the National Forests will reflect the economic factors affecting the livestock industry as a whole in the United States, while demand by small producers and needs for livestock to manipulate vegetation will be the base program.

In summary, the management of National Forests in the Southeast will be one of:

1. More importance placed on rich and diverse forest ecosystems on public lands. The shift to biotic diversity and multipurpose forest vegetation management will be a major criteria for good forestry on National Forest System lands. Silvicultural prescriptions will address a richer set of purposes.
2. Foresters, livestock managers, wildlife managers and others working as a team to increase their sense of partnership. The passwords are integration and leadership.
3. Shortages of the available supply of timber, recreation opportunities, and fish and wildlife, which will increase pressure for production of these resources.

National Forest System Management Perspectives: Timber, Livestock, Wildlife

Marvin C. Meier

Abstract--The Forest Service manages 12.5 million acres of forests in the Southern Region. These lands are managed to sustain a yield of high quality forest resources, while protecting the environment and providing for other desired uses of the forests.

Forest land management that incorporates ecological principles has come of age! A good example is the Southern Evaluation Project (SEP). This forward-looking project provided the opportunity to research the interactions among resources and apply findings. The need to manage the forest types studied, with an understanding of their ecological relationships, is increasingly more important.

Some examples:-

- the concern over clearcutting (diversity, visual soil and water implications).
- the increased interest in hardwoods, particularly mast-producing hardwoods, in coastal plain, piedmont and mountain forests.
- the wiregrass longleaf community.
- the titi/slash pine relationship.
- the increasing need for management and protection of endangered, threatened and sensitive plant and animal species (red-cockaded woodpecker, gopher tortoise, roundleaf birch, Harper's beauty, small whorled pogonia).
- increased concern over competition between wildlife and livestock.

In the past, we have dealt mostly with populations. Particularly, populations of commercial timber species, i.e., loblolly, longleaf, etc., or even deer in terms of numbers. We have begun to think more of plant communities, still with emphasis on a few members of the community. This perspective is appropriate. We need to move more and more to community management. Use of habitat relationship models support this principle.

It is all right to focus on key species in the community as long as we realize two things. First, that the models provide only an approximation of impacts to the whole community; and second, we must use an appropriate indicator species. This is an important aspect of the knowledge known beforehand or gathered in studies such as those done for these projects.

We are thinking more toward ecosystem management. Why? Because we collectively (the Forest Service and the users) are demanding a variety, a broad spectrum, of outputs from communities and ecosystems (figs. 1 and 2).

In the long run, both we, internally, and the public, expect that the basic natural ecosystem will or should remain. We face no small task to extract figuratively and literally the "products" we want from an ecosystem, and still maintain ecological stability over time.

We still have our terminology--we manage timber. We manage range and wildlife. That concept is acceptable as long as we don't lose sight of the fact that each resource is only a part of the overall system.

We are not charged with "hands off" ecosystem management--just letting the natural cycles run. We are charged with managing forests to extract the "products" desired, while protecting long-run productivity. Our policies need to foster and carry out management concepts that would not destroy the natural aspect, but would provide a flow of products. We need, also, to say when a threshold is reached that precludes further production of a given product without undue damage to the natural system. The level at which this occurs is often based on our understanding of the total system and our ability to work within rather than outside natural processes. This is why the SEP was so important. For example, years ago we had not found a successful way to regenerate longleaf pine at an acceptable cost. So we planted slash pine on longleaf sites. When we cut longleaf on many sites we destroyed the longleaf community. The solution wasn't to stop extracting the longleaf products, but to find a feasible way to regenerate longleaf. Another example may be the red-cockaded

Remarks by Marvin C. Meier, Deputy Regional Forester for Resources Southern Region, USDA Forest Service, 1720 Peachtree Road, NW, Atlanta, GA 30367

Figure 1.--A natural ecosystem is a closed system as far as our utilization of products is concerned, except for such things as migratory birds and water.

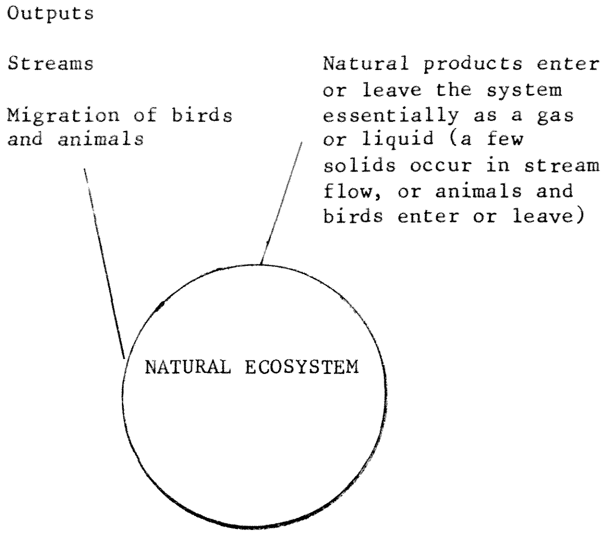
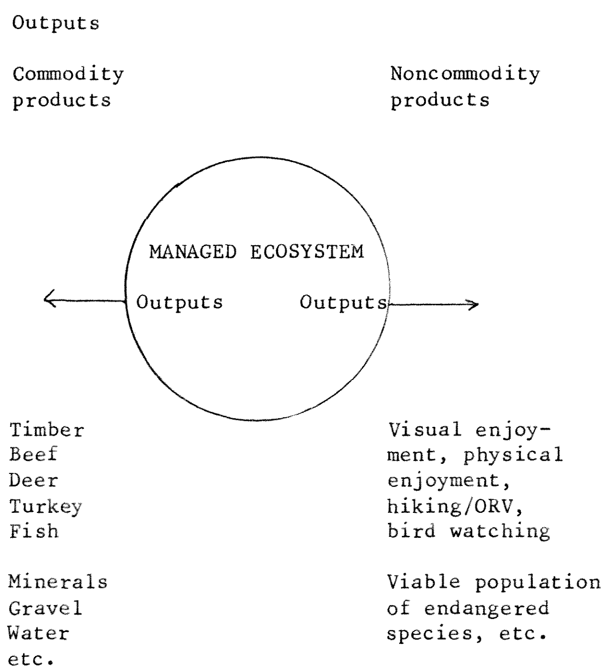


Figure 2.--We expect or demand a wide variety of outputs or "products" from a managed ecosystem.



woodpecker (RCW), as an endangered species. These birds require mature or old longleaf, loblolly or shortleaf. The solution is not to leave all these stands, but to find ways to extract the "products" we want, including the RCW, by modifying our methods. We have made some headway, but we have a ways to go.

A third example relates to extracting (maintaining) the visual resource while extracting timber or logs. We have moved toward clear-cut shaping, shelterwoods--more seed tree cutting to maintain better visual resources. We have an opportunity to use uneven-aged management in some cases. Note, however, that changing practices affect other ecosystems' "products", potentially on the basic structure of the system itself, so changes must be evaluated.

Consider the timber management/production and silvicultural systems in this Region. Criteria for prescribing appropriate silviculture systems are applied according to the management type under consideration. In the longleaf/slash and loblolly/shortleaf timber types, the even-aged system is more commonly used.

For each silvicultural system, there are two or more harvest (regeneration) cutting methods that may be used. The most appropriate harvest cutting method for a given timber stand depends on many factors. For example: species, silvics, seed production, site characteristics, regeneration time, economics, availability of genetically-improved planting stock, aesthetic quality, other resource needs and requirements. The specific interactions of these factors must be considered on a case-by-case basis. The three harvest methods used in even-aged management are: clearcut, seed-tree and shelterwood.

Rotation in the even-aged management of southern pines will vary between species and may vary within a management prescription for an analysis area.

Rotations are at least 180 years for longleaf and 70 years for other pines within compartments managed for RCW. Other alternatives are considered in the forest planning process and from informal consultation with the Fish and Wildlife Service.

As mentioned earlier, the principal concerns related to range in the Region are: economics of range grazing, range capability, the potential for resource damage, possible conflict with other resource uses and reducing grazing on National Forest System lands where such use is economically submarginal.

Some of the Coastal Plain forests (Texas, Florida, Mississippi and Louisiana) have been involved in the SEP project. Foresters there are trying some management practices that have provided some valuable management information. Much of that data is mentioned in some of the more technical presentations.

Significant aspects of the wildlife program, as mentioned, include: threatened and endangered species, habitat improvement for big game, small game, and non-game species and coordination with State agencies regarding game population management.

Active management (regeneration cuts, site preparation burning) of the longleaf/slash pine forests predominates in much of the southern Coastal Plain from North Carolina to south-eastern Texas. These management practices have been beneficial for several wildlife species, including the RCW.

For example, the RCW increases in the longleaf type that has a history of burning, with little or no hardwood midstory. However, the RCW declines in the loblolly type in which hardwoods exist because of the lack of fire.

As stated earlier, our treatment of forests, specifically those studied by SEP, has evolved from total utilization of the timber--in some cases range--to timber and range emphasis coordinated with other needs and now toward more integrated management of all the various "products". The presently increasing demands for various products make it imperative that we use all the knowledge made available by SEP.

This conference promised to be very beneficial and important, by adding to our ecological knowledge. The information will certainly influence many of our management thoughts and practices. The personal contacts, presentations and a final proceedings are well worth the time spent.

A Basis for the Southern Evaluation Program

Gale L. Wolters and Ronald D. Lindmark

In the early 1970's a Forest Service study was designed to explore the current and potential production of resources and the role of grazing on all forest and range ecoystems--the forest-range--within the 48 contiguous United States. The purpose of the Forest-Range Environmental Study, better known as the FRES study, was to assemble information about all of the Nation's range and to develop technology for its evaluation that would serve the planning needs of the Forest Service. Needed was an orderly arrangement of management alternatives, each based upon an evaluation of information about the physical and biological resources of the environment. Social, political, and economic needs were also to be considered.

It was concluded from the FRES study that grazing of the Nation's forest-range environment was compatible with the increasing demands for livestock feed, and that these increases could be achieved on a national basis, and without reduction in enviromental quality. Specifically, the FRES study reported that animal unit months of grazing could increase 50 percent nationally and 147 percent on Eastern forest-range without reduction in environmental quality. As all of you may suspect--and as many of you will recall--there were many skeptics of the study findings; many questioned the validity of the data. There were factions who swore **by** the study implications and other factions who swore **at** the study implications within the Forest Service as well as outside the agency.

In an attempt to resolve conflicts in opinion and professional judgment the Chief of the Forest Service, John R. McGuire and Staff agreed in 1973 to support an Accelerated Range Program. The program provided authorization for an interdisciplinary team of scientists to monitor and research the social, economic, biological, and ecological interrelationships of forest-range resources to management strategies; to provide feedback for adjusting program direction nationwide; and to demonstrate resource interrelationships on an operational scale. Because of the multiresource flavor, professionals from many scientific disciplines contributed. Among the disciplines represented were: forestry, range, ecology, watershed, hydrology, soils, wildlife and fisheries, economics, recreation, landscape architecture, and computer science.

The Accelerated Range Program was a major Agency effort. It included three regional research and demonstration test sites and personnel from each of the nine Forest Service administrative regions, eight Forest and Range Experiment Stations, and two State and Private Forestry Areas. The National Forest System provided demonstration and study sites, financial support (which was a major contribution to the Southern Evaluation program), and technical expertise.

State and Private Forestry provided technical expertise, financial support and leadership for range improvements on private lands, interagency coordination, and technology transfer. Forest Service Research provided financial support, technical expertise and leadership for planning and implementation of the overall program, and facilitated technology transfer through various processes such as the current workshop.

The Accelerated Range Program was not totally a Forest Service program. Agricultural Research Service, Agricultural Stabilization and Conservation Service, and the Soil Conservation Service were valuable USDA cooperators. However, many industrial timber companies, state and private landowners, universities and research institutions also contributed substantially to the success of the Accelerated Range Program as you will hear more about during the next day and a half.

The three test sites selected for the Accelerated Range Program were: Eastern Oregon, Central Utah, and the Southern Coastal Plain. However, as a result of budget recession and changing agency objectives, plans for the three evaluation programs were restructured. For example, the Eastern Oregon program was completed in FY 1986 but the number of forest-range resources evaluated were scaled back from 18 to 6. The six remaining outputs were (1) herbage and browse, (2) water quantity, (3) water quality, (4) storm runoff, (5) economic cost--accounting, and (6) economic impacts. Likewise, the Central Utah program was trunkated to the point that it never preceded beyond an initial implementation stage. The Southern Evaluation Program, as we will hear about in detail the next couple of days, was initiated and substantial technology was developed.

Timber production in the South is and undoubtedly will remain the primary object of forest-range management. Historically the "burden of proof" for compatible multiple use management of Southern forest range was incumbent upon the non-timber resource advocates. Some technical information on southern forest range multiple resource

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interrelationships and their compatible uses was available prior to the Southern Evaluation Program. However, the Southern Evaluation Program contributed substantially to filling gaps in our knowledge and enhancing our knowledge of natural resource relationships on Southern forest range. This new knowledge base will significantly facilitate land management planning and sound multiple resource decision making in the future.

I am excited to be here and have opportunity to hear specifically how this new technology will improve integrated resource management on our Southern forest ranges. I am also interested in learning how this knowledge will be used to direct our future research programs in the Forest Service.

The Southern Evaluation Project: Development and Results

Henry A. Pearson

Abstract.--The Southern Evaluation Project was a collaborative effort by several organizations to evaluate range, timber, wildlife, and watershed resources on National Forest System lands in the Southern United States. Sponsored by the USDA Forest Service, the project's goal was to promote sound, multiple-use management of the southern forested lands. The study was located in longleaf-slash pine (*Pinus palustris*-*P. elliottii*) and loblolly-shortleaf pine (*P. taeda*-*P. echinata*) forest types. Five study areas, each 8 to 12 thousand acres in size, were subdivided into four units to accommodate future range, timber, and wildlife management strategies. The subdivisions also provided replication of measured parameters. Soil, water, flora, fauna, and socioeconomic parameters were measured on the study areas. These measurements provided data for evaluating management, soil, vegetation, and wildlife diversity on the USDA Forest Service Southern Region's national forests. The project lasted for 5 years, and some watershed evaluations extended for 10 years.

INTRODUCTION

Population increases indictate a growing competition in the future for the use of the land. Land use practices will inevitably intensify as the nation attempts to support population growth and meet the demands for food and fiber. Since multiple-use or multi-purpose forest management has been practiced and discussed, both practitioners and researchers are interested in the interactions between timber, range, wildlife, and other renewable resources on southern pine forests. When the Southern Evaluation Project was approved by the Chief of the USDA Forest Service in 1978, forest managers and researchers had their first opportunity in the South for an indepth examination of these interrelationships by major pine types over a broad area.

The Resources Planning Act of 1974, the Resources Conservation Act of 1977, the National Forest Management Act of 1976, and the Multiple Use-Sustained Yield Act of 1960 provided for the future management, supply, and use of multiple forest and range land resources. The Southern Evaluation Project was initiated to reinforce these Acts and to evaluate multiple-use interactions in the South. The goal of the study was to promote sound multiple-use management of the southern forested lands. In order to achieve this goal, three specific objectives were established:

1. To evaluate impacts of timber, wildlife, and range management alternatives from a biological, physical, economic, and social standpoint.

2. To provide appropriate technology transfer.

3. To demonstrate selected management strategies on an operational scale.

COOPERATION AND ORGANIZATION

The project was a joint effort of State and Private Forestry, Research, and the National Forest System of the U. S. Forest Service, with coordination from other agencies and organizations. Over 60 institutions, agencies, organizations and individuals provided input for the original project plan. Interested agencies and organizations were continually apprised of activities through appropriate designated contacts. The National Forest System was responsible for facility installation and maintenance as well as management. State and Private Forestry was responsible for technology transfer, and Research was responsible for measurement. Universities and organizations participating in measurements and/or technology transfer were: Texas A & M University, Stephen F. Austin State University, Louisiana State University, Northwestern State University (Louisiana), Mississippi State University, University of Florida, Virginia Polytechnic Institute and State University, USDA Soil Conservation Service, USDA Forest Service, USDA Agricultural Research Service, and Southern

Henry A. Pearson, Supervisory range scientist, Southern Forest Experiment Station, USDA Forest Service, Pineville, LA 71360.

Ecology Laboratory, Starkville, Mississippi. The project was endorsed by the U.S. Department of State's U.S. Man and the Biosphere Program Directorate on Grazing Lands (MAB-3).

BACKGROUND

In October 1980, a workshop was conducted in Lufkin, Texas, to explain past and present progress of the cooperative project and some of the anticipated results. More than 60 people from 3 State agencies, 9 universities, 4 Federal agencies and several special interest groups attended. Each received an abstract of the papers presented.

A report on the potential grazing systems to be used in the SEP was made at the 1981 annual meeting Society for Range Management, Tulsa, Oklahoma. Ideas were solicited from the 25 professionals who attended that session and were incorporated into project plans where possible.

The project has been discussed and interim reports made at several formal meetings including the 1980 Society for Range Management meeting in San Diego, California, the 1981 International Grassland Congress at Lexington, Kentucky, and the 1981 National Gopher Tortoise Council meeting in Jackson, Mississippi.

STUDY AREAS

The project was initiated on National Forest System lands in Texas, Louisiana, Mississippi, and Florida (figure 1). Two study areas located in Texas and Louisiana represent the loblolly-shortleaf pine (*Pinus taeda-P. echinata*) type; three study areas in Louisiana, Mississippi, and Florida provided the longleaf-slash pine (*P. palustris-P. elliottii*) type. The five areas were each 8 to 12 thousand acres in size. All study areas were managed according to the USDA Forest Service Southern Region's guidelines for timber, range and wildlife. These guidelines are discussed in these proceedings by M. C. Meier, Deputy Regional Forester, Southern Region, National Forest System. All areas selected had a history of livestock grazing but were not necessarily being grazed when the study began (table 1).

MEASUREMENTS

Scientists and managers from several universities and the Forest Service determined appropriate sampling methods for general physical and biological monitoring. Cooperative agreements between the Forest Service and cooperating scientists provided the appropriate expertises for evaluating physical and biological responses. Standardized measurement

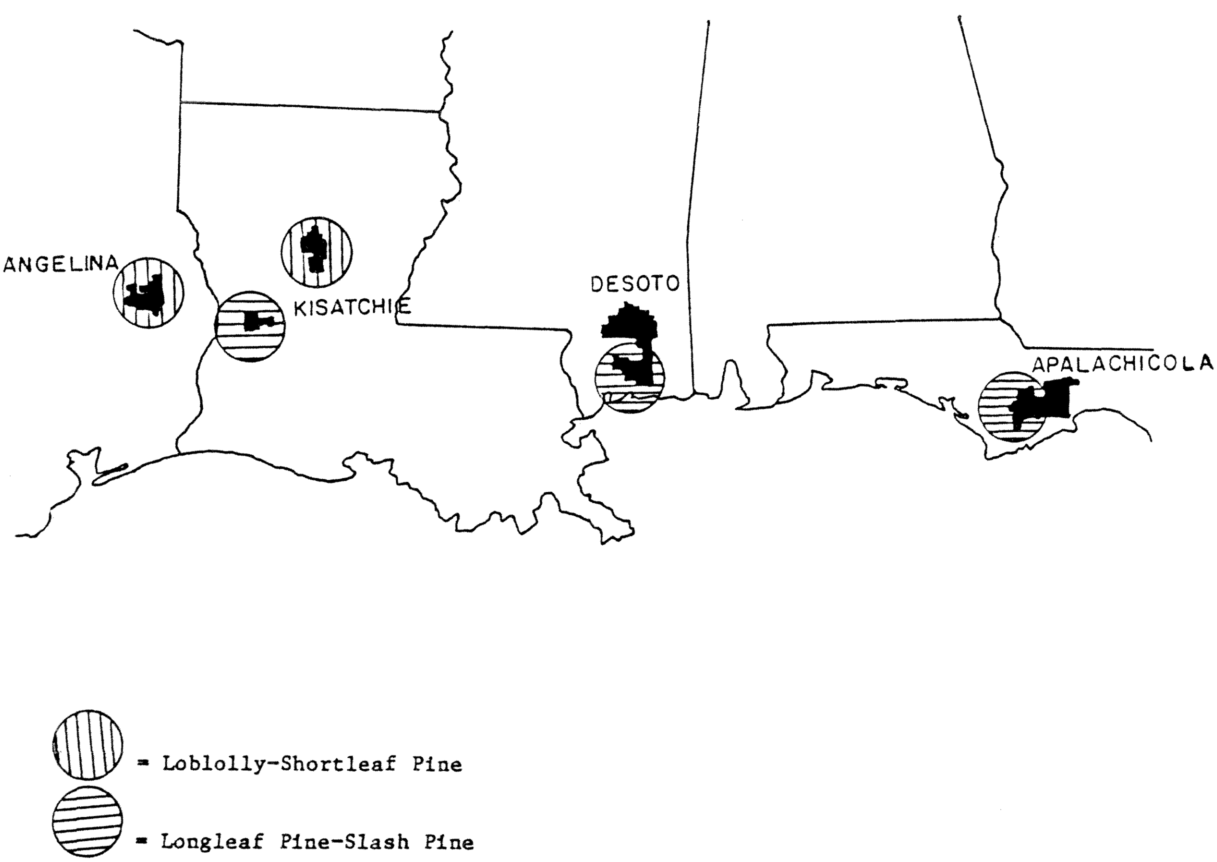

FIGURE 1. Southern Evaluation Project locations.

Table 1.--Grazing history on the Southern Evaluation Project areas

Forest type	State	National Forest Ranger District	Grazing History
Loblolly-shortleaf pine	Texas	Angelina	No grazing since 1969; controlled light grazing 1963-69; uncontrolled moderate grazing prior to 1963.
Loblolly-shortleaf pine	Louisiana	Catahoula	No grazing since 1973; light to moderate grazing since 1967; moderate to heavy uncontrolled grazing prior to 1967.
Longleaf-slash pine	Louisiana	Vernon	Moderate controlled grazing on all areas since 1967; heavy grazing prior to adjudication in 1967.
Longleaf-slash pine	Mississippi	Biloxi	Moderate grazing on three areas since 1966; no grazing on one area; uncontrolled heavy grazing by cattle and sheep on all four areas prior to 1966.
Longleaf-slash pine	Florida	Apalachicola	No grazing until 1978; moderate grazing on two areas; no grazing on two areas since 1978.

techniques were utilized at different locations to attain comparable results where possible; however, specific techniques and sampling intensities were determined by the scientists in charge of the individual projects. Measurements included the following elements: soil, water, climate, flora, fauna, and socioeconomic influences.

DISCUSSION

Soil surveys were completed on all the study areas. Watershed evaluations were performed on the Louisiana longleaf-slash pine and Texas loblolly-shortleaf pine types. Social assessments of community development were conducted only in Mississippi. Economic evaluations were made to assess the forest-range livestock enterprise, alternative livestock strategy economies, and regional impacts of implementation of forest grazing programs in the South. Vegetation, amphibian, reptile, mammal, and bird measurements were completed on all the study areas. These evaluations reflect present land management and provide baseline data for future management assessments and land use planning.

The Southern Evaluation Project has resulted in 42 publications including proceedings, professional and trade journals, USDA bulletins, agricultural experiment station bulletins, and theses (Appendix I), 24 formal presentations (Appendix II), and 58 reports (Appendix III). These reports are filed at the Southern Forest Experiment Station, Range Management Research Work Unit, Pineville, Louisiana. The 32 papers published in these workshop proceedings conclude work initiated through the Southern Evaluation Project.

LOBLOLLY-SHORTLEAF PINE TYPE

Moderator:

Kent T. Adair
Stephen F. Austin State University
Nacogdoches, Texas

Loblolly-shortleaf pine-hardwood forests comprise the most extensive forest range type in the South. The area totaling about 55 million acres, reaches almost unbroken from eastern Texas to northeatern Virginia and varies from 150 to 300 miles wide.

Soils of the Loblolly-Shortleaf Pine-

Hardwood Type, Angelina National Forest, Texas

Raymond Dolezel and Fred E. Smeins

Abstract.--The Texas site for the Southern Evaluation Project was a 10,665 acre area on the Angelina National Forest in East Texas. The landscape is gently rolling and varies in elevation from 150 to 400 feet. Two major geologic formations (Yegua and Cook Mountain) underlie the area. Vegetation is dominated by loblolly and shortleaf pine with admixtures of longleaf pine and various hardwoods. Soils are primarily Alfisols, Ultisols and Vertisols in the uplands and Entisols in the bottomlands. Twelve soil series were identified and a detailed soils map was prepared. Soils vary from deep sands to relatively shallow loamy sands and loams over a claypan of montmorillonitic clays. The majority of soils within the area would be considered to have moderate production potential for timber and understory plants.

INTRODUCTION

The Texas site for the Southern Evaluation Project was located on the Angelina National Forest (fig. 1) in east, central Texas within the East Texas Timberlands Resource Area (= Pineywoods) (Godfrey and others 1973, Freeouf 1977). It is characterized by mixed pine (loblolly, shortleaf, longleaf)-hardwood forests. Most upland soils are Alfisols and Ultisols, however, clayey substrates have produced Vertisols as well (Dolezel and Holt 1979). Inceptisols and Entisols occur in the bottomlands.

The purpose of this evaluation was to provide baseline soils data for proposed grazing and silvicultural treatments which were to be applied to the area. This information would provide a basis for interpretation of soil and vegetation responses to the various treatments. Specific objectives were to: 1) identify, describe and map the soils of the area at an Order 2 soil survey as defined by the Soil Conservation Service, and 2) to qualitatively and quantitatively characterize selected physical and chemical properties of selected soils and sites.

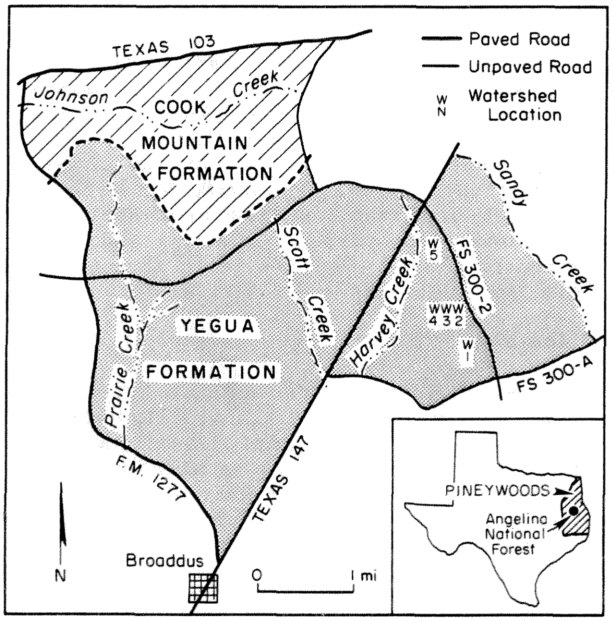

Figure 1.--Location and physical features of the Texas Southern Evaluation Project site.

Raymond Dolezel is a Soil Scientist, Soil Conservation Service, Nacogdoches, Texas. Fred E. Smeins is a Professor, Range Science, Texas A&M University, College Station, Texas.

STUDY AREA

Location and Landscape

The 10,665 study area was located on the 116,000 acre Angelina National Forest in San Augustine County, Texas (centered at 94'15°W, 31° 15'N). It is approximately 30 miles east of Lufkin, Texas. The western boundary is defined by Texas Farm Road 1277, the northern by Texas Highway 103, the eastern by Sandy Creek and the southeastern by Texas Highway 147 and Forest Service Road 300-A (fig. 1).

The area is in the Gulf Coastal Plain Physiographic Province. The landscape is gently rolling and varies in elevation from 150 to 400 feet. Three perennial creeks, Prairie, Scott and Harvey, drain the southern two-thirds of the area southward into Sam Rayburn Reservoir. The northern portion is drained northward by tributaries of Johnson Creek. Other than riparian areas there are no significant wetland areas (fig. 1).

Geology

Two Eocene geologic formations underlie the area: the Yegua and the Cook Mountain (Geol. Atlas Tex. 1974) (fig. 1). The Yegua formation underlies the southern three-fourths of the area and is a heterogeneous complex of layers of sand, clay, lignite and carbonaceous clay lentils. It is essentially a piedmont of coastal alluvial fans built up by coalescing stream levees and deltas and later reinundated by the ocean. The northern part of this formation was deposited as a beach and consists of deep sand deposits. The Cook Mountain formation underlies the northern one-fourth of the area and is made up of montmorillonitic clays and fine-grained sands. It was formed from sediments of bays and shallow near-shore ocean environments. Gypsum ($CaSO_4$) and calcium carbonate ($CaCO_3$) occur variably throughout the formation (Sellards and others 1966).

Climate

The climate of the area is mesothermal, humid subtropical with rainfall throughout the year. The frost-free period is 238 days with the first frost occurring in mid-November and the last in mid-March. Mean temperatures range from 47°F in January to 82° F in July (fig. 2). Annual precipitation averages 49 inches with greater than three inches falling during each month. Approximately 25 inches of rainfall occurs in April through September which is the growing season. July and August can be dry during some years and there can be considerable year to year variation. For example, during the years of study, 1979 and 1980, total precipitation was 75 and 48 inches, respectively. June, July and August were extremely dry in 1980 and collectively these months recorded only 3.5 inches, while the same months in 1979 received 12.8 inches. Also temperatures were higher in 1980 with June, July and August averages of 81.9, 84.9 and 84.2, respectively, while 1979 averages for the same months were 78.3, 81.4 and 80.7.

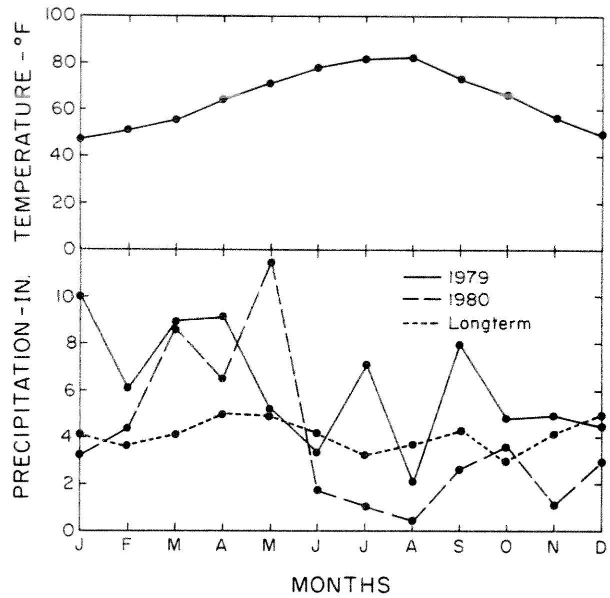

Figure 2.--Long-term temperature and precipitation and precipitation for 1979 and 1980.

Vegetation

Detailed analysis of the vegetation of the area is presented in the following paper (Smeins and Hinton, this volume). Generally, most of the area is forested with less than 5 percent in clearcuts, pastures or crops. The forests are second growth and most are mixtures of pines and hardwoods. Loblolly pine (*Pinus taeda*) shortleaf pine (*P. echinata*) and longleaf pine (*P. palustris*) occur throughout the area with associated oaks (*Quercus* sp.), sweetgum (*Liquidamber stryraciflua*) and other hardwoods.

METHODS AND PROCEDURES

Soil Survey and Mapping

Black and white aerial photographs at a scale of 1:15840 (4 inches = 1 mile) taken on June 6, 1955, along with USGS 7.5 minute quadrangle maps were obtained to provide a baseline for investigation of soil-topographic relationships (Dolezel and Holt 1979). Topographic contours were identified on the photograph as the first approximation of variation within the area. A field reconnaissance was made of the entire area by Soil Conservation Service soil scientists to obtain an initial evaluation of the variety of soils to be found.

Based upon the topographic variation and impressions of the field reconnaissance, uniform areas within topographic contours were identified on the photographs for more intensive study. Examples of all topographic-landscape combinations were selected for study.

In the field, transects were traversed across each identified area on the photograph and several (a minimum of ten) soil cores were described for each location. Sample points on each transect were permanently marked with white metal stakes. Cores were obtained with a 2-inch diameter hydraulic, pick-up mounted soil auger, or with a hand-operated soil auger where vehicle access was impossible.

Soil profiles were described in the field and for each horizon, color, texture, organic matter, structure, drainage regime and other observable soil properties were qualitatively evaluated. Slope, aspect, parent material, past land use and other notable features of the sample areas were recorded. Based upon field descriptions each soil was classified according to the Soil Taxonomy System (Soil Survey Staff 1975).

Based upon interpretation of aerial photographs and the field survey and classification of soils, a map was prepared to show the kinds and patterns of soils that occur within the study area. Each map unit identified represents a soil series and as such serves as a guide to the suitability of the soil for specific uses, to identify plant production potential and to identify limitations and principal hazards to be considered in management planning. The soil survey and map preparation was conducted during 1979.

Soil Characterization

Thirty-three mapping units which represented most of the soil series identified in the area were selected for further soil analysis (fig. 3). Mapping units were selected for study if they 1) exhibited uniformity of soil features and topography, 2) had homogeneity of vegetation in all strata, and 3) were of sufficient size to obtain a representative sample and to avoid edge effects. Along the transects established across the mapping unit during the soil survey several (a minimum of 10) 0- to 6-inch soil cores were collected during August 1980. These cores were pooled to form a composite sample, placed in paper bags, transported to the laboratory and immediately air dried.

In the laboratory, texture, percent organic matter, and soil pH were determined for each sample using the hydrometer method (Day 1957),

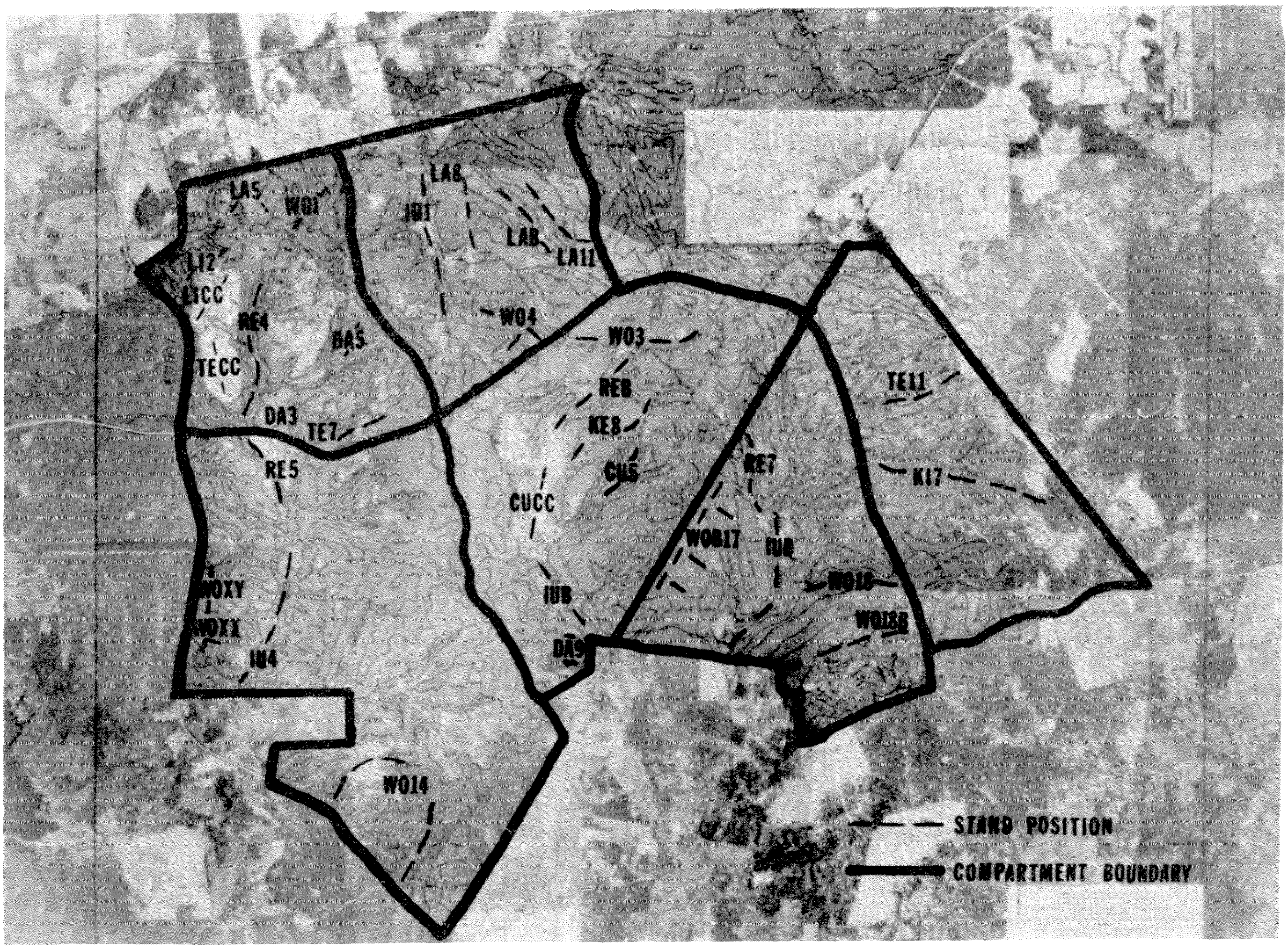

Figure 3.-- Generalized soils map of the study area with each study stand (e.g. WO14) identified within National Forest management compartments. Abbreviations (e.g. WO, RE, etc.) refer to soils described in Table 1.

Wakely-Blake method (Black and others 1965), and a HACH pH meter, respectively.

Depth to the claypan was determined in the field in each sample area using a 3/8-inch radius, 4-foot long metal rod which was incremented into 4-inch intervals. The rod was driven into the soil at several locations near each sample point, depth to the claypan was recorded for each probe and an average depth was obtained for the stand. Slope position (top, middle, bottom), aspect (compass) and inclination (abney level) were recorded for each stand.

Two replications of four soil series were selected for additional characterization. They included a Tenaha loamy fine sand, a Cuthbert fine sandy loam, a Woodtell very fine sandy loam and a Lacerda clay. Within each of these sites five samples (0-12 inches) were collected in mid-August 1980 along the established transect and pooled for later analysis. They were analyzed for pH, calcium, magnesium, phosphorus and potassium by the Soil Testing Laboratory, Texas A&M University (Chapman and Pratt 1961). Moisture release curves were determined by the Texas A&M University Forest Science Laboratory (Richards 1965). Samples were collected during August 1980.

RESULTS AND DISCUSSION

Soils of the Area

Twelve soil series were recognized within the area (table 1). For the Lacerda and Woodtell series two phases were mapped for a total of 14 soil mapping units. Upland soils are Alfisols, Ultisols or Vertisols, while bottomlands area primarily Entisols and Ultisols (table 1). Woodtell, Lacerda and Cuthbert were the predominant upland series and covered 65 percent (6,926 acres) of the total area. Rentzel and Iuka are the major bottomland soils and covered 1409 acres or 13 percent of the total area.

A reduced map of the study area with topographic contors and map units is presented (fig. 3). Maps of greater detail and clarity are available in the report by Dolezel and Holt (1979) if greater resolution is desired. Also identified on figure 3 are the specific study transects used for soils and vegetation sampling (Smeins and Hinton, this volume).

Detailed descriptions of the profile of the soils found on the area are presented elsewhere (Dolezel and Holt 1979, Dolezel and Fuchs 1980). Upland soils vary from deep sands to clays with shallow clay loam surface horizons (table 2). Darco and, to a lesser extent, Lilbert, Tenaha and Keltys soils are sandy with a relatively deep solum (table 2). Surface soil sand content exceeds 65% for all of these series. Their subsoils are loamy sands or sandy loams (fig. 4). They have medium acid surface horizons and strongly acid subsoils (table 2). Permeability is generally rapid and moisture retention low (fig. 5). These soils developed from the sandy Yegua Formation with Darco soils formed on deep beach deposits of this Formation (fig. 6).

Table 1.--Soil name, taxonomic class and acreage for soil types on the Southern Evaluation site, Angelina National Forest, Texas. Information adapted from Dolezel and Holt 1979.

Soil Name and Map Unit	% Slope	Map Symbol	Acres	Taxonomic Class
Upland				
Darco lfs	1-8	Da	48	Loamy, siliceous, thermic Grossarenic Paleudults
Lilbert lfs	1-8	Li	326	Loamy, siliceous, thermic Arenic Plinthic Paleudults
Tenaha lfs	5-20	Te	634	Loamy, siliceous, thermic Arenic Hapludults
Keltys[1/] fsl	1-5	Ke	584	Fine-loamy, siliceous, thermic Aquic Hapludults
Kullit l	0-4	Ku	128	Fine-loamy, siliceous, thermic Aquic Paleudults
Kirvin fsl	1-8	Ki	610	Clayey, mixed, thermic Typic Hapludults
Cuthbert fsl	5-20	Cu	1,471	Clayey, mixed, thermic Typic Hapludults
Woodtell vfsl	1-5	Wob	2,692	Fine, montmorillonitic, thermic Vertic Hapludalfs
Woodtell vfsl	5-20	Wod	1,149	Fine, montmorillonitic, thermic Vertic Hapludalfs
Lacerda cl	1-5	Lab	464	Very-fine, montmorillonitic, thermic Aquentic Chromuderts
Lacerda cl	5-20	Lad	1,150	Very-fine, montmorillonitic, thermic Aquentic Chromuderts
Bottomland				
Iuka fsl	0-1	Iu	457	Siliceous, thermic Typic Psammaquents
Rentzel lfs	0-5	Re	952	Coarse-loamy, siliceous, acid, thermic Aquic Udifluvents
Osier[2/]	0-1	Os	-	Loamy, siliceous, thermic Arenic Plinthaquic Paleudults
TOTAL			10,665	

[1/] Tentative series

[2/] Mapped as inclusion with Rentzel

Cuthbert, Kullit, Kirvin and Woodtell soils have loamy surfaces with clay or clay loam subsoils (fig. 4). Sand content of the surface horizon is between 60 and 70%, while subsoils tend to be clayey (table 2). Surface and subsurface horizons are strongly to very strongly acid (table 2). Permeability is moderate to moderately rapid and moisture retention is relatively low (fig. 5). These soils formed on clayey sediments of the Yegua Foundation and clays of the Cook Mountain Foundation (fig. 6.).

Table 2.--Mean physical and chemical soil properties of the surface soil (0-6 in) of selected soil series[1] on the Angelina National Forest study area, Texas. Samples collected in August 1980. Data adapted from Hinton 1981

	Sand (%)	Silt (%)	Clay (%)	Organic matter (%)	pH	Claypan depth (in)
Uplands						
Darco (3)[2]	74	10	12	1.4	4.8	36
Lilbert (1)	71	12	17	1.8	4.9	25
Tenaha (2)	68	12	22	1.8	4.6	18
Keltys (1)	65	19	16	1.9	4.3	20
Kirvin (1)	63	15	22	1.8	4.4	13
Cuthbert (1)	70	11	19	2.0	4.4	16
Woodtell (9)	58	17	24	1.8	4.3	10
Lacerda (4)	26	26	48	1.5	4.2	2
Bottomlands						
Rentzel (4)	71	9	10	1.8	4.1	39
Iuka (4)	66	15	19	1.7	4.2	35

[1]Kullit and Osier series not evaluated

[2]Numbers of stands sampled

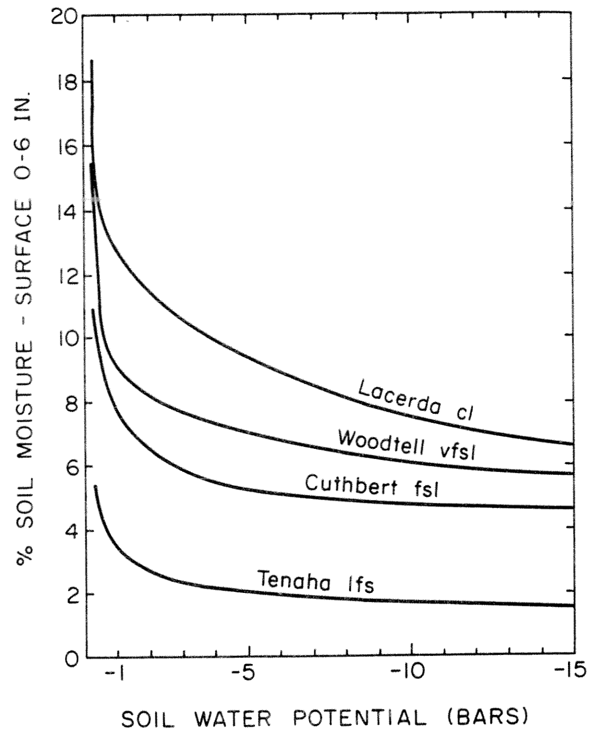

Figure 5.--Soil moisture release curves for four selected upland soil series.

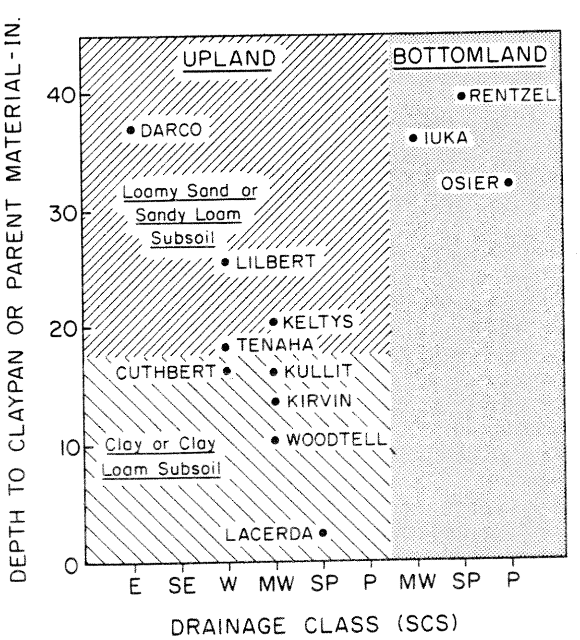

Figure 4.--Generalized diagram to illustrate the relationship of soil series to one another based upon depth to claypan and drainage class.

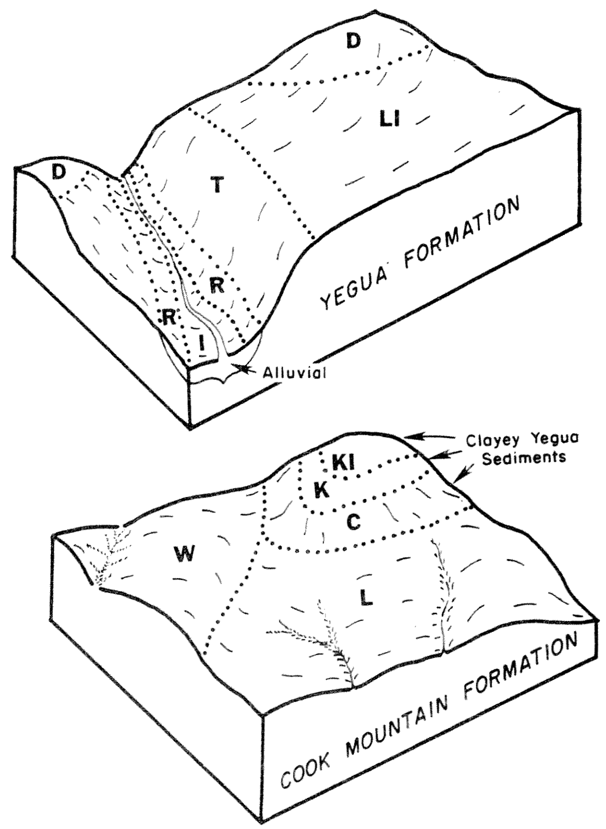

Figure 6.--The relationship of soil series of the area to geology and topography. Letters refer to series identified in table 1.

Lacerda soils are notably different from other upland series. They have a very shallow (< 3 in) clay loam surface horizon and clay subsoils (fig. 4, table 2). They are strongly acid throughout the profile. Permeability is very slow, but moisture retention is relatively high (fig. 5). These soils developed from clay deposits of the Cook Mountain Formation (fig. 6) on the northern portions of the study area (fig. 1).

Bottomland soils have a deep solum which exceeds 35 inches for all series studied (fig. 4, table 2). They have formed along Johnson, Prairie, Scott, Harvey and Sandy Creeks and their tributaries (fig. 1). These soils all experience periods of impeded drainage due to flooding or high water table. The solum is sandy loam to loam throughout. Iuka soils occur at the moderately well-drained immediate margins of the streams, while Rentzel soils form the broad, somewhat poorly-drained floodplains of the stream bottoms (figs. 4 and 6). Osier soils are found in small, usually less than one-half acre, poorly drained pockets within the Rentzel series. All bottomland series have greater than 65% sand in the surface horizon and they are strongly acid throughout (table 2).

Chemical analyses of the surface 12 inches of four upland series indicated low values of phosphorus, potassium, calcium and magnesium for the sandy series, while the clay textured Lacerda series had comparatively higher values for all cations (table 3).

Table 3.--Mean concentration (ppm) of selected nutrients within the surface (0-12 in) of four selected soil series on the Angelina National Forest, Texas. Samples collected in August 1980. Data adapted from Howell 1981

Soil Series	Phosphorus	Potassium	Calcium	Magnesium
Tenaha	1	60	360	50
Cuthbert	5	48	200	65
Woodtell	2	48	160	115
Lacerda	3	284	1600	>500

Moisture release curves of selected upland soils showed all to have limited storage capacity (fig. 5). The clay loam surface horizon of the Lacerda series had the highest retention and greatest potential storage, while the loamy fine sand of the Tenaha series had minimal ability to store significant amounts of water.

Plant production potential is variable across the soil series (table 4). For upland series the clay profiles of the Lacerda series have the lowest site index for loblolly pine, 65 feet. The relatively shallow Cuthbert and Woodtell series with clay subsoils and the deep sand Darco series have site indices of 70, while the remainder of upland soils have values of 80 to 90. Floodplain soils have site index values for loblolly pine of 80 to 100, while the water-logged Osier series has values of about 80.

Table 4.--Estimated site index for loblolly pine and understory production for soil series within the Angelina National Forest, Texas. Data adapted from the Soil Conservation Service 1980 Soil Survey of Nacogdoches County, Texas

Soil Series	Site Index (Loblolly pine)	Woodland Understory Production (lb/acre)
Upland		
Darco	70	1,500 - 3,000[1/]
Lilbert	80	1,500 - 3,000
Tenaha	80	1,250 - 2,500
Kullit	90	1,600 - 2,500
Kirvin	80	1,250 - 2,500
Cuthbert	70	1,250 - 2,500
Woodtell	70	2,000 - 3,500
Lacerda	65	1,500 - 3,500
Bottomland		
Rentzel	90	1,400 - 2,000
Iuka	100	2,000 - 5,000
Osier	80	800 - 1,800

1/ Values represent the range from unfavorable to favorable growing seasons

Understory production across all upland series varies from 1250 to 3500 lb/acre across years with most averaging approximately 1,800 to 2,000 (table 4). This assumes a relatively open canopy. When canopy cover is very great understory production is greatly reduced and seldom exceeds 200 to 300 lb/acre (Smeins and Hinton, this volume).

The study area is relatively representative of the East Texas Timberlands Resource Area. It is a moderately rolling landscape with two major geologic formations. Topography varies from 150 to 400 feet and is variable across short distances. This, along with considerable dissection of the area by several streams, creates a diverse mosaic of soils. Soils in the uplands vary from deep sands to clays and represent primarily Alfisols, Ultisols and Vertisols. Bottomland soils are primarily Entisols with some Inceptisols and Ultisols. Within upland soil series there is moderate variation in plant production potential, however, the series that cover the majority of the landscape, that is, the Cuthbert, Woodtell, Lacerda and Rentzel series tend to be sites with lower productivity.

LITERATURE CITED

Black, C. H. [and others] eds. Methods of soil analysis. Madison, WI: American Society of Agronomy, Inc. 1965. 1572 p.

Chapman, H. D.; P. F. Pratt. Methods of analysis for soils, plants and waters. Davis CA: University of California, Division of Agricultural Science. 1961. 309 p.

Day, P. R. Report of the committee on physical analysis. Proceedings of the Soil Society of America 21:662. 1957.

Dolezel, R.; C. Fuchs. Soil survey of Nacogdoches County, Texas. U.S. Department of Agriculture, Soil Conservation Service, and Texas Agricultural Experiment Station. 1980. 146 p. (plus maps).

Dolezel, R.; T. Holt. Angelina National Forest study area soil survey in San Augustine County, Texas. Nacogdoches, TX: U.S. Department of Agriculture, Soil Conservation Service. 1979. 68 p. (plus maps).

Freeouf, J. Soil resource inventory Angelina National Forest. Soil Survey Report, Lufkin, TX: U.S. Forest Service. 1977. 88 p.

Geologic Atlas of Texas. Palestine sheet. Austin, TX: Bureau of Economic Geology, University of Texas. 1974. (map 1:250,000)

Godfrey, C. L.; G. S. McKee; H. Oakes. General soils map of Texas. Texas Agricultural Experiment Station and U.S. Department of Agriculture, Soil Conservation Service. 1973. (map 1:1,500,000).

Hinton, J. Z. Vegetation, edaphic and topographic interrelationships in an East Texas Forest. College Station, TX: Texas A&M University. 1981. 78 p. M.S. Thesis.

Howell, J. W. Nutritive value of eastern little bluestem and sweetgum as influenced by canopy condition and soil. College Station, TX: Texas A&M University. 1981. 87 p. M.S. Thesis.

Richards, L. A. Physical condition of water in soil. pp. 128-151. In: Methods of soil analysis. Edited by C. A. Black [and others]. Madison, WI: American Society of Agronomy. 1572 p.

Sellards, E. H.; W. S. Adkins; F. B. Plummer. The geology of Texas. Vol. I. Stratigraphy The Univ. Tex. Bull. No. 3232. 1966. 1007 p.

Smeins, F. E.; J. Z. Hinton. Vegetation of the loblolly-shortleaf type, Angelina National Forest, Texas. In: Proceedings of the Southern Evaluation Workshop. 1987 May 26-27. Long Beach, MS: Compiled by: H. A. Pearson; F. E. Smeins. U.S. Department of Agriculture, Forest Service, Southern Evaluation Workshop. 1987.

Soil Survey Staff. Soil taxonomy. U.S. Department of Agriculture, Soil Conservation Service, Agricultural Handbook No. 436. 1975. 754 p.

Vegetation of the Loblolly-Shortleaf Pine-Hardwood Type, Angelina National Forest, Texas

Fred E. Smeins and Johnny Z. Hinton

Abstract.--The Texas site for the Southern Evaluation Project was a 10,655 acre portion of the Angelina National Forest in East Texas. The purpose of this investigation was to quantitatively describe the vegetation of the site and relate the plant communities to topo-edaphic variables of the area. Ninety-seven percent of the area is characterized by closed canopied forests of 50 to 60 year old loblolly, shortleaf and longleaf pine. Pines contribute 70% or more to the basal area in nearly all stands. Hardwoods contribute less than 40% of all dbh classes in most stands and they occur primarily in the smaller dbh classes. Three percent of the area was in 2 to 8 year old clearcuts. Composition and structure were similar across communities with subtle responses to soil texture, soil depth, drainage regime and topographic position. Longleaf pine was, for example, found throughout except on the clayey Lacerda soil series. Browse and herbage yield in forested areas was less than 400 lb/acre in any sampled stand which makes the carrying capacity for larger herbivores very low. Clearcuts yielded from 1400 to 1800 lb/acre.

INTRODUCTION

The Southern Evaluation Project in Texas was located on the Angelina National Forest which is situated in East Texas (fig. 3, Dolezel and Smeins, this volume). This was one of two loblolly-shortleaf pine-hardwood type locations designated for study in Texas and Louisiana. This paper presents vegetation data for the area and is a companion study to the preceding paper by Dolezel and Smeins which describes the soils information for the area.

The purpose of this investigation was to provide baseline vegetation and vegetation-soil-topographic relationship data for proposed grazing and silvicultural treatments which were to be applied to the area. The data would provide a base for interpretation of vegetation responses to the various treatments. Specific objectives were to: 1) provide a quantitative description of the plant communities of the area and 2) establish relationships between plant communities and associated soils, topography and land use history.

STUDY AREA

A detailed description of the physical environment of the study site is presented in the preceding paper by Dolezel and Smeins and only a brief overview is presented here. The study was conducted on a 10,665 acre portion of the Angelina National Forest in East Texas. This gently rolling portion of the Gulf Coastal Plain Physiographic Province occurs over two major geologic substrates, the Yegua and Cook Mountain Formations. The Yegua Formation produces medium to strongly acid, relatively permeable, sandy soils over claypan subsoils, while the Cook Mountain Formation gives rise to montmorillonitic clay soils which are strongly acid and slowly permeable. All soils are relatively low in fertility. Twelve soil series were identified across the area.

The climate is classified as mesothermal, humid subtropical. Mean annual precipitation is 49 inches. The growing season is 238 days. Plant communities are dominated by varying combinations of loblolly (Pinus taeda), shortleaf (P. echinata) and longleaf (P. palustris) pine with admixtures of hardwoods, primarily oaks (Quercus) and sweetgum (Liquidambar styraciflua).

The area became part of the National Forest system in 1936. No exact land use records exist prior to that time. Aerial photographs from 1942 show most of the area to have been extensively thinned or clearcut (Hinton 1981). The only continuous strips of timber occurred along stream floodplains. Since inclusion in the National Forest only a few, small, scattered areas of less than 50 acres have had timber harvested.

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No wild fires have been recorded on the area for the past 50 years. Some small segments of the study site have been subjected to prescribed burning to thin out the understory. These fires were initiated in the mid-1970's and at the time of the study less than 500 acres had been burned. No burned areas were included in this investigation. No record of grazing exists prior to 1936. From then until 1962 moderate extensive grazing occurred but no exact records exist. From 1963 to 1969 a controlled grazing plan with a light stocking rate was implemented and since 1970 no grazing has occurred. Another factor that has influenced composition and structure of these plant communities was the apparent widespread girdling in upland stands of hardwoods that had been left from earlier timber harvests or that had regrown. No exact records exist as to when and to what extent this practice was applied.

METHODS AND PROCEDURES

Sampling Design and Intensity

Based upon delineations of soil series on the soils map (fig. 3, Dolezel and Smeins), representative examples of the major soil series from across the study area were selected for evaluation. Areas selected were inspected in the field to determine uniformity of soil, slope and plant community before being utilized as a study stand. Thirty-three study sites were selected for vegetation measurements.

Once identified, the stand, depending on its size and configuration, had one to several parallel lines established across it. Along these lines 10 to 30 random sample points were selected for detailed vegetation sampling. Where possible, these lines connected already existing permanently marked soil points. Each additional sample point was marked in the same manner as the permanent soil points. The number of points sampled was determined by the size of the stand and the homogeneity of the vegetation. The location of the study stands was identified on the mosaic soil survey photograph (fig. 3, Dolezel and Smeins). A detailed description of their location and physical features is presented by Smeins and Hinton (1981).

Sample Frequency and Duration

Overstory and middlestory measurements were made during the periods of May through September, 1979 and May through July, 1980. Herbaceous and browse yield measurements were made during October, 1979 and October, 1980.

Overstory (Trees) Measurements.--At each sample point overstory woody plants (stems more than one inch dbh and greater than 5 feet in height) were sampled for:

1) basal area with a 10 factor prism (Bruce 1955)
2) canopy cover using a spherical densiometer (Lemmon 1957)
3) dbh of each stem recorded in the prism using a diameter tape
4) height of 2 to 4 canopy dominants by use of a SUUNTO clinometer
5) age of selected individuals recorded in the prism by obtaining cores with an increment borer
6) density of stems determined from the equation (Husch and others 1972):

$$\text{Density} = \frac{\text{basal area factor}}{0.005454\ (\text{DBH})^2}$$

7) tree classification: nonstocked with pine regeneration (pines 3 years old or younger), saplings (pines more than 3 years old and up to 4 inches dbh), poles (pines 4-9 inches dbh), or sawtimber (pines more than 9 inches dbh)

Middlestory (Trees, Shrubs and Vines) Measurements.--Middlestory woody plants (stems less than one inch dbh and greater than 5 feet in height) were sampled as follows. An 11-foot 8-inch radius plot was established around each sample point. Every individual of each species was recorded and its canopy diameter and height measured.

All Woody Plants.--A 33-foot radius plot was sampled around each point to record the presence of any woody plant of any size or growth form.

Snags and Cavities.--The number of snags and cavities were recorded within the same 33-foot radius plot. A snag is any standing dead tree or part of a dead tree at least 10 inches dbh and 10 feet tall. A cavity was defined as any hole in any standing live or dead tree that permitted use by mammals or birds.

Browse and Herbage Measurements.--Browse (current years growth from woody plants below a height of 5 feet) and herbage (current years growth of herbaceous plants to ground level) was sampled using the quadrat method. At randomly selected sample points within each stand 3, 38.5 ft^2 (3.5 ft. radius), circular plots were located at a distance of 10 feet from the sample point at random compass orientations. All browse species and all herbaceous species were clipped separately and weighed in the field. Selected samples were returned to the laboratory for determination of percent moisture so that all values could be reported on an oven-dry basis. A minimum 15 plots for both browse and herbaceous plants were sampled in each stand.

Other Measurements.--Within each biomass plot percentage mulch cover was estimated to the nearest 10 percent and mulch depth was measured to the nearest tenth inch.

Taxonomic Nomenclature.--Taxonomic nomenclature follows Correll and Johnston (1970) for forbs and woody plants and Gould (1975) for grasses. Plant names were standardized to agree with the national list of scientific plant names developed by the Soil Conservation Service (1971).

RESULTS AND DISCUSSION

Stand Summary by Soil Series

A summary of overstory and middlestory plant characteristics for all stands is given in table 1. With the exception of three clearcuts (not included in the table), measurements exhibit only slight differences between stands and between uplands and bottomlands. Densiometer values ranged from 68 to 99 percent. The majority were over 85 percent. One stand on a Keltys soil was the lowest (68%) because several points sampled were beside openings along an old logging road. Basal areas were distinctly higher in bottomland stands. Diameter at breast height averaged between 10 and 18 inches per tree. On the uplands all but three Darco stands averaged 11, 12 or 13 inches, while bottomlands averaged 15 or 16 dbh per tree.

Density values varied across all stands from 286 to 778 trees per acre. Densities were high because all stems above 1 inch in diameter and 5 feet in height are included. All stands had an average age between 42 and 70 years with most between 50 and 60 years. One Rentzel stand averaged 94 years. Average overstory height ranged from 54 to 75 ft with most over 65 ft on the uplands and 89 to 96 ft on the bottomlands. Middlestory canopy (ft^2/acre) varied across all stands and ranged from 2371 to 10,560 ft^2/acre (5 to 24%). Middlestory height varied little and averaged between 7 and 8 feet across all stands.

Snags and cavities were few in number. This can be attributed to the relatively young age of the trees. Snags ranged from 0 to 4 per acre on the uplands and 1 to 2 per acre on the bottomlands, and cavities from 0 to 3 on the uplands and 3 to 11 on the bottomlands. More cavities exist on the Iuka soils because they support an older stand of beech which had many cavities near its base. Mulch cover averaged over 90 percent in most stands and mulch depth averaged near 1 inch. Number of woody species ranged from 44 to 70 with most stands having at least 50 species.

In general, all upland and bottomland stands have high canopy cover, basal area and density and may be considered overstocked for either optimum timber production or forage

Table 1.--Summary of measured plant characteristics for sampled stands on upland and bottomland soils within the loblolly-shortleaf pine-hardwood type, Angelina National Forest, Texas

	UPLAND								BOTTOMLAND	
Number of Stands	Darco (3)	Lilbert (1)	Tenaha (2)	Keltys (1)	Kirvin (1)	Cuthbert (2)	Woodtell (9)	Lacerda (4)	Rentzel (4)	Iuka (4)
Overstory Canopy (%)	85	89	92	68	94	82	88	90	91	99
Basal Area (ft^2/ac)	120	136	138	116	143	125	135	141	171	160
dbh (in/tree)	10	13	13	13	12	13	12	11	15	16
Density (per ac)	778	329	467	480	462	286	533	633	558	553
Age (yrs)	42	56	53	51	60	51	56	62	70	61
Overstory Height (ft)	54	73	71	69	73	75	72	64	89	96
Middlestory Canopy (ft^2/ac)	10560	4899	6786	3509	9270	2371	7571	10058	9426	6972
Middlestory Height (ft)	8	7	7	7	7	8	7	7	8	7
Snags (per ac)	-	4	2	-	1	-	2	1	1	2
Cavities (per ac)	-	1	1	-	-	-	2	3	3	11
Mulch Cover (%)	95	57	74	100	100	63	98	100	98	90
Mulch Depth (%)	1	1	1	1	1	1	1	1	1	1
No. Woody Species	44	46	59	59	53	50	53	57	69	70

production. Approximately 97 percent of the study area is covered with mature pole to sawtimber type forests. Less than one percent is in a sapling stage of development. Also, slightly over two percent is in a relatively recent clearcut condition (fig. 3, Dolezel and Smeins).

Composition

A total of 268 species were sampled on the study area. The number of species by growth form group was:

Trees	44
Shrubs	35
Vines	24
Grasses	37
Forbs	123
Ferns	5
TOTAL	268

Important families represented by 3 or more species of trees were Fagaceae (12), Juglandaceae (3), Ulmaceae (4) and Pinaceae (3). Shrub families with 3 or more species included Caprifoliaceae (4), Ericaceae (3) and Rosaceae (4), while vines were primarily in the Liliaceae (6) and Vitaceae (4). The gramineae had 37 species, while forb families with more than 6 species were the Compositae (45), Euphorbiaceae (7), Labiatae (9) and Leguminosae (17). Details of total species composition and their contribution to structural and biomass data for each sampled stand are presented in Smeins and Hinton (1981).

To provide a general comparison of composition of uplands and bottomlands importance values are presented for selected species averaged across upland and bottomland stands (table 2). Species of similar importance to uplands and bottomlands are: hickories (Carya ovata), ash (Fraxinus spp.), longleaf pine (Pinus palustris), loblolly pine (P. taeda) and red oak (Quercus falcata). Species of greater importance in the uplands were: flowering dogwood (Cornus florida), shortleaf pine (P. echinata), blackjack oak (Q. marilandica) and post oak (Q. stellata). Red maple (Acer rubrum), American hornbeam (Carpinus caroliniana), sweetgum (Liquidambar styraciflua), American beech (Fagus grandifolia), magnolias (Magnolia spp.), black gum (Nyssa sylvatica), American hophornbeam (Ostrya virginiana), white oak (Q. alba), water oak (Q. nigra) and willow oak (Q. phellos) were more important on bottomland sites.

Table 2.--Importance values[1] for selected woody species in the loblolly-shortleaf pine-hardwood type, Angelina National Forest, Texas

Species	Upland	Bottomland
Acer barbatum	0.3	3.0
A. rubrum	1.0	21.7
Carpinus caroliniana	1.0	17.8
Carya ovata	0.4	0.6
C. texana	4.0	2.7
Cornus florida	10.8	4.9
Fagus grandifolia	2.0	29.0
Fraxinus spp.	2.0	2.7
Ilex opaca	0.5	1.0
Liquidambar styraciflua	15.6	23.1
Magnolia grandifolia	0.1	6.0
M. virginiana	-	9.1
Nyssa sylvatica	4.8	17.0
Ostrya virginiana	0.1	10.2
Pinus echinata	78.4	8.7
P. taeda	66.9	82.7
P. palustris	36.9	47.8
Quercus alba	4.8	16.3
Q. falcata	11.1	13.5
Q. incana	0.6	-
Q. marilandica	13.6	-
Q. nigra	0.8	6.3
Q. phellos	0.6	7.9
Q. prinus	-	1.4
Q. stellata	35.6	3.1
Q. velutina	0.7	0.4
Rhus copallina	2.5	-
Sassafras albidum	0.9	2.9

[1] Importance values obtained from the sum of relative dominance, relative density, and relative frequency (rounded to nearest tenth).

Table 3.--Average basal area (ft^2/ac) for selected species across soil series within the loblolly-shortleaf pine-hardwood type on the Angelina National Forest, Texas. All values recorded to the nearest whole number

	UPLAND								BOTTOMLAND	
Number of Stands	Darco (1)	Lilbert (1)	Tenaha (2)	Keltys (1)	Kirvin (1)	Cuthbert (2)	Woodtell (9)	Lacerda (4)	Iuka (4)	Rentzel (4)
Species										
Fagus grandifolia	---	---	---	---	---	---	---	---	29	6
Liquidambar styraciflua	---	3	8	7	6	5	5	2	5	9
Nyssa sylvatica	---	---	2	2	5	2	1	---	5	10
Pinus echinata	40	81	11	13	45	6	54	42	4	9
P. palustris	36	13	60	40	45	55	10	---	---	8
P. taeda	22	19	28	42	30	30	39	48	71	86
Quercus alba	---	---	1	---	1	2	2	1	7	6
Q. falcata	2	2	3	1	3	9	4	3	6	9
Q. marilandica	5	8	8	---	3	5	2	3	---	---
Q. stellata	9	3	15	6	5	7	13	9	1	1

Basal areas for selected species were averaged across soil series to depict quantitative patterns of distribution (table 3). Pine species are clearly the dominants in all stands. All pine species occur on all series except P. palustris which is absent from the clayey Lacerda soils and stream margin Iuka soils. In the uplands Liquidambar styraciflua, Quercus stellata, Q. marilandica and Q. falcata are secondary species, while in the bottomlands, Fagus grandifolia becomes an important secondary species.

Absolute frequency for selected woody plants averged by soil series shows the general response of species to soil type and to upland and bottomland topographic position (table 4). Similar patterns are reflected for trees as shown by basal area values (table 3). Most species have wide distribution across soils. A few such as Quercus incana, which is found only on deep sands, have a restricted distribution.

Shrubs which were common to both uplands and bottomlands were American beautyberry (Callicarpa americana), possum-haw (Ilex decidua), southern wax myrtle (Myrica cerifera), deerberry (Vaccinium stamineum) and arrow-wood (Viburnum dentatum). More common on uplands were haws (Crataegus spp.), yaupon (Ilex vomitoria), sparkleberry (V. arboreum) and rusty blackhaw (Viburnum rufidulum). Species frequent on bottomlands and not uplands were strawberry bush (Euonymus americanus), sebastian bush (Sebastiana fruticosa) and sweet-leaf (Symplocos tinctoria).

Vines common throughout the area are yellow jasmine (Gelsemium sempervirens), poison ivy (Rhus toxicodendron), grapes (Vitus spp.) and briars (Smilax spp.), although S. glauca and S. walteri were more frequent on bottomlands. Rattan vine (Berchemia scandans) was more common on uplands sites and partridge berry (Mitchella repens) more frequent on the bottomlands.

Biomass Relationships

Available herbage and browse was sampled October, 1979 and October, 1980. Mean total yield averaged across upland stands for October, 1979 was 144 and 86 lb/acre for woody and herbaceous plants, respectively (table 5). Corresponding values for bottomlands were 97 and 15 lb/acre. Rainfall in 1979 exceeded the average by 27.3 inches (Dolezel and Smeins, this volume) and thus, production was relatively high. In October of 1980 production values for woody and herbaceous plants were, respectively, 114 and 28 lb/acre across upland stands and 77 and 5 lb/acre across bottomland stands. Precipitation during 1980 fell below average by 10.3 inches and production values reflect this reduction. Overall production decreased 63 percent in the uplands and 72 percent in the bottomlands from October, 1979 to October, 1980. Bottomland forested sites generally produced only about one-half of forested uplands in both years.

In the uplands, biomass values from three clearcut stands (2 to 8 years since clearcutting) exceeded forested areas by approximately four times. Most forested areas had total biomass values between approximately 100 and 300 lb/acre. Clearcuts range from approximately 1400 to 1800 lb/acre.

In upland stands trees contributed most to total productivity in 1979 and 1980 (table 5). Graminoids were the next highest followed by vines and shrubs in both years. Ferns and forbs produced more green forage in 1979 (wet year) than in 1980 (dry year). Lack of precipitation in 1980 did not affect the production of trees and shrubs on upland stands. Production of vines in 1980 was nearly 50 percent less than in 1979. In upland stands forbs decreased 58%, graminoids decreased 61% and ferns decreased 95% from October, 1979 to October, 1980.

In the bottomlands woody production accounted for 87% and 95% of the total production in 1979 and 1980, respectively. Vines were the highest available green forage followed by trees and shrubs during both years. Hardest hit by the lack of moisture in 1980 were forbs and ferns. No production of ferns was recorded in 1980.

Based upon the yield values obtained stocking rates were estimated for the area (Smeins and Hinton 1981). During 1979 approximately 180 acres would be necessary to carry one animal unit for one year, while in 1979 it would have required about 285 acres. Obviously this rather closed canopy pine dominated forest produces minimal browse and herbage for animal consumption. When it is considered that pine seedlings and saplings are major contibutors to tree browse in the uplands this would further reduce the animal carrying capacity.

Species contribution to browse and herbage yield was quite variable from stand to stand. Below are listed species within each growth form class that were primary contributors to biomass yield in upland stands. Species marked with an asterisk had consistently high values across stands.

Trees: Cornus florida, Liquidambar styraciflua, Pinus echinata, P. palustris, P. taeda*, Quercus stellata*, Rhus copallina, Sassafras albidum

Shrubs: Callicarpa americana, Ilex vomitoria, Myrica cerifera*, Vaccinium arboreum, V. stamineum, Viburnum dentatum

Vines: Berchemia scandens, Gelsemium sempervirens*, Rhus toxicodendron, Rubus spp*., Smilax rotundifolia, Vitus rotundifolia

Table 4.-- Absolute frequency values of seleceted trees, shrubs and vines averaged by soil series for the loblolly-shortleaf pine-hardwood type on the Angelina National Forest, Texas

	UPLAND								BOTTOMLAND	
Number of Stands	Darco (3)	Lilbert (1)	Tenaha (2)	Keltys (1)	Kirvin (1)	Cuthbert (2)	Woodtell (9)	Lacerda (4)	Iuka (4)	Rentzel (4)
TREES										
Acer rubrum	62	44	58	73	86	73	57	37	90	99
Asimina triloba	39	44	15	26	5	20	3	1	34	3
Carpinus caroliniana	--	--	--	--	--	--	9	3	86	54
Carya texana	55	100	68	7	70	20	48	70	52	14
Chionathus virginica	--	100	60	20	30	67	25	47	60	44
Cornus florida	52	100	93	100	95	87	92	56	69	34
Fagus grandifolia	10	--	--	--	25	7	1	--	68	76
Ilex opaca	10	11	13	73	45	87	37	5	64	46
Liquidambar styraciflua	64	100	75	80	100	93	84	47	93	56
Magnolia grandifolia	--	--	3	--	--	--	4	1	55	68
M. virginiana	--	--	--	--	25	--	1	--	28	53
Nyssa sylvatica	20	55	50	73	95	87	71	49	81	71
Ostrya virginiana	--	--	--	7	--	--	1	12	66	43
Pinus echinata	100	89	73	60	100	40	99	45	21	43
P. palustris	80	--	48	100	95	100	41	--	5	45
P. taeda	100	78	93	93	95	87	97	93	100	84
Prunus serotina	44	--	13	33	20	50	30	15	33	39
Quercus alba	--	--	25	--	25	27	21	24	84	69
Q. falcata	2	55	23	7	30	5	27	87	36	71
Q. incana	33	67	--	--	--	--	1	--	--	--
Q. marilandica	88	100	60	40	60	53	67	63	--	5
Q. phellos	17	55	18	40	30	53	39	46	89	68
Q. stellata	80	100	90	80	85	73	85	86	12	11
Rhus copallina	75	100	48	27	55	27	73	51	10	5
Sassafras albidum	100	100	68	73	75	80	38	--	29	32
Ulmus alata	--	22	15	13	25	--	5	64	42	19
SHRUBS										
Ascyrum hypericoides	53	22	38	13	10	7	23	26	6	6
Callicarpa americana	59	89	38	60	100	33	75	81	77	74
Crataegus crus-galli	--	22	20	13	25	--	44	48	3	5
C. marshallii	--	--	45	33	60	20	64	71	16	9
Euonymus americana	--	--	--	--	--	--	--	--	24	20
Hammamelis vernalis	--	--	--	--	--	--	--	--	29	5
Ilex decidua	7	27	20	--	15	13	56	55	26	17
I. vomitoria	72	22	40	93	65	73	72	21	16	13
Myrica cerifera	45	89	73	87	80	80	57	12	10	48
Prunus mexicana	--	100	43	7	5	13	15	8	--	4
Rhamnus caroliniana	23	11	43	87	20	80	19	--	20	2
Sebastinana fruticosa	--	--	3	--	--	--	1	--	34	35
Symplocos tinctoria	--	--	3	--	--	--	1	--	34	35
Vaccinium arboreum	55	55	65	47	85	10	55	54	40	12
V. stamineum	43	55	65	40	65	60	59	63	76	89
Viburnum acerifolium	--	--	18	20	--	30	6	--	58	41
V. dentatum	23	11	25	20	65	60	58	26	82	38
V. rufidulum	48	67	60	33	45	27	65	41	16	4
VINES										
Berchemia scandens	35	44	28	73	30	53	66	58	12	18
Ceanothus americana	--	33	13	--	--	13	13	15	--	--
Gelsemium sempervirens	69	89	73	93	95	93	90	70	72	77
Mitchella repens	--	--	13	7	5	--	24	5	93	72
Parthenocissus quinquefolia	15	20	35	33	5	7	46	25	34	4
Rhus toxicodendron	100	100	68	87	85	100	74	92	45	33
Rubus spp.	42	100	73	47	85	40	69	73	5	1
Smilax bona-nox	23	33	23	7	15	7	38	43	16	4
S. rotundifolia	65	44	70	67	85	60	82	44	91	85
S. smallii	13	11	15	33	65	20	29	4	9	24
S. walteri	19	22	38	93	55	53	24	-	72	25
Vitus aestivalis	35	78	45	27	20	20	22	11	26	18
V. rotundifolia	--	78	33	40	--	60	56	74	97	64

Table 5.--Herbage and browse yield (lb/acre) for October 1979 and 1980 of forested upland and bottomland stands within the loblolly-shortleaf pine-hardwood type on the Angelina National Forest, Texas

	October 1979		October 1980	
UPLANDS				
Trees	77		72	
Shrubs	26		20	
Vines	41		22	
Total Woody		144		114
Graminoids	61		24	
Forbs	7		3	
Ferns	18		1	
Total Herbaceous		86		28
Grand Total		**230**		**142**
BOTTOMLANDS				
Trees	28		20	
Shrubs	11		9	
Vines	58		48	
Total Woody		97		77
Graminoids	6		4	
Forbs	5		1	
Ferns	4		0	
Total Herbaceous		15		5
Grand Total		112		**82**

Forbs: Desmodium sessilifolium, Eupatorium capillifolium, Solidago odora, S. rugosa, Stylosanthes biflora

Graminoids: Chasmanthium sessiliflorum*, Dicanthelium oligosanthes and others, Eragrostis spectabilis, Panicum anceps, P. brachyanthum*, Schizachyrium scoparium*

Ferns: Pteridium aquilinum*

For bottomland stands these species contributed significantly to browse and herbage yield.

Trees: Carpinus caroliniana*, Fagus grandifolia, Ilex opaca, Liquidambar styraciflua*, Magnolia grandiflora*, Quercus alba, Quercus phellos*, Symplocos tinctoria*

Shrubs: Callicarpa americana, Myrica cerifera, Vaccinium stamineum*, Viburnum dentatum

Vines: Gelsemium sempervirens*, Mitchella repens*, Smilax glauca, S. rotundifolia, Vitus rotundifolia

Forbs: Elephantopus tomentosus

Graminoids: Chasmanthium sessiliflorum, Sedge spp., Dichanthelium spp.

Ferns: Osmunda cinnamonomea*

Correlation coefficients were calculated for biomass variables against measured plant characteristics for October, 1979 and October 1980 (Smeins and Hinton 1981). Since most stands had similar values for basal area, canopy cover and other variables, most correlations were relatively low. Significant factors ($p \leq 0.05$) that negatively affected biomass across all stands were high values of canopy cover, basal area, dbh, age, middlestory canopy and overstory height. All had r values between -0.50 and -0.65. The results indicated that a mature pine dominated forest will likely have low productivity with regard to browse and herbaceous forage.

Synthesis

Upland vegetation on the study area is similar to the oak-pine forests of the upper coastal plain (Braun 1950). Bottomland vegetation resembles her southern floodplain forest. Vegetation on the area is similar to that studied by Quarterman and Keever (1962). They stated that 14 species of plants were the "core of species typical of the pine-hardwood and early hardwood communities" which they called the southern mixed hardwood forest. Twelve of their fourteen core species were present on this study area which suggests that it is closely related to their southern mixed hardwood forest. Quercus laurifolia and Carya glabra were the two species not present on the study area. Although, Quarterman and Keever (1962) stated that there was no strong influence of soil moisture on community type, Marks and Harcombe (1975) showed that a moisture gradient was the cause for high beta (between-habitat) diversity on forests of the Texas coastal plain. It is apparent from data presented here that species of the southern mixed hardwood forest on this study area follow a soil moisture gradient which incorporates the interaction of soil depth, soil texture, and topographic position.

Within the study area, little timber harvesting has occurred since the establishment of the National Forest (1936). Records show that much of the study area was severely thinned or clearcut sometime prior to 1941 (Hinton 1981). Since that time, the study area has had no burning or timber harvesting, except for a few small clearcuts during the late 1970's. Many regenerating or remnant hardwoods were girdled which has slowed the rate of hardwood ingress. Since the early 1940's the forest has regenerated itself and became dominated by pine species. The importance of pine in the present forest's overstory is apparent and ages of upland overstory dominants (pines) indicate that most individuals are between 50 and 60 years old.

Pines ranged from 60 to 91% of all individuals in all diameter classes across all soil series on upland sites, while oaks ranged from 6 to 26% (Hinton 1981). Upland pines included loblolly, shortleaf and longleaf while upland oaks included post oak, red oak and blackjack oak. On bottomland sites, pines ranged from 50 to 59% and oaks ranged from 13 to 41% of the individuals across all size classes. Bottomland sites have primarily loblolly pine and red and white oaks. Liquidambar (sweetgum) and Carya (hickory) were contributing elements on some upland sites. Magnolia (magnolia), Fagus (beech), Nyssa (blackgum) and Acer (maple) were contributing elements on bottomland sites.

Inspection of size class distribution between pines and hardwoods indicates that most pines are in the larger size classes while hardwoods have their greatest numbers in the lower size classes (Hinton 1981). These data clearly suggest that hardwoods will potentially replace or at least become co-dominant with the pines if left undisturbed. This successional trend agrees with previous observations for forests in eastern Texas (Quarterman and Keever 1962, Marks and Harcombe 1981).

The closed canopy of most stands reduces yield of herbaceous and browse species. Generally less than 300 lb/acre of forage is available. Much of this consists of pines which are relatively unpalatable to most herbivores.

LITERATURE CITED

Braun, E. L. Deciduous forests of eastern North America. The Blackiston Company, Philadelphia, PA. 1950.

Bruce, D. A New way to look at trees. Journal of Forestry. 53:163-167; 1955.

Correll, D. S.; Johnston, M. C. Manual of vascular plants of Texas. Renner, TX: Texas Research Foundation; 1970. 1881 p.

Dolezel, R.; Smeins F. E. Soil of the loblolly-shortleaf pine-hardwood type, Angelina National Forest, Texas. In: Proceedings of the Southern Evaluation Workshop. 1987. May 26-27. Long Beach, MI: Compiled by: H. H. Pearson; F. E. Smeins. U.S. Department of Agriculture, Forest Service, Southern Evaluation Workshop 1987.

Gould, F. W. The grasses of Texas. College Station, TX: Texas A&M University Press; 1975. 653 p.

Hinton, J. Z. Vegetation, edaphic and topographic interrelationships in an East Texas Forest. College Station, TX: Texas A&M University; 1981. 87 p. M.S. Thesis.

Husch, B.; Miller, C. I., Beers, T. W. Forest mensuration. New York, NY: The Ronald Press Company; 1972.

Lemmon, P. E. A spherical densiometer for estimating forest overstory density. Forest Science 2:314-320; 1956.

Marks, P. L.; Harcombe, P. A. Forest vegetation of the Big Thicket southeast Texas. Ecological Monographs 51:287-305; 1981.

Quarterman, E.; Keever, C. Southern mixed hardwood forest: Climax in the southeastern coastal plain. Ecological Monographs 3:167-185; 1962.

Smeins, F. E.; Hinton, J. Z. Vegetation inventory in the loblolly-shortleaf pine type, Angelina National Forest, Texas. Final Report FS-SO-1701-3.16. Alexandria, LA: U.S. Department of Agriculture, Forest Service. Southern Forest Experiment Station. 1981. 142 p.

Soil Conservation Service. National list of scientific plant names. U.S. Department of Agriculture, Soil Conservation Service, Lincoln, NE. 1971.

HERPETOFAUNA IN LOBLOLLY-SHORTLEAF PINE STANDS OF EAST TEXAS

R. Montague Whiting, Jr., Robert R. Fleet and Vincent A. Rakowitz

Abstract.--Amphibians and reptiles in seedling, sapling, pole and sawtimber pine stands were studied in the Angelina National Forest in eastern Texas. Amphibians (especially frogs and toads) were more abundant in winter while reptiles dominated in spring. Winter amphibians had a stronger relationship with the availability of ponds suitable for breeding than with stand age or vegetation structure. Spring amphibians were more dependent on vegetation structure. Lizards were the dominant reptile during winter. Spring reptile communities were evenly balanced between lizards and snakes. Generally, there were differences in species compositions between study areas in the amphibian and reptile communities.

INTRODUCTION

Forest habitats are essential for many vertebrates. Management for wood and other forest resources often changes forest structure. Various vertebrate species require different forest age classes and structures (Thomas 1979). Although wildlife and timber can coexist in a managed forest (Thomas 1979), coordination of habitat and timber management is necessary, especially for many nongame wildlife species in the southern forests (Conner et al. 1975).

The objective of this study was to describe the species compositions and relative abundances of amphibians and reptiles in pine stands of 4 different tree size classes within the loblolly (*Pinus taeda*)-shortleaf (*P. echinata*) pine-hardwood ecosystem in eastern Texas.

METHODS AND MATERIALS

Study areas were located within the Angelina National Forest in San Augustine County, near Broaddus, Texas. The 4 stands selected were classified by tree size as seedling, sapling, pole and sawtimber. Criteria for selecting and establishing study areas have been previously described (Rakowitz 1983, Whiting and Fleet 1985). For reference, the study areas selected were numbered 9 (seedling), 6 (sapling), 3 (pole) and 8 (sawtimber) by Whiting and Fleet (1985).

SAMPLING

Within each study area, 5 line transects, each 984 ft (300 m) long (Fig. 1), were positioned across contours. Transects were 164 ft (50 m) apart and at least that far from a different vegetation type. Four 33 ft (10 m) drift fences were installed at 328 ft (100 m) intervals along each transect (Fitch 1951). Funnel traps were placed on both sides and at each end of every fence, thus a total of 20 fences and 80 funnel traps per study area (Fig. 1). Additionally, 4 hardwood boards, forming artificial cover habitat, were systematically placed about each drift fence. White polyethylene vinyl sheets were placed over the traps to protect captured animals from direct sunlight.

Amphibians and reptiles in each study area were monitored winter (5 February-5 March) and spring (5 April-4 May) during 1979, 1980 and 1981, thus a total of 6 sampling periods. Winter and spring sampling periods were chosen to include peak breeding periods for amphibians and reptiles, respectively (Bishop 1943, Dickerson 1969).

Traps and boards were checked at least every other day during each 30-day sampling period. Each week, transects were walked during the day while searching 33 ft on either side of the line under logs, rocks, discarded metal, cardboard, and in the open for reptiles and amphibians. Also each week, male frogs and toads in breeding choruses were censused along each

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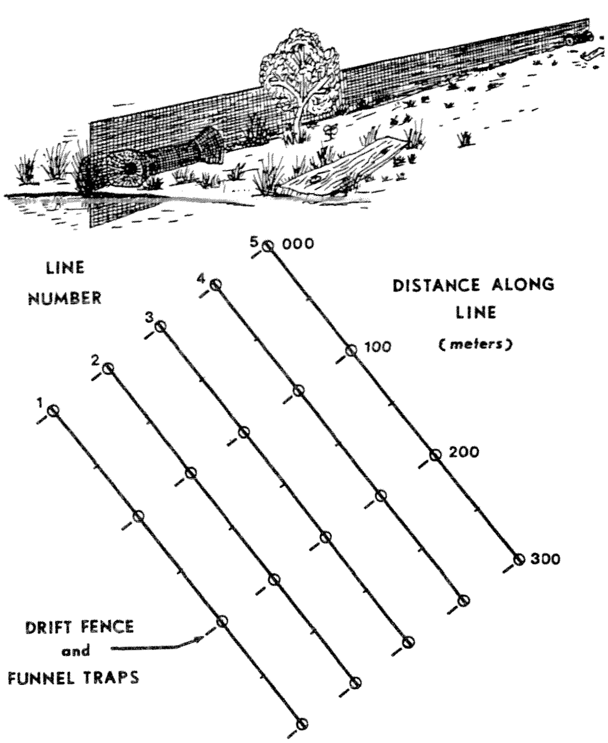

Figure 1. Schematic diagram of drift fence placement along transect lines and funnel traps and artificial cover about the drift fence.

transect line at night.

Captured animals were marked by toe clipping frogs, toads, salamanders and lizards (Martof 1953), heat branding snakes (Clark 1971), or notching the carapace of turtles (Cagle 1939). Marked animals were released at the point of capture.

Plant communities of each study area were surveyed during summer 1980. Percent coverage parameters, including ground cover by type, understory cover by type, overhead obscurity and foliage density and characteristics of small and large vegetation were evaluated. Vegetation and soil survey methods are described elsewhere (Dolezel and Holt 1979, Rakowitz 1983, Whiting et al. 1983, Whiting and Fleet 1985); weather data were taken from U.S. Forest Service records, Lufkin, Texas.

Statistical Analyses

Abundance (numbers of individuals), species richness (numbers of species), species diversity (Shannon and Weaver 1963) and equitability (Pielou 1966) were computed for pines, hardwoods and their combination for both small and large vegetation. The Pearson chi-square test of homogeneity (Dixon and Brown 1981) and Kruskal-Wallis one-way analysis of variance by ranks (Nie and Hull 1981) with multiple comparisons (Daniel 1978) were used to test differences in vegetation and soil characteristics between the study areas.

Species compositions of the amphibian and reptile communities were compared between study areas using the Pearson chi-square test of homogeneity. The same tests were used to compare the lizard and snake communities between study areas during spring. Abundance, species diversity and equitability of amphibians and reptiles and abundance of individuals by herpetofauna taxa (i.e. salamanders, frogs and toads, turtles, lizards, snakes) were compared between study areas using Kruskal-Wallis one-way analysis of variance by ranks with multiple comparisons.

The null hypothesis of no difference between groups was used and a significance level of 0.05 was accepted for chi-square and Kruskal-Wallis tests. The "experimentwise error rate" was set at p=0.30 for comparing the mean ranks of groups (Daniel 1978).

DESCRIPTION OF THE STUDY AREAS

Soils

Surface soil type was visually determined and selected areas had relatively sandy surface layers. Although the percentages of soil types were significantly different between the study areas (Rakowitz 1983), soil texture, permeability, drainage and water capacity, percent slope and erosion hazard were similar (Dolezel and Holt 1979).

Vegetation

The seedling study area contained no trees with a diameter at breast height (dbh) greater than 4.0 inches (100 mm). During the study, many planted pine seedlings died due to drought and/or damage by leaf-cutter ants (*Atta texana*). The dominant species was shining sumac (*Rhus copallina*) which comprised 42% of the plants present (Rakowitz 1983, Whiting and Fleet 1985).

The sapling area was characterized by a high density of sapling pines (>4" dbh). No trees were designated as dominants or as midstory due to crowding into 1 height level. Dominant species in the understory were blackberry (*Rubus* spp.) and poison ivy (*Toxicodendron radicans*).

The pole and sawtimber study areas were characterized by a progressive trend toward increased height and dominance of the pines with increased stand age. The pole stand understory had large numbers of open patches dominated by loblolly pine seedlings. The open patches were due to southern pine beetle (*Dendroctonus frontalis*) spots and old logging roads. The sawtimber understory was dominated by dense patches of poison ivy. Woody vines were more prevalent than in the other study areas.

Comparisons Between Study Areas

The most contrasting vegetation characteristics between study areas were the differences in the percentages of understory and ground cover. As successional patterns changed with increasing age, the open canopy with high percentages of bare soil and grasses shifted toward a dense canopy and the accumulation of a substantial litter layer. Since most amphibians and reptiles are terrestrial, these variations had a strong influence on the structure of the herpetofauna communities in the stands. Rakowitz (1983) and Whiting and Fleet (1985) compared the vegetation of the study areas in detail.

RESULTS AND DISCUSSION

A total of 649 amphibians of 15 species and 764 reptiles of 23 species were recorded during the 3 year study. The buttermilk snake and the southern black racer were treated as separate species. Amphibians (especially frogs and toads) were more abundant in winter while reptiles dominated spring samples. A notable seasonal difference was the emergence of box turtles during spring. Herpetofauna found in the study are classified in Table 1.

Winter Herpetofaunal Communities

During the 3 winter censuses, 462 amphibians of 10 species and 210 reptiles of 15 species were recorded.

Amphibians.--Total numbers of amphibians recorded across stand ages created a U-shaped pattern (Table 2). Species compositions of amphibian populations were significantly different between areas as were differences in abundances and species diversity and equitability values, and in numbers of frogs and toads (Rakowitz 1983). Although species compositions of the study areas were different, occurrence and abundance during winter appeared to be more strongly related to the availability and longevity of intermittent ponds suitable for breeding than to stand age.

The greatest numbers of amphibian species and individuals were encountered in the seedling study area (Table 2) which was adjacent to a large natural pond. Amphibians recorded in this area (especially frogs and toads) were presumed to be migrating toward the pond. The sapling and sawtimber areas also contained intermittent ponds; however, these were not as large or persistent as the seedling area pond. Although the pole area contained several intermittent streams, these drained rapidly after rainfall and provided very limited suitable amphibian breeding habitat. As a result, the numbers of frogs and toads recorded in the pole study area were significantly lower than in the other study areas.

Reptiles.--During winter, species compositions of reptiles were significantly different among study areas; reptile populations were different in abundances, with significantly fewer individuals recorded in the pole study area. Three species did show trends in numbers across the stands (Table 2). Northern fence lizards were most abundant in the seedling area. This species prefers dry, sandy, open woods (Smith 1946). Ground skinks were progressively more abundant in the older stands where greater percentages of litter and increased numbers of decaying logs provided cover and foraging sites (Smith 1946). Semi-arboreal green anoles increased in numbers in the older stands which contained higher densities of shrubby understory vegetation greater than 4.5 ft in height.

Forty-two southern coal skinks were recorded during winter samples while only 2 were recorded during spring samples. This suggests that the species is adapted to an annual winter activity cycle which is different from that of other Eumeces. The reason for the disproportionately large numbers in the sapling stand was not clear.

Eastern hognosed snakes were the most common snake recorded during winter sampling. Winter activity by this species is probably an adaptation to syncronize with prey activity. Hognosed snakes dig food items, primarily toads, from burrows in the soil. It is not a coincidence that the largest numbers of this snake, both in winter and spring, were recorded in the sapling area which also had the greatest number of Hurter's spadefoot toads, a large burrowing toad.

Winter reptile populations were probably strongly influenced by fluctuations in temperatures. Lizards, with small, easily heated biomass, were able to become active in and exploit short periods of warm weather within the otherwise cold regime. Thus lizards were disproportionately represented in the winter sample when compared with snakes.

Snakes, of larger biomass, were at a thermal disadvantage during winter and were generally unable to become active during brief warming periods. The greater numbers of individuals and species of snakes recorded in winter were from the seedling and sapling study areas. These study areas accounted for 32 individuals of 9 species whereas only 9 individuals of 2 species were recorded in the pole and sawtimber study areas (Table 2). Greater snake activity within the seedling study area probably resulted from higher soil temperatures due to greater solar radiation through the reduced vegetation canopy. Feeding hognosed snakes accounted for the high numbers in the sapling study area.

Spring Herpetofaunal Communities

Five hundred fifty-four reptiles of 22 species and 187 amphibians of 14 species were recorded during the 3 spring censuses. The seedling study area contained the greatest abundance of both amphibians and reptiles (Table 2).

Amphibians.--Species compositions of amphibians were significantly different between the study areas (Rakowitz 1983); spring amphibian populations were significantly different in abundances only.

Amphibians were less than half as abundant in the spring censuses as in winter censuses although more species were recorded. During spring, the majority of animals were trapped rather than recorded by call counts. Since most spring amphibians were in the post-breeding condition, they were less dependent on water and were probably foraging or migrating when captured. Although the seedling area had the greatest numbers, the numerical differences between the

Table 1. Class, order, family, scientific and common names of amphibians and reptiles recorded on the study areas (Conant 1975).

Classification	Common name
Class Amphibia	
Order Caudata	
Family Ambystomatidae	
Ambystoma maculatum	spotted salamander
Ambystoma opacum	marbled salamander
Ambystoma talpoideum	mole salamander
Family Plethodontidae	
Eurycea quadridigitata	dwarf salamander
Order Anura	
Family Pelobatidae	
Scaphiopus holbrooki hurteri	Hurter's spadefoot toad
Family Hylidae	
Acris crepitans crepitans	northern cricket frog
Hyla chrysoscelis	southern gray treefrog
Hyla crucifer crucifer	northern spring peeper
Pseudacris triseriata feriarum	upland chorus frog
Family Bufonidae	
Bufo valliceps valliceps	gulf coast toad
Bufo woodhousei woodhousei	Woodhouse's toad
Family Ranidae	
Rana catesbeiana	bullfrog
Rana clamitans clamitans	bronze frog
Rana utricularia	southern leopard frog
Family Microhylidae	
Gastrophryne carolinensis	eastern narrow-mouthed toad
Class Reptilia	
Order Testudines	
Family Emydidae	
Terrapene carolina triunguis	three-toed box turtle
Terrapene ornata ornata	ornate box turtle
Order Squamata	
Family Iguanidae	
Anolis carolinensis carolinensis	green anole
Sceloporus undulatus hyacinthinus	northern fence lizard
Family Scincidae	
Eumeces anthracinus pluvialis	southern coal skink
Eumeces fasciatus	five-lined skink
Eumeces laticeps	broadhead skink
Scincella lateralis	ground skink
Family Teiidae	
Cnemidophorus sexlineatus sexlineatus	six-lined racerunner
Family Colubridae	
Coluber constrictor anthicus	buttermilk snake
Coluber constrictor priapus	southern black racer
Elaphe obsoleta lindheimeri	Texas rat snake
Heterodon platyrhinos	eastern hognosed snake
Lampropeltis calligaster calligaster	prairie kingsnake
Lampropeltis getulus holbrooki	speckled kingsnake
Masticophis flagellum flagellum	eastern coachwhip
Natrix erythrogaster flavigaster	yellow-bellied water snake
Opheodrys aestivus	rough green snake
Thamnophis proximus proximus	western ribbon snake
Thamnophis sirtalis sirtalis	eastern garter snake
Family Elapidae	
Micrurus fulvius tenere	Texas coral snake
Family Viperidae	
Agkistrodon contortrix contortrix	southern copperhead
Agkistrodon piscivorus leucostoma	western cottonmouth

Table 2. Numbers of individual herptiles per species recorded on the seedling, sapling, pole and sawtimber study areas during winter and spring censuses of 1979-1981.

	Numbers of individuals										
	Winter					Spring					
Taxa	Seed	Sapl	Pole	Sawt	Total	Seed	Sapl	Pole	Sawt	Total	Study total
AMPHIBIANS											
Dwarf salamander	1	3	13	6	23	-	-	2	4	6	29
Marbled salamander	-	-	2	11	13	1	1	-	3	5	18
Mole salamander	8	-	-	2	10	15	-	-	-	15	25
Spotted salamander	7	1	-	-	8	-	-	-	-	-	8
Bronze frog	-	-	-	-	-	9	-	-	-	9	9
Bullfrog	-	-	-	-	-	1	-	-	-	1	1
Upland chorus frog	7	2	1	32	42	-	-	-	1	1	43
N. cricket frog	9	1	-	-	10	1	-	-	1	2	12
S. gray tree frog	-	-	-	-	-	14	11	15	8	48	48
S. leopard frog	94	5	4	3	106	7	4	8	-	19	125
Gulf coast toad	-	-	-	-	-	1	-	-	-	1	1
Hurter's spadefoot toad	5	59	-	1	65	3	17	1	1	22	87
E. narrow-mouth toad	-	-	-	-	-	5	4	3	4	16	16
Woodhouse's toad	1	-	-	7	8	2	2	9	4	17	25
N. spring peeper	115	18	-	44	177	15	3	-	7	25	202
No. Species	9	7	4	8	10	12	7	6	9	14	15
No. Individuals	247	89	20	106	462	74	42	38	33	187	649
REPTILES											
Ornate box turtle	-	-	-	-	-	1	1	1	-	3	3
Three-toed box turtle	-	-	-	-	-	2	5	7	1	15	15
Green anole	1	11	7	17	36	5	9	11	12	37	73
N. fence lizard	38	3	-	-	41	109	14	2	-	125	166
Six-lined racerunner	-	-	-	-	-	38	1	-	-	39	39
Broadhead skink	-	-	-	1	1	-	-	8	7	15	16
Five-lined skink	-	1	-	3	4	-	5	10	23	38	42
Ground skink	4	5	13	23	45	5	19	54	55	133	178
S. coal skink	1	37	3	1	42	-	1	1	-	2	44
S. black racer	1	1	-	-	2	-	2	2	-	4	6
E. coachwhip	-	-	-	-	-	2	-	-	-	2	2
S. copperhead	-	4	2	6	12	1	23	15	23	62	74
W. cottonmouth	-	-	-	-	-	-	-	1	-	1	1
Prairie kingsnake	1	-	-	-	1	3	-	-	-	3	4
Speckled kingsnake	-	-	-	-	-	1	-	-	-	1	1
Buttermilk snake	3	1	-	-	4	14	9	3	-	26	30
Texas coral snake	1	-	-	-	1	4	4	3	1	12	13
E. garter snake	-	1	-	-	1	-	-	-	-	-	1
Rough green snake	-	1	-	-	1	-	1	1	-	2	3
E. hognosed snake	3	14	1	-	18	5	12	1	5	23	41
Texas rat snake	-	-	-	-	-	1	1	1	1	4	4
W. ribbon snake	1	-	-	-	1	5	-	-	-	5	6
Yellow-bellied water snake	-	-	-	-	-	1	-	1	-	2	2
No. Species	10	11	5	6	15	16	15	17	9	22	23
No. Individuals	54	79	26	51	210	197	107	122	128	554	764
Total Species	19	18	9	14	25	28	22	23	18	36	38
Total Individuals	301	168	46	157	672	271	149	160	161	741	1413

areas were much reduced, reflecting the reduced role of the breeding pond. This does suggest, however, that the seedling study area provided optimum habitat for a wider array of amphibians than did the other study areas. For example, mole salamanders were recorded exclusively in the seedling area during spring. As terrestrial adults, they are found in ground burrows in loose sand, or under logs, debris or leaf litter (Bishop 1943, Hardy and Raymond 1974).

Reptiles.--During spring, species compositions of reptiles were significantly different between study areas as were numbers of individual reptiles and numbers of lizards (Rakowitz 1983). The seedling study area had a greater number of reptiles than did the other study areas (Table 2).

For lizards, species compositions of the seedling and sapling study areas were significantly different from each other and from the pole and sawtimber study areas. Species compositions of the latter 2 study areas were not different. The differences were probably due to differences in ground cover and density of the understory and overhead foliage. Six-lined racerunners were most abundant in the seedling area (Table 2); it contained high percentages of bare soil and vegetative ground cover, necessary for burrowing and foraging, respectively. This lizard is characterized by a high metabolic rate and requires high temperatures to be active (Smith 1946). It is not surprising that this species was found only in spring. As with winter censuses, northern fence lizards were abundant in the seedling area. Abundance of insect prey may have been responsible for the relatively high numbers of this species. Both species are typical of early successional stages and were found in decreasing numbers or were absent in the older stands.

Four of the lizard species observed are adapted to mature forests (Smith 1946, Conant 1975). As with winter, numbers of green anoles and ground skinks captured in spring increased with stand age (Table 2). Five-lined skinks and broadhead skinks are also climbing lizards, and prefer dead trees with loose bark as foraging sites and cover. These species were absent from the seedling area and generally increased in numbers in the older study areas.

Substantially greater numbers of individuals and species of snakes were recorded during spring than during winter (Table 2). The southern copperhead was the most commonly encountered snake; buttermilk snakes ranked second. Eastern hognosed snakes dropped from most abundant in the winter sample to third in spring; its numbers in the sapling stand were associated with the large numbers of spadefoot toads. During spring, snake species composition of the seedling study area proved to be significantly different from those of the other stands. Species compositions of the sapling, pole and sawtimber study areas were not different from each other.

Herpetofaunal Community Changes Over Time

A general drying trend persisted during the 3 years of the study (Rakowitz 1983, Whiting and Fleet 1985). Likewise, East Texas was subjected to a severe heat wave and drought during summer 1980. Due to high mortality of the planted pine seedlings, the seedling stand was burned and replanted between the 1979 and 1980 censuses and replanted again between the 1980 and 1981 censuses. These factors definitely impacted the herpetofaunal communities.

Winter.--Increasing drought conditions had the most severe impact on winter amphibians. Although numbers of species remained relatively constant over the 3 year study period (Table 3), numbers of individuals declined, especially in the seedling and sapling study areas (Fig. 2). These declines were a result of reduced breeding sites.

During 1979, each study area had potential breeding sites. The pond associated with the seedling area attracted a variety of species. Rainfall filled intermittent ponds on the sapling area where a breeding aggregate of 37 Hurter's spadefoot toads were recorded 2 days after an intense rainfall followed by a warming trend. This species is stimulated by heavy rains during warm periods, emerging in great numbers to migrate to breeding pools (Porter 1967, Conant 1975). Even with the high moisture conditions of 1979, low numbers of salamanders, frogs and toads in the pole study area were probably due to a lack of adequate breeding sites. Dwarf salamanders, which are mostly terrestrial (Bishop 1943), were captured in the pole study area under artificial cover in relatively moist sites adjoining an intermittent stream. Intermittent streams on the sawtimber study area contained numerous persistent pools that attracted toads and frogs (Rakowitz 1983). The lack of salamanders on that stand (Table 2) seemed unusual since there was abundant suitable habitat (rotting logs, leaf litter, debris, ponds).

Winter 1980 was considerably drier than winter 1979. The only rainfall during the census period was accompanied by a decrease in air temperature which eliminated most herpetofaunal activity. Relatively dry conditions eliminated intermittent ponds in the sapling and sawtimber stands. Although reduced in size, the pond in the seedling area accommodated a moderate population of amphibians.

There was a significant decrease in abundance of amphibians in comparison with the 1979 winter sample. No frogs or toads were recorded in the sapling study area. Also, there was a 50% reduction in frog and toad numbers in the seedling area. Noticeable in the seedling study area was the presence of marbled salamanders, which frequent drier habitats than other salamanders, and the absence of mole salamanders. Reduced overall numbers may also have been the result of mortality due to habitat disturbance by prescribed burning in December 1979 and machine planting of pine seedlings in January 1980.

Table 3. Numbers of species and individuals of amphibians and reptiles recorded on the seedling, sapling, pole and sawtimber study areas during each sampling period. Significant differences between stands by sampling period are also noted.

Taxa	Winter					Spring					Yearly
	Seed	Sapl	Pole	Sawt	Total	Seed	Sapl	Pole	Sawt	Total	total
	1979										
AMPHIBIANS											
No. Species	8	8	1	5	9	7	4	4	4	10	14
No. Indivi.	143	81	2	53[a]	279	23	28	7	10	68	347
REPTILES											
No. Species	6	6	3	4	10	8	10	10	6	15	17
No. Indivi.	31	19	5	9	64	78	38	44	23[a]	183	247
ALL HERPTILES											
No. Species	14	14	4	9	19	15	14	14	10	25	31
No. Indivi.	174	100	7	62	343	101	66	51	33	251	594
	1980										
AMPHIBIANS											
No. Species	6	1	2	4	7	7	3	5	5	11	13
No. Indivi.	66	2	9	23[a]	100	45	5	23	20[a]	93	193
REPTILES											
No. Species	2	8	3	3	9	12	10	12	8	18	19
No. Indivi.	7	26	10	29	72	59	32	43	75	209	281
ALL HERPTILES											
No. Species	8	9	5	7	15	19	13	17	13	29	32
No. Indivi.	73	28	19	52	172	104	37	66	95	302	474
	1981										
AMPHIBIANS											
No. Species	5	2	4	7	10	3	4	4	2	5	12
No. Indivi.	38	8	9	30	85	7	9	8	3	27	112
REPTILES											
No. Species	8	7	4	6	12	11	9	9	6	19	21
No. Indivi.	16	34	11	14	75	60	37	36	31	164	239
ALL HERPTILES											
No. Species	13	9	8	13	22	14	13	13	8	24	33
No. Indivi.	54	42	20	44	160	67	46	44	34	191	351

[a]Denotes significant differences ($p < 0.05$) between stands by season. See Rakowitz (1983) for study area rankings.

Although 1981 abundances of amphibians were lower than 1980, the difference between years was not significant. Numbers of individuals in the seedling area declined, probably due to the diminished influence of the pond and the tree planting operation in January 1981. There was a slight increase in numbers of individuals in the sapling and sawtimber study areas. The high number of species in the sawtimber area was due to increased occurrence of salamanders (Rakowitz 1983). This was the only winter sampling period during which abundances of amphibians between the study areas were not different.

Numbers of winter reptiles showed no strong patterns across the 3 years (Fig. 2). In the seedling study area, numbers of reptile species and individuals decreased from 1979 to 1980, then increased from 1980 to 1981. This suggests that the combined effects of the prescribed burn and the tree planting between 1979 and 1980 were more detrimental to reptiles than tree planting only, which occurred between 1980 and 1981.

Abundances in the older stands generally increased over the 3 years. As a result, total numbers of reptiles recorded did not vary among years (Fig. 2). However, snake populations of all areas increased in 1981 when compared to the previous winters (Rakowitz 1983), probably due to warm temperatures during late February which stimulated an earlier emergence.

Spring.--Abundances of amphibians recorded during spring were consistently lower than during winter. However, during 1979 and 1980, numbers of species were higher (Table 3). Total numbers of individual amphibians showed a different trend across years during spring than winter (Fig. 2). Although amphibians are less dependent on water for breeding during spring than winter, changes in abundances across years were related to moisture conditions.

During 1979, some spring amphibians were associated with breeding sites. Chorusing southern gray treefrogs were recorded on the seedling and sapling study areas, as were

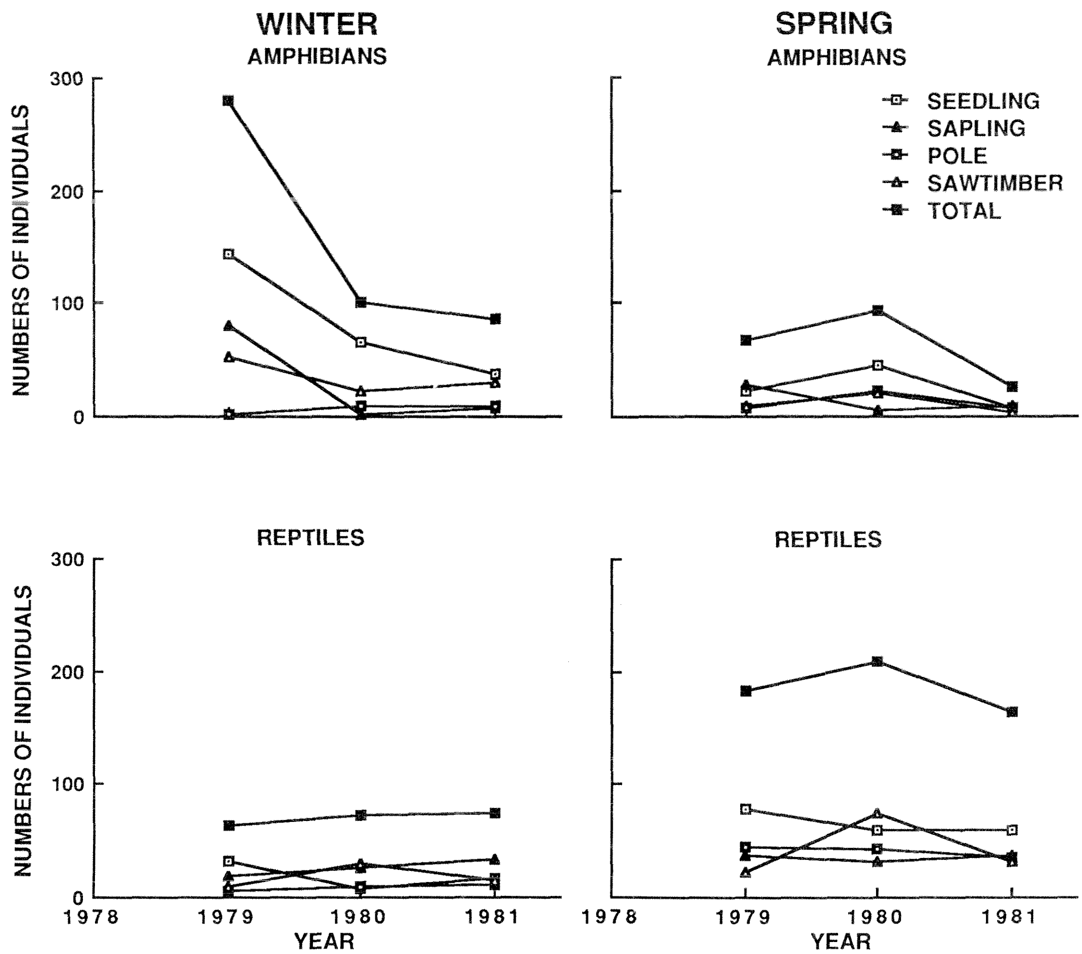

Figure 2. Relationships in numbers of amphibians and reptiles recorded during winter and spring sampling periods in 1979, 1980 and 1981.

Hurter's spadefoot toads on the sapling stand. On the droughty seedling study area, presence of eastern narrow-mouthed toads, which prefer moist sites (Conant 1975), was due to the abundance of ants. As a result of the relatively low amphibian numbers recorded, differences among study areas were not significant.

During 1980, greater numbers of individual amphibians were recorded in the seedling, pole and sawtimber study areas than during 1979. Although total precipitation declined, a heavy March rainfall recharged intermittent ponds on the seedling and sawtimber study areas. The increased number of amphibians on the pole stand may also have been due to that rain. Lack of rainfall during the actual study period prevented the emergence of spadefoot toads in the sapling study area; as a result, the number of individuals recorded there declined. The abundance of amphibians in the seedling study area was significantly greater than in the sapling and pole study areas, but not different from the sawtimber study area. Abundances in the sapling, pole and sawtimber areas were not significantly different.

During 1981, total numbers of individual amphibians were significantly lower than during 1980. Except the sapling study area, where low numbers were recorded both years, numbers of both species and individuals declined. Declines in numbers were due to the drought. Few breeding amphibians were noted in 1981, especially in the seedling study area (Table 3). However, more eastern narrow-mouthed toads were captured during this period than any other (Rakowitz 1983). Amphibian abundances between study areas were not significantly different in 1981.

Reptiles were more abundant during spring than winter in all study areas each year. During spring 1979 and 1981, more individuals were recorded in the seedling study area than in the other study areas (Table 3). During 1979, significantly more individuals were recorded in the seedling study area than in the sapling and sawtimber study areas. This was a result of high numbers of northern fence lizards, which represented approximately 80% of the spring 1979 reptile sample, and six-lined racerunners (Rakowitz 1983). The conditions of the seedling study area seemed to provide ideal habitat for those species (Smith 1946).

During spring 1980, reptile populations of the 4 study areas were not significantly different. This was due to a more even distribution in numbers of snakes between study areas and the decrease in numbers of lizards in the seedling area (Table 2). Reduced numbers of fence lizards and racerunners were probably a result of the tree planting activities. The increase in reptile abundance of the sawtimber study area from 1979 to 1980 (Fig. 2) was the result of a fourfold increase in ground skinks (Rakowitz 1983), for which that stand contained excellent habitat (Smith 1946).

Overall reptile abundance decreased approximately 22% from 1980 to 1981. The decrease was concentrated in the pole and sawtimber stands; there were slight increases in the seedling and sapling stands. Ground skinks in the sawtimber stand were rare; only 3 were captured, compared to 42 in 1980 (Rakowitz 1983). Two relatively aquatic snakes were captured in the pole area, a yellow-bellied water snake and a western cottonmouth. Both specimens were probably foraging out of the preferred habitat. These findings suggest that the drought had a greater negative impact on the reptile communities of the pole and sawtimber stands than on the seedling and sapling stands.

CONCLUSION

Species compositions and numbers of individuals of the amphibian communities were significantly different between the seedling, sapling, pole and sawtimber study areas during both seasons. The winter amphibian populations were probably more closely related to availability of ponds suitable for breeding than to stand age or vegetation structure. Most winter records of amphibians were from breeding choruses or aggregations. The fewer spring records were primarily captures of foraging or migrating individuals. Abundances of spring amphibians were more closely related to vegetational structure and thus stand age than were winter amphibian abundances.

Based on different ecological strategies, the reptile community can be divided into lizards and snakes. In winter, lizards, of small biomass, became active during brief warm periods and were numerically over-represented when compared with snakes. Amount of canopy closure affects soil warming, so vegetation structure probably affected the amount of winter snake activity. As a result, numbers of snakes recorded in the older stands were low during winter.

Temperature was not a factor affecting reptile abundances in the spring. Lizard populations were significantly greater in the seedling study area than in other study areas. Lizard species demonstrated both a functional and a numerical response to changing habitat conditions. High numbers of individuals of species adapted to early succession vegetation (six-lined racerunners, northern fence lizards) were responsible for the significantly greater lizard abundance in the seedling study area. Lizard species better adapted to older forest stands (green anoles, five-lined skinks, broadheaded skinks, ground skinks) were represented in greater numbers in the older stands.

The spring snake community did not show significant differences in total numbers between study areas. There were, however, differences in species composition. The seedling study area had more species and a more even distribution of numbers than did the other study areas. This was due to the presence of grassland species (prairie kingsnake, speckled kingsnake, eastern coachwhip, western ribbon snake). This shows that snakes responded to radical changes in vegetation structure by changes in species composition but not changes in numbers of individuals.

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LITERATURE CITED

Bishop, S. C. 1943. Handbook of salamanders: the salamanders of the United States, of Canada, and of lower California. Comstock Publ. Co. Inc., Ithaca, New York.

Cagle, F. R. 1939. A system of marking turtles for future identification. Copeia 1939:170-172.

Clark, D. R., Jr. 1971. Branding as a marking technique for amphibians and reptiles. Copeia 1971:148-151.

Conant, R. 1975. A field guide to the reptiles and amphibians of eastern and central North America. Houghton Mifflin Co., Boston.

Conner, R. N., R. G. Hooper, H. S. Crawford, and H. S. Mosby. 1975. Woodpecker nesting habitat in cut and uncut woodlands in Virginia. J. Wildl. Manage. 39:144-150.

Daniel, W. W. 1978. Applied nonparametric statistics. Houghton Mifflin Co., Boston.

Dickerson, M. C. 1969. The frog book. North American toads and frogs, with a study of the habits and life histories of those of the northeastern United States. Dover Publications Inc., New York.

Dixon, W. J., and M. B. Brown. 1981. Biomedical Computer Programs: P-series, 1981. University of California Press, Berkley.

Dolezel, R., and T. Holt. 1979. Angelina National Forest study area soil survey in San Augustine County, Texas. USDA, Soil Conservation Service, Nacogdoches, Texas.

Fitch, H. S. 1951. A simplified type of funnel trap for reptiles. Herpetologica 7:77-80.

Hardy, L. M., and L. R. Raymond. 1974. The breeding migration of the mole salamander, *Ambystoma talpoideum*, in Louisiana. J. Herpetol. 14:327-335.

Martof, B. S. 1953. Territoriality in the green frog, *Rana clamitans*. Ecology 42:594-598.

Nie, N. H., and C. H. Hull. 1981. SPSS update 7-9: New Procedures and facilities for releases 7-9. McGraw-Hill Book Co., New York.

Pielou, E. C. 1966. Species-diversity and pattern-diversity in the study of ecological succession. J. Theoret. Biol. 10:370-383.

Porter, G. 1967. The world of the frog and toad. J. B. Lippincott Co., Philadelphia.

Shannon, C. E., and W. Weaver. 1963. The mathematical theory of communication. University of Illinois Press, Urbana.

Smith, H. M. 1946. Handbook of lizards. Comstock Publishing Co., Ithaca, New York.

Thomas, J. W., ed. 1979. Wildlife habitats in managed forests of the Blue Mountains of Oregon and Washington. USDA For. Ser., Agr. Handbook No. 553.

Rakowitz, V. A. 1983. Comparison of the herpetofauna of four different-aged stands in the loblolly-shortleaf pine-hardwood ecosystem of East Texas. M.S. Thesis. Stephen F. Austin State University, Nacogdoches, Texas.

Whiting, R. M., R. R. Fleet, and H. A. Pearson. 1983. Implementing and maintaining a system to monitor small mammal and bird populations. Pages 420-423 *in* Renewable resource inventories for monitoring changes and trends. Proc. of an international conference (J. F. Bell and T. Atterbury, eds.). College of Forestry, Oregon State University, Corvallis.

__________, and __________. 1985. Small animal population inventories on a mixed pine-hardwood forest of East Texas. Final report, FS-SO-1701-4.11, USDA-For. Serv., So. For. Expt. Sta., Alexandria, La.

BIRD AND SMALL MAMMAL COMMUNITIES OF LOBLOLLY-SHORTLEAF PINE STANDS IN EAST TEXAS

R. Montague Whiting, Jr. and Robert R. Fleet

Abstract.--Species compositions and relative abundances of birds and mammals were investigated on 16 study areas in the Angelina National Forest in San Augustine County, near Broaddus, Texas. Four study areas were established in pine stands of each of the following tree sizes: seedling, sapling, pole, sawtimber. Generally, the highest numbers of species and individuals of birds and small mammals were found in seedling study areas. Numbers of birds and mammals generally decreased as stand age and thus tree size increased. A drought after the 1st sample year adversely affected both birds and small mammals. As bird data were collected only during the 1st year following the drought, no trends could be developed. However, small mammals were censused 2 years thereafter, and several trends were evident. Cotton rat populations crash immediately following the drought, but rebounded strongly the following year. Excluding eastern woodrats, populations of the remaining small rodents also crashed after the drought, and did not recover in 2 years. Numbers of woodrats declined in the trapping period immediately following the drought, but had recovered by the following trapping period.

INTRODUCTION

In 1978, the Chief of the U.S. Forest Service approved the Southern Evaluation Project. The project was designed to study biological, physical, economic and social attributes as affected by timber, range and wildlife management in the southern United States (Pearson 1981). This study, which was a part of the Southern Evaluation Project, was designed to describe the species compositions and relative abundances of birds and mammals in seedling, sapling, pole and sawtimber tree size class stands in East Texas.

STUDY AREAS

Study areas were selected from a contiguous tract of approximately 8000 acres (3200 ha) in the pine-hardwood forest of the Angelina National Forest in San Augustine County, east of the Attoyac arm of Sam Rayburn Reservoir. Four study sites, each approximately 2000 acres (800 ha) were used. Within or adjacent to each study site, 4 evenage pine stand study areas, classified by tree size as seedling, sapling, pole or sawtimber, were selected. The 16 study areas varied somewhat in size, but all were large enough to permit establishment of strip transects totaling 22.5 acres (9 ha) with appropriate buffers. Study areas were selected on the basis of homogeneity of soils and overstory vegetation. Soils of the study areas included the Cuthbert, Lacerda, Renzel, Tenaha and Woodtell series (Dolezel and Holt 1979). Detailed descriptions of each study area may be found in Whiting and Fleet (1985). The study areas were numbered as follows: seedling 1, 5, 9, 13; sapling 2, 6, 10, 14; pole 3, 7, 11, 15; and sawtimber 4, 8, 12, 16.

METHODS

All taxa were monitored using transects 984 ft (300 m) long. Each study area had 3 such transects, thus 3 replications per study area. Transects were parallel in cardinal directions, at least 328 ft (100 m) apart, and no closer than 246 ft (75 m) to a different vegetation type. To facilitate travel, transect lines were cleared of brush as needed. Perpendicular distances were marked at 164 ft intervals along each transect line (Whiting et al. 1983).

Vegetation

Vegetation of each study site was extensively inventoried by other scientists

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(Smeins and Hinton 1981). However, in order to characterize the study areas, some vegetation data were collected during summer 1980 and winter 1981. Sampling methods for vegetation are detailed in Whiting et al. (1983) and Whiting and Fleet (1985).

Birds

Birds were censused during the winter (January-February) and spring (May-June) seasons of 1980 and 1981. The same 4 census-takers were used throughout a season. Birds were censused only on days when all census-takers could work. Each census-taker sampled 2 study areas per census-day. On successive census-days, census-takers sampled different study areas until each had sampled all 16 study areas twice; this provided a total of 8 censuses per study area and 128 per season. The 1st sample order was reversed the 2nd time a given census-taker sampled the same pair of study areas. Birds seen or heard within 164 ft (50 m) of the transect line were recorded. Information recorded included observer name, Julian date, starting and ending time of the census, stand number, and stand age. For each bird observation, data recorded included American Ornithological Union (AOU) number, number of individuals, sex, observer-to-bird distance, and coordinates of the bird. If a bird was heard but not seen, the number of individuals was coded as 1 and sex as unknown. (Whiting and Fleet 1985).

Small Mammals

Population densities of small mammals, primarily rodents, were evaluated using standard capture-recapture techniques (Overton 1971). Trapping seasons were set to coincide with winter and spring bird sampling seasons. However, small mammals were trapped for 3 consecutive years (1980-1982).

To capture small mammals, 16 Sherman live traps were spaced at 66 ft (20 m) intervals along each transect, thus 48 traps per study area. Traps were baited daily with a 50:50 mixture of chicken scratch and rolled oats and checked each morning for 14 consecutive days. This provided 672 trap-days per study area per season.

The 1st time a mammal was captured, a single toe was clipped on a specific foot. Age (adult, juvenile) and sex (male, female, unknown, pregnant/lactating) of the animal were noted prior to release at the point of capture. Other data recorded included observer name, Julian date, stand number and age, transect and trap number, species code, whether the animal was a recapture or not, and if it was alive or dead.

Squirrels

Tree squirrel numbers were estimated using time-area and nest counts (Goodrum 1961). The 4 sampling periods used when estimating squirrel numbers were early fall in 1979 and 1980 and early spring in 1980 and 1981. Squirrel censuses were completed before the hunting season opened. During each sampling period, 4 2-hour time-area counts were made along the transect lines of each pole and sawtimber study area. For each study area and sampling period, 2 counts were made early in the morning and 2 in the afternoon. The observer-to-squirrel distance for each squirrel seen was recorded. Estimated densities were then calculated (Goodrum 1961).

Squirrel nests were counted during February of 1980 and 1981. On each pole and sawtimber stand, 4 observers independently counted the number of active nests within 164 ft of either side of the transect. For each stand, the average number of nests per acre was determined.

Large and Mid-sized Mammals

Mammals too large to be captured in live traps were counted at night during fall 1979 and 1980 and spring 1980 and 1981. Using a spotlight, an observer slowly walked each transect and recorded, by species, the numbers of animals seen or heard. Spotlight counts generally started about an hour after sunset and took about 45 minutes per study area. Also, during the bird and small mammal censuses, incidental mammals observed were recorded.

Statistical Analyses

Diversity index values were computed using Shannon's (1948) measure of information (species diversity); equitability, or "evenness" values were computed using Pielou's (1966) method. When comparing vegetational, avian and small mammal data, nonparametric tests were used. Comparisons were made between study areas of the same tree size class; none were made between study areas of different tree size classes. Generally, Kruskel-Wallis one-way analysis of variance by ranks (Nie and Hull 1981) and multiple comparison tests (Daniel 1978) were used. The null hypothesis of no difference between groups being tested was used throughout, as was the 0.05 level of significance.

RESULTS AND DISCUSSION

There was a general drying trend during 1979-1981 (Rakowitz 1983). The summer of 1980 was the hottest and driest recorded during the 1965-1984 period. The eastern half of Texas was subjected to a severe heat wave and an associated drought from mid-June to mid-September. Virtually all temperature and moisture parameters reflected the extreme conditions during that summer (Whiting and Fleet 1985). The climatic extremes had drastic impacts on avian and small mammal communities. Heat and lack of moisture adversely affected the plant communities also.

As the treatment block and study sites were established before this project was initiated, "classic" seedling, sapling, pole and sawtimber stands (Stoddart 1959, Young 1982) were not available within each study site. As a result, there was overlap of some parameters between study areas of different tree size classes. However, we believe that the 4 stands chosen for each size class were representative (Table 1).

Table 1. Stand ages and structural characteristics of large vegetation (> 4.0 inches dbh) as tallied on 18 1/10 acre plots (= 1.8 acres) on each study area during summer 1980. Average dbh and height values for stands 1 & 5 are for residual overstory trees. Average height of the pine and hardwood seedlings (grouped) are shown in parentheses.

Study area no.	Tree size class	Average dbh (inches) Pine	Hdwd	Combined	Average height (feet) Pine	Hdwd	Combined	Average age (pines)
1	Seedling	7.3[a]	6.9	7.0[a]	55.4[a]	39.4	43.0 (5.9)[a]	ca 3.5
5	Seedling	4.7	5.5	5.4	50.0	35.1	36.4 (5.2)	ca 2.5
9	Seedling	-	-	-	-	-	- (2.3)	0.5
13	Seedling	-	-	-	-	-	- (5.9)	ca 3.5
2	Sapling	4.8	4.8	4.8	28.9	29.5	28.9	7.5
6	Sapling	5.6	5.4	5.6	34.4	29.2	34.4	13.5
10	Sapling	5.3	5.8	5.3	31.2	30.1	31.2	12.5
14	Sapling	5.4	5.7	5.5	35.4	34.8	35.4	9.5
3	Pole	8.4[a]	7.0	7.9	60.0	44.9	54.1	36.5[c]
7	Pole	10.8	6.6	9.6	64.9	43.6	59.0	40.7
11	Pole	8.9	6.1	7.9	63.0	44.9	56.4	50.2[b]
15	Pole	10.8	6.5	9.0	67.2	44.0	57.7	38.4[b]
4	Sawtimber	12.1	7.9	9.5	80.0	60.0	67.6	57.0
8	Sawtimber	9.9	6.4	8.5	68.2	47.9	60.0	59.7
12	Sawtimber	11.1	6.0	8.5	67.9	44.6	56.1	53.4[b]
16	Sawtimber	11.7	6.7	9.5	74.5	47.2	62.3	45.3[b]

[a] Indicates a significant difference, at the 0.05 level, between diameters or heights in stands of the same tree size class (Kruskal - Wallis test). Hardwoods were not tested.

[b] Indicates a significant difference, at the 0.05 level, between lines within the specific study area (Kruskal - Wallis test).

[c] Duncan's Multiple Range tests grouped ages of the pole and sawtimber stands as follow (youngest to oldest): Study area numbers 3 & 15; 15 & 7; 7 & 16; 16 & 11; 11 & 12; and 12, 4 & 8. However, a paired t-test showed that the pines on the sawtimber study areas were significantly ($P \leq 0.05$) older than those on the pole areas.

Characteristics of the vegetation of the study areas are discussed in detail in Whiting and Fleet (1985).

BIRDS

A total of 13,358 birds representing 115 species were recorded while making 512 censuses during the 2 year study period (Table 2). In a similar study, Whiting (1978) recorded 13 species that we did not, and we recorded 17 that he did not.

Differences Between Years

There were notable differences in numbers of species and individuals recorded between years. For winter censuses, numbers of individuals declined drastically from 1980 to 1981. Declines were 40, 52, 24, and 23% for the seedling, sapling, pole and sawtimber study areas, respectively. Also, there were slight declines in numbers of species (Table 2); these declines can be attributed to the drought.

The larger declines occurred on the younger age study areas; probably the plants in the seedling and sapling study areas were more susceptible to the drought than were those of the pole and sawtimber study areas. Ground foraging species such as bobwhites, common flickers, eastern meadowlarks, white-throated sparrows, chipping sparrows and slate-colored juncos were recorded in reduced numbers in 1981. Other species recorded in reduced numbers in 1981 included cedar waxwings, yellow-rumped warblers and robins (Table 2).

For spring censuses, more birds were recorded in 1981 than in 1980 (Table 2). Numbers of individuals increased in all stands and numbers of species increased in all but the sawtimber stands. Reasons for these increases after the drought are unclear. Spring censuses started after 30 April in both years, well after the vegetation had resumed growth. More vegetative material may have been produced in the spring after the drought (1981) and thus increased both feeding and nesting sites for a variety of birds.

Table 2. Numbers of individual birds recorded by tree size class study area, species and season (W = winter, S = spring, C = combined) for each year, with study area and seasonal totals and totals for the whole study period.

AOU no.	Common name Scientific name		Study area: Seedling 1980	1981	Total	Sapling 1980	1981	Total	Pole 1980	1981	Total	Sawtimber 1980	1981	Total	Yearly and seasonal totals 1980	1981	Total	Study total
144	Wood Duck	W	4	–	4	–	–	–	–	–	–	–	–	–	4	–	4	
	Aix sponsa	S	1	–	1	–	–	–	–	–	–	–	–	–	1	–	1	5
201	Green-backed Heron	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Butorides striatus	S	1	–	1	–	–	–	–	–	–	–	–	–	1	–	1	1
228	American Woodcock	W	8	7	15	1	1	2	1	1	2	–	–	–	10	9	19	
	Scolopax minor	S	–	1	1	–	–	–	–	–	–	–	–	–	–	1	1	20
289	Northern Bobwhite	W	62	10	72	30	10	40	–	–	–	10	–	10	102	20	122	
	Colinus virginianus	S	30	13	43	3	5	8	4	1	5	5	–	5	42	19	61	183
316	Mourning Dove	W	31	105	136	–	–	–	–	–	–	–	–	–	31	105	136	
	Zenaida macroura	S	17	10	27	4	4	8	4	1	5	3	6	9	28	21	49	185
325	Turkey Vulture	W	–	11	11	–	–	–	–	–	–	4	1	5	4	12	16	
	Cathartes aura	S	2	1	3	–	–	–	–	–	–	–	–	–	2	1	3	19
326	Black Vulture	W	–	–	–	–	–	–	–	2	2	–	–	–	–	2	2	
	Coragyps atratus	S	1	–	1	–	–	–	–	–	–	–	–	–	1	–	1	3
332	Sharp-shinned Hawk	W	–	–	–	–	–	–	–	–	–	–	4	4	–	4	4	
	Accipiter striatus	S	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4
333	Cooper's Hawk	W	–	–	–	–	–	–	–	–	–	1	–	1	1	–	1	
	Accipiter cooperii	S	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
337	Red-tailed Hawk	W	3	2	5	–	–	–	–	–	–	–	–	–	3	2	5	
	Buteo jamaicensis	S	1	–	1	–	–	–	–	–	–	–	–	–	1	–	1	6
339	Red-shouldered Hawk	W	–	–	–	–	2	2	–	1	1	–	–	–	–	3	3	
	Buteo lineatus	S	–	–	–	–	–	–	–	–	–	–	1	1	–	1	1	4
343	Broad-winged Hawk	W	–	–	–	1	–	1	–	–	–	–	–	–	1	–	1	
	Buteo platypterus	S	–	–	–	–	–	–	1	1	2	–	–	–	1	1	2	3
360	American Kestrel	W	2	1	3	1	–	1	–	–	–	–	–	–	3	1	4	
	Falco sparverius	S	1	–	1	–	–	–	–	–	–	–	–	–	1	–	1	5
368	Barred Owl	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Strix varia	S	–	–	–	–	–	–	–	–	–	1	–	1	1	–	1	1
375	Great Horned Owl	W	–	–	–	–	–	–	–	–	–	1	–	1	1	–	1	
	Bubo virginianus	S	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
385	Greater Roadrunner	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Geococcyx californianus	S	–	–	–	–	1	1	–	–	–	–	–	–	–	1	1	1
387	Yellow-billed Cuckoo	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Coccyzus americanus	S	2	9	11	10	6	16	1	1	2	4	5	9	17	21	38	38
388	Black-billed Cuckoo	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Coccyzus erythropthalmus	S	–	–	–	–	–	–	–	–	–	–	1	1	–	1	1	1
393	Hairy Woodpecker	W	5	10	15	1	1	2	4	–	4	3	3	6	13	14	27	
	Picoides villosus	S	2	3	5	2	1	3	1	4	5	–	–	–	5	8	13	40
394	Downy Woodpecker	W	8	11	19	3	2	5	5	5	10	6	8	14	22	26	48	
	Picoides pubescens	S	2	5	7	–	2	2	–	1	1	4	1	5	6	9	15	63
402	Yellow-bellied Sapsucker	W	7	6	13	2	3	5	9	6	15	13	31	44	31	46	77	
	Sphyrapicus varius	S	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	77
405	Pileated Woodpecker	W	4	9	13	2	–	2	5	3	8	18	17	35	29	29	58	
	Dryocopus pileatus	S	6	1	7	1	1	2	4	3	7	7	6	13	18	11	29	87
406	Red-headed Woodpecker	W	17	–	17	–	–	–	–	–	–	–	1	1	17	1	18	
	Melanerpes erythrocephalus	S	39	20	59	2	–	2	3	5	8	–	1	1	44	26	70	88
409	Red-bellied Woodpecker	W	11	19	30	3	1	4	8	15	23	23	16	39	45	51	96	
	Melanerpes carolinus	S	11	17	28	3	–	3	7	7	14	11	15	26	32	39	71	167
412	Northern Flicker	W	27	5	32	15	5	20	1	–	1	5	2	7	48	12	60	
	Colaptes auratus	S	1	–	1	–	–	–	–	–	–	–	–	–	1	–	1	61
416	Chuck-will's-widow	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Caprimulgus carolinensis	S	–	–	–	1	–	1	1	1	2	1	3	4	3	4	7	7
423	Chimney Swift	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Chaetura pelagica	S	5	–	5	–	–	–	–	–	–	–	–	–	5	–	5	5
428	Ruby-throated Hummingbird	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Archilochus colubris	S	4	15	19	–	1	1	–	–	–	–	–	–	4	16	20	20
444	Eastern Kingbird	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Tyrannus tyrannus	S	10	5	15	–	–	–	–	–	–	–	–	–	10	5	15	15
452	Great Crested Flycatcher	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Myiarchus crinitus	S	32	22	54	6	10	16	4	3	7	16	15	31	58	50	108	108

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Table 2. Continued.

AOU no.	Common name / Scientific name		Seedling 1980	Seedling 1981	Seedling Total	Sapling 1980	Sapling 1981	Sapling Total	Pole 1980	Pole 1981	Pole Total	Sawtimber 1980	Sawtimber 1981	Sawtimber Total	Yearly and seasonal totals 1980	Yearly and seasonal totals 1981	Yearly and seasonal totals Total	Study total
456	Eastern Phoebe	W	2	1	3	3	1	4	1	2	3	2	–	2	8	4	12	
	Sayornis phoebe	S	–	–	–	–	–	–	–	–	–	3	–	3	3	–	3	15
461	Eastern Wood-pewee	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Contopus virens	S	5	2	7	1	–	1	1	3	4	6	9	15	13	14	27	27
465	Acadian Flycatcher	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Empidonax virescens	S	1	–	1	–	–	–	1	2	3	16	23	39	18	25	43	43
477	Blue Jay	W	26	25	51	34	51	85	18	15	33	38	27	65	116	118	243	
	Cyanocitta cristata	S	32	9	41	26	28	54	14	18	32	27	24	51	99	79	178	412
488	American Crow	W	26	12	38	6	14	20	7	15	22	17	1	18	56	42	98	
	Corvus brachyrhynchos	S	1	1	2	8	1	9	4	1	5	7	2	9	20	5	25	123
495	Brown-headed Cowbird	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Molthrus ater	S	67	63	130	17	5	22	16	4	20	16	9	25	116	81	197	197
501	Eastern Meadowlark	W	63	33	96	–	–	–	–	–	–	–	–	–	63	33	96	
	Sturnella magna	S	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	96
506	Orchard Oriole	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Icterus spurius	S	2	2	4	–	–	–	–	1	1	–	–	–	2	3	5	5
507	Northern Oriole	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Icterus galbula	S	1	6	7	–	4	4	–	–	–	–	–	–	1	10	11	11
511	Common Grackle	W	–	–	–	79	–	79	–	–	–	–	–	–	79	–	79	
	Quiscalus quiscula	S	3	–	3	–	–	–	–	–	–	–	–	–	3	–	3	82
517	Purple Finch	W	–	25	25	–	4	4	–	2	2	–	–	–	–	31	31	
	Carpodacus purpureus	S	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	31
529	American Goldfinch	W	7	36	43	–	–	–	–	5	5	–	–	–	7	41	48	
	Carduelis tristis	S	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	48
533	Pine Siskin	W	–	21	21	–	–	–	–	–	–	–	–	–	–	21	21	
	Carduelis pinus	S	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	21
540	Vesper Sparrow	W	8	–	8	–	–	–	–	–	–	–	–	–	8	–	8	
	Pooecetes gramineus	S	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	8
542	Savannah Sparrow	W	20	1	21	–	–	–	–	–	–	–	–	–	20	1	21	
	Passerculus sandwichensis	S	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	21
546	Grasshopper Sparrow	W	1	2	3	–	–	–	–	–	–	–	–	–	1	2	3	
	Ammodramus savannarum	S	1	–	1	–	–	–	–	–	–	–	–	–	1	–	1	4
554	White-crowned Sparrow	W	–	–	–	3	–	3	–	–	–	–	–	–	3	–	3	
	Zonotrichia leucophrys	S	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
558	White-throated Sparrow	W	191	125	316	36	31	67	1	53	54	1	19	20	229	228	457	
	Zonotrichia albicollis	S	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	457
560	Chipping Sparrow	W	69	–	69	3	–	3	–	–	–	–	–	–	72	–	72	
	Spizella passerina	S	–	–	–	–	–	–	1	–	1	2	1	3	3	1	4	76
563	Field Sparrow	W	–	–	–	–	2	2	–	–	–	–	–	–	–	2	2	
	Spizella pusilla	S	3	–	3	–	–	–	–	–	–	–	–	–	3	–	3	5
567	Dark-eyed Junco	W	345	110	455	1	16	17	–	9	9	–	24	24	346	159	505	
	Junco hyemalis	S	–	–	–	–	–	–	–	1	1	–	–	–	–	1	1	506
575	Bachman's Sparrow	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Aimophila aestivalis	S	12	2	14	–	–	–	–	–	–	–	–	–	12	2	14	14
581	Song Sparrow	W	10	6	16	–	–	–	–	–	–	–	1	1	10	7	17	
	Melospiza melodia	S	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	17
583	Lincoln's Sparrow	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Melospiza lincolnii	S	–	11	11	–	–	–	–	–	–	–	–	–	–	11	11	11
584	Swamp Sparrow	W	6	–	6	–	–	–	–	–	–	–	–	–	6	–	6	
	Melospiza georgiana	S	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6
585	Fox Sparrow	W	–	2	2	1	–	1	–	–	–	–	–	–	1	2	3	
	Passerella iliaca	S	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
587	Rufous-sided Towhee	W	28	9	37	5	5	10	–	–	–	–	–	–	33	14	47	
	Pipilo erythrophthalmus	S	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	47
593	Northern Cardinal	W	83	82	165	87	86	173	67	60	127	43	49	92	280	277	557	
	Cardinalis cardinalis	S	85	127	212	115	151	266	95	92	187	84	84	168	379	454	833	1390
595	Rose-breasted Grosbeak	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Pheucticus ludovicianus	S	–	3	3	–	–	–	–	–	–	–	2	2	–	5	5	5
597	Blue Grosbeak	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Guiraca caerulea	S	11	15	26	1	–	1	–	–	–	–	–	–	12	15	27	27

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Table 2. Continued.

AOU no.	Common name / Scientific name		Seedling 1980	Seedling 1981	Seedling Total	Sapling 1980	Sapling 1981	Sapling Total	Pole 1980	Pole 1981	Pole Total	Sawtimber 1980	Sawtimber 1981	Sawtimber Total	Yearly and seasonal totals 1980	Yearly and seasonal totals 1981	Yearly and seasonal totals Total	Study total
598	Indigo Bunting	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Passerina cyanea	S	134	188	322	5	7	12	–	–	–	3	–	3	142	195	337	337
601	Painted Bunting	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Passerina ciris	S	–	2	2	–	3	3	–	–	–	–	–	–	–	5	5	5
604	Dickcissel	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Spiza americana	S	1	–	1	–	–	–	–	–	–	–	–	–	1	–	1	1
608	Scarlet Tanager	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Piranga olivacea	S	–	–	–	–	–	–	–	1	1	–	–	–	–	1	1	1
610	Summer Tanager	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Piranga rubra	S	23	47	70	19	11	30	32	24	56	35	44	79	109	126	235	235
611	Purple Martin	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Progne subis	S	1	3	4	–	–	–	–	–	–	–	–	–	1	3	4	4
613	Barn Swallow	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Hirundo rustica	S	–	1	1	–	–	–	–	–	–	–	–	–	–	1	1	1
614	Tree Swallow	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Tachycineta bicolor	S	5	–	5	–	–	–	–	–	–	–	–	–	5	–	5	5
619	Cedar Waxwing	W	20	–	20	–	–	–	8	–	8	2	–	2	30	–	30	
	Bombycilla cedrorum	S	–	6	6	–	–	–	–	3	3	–	–	–	–	9	9	39
622	Loggerhead Shrike	W	2	1	3	–	–	–	1	–	1	–	–	–	3	1	4	
	Lanius ludovicianus	S	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4
624	Red-eyed Vireo	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Vireo olivaceus	S	11	32	43	24	28	52	60	71	131	87	113	200	182	244	426	426
626	Philadelphia Vireo	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Vireo philadelphicus	S	–	–	–	–	–	–	–	1	1	–	–	–	–	1	1	1
627	Warbling Vireo	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Vireo gilvus	S	–	–	–	–	–	–	–	–	–	–	1	1	–	1	1	1
628	Yellow-throated Vireo	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Vireo flavifrons	S	2	1	3	2	–	2	3	3	6	4	3	7	11	7	18	18
629	Solitary Vireo	W	–	–	–	1	–	1	–	2	2	–	–	–	1	2	3	
	Vireo solitarius	S	–	–	–	–	1	1	–	–	–	–	–	–	–	1	1	4
631	White-eyed Vireo	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Vireo griseus	S	57	71	128	52	89	141	–	–	–	2	–	2	111	160	271	271
636	Black-and-white Warbler	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Mniotilta varia	S	5	10	15	30	58	88	12	20	32	12	19	31	59	107	166	166
638	Swainson's Warbler	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Limnothlypis swainsonii	S	–	–	–	–	–	–	–	–	–	1	–	1	1	–	1	1
639	Worm-eating Warbler	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Helmitheros vermivorus	S	–	3	3	23	12	35	6	6	12	3	–	3	32	21	53	53
647	Tennessee Warbler	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Vermivora peregrina	S	–	1	1	–	–	–	–	–	–	–	–	–	–	1	1	1
648	Northern Parula	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Parula americana	S	18	6	24	2	–	2	–	–	–	–	–	–	20	6	26	26
655	Yellow-rumped Warbler	W	39	18	57	68	27	95	74	37	111	87	60	147	268	142	410	
	Dendroica coronata	S	1	–	1	–	–	–	–	–	–	–	–	–	1	–	1	411
657	Magnolia Warbler	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Dendroica magnolia	S	–	1	1	–	–	–	–	–	–	–	–	–	–	1	1	1
658	Cerulean Warbler	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Dendroica cerulea	S	–	–	–	–	2	2	–	–	–	–	–	–	–	2	2	2
660	Bay-breasted Warbler	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Dendroica castanea	S	–	–	–	–	6	6	–	–	–	–	–	–	–	6	6	6
663	Yellow-throated Warbler	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Dendroica dominica	S	–	2	2	8	3	11	–	–	–	1	1	2	9	6	15	15
667	Black-throated Green War.	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Dendroica virens	S	–	2	2	–	3	3	–	–	–	–	–	–	–	5	5	5
671	Pine Warbler	W	6	18	24	26	26	52	209	138	347	150	103	253	391	285	676	
	Dendroica pinus	S	3	2	5	9	19	28	79	120	199	71	109	180	162	250	412	1088
673	Prairie Warbler	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Dendroica discolor	S	19	34	53	1	1	2	–	–	–	–	–	–	20	35	55	55
674	Ovenbird	W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Seiurus aurocapillus	S	–	–	–	–	1	1	–	–	–	–	–	–	–	1	1	1

Continued on next page.

Table 2. Continued.

AOU no.	Common name / Scientific name		Seedling 1980	Seedling 1981	Seedling Total	Sapling 1980	Sapling 1981	Sapling Total	Pole 1980	Pole 1981	Pole Total	Sawtimber 1980	Sawtimber 1981	Sawtimber Total	Yearly and seasonal totals 1980	Yearly and seasonal totals 1981	Yearly and seasonal totals Total	Study total
676	Louisiana Waterthrush	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	Seiurus motacilla	S	-	-	-	-	-	-	-	1	1	-	2	2	-	3	3	3
677	Kentucky Warbler	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	Oporornis formosus	S	7	26	33	38	36	74	7	2	9	1	2	3	53	66	119	119
681	Common Yellowthroat	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	Geothlypis trichas	S	23	37	60	6	1	7	1	-	1	-	-	-	30	38	68	68
683	Yellow-breasted Chat	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	Icteria virens	S	133	172	305	53	24	77	-	-	-	1	-	1	187	196	383	383
684	Hooded Warbler	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	Wilsonia citrina	S	6	2	8	27	28	55	41	47	88	35	34	69	109	111	220	220
687	American Redstart	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	Setophaga ruticilla	S	-	1	1	-	-	-	-	-	-	-	-	-	-	1	1	1
704	Gray Catbird	W	-	-	-	-	1	1	-	-	-	-	-	-	-	1	1	
	Dumetella carolinensis	S	-	17	17	-	2	2	-	-	-	-	-	-	-	19	19	20
705	Brown Thrasher	W	6	3	9	25	12	37	-	2	2	1	-	1	32	17	49	
	Toxostoma rufum	S	-	-	-	1	1	2	1	-	1	-	-	-	2	1	3	52
718	Carolina Wren	W	90	60	150	33	35	68	62	55	117	49	76	125	234	226	460	
	Thryothorus ludovicianus	S	51	35	86	38	37	75	77	42	119	56	34	90	222	148	370	830
721	House Wren	W	-	-	-	-	1	1	-	-	-	-	1	1	-	2	2	
	Troglodytes aedon	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
722	Winter Wren	W	2	-	2	-	-	-	2	-	2	-	1	1	4	1	5	
	Troglodytes troglodytes	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
726	Brown Creeper	W	-	3	3	-	-	-	4	16	20	2	13	15	6	32	38	
	Certhia americans	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	38
727	White-breasted Nuthatch	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	Sitta carolinensis	S	-	4	4	-	-	-	-	-	-	-	2	2	-	6	6	6
729	Brown-headed Nuthatch	W	12	12	24	2	-	2	4	7	11	7	15	22	25	34	59	
	Sitta pusilla	S	7	17	24	1	-	1	7	10	17	12	18	30	27	45	72	131
731	Tufted Titmouse	W	27	33	60	13	24	37	68	56	124	43	31	74	151	144	295	
	Parus bicolor	S	28	41	69	31	40	71	39	69	108	81	70	151	179	220	399	694
736	Carolina Chickadee	W	72	61	133	46	29	75	80	111	191	82	95	177	280	296	576	
	Parus carolinensis	S	41	59	100	54	40	94	42	86	128	41	45	86	178	230	408	984
748	Golden-crowned Kinglet	W	-	8	8	20	27	47	81	56	137	26	28	54	127	119	246	
	Regulus satrapa	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	246
749	Ruby-crowned Kinglet	W	39	27	66	91	13	104	117	38	155	134	16	150	381	94	475	
	Regulus calendula	S	-	1	1	-	1	1	-	-	-	-	-	-	-	2	2	477
751	Blue-gray Gnatcatcher	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	Polioptila caerulea	S	28	40	68	4	3	7	6	1	7	5	2	7	43	46	89	89
755	Wood Thrush	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	Hylocichla mustelina	S	-	-	-	-	-	-	8	-	8	29	8	37	37	8	45	45
757	Gray-cheeked Thrush	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	Catharus minimus	S	-	-	-	-	-	-	-	1	1	-	-	-	-	1	1	1
758	Swainson's Thrush	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	Catharus ustulatus	S	-	-	-	-	1	1	-	1	1	-	-	-	-	2	2	2
759	Hermit Thrush	W	11	21	32	39	23	62	15	14	29	12	8	20	77	66	143	
	Catharus guttatus	S	-	-	-	-	-	-	-	-	-	-	1	1	-	1	1	144
761	American Robin	W	192	8	200	274	3	277	105	3	108	67	1	68	638	15	653	
	Turdus migratorius	S	-	-	-	-	-	-	3	-	3	-	-	-	3	-	3	656
766	Eastern Bluebird	W	20	5	25	1	-	1	2	-	2	-	-	-	23	5	28	
	Sialia sialis	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	28
	Total species	W	42	41	48	34	29	39	27	28	34	28	28	34	52	50	60	
		S	54	55	69	36	41	49	34	38	43	36	36	44	65	76	93	
		C	75	79	93	57	57	71	49	54	61	51	51	63	89	102	115	
	Total individuals	W	1612	964	2576	956	456	1412	959	729	1688	847	652	1499	4374	2801	7175	
		S	996	1227	2223	628	678	1306	586	659	1245	693	716	1409	2903	3280	6183	
		C	2608	2191	4799	1584	1134	2718	1545	1388	2933	1540	1368	2908	7277	6081	13358	

Differences Between Tree Size Class Study Areas

Winter.--During winter surveys, more bird species and individuals were recorded in the seedling study areas than in the other study areas (Table 2). These results are similar to those of other studies (Whiting 1978, Baggett 1983) for the same reasons: more flocking granivorous birds in the seedling stands than on the other stands. Dickson and Segelquist (1977) recorded greater winter bird densities in young sapling study areas which were described as having characteristics intermediate between our seedling and sapling study areas. This suggests that high numbers of winter birds characteristic of pine seedling stands may be maintained into the young sapling stage.

Trends in numbers of species were similar between years (Fig. 1). These trends seem to be intermediate between those found by Dickson and Segelquist (1977), which showed a flattened line, and by Whiting (1978), which showed a U-shaped curve. Trends in numbers of individuals differed somewhat between study years (Fig. 1). This was a result of reduced numbers of birds tallied in the seedling and sapling study areas during the winter 1981 censuses. These trends were similar to those found by Dickson and Segelquist (1977), but differed from those found by Whiting (1978).

Spring.--During both spring surveys, more species and individuals were recorded on the seedling study areas than on other study areas (Table 2). These results are somewhat different from those of other researchers working in similar areas (Whiting 1978, Dickson and Segelquist 1979, Baggett 1983). Generally, numbers of species and individuals that we recorded in seedling stands were higher in relation to the other stands than was the case in other studies. This can be attributed to the fact that 3 of our seedling study areas were naturally seeded southern pine beetle salvage areas rather than site prepared, planted stands. The naturally seeded study areas were structurally and functionally more diverse than the planted study area (Whiting and Fleet 1985).

Trends in numbers of species and individuals between tree size class stands for our spring data (Fig. 2) are very similar to trends for our winter data (Fig. 1). However, trends in our spring data are dissimilar to those found by other researchers (Whiting 1978, Dickson and Segelquist 1979). This likewise can be attributed to the fact that stand structures of our study areas were different from the structures described by other researchers.

Differences Among Tree Size Class Study Areas

Seedling study areas.--During winter 1980, differences in the numbers of individuals recorded among the seedling study areas were significant. Over twice as many birds were recorded on the planted seedling stand (study area 9) as on any of the other seedling stands (Table 3). However, 59% of the birds recorded on the planted study area were juncos and robins. When eastern meadowlarks and chipping sparrows are included, these 4 species comprised 76.5% of all birds recorded. During winter 1981, differences in numbers of individuals recorded among the 4 seedling study areas were not significant (Table 3); however, differences in numbers of species were. Juncos, robins and chipping sparrows were virtually absent from the planted seedling study area; bird numbers were dominated by doves and meadowlarks, which comprised 77% of all birds tallied there. The number of species recorded on that stand was significantly lower than the numbers recorded on the other stands (Whiting and Fleet 1985). When data for both winters were combined and tested among stands, differences in numbers of individuals were not significant (Table 3). The high numbers for planted study area in 1980 were offset by the low numbers in 1981.

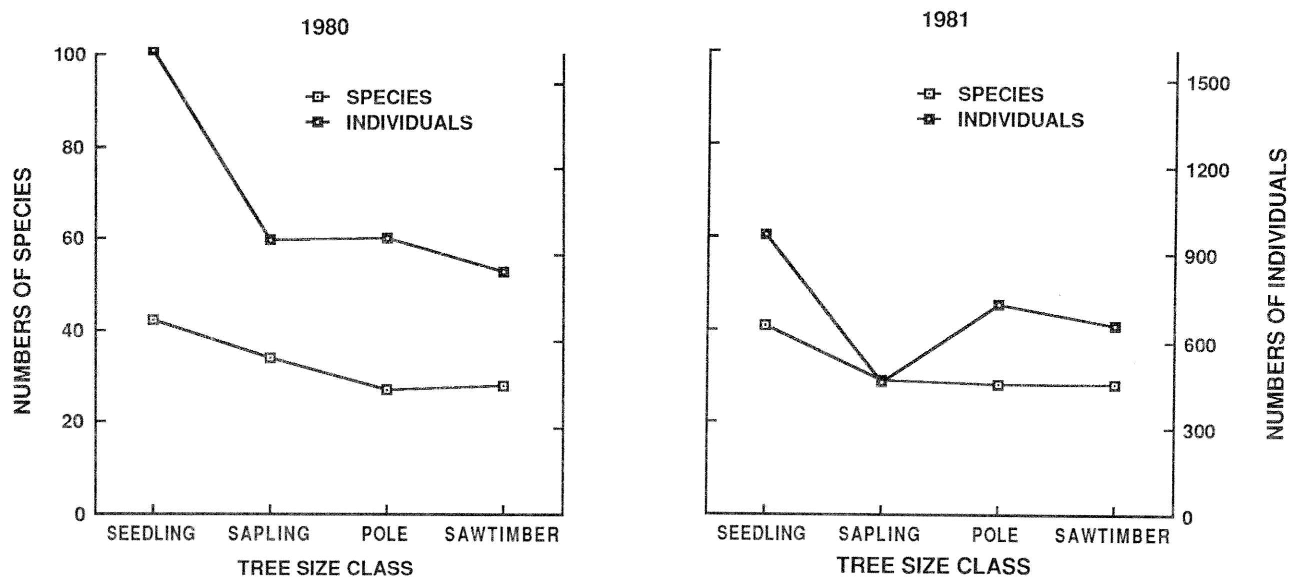

Figure 1. Total numbers of bird species and individuals recorded on the seedling, sapling, pole and sawtimber study areas during the winters of 1980 and 1981.

Table 3. Total numbers of species and individual birds and average species diversity (H') and equitability (J) values by study area number, year and season. Stands are grouped by tree size class.

	Study area number							
	1980				1981			
Tree size/ Parameter	1	5	9	13	1	5	9	13
SEEDLING								
	Winter							
Total species	24	25	19	32	28	31	14	26[a,b]
Total individ.	243	351	732	286[a]	265	347	168	184
H'	2.060	1.999	1.446	1.905[a]	2.153	1.901	0.621	1.863[a,b]
J	0.896	0.887	0.712	0.822[a]	0.900	0.813	0.478	0.839[a,b]
	Spring							
Total species	40	25	21	26[a,c]	42	32	17	35[a,b,c]
Total individ.	363	228	197	208[a]	375	329	199	324[a,b,c]
H'	2.698	2.327	1.930	2.020[a,c]	2.697	2.457	1.571	2.332[a,b,c]
J	0.935	0.922	0.888	0.893[c]	0.917	0.908	0.797	0.899[a,b,c]
SAPLING	2	6	10	14	2	6	10	14
	Winter							
Total species	21	17	22	21	19	13	22	15
Total individ.	340	181	310	125[a]	174	102	101	79[a,b]
H'	1.578	1.605	1.446	1.661	1.712	1.396	1.333	1.430
J	0.735	0.819	0.712	0.917	0.902	0.786	0.809	0.928[b]
	Spring							
Total species	22	25	21	27[a]	21	24	24	22[b]
Total individ.	184	155	115	174[a]	190	186	137	165[b,c]
H'	2.026	2.082	1.849	2.238[a]	1.792	1.972	1.825	2.093[b]
J	0.901	0.907	0.918	0.929[c]	0.844	0.892	0.906	0.918[a,b]
POLE	3	7	11	15	3	7	11	15
	Winter							
Total species	15	20	19	22	17	22	19	17
Total individ.	157	388	246	168	152	265	174	138
H'	1.703	1.848	1.837	1.743	1.732	1.847	1.880	1.864
J	0.892	0.869	0.870	0.869	0.852	0.906	0.920	0.906
	Spring							
Total species	17	25	21	21[a]	18	21	19	21[b]
Total individ.	135	200	121	130[a,c]	163	213	142	141[b,c]
H'	2.056	2.121	1.916	1.876	1.942	2.047	1.810	2.017
J	0.947	0.924	0.944	0.918	0.915	0.892	0.903	0.940
SAWTIMBER	4	8	12	16	4	8	12	16
	Winter							
Total species	20	19	22	18	17	17	22	21
Total individ.	188	275	257	127	146	162	193	151
H'	1.915	1.626	1.912	1.704	1.860	1.712	1.930	1.855
J	0.905	0.874	0.880	0.917	0.930	0.889	0.865	0.880
	Spring							
Total species	24	19	26	23[c]	24	16	23	23
Total individ.	206	158	187	142	166	160	225	165
H'	2.251	1.968	2.251	2.088[c]	1.877	1.994	2.132	2.096
J	0.939	0.920	0.938	0.932	0.886	0.924	0.921	0.928

[a] Indicates a significant difference, at the 0.05 level, between values for study areas of the same tree size class within a season (Kruskal-Wallis tests).

[b] Indicates a significant difference, at the 0.05 level, when data for the same season were combined and tested between study areas of the same tree size class (Kruskal-Wallis tests).

[c] Indicates a significant difference, at the 0.05 level, when data were combined by year and tested between study areas of the same tree size class (Kruskal-Wallis tests).

During spring 1980, the lowest numbers of species and individuals were recorded on the planted study area (Table 3). Approximately 37% more individuals were recorded on study area 1 than on any of the other seedling study areas. Woodpeckers, flycatchers and brown-headed cowbirds were common, no doubt due to the abundance and size of residual pines and hardwoods within that study area (Whiting and Fleet 1985). During spring 1981, numbers of species and individuals recorded on the planted study area were significantly lower than were numbers for the other seedling study areas. The differences were due to land management practices and the drought. The planted study area was burned and replanted between the 1980 and 1981 spring censuses. This action, coupled with previous site preparation activites, resulted in a grassy ground cover. Except for a few scattered hardwood saplings, which were heavily used by indigo buntings, nesting sites were limited to ground nesting species. When data for the spring censuses were combined, there were significant differences in all parameters (Table 3).

Yearly differences, i.e. winter and spring data combined by year then compared among study areas, were significant for numbers of species and species diversity and equitability values for 1980, and for all parameters in 1981 (Table 3). In all cases, values for the planted study area were significantly lower than those of the other stands.

Sapling study areas.--Differences in bird population parameters among the sapling study areas were not as pronounced as among seedling areas. During both winters, there were significant differences only between total numbers of individuals recorded among the sapling stands (Table 3). During winter 1981, numbers of species and individuals tallied were severely reduced from 1980. However, relationships between the stands were similar. When winter 1980 and 1981 data were combined, there were significant differences among stands in numbers of individuals and equitability values. Reduced abundances on study areas 6 and 14 (Table 3) were the result of high densities of pines which limited production by seed bearing plants and thus reduced food availability for wintering granivores.

During the spring 1980 censuses, significantly fewer species were recorded on study areas 2 and 10; significantly fewer individuals were recorded on study area 10 during both springs. Reasons for the low number of species in study area 2 are unclear; low numbers of species and individuals in study area 10 resulted from the lack of woody vegetation, vines, etc. in the understory. Herbaceous plants, which furnish nesting sites for very few species, dominated the understory (Whiting and Fleet 1985). Study area 14 was mechanically thinned between the winter and spring censuses of 1980. The thinning appears to have had little impact on the bird communities, however.

Pole study areas.--There were no significant differences in numbers of species, individuals, species diversity values or equitability values among the pole stands for either winter censuses or when winter census data were combined (Table 3). Lack of differences among stands was a result of the transitory nature of winter birds inhabiting older stands which caused wide variations in the numbers of birds recorded (Noble and Hamilton 1976, Whiting 1978, Dickson and Segelquist 1979). During both spring census periods, highest numbers of individual birds were tallied in the study area 7 which was thinned in 1979. In 1980 the differences were significant.

Sawtimber study areas.--None of the comparisons made using either winter or spring data collected on the sawtimber study areas were significant (Table 3). As with the pole stands,

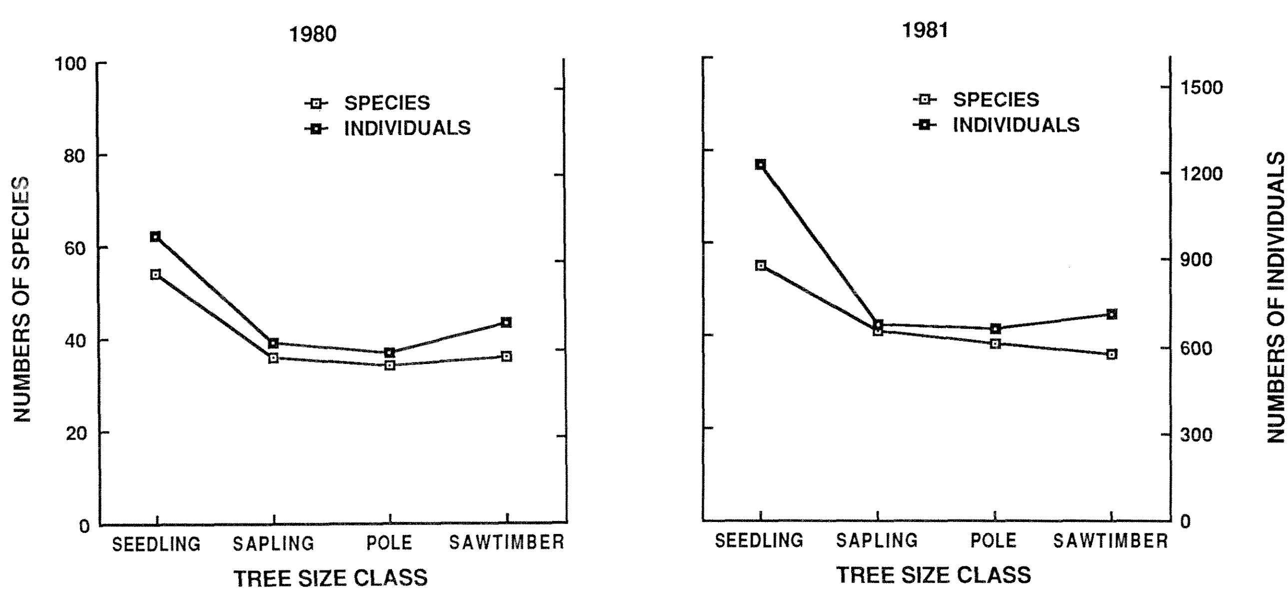

Figure 2. Total numbers of bird species and individuals recorded on the seedling, sapling, pole and sawtimber study areas during the springs of 1980 and 1981.

winter numbers varied widely among censuses. During both seasons, generally fewer species but more individuals were recorded in study areas containing higher pine components in the overstory (Whiting and Fleet 1985).

Summary.--There were differences in bird community parameters between different tree size classes. Among tree size class stands, there were also differences between seasons. We did detect significant differences between study areas among seasons. Differences among winter census periods were due to the summer drought which occurred between the study years. Throughout the study areas, numbers of winter birds declined after the drought. As stand age increased, the magnitude of the change decreased.

Numbers of birds recorded during spring census periods increased from the predrought to the postdrought censuses. As with winter birds, magnitude of the change decreased with increased stand age. These data demonstrate that birds inhabiting older stands are less affected by climatic variation than those of younger stands.

SMALL MAMMALS

During the 3 year study period, there were 6,851 small mammals recorded, including captures and recaptures (Table 4). For each of 6 study seasons, there were 10,752 trap-nights, for a total of 64,512; approximately 1 small mammal per 9.4 trap-nights was captured. Of the 13 species captured, hispid cotton rats, eastern woodrats, cotton mice, fulvous harvest mice, golden mice and rice rats were the most common, comprising approximately 43, 18, 18, 9, 8, and 3%, respectively, of the total capture.

No attempt was made to differentiate between new animals and recaptures for shorttail shrews, opossums, cottontails or flying squirrels. Shrews were too small to toe clip and the latter 3 were nontarget species. However, an opossum was definitely captured twice and a flying squirrel was captured at least 3 times. Cotton rats were the most susceptible to being recaptured (Table 5). They comprised 30.8% of the individuals captured and 43.1% of the total captures. These results are similar to those of Fleet and Dickson (1984), who recorded 36% of the individuals and 68% of the total captures as cotton rats.

Table 5. Capture-recapture characteristics of selected small mammals.

Species	No. indiv.	Total capt.	Pct. new animals
F. harvest mouse	433	596	72.7
E. harvest mouse	2	2	100.0
Cotton mouse	551	1243	44.3
Golden mouse	372	522	71.3
Rice rat	66	188	35.1
H. cotton rat	942	2952	31.9
E. woodrat	522	1255	41.6
Pine vole	4	5	80.0
House mouse	1	1	100.0
Total	3056	6601	$\bar{x}$ = 46.3

Some individuals were captured as many as 4 seasons after the initial capture (Table 6). Generally, the larger species, i.e. cotton rats and woodrats, were more likely to be recaptured after more than 1 trapping season. No doubt body size, as related to energy needs, thermoregulatory efficiency, and susceptibility to predation, was partially responsible for this

Table 4. Total numbers of individual mammals as recorded (captures and recaptures) by species and season for each year, with subtotals by season and totals for the whole study period.

		Numbers of individuals								
		Winter				Spring				
Common name	Scientific name	1980	1981	1982	Subt.	1980	1981	1982	Subt.	Total
Shorttail shrew	*Blarina brevicauda*	15	4	9	28	11	3	8	22	50
Fulvous harvest mouse	*Reithrodontomys fulvescens*	240	94	97	431	130	9	26	165	596
Eastern harvest mouse	*Reithrodontomys humulis*	2	0	0	2	0	0	0	0	2
Cotton mouse	*Peromyscus gossypinus*	546	83	73	702	473	39	29	541	1243
Golden mouse	*Peromyscus nuttalli*	212	53	46	311	156	21	34	211	522
Rice rat	*Oryzomys palustris*	128	0	0	128	52	1	7	60	188
Hispid cotton rat	*Sigmodon hispidus*	401	213	830	1444	408	189	911	1508	2952
Eastern woodrat	*Neotoma floridana*	214	129	314	657	129	220	24	598	1255
Pine vole	*Pitymys pinetorum*	0	0	3	3	0	2	0	2	5
House mouse	*Mus musculus*	1	0	0	1	0	0	0	0	1
Virginia opossum	*Didelphis virginiana*	0	0	0	0	0	7	6	13	13
Eastern cottontail	*Sylvilagus floridanus*	0	0	0	0	10	1	0	11	11
S. flying squirrel	*Glaucomys volans*	0	2	10	12	1	0	0	1	13
Number species		9	7	8	11	9	10	8	11	13
Number individuals		1759	578	1382	3719	1370	492	1270	3132	6851

phenomenon. Also, it is possible that the marking procedure, i.e. toe clipping, was more traumatic for smaller rodents. Finally, the fact that cotton rats and woodrats ranked 1st and 3rd in numbers of individuals captured contributed to their relatively high numbers of recaptures.

Table 6. Total numbers of small mammals captured by species and tree size class, and numbers recaptured 1, 2, 3, and 4 seasons after the original capture.

Species	Total no. capt.	Number recaptured after 1	2	3	4 seasons
	Seedling				
F. harvest mouse	351	29	2	0	0
Cotton mouse	103	6	1	0	1
Golden mouse	67	4	1	0	0
Rice rat	35	0	0	0	0
H. cotton rat	804	108	4	4	4
E. woodrat	163	8	7	5	3
	Sapling				
F. harvest mouse	47	3	1	0	0
Cotton mouse	73	3	0	0	0
Golden mouse	156	4	2	1	0
Rice rat	23	5	0	0	0
H. cotton rat	130	10	1	0	0
E. woodrat	230	18	4	3	2
	Pole				
F. harvest mouse	24	0	0	0	0
Cotton mouse	218	19	3	0	0
Golden mouse	91	6	0	0	0
Rice rat	7	0	0	0	0
H. cotton rat	4	0	0	0	0
E. woodrat	56	3	1	0	0
	Sawtimber				
F. harvest mouse	11	1	0	0	0
Cotton mouse	157	15	2	0	0
Golden mouse	58	3	1	0	0
Rice rat	1	0	0	0	0
H. cotton rat	4	0	0	0	0
E. woodrat	73	5	1	2	1

Differences Between Seasons

With the exception of cotton rats, we had more total captures of each small mammal species during winter than spring (Table 4). Higher spring cotton rat captures may have been associated with the drought induced population decline in 1981 followed by the population boom in 1982. All of the opossums and cottontails were captured in the spring and were immature animals. In winter, these species were too large to enter the traps.

The most notable spring to winter decrease was in numbers of fulvous harvest mice, which declined 62% between seasons. Rice rats, golden mice, cotton mice and woodrats showed 53, 32, 23 and 9% declines, respectively. Cotton rats increased 4%. Other studies in Texas and Louisiana have shown similar results (Kroll et al. 1980, Smith 1983).

These data indicate that there is commonly a major decline in the numbers of small mammals trapped from winter to spring. However, whether this decline is a result of reduced trap susceptibility during spring or a real reduction in numbers of animals present is unknown.

Differences Between Years

As a result of the drought during the summer of 1980, there were major differences in capture numbers among each species between years. During the 1st trapping period after the drought (winter 1981), numbers trapped declined for each species. Except woodrats, all declined during the 2nd trapping period (spring 1981) also. In Louisiana, similar results were found (Constantin 1983).

Among mouse species, the greatest decline occurred in numbers of cotton mice (Fig. 3). Declines in numbers of fulvous harvest mice and golden mice were similar. Numbers of shorttail shrews captured were low throughout the study. However, numbers captured declined during both trapping periods in 1981, and then increased during both trapping periods in 1982 (Table 4, Fig. 4).

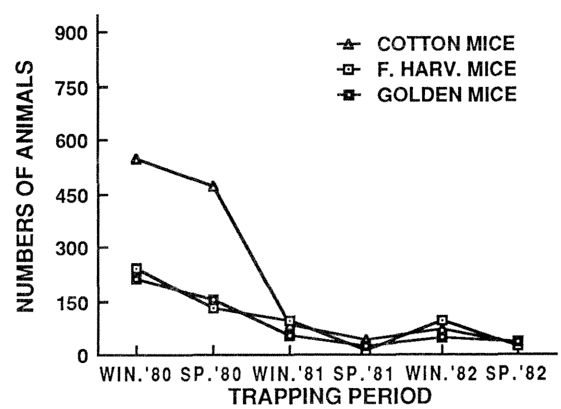

Figure 3. Total numbers of fulvous harvest, cotton and golden mice captured (including recaptures) during each 14 day trapping period.

Hispid cotton rats demonstrated the most drastic responses to the drought (Fig. 4). In the year following the drought (1981), capture numbers captured declined approximately 50%, then increased approximately fourfold from 1981 to 1982. Eastern woodrat captures demonstrated a similar pattern, although not as pronounced (Fig. 4). Rice rats were virtually eliminated with only 8 being captured during the 4 trapping periods following the drought (Table 4). This species feeds and nests in marshy areas (Burt and Grossenheider 1976) and there were no such areas

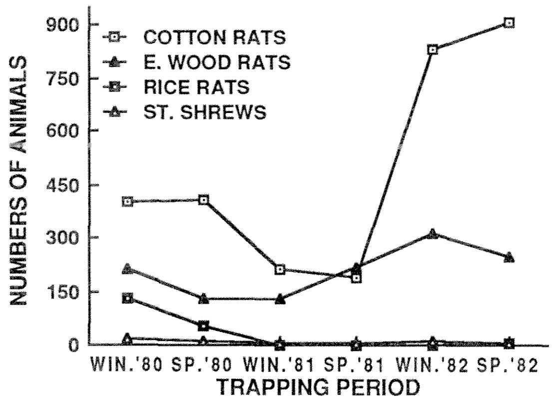

Figure 4. Total numbers of rice rats, hispid cotton rats and eastern woodrats and shorttail shrews captured (including recaptures) during each 14 day trapping period.

in or adjacent to any of the study areas during summer 1980.

The rapid recovery of the hispid cotton rats from the adverse impacts of the drought could be attributed to a number of factors. The species is extremely prolific (Burt and Grossenheider 1976) and is capable of rapidly colonizing favorable habitat. Almost 90% of the cotton rats captured were in seedling study areas. Most of the remainder were sapling study area captures (Table 4).

Fulvous harvest mice and eastern woodrats were also commonly captured on the seedling study areas. Captures of both species increased in winter 1982, although not in the magnitude of cotton rats (Figs. 3 & 4). Neither species has the biotic potential of cotton rats (Burt and Grossenheider 1976).

Neither cotton mouse or golden mouse captures increased in 1982. Both species are seed-eaters (Burt and Grossenheider 1976). This suggests that the vegetation did not recover sufficiently in the spring and summer of 1981 to allow these 2 species to increase in numbers. It is also possible that competition from the 2 rat species adversely impacted the mice during 1982.

Differences Between Tree Size Class Study Areas

Total numbers of small mammal species captured did differ among study years and between tree size class study areas during both seasons (Tables 4 and 7). During both trapping periods, total numbers of species and individuals captured were highest in seedling study areas and declined as stand age increased.

Of the 13 species captured, all except flying squirrels were recorded at least once in seedling stands. The cotton mouse was the only species captured on all 16 study areas. Fulvous harvest mice, rice rats and cotton rats were all captured in greater numbers in seedling stands than in the remaining stands (Figs. 5 & 6). Numbers of woodrats, shorttail shrews and golden mice captured peaked in the sapling stands. Numbers of cotton mice were highest in the pole study areas; that is the only target species for which number of captures peaked in either the pole or sawtimber stands. Numbers captured for all other species declined from the sapling to the pole study areas. As compared to the pole stands, numbers of woodrats and shrews increased slightly in the sawtimber stands; all other species declined and fulvous harvest mice, rice rats and cotton rats were almost excluded (Figs. 5 & 6). As would be expected, the numbers of flying squirrels captured were highest in the sawtimber study areas (Table 7). Generally, our data are similar to that of other researchers working in the South (Atkeson and Johnson 1979, Kroll et al. 1980, Kitchings and Levy 1981, Smith 1983, Fleet and Dickson 1984). Whiting and Fleet (1985) discuss similarities and differences in the small mammal communities in detail.

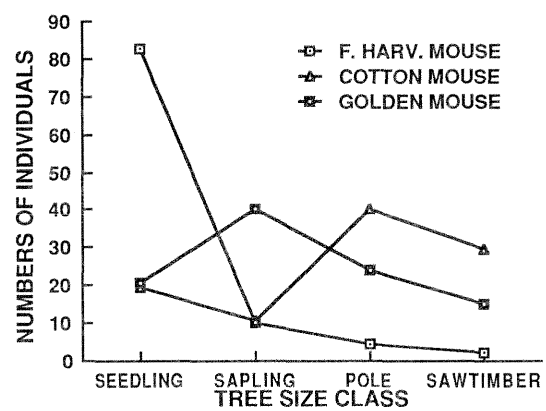

Figure 5. Total numbers (winter and spring combined) of fulvous harvest, cotton and golden mice captured in the study areas of each tree size class.

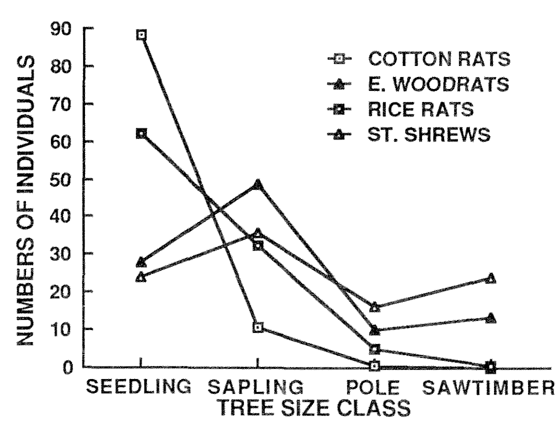

Figure 6. Total numbers (winter and spring combined) of rice rats, cotton rats, eastern woodrats and shorttail shrews captured in the study areas of each tree size class.

Table 7. Total numbers of individual mammals by species as recorded (captures and recaptures) in study areas of each tree size class during winters and springs of 1980, 1981 and 1982.

	Seedling				Sapling				Pole				Sawtimber			
Species	1980	1981	1982	Totl	1980	1981	1982	Totl	1980	1981	1982	Totl	1980	1981	1982	Totl
									Winter							
Shorttail shrew	5	1	1	7	6	3	3	12	1	0	1	2	3	0	4	7
F. harvest mouse	196	83	90	369	19	9	5	33	15	2	1	18	10	0	1	11
E. harvest mouse	1	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0
Cotton mouse	127	37	19	183	66	1	8	75	210	33	18	261	143	12	28	183
Golden mouse	25	13	10	48	81	25	18	124	60	10	11	81	46	5	7	58
Rice rat	110	0	0	110	12	0	0	12	6	0	0	6	0	0	0	0
H. cotton rat	377	199	793	1369	21	14	33	68	3	0	3	6	0	0	1	1
E. woodrat	37	54	91	182	124	64	147	335	20	11	32	63	33	0	44	77
Pine vole	0	0	3	3	0	0	0	0	0	0	0	0	0	0	0	0
House mouse	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
S. flying squirrel	0	0	0	0	0	1	0	1	0	0	3	3	0	1	7	8
Total Species	9	6	7	10	8	7	6	9	7	4	7	8	5	3	7	7
Total Individ.	879	387	1007	2273	330	117	214	661	315	56	69	440	235	18	92	345
									Spring							
Shorttail shrew	3	1	1	5	2	1	3	6	4	0	2	6	2	1	2	5
F. harvest mouse	95	7	22	124	25	0	2	27	6	2	2	10	4	0	0	4
E. harvest mouse	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cotton mouse	48	10	2	60	53	1	1	55	209	19	12	240	163	9	14	186
Golden mouse	42	7	10	59	60	11	15	86	36	2	7	45	18	1	2	21
Rice rat	2	1	4	7	47	0	2	49	2	0	1	3	1	0	0	1
H. cotton rat	314	126	805	1245	87	63	100	250	7	0	0	7	0	0	6	6
E. woodrat	7	70	91	168	65	102	109	276	25	18	22	65	32	30	31	93
Pine Vole	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Virginia opposum	0	1	1	2	0	0	1	1	0	6	1	7	0	0	3	3
E. cottontail	7	1	0	8	3	0	0	3	0	0	0	0	0	0	0	0
S. flying squirrel	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Total Species	8	10	8	10	8	5	8	9	7	5	7	8	7	4	6	9
Total Individ.	518	226	936	1680	342	178	233	753	289	47	47	383	221	41	58	320

Differences Among Tree Size Class Study Areas

There were significant differences in numbers of individuals and species diversity and equitability values among all tree size class study areas. Cottontails, opossums and flying squirrels were not used in calculating species diversity and equitability values. Also, in some study areas we captured as many as 11 individuals of 3 species during a trapping period, yet average species diversity and equitability values were zero (Whiting and Fleet 1985). This is a result of the fact that we captured members of only 1 species on any given census-day.

Seedling study areas.--With the exception of winter 1982, there were significant differences between the seedling study areas in numbers of small mammals captured during each study season (Table 8). Generally, numbers of captures were lowest on the site prepared, planted seedling study area, i.e. 9. This was a result of intensive site preparation which took place prior to and during the 3 year sampling period. These activities eliminated the debris and small woody plants that were common on the other seedling study areas. However, as a result of the relatively moist summer of 1981, numbers of cotton rats captured in that study area in 1982 increased to the extent that the differences among study areas were not significant during winter. In the spring, significantly more were captured there than on study areas 5 and 13 (Table 8). As cotton rats are herbaceous feeders and the vegetation was dominated by grasses and herbaceous plants, this was not unexpected.

During several seasons, numbers of species and individuals captured were highest in study area 1 (Table 8). The stand was probably the most diverse; it had the most residual trees and tree species. Residual trees were larger than in other seedling stands (Table 1). Also, more of the study area was occupied by a stream, which had water in it more regularly than other seedling stands. Finally, a young planted pine plantation was within 240 ft of the study area. Mature mixed pine-hardwood stands also juxaposed the study area. Probably some of the animals captured were dispersing from adjacent habitats.

When data were combined by season and tested between study areas, there were significant differences in numbers of captures (Table 8); generally the same was true when data was combined by year and compared. During 1982, cotton rats comprised 76, 74, 97 and 81% of captures in study areas 1, 5, 9 and 13 respectively. This emphasizes the biotic potential of the species

Table 8. Total numbers of species and individuals and average species diversity (H') and equitability (J) values for small mammals recorded in each study area by year and season. Combined seasonal values are also shown.

		Winter				Spring			
		Total		Average		Total		Average	
Year	Stand no.	Spec.	Indiv.	H'	J	Spec.	Indiv.	H'	J
				Seedling					
1980	1	8	327	1.3010	0.8255	6	165	0.9412	0.8346
	5	7	216	1.3610	0.8450	6	94	0.8622	0.7913
	9	3	72	0.4878	0.6636	4	38	0.2112	0.3105
	13	6	264[a]	0.8032[a]	0.6507[a]	6	221[a,c]	0.6170[a,c]	0.6066[a,c]
1981	1	5	81	0.7805	0.7469	6	48	0.6128	0.6821
	5	5	66	0.7774	0.7166	5	68	0.6742	0.8268
	9	2	28	0.0455	0.0656	5	16	0.0743	0.0676
	13	6	212[a]	1.0126[a]	0.7673[a]	6	94[a,c]	0.6957[a,c]	0.8633[a,c]
1982	1	7	265	0.8489	0.6637	4	253	0.5518	0.5337
	5	4	242	0.8279	0.8026	6	198	0.4080	0.4278
	9	2	244	0.1476	0.2129	3	284	0.0719	0.0816
	13	5	256	0.4314[a]	0.4797[a]	5	201[a]	0.5498[a,b]	0.7148[a,c]
Comb.	1	9	673	0.9768	0.7454	8	466	0.7019	0.6835
	5	7	524	0.9888	0.7881	8	360	0.6481	0.6820
	9	3	344	0.2270	0.3140	6	388	0.1191	0.1532
	13	8	732[b]	0.7490[b]	0.6326	8	516[b]	0.6208[b]	0.7282[b]
				Sapling					
1980	2	8	122	1.1212	0.8487	7	150	0.8287	0.7151
	6	5	45	0.4794	0.5431	6	75	0.9150	0.8648
	10	4	26	0.2640	0.2667	4	43	0.6515	0.7448
	14	7	137[a]	0.7899[a]	0.7742[a]	6	74[a,c]	0.8518	0.9255[a]
1981	2	5	39	0.4372	0.5510	3	106	0.6449	0.7228
	6	2	24	0.0874	0.1261	2	23	0.0455	0.0656
	10	4	17	0.1064	0.1252	3	11	0.0000	0.0000
	14	3	37[a]	0.3609[a]	0.5207[a]	3	38[a,c]	0.1149[a,c]	0.1658[a,c]
1982	2	5	96	0.7901	0.6964	7	89	0.6883	0.7290
	6	2	32	0.0455	0.0656	3	38	0.0495	0.0714
	10	2	11	0.0495	0.0714	2	35	0.4054	0.5849
	14	6	75[a]	0.3738[a]	0.3681[a]	4	71[a,c]	0.5160[a,c]	0.6349[a,c]
Comb.	2	8	257	0.7828	0.6987	9	345	0.7206	0.7223
	6	6	101	0.2041	0.2449	6	136	0.3367	0.3339
	10	6	54	0.1320	0.1544	5	89	0.3523	0.4432
	14	7	249[b]	0.5082[b]	0.5543[b]	6	183[b]	0.4942[b]	0.5744
				Pole					
1980	3	5	101	0.3744	0.4114	5	96	0.5768	0.5652
	7	6	88	0.9460	0.8576	6	69	0.9119	0.8865
	11	3	46	0.1931	0.2786	2	59	0.1527	0.2203
	15	4	80	0.2037[a]	0.2152[a]	3	65[a,c]	0.1743[a,c]	0.2212[a,c]
1981	3	2	14	0.0402	0.0580	3	17	0.0000	0.0000
	7	4	23	0.2847	0.3482	3	17	0.1819	0.2740
	11	2	7	0.0000	0.0000	2	9	0.0495	0.0714
	15	2	12	0.0495[a]	0.0714[a]	3	4[a,c]	0.0785[c]	0.0714[c]
1982	3	2	6	0.0000	0.0000	2	3	0.0000	0.0000
	7	5	41	0.4236	0.5748	5	23	0.1959	0.2046
	11	3	20	0.1445	0.2085	3	11	0.0000	0.0000
	15	2	2	0.0000	0.0000	4	10[a,c]	0.0950[c]	0.1370[c]
Comb.	3	5	121	0.1392	0.1565	6	116	0.1923	0.1884
	7	6	152	0.5514	0.5935	7	109	0.4299	0.4550
	11	5	73	0.1125	0.1624	3	79	0.0674	0.0972
	15	5	94	0.0844	0.0955	5	79	0.1159[b]	0.1432[b]

Continued on next page.

Table 8. Continued.

Year	Stand no.	Winter Total Spec.	Winter Total Indiv.	Winter Average H'	Winter Average J	Spring Total Spec.	Spring Total Indiv.	Spring Average H'	Spring Average J
		Sawtimber							
1980	4	4	69	0.3646	0.3828	3	25	0.0803	0.1159
	8	3	58	0.7726	0.8037	5	95	0.7359	0.8333
	12	3	40	0.3781	0.4352	4	45	0.3364	0.3687
	16	4	68	0.3869[a]	0.4628[a]	3	56[a,c]	0.2712[a,c]	0.3582[a,c]
1981	4	0	0	0.0000	0.0000	2	2	0.0000	0.0000
	8	2	5	0.0000	0.0000	4	18	0.1692	0.2046
	12	3	11	0.0000	0.0000	2	8	0.0000	0.0000
	16	2	2[a]	0.0495	0.0714	2	13[a,c]	0.1859[a,c]	0.2682[a,c]
1982	4	3	6	0.0455	0.0656	4	17	0.1957	0.3437
	8	4	39	0.1749	0.2524	3	23	0.0455	0.0656
	12	2	19	0.0976	0.1408	3	11	0.1280	0.1429
	16	7	28[a]	0.2591	0.2696	4	7[c]	0.0990	0.1429
Comb.	4	5	75	0.1367	0.1495	4	44	0.0920	0.1532
	8	4	102	0.3158	0.3520	6	136	0.3169	0.3678
	12	4	70	0.1586	0.1920	5	64	0.1548	0.1705
	16	7	98[b]	0.2318	0.2679	6	76[b]	0.1854[b]	0.2564

[a]Indicates a significant difference, at the 0.05 level, between values for study areas of the same tree size class within a season. Differences in numbers of species were not tested.

[b]Indicates a significant difference, at the 0.05 level, when data for the same 3 seasons were combined and tested between study areas of the same tree size class.

[c]Indicates a significant difference, at the 0.05 level, when data were combined by year (i.e. winter and spring) and tested between study areas of the same tree size class.

and suggests that the 3 seedling areas which were naturally regenerated met cotton rat habitat requirements almost equally.

Sapling study areas.--During all 6 sampling periods, there were significant differences in numbers of captures among the sapling study areas (Table 8). Relatively high numbers in study areas 2 and 14 were due to the presence of windrows. Study area 14 was mechanically thinned in early spring 1980 and numbers of captures declined from winter to spring 1980 (Table 8). That numbers captured did not increase from winter to spring 1981 as did numbers in study area 2 was also related to the thinning. Low numbers in study areas 6 and 10 were because both had been clearcut, prescribed burned, then broadcast seeded to shortleaf pine, thus there were no windrows and very little debris present.

Pole study areas.--During 1980 only, study area 3 ranked highest in numbers of animals captured (Table 8). During spring, the differences were significant. High 1980 capture numbers were due to the abundance of cotton and golden mice (Whiting and Fleet 1985). Both study area 3 and study area 15, which was directly across state highway 47 from study area 3, showed severe post-drought declines in numbers of animals captured. Rakowitz (1983) characterized the understory of study area 3 as atypical, containing large numbers of open patches dominated by volunteer loblolly pine seedlings. From summer 1980 to winter 1981, declines in the proportions of woody plants in the understory (Whiting and Fleet 1985), demonstrated that many of the pine seedlings present in 1980 died as a result of the drought. Before the drought, it is likely that these seedlings provided cover for the cotton and golden mouse communities. After the drought, suitable cover was no longer present.

Sawtimber study areas.--Significantly greater numbers of small mammals were captured on study area 8 than on other sawtimber study areas during spring 1980 (Table 8). High numbers of cotton mice and woodrats captured were a result of differing vegetational characteristics. Small vegetation on this stand was significantly different from that of the remaining sawtimber study areas in several ways (Whiting and Fleet 1985). There were more plant species and individuals and thus higher plant species diversity values were recorded there. Also, small vegetation was somewhat taller and dominated by poison ivy, (*Toxicodendron radicans*) and more grass occurred in the understory and ground cover (Rakowitz 1983).

During winter 1981, only 12 individuals were captured in the sawtimber stands; the remaining 6 were recaptures. During spring of that year, only 20 different individuals were captured. Numbers of individuals captured did not increase greatly in 1982, with 33 during winter and 28 during spring. These data support Dueser and Shugart's (1978) suggestion that older pine communities may be ecologically saturated, even at low rodent densities.

Summary.--There were differences in the small mammal communities between the various tree size class stands. The seedling study areas were utilized by a wider variety of species and more individuals than were the remaining study areas. Numbers of species and individuals generally decreased as size of the trees on the study area increased. There were also differences between study areas of the same tree sizes. These differences were no doubt a result of variations in previous forest management practices and soil/site factors.

Perhaps most notable were the drought effects on small mammal communities. Captures of 5 of the 6 common species declined drastically after the drought. Only cotton rats recovered to or above predrought numbers during the remainder of the study period.

OTHER MAMMALS

We made 4 squirrel censuses and 2 squirrel nest counts on the pole and sawtimber study areas. Generally we recorded more squirrels in the sawtimber than the pole study areas. More squirrels and a higher density were recorded on study area 4 than on the other study areas. This is no doubt a result of the fact that pines comprised a lower proportion of the overstory there (Whiting and Fleet 1985).

Numbers of squirrel nests varied widely among the pole and sawtimber study areas and we were unable to relate numbers of squirrel nests to numbers of squirrels. It is likely that the numbers of nests were inversely related to the numbers of den trees present, perhaps more strongly than to the numbers of squirrels present. Of possible interest was a fox squirrel seen after dark on the ground in a sawtimber stand during a spring night spotlight census.

We recorded large and mid-sized mammals seen or heard incidental to bird and small mammal censuses during 1980 and 1981. There were no obvious trends in numbers recorded among study areas. However, during both seasons, more white-tailed deer and cottontails were tallied than any other species. Fewer total animals were recorded during winter than during spring.

During fall night spotlight censuses, we recorded 68 individuals of 9 large and mid-sized mammal species; during spring, we tallied 77 individuals of 8 species (Whiting and Fleet 1985). Less than 2 animals per census-hour were recorded, thus these censuses were discontinued after spring 1981. There were no trends in numbers of animals recorded among the various study areas. During both seasons, we tallied more armadillos than any other species. Cottontails ranked 2nd.

In summary, neither the squirrel nor the large to mid-sized mammal census technique proved to be satisfactory. All were too labor intensive and costly for reliable data collection.

CONCLUSIONS

Due to the unavailability of ideal stands for each tree size class, there were differences in flora and fauna among stands of the same tree size classes. As a result, differences between tree size class study areas were not tested. Generally, differences among tree size class study areas were greatest for the seedling study areas. The differences were due largely to the past forest management practices. Variations in soil/site factors were probably of secondary importance on the seedling study areas. As stand age increased, the effects of past forest management practices decreased and the influence of soil/site factors increased.

Examination of the vegetational data did indicate that differences among study areas of the same tree size class were much less than were differences between study areas of the different tree sizes. As a result, both the bird and small mammal community structures varied greatly between the seedling, sapling, pole and sawtimber study areas. Generally, the highest numbers of species and individuals of both birds and small mammals were recorded on the seedling study areas. Numbers of both birds and mammals generally decreased as stand age increased.

An extreme drought after the 1st sample year adversely impacted both birds and small mammals. Most noteworthy was the trend in cotton rat numbers which crashed following the drought and rebounded strongly the following year. Excluding eastern woodrats, populations of the remaining small rodents also crashed after the drought, and had not recovered 2 years thereafter. Numbers of woodrats captured declined in the trapping period immediately following the drought, but recovered by the next period. These data suggest that the high numbers of cotton rats during the 2nd year after the drought prevented the remaining small rodent species from recovering as rapidly as did the cotton rats.

ACKNOWLEDGMENTS

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LITERATURE CITED

Atkeson, T. D., and A. S. Johnson. 1979. Succession of small mammals on pine plantations in the Georgia Piedmont. Am. Midl. Nat. 101:384-392.

Baggett, S. C. 1983. A comparison of two avian census methods: strip transect and fixed circular plot. M.S. Thesis. Stephen F. Austin State University, Nacogdoches, Tx.

Burt, W. H., and R. P. Grossenheider. 1976. A field guide to the mammals. Houghton Mifflin Co., Boston.

Constantin, B. U. 1983. Some effects of four regeneration methods of loblolly pine on the understory and wildlife in southeastern Lousiana. M.S. Thesis. Louisiana State University, Baton Rouge.

Daniel, W. W. 1978. Applied nonparametric statistics. Houghton Mifflin Co., Boston.

Dickson, J.G., and C. A. Segelquist. 1977. Winter bird populations in pine and pine-hardwood forest stands in east Texas. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 31:134-137.

__________, and __________. 1979. Breeding bird populations in pine and hardwood forests in Texas. J. Wildl. Manage. 43:549-555.

Dolezel, R., and T. Holt. 1979. Angelina National Forest study area soil survey. USDA-Soil Conservation Service, Nacogdoches, Tx.

Dueser, R. D., and H. H. Shugart, Jr. 1978. Microhabitats in a forest-floor small mammal fauna. Ecology 59:89-98.

Fleet, R. R., and J. G. Dickson. 1984. Small mammals in two adjacent forest stands in East Texas. Pages 264-269 in Proc. workshop on management of nongame species and ecological communities (W. C. McComb, ed.). University of Kentucky, Lexington.

Goodrum, P. D. 1961. The gray squirrel in Texas. Texas Game & Fish Comm., Austin.

Kitchings, J. T., and D. J. Levy. 1981. Habitat patterns in a small mammal community. J. Mammal. 62:814-820.

Kroll, J. C., R. R. Fleet, S. McIntyre, and D. L. Kulhavy. 1980. Ecological assessment of 2,4-D herbicide treatment of a southern mixed pine-hardwood ecosystem. Final report, cooperative agreement no. 19-248, USDA-For. Serv., So. For. Expt. Sta., New Orleans, La.

Nie, N. H., and C. H. Hull. 1981. SPSS Update 7-9: New procedures and facilities for releases 7-9. McGraw-Hill Book Co., New York.

Noble, R. E., and R. B. Hamilton. 1976. Bird populations in even-aged loblolly pine forests of southeastern Louisiana. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Comm. 29:441-450.

Overton, W. S. 1971. Estimating the numbers of animals in wildlife populations. Pages 403-495 in Wildlife Management Techniques. (R. H. Giles, Jr., ed.). The Wildlife Society, Washington, D. C.

Pearson, H.A. 1981. The southern evaluation project: a status report. Pages 35-43 in Proc. 2nd Ann. Meeting, Gopher Tortoise Council. Jackson, Ms.

Pielou, E. C. 1966. Species-diversity and pattern-diversity in the study of ecological succession. J. Theoret. Biol. 10:370-383.

Rakowitz, V. A. 1983. Comparison of the herpetofauna of four different-aged stands in the loblolly-shortleaf pine-hardwood ecosystem of east Texas. M.S. Thesis. Stephen F. Austin State University, Nacogdoches, Tx.

Shannon, C. E. 1948. A mathematical theory of communication. Bell Syst. Tech. J. 27:379-423, 623-656.

Smeins, F. E., and J. Z. Hinton. 1981. Vegetation inventory in the loblolly-shortleaf pine type, Angelina National Forest, Texas. Final report, FS-SO-1701-3.16, USDA-For. Serv., So. For. Expt. Sta., Alexandria, La.

Smith, J. C. 1983. Community structure of small mammals in a southern pine forest, with comment on multivariate niche analysis. M. S. Thesis. Louisiana State University, Baton Rouge.

Stoddard, C. H. 1959. Essentials of forestry practice. The Roland Press Co., New York.

Whiting, R. M. 1978. Avian diversity in various age pine forests in East Texas. Ph.D. dissertation. Texas A&M University, College Station.

__________, R. R. Fleet, and H. A. Pearson. 1983. Implementing and maintaining a system to monitor small mammal and bird populations. Pages 420-423 in Renewable resource inventories for monitoring changes and trends. Proc. of an international conference (J. F. Bell and T. Atterbury, eds.). College of Forestry, Oregon State University, Corvallis.

__________, and __________. 1985. Small animal population inventories on a mixed pine-hardwood forest of East Texas. Final report, FS-SO-1701-4.11, USDA-For. Serv., So. For. Expt. Sta., Alexandria, La.

Young, R. A., ed. 1982. Introduction to forest science. John Wiley & Sons, New York.

Soils of the Loblolly/Shortleaf and Longleaf/Slash Pine Project:

Grant and Vernon Parishes, Louisiana

W. Wayne Kilpatrick

The purpose of the soil survey conducted on United States Forest Service land was to use soil types as a baseline environmental setting upon which the vegetation could be superimposed. It is assumed that a correlation exists between vegetation and soil types. This documented correlation could be of benefit to future and present studies.

The soil survey for the Forest Range Project of Grant Parish was completed in July 1979. It consists of approximately 8,000 acres of loblolly-shortleaf forest types. The Vernon Parish soil survey Range Project was completed in August 1979, and consists of approximately 6,785 acres of longleaf-slash forest types.

Soil delineations were based on soil series, surface texture, slope percent and other factors, such as flooding. Procedures and standards were followed according to the National Soils Handbook.

The soils of the project area contain a full array of textures. These range from loose coarse loamy soils to dense sticky clayey soils, and from the well drained soils on the uplands to the poorly drained soils of the floodplains in the upland drainageways.

The Grant Parish study area is located approximately 15-20 miles north of Alexandria in central Louisiana. Soils in the project area of Grant Parish formed in parent material of Pleistocene Age. The study area consists of Prairie, Montgomery, and Bentley terraces. The Bentley terraces are the oldest and were formed as deltaic plains of the Mississippi River. They have been continuously exposed to weathering and soil formation since their deposition more than 300,000 years ago. The Bentley terrace is best developed in central Grant Parish where it is preserved as a narrow area at the foot of a fairly well defined escarpment one mile north of Bentley.1/ The soils developed in these deposits are mainly Beauregard, Malbis, Ruston, and Smithdale soils. They are highly weathered and leached and are characterized by a distinct B horizon of secondary accumulations of clay. These soils are classified as Ultisols and, consequently, have low base status and acid soil reactions throughout. Typically, the base status and soil reaction are highest in the surface horizon and decrease with depth into the B horizon. In most areas, the reaction and base status do not increase at greater depths within the soil because of the highly weathered and leached conditions.

Sediments of the Montgomery Terrace Formation are intermediate in age between Bentley and Prairie terraces. The principal occurrence of the Montgomery terrace is in the form of a coastwise terrace of fluvial and possibly deltaic origin located in southeastern Louisiana.2/ The parent material of these soils has been continuously exposed to weathering and soil formation since their deposition more than 100,000 years ago. Although highly weathered and leached, soils developed on the Montgomery Terrace, such as Guyton, are higher in bases and generally have higher reaction in the lower horizons than soils formed on the Bentley terraces. Typically, their base saturation and soil reaction increase with depth in the lower solum. These soils have a distinct B horizon of secondary accumulations of clay and are classified as Alfisols.

The youngest of the four major Pleistocene Terrace formations, the Prairie, was deposited as upper deltaic or lower alluvial plains of the Mississippi and Red Rivers. It has been continuously exposed to weathering and soil forming processes since its deposition perhaps 30,000 or more years ago.

The terrace deposits of the Prairie Formation are the parent material of the Gore soils. These soils are in areas that flank the escarpments of some drainageways in the uplands. Gore soils formed in reddish calcareous clays. They are classified as Alfisols and, as such, have a B horizon characterized by secondary accumulations of clay. Typically, soil reaction and base saturation decrease with depth from the surface horizon

1/ Fisk, H. N. Geology of Grant and LaSalle Parishes. Geological Bulletin No. 10. 1938. 59-60.

2/ Saucier, Roger T. Quarternary Geology of the Lower Mississippi Valley. Series No. 6. Ark. Archeological Survey; 1974. 6 p.

W. Wayne Kilpatrick, Soil Scientist, USDA Soil Conservation Service, Minden, Louisiana.

to minimum values in the upper part of the B horizon. Below these minimum levels, reaction and base status typically increase with depth.

The Vernon Parish project area is located in western Louisiana approximately 35-40 miles northwest of Alexandria. Soils in this project area are of parent material similar to the Grant Parish project. Landscape consists of nearly level to gently sloping soils. The more sloping soils are adjacent to drainageways which dissect the area. Loamy Cahaba soils are delineated along low-lying terraces in the Vernon Parish project area. Figure 1 shows the proximity of the project areas.

A comparison of temperature and precipitation for the Grant and Vernon Parish project areas is depicted in Figure 2. The top figure is data collected at Esler Field which is very near the Grant project area. The bottom portion of the table is data from Elizabeth, Louisiana near the Vernon project area. The main difference depicted is the average daily maximum and average total precipitation. The average daily maximum differs by 2 degrees, and the average precipitation differs by 2.1 inches.

Approximately 50 percent of the precipitation usually falls in April through September. The growing season for most plants falls within this time period. The heaviest one-day rainfall during the period of record was nine and one-half inches at Belah on April 29, 1953. Thunderstorms occur about 70 days each year, and most occur in summer.

The average relative humidity in mid-afternoon in these areas is about 60 percent. Humidity is higher at night, and the average at dawn is about 90 percent. The sun shines 60 percent of the time possible in summer, and 50 percent in winter. The prevailing wind is from the south. Average windspeed is highest, 6 miles per hour, in spring.

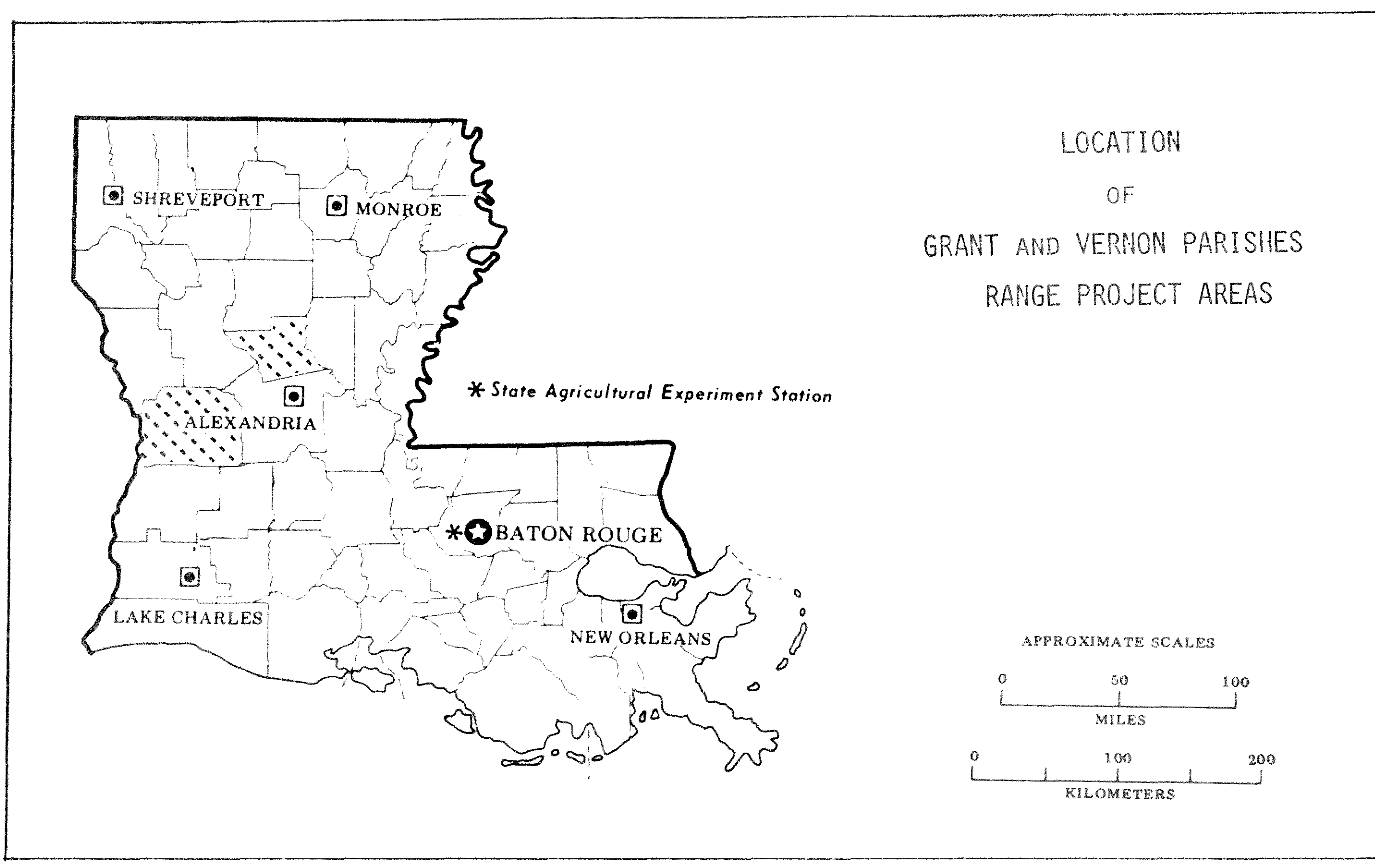

Figure 1.--Location of Grant and Vernon Parishes Range Project Areas

TEMPERATURE and PRECIPITATION DATA
(Recorded in the period 1941-70 at Elizabeth, Louisiana)

Month	Temperature					Precipitation		
	Average Daily Maximum	Average Daily Minimum	Extreme Maximum and Minimum	2 years in 10 will have-- Maximum Temperature Higher Than--	2 years in 10 will have-- Minimum Temperature Lower Than--	Average	2 years in 10 will have-- Lower Than--	2 years in 10 will have-- Higher Than--
	°F	°F	°F	°F	°F	In.	In.	In.
January. . . .	61	38	82/6	80	17	4.9	2.9	7.1
February . . .	64	40	85/6	80	21	4.9	2.8	6.8
March.	71	46	90/20	86	28	5.1	3.2	7.7
April.	79	56	93/33	89	35	5.6	2.3	8.0
May.	85	62	100/42	94	46	5.0	2.9	8.4
June	91	68	106/51	98	55	5.0	2.2	7.9
July	93	70	103/54	100	64	5.1	2.8	7.9
August	93	70	107/58	103	60	4.1	2.7	5.3
September. . .	89	65	103/36	98	49	4.2	2.4	6.8
October. . . .	82	54	98/31	94	34	3.5	0.6	5.6
November . . .	71	45	88/24	87	26	4.6	2.2	6.7
December . . .	64	40	83/16	80	20	6.3	3.6	8.6
YEAR. . . .	79	55	107/6	102	16	59.1	50.8	68.0

Figures 2 & 2A.--Temperature and Precipitation Comparison Data

TEMPERATURE and PRECIPITATION DATA
(Alexandria, Louisiana - Esler Field)

Month	Temperature				Precipitation		
	Average Daily Maximum	Average Daily Minimum	Average Highest	Average Lowest	Average total	One year in 10 will have-- Less than-	One year in 10 will have-- More than-
	°F	°F	°F	°F	In.	In.	In.
January	59	38	76	18	5.0	1.9	8.4
February.	63	40	78	23	4.9	2.0	8.3
March	70	46	82	29	5.1	1.8	9.4
April	78	56	87	39	5.4	1.8	9.5
May	85	62	92	48	5.7	1.8	10.8
June.	90	69	96	58	4.4	1.4	8.2
July.	93	72	98	65	5.1	1.8	8.9
August.	92	71	98	63	3.6	.9	7.2
September	88	66	94	52	3.4	.9	7.0
October	80	54	90	37	3.6	.7	8.0
November.	69	45	83	27	5.0	.9	10.6
December.	61	39	77	23	6.0	3.4	11.9
Year	77	55	99	17	57.2	43.2	72.7

The following graph (fig. 3), shows surpluses and deficits of water in inches by seasons. The data was collected over a period of 29 years.

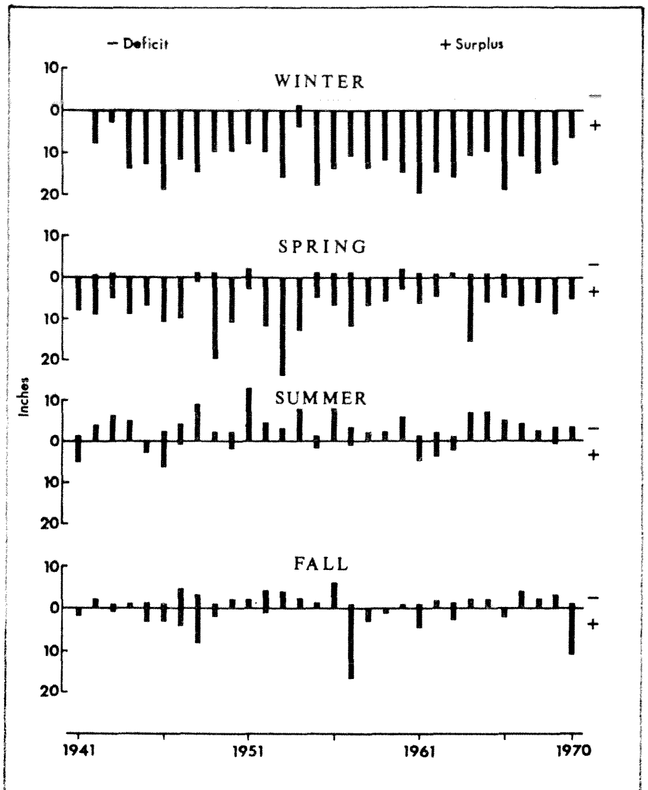

Figure 3.--Monthly water-budget surpluses and deficits in inches, by season. Recorded in the period 1941-70 at Elizabeth, La.

METHOD

Soil scientists went over the area and studied the soils to depths of 4 to 6 feet. After examining the color of the soil, the texture, structure, and the thickness of the varying layers, they classified the soil using a nationwide system of soil classification. Then they plotted the boundaries on aerial photographs and placed a symbol within each delineation. For example, the symbol 81 indicates the soil is Gore silt loam, 1 to 5 percent slope. All soils with the same symbol have the same name, and are called soil mapping units. There is no general rule for guiding the number of soil examinations required per unit area, nor for the intervals between transverses, except that these can rarely be more than one-fourth mile wide and usually need to be narrower. 3/ Every effort is made to include within any one delineation, only those conditions as are indicated by the mapping unit name. Even with care, there are in most delineations, inclusions of similar and sometimes dissimilar soils which are not indicated on the map.

The two major reasons for mapping unit inclusions are the scale of the map and the character of the soils. Using the map scale, it is difficult to show areas smaller than 3 acres in size. Also, the width of a pencil line on the map represents several feet on the ground. Soils, except in rare cases, do not have distinct boundaries, but gradually change from one to another. This change may take place in a few feet, or 50 to 100 feet. The soil scientist, with a reasonable amount of investigation, must draw a line somewhere indicating a change from one soil to another while keeping transitions to a minimum on either side of the line.

RESULTS

A typical landscape on the Grant Parish project is shown in Figure 4. The dominant soils of the Grant Parish project are the Beauregard and Malbis series that occur on level and nearly level ridges. The Ruston soils occur on narrow convex ridgetops. The Gore and Smithdale soils occur on sideslopes. Another series in this area is the Guyton series that generally occurs on level floodplains along stream channels and drainageways. The Beauregard soil has a mottled brown, yellow, and red, friable sandy clay loam subsoil with weak, subangular blocky structure. Malbis soils have yellowish brown, friable sandy clay loam subsoil with a weak, blocky structure. Gore soils have red, firm clay subsoils with a weak, blocky structure. Ruston and Smithdale soils have reddish loamy subsoils. Guyton soils have gray, brown-mottled, silty clay loam subsoils with a compound subangular blocky and prismatic structure.

Figure 5 shows that the dominant soils of the Vernon Parish project are the Beauregard and Malbis series that occur on level or nearly level ridges, and the Susquehanna series that occurs on sideslopes. Also in this area is the Guyton soil series that occurs along stream channels and drainageways. The Beauregard soil has a mottled brown, yellow, and red, friable sandy clay loam subsoil with a weak, subangular blocky structure, and lies on broad flat ridges. Malbis soils have yellowish brown subsoil layers, and are on convex ridgetops. Susquehanna soils have a mottled gray, brown, and red firm clay subsoil with a weak, blocky structure, and are on sideslopes. Cahaba soils have reddish loamy subsoils, and are on low terraces adjacent to major drainageways. Guyton soils have a gray, brown-mottled silty clay loam subsoil with a compound subangular blocky and prismatic structure.

3/ U.S. Department of Agriculture, Soil Conservation Service. Soil Survey Manual. Agric. Handb. 18. Washington, DC: U. S. Department of Agriculture, Soil Conservation Service; 1962. 16 p.

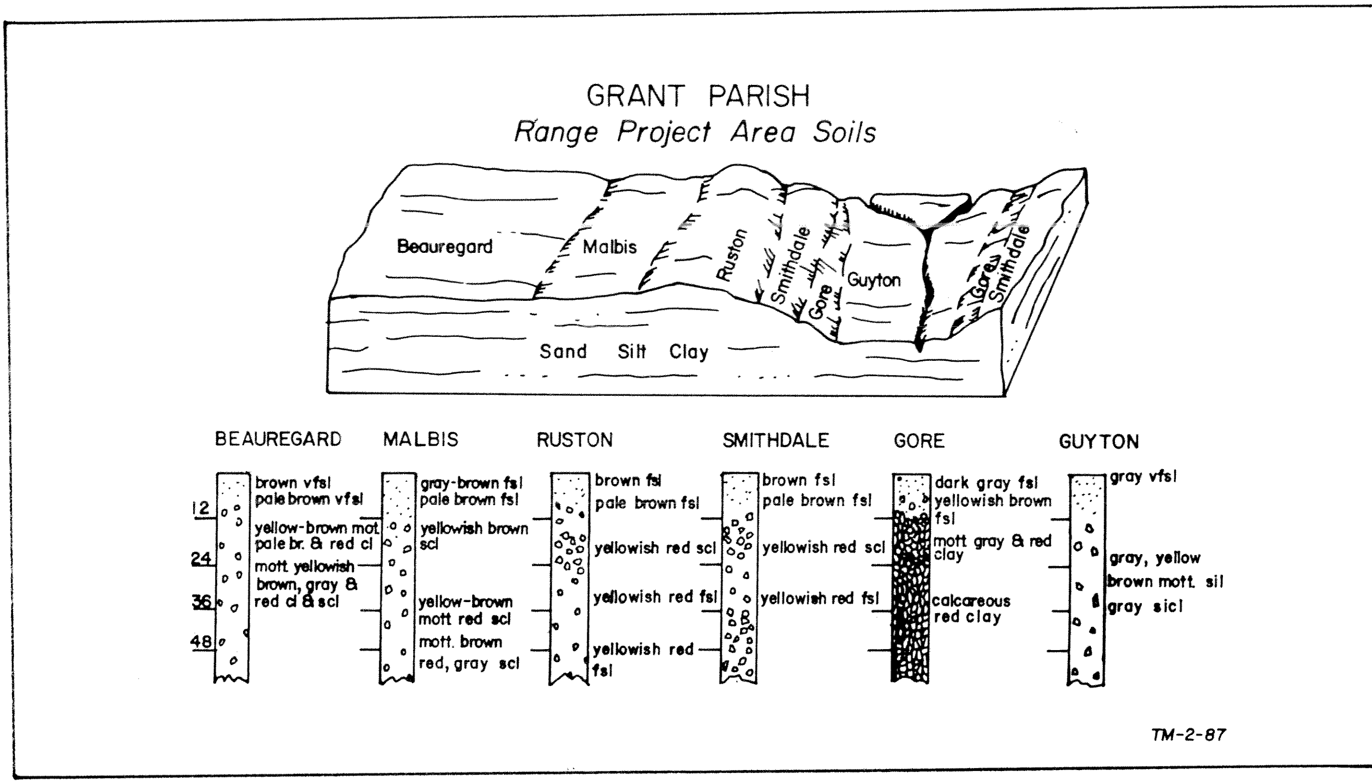

Figure 4.-Grant Parish Range Project Area Soils

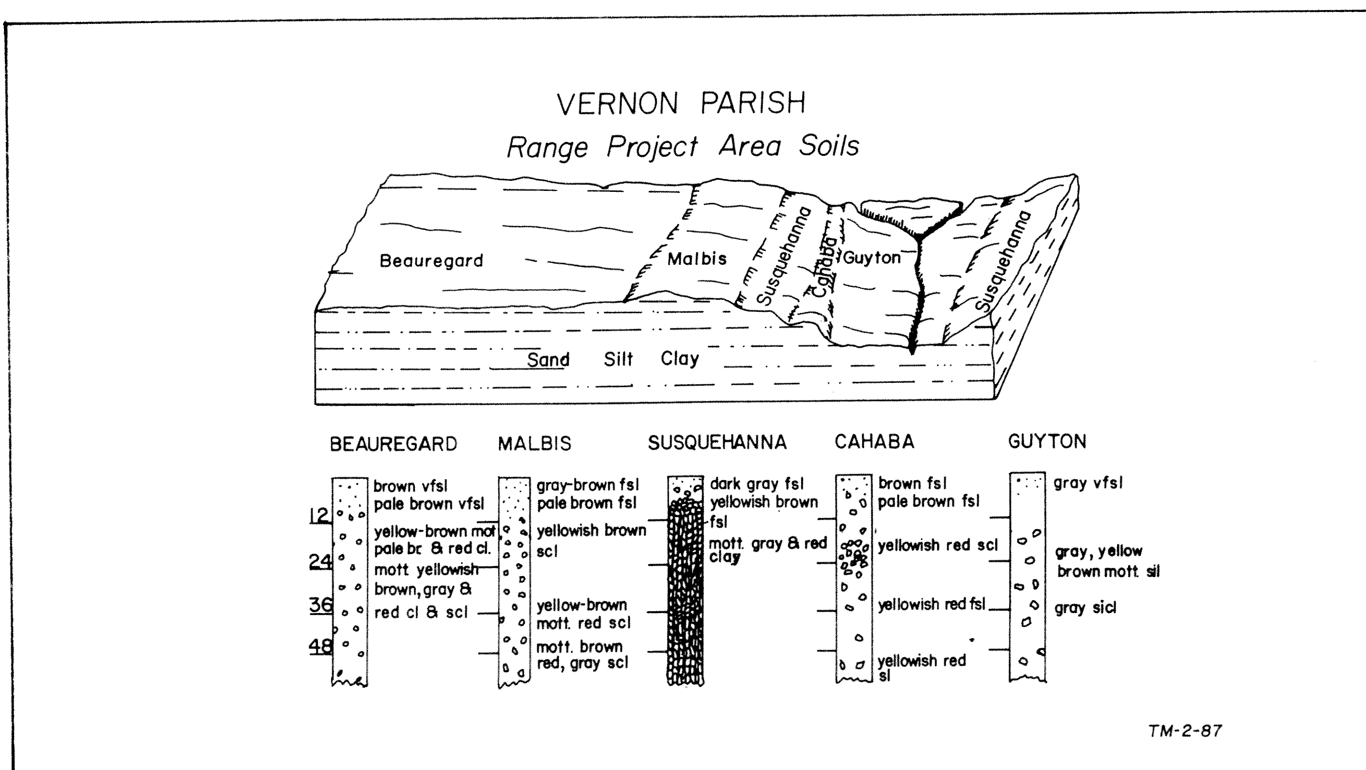

Figure 5.-Vernon Parish Range Project Area Soils

The map units on the detailed soil maps of this survey represent the soils in the survey area. The map unit descriptions, along with the soil maps, can be used to determine the suitability and potential of a soil.

Each map unit on the detailed soil maps represents an area on the landscape and consists of one or more soils for which the unit is named.

A symbol identifying the soil precedes the map unit name in the soil descriptions. Each description includes general facts about the soil, a brief description of the soil profile, and a listing of the principal hazards and limitations to be considered in planning management for woodland and range uses. The important soil properties affecting woodland and range uses are as follows:

Wetness-The upland soils are well drained or moderately well drained. Surface water runs off at a medium rate and wetness is seldom a problem. Soils in the drainageways are wet, however, and subject to flooding.

Slope-The nearly level to strongly sloping topography is no serious hazard for woodland and range uses.

Soil Erosion-The sloping upland soils in overgrazed areas and mechanically disturbed areas are subject to erosion. If uncontrolled, topsoil is lost and gullies develop. Erosion can be controlled by maintaining proper stocking rates and by using wise woodland practices during harvesting operation.

Permeability-Due to clay layers in some of the soils, downward movement of water is slow. This may create some wet conditions around supplemental feeding areas and catch-pens during the winter and early spring months. The wet conditions also may hinder woodland harvesting.

Engineering Properties-Engineering properties for pond reservoir areas and embankments for levee type ponds range from good to poor, depending on the soil. The seepage hazards and piping potentials are slight in some soils and severe in others.

Figure 6, representing some of the soils that were mapped in the project areas, show chemical data that is important in classifying soils and on effecting types of vegetation. Generally, most of the soils are acid and low in natural fertility.

The soils are placed in two orders based on the national classification system used by the Soil Conservation Service. The following soils are classified as Ultisols: Beauregard, Malbis, Ruston, Cahaba, and Smithdale. Ultisols are soils that have an argillic horizon and have a base saturation of less than 35 percent at a depth of 50 inches below the upper boundary of the argillic horizon, or at a depth of 72 inches below the surface of the soil, whichever is shallower. The remaining soils were

CHEMICAL DATA ON SELECTED SOILS

Soil Series	Depth in Inches	Horizon	USDA Texture	pH	Organic Matter	Cation Exch. Capacity	Extractable Cations					Base Saturation
							Ca	Mg	K	Na	H	
BEAUREGARD (Plinthaquic Paleudults)	0-3	A1	SiL	5.2	2.7	6.2	1.0	0.3	0.1	--	6.1	19
	3-8	E	SiL	5.1	.79	5.2	0.5	0.3	--	0.1	4.9	16
	8-16	BE	SiL	5.1	.34	7.3	0.2	0.4	0.1	0.1	8.1	9
	16-27	Bt1	SiL	5.2	.24	9.3	0.7	0.1	0.1	0.1	9.0	13
	27-40	Btv	SiL	5.4	.08	8.4	0.4	0.9	0.1	0.1	8.2	15
	40-60	Btvg	Sicl	5.3	.01	12.6	1.4	2.3	0.1	0.4	9.8	30
GUYTON (Typic Glossaqualfs)	0-6	A1	SiL	4.9	1.30	5.8	1.0	0.4	0.1	0.1	0.4	28
	6-13	Eg1	SiL	4.9	1.39	4.3	0.6	0.3	0.1	0.1	0.4	26
	13-23	Eg2	SiL	5.0	1.29	4.0	0.4	0.3	0.1	0.1	0.6	22
	23-32	E/B	SiL	5.3	0.29	7.3	0.5	0.6	0.1	0.3	1.1	20
	32-42	Btg1	Sicl	5.2	0.19	11.1	0.4	0.9	0.1	0.8	0.8	25
	42-60	Btg2	Sicl	5.1	0.15	10.6	0.7	1.1	0.1	1.4	0.9	36
CAHABA (Typic Hapludults)	0-6	A1	fsl	6.3	--	--	3.6	0.9	0.4	--	1.9	72
	6-12	E	fsl	5.4	--	--	0.7	1.2	0.4	--	2.3	51
	12-16	B/E	fsl	4.8	--	--	0.4	1.1	0.5	--	4.6	32
	16-22	Bt1	scl	4.6	--	--	0.6	1.8	0.4	--	6.6	30
	22-34	Bt2	scl	4.6	--	--	0.9	2.0	0.4	--	8.9	27
	34-46	Bt3	scl	4.6	--	--	1.4	2.2	0.4	--	10.	28
	46-65	BC	sl	4.6	--	--	0.6	1.2	0.2	--	6.5	24
MALBIS (Plinthic Paleudults)	0-4	A1	fsl	5.0	2.40	5.7	0.6	--	0.1	--	5.7	11
	4-11	E	fsl	5.4	.67	2.6	0.4	0.2	--	--	2.0	23
	11-21	Bt1	scl	5.0	.27	10.0	1.0	1.4	0.1	--	9.0	22
	21-31	Bt2	scl	5.1	.13	8.8	--	1.1	0.1	--	8.1	13
	31-43	Btv	scl	5.1	.01	8.4	--	1.1	0.1	--	6.9	15
	43-65	Btv2	scl	5.0	.01	9.2	--	1.5	0.1	--	8.1	16
RUSTON (Typic Paleudults)	0-5	A1	fsl	5.9	.98	2.9	0.8	0.4	0.1	--	2.8	32
	5-10	E2	fsl	5.5	.43	2.9	0.6	0.4	0.2	--	1.6	43
	10-17	Bt1	scl	5.3	.22	3.5	0.4	0.5	0.1	--	2.8	26
	17-27	Bt2	scl	5.2	.18	8.7	--	2.0	0.2	--	2.0	24
	27-33	B/E	fsl	5.1	.13	10.3	--	2.0	0.2	--	2.8	22
	33-45	Bt'	fsl	4.9	.10	11.5	0.6	2.9	0.2	--	8.7	30
	45-65	Bt'2	scl	4.9	.10	12.1	--	2.4	0.1	--	2.8	24

Figure 6.--Chemical Data on Selected Soils

classified as Alfisols. These soils also have an argillic horizon, but the base saturation is more than 35 percent at the critical depths as described above.

Much valuable information about soils can be obtained through a study of those physical properties that can be readily seen or easily measured. 4/ With soil surveys, many interpretations can be made about the behavior of the soils under certain uses or systems of management. Predictions can be made about the suitability of the soils for selected uses and about management requirements.

4/Lytle, S. A. The Morphological Characteristics and Relief Relationships of Representative Soils in Louisiana. Bulletin No. 631. La Agric. Exp. Station; 1968. 21 p.

Vegetative Analysis in the Loblolly Pine - Shortleaf Pine -

Upland Hardwood Forest Type, Louisiana

Donald P. Reed[1/] and Robert E. Noble[2/]

Abstract.--Vegetative yield was measured on the Catahoula District of the Kisatchie National Forest near Dry Prong, Louisiana during 1979 and 1980. Results were compared with different soil types, stand types, stand ages, basal areas, and canopy covers. Canopy cover was the most significant variable affecting understory vegetative yield, followed by basal area. As available sunlight decreased, understory vegetative yield also decreased.

INTRODUCTION

Cattle grazing on portions of the South's National Forests has long been a controversy between cattlemen, foresters, wildlife biologists, environmental organizations, and other groups pushing for their favored use of a public resource. The purpose of this study was to obtain quantitative data on forage production of a particular area. This may assure the best possible use of a public area within the framework of a "multiple use" concept. In obtaining these forage production figures, an inventory was made of the plant composition on the area. The major objective of the study was to show how plant composition and forage production were affected by soil type, stand type, and stand age.

STUDY AREA

The loblolly pine-shortleaf pine-upland hardwood forest type studied is located on the Catahoula District of the Kisatchie National Forest, Grant Parish, Louisiana. The study area comprised approximately 8,000 acres.

Overstory vegetation consisted of the pine-upland hardwood forest type with scattered streambottom hardwoods. Hardwoods comprised 47% of the total basal area. The establishment of pine plantations with hardwood removal and prescribed burning, influenced the vegetative composition on certain areas. The following stand ages were recognized on the study area, along with their respective percentages of the total area.

Stand types:
1. No forest 2.9%
2. Upland hardwoods 1.3%
3. Stream-bottom hardwoods 1.3%
4. Loblolly, shortleaf pine, upland hardwoods 94.5%

Stand ages:
1. Non-stocked (no timber present) 2.9%
2. Seedlings (trees less than 3 years old) 4.3%
3. Saplings (trees greater than 3 years old and less than 4 in. dbh) 13.4%
4. Poles (trees between 4 in. and 9 in. dbh) 23.2%
5. Sawtimber (trees greater than 9 in. dbh) 56.2%

METHODS AND PROCEDURES

Sampling Design and Intensity

Vegetative measurements were carried out around 1000 permanent sample plot centers. Plots were placed along 37.8 miles of transect lines, and were 200 ft. apart. Transect lines were drawn on 15 minute series quadrangle maps and then reproduced in the field as accurately

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as possible using a hand-held compass. Each plot center was monumented with a steel reinforcement rod and a plastic yellow flag attached to a stiff wire. The plot centers served in the following measurements:

Understory Vegetative Clipping.--Forage yield was determined by using the clipping method described by Cook et al. (1962). Frames used to delineate the clipping area were 3.12 ft. sq. and were constructed by bending number 10 gauge steel wire. The frames were placed 9 ft. from plot center to avoid biasing future vegetative cover estimates. Frames were placed in a different compass direction around the plot center each time clipping was carried out. This allowed an undisturbed area to be clipped each time. All understory greenery constituting the current years growth was removed from ground level to a height of 6 ft. Vegetative plant material was dried for 48 hours at 100°C and weights were recorded to the nearest 0.01 gram by using a Mettler P 1210 balance scale. The number of plots sampled during each phase of understory vegetative clipping was:

Spring 1979: 206

Summer 1979: 256

Spring 1980: 145

Summer 1980: 265

Collection of understory vegetative biomass samples for 1979 began on April 28th and ended on November 4th. In 1980, data collections ran from May 3rd to October 12th. During both years, sampling began after the spring greenup and ended before the first frost.

Overstory Tree Measurements.--Overstory vegetation, (4 in. dbh and greater), was sampled in 0.1 acre circular plots. Dbh was measured with a tree caliper. The height and age of a representative dominant and co-dominant tree (where applicable) were recorded for pines and hardwoods. Heights were taken with a Suunto clinometer and ages were determined with an increment borer. The number of snags (a dead tree at least 10 ft. tall and 10 in. dbh) was recorded. Percent overhead canopy cover was estimated for each plot.

Middlestory Vegetative Measurements.--Regeneration (trees and shrubs less than 4 in. dbh and taller than 6 ft.) was sampled in 0.25 acre circular plots. The number of stems of pines, hardwoods, and shrubs, was recorded. Any woody perennial plant, characterized by a low growing posture and branching from the base, was classified as a shrub. Overstory tree measurements and regeneration data were collected at 501 plot locations.

Taxonomic Nomenclature and Data Analysis.--The taxonomic nomenclature of plants is from Radford et al. (1968). A regression equation was used to illustrate the differences in vegetative yield brought about by altering basal areas between pines and hardwoods. An analysis of covariance showed the importance of canopy cover, soil type, stand type, and stand age on understory vegetative yield.

RESULTS AND DISCUSSION

Overstory and Middlestory

The amount of understory vegetative biomass in lbs/ac produced under the various stand ages was:

stand age	highest yield	lowest yield	average yield
seedlings	1957	78	688
saplings	783	39	412
poles	380	11	134
sawtimber	507	2	178

The percent overhead canopy closure of a stand had the greatest effect on understory vegetative yield (Table 1). As canopy closure

Table 1. Analysis of covariance, with dependent variable being understory vegetative yield in lbs./ac., Dry Prong vegetative yield study

Source of variation	Degrees of Freedom	Sums of squares	F Value	Probability 1/
Canopy	1	13597.79	333.07	0.0001
Soil type	9	965.22	2.63	0.0054
Stand type	7	762.85	2.67	0.0099
Stand age	4	592.01	3.63	0.0061

1/Values less than 0.05 are significantly different.

increased, vegetative yield decreased. The wide-spreading crowns of hardwood trees generally shaded a larger area than pine trees of equal basal area. As illustrated in Table 2, 143 lbs of understory vegetative biomass can be produced by shifting basal areas of a stand from hardwoods to pines. Overstory and middlestory characteristics on the study area are presented in Table 3.

Table 2.--Regression equation for predicted understory vegetative yield, based on contrived hardwood and pine basal areas

Basal area hardwoods sq. ft./ac.	Basal area pines sq. ft./ac.	Vegetative yield lbs./ac.
10	90	195
90	10	52
25	75	161
75	25	72
50	50	112
0	25	452
25	0	367
30	60	172
35	70	131
25	70	172

Browse and Herbage

In 1979, understory vegetative biomass on the study area was 321 lbs/ac during the spring (greenup through May 31) and 315 lbs/ac during the summer (June 1 until first frost). A drier year in 1980 caused understory vegetative weights to be significantly different. During spring and summer 1980, understory vegetative biomass was 237 lbs/ac and 268 lbs/ac, respectively. Rainfall amounts[1] in 1979 totalled 74.28 inches as compared to 55.62 inches in 1980. As indicated in Table 4, the majority of the vegetative biomass produced came from woody plants. *Quercus* spp. was the number one woody plant in terms of understory vegetative biomass production and was second behind only *Andropogon* spp. as the top biomass producer (Table 5).

[1]Rainfall data taken from Alexandria weather station located 20 miles south of study area.

Table 3.--Characteristics of Stand Types and Stand Ages, Dry Prong Vegetative Yield Study

	Stand Type									
	No Forest	Loblolly-Shortleaf Pine-Upland Hardwoods				Upland Hardwoods			Stream bottom	
Characteristics	non-stocked	seedlings	saplings	poles	sawtimber	saplings	poles	saw-timber	poles	saw-timber
% canopy cover	c[1/]	10	16	53	55	5	60	48	95	50
basal area pines[2/]	c	30	16	46	68	0	2	3	1	0
basal area hardwoods	c	4	17	28	31	12	68	65	89	68
no. snags/ac.	0.14	0	0.12	0.15	0.08	0	0	0.5	1.0	0.4
ht. dominant hardwoods[3/]	c	20	45	43	54	44	60	50	58	72
ht. co-dominant hardwoods	c	c	51	37	50	c	72	41	32	54
ht. dominant pine	c	52	46	43	73	c	42	38	c	c
ht. codominant pine	c	c	70	44	64	c	c	c	c	c
age dominant hardwoods[4/]	c	27	40	43	50	39	59	53	58	62
age co-dominant hardwood	c	c	40	29	46	c	58	37	25	38
age dominant pine	c	38	29	25	45	c	21	34	c	c
age co-dominant pine	c	c	28	23	39	c	c	c	c	c
pine regeneration stems/ac.	3	340	704	241	159	40	0	0	40	0
hardwood regeneration stems/ac.	114	360	977	747	662	960	980	980	1120	808

[1/]condition does not exist for that situation.

[2/]basal area in ft.^{2} per acre.

[3/]height in feet.

[4/]age in years.

Table 4.--Understory Vegetative Biomass in lbs./ac. by Season of Clipping and Life Form, Dry Prong Vegetative Yield Study

	Season			
Life Form	Spring 1979	Summer 1979	Spring 1980	Summer 1980
Woody	197	152	139	160
Forbs	12	25	10	15
Grass	51	99	37	48
Vines	53	36	50	43
Legumes	4	1	1	1
All of the above which made up less than 0.01 lbs./ac.	4	2	0	1
TOTAL	321	315	237	268

Synthesis

Control over canopy closure is the key factor influencing understory vegetative yield. In areas where sunlight was able to reach the ground, increased amounts of vegetative biomass was produced. Both annuals and perennials benefited from the increased levels of sunlight. Canopy closure is influenced by basal area composition (hardwoods vs. pines) and amount. Basal area composition can be controlled by selectively cutting pines or hardwoods, while basal area amount is influenced by the stocking and age of the stand. Rainfall amounts influenced vegetative yield during the two years the study was conducted.

LITERATURE CITED

Cook, C. W.; Biswell, H. H.; Clark, R. T.; Reid, F. H.; Stoddart, L. A.; Upchurch, M. L. Basic problems and techniques in range research. In: A report of a joint committee of the American society of range management and the agricultural board. Washington National Academy of Sciences, Wash. D.C. Pub. No. 890; 1962. 341p.

Radford, A. E.; Ahles, H. E.; Bell, C. R. Manual of the vascular flora of the Carolinas. Chapel Hill, N.C.: Univ. of North Carolina Press; 1968. 1183p.

Table 5.--Major Species[1] Contributing to the Total Vegetative Biomass by each Season of Clipping, Dry Prong Vegetative Yield Study

	Vegetative Biomass lbs./ac.					
Taxon	Spring 1979	Summer 1979	1979 avg.	Spring 1980	Summer 1980	1980 avg.
Andropogon spp.	22.92	47.22	35.07	15.95	27.49	21.72
Quercus spp.	24.99	29.92	27.45	13.92	34.73	24.32
Myrica cerifera	22.56	20.01	21.28	8.97	21.14	15.05
Cornus florida	24.20	16.45	20.32	15.88	13.22	14.55
Vaccinium spp.	20.71	16.70	18.71	10.99	19.26	15.12
Gelsemium sempervirens	15.27	15.84	15.56	7.32	18.50	12.91
Acer rubrum	17.65	9.94	13.80	20.10	9.19	14.65
Panicum spp.	12.52	20.76	16.64	8.60	4.76	6.68
Vitus rotundifolia	13.98	5.90	9.94	16.79	10.02	13.40
Liquidambar styraciflua	12.75	10.75	11.75	12.33	9.68	11.01
Rubus spp.	17.19	8.20	12.69	13.11	6.45	9.78
Pinus spp.	13.83	13.57	13.70	2.75	10.31	6.53

[1]A taxon was considered major if the average biomass produced during 1979 and 1980 was 10 lbs./ac. or greater.

AMPHIBIANS AND REPTILES OF LOBLOLLY-SHORTLEAF PINE STANDS IN CENTRAL LOUISIANA

Kenneth L. Williams and Keith Mullin

Abstract.--Amphibian and reptile species composition and abundance were surveyed on four study sites, each 2000 acres, on the Catahoula Ranger District, Kisatchie National Forest, in central Louisiana, from August 1979 to May 1981. Four stand size classes (habitats) were sampled within each study area--regeneration, sapling, poletimber, and sawtimber. A variety of census methods were used, including walking transects and fence arrays with pitfalls and funnel traps. Sawtimber exhibited the most herpetofauna diversity. Amphibians were not abundant in any stand type. Reptiles were more abundant, but with the exception of three species of lizards, probably not abundant enough to serve as good indicators of habitat change resulting from grazing.

INTRODUCTION

Catahoula Ranger District, Kisatchie National Forest, is located in Louisiana in Grant Parish, in the vicinity of Dry Prong. The study sites consist of four fenced areas of approximately 2000 acres each.

The area is generally described as loblolly-shortleaf pine, with loblolly distinctly dominant. Reed (1981) in his analysis of the vegetation, indicated that the basal area consisted of 47% hardwoods. Loblolly is considered to be more shade tolerant than other pines of this area. This factor may account for the large percent of hardwoods (Shelford, 1963). The soil of this study area is presented in a detailed publication by the U.S. Department of Agriculture (1979, for Grant Parish).

The two major objectives of this study were:

I. To determine the kinds of amphibians and reptiles in the four stand types.

II. To obtain quantitative data for each stand type, which could be utilized in later phases of the study.

The overall purpose was to obtain data fulfilling these objectives and then utilize these data in later studies to evaluate the effect of cattle grazing on herpetofauna occurrence and abundance.

Due to United States Forest Service timber management practices the forest is in various stages of development ranging from clearcut areas of varying sizes up through mature pine stands. For sampling purposes four stand size classes were recognized:

1. regeneration: "recently site prepared, with or without pine seedlings.
2. Saplings: trees up to 4 inches dbh.
3. Poletimber: trees from 4 inches to 10 inches dbh.
4. Sawtimber: trees 10 inches or more dbh, most would be classified as immature sawtimber.

Amphibians and reptiles are common animals of this area of Louisiana. Within this area piney woods are probably the least desirable habitat for many amphibians and reptiles (see the list below species that occur/or may occur in the region of Louisiana where the study sites are located). The numbers following each species in the list are: 1=obtained in study, 2=known to occur in similar habitat locally, but not obtained in present study, 3=not recorded from general area, but very likely occurs, and 4=range maps show it occurring in this area, but not likely due to lack of suitable habitat.

Species (Amphibia)	Category
Siren intermedia	3
Amphiuma tridactylum	4
Necturus beyeri	4
Notophthlamus viridescens	3
Ambystoma talpoideum	3
Ambystoma texanum	3
Ambystoma maculatum	3
Ambystoma opacum	1
Desmognathus auriculatum	3

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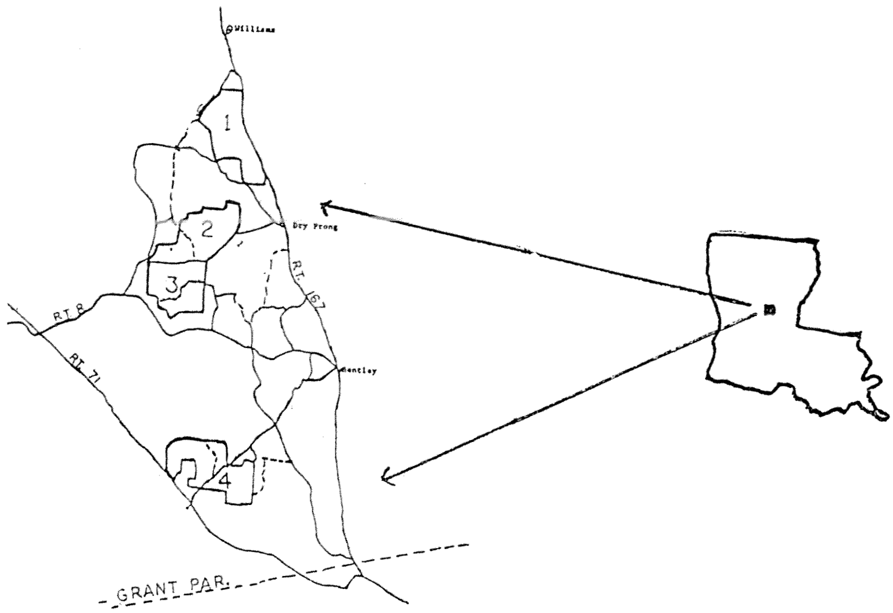

Figure 1. Location of the Catahoula Ranger District study sites, Grant Parish, Louisiana. (Scale one-fourth inch=one mile)

Species	Category
Plethodon glutinosus	4
Eurycea quadridigitata	1
Scaphiopus holbrooki	3
Gastrophryne carolinensis	1
Bufo woodhousei	1
Bufo valliceps	1
Hyla crucifer	1
Hyla cinerea	1
Hyla versicolor	1
Hyla squirella	3
Pseudacris triseriata	2
Acris crepitans	1
Rana clamitans	1
Rana catesbeiana	4
Rana sphenocephala	1
Rana areolata	4

Species (Reptilia)	Category
Alligator mississippiensis	4
Macroclemys temmincki	4
Chelydra serpentina	2
Sternotherus odoratus	3
Sternotherus carinatus	4
Kinosternon subrubrum	3
Graptemys pseudogeographica	4
Graptemys kohni	4
Chrysemys concinna	4
Chrysemys floridana	4
Chrysemys scripta	4
Chrysemys picta	4
Deirochelys reticularis	4
Terrapene carolina	1
Trionyx muticus	4
Trionyx spinifer	4
Anolis carolinensis	1
Sceloporus undulatus	1
Scincella lateralis	1

Species	Category
Eumeces fasciatus	1
Eumeces laticeps	1
Eumeces anthracinus	1
Cnemidophorus sexlineatus	1
Ophiosaurus attenuatus	3
Nerodia erythrogaster	4
Nerodia rhombifera	4
Nerodia cyclopion	4
Regina rigida	4
Regina grahami	1
Thamnophis sirtalis	3
Thamnophis proximus	4
Virginia striatula	3
Storeria dekayi	1
Storeria occipitomaculata	3
Heterodon platyrhinos	1
Diadophis punctatus	1
Opheodrys aestivus	1
Farancia abacura	4
Coluber constrictor	1
Masticophis flagellum	1
Pituophis melanoleucus	3
Elaphe obsoleta	1
Elaphe guttata	3
Cemophora coccinea	3
Lampropeltis triangulum	3
Lampropeltis calligaster	3
Lampropeltis getulus	1
Tantilla gracilis	3
Agkistrodon piscivorus	1
Agkistrodon contortrix	1
Sistrurus miliarius	3
Crotalus horridus	3
Micrurus fulvius	1

When hardwoods are allowed to develop along creek bottoms providing more diversity, kinds and numbers of organisms, including amphibians and reptiles increase. However, as this study indicates piney woods can sustain a moderate variety of amphibians and reptiles, and in a few cases substantial populations. Some of the species recorded herein are dependant upon the small sources of water in the area.

Amphibians and reptiles are basically second or third level consumers in the food chain. They likely are important links in the food web of the piney woods studied.

METHODS AND PROCEDURES

Straight line transects were established and walked. Shrubs and trees (6 ft. or lower) were checked for herpetofauna (especially the lizards Anolis and Sceloporus), and ground cover was watched, especially for the lizards Scincella and Cnemidophorus. In addition debris (logs mainly) within 10 yards on either side of the transect were rolled over or if rotten "pulled apart" and searched for herpetofauna.

Each transect was located within a specific habitat type and was searched for a recorded amount of time. A compass was used to maintain a straight line.

The other primary method used was a drift fence with associated five gallon buckets (sunk in soil) and funnel traps (Campbell and Christman, 1982; see Williams and Mullin, 1987 for diagram). The traps were randomly established in each of the habitat types and maintained throughout the study.

Other census methods were occasionaly used with varying success. However, they did allow the addition of several species that would not have been otherwise recorded. These methods were:

1. Accidental observation while moving through the area, often from one trap site to another.
2. Driving the roads at night during warmer months. When a specimen was discovered in this manner, the type of habitat closest was recorded.
3. At the beginning of the study, quadrats were randomly set up and walked for a set amount of time. This procedure was discontinued and the transect method (discribed above) was substituted. The time involved in establishing randomly located quadrats was prohibitive.

The study sites were visited an average of twice a month. Usually one or two days were spent on the site each trip. During cold weather the visits were less frequent. Visits were made by one or both of the authors.

Sawtimber was the most abundant habitat; sapling stands were second in abundance. Poletimber and regeneration habitats were less available. Consequently, sampling by necessity, were greater in sawtimber and sapling stands. For all comparisons given here, data are expressed as mean/unit effort (i.e., number per trap night or per hour searched).

We used Conant (1975) and occasionaly Keiser and Wilson (1979) for species identification. Nomenclature follows Conant (1975) except for watersnakes, where Nerodia was used instead of Natrix.

RESULTS AND DISCUSSION

The amphibians collected indicate a moderately diverse group of species (Table 1). They are most abundant in sawtimber, uncommon in poletimber, and virtually absent in sapling and regeneration.

Table 1. Number of amphibians trapped or encounted (parenthesis value).

Species	Sawtimber[1]	Pole[1]	Sapling[1]	Regeneration[2]
Ambystoma opacum	1(4)	0(0)	0(0)	0(0)
Eurycea quadridigitata	2(4)	1(1)	1(0)	0(0)
Bufo woodhousei	8(2)	2(3)	1(0)	0(0)
Bufo valliceps	1(0)	0(0)	0(0)	0(0)
Gastrophryne carolinensis	6(4)	3(0)	9(0)	0(0)
Acris crepitans	0(2)	0(0)	0(0)	0(0)
Hyla cinerea	0(1)	0(0)	0(0)	0(0)
Hyla crucifer	0(2)	0(0)	0(0)	0(0)
Hyla versicolor	1(3)	0(0)	0(0)	0(0)
Rana spenocephala	4(7)	0(1)	0(0)	0(0)
Rana clamitans	0(4)	0(0)	0(0)	0(0)
"frogs"	5(0)	0(0)	1(0)	0(0)
Totals	28(33)	6(5)	12(0)	0(0)

[1] The data for trapping results represents the totals for 104 trap nights. The data for transect walks represents 60 hours totâl time.

[2] The data for trapping results represents the totals for 68 trap nights. The data for transect walks represents 30 hours total time.

Factors that may account for this are: 1)presence or absence of water, and 2) shaded cover. Both factors were most frequent in sawtimber. Also certain species were only/or more frequently encountered where transects crossed creeks.

Reptiles (Table 2) were more numerous and in most cases less restricted to water or wet situations. Thus, they are of more potential use as indicators of habitat disturbance.

Regeneration appears to be virtually sterile. Sapling and poles when trap and transect results are combined appear rather similar but still with sparce populations. Sawtimber shows greater diversity in both trap and transect results.

Lizards were the most abundant reptile group. The three lizard species exhibiting obserable abundance were the fence lizard (Sceloporus undulatus), the ground skink (Scincella lateralis), and the American anole (Anolis carolinensis) (Table 3). Although Anolis carolinensis and Sceloporus undulatus are found in all habitat types, in sapling and regeneration many records, especially Anolis, were obtained as transects passed near isolated hardwoods (often black-jack oak).

Table 2. Number of reptiles trapped or encountered (parenthesis value).

Species	Sawtimber[1]	Pole[1]	Sapling[1]	Regeneration[2]
Terrapene carolina	5(3)	6(1)	8(1)	0(0)
Anolis carolinensis	6(2)	2(4)	1(6)	0(1)
Sceloporus undulatus	17(14)	3(6)	1(7)	0(1)
Scincella lateralis	21(28)	7(13)	2(0)	0(1)
Eumeces fasciatus	2(4)	0(0)	0(0)	0(0)
Eumeces anthracinus	2(1)	0(0)	0(0)	0(0)
Cnemidophorus sexlineatus	0(1)	0(1)	0(0)	0(0)
Coluber constrictor	0(0)	1(2)	0(2)	0(2)
Diadophis punctatus	1(0)	0(0)	0(0)	0(0)
Elaphe obsoleta	0(1)	0(1)	0(2)	0(0)
Masticophis flagellum	0(2)	0(0)	0(0)	0(0)
Opheodrys aestivus	0(1)	0(0)	0(0)	0(0)
Lampropeltis getulus	0(0)	0(0)	0(1)	0(0)
Storeria dekayi	1(4)	0(1)	1(0)	0(0)
Heterodon platyrhinos	0(0)	2(0)	0(0)	0(0)
Regina grahami	0(1)	0(0)	0(0)	0(0)
Agkistrodon contortrix	1(5)	0(1)	1(0)	0(0)
Agkistrodon piscivorus	0(7)	0(0)	0(0)	0(0)
Sistrurus miliarius	1(2)	0(1)	0(0)	0(0)
Micrurus fulvius	1(0)	0(0)	0(0)	0(0)
Totals	57(76)	21(31)	13(16)	0(5)

[1]The data for trapping results represents the totals for 104 trap nights. The data for transect walks represents 60 hours total time.

[2]The data for trapping results represents the totals for 68 trap nights. The data for transect walks represents 30 hours total time

Comparisons between the results given here and Vernon Ranger District results are presented in Williams and Mullin (1987).

Table 3. Occurrence(%) of the three most common lizards by stand size class.

Species	Sawtimber	Poles	Saplings	Regener.
Anolis	33	29	33	05
Scincella	68	28	03	01
Sceloporus	62	19	17	02

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LITERATURE CITED

Campbell, H.M., and S.P. Christman. 1982. Field techniques for herpetofaunal community analysis, pp. 193-200 in Herpetological communities (N.J. Scott, ed.). U.S. Dept. Interior, Fish & Wildlife Service. Wildlife Res. Rept. 13.

Conant, R. 1975. A field guide to reptiles and amphibians of eastern and central North America. Second ed., H.M. Co. xviii + 429 pp.

Keiser, E.D., and L.D. Wilson. 1979. Checklist and key to the amphibians and reptiles of Louisiana. Lafayette Nat. Hist. Mus. Bull. (1): 49 pp.

Reed, D.P. 1981. Understory vegetation yield in the loblolly-shortleaf pine-upland hardwood forest type, Louisiana. Unpubl. M.S. thesis, Louisiana State Univ., Baton Rouge 257 pp.

Shelford, V.E. 1963. The ecology of North America. Univ. Illinois Press xxii + 610 pp.

United States Department of Agriculture. 1979. Soil survey of the range management research units, Grant Parish. Soil Conservation Service.

Williams, K.L., and K. Mullin. 1987. Amphibians and reptiles of longleaf-slash pine stands in central Louisiana. This volume.

Mammalian use of Habitat in the Loblolly-Shortleaf Pine Type of Louisiana

Robert B. Hamilton, Steven W. Ellsworth, and Joe Clint Smith

Abstract.--Indices of mammalian abundance were obtained for 26 species on four study areas. Small mammals were snap-trapped along vegetation transects and differed in habitat preferences. Larger mammals were sampled with scent-posts, night-light, and track counts. Indices differed by area and season. Suggestions are made for future sampling.

INTRODUCTION

Because of recent controversy over grazing on some southern national forests, a Southern Range Evaluation Project was begun in 1978 on two forest types in four southern states to evaluate the effects of grazing. Baseline data on the relative abundances of mammalian species at specific grazing levels are needed if the effects of grazing are to be evaluated. This study was designed to provide such data for ungrazed national forests of central Louisiana. The data gathered will be analyzed with respect to study area because future treatments will be on a study area basis.

The relative efficiency of the many techniques available for assessing abundance of free-ranging mammals is not well known. Because wild mammals are primarily nocturnal and often cannot be observed easily, many of the techniques do not require direct observation. Mammals vary greatly in size, behavior, and means of locomotion and, therefore, there is variation in the applicability of techniques among species. In addition, some mammalian sampling is destructive and can al+ter abundance. It is not clear which techniques will provide the most reliable indices for various species of mammals or what sample sizes are required to provide a reliable index. We will evaluate the techniques we used to determine mammalian abundance in this paper, in addition to reporting the relative abundance indices that we obtained. We will also attempt to determine the maximum sampling intensity required in the future in order to detect a 20% change in abundance on an area.

Our specific objectives in this study are to 1) determine the species present and their abundances in different habitats, study areas, and seasons. 2) evaluate the techniques used as to effectiveness for various species. 3) determine the sampling intensity required to detect a 20% change in abundance if variance of the new sample is no greater than the variance of our combined data set (This is almost a worst case condition.), and 4) determine the habitat preferences of the small mammals that are present on the study areas.

We want to thank all those who helped to make this study possible. The field work was financed by the U.S. Department of Agriculture, Forest Service, the LSU Agricultural Center and Louisiana Agricultural Experiment Station. Most of this work was performed by Steve Ellsworth and Clint Smith and the data were used in their M.S. Theses. We were aided in the field by students, Lloyd Mitchell, Gary Lester, Robert Abernathy, Bill Hickman, and Kathy Fouchi. Dr. Robert Noble and Don Reed helped with vegetation analysis and set up the vegetation transects that we used. Drs. Nancy Keith, James Geaghan and Vernon Wright helped with the statistical analysis. We appreciate the help we received from Forest Service employees, especially Dr. Henry Pearson. The Louisiana Department of Wildlife and Fisheries provided living quarters near the study area.

STUDY AREA

Field work was conducted on the same four study areas in the Catahoula Ranger District of the Kisatchie National Forest that are described elsewhere in this publication (see Hamilton and Lester 1987). Differences in detail between the studies will be discussed, where appropriate.

Sampling Areas

Small mammal trapping was primarily conducted along the existing vegetation sampling lines described by Reed (1981). He identified five stand ages based on age or dbh of dominant trees. Age frequencies varied greatly among study areas (tab. 1). "Sawtimber", with a low of 40.3% on Area 1 and a high of 76.7% on Area 4, was the most frequently occurring age on each of the study areas.

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Stand Types

Reed (1981) classified the vegetation into eight stand types. We used six of these types because his distinctions were finer than necessary for mammal sampling and we had difficulty at times obtaining sufficient sample sizes. His "loblolly-shortleaf-occasional longleaf pine forest"[1] and "longleaf pine" types were combined into "pure pine" and his "loblolly-shortleaf pine-upland hardwood" and "loblolly-shortleaf-longleaf pine-upland hardwood" were combined into "pine-upland hardwood". The relative proportions of these types varied considerably among the study areas (tab. 2).

Table 1.-- Relative frequency of occurrence (%) of forest stand ages in each study area, 1980

Stand Age[1]	Area 1	2	3	4	1-4
Unstocked	0.7	0.4	0.0	11.5	2.9
Seedlings	0.7	17.0	0.0	0.0	4.3
Saplings	18.3	8.3	24.5	0.9	13.4
Poles	40.3	29.5	7.2	11.0	23.2
Sawtimber	40.0	44.8	68.3	76.6	56.2

1 Stand ages follow Reed (1981:12).

Table 2.-- Relative frequency of occurrence (%) of forest stand types in each study area, 1980

Stand Type	Area 1	2	3	4	1-4
Unstocked	0.3	0.0	0.0	11.5	2.9
Pine-UpHard	82.0	40.3	70.5	50.2	60.7
Pine StHard	6.4	8.3	21.9	3.5	10.0
Upl. Hard.	0.3	3.3	1.3	0.4	1.3
Pure Pine	9.5	47.7	4.6	32.6	23.6
Stream. Hard.	1.4	0.4	1.7	1.8	1.3

Ecological Description

The boundaries between the habitats were relatively sharp. Although some of the more inaccessible parts of the study areas held uneven-aged stands, many large (50-200 ac), even-aged blocks, of various ages were present.

Management

The study areas had once been used as open range for cattle and hogs, but there has been no legal grazing on the study areas for the 20 years prior to the study. The forest is presently managed for timber and pulp production. Clearcutting and prescribed burning are extensively practiced. Regeneration is often by the seed tree method or by planting.

METHODS AND PROCEDURES

Because the many different combinations of stand types and ages present could not all be adequately sampled with the resources available and the different types of mammals expected to be present could not all be sampled the same way, we used procedures designed to maximize the rate of data collection from various groups for the effort involved. We accomplished this by collecting data along transect lines rather than in scattered plots and thereby used our time efficiently. We chose methods that minimized transportation difficulties by placing plots along existing transect lines, trails, or roads. We gathered data at its times of maximum availability or when the expected rate of data acquisition would be near a maximum. There were projects on both birds and mammals and those responsible for data gathering for both groups helped each other as much as possible (for example, much of the bird work was done in the mornings and much of the mammal work was done in the afternoon by all the people involved). In addition, we gathered as much data as possible at or between the existing vegetation sampling points so as to minimize the amount of vegetation sampling required for habitat description.

Methods were chosen that were repeatable and would provide reliable indices of abundance. Obtaining absolute abundance information would have been almost impossible for any species on the study areas and such information was not required for the purposes of the study.

Sampling Procedures

Mammals were detected through the use of scent posts, snap traps, predator calls, and night lights. We also counted tracks, counted squirrel leaf nests, and shot bats.

Indices of mammalian abundance by area, season, stand type, and stand age with standard errors and coefficients of variation were prepared when sample sizes were sufficient. Comparisons between the various indices of mammal abundance were made with Chi-square tests or ANOVA. Where differences were found with ANOVA, Duncan's Multiple Range Test was used to ascertain the treatment(s) where the differences in index occurred.

When possible, we calculated the sample sizes required in the future to determine a 20% change in mammal numbers for the groups we studied. For these calculations we assumed the variance of the future sample would be the same as the variance we obtained in this study. The variances we used in these calculations were obtained from the entire data set (results from different for each group and consequently the variances we used were relatively high.

In addition, the effects of habitat variables on small mammal occurrence were tested with

[1] See Reed (1981) for type descriptions.

ANOVA and Duncan's Multiple Range Test to ascertain which species was (were) significantly different with respect to the variables. Calculations were performed using programs of the Statistical Analysis System (SAS) (Helwig & Council 1979) on an IBM 3033 computer at the Systems Network Computer Center, Louisiana State University. To evaluate the importance of these variables, a Stepwise Discriminant Analysis was performed with programs from the Statistical Package for the Social Sciences (SPSS) (Nie et al. 1975). Redundant variables were removed from the analysis based on the results of a correlational analysis.

An alpha level of 0.05 was used for all tests.

Field Methods

Small Mammals.--The existing vegetation transects formed modified Calhoun Lines (Linn 1963). Trapping along the transects was done twice, primarily on week-ends, from October 1979 to June 1980, and continued from November 1980 until June 1981. Trapping success was negligible in the heat of summer.

When trapping along the transect, we placed five museum special traps, baited with peanut butter, at places we judged to be the most likely spots for small mammal use within 40 ft of plot centers. Each trap had been modified by stretching a wire midway across the trap bar to facilitate catch of smaller species. Traps were set for 1 night and moved. Captured animals were prepared as museum specimens and placed in the Louisiana State University, Museum of Natural Science.

Large mammals.--Indices of abundance of large mammals were prepared by study area. Sampling by habitat type was impractical and probably not meaningful because the home ranges of many of the mammals were large enough to include several adjacent habitat types.

Scent Post Counts

Twenty, permanent, 1.0-m diameter circular track stations were placed near abandoned logging roads in each of the four study areas at 0.2-mi intervals (see Linhart and Knowlton 1975). Station locations are indicated in Ellsworth (1983:173-176). Surface vegetation was removed prior to sampling, track beds were brushed clean, dolomitic limestone was spread evenly, and a capsule containing 1 ml of attractant (synthetic fatty acid scent; Bullard et al. 1978a, 1978b, Roughton and Sweeny 1982) was applied prior to the first day of a 3-day trapping period. We initially attempted to make a track surface by raking the soil but most tracks were not discernible. The clay soils on the area would not take a track from relatively light animals and some of the loamy soils became powdery and lost their ability to hold tracks in dry weather. The limestone made a better track surface, especially when the soil beneath it was hard. Morrison (1981) had more responses of rabbits (*Sylvilagus* spp)[2] and coyotes (*Canis latrans*) with limestone than with natural soils. When the stations were checked after the first and second night, responses were recorded at each station by species or species group (where individual species could not be differentiated, such as for rabbits, data were recorded as a species group), the tracking surface was refurbished, and 0.5 ml of attractant was added. After the third night, only data were recorded. Lines were run 6 times, once every 3 months, from 1 Apr. 1980 to 20 Jul. 1981.

Spot-lighting

Standardized survey routes along suitable roads were selected in Areas 1-3 (Ellsworth 1983:181-2). No suitable roads existed in Area 4. The routes were sampled, at least once/month, when possible, except July and September, by two observers (driver and passenger) at night, beginning between sunset and 1 hr. past by driving slowly (10-12 mph) and scanning both sides of the road with a 200,000 candlepower "Q-beam" spotlight. Animals seen by the driver or passenger were recorded by area and road. Surveys were done from Oct. 1979 until May 1981.

Track Counts

Monthly track counts were made along all suitable gravel roads on areas 1-3 (Ellsworth 1983:183-184). We walked up one side of a road and down another, preferably 2 days after a rain, and counted all tracks.

Other methods

Squirrel leaf-nest counts, bat shooting, and predator call counts were also made (see Ellsworth 1983), but detailed results will not be reported here.

RESULTS

Weather

Weather patterns may have differed slightly from long term averages (tab. 3). but patterns of mammalian abundance prior to our study are not known and it is impossible to evaluate weather effects on abundance data. However, there was a draught in the summer of 1981 that prevented track formation and interfered with data gathering.

2 Common and Scientific names are from Lowery (1974).

Table 3.-- Some climatological data for overall study area[1], January 1980 to June 1981 with 20 year averages (1951-1973) recorded at Winnfield, 18 mi north of Area 1 (from Ruffner 1979)

	Mean Max.Daily Temp (°F)		Mean Min.Daily Temp (°F)		Tot.monthly precip. (in)	
Mon.	20-yr	80/81	20-yr	80/81	20-yr	80/81
Jan	59.2	60.6	36.3	39.9	4.5	5.0
	"	57.9	"	34.0	"	1.8
Feb	63.0	64.6	38.5	38.7	4.6	4.4
	"	60.4	"	41.2	"	3.3
Mar	70.3	68.2	44.4	44.8	4.8	10.6
	"	68.5	"	43.2	"	5.4
Apr	78.8	77.2[2]	52.0	47.7[2]	5.2	3.3
	"	78.6	"	56.5	"	1.0
May	84.7	82.8	60.4	62.4	6.1	6.6
	"	79.3	"	59.2	"	6.8
Jun	90.9	91.2	67.5	70.0	3.6	4.4
	"	90.1[3]	"	71.8[3]	"	6.6
Jul	93.0	96.6	70.2	72.5	5.4	1.5
Aug	93.0	95.9	69.1	69.6	3.3	1.5
Sep	88.7	93.9	64.0	67.6	4.7	6.4
Oct	79.9	77.9	52.2	49.1	2.6	6.4
Nov	68.5	66.6	43.0	41.7	4.1	4.2
Dec	60.8	62.4	37.8	38.8	5.4	0.5

[1] Recorded ca. 8.8 km (5.5 mi) northeast of Area 4, at the Catahoula Forest, Catahoula Ranger District, Kisatchie National Forest (pers. comm. Mr. Charles Turner, climatologist, USDA Forest Service, Kisatchie National Forest, Pineville, Louisiana.)

[2] 5 days of data missing.

[3] 3 days of data missing.

Snap-trapping.--Golden mice (*Ochrotomys nuttalli*)2, cotton mice (*Peromyscus gossypinus*), short-tailed shrews (*Blarina brevicauda*), fulvous harvest mice (*Reithrodontomys fulvescens*), and white-footed mice (*Peromyscus leucopus*) were the most frequently captured species (tab. 4). The Least shrew (*Cryptotis parva*) and the cotton rat (*Sigmodon hispidus*) were not caught enough for analysis.

Table 4.-- Abundance indices (number caught/100 trap-nights) and sample sizes (S.S.) needed to detect a 20% change in density calculated from 9070 trap-nights for the entire area, 1979-1981

Species	Statistics caught	index	S.E.	S.S.
Cotton mouse	150	1.65	0.15	6,786
Wh-ft. mouse	49	0.54	0.10	29,840
Golden mouse	158	1.74	0.15	6,440
F. ha. mouse	53	0.58	0.09	19,139
Sh-tl. shrew	107	1.18	0.11	7,976
Least shrew	2	0.02	0.02	
H. cotton rat	4	0.04	0.02	

Total catch of all small mammals varied with forest stand type (tab. 5). Trap success was almost 50% better in the "non-forested" area (10.3%) than any of the forested ones. In forests, total trap success varied from a low of 5.5% in the "pine-upland hardwoods" to 7.1% in the "pine-streambottom hardwoods". Standard errors and other statistics can be found in Ellsworth (1983:141-146).

Table 5.-- Abundance indices (number caught/100 trap nights) of small mammals by stand type, 1979-1981

	Stand Type[1]					
	Z	P	PU	PS	U	S
Cotton mouse	5.6	0.9	1.5	3.3	4.2	4.0
Wh-ft. mouse	2.6	1.2	0.3	0.0	0.0	0.0
Golden mouse	0.0	1.7	2.0	0.8	1.7	1.0
F. ha. mouse	0.5	1.3	0.4	0.0	0.0	0.0
Sh-tl. shrew	1.0	1.4	1.0	1.3	0.0	1.0
All[2]	10.3	6.8	5.5	7.1	5.8	6.0
Trap-nights	195	2460	5355	840	120	100

[1] Z = unforested, P = pine, PU = Pine-Upland Hardwoods, U = Upland Hardwoods, S = Streambottom Hardwoods.

[2] All = Total for all small mammals.

Small mammals were caught more in the younger aged stands. Short-tailed shrews were caught almost equally in all of the older stands as were golden mice (tab. 6). Standard errors and other statistics are in Ellsworth (1983:147-151).

We tested stand type and stand age preference with a "suitability index", the percentage caught in a habitat divided by the percentage of trap nights in the habitat times 10. Use of this index allows comparisons of habitat importance among species. An index value of 10 represents random distribution. "Seedling" and "sapling" ages were preferred by four of the five species for which we have data (tab. 7).

"Pine" and "unforested" were preferred by three and two species, respectively (tab. 8).

Table 6.-- Snap-trap abundance indices (number caught/100 trap nights), by stand age, 1979-1981

	Stand Age				
	Zero	Seed	Sap.	Pole	Saw.
Cotton mouse	5.00	0.22	2.34	0.89	1.81
Wh-ft. mouse	2.27	5.33	0.45	0.28	0.17
Golden mouse	0.00	2.22	2.88	1.20	1.11
F. ha. mouse	0.45	4.67	0.90	0.14	0.35
Sh-tl. shrew	0.91	1.56	1.35	1.64	1.57
All	9.09	14.89	8.02	4.30	5.50
Trap-nights	220	450	1110	2140	5150

Table 7.-- Suitability indices, derived from 9070 trap-nights, for forest stand age classes 1979-1981

	Stand Age				
Species	Zero	Seed	Sap.	Pole	Saw.
Cotton mouse	30.2	1.3	14.2	5.4	10.9
Wh-ft. mouse	42.1	98.7	8.3	5.2	3.2
Golden mouse	0.0	12.8	16.5	9.4	9.0
F. ha. mouse	7.8	79.9	15.4	2.4	6.0
Sh-tl. shrew	7.7	13.2	11.4	10.3	9.4

Table 8.-- Suitability indices, derived from 9070 trap-nights, for forest stand type classes, 1979-1981

	Stand Type[1]					
	Z	P	PU	PS	U	S
Cotton mouse	34.1	5.4	9.0	20.2	25.2	24.2
Wh-ft. mouse	47.5	21.8	5.2	0.0	0.0	0.0
Golden mouse	0.0	9.6	11.5	4.8	9.6	5.7
F. ha. mouse	8.8	21.6	6.7	0.0	0.0	0.0
Sh-tl. shrew	8.7	12.1	9.2	4.8	0.0	8.5

[1] Z = unforested, P = pine, PU = Pine-Upland Hardwoods, U = Upland Hardwoods, S = Streambottom Hardwoods.

Sample sizes required to detect a 20% change in response rate were estimated with the formula $n=s^2t^2/d^2$ (Steel and Torrie 1980:120) where "n" is the required sample size, "s^2" is the variance of the index, and "t" is the appropriate value from a "t table" at the desired alpha level and observed degrees of freedom. Thus, the required future sampling intensity can be estimated. If the variability in future trapping data could not be reduced below that in the present data set, we would need to repeat the sampling effort of this study to detect at an alpha level of .05 a 20% change in the index for three species: cotton mouse, golden mouse and short-tailed shrew (tab. 4). Increased sampling efforts would be needed to detect a 20% change (tab. 4) in density of white-footed mice and fulvous harvest mice. However, the standard error and thus the required sampling effort could be decreased by concentrating trapping effort in the most suitable environments or at the most suitable times (tab. 7 & 8). We cannot practically evaluate density changes of the other snap-trapped species unless variance could be greatly reduced.

Five species were captured often enough for habitat analysis and had different patterns of habitat preference for the variables used (tab. 9). All habitat variables except stem density were associated with differences in small mammal abundances with this analysis.

Table 9.-- Results of Duncan's Multiple Range Test performed on the 10 habitat parameters used in the study. Species grouped horizontally by the same letter are not significantly different

	Species[1]				
	B. b.	*R. f.*	*P. l.*	*P. g.*	*O. n.*
% Canopy Cover F=12.36,p=.0001	A	B	B	A	A
BA[2] Hardwoods F=7.58,p=.0001	A	B	B	A	A
BA Pines F=4.42,p=.0018	A B	A B C	C	B C	A
Ht dom Hardwood F=8.55,p=.0001	B	C	C	A	B
Ht codom Hard. F=2.31,p=.0584	A B	B	B	A	A B
Ht dom Pine F=5.24,p=.0005	A	A B	B	A	A
Ht codom Pine F=1.85,p=.1207	A B	A B	B	A	A
Stem density F=0.41,p=.8039	A	A	A	A	A

[1] B.b. = *Blarina brevicauda*, R.f. = *Reithrodontomys fulvecvens*, P.l.=*Peromyscus leucopus*, P.g. = *Peromyscus gossypinus*, O.n. = *Ochrotomys nuttalli*

[2] BA = Basal Area.

Community structure is more evident from the habitat preferences indicated by the multivariate discriminant analysis than from the raw trapping data. Three discriminant functions (DF) were generated from the variables used and accounted for 67.3% (DF I), 15.5% (DF II), and 12.3% (DF III) of the total variance, respectively. DF I is weighed most heavily by stand age and % canopy cover and the axis represents a gradient from open, disturbed habitat to a closed canopy forest. DF II is most influenced by the height of the dominant hardwood, and DF III by stem density (tab. 10). Further details on the procedures used and an evaluation of the technique can be found in Smith (1983).

The position of the species along these axes represents their habitat preferences (fig. 1).

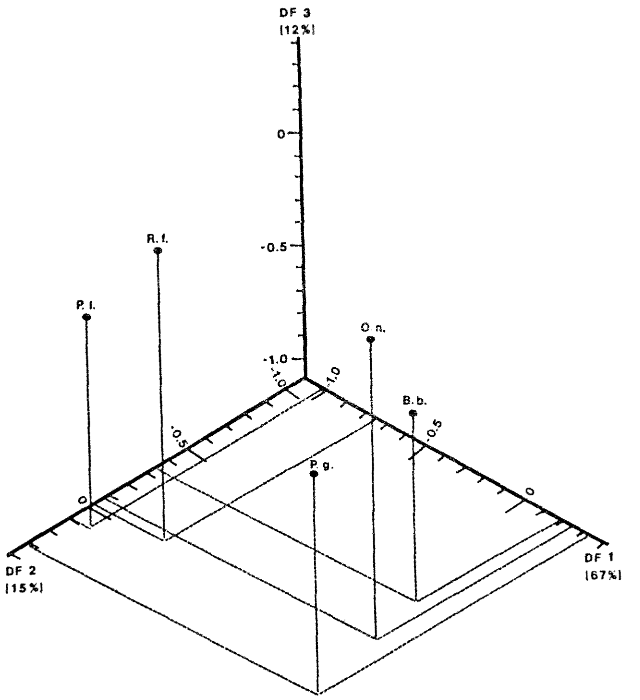

Figure 1.--Positions of the centroids for five small mammal species in 3-dimensional discriminant space. Numbers in parentheses represent the percentage of the total sample variance accounted for by each discriminant function (DF)

All species pairs are separable except *P. leucopus* and *R. fulvescens* (tab. 11).

Even though stem density was the only habitat variable not specifically associated with species differences (tab. 9), it was the most important component to discriminate function III (tab. 10), which was the variable that best separated *Peromysus leucopus* and *Reithrodontomys fulvecvens*.

Table 10.-- Standardized canonical discriminant function coefficients (DF)

Variable	Discriminant Function		
	DF I	DF II	DF III
Stand Age	0.46978	-0.35859	0.39246
% Canopy Cover	0.45420	-0.59569	0.01436
Ht of Dom Hard	0.28698	0.86985	0.07315
Stem Density	0.28445	-0.05975	0.86139
Ht Codom Hard	-0.15331	-0.58490	-0.53311
Ht Codom Pine	0.01985	0.62675	0.13738
Basal Area	0.19586	0.31282	-0.30607

Scent Posts.--Seven species visited scent posts frequently enough for the data to be analyzed statistically. The index (mean number of visits/100 stations) for the area taken as a whole was approximately 4 times greater for rabbits than for armadillos (*Dasypus novemcinctus*), foxes (*Vulpes fulva* and *Urocyon cinereoargentatus*), coyotes, or dogs (*Canis familiaris*) (tab. 12), which had indices that were approximately the same.

Table 11.-- F statistics and significance values between pairs of species. Degrees of freedom = 7 and 430)

Species	Species			
	P. g.	*P. l.*	*B. B.*	*O. N.*
P. leuco.	9.4676[1] 0.0000[2]			
B. brevi.	3.3808 0.0016	7.7030 0.0000		
O. nutt.	2.7572 0.0082	9.2423 0.0000	2.6166 0.0119	
R. fulv.	6.8926 0.0000	1.5866 0.1374	5.4443 0.0000	5.7092 0.0000

1 F value.

2 P value.

Table 12.-- Scent post indices (visits/100 stations), by species, and sample sizes required (S.S.) to detect a 20% or greater change in scent-post indices, based on the variability exhibited in 1149 scent-post nights, 1979-1981

	Statistics		
Species	Index	S. E.	S.S.
Rabbit	15.40	1.06	1609
Armadillo	4.18	0.59	1827
Raccoon	1.48	0.36	1825
Opossum	1.22	0.32	1850
Dog	3.39	0.53	1827
Fox	3.92	0.57	1828
Coyote	3.57	0.55	1868
Squirrel	0.78	0.26	1911
Bobcat	0.70	0.24	1814
Deer	0.09	----	----
Hog	0.08	----	----
Mink	0.09	----	----

For subsequent statistical analysis each night's results had to be independent. We tested the observed frequency distributions for the 3 nights with the expected binomial frequencies with X^2 tests and found differences for rabbits, foxes and coyotes. Raccoons (*Procyon lotor*) and opossums (*Didelphis virginiana*) had too many cells with expected frequencies less than 1 to be included in the analysis. Observations for the number of nights visited/3-night trapping period was therefore used as the observation for subsequent tests.

Species	X^2	p
Rabbit	34.34	<0.0005
Armadillo	0.85	>0.6
Dog	3.17	>0.2
Fox	16.53	<0.0005
Coyote	12.02	<0.005

From a runs test for independence of samples (Siegel 1956:52-56) at consecutive posts, we found that armadillos and raccoons (*Procyon lotor*) tended to be recorded at consecutive stations. This was probably due to concentrations of visits at clumps of favorable habitats along the routes rather than visits to consecutive stations by the same individuals. The stations were 0.2 mi apart, a distance probably farther than many of these animals travel in a night. The habitat was arranged in a series of patches that should have prevented random habitat distribution on the lines.

Species	Z	p
Rabbit	1.76	0.08
Armadillo	-2.01	0.04
Raccoon	-2.56	0.01
Opossum	0.43	0.67
Dog	-0.85	0.39
Fox	0.60	0.55
Coyote	-1.52	0.13

Significant seasonal differences of abundance occurred for armadillos, dogs, and foxes (tab. 13).

Table 13-- Scent-post indices (visits/100 stations) and their significance, by season, computed from the raw data set (n=1149), 1980-1981

	Index			
Species	Spring n=293	Summer n=377	Fall n=239	Winter n=240
Rabbit F=2.00,p=.11	18.08	15.12	16.74	11.25
Armadillo F=3.45,p=.02	2.05	5.31	5.86	3.33
Opossum F=2.20,p=.09	2.05	1.86	0.42	0.00
Raccoon F=.099,p=.40	2.05	1.33	2.09	0.42
Dog F=7.01,p=.00	6.48	2.65	0.42	3.75
Fox F=5.35,p=.00	3.75	0.53	5.44	7.92
Coyote F=2.48,p=.06	3.07	2.12	3.77	6.25
Squirrel	1.71	0.00	0.42	1.25
Bobcat	1.37	0.79	0.00	0.42
Total F=2.82,p=.0001	40.61	29.71	35.16	34.59

Scent post indices varied among areas for rabbits, armadillos, raccoons, and foxes (tab. 14). These differences may have been due to different proportions of habitats sampled in the different areas (tab. 1 & 2).

All species were under-sampled at scent posts in our study (*i. e.*, a 20% change in density would not be detected in the future with equal sampling intensity and variance) (tab. 12). However, the sample size required can be reduced by any method that reduces variance (for example, by sampling in 1 season only).

Night-light surveys.--Rabbits were by far the most abundant species detected on the night-light surveys. The index (mean no./100 km) for rabbits is 12 times that of the armadillo, the second most abundant species, (Tab. 15).

Rabbit indices were somewhat lower than many reported in the literature, (Fafarman and Whyte 1979, Wight 1959, and Krug 1960, *e. g.*) especially those from farmland where visibility is greater.

Table 14.-- Area scent-post indices (visits/100 stations) and their significance computed from the raw data set (n=1149), 1980-1981

	Index			
Species	Area 1 n=237	Area 2 n=341	Area 3 n=275	Area 4 n=296
Rabbit F=3.72,p=.00	18.99	18.77	12.36	11.49
Armadillo F=2.64,p=.05	5.06	5.28	4.73	1.69
Opossum F=2.06,p=.10	1.26	1.17	0.00	2.36
Raccoon F=3.23,p=.02	2.11	2.93	0.36	0.34
Dog F=1.25,p=.29	6.33	2.05	2.91	3.04
Fox F=4.47,p=.00	7.59	4.69	1.82	2.03
Coyote F=1.37,p=.25	3.38	4.39	1.82	4.39
Squirrel	1.27	0.88	0.00	1.01
Bobcat	1.27	0.00	1.09	0.67
Total F=2.49,p=.0001	7.26	40.16	25.09	27.02

Significant differences were found in the rabbit (F = 9.93, p =.0001) and opossum (F = 3.33, p = .0383) indices among areas. These differences did not correspond with the results for scent-posts. The inconsistency is almost surely due to differences in proportions of habitat type sampled among areas with the two methods. Representative sampling (*i. e.*, in proportion to habitat availability) was not achieved and was not practical for scent-posts, night-lighting, or track counting in this study because of time constraints. However, meaningful temporal comparisons could be made with these techniques if the same routes were run repeatedly in a similar manner. Locations of the routes are in Ellsworth (1983:173-176,181-182). The variability in habitat proportions can be seen by comparing results from different areas (tab. 12).

Table 15.-- Night-light indices (no./100km) and sample sizes (S.S.) of night-light counts needed to produce indices precise enough to detect 20% or greater changes in abundance, based on 183 counts (3 areas, 61 occasions), 1979-1981

	Statistics		
Species	Index	S.E.	S.S.
Rabbit	24.47	2.39	142
Armadillo	2.03	0.49	1074
Opossum	1.95	0.44	858
Raccoon	0.13	0.09	---
Striped Skunk	0.90	0.31	---
House Cat	0.50	0.22	---
Feral Hog	0.06	0.06	---
Gray Fox	0.12	0.12	---

Table 16.-- Night-light indices, (no./100 km) by area, calculated from 61 counts

	Index		
Species	Area 1	Area 2	Area 3
Rabbit[1]	14.83	37.91	20.68
Armadillo	1.14	3.16	1.80
Raccoon	0.38	0.00	0.00
Opossum	1.14	3.51	1.20
Striped Skunk	0.00	2.11	0.60
House Cat	0.19	0.70	0.60
Feral Hog	0.19	0.00	0.00
Gray Fox	0.00	0.35	0.00

[1] The variable rabbit includes swamp rabbits and eastern cottontails.

Rabbit numbers varied among Areas (F = 9.93, p = 0.0001) as did opossum numbers (F = 3.33, p = 0.0383). Sample sizes were too small to make comparisons of the other species.

Significantly different monthly indices for rabbit were found (F = 2.43, p = 0.0129) (tab. 17), with higher values in late winter and spring. Rabbit indices were largest before the reproductive season; presumably the rabbits moved to the roadside at this time to consume the new vegetation. In future surveys, more counts should be conducted when the index is large in order to facilitate comparisons. The phase of the moon did not affect the night-light indices significantly (see Ellsworth 1983).

If equal sampling intensity were used in the future, changes of density of 20% could only be obtained with rabbits (tab. 15).

Table 17.-- Night-light indices (no./100 km) for rabbit, by month, 1979-1981[1]

Month	Statistics n[2]	Index	S.E.[3]	C.V.[4]
Jan	9	27.51	10.00	109.01
Feb	36	31.55	6.36	120.89
Mar	36	36.53	7.42	121.87
Apr	18	32.93	5.86	75.50
May	21	13.06	3.67	128.80
Jun	9	16.90	7.28	129.31
Aug	3	6.09	6.09	173.21
Oct	6	7.44	4.71	155.11
Nov	21	16.68	4.92	135.10
Dec	24	14.52	4.89	164.88

[1] Each count was 18.7 km long for a total of 1140.7 km.

[2] Each sample included a count of each of the 3 areas; therefore N = 9 when 3 counts are made in each of the 3 areas. The area is the sampling unit.

[3] S.E. is the standard error of the mean (index).

[4] C.V. is the coefficient of variation of the index.

Sample sizes were low because sampling was done 1 or 2 days after a rain and the weather did not always cooperate. Drought made counting impossible in June and July 1981 (tab. 3). However, this method was the only one that detected many deer and should be continued for that reason. The deer index (mean no. of tracks/km) with equal sampling intensity in the future could detect a 40% change in density. In the future, track sampling should be more intensive.

Species list.--Thirty of the 46 species that are likely to occur in central Louisiana (Lowery 1974) were recorded in this study (tab. 18) and we obtained abundance indices for 26 of these.

Track counts.--Thirteen species were detected by track counting.

Taxon	Index[1]	S.E.
Dog	194.44	54.22
Fox	102.39	63.99
Coyote	23.54	8.16
Deer	93.42	19.45
Armadillo	59.89	10.20
Feral Hog	1.53	1.24
Rabbit	129.15	24.65
Opossum	10.28	6.10
Raccoon	12.20	3.39
Striped Skunk	1.58	0.91
Squirrel	8.28	2.74
House Cat	9.15	5.32
Bobcat	0.28	0.23

[1] Mean no. of tracks/km.

Table 18.-- Species likely to be on the study area and their status as determined by this study

Scientific name[1]	Occurrence Ind[2]	Ob[3]	sign[4]	Ab[5]
Didelphis virginiana	*	y		com
Myotis austroriparius		n		r
Pipistrellus subflavus	*	y		ab
Eptesicus fuscus		n		
Lasiurus seminolus		n		
Lasiurus borealis	*	y		ab
Lasiurus cinereus		n		
Lasiurus intermedius		n		
Nycticeius humeralis	*	y		com
Plecotus rafinesquii		n		
Tadarida braziliensis		n		
Scalopus aquaticus		y		com
Blarina brevicauda	*	y		ab
Cryptotis parva	*	y		r
Dasypus novemcinctus	*	y		ab
Sylvilagus floridanus	*	y		ab
Sylvilagus aquaticus	*	y		ab
Sciurus carolinensis	*	y		ab
Sciurus niger	*	y		ab
Glaucomys volans	*	y		com
Geomys bursarius		n	*	com
Castor canadensis		n	*	r
Oryzomys palustris		n		r
Reithrodontomys humulis		n		r
Reithrodontomys fulvescens	*	y		com
Peromyscus leucopus	*	y		com
Peromyscus gossypinus	*	y		ab
Ochrotomys nuttalli	*	y		ab
Sigmodon hispidus	*	y		r
Neotoma floridana		n		r
Microtus pinetorum		n		r
Rattus rattus		n		r
Rattus norvegicus		n		r
Mus musculus		n		r
Myocastor coypus		n	*	r
Canis latrans	*	y		ab
Urocyon cinereoargentatus	*	y		ab
Vulpes fulva	*	n	*	com
Euarctos americanus		n		r
Procyon lotor	*	y		ab
Mustela vison	*	y		com
Mephitis mephitis	*	y		com
Lutra canadensis		n		r
Lynx rufus	*	y		com
Odocoileus virginianus	*	y		ab
Sus scrofa	*	y		com

[1] Scientific names follow Lowery (1974).

[2] Data on the species was recorded by one of the techniques reported in this document.

[3] A specimen was observed (live or dead) on the study area.

[4] Only sign of the animal (*e. g.* nests, tracks, scats) was observed, not an entire specimen.

[5] Abundance was estimated from indices reported in this document, observations on the study area (specimens or sign), or if we believed none of the techniques were suitable then on the basis of Lowery (1974).

With the possible exception of some bats and human commensals, few species that are likely to be common on the study areas were missed.

Species diversity.--Different methods, sampling intensities, and sampling locations were used for different species throughout this study and species diversity calculations at any particular location could not be compared with values at other locations or in the literature.

SUMMARY AND DISCUSSION

Four of the seven techniques used to index mammals in four study areas of a "loblolly-shortleaf pine, upland hardwood" forest produced satisfactory results. Snap-trapping, scent posts, night-light surveys and track counts for different sets of species. Squirrel leaf-count surveys were efficient but had highly variable results among watersheds and could only be used to compare the same watersheds in time. Results of collecting bats could only be used for determining relative abundance shifts if identical techniques were used in the future. Predator-call surveys were unsuccessful because of the dense cover that was present at many of the sampling stations. Mammal abundance was high with respect to values found in the literature. Of the 46 mammal species believed to occur or to have occurred in central Louisiana, we found 30 and obtained usable indices of 26. Many bats were not found because of sampling problems. We also did not find commensal rodents or species such as the otter (*Lutra canadensis*) that have specialized habitat requirements.

We obtained usable indices of abundance for five small mammal species and trapped three other species. Golden mouse was the most commonly trapped species (158); next were cotton mouse (150), short-tailed shrew (107), fulvous harvest mouse (53) and white-footed mouse (49), respectively.

The short-tailed shrew was ubiquitous in the forest. There were differences in capture frequencies of cotton mice, white-footed mice, and fulvous harvest mice, among both stand types and stand ages. Golden mice captures varied only among stand ages.

Cotton mice were most abundant in "hardwood" stands and "sapling" ages and white-footed mice were most abundant in the "unforested" and "pine" stand types and the "non-stocked" and "seedling" ages. Golden mice were captured most in the early successional stages. Total captures were most frequent in the "seedling" age class.

A more specific habitat analysis with stepwise discriminant functions allowed us to identify habitat requirements in more detail. As expected, the two most closely related species, cotton mouse and white-footed mouse, had the greatest habitat separation. The cotton mouse occupied the more mature forest habitats and the white-footed mouse occupied early successional areas created by logging. The golden mouse occurred in all stages of succession but only where the understory was dense. The fulvous harvest mouse specialized in grassy areas under open canopies. The short-tailed-shrew occurred throughout the area.

The snap-trap sample size would be sufficient to determine a 20% change (a rather small change for small mammals) in abundance of the three most common species in the future if the variance were to remain the same. However, the two species with insufficient sample sizes, fulvous harvest mouse and white-footed mouse, prefer habitat types that were relatively rare and therefore sampled less. Differences in these species could be detected by increasing sample sizes in the appropriate habitats. Smaller samples would be adequate in the future if the variance could be reduced. Sampling at times of maximum trap response and density (winter in this study) would accomplish this, as well as would analyzing the results by habitat type rather than by area.

Snap-traps are poor at sampling some species such as shrews. We were able to obtain sufficient sample sizes because of the wire across the trap bar, but additional methods could be employed. Pit-fall traps would be ideal for shrews and some other small mammals, but considerable effort is required to set out and maintain a series of these traps.

We obtained information on 12 species of mammals with scent-post surveys. Many of these were game and furbearing species of economic importance. We believe sampling intensity should be increased to 2,000 post-nights in the future to increase the precision of the sample. Our sample size, 1,149 post-nights, was sufficient to make some comparisons. The study areas were almost too small, 2,000 ac each, for the required sampling intensity. Because we sampled what we thought to be all practical locations along logging roads and other areas of easy access, we could not increase the number of posts without placing them closer together. That would increase the problem of serial correlation; each post would not be an independent sample because mammals could move from post to post. Some evidence of mammals moving between posts was present in our data but the same results could have resulted from clumping of preferred habitats. We sampled 4 times/yr and sample sizes could be increased by sampling more frequently.

Different indices were found among areas for rabbit, armadillo, raccoon and fox. We believe the differences were due to different proportions of stand ages and types among areas. A knowledge of the precise habitat requirements of the species involved would be required to test this hypothesis.

Seasonal differences were found in scent-post response of armadillos, dogs, and foxes. No season was preferred by all species.

We surveyed the night-light route 61 times and observed rabbits, armadillos and opossums enough to analyze the data, but only rabbits were found with enough precision, with this sampling effort, to detect a future 20% change in abundance with sampling of the same precision.

Rabbits varied by area and month and armadillos varied by area. The differences among areas was probably due to different habitat distributions. This technique is a good one for rabbits, especially if the surveys are made at times of maximum encounter (January through April).

We found 13 identifiable wildlife track types on our counts and this method was the only suitable one for deer. It depends greatly on weather conditions and a severe drought limited our sampling during the study. We only made 45 counts but we believe approximately 180 are needed. This type of count has promise for testing deer and other mammal abundance, but care must be taken to sample at a known time after a rain or after clearing the track-bed so that the temporal span of track accumulation is known. Additionally, this method can only be used where soils are suitable. Often fill-soil associated with roads makes very good track-beds. We attempted to create beds in the forest for sampling tracks and found the soil unsuitable. We could not even detect our own tracks immediately after we made the bed. Edges of water courses were suitable for track counts in the study areas.

In conclusion, our efforts were adequate to produce indices of abundance for 26 of the 30 mammal species encountered. Sample sizes were sufficient to identify differences in abundance of some of these species with respect to habitat, area, or season. However, we were only able to detect a 20% change in abundance in four species when all the data for a method were grouped together. Grouping of all the data together would be done if comparisons of the entire study area were to be done because of future treatments on an area basis. Grouping the data together will result in reduced variance and increased efficiency only where there are no differences in the abundance indices among the units lumped. We found differences in indices in many situations and believe if comparisons are to be made in the future, they should be made by habitat or season so as to reduce the variance and the required sample sizes. Comparison among study areas are impractical because of different mixes of habitats and management among them. Furthermore, temporal comparisons at any place would only be possible where there were no changes in habitat that were unrelated to treatment at that place between the times of the comparisons.

LITERATURE CITED

Bullard, R. W., S. A. Shumake, D. L. Campbell, and F. J. Turkowski. 1978a. Preparation and evaluation of a synthetic fermented egg coyote attract and deer repellent. J. Agric. Food Chem. 26(1):180-183.

Bullard, R. W., J. J. Leiker, J. E. Peterson, and S. R. Kilburn. 1978b. Volatile components of fermented egg, an animal attractant and repellent. J. Agric. Food Chem. 26(1):155-159.

Ellsworth, S. W. 1983. Mammalian abundance indices in the loblolly-shortleaf pine, upland hardwood forest type of central Louisiana. M.S. Thesis, Louisiana State University, Baton Rouge. 188pp.

Fafarman, K. R., and R. J. Whyte. 1979. Factors influencing night-time counts of cottontail rabbits. J. of Wildl. Manage. 43(3):765-767.

Hamilton, R. B., and G. D. Lester. 1987. Bird habitat use and its measurement on the Catahoula District of the Kisatchie National Forest, Louisiana. [elsewhere in this volume]. pp.

Helwig, J. T., and K. A. Council, eds. 1979. SAS user's guide. SAS Institute, Raleigh, N. C. 494pp.

Krug, A. S. 1960. Evaluation of intensified rabbit management procedures on public areas in south-central Virginia. M.S. Thesis, Virginia Polytechnic Institute, Blacksburg. 68pp.

Linhart, S. B., and F. F. Knowlton. 1975. Determining the relative abundance of coyotes by scent station lines. Wildl. Soc. Bull. 3:119-124.

Linn, H. 1963. A theory of small mammal trapping. Proc. Intern. Congr. Zool. 16:234-242.

Lowery, G. H., Jr., 1974. The mammals of Louisiana and its adjacent waters. Louisiana State University Press, Baton Rouge. 565pp.

Morrison, D. W. 1981. Evaluation of specific variables for a scent station survey in north central Louisiana. M.S. Thesis, Louisiana Tech University, Ruston. 35pp.

Nie, N. H., C. H. Hall, J. G. Jenkins, K. Steinbrenner, and D. H. Bent. 1975. Statistical package for the social social sciences. McGraw-Hill, New York. 675pp.

Reed, D. P. 1981. Understory vegetative yield in the loblolly-shortleaf pine-upland hardwood forest type, Louisiana. M.S. Thesis, Louisiana State University, Baton Rouge. 257pp.

Roughton, R. D., and Sweeny. 1982. Refinements in scent station methodology for assessing trends in carnivore populations. J. Wildl. Manage. 46(1):217-229.

Ruffner, J. 1980. Climates of the states. .Gale Research Co., Detroit. Vol. 1:321.

Siegel. S. 1956. Nonparametric statistics for the behavioral sciences. McGraw-Hill, New York. 633pp.

Smith, J.C. 1983. Community structure of small mammals in a southern pine forest, with comment on multivariate niche analysis. M.S. Thesis, Louisiana State University, Baton Rouge. 61pp.

Steele, R. G. D., and J. H. Torrie. 1980. Principles and procedures of statistics: a biometrical approach. McGraw-Hill, New York. 633pp.

Wight, H. 1959. Eleven years of rabbit population data in Missouri. J. Wildl. Manage. 23(1):34-39.

Bird Habitat Use and its Measurement on the Catahoula District of Kisatchie National Forest

Robert B. Hamilton and Gary D. Lester

Abstract.--Indices of avian abundance were obtained and compared from transect and point-count data for five stand ages and five stand types on four study areas. From 33 to 134 ac were needed to achieve stable diversity. Diversities varied with season, habitat, and sample size. Transects were more efficient than point-counts.

INTRODUCTION

The "loblolly-shortleaf pine-upland hardwood" forest type is a widespread habitat in the South and occupies about 70 million acres of the Upper Coastal Plain from east Texas and Oklahoma to Florida and Virginia (Byrd and Lewis 1976). It is possible that the flora and fauna of this forest type have undergone change after cattle grazing was initiated with the arrival of the Spanish in the 16th century.

Because of the controversy concerning the effects of cattle grazing on national forests of the South, in 1979 the Southern Forest Experiment Station, USDA Forest Service, began a 10-yr study on the effects of cattle grazing in the "loblolly-shortleaf pine-upland hardwood" and "longleaf pine" forest types. The ultimate objective of the study was to promote sound multiple-use management on southern forest lands. Three phases were identified in the study plan:

1) Gathering pre-grazing baseline data on soils, water, vegetation, and wildlife.

2) Institution of livestock grazing at three intensity levels.

3) Repeating measurements performed in Phase 1.

This study is part of Phase 1; subsequent phases were terminated prematurely because of funding problems.

Methods employed in a base-line study on large tracts with many habitats of various ages should be efficient. Point count and transect methods are both relatively cost-effective (Dawson 1981) and we used both methods in order to evaluate their effectiveness.

Species diversity is an important community parameter that reduces to one number large amounts of relative abundance data (Hair 1980:269). All of the more than a dozen ways that have been used to evaluate species diversity (Peet 1974) depend to some degree on area sampled. However, the sample area required for a valid species diversity measurement is not known.

Specific objectives of this study were to

1) report baseline information on avian abundance on the habitats of the study area;

2) compare point count and line transect techniques;

3) investigate the minimal sample size required for calculating valid bird species diversity (BSD) indices for the habitats of the study area; and

4) examine variation in BSD and other community parameters on the study areas.

We want to thank all those who helped to make this study possible. The field work was financed by the U.S. Forest Service and the LSU Agricultural Center and Louisiana Agricultural Experiment Station. Most of the work was performed by Gary Lester and the data on species diversity were used in his M. S. Thesis. The majority of the field work was done by Gary Lester with the assistance of Steve Ellsworth and Clint Smith aided by students, Loyd Mitchell, Bill Hickman, and Kathy Fouchi. Dr. Robert Noble and Don Reed helped with vegetation analysis and set up the vegetation transects that we used. Ahmed Alwi and Mark Dugas of the Department of Experimental Statistics, Louisiana State University, aided in the statistical analysis and computer programming. We appreciate the help we received from Forest Service employees, especially Dr. Henry Pearson who provided living quarters near the study areas and assisted in many other ways.

STUDY AREA

Field work was conducted on four study areas in the Catahoula Ranger District of the Kisatchie National Forest. Each of the study areas is approximately 2000 ac of predominantly "loblolly-shortleaf pine-upland hardwoods". Areas 1-3 are traversed by maintained gravel roads and Area 4 is bisected by a single paved parish road. The terrain is level to gently rolling with a maximum slope of 10%. Elevations are between 140 ft and 290 ft above sea level. The upland soils are moderately well-drained and consist of loamy topsoils and clayey or loamy subsoils. In the stream bottoms, soils are loamy and poorly drained.

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The study areas are in the south-central portion of Grant Parish, approximately 25 mi north of Alexandria, Louisiana. Area 2 is contiguous with Area 3 on its north boundary and lies 1.82 mi west of Dry Prong. Area 1 is 0.6 mi northeast of these areas and Area 4 is about 7.8 mi southwest (fig. 1).

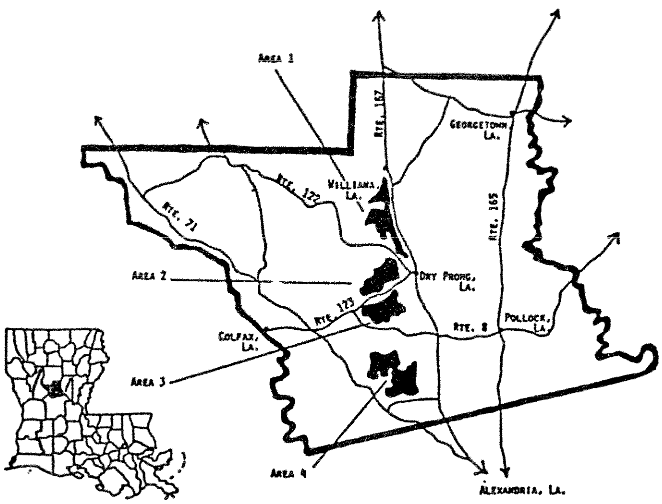

Figure 1.-- Location of the four study areas in Grant Parish, Louisiana.

Stand-Age Classes

The vegetation had been previously sampled by Reed (1981). He identified five stand ages that were based on age or dbh of dominant trees. Less than 4.5% of the total plots were of the "unstocked" or "seedling" type, and although some of the bird plots occurred in these types, there were not enough to be used for analysis of avian diversity.

As determined by Reed (1981), "sawtimber" was the most frequently occurring age type on each of the study areas (mean = 56.2%), with a low frequency of 40.3% on Area 1 and a high of 76.7% on Area 4. Poles were the next most frequent (mean = 23.2%). In general, the mean age distribution on the study areas is what would be expected with the prevailing management. The stand age distribution was somewhat different among study areas (tab. 1).

Age distribution in the bird plots also varied greatly among study areas, but for the total area bird plot distribution corresponded closely with the total plot distribution. "Sapling" and "sawtimber" were slightly over-sampled and "pole" was slightly under-sampled (tab. 1).

Habitat age distribution of bird study plots in each study area also corresponded closely with the habitat distribution for the total study area. Therefore, any differences found in avian abundance among areas probably could not be attributed to non-representative sampling.

Table 1.-- Relative frequency of occurrence (%) of forest stand ages in each study area and in bird plots, Catahoula Ranger District, Kisatchie National Forest, Dry Prong, Louisiana, 1980

	Area				
Stand Age	1	2	3	4	Total
Unstocked					
Total Area	0.7	0.4	0.0	11.5	2.9
Bird Plots	0.9	0.0	0.0	14.8	3.8
Seedlings					
Total Area	0.7	17.0	0.0	0.0	4.3
Bird Plots	1.8	18.2	0.0	0.0	5.4
Saplings					
Total Area	18.3	8.3	24.5	0.9	13.4
Bird Plots	17.1	12.9	33.1	0.9	16.1
Poles					
Total Area	40.3	29.5	7.2	11.0	23.2
Bird Plots	20.7	27.3	4.1	9.6	15.7
Sawtimber					
Total Area	40.0	44.8	68.3	76.6	56.2
Bird Plots	59.5	41.7	62.8	74.8	59.1

Stand Types

Reed (1981) classified the vegetation into eight stand types. We felt that his distinctions were finer than necessary for our bird sampling and collapsed his types into five. We called his "loblolly-shortleaf, occasional longleaf pine forest"[1] "pure pine" for brevity. Three of his categories: "loblolly-shortleaf pine-upland hardwood", "loblolly-shortleaf-longleaf pine-upland hardwood", and "upland hardwood", were combined into the category "pine-upland hardwood". Our "pine-streambottom hardwood" consists of his "streambottom hardwood" and "loblolly-shortleaf pine-streambottom hardwood-occasional longleaf pine". We used the modified stand type classification when reporting indices of abundance for birds.

The relative proportions of these types varied considerably among the study areas but overall our sample rather closely matched the type distribution as determined by Reed (1981) (tab. 2). "Pine-upland hardwoods" was the predominant stand type (mean = 62.0%) with a frequency varying from 40.3% on Area 2 to 82% on Area 1. "Pure pine" was frequent on Areas 2 and 4 and hardwoods were especially abundant on Areas 1 and 3. The unforested type was especially abundant in Area 4 (tab. 2).

Stand type frequency distributions more closely matched that of the vegetation transects than stand age frequency distributions (tabs 1 & 2) and results for stand type are not likely to be biased by non-representative sampling.

[1] Descriptions of stand types can be found in Reed (1981)

To make meaningful diversity comparisons among locations of different sizes, diversity at all places of interest must have a constant or nearly constant value that is not affected by the area of the samples, or comparisons must be made among areas of equal size -- the size of the smallest area to be compared. Because using the smallest sample area is undesirable for a variety of reasons, our goal was to find the minimum plot size necessary to attain a stable diversity value. This would facilitate making comparisons among areas and would also provide a diversity value comparable to similarly attained literature values. To maximize our chances of achieving a sufficient sample size for diversity comparisons, we grouped the habitat types even further than described earlier. We included the relatively rare "upland hardwoods" with the "pine-upland hardwoods" and the rare "streambottom hardwoods" with "pine-streambottom hardwoods". This resulted in three rather unique habitat types, each with sample sizes as large as practical.

Ecological Description

The study areas are typical of the "loblolly-shortleaf pine-upland hardwood" forest type. Reed (1981) found that hardwoods constituted 45% of the total basal area. The most prevalent hardwoods were southern red oak (*Quercus falcata*)[2], post oak (*Q. stellata*), blackjack oak (*Q. marilandica*), hickories (*Carya* spp.), sweetgum (*Liquidambar styraciflua*), magnolias (*Magnolia* spp.) blackgum (*Nyssa sylvatica*), flowering dogwood (*Cornus florida*), and red maple (*Acer rubrum*). The major conifers were loblolly pine (*Pinus taeda*), shortleaf pine (*P. echinata*), and longleaf pine (*P. palustris*). Reed (1981) found 180 understory taxa in the study areas, among which yellow jasmine (*Gelsemium sempervirens*), blackberry (*Rubus* spp.), and waxmyrtle (*Myrica cerifera*) were the most frequent. As a whole, the study areas is a patchy collection of internally homogeneous habitats that differ by forest type and stand age. The boundaries between the habitats tend to be relatively sharp. Many large even-aged blocks of 50-200 ac of various ages were present.

Management

The study areas had once been used as open range for cattle and hogs, but there had been no legal grazing on them for the 20 years prior to the study. The forest is presently managed for the production of timber and pulp wood. Clearcutting and prescribed burning are extensively practiced. Regeneration is often done by the seed tree method or by planting.

[2] Scientific names of plants are from Radford et al. (1968).

Table 2.-- Relative frequency of occurrence (%) of forest stand types in each study area and in bird plots, Catahoula Ranger District, Kisatchie National Forest, Dry Prong, Louisiana, 1980

Stand Type	Area 1	2	3	4	Total
Unforested					
Total Area	0.3	0.0	0.0	11.5	2.7
Bird Plots	0.9	0.0	0.0	14.8	3.8
Pine-Upl[1] Hards[2]					
Total Area	82.0	40.3	70.5	50.2	62.0
Bird Plots	79.3	43.9	71.1	54.8	61.6
Upland Hardwoods					
Total Area	0.3	3.3	1.2	0.4	1.3
Bird Plots	0.0	3.0	1.7	0.9	1.5
Str[3] Hardwoods					
Total Area	1.4	0.4	1.7	1.8	1.3
Bird Plots	0.9	0.0	0.0	3.5	1.0
Pine-Str Hards					
Total Area	6.4	8.3	21.9	3.5	9.9
Bird Plots	8.4	9.8	25.6	2.6	11.7
Pure Pine					
Total Area	9.5	47.7	4.6	32.6	22.8
Bird Plots	10.8	43.2	1.7	23.5	20.5

[1] Upl = upland.

[2] Hards = hardwoodas.

[3] Str = streambottoms.

METHODS AND PROCEDURES

Because of the many different combinations of stand types and stand ages that were present, the relatively small size of some of them, their scattered distribution, and the inaccessibility of some of them with respect to passable roads, we did not attempt to sample only one habitat at a time but used procedures that would let us gather data continuously at a maximum rate in all habitats. We accomplished this by primarily sampling along transects and by using starting and stopping points that had convenient access. Although we used belt transect lines, we subdivided them and analyzed the results as plots, with the habitat characteristic of each plot being that of the associated vegetation sample. We gathered data at its times of maximum availability and we gathered as much data as possible at or between the existing vegetation sampling points so as to minimize the amount of vegetation sampling necessary. For testing sampling procedures, we alternated sampling schemes along the same transect lines during each sample count; this protocol not only was efficient, but it minimized variability between methods due to extraneous factors such as weather, time of day, and time of year.

Field Methods

A variety of field methods was used in this study. The primary sampling of birds was conducted along transects superimposed on vegetation sampling transects that had already been established by Reed (1981) and included sampling points every 200 ft. Reed's lines included 1000 vegetation sampling points and totaled 38 mi in length. Transects were continuous in each area and generally ran either east-west or north-south, with perpendicular turns near area boundaries. In addition, nocturnal counts were made along existing roads. Each sampling point had been marked with a yellow flag mounted on a 3-ft tall stiff wire and attached to a 3½ ft steel reinforcing rod. Orange plastic flagging was used to help mark the transects.

Transects.--In each area, we selected two segments of the vegetation transects that reflected that area's stand composition (tabs. 1, 2) and used these segments for bird sampling. Additionally, an attempt was made to limit to two the number of stand ages/transect and to make end points easily accessible. In order to meet these criteria, it was necessary to alter the transect routes somewhat by establishing, a total of 10 new points at critical locations. The resulting lines served as mid-points for a continuous series of both bounded and unbounded belt-transects plots. For bounded plots, birds were counted for an estimated 25 m (82 ft) on each side of the transect. This width was selected because it was the smallest distance that allowed a reasonable chance of detecting birds in the densest habitats. The plot border along the transect line of each plot was midway between vegetation sampling points, or 100 ft from the center. Each plot was therefore 200 by 164 ft, or 0.753 ac.

Sampling began at dawn or soon afterwards and lasted approximately 4 hrs. It took approximately 3 minutes to sample each transect plot and we sampled one transect each morning. The number of plots that could be completed before avian activity declined significantly in a morning was estimated to be about 60. Opposite ends of the bird transects were used as points of origin on alternate counts, where possible. Data were gathered during 4 periods: winter 1980 (1 Jan. to 31 Mar.), summer 1980 (1 May to 31 July), winter 1981 (1 Dec. 1980 to 13 Mar. 1981), and summer 1981 (1 May to 2 July). These dates were chosen to reduce the number of migrating birds we encountered.

All birds heard or seen initially within the plots were counted. Birds flying overhead that were merely in transit over the plots were not included.

Circular Plots.--In conjunction with the transect counts, circular point-count plots were sampled for 3 minutes at every fifth plot center. All birds heard or seen using the area within an estimated 25 m (82-ft) radius of the center were tabulated.

Nocturnal owl counts.--We conducted counts at night by driving and stopping every 0.5 mi along the main roads. We started about 30 minutes after sunset, and counted the birds heard or seen in 3 minutes at each stop point.

Statistical Methods

Because of the intermixing of habitats (by "habitat" we mean a discrete block of a particular stand/age class) along the transects and the lack of large blocks of continuous habitats, each habitat type was sampled haphazardly with respect to block size and in no case were the block size patterns consistent among habitats and transects (see Lester 1983, fig. 6-13). Diversity is dependent on block size (Hair 1980), and has only properly been compared among habitats of the same size. Without using a meaninglessly small block size, we could not compare diversities of different block sizes on our transects. If diversity increased with area until reaching a horizontal asymptote, it could be compared among sites as large or larger than necessary to achieve such an asymptote. We attempted to ascertain if the areas sampled were large enough for diversity to reach an asymptote by plotting diversity-area curves.

To calculate a Brillouin index of diversity, we used the formula

$$H = (1/n) \ln N! - \textstyle\sum \ln n_i!$$

where N is the total number of individuals in the collection and n_i is the number of individuals of the ith species. We used the Brillouin index (H) (Brillouin 1962, Margalef 1958, and Pielou 1975) rather than the Shannon-Weaver H' (Shannon and Weaver 1949) because the Brillouin does not require the assumption of random bird distribution and because it is not biased at non-infinite sample sizes. We used the jackknife method in the diversity calculations. so that statistical comparisons could be made among diversities at different places. Zahl (1977) and Heltshe and Bitz (1979:140-142) discussed the application of the jackknife procedure to the Brillouin index to reduce bias and to estimate sampling variance.

We used the IBM 3033 computer at the Systems Network Computer Center, Louisiana State University, to generate diversity-area curves by randomly selecting plots of a desired habitat type, calculating diversity, and plotting the curves. For the plots, diversity was the dependent variable and number of plots (area) was the independent variable. As each additional plot was added to the sample, we recalculated the diversity of the synthetic community that had accumulated. Diversities were deemed to be comparable when enough plots were available for H values to reach an asymptote, which was defined as a diversity change of less than 0.05/10 plots.

We compared areas (number of plots) necessary to obtain a stable diversity and the diversities themselves with F and t tests, where appropriate. The area required for stable diversity estimates was regarded as a measure of environmental complexity.

F and t tests were used to compare point and transect count methods. An alpha level of 0.05 was used for all tests. Computations were performed using programs of the Statistical Analysis System (SAS) (Helwig and Council 1979).

RESULTS

The number of combinations among four study areas, five stand ages, five stand types, two seasons and the presence of 106 observed bird species precludes the inclusion in this report of tables of the number of birds, by species, that occur with each combination of variables. Potentially 200 tables, each with a number of empty cells, would be required. Data included in this report were obtained for plot types for which relatively large sample sizes existed; at times we obtained these sample sizes by grouping the data in meaningful ways. No data for individual species are included except for one summary tabulation.

The weather was more or less typical for the area (Hamilton et al. 1987:tab. 3), but was not analyzed with respect to bird numbers. There were only 4 days with maximum temperatures over 100½ F in the study period, 3 in July and 1 in August 1980. Because we do not know what the various index values are in "typical years" we are unable to evaluate the influence of weather on the data.

Species Abundance and Richness

The species found in the study are listed below with the number of times (N) each was seen.

Common Name[3]	Scientific Name	N
N. Cardinal	*Cardinalis cardinalis*	771
Blue Jay	*Cyanocitta cristata*	427
Carolina Wren	*Thryothorus ludovicianus*	422
White-eyed Vireo	*Vireo griseus*	389
Tufted Titmouse	*Parus bicolor*	358
Pine Warbler	*Dendroica pinus*	350
Hooded Warbler	*Wilsonia citrina*	335
Car. Chickadee	*Parus carolinensis*	326
Red-eyed Vireo	*Vireo olivaceus*	321
R.-b. Woodpecker	*Melanerpes carolinus*	268
Acadian Flycatch.	*Empidonax virescens*	218
Yl.-breasted Chat	*Icteria virens*	218
American Crow	*Corvus brachyrhynchos*	196
N. Bobwhite	*Colinus virginianus*	128
Kentucky Warbler	*Oporornis formosus*	120
Summer Tanager	*Piranga rubra*	118
B.-and-w. Warbler	*Mniotilta varia*	116
Ruf.-sided Towhee	*Pipilo erythrophthalmus*	111
Wood Thrush	*Hylocichla mustelina*	107
Ru.-cr. Kinglet	*Regulus calendula*	105
B.-g. Gnatcatcher	*Polioptila caerulea*	103
Yel.-rp. Warbler	*Dendroica coronata*	101
Pil. Woodpecker	*Dryocopus pileatus*	97
Yel.-thr. Vireo	*Vireo flavifrons*	88
N. Flicker	*Colaptes auratus*	84
Yel.-bil. Cuckoo	*Coccyzus americanus*	79
E. Wood-Pewee	*Contopus virens*	78
American Robin	*Turdus migratorius*	76
Mourning Dove	*Zenaida macroura*	75
G. Cr. Flycatcher	*Myiarchus crinitus*	72
Brown Thrasher	*Toxostoma rufum*	71
Hermit Thrush	*Catharus guttatus*	63
Br.-hd. Nuthatch	*Sitta pusilla*	62
Rd.-br. Nuthatch	*Sitta canadensis*	60
Worm-eat. Warbler	*Helmitheros vermivorus*	56
Br.-hd. Cowbird	*Molothrus ater*	53
Indigo Bunting	*Passerina cyanea*	49
Yel.-br. Sapsucker	*Sphyrapicus varius*	40
Gd.-cr. Kinglet	*Regulus satrapa*	37
Com. Grackle	*Quiscalus quiscula*	27
Wh.-thr. Sparrow	*Zonotrichia albicollis*	27
Downy Woodpecker	*Picoides pubescens*	24
R.-h. Woodpecker	*Melanerpes erythrocephalus*	22
Fish Crow	*Corvus ossifragus*	20
Cattle Egret	*Bubulcus ibis*	17
Prairie Warbler	*Dendroica discolor*	16
Com. Yellowthroat	*Geothlypis trichas*	13
Brown Creeper	*Certhia americana*	12
Br.-winged Hawk	*Buteo platypterus*	11
N. Mockingbird	*Mimus polyglottos*	10
Turkey Vulture	*Carthartes aura*	10
Eastern Phoebe	*Sayornis phoebe*	9
Dark-eyed Junco	*Junco hyemalis*	8
Gray Catbird	*Dumetella carolinensis*	8
Hairy Woodpecker	*Picoides villosus*	8
Barred Owl	*Strix varia*	7
Cedar Waxwing	*Bombycilla cedrorum*	7
Chipping Sparrow	*Spizella passerina*	7
Fox Sparrow	*Passerella iliaca*	7
Sh.-shinned Hawk	*Accipiter striatus*	7
Am. Woodcock	*Scolopax minor*	6
Black Vulture	*Coragyps atratus*	6
Orchard Oriole	*Icterus spurius*	6
Rd.-sh. Hawk	*Buteo lineatus*	6
Ch.-will's-widow	*Caprimulgus carolinensis*	5
Am. Goldfinch	*Carduelis tristis*	4
Bachman's Sparrow	*Aimophila aestivalis*	4
O.-cr. Warbler	*Vermivora celata*	4
Red-tailed Hawk	*Buteo jamaicensis*	4
R.-th. Hummingbird	*Archilochus colubris*	4
Song Sparrow	*Melospiza melodia*	4
Field Sparrow	*Spizella pusilla*	3
Wh.-cr. Sparrow	*Zonotrichia leucophrys*	3
American Kestrel	*Falco sparverius*	2
Blue Grosbeak	*Guiraca caerulea*	2
Chimney Swift	*Chaetura pelagica*	2
Cooper's Hawk	*Accipiter cooperii*	2
Northern Oriole	*Icterus galbula*	2
Proth. Warbler	*Protonotaria citrea*	2
Purple Finch	*Carpodacus purpureus*	2
Mississippi Kite	*Ictinia mississippiensis*	2
R.-w. Blackbird	*Agelaius phoeniceus*	2
Wh.-fronted Goose	*Anser albifrons*	2
Winter Wren	*Troglodytes troglodytes*	2
Wood Duck	*Aix sponsa*	2
Y.-cr. Night-Heron	*Nycticorax violaceus*	2
Eastern Kingbird	*Tyrannus tyrannus*	1

[3] Common and Scientific names of birds are from the AOU Check-list (AOU 1983).

Gr.-backed Heron	*Butorides striatus*	1
Lark Sparrow	*Chondestes grammacus*	1
Little Blue Heron	*Egretta caerulea*	1
Loggerhead Shrike	*Lanius ludovicianus*	1
Northern Parula	*Parula americana*	1
Painted Bunting	*Passerina ciris*	1
Scarlet Tanager	*Piranga olivacea*	1
Snow Goose	*Chen caerulescens*	1
Solitary Vireo	*Vireo solitarius*	1
Swainson's Warb.	*Limnothlypis swainsonii*	1
Eastern Bluebird	*Sialia sialis*	1
Great-horned Owl	*Bubo virginianus*	1
E. Screech Owl	*Otus asio*	1
Swamp Sparrow	*Melospiza georgiana*	1
Wild Turkey	*Meleagris gallopavo*	1
House Wren	*Troglodytes aedon*	1
Un. species		69
Un. vireo		46
Un. woodpecker		5
Un. hawk		4

A total of 106 species was identified in the study areas, with Northern Cardinal, Blue Jay, Carolina Wren, White-eyed Vireo and Tufted Titmouse being the most common. Approximately half of the species seen were encountered less than 10 times each.

No endangered species were found. Some migratory species, such as the Hooded Warbler, Kentucky Warbler, and Worm-eating Warbler, that are considered threatened by some people were relatively abundant and the density of Black-and-white Warblers was higher than we have encountered elsewhere in Louisiana. Few game birds were found.

Mean numbers of species and individuals per plot varied among seasons and area (tab. 3).

In each study area, mean density (mean number of individuals/plot) and mean species richness (mean number of species/plot) were higher in the winter of 1981 than the winter of 1980. This relationship was not as pronounced in Area 2 as in Areas 1 and 3 (Area 4 was not sampled the first winter). In the summer, the pattern was reversed with mean density and mean species richness being lower in 1981 than 1980, except for Area 2. In all cases, the comparisons in time were the same for both mean number and mean species richness.

When the data are analyzed by stand type, patterns were discernible although the absolute results for mean density (mean number of individuals/plot) and mean species richness (mean number of species/plot) were quite variable (tab. 4). Much of the variability is probably related to the relatively small sample sizes. The largest mean number of species (8.5) occurred on the "upland hardwood" plots of Area 3 in the summer of 1980. The second largest number (8) was on the same plots in the summer of 1981. The most individuals (17) were on the hardwood plots of Area 2 in the winter of 1981 and second most (11.5) were on the hardwood plots of Area 3 in the summer of 1981. On the other hand, no birds were found on the hardwood plots of Area 4 in the summer of 1981 (tab. 4). There was a tendency for "upland hardwood-pine" plots to have the highest numbers of individuals and species.

Table 3.-- Average number of individuals and species recorded per plot using the line transect and timed area count techniques during 1980 and 1981, by area

AREA	YEAR	SEASON	NUMBERS	SPECIES
1	1980	Winter	3.20588	1.52727
1	1980	Summer	5.70370	4.55455
1	1981	Winter	6.63043	3.01852
1	1981	Summer	3.63918	2.97115
2	1980	Winter	5.11688	1.40769
2	1980	Summer	4.39623	2.95276
2	1981	Winter	5.93333	2.11538
2	1981	Summer	7.30400	5.17692
3	1980	Winter	4.08696	2.11667
3	1980	Summer	7.49167	6.19167
3	1981	Winter	6.18692	3.80000
3	1981	Summer	6.75214	5.73333
4	1980	Summer	6.32456	5.03509
4	1981	Winter	8.30488	1.93913
4	1981	Summer	5.12150	3.63158

With respect to stand age means, results were again quite variable. The highest mean number of species/plot, 12, was found on "seedling" plots of Area 1 in the winter of 1980 as were the most individuals/plot, 15.5. There were no birds found on "pole" plots of Area 4 in the summer of 1981 (tab. 5). No specific pattern emerges from the data, however.

When plots were grouped together by stand type, the most species (48) were on "upland hardwood-pine" in the summer of 1980. Fewest species were (19) in "pole" stands in the summer of 1980 and (17) in the "streambottom hardwood-pine" in the winter of 1980 (tab. 6). The pattern of total number of species increasing in the winter between 1980 and 1981 and decreasing in the summer was again evident and seems unrelated to sample sizes.

When all plots of each stand age were grouped together, the largest number of species (40) was found on "sawtimber" plots in the winter of 1981 (tab. 7). The total number found may be affected by the size of the area sampled (These results can be obtained in tab. 6 and 7 by adding the areas that correspond to the number of plots in the "T" columns for point count and transect methods). In the winter, the total number of species for each age type was higher in 1981 than 1980 but the number present in summer tended to decrease between the 2 years. The differences do not appear related to number of plots sampled; in fact, the largest differences occurred in the "sawtimber" type, the one with the largest sample size (tab. 7).

Species Diversity

Species diversity for both transect and point-count data was calculated for the three stand ages for which we believed there were enough data and for the three stand types in the collapsed habitat type classification (tabs. 6 & 7). We generated diversity by area curves for these habitats, thereby enabling us to evaluate where our sampling intensity was sufficient. Curves for "upland hardwood-pine" are shown for the winter of 1980 (fig. 2) and the summer of 1981 (fig. 3).

The patterns are different for the two seasons and the number of plots required to reach a stable diversity is quite different. The number of plots required for diversity to stabilize for transect counts varied from a low of 44 (33 ac) in "pure pine" in the winter of 1980 to a high of 182 (134 ac) in "sawtimber" in the summer of 1981 (tabs. 6 & 7). A significant difference was found in the number of plots required to attain stability (tab. 6 & 7) in summers between "upland hardwood-pine" stands (145 plots) and "pure pine" stands (67 plots). There was no difference in the winter.

It was necessary to use data from all study areas together to achieve sufficient sample sizes for a habitat to attain H stability. This could not be done if the null hypothesis being tested were that there were "no differences among areas (treatments)". If data from individual habitats could be grouped together because of the lack of statistical differences among them to attain a sufficient sample, it would be desirable to choose study areas as matched as possible in frequency distribution of habitats and in management in order to increase the precision of the sample.

Even with the collapsed habitat classification, we sampled intensively enough to determine valid diversities in only two stand types out of three ("upland hardwood-pine" and "pure pine") and only in one stand age out of three ("saw-timber") in all seasons (tabs. 6 & 7).

There was a significant difference between winter and summer H values in pine stands, and there was no seasonal difference for "upland hardwood-pine" stands.

Among stand age classes, valid H values were determined in both seasons only for "sawtimber" stands in all seasons, but no statistical differences were found between seasons even though the trend is in the expected direction (tab. 6).

Method Comparisons

We did not analyze the unbounded counts because our ability to find various species varied with distance, and our experience in the field led us to doubt the validity of unbounded transects for our sampling situation. Although observers should be alert for endangered species and birds at the higher trophic levels that may occur outside of the transect proper in order to document species composition, we believe that using unbounded transects is unnecessary. We did not observe any species in the unbounded counts that we did not find in the bounded counts.

Table 4.-- Average number of individuals and species recorded per plot using the line transect and timed area count techniques during 1980 and 1981 (by stand type within each area)

		Area 1		Area 2		Area 3		Area 4	
S[1]	T[2]	#	Sp.	#	Sp.	#	Sp.	#	Sp.
1	0	2.00	1.00	----	----	----	----	----	----
1	1	3.44	1.68	3.50	1.46	5.66	2.86	----	----
1	2	----	----	2.00	1.50	----	----	----	----
1	3	8.00	3.00	----	----	----	----	----	----
1	4	2.80	2.16	2.50	0.84	2.33	0.92	----	----
1	5	1.75	0.66	2.40	1.42	2.37	1.70	----	----
1	7	3.20	1.33	7.51	1.48	----	----	----	----
2	0	7.00	7.00	----	----	----	----	9.00	5.70
2	1	5.44	4.22	3.90	2.72	7.27	6.07	5.23	4.52
2	2	----	----	7.00	3.25	11.50	8.50	2.00	2.00
2	3	4.00	4.00	----	----	----	----	6.50	5.00
2	4	6.77	5.88	5.16	3.76	7.80	6.45	6.00	5.33
2	5	6.62	5.37	5.71	4.57	7.47	6.00	5.63	5.09
2	7	5.18	4.27	4.26	2.73	6.00	5.50	7.14	5.62
3	0	1.00	1.00	----	----	----	----	10.10	2.82
3	1	6.13	2.97	6.90	2.33	6.63	3.98	12.00	1.42
3	2	----	----	17.00	2.25	9.00	7.50	4.00	4.00
3	3	2.00	2.00	----	----	----	----	4.00	1.50
3	4	3.87	2.62	4.70	2.30	4.92	3.48	2.50	1.00
3	5	8.90	3.13	2.66	0.85	6.06	3.21	5.00	1.90
3	7	10.00	3.66	5.16	2.01	10.00	4.50	5.16	2.01
4	0	1.00	1.00	----	----	----	----	7.05	4.82
4	1	3.81	3.14	8.83	5.13	6.82	5.80	4.59	3.63
4	2	----	----	1.50	1.50	12.50	8.00	0.00	0.00
4	3	1.00	1.00	----	----	----	----	5.00	3.25
4	4	3.37	3.12	6.00	5.61	6.36	5.78	3.33	2.66
4	5	3.46	2.33	5.00	4.57	6.36	5.78	7.00	3.54
4	7	3.50	3.00	6.98	5.45	8.00	5.00	4.32	3.19

[1] Season: 1 = winter 1980, 2 = summer 1981, 3 = winter 1981, 4 = summer 1983.

[2] Stand Type: 0 = "non-forested", 1 = "loblolly, shortleaf, upland hardwoods", 2 = "upland hardwoods", 3 = "streambottom hardwoods", 4 = "loblolly, shortleaf, streambottom hardwoods, occasional longleaf", 5 = "loblolly, shortleaf, longleaf, upland hardwoods", 7 = "loblolly ,shortleaf, occasional longleaf".

Nocturnal Counts

Screech Owls, the most abundant nocturnal bird, were found an average of 1.22 times/stop. There were obvious seasonal differences that were probably related to seasonal detectability differences as well as to the expected seasonal abundance pattern changes. Barred Owls, which are usually regarded as a bottomland species, were much more abundant than Great Horned Owls (table 8). Chuck-will's-widow was relatively abundant, 0.44/stop, when it was present during its breeding season (tab. 8).

Table 5.-- Average number of individuals and species recorded per plot using the line transect and timed area count techniques during 1980 and 1981 (by stand age within each area)

S[1]	A[2]	Area 1 #	Area 1 Sp.	Area 2 #	Area 2 Sp.	Area 3 #	Area 3 Sp.	Area 4 #	Area 4 Sp.
1	1	2.00	1.00	----	----	--------		----	----
1	2	5.50	5.50	12.10	2.30	--------		----	----
1	3	3.09	1.53	12.10	2.30	7.534.46		----	----
1	4	2.33	0.85	2.73	1.30	1.000.33		----	----
1	5	3.23	1.43	2.48	0.94	2.781.40		----	----
2	1	7.00	7.00	----	----	--------		----	----
2	2	5.50	5.50	3.56	2.40	--------		----	----
2	3	4.68	3.78	2.42	1.75	7.646.25		2.00	2.00
2	4	4.63	3.73	5.25	3.00	7.205.60		3.72	2.81
2	5	6.04	4.80	4.75	3.47	7.436.19		6.17	5.22
3	1	1.00	1.00	----	----	--------		10.10	2.82
3	2	10.50	2.50	6.38	2.31	--------		----	----
3	3	8.05	3.36	9.11	1.64	7.654.53		4.00	4.00
3	4	3.00	1.60	5.08	1.94	2.602.20		12.20	2.45
3	5	7.05	3.39	5.51	2.29	5.593.52		7.44	1.67
4	1	1.00	1.00	----	----	--------		7.05	4.82
4	2	4.50	4.50	7.76	5.68	--------		----	----
4	3	3.17	2.72	11.40	4.05	6.766.07		----	0.00
4	4	3.68	2.90	5.38	4.72	4.604.40		4.66	2.90
4	5	3.77	3.04	7.11	5.61	6.895.64		4.76	3.52

[1] Season: 1 = winter 1980, 2 = summer 1981, 3 = winter 1981, 4 = summer 1983.

[2] Stand Ages: 1 = non-stocked, 2 = seedling, 3 = sapling, 4 = poles, 5 = sawtimber.

Valid diversities could not be generated from the point count data. In no case did point-count plots' diversity area curves stabilize, but the maximum number of plots available (53) was near the minimum number required (tabs. 6 & 7).

DISCUSSION AND SUMMARY

We gathered base-line data on bird abundance along a preexisting vegetation transect in four study areas of predominantly "loblolly-shortleaf pine-upland hardwood" forest on the Catahoula District of the Kisatchie National Forest of Louisiana. The bird transects approximated the habitat distribution as determined from a vegetation transect (Reed 1983). Data on bird abundance were gathered both when moving down the 50 m wide transect in plots 200 ft long and when stationary in a circular plot with a radius of 25 m.

The only data for each of the 106 individual species reported are the total number of observations during the four study periods. Individual species data were combined and mean density and mean richness per plot were calculated by area, season, and habitat.

The community data were extremely variable (tabs. 3-5) but because of consistent patterns between years, the variability was a function of fluctuation in avian abundance and not inadequate sampling. Habitat differences among study areas probably accounted for the different pattern among areas. Areas 2 especially and Area 4 to a lesser extent were more variable with respect to habitat (especially stand age) and included more young ages and more "pure pine" (tabs. 1 & 2) than the mean value for the areas as a whole. The differences in mean density and mean species richness between years and the different patterns in summer and winter were probably related to the migratory nature of the avian communities on the study areas and could have been due to events that occurred on a migrant's breeding grounds, on a migrant's wintering grounds, or during migration as well as to what happened to residents and migrants on the study areas themselves. Because variation in abundance of migratory birds may be due to events that have occurred elsewhere, it will be very difficult to link changes in abundance with any particular treatment without careful experimental design.

Table 6.-- Seasonal bird species diversities (BSD) derived from two field techniques and associated with three stand types within the catahoula ranger District, Kisatchie National Forest (R = No. of plots required for BSD to stabilize, T = total no. of plots surveyed, UHP = "upland hardwood-pine", P = "pure pine", PSH = "pine-streambottom hardwood")

S[1]	Type	N[2]	Transect BSD	Transect R	Transect BSD	Transect T	Pt Count BSD	Pt Count T
1	UHP	26	2.70[3]	70	2.71	90	2.30	24
2	UHP	48	2.75	132	2.80	180	2.62	48
3	UHP	43	2.62	94	2.67	180	2.25	48
4	UHP	38	2.82	158	2.82	180	2.35	48
1	P	24	2.22	44	2.25	55	2.00	13
2	P	40	2.85	64	2.85	75	2.47	19
3	P	26	2.02	70	2.06	80	1.47	19
4	P	33	2.75	70	2.75	80	2.00	19
1	PSH	17	DNS[4]		0.79	1	1.28	8
2	PSH	35	DNS		1.24	4	0.35	1
3	PSH	28	DNS		0.79	4	2.18	13
4	PSH	26	DNS		0.76	4	0.00	1

[1] Season: 1 = winter 1980, 2 = summer 1981, 3 = winter 1981, 4 = summer 1983.

[2] N = number of species found in the habitat type.

[3] BSD is Brillouin Index, H.

[4] DNS = Did not stabilize.

If the affects of density changes due to events elsewhere were different among the avian communities that inhabited the different habitats of the study area, as appears to be the case, analysis of patterns becomes even more complicated because the habitat mixes on the areas were not identical.

Species richness is a component of species diversity (Tramer 1969) and, like diversity, tends to increase to an asymptote with sample size. The large number of species in "upland hardwood-pine" may have been almost a maximum number because of the large sample size. The smaller numbers for the other habitat types may have been caused by either a sample size being too low for richness values to stabilize or by "upland hardwood-pine" having the capability of supporting more species.

Table 7.-- Seasonal bird diversities (BSD) derived from two field techniques and associated with three stand types within the Catahoula Ranger District, Kisatchie National Forest (R = no. of plots required for BSD to stabilize, T = Total no. of plots surveyed, Sap = "sapling", Pol = "pole", and Saw = "sawtimber")

			Transect				Pt Count	
S[1]	Age	N[2]	BSD	R	BSD	T	BSD	T
1	Sap	22	DNS[3]		2.52	40	2.10	11
2	Sap	38	DNS		2.45	60	1.90	13
3	Sap	33	2.37	50	2.42	60	1.26	13
4	Sap	32	DNS		1.78	60	1.04	13
1	Pol	19	DNS		2.12	37	1.50	9
2	Pol	31	DNS		2.67	55	1.90	10
3	Pol	20	DNS		2.08	55	1.36	10
4	Pol	31	DNS		2.60	55	1.57	10
1	Saw	26	2.37[4]	90	2.37	104	1.92	24
2	Saw	46	2.93	178	2.93	222	2.65	53
3	Saw	40	2.77	160	2.78	222	2.35	53
4	Saw	32	2.82	182	2.82	222	2.57	53

[1] Season: 1 = winter 1980, 2 = summer 1981, 3 = winter 1981, 4 = summer 1983.

[2] N = number of species found in the habitat type.

[3] DNS = Did not stabilize.

[4] BSD is calculated as the Brillouin Index, H.

Densities found were the same for transect and point-count plots. However, we did not gather enough point-count information to be able to adequately determine diversity. A different experimental design would have allowed us to have gathered more point-count data at the expense of transect data and total bird data. Diversities measured in the same habitats by both methods should in theory be the same. However, in all comparisons between methods (tabs. 6 & 7), the method with the most plots (largest area sampled) had the highest diversity. Transect counts usually produced the highest diversity because there were more transect plots, but there were several comparisons where more point-count data were available and diversity was correspondingly higher in the point-count plots. Approximately 76% of our observations were on transect plots and 24% on point-count plots.

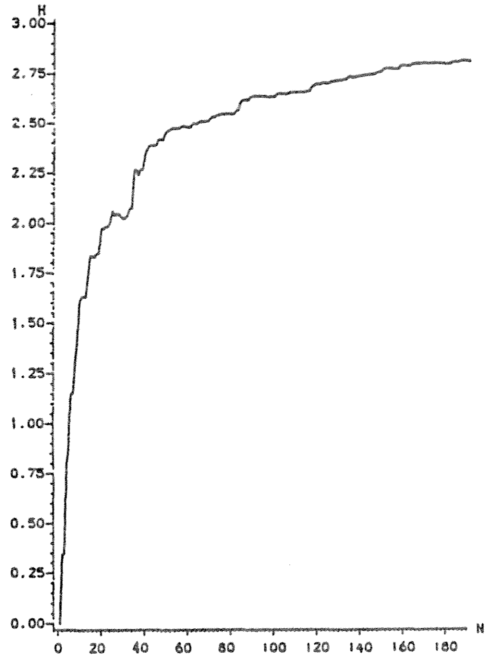

Figure 2.-- Avian diversity (H) plotted against the number of randomized plots (N) used to compute H for "upland hardwood-pine" in the winter of 1980.

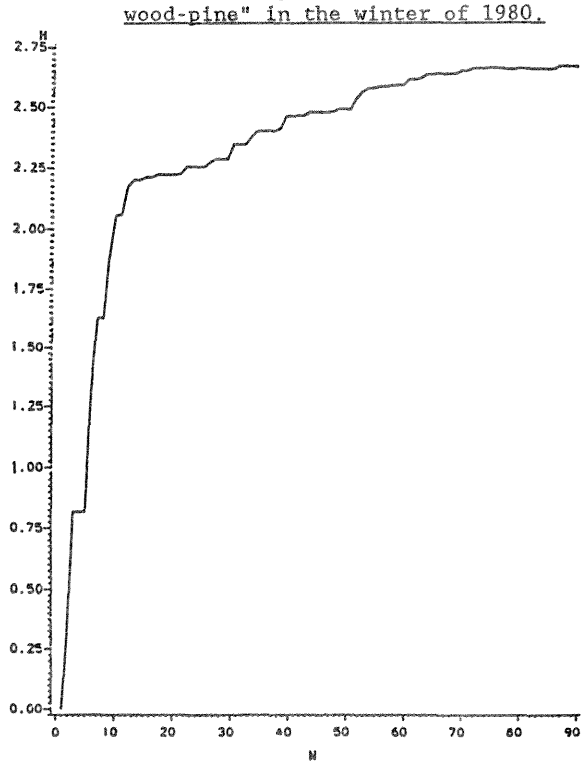

Figure 3.-- Avian diversity (H) plotted against the number of randomized plots (N) used to compute H for "upland hardwood-pine" in the summer of 1981.

Table 8.-- Summary of night owl and goatsucker counts during the period September 1980 through June 1981 in the Kisatchie National Forest, Catahoula District, Grant Parish, Louisiana

Season	Area	Stops	Species[1] SO	BO	GHO	CWW
Fall 1980	1	6	14	1	0	0
	2	12	26	4	0	0
	3	6	4	0	0	0
Winter 1980-81	1	11	11	7	0	0
	2	7	5	0	0	0
	3	8	7	1	0	0
	4	4	8	1	1	0
Spring1981	1	6	8	2	0	0
	4	3	5	0	0	0
Summer 1981	1	6	1	0	0	5
	2	15	14	3	0	7
	3	8	9	4	0	2
	4	3	3	0	0	0
Totals		95	115	23	1	14

1 SO = Screech Owl, BO = Barred Owl, GHO = Great Horned Owl, CWW = Chuck-Will's-Widow.

We compared densities of birds in the transect plots with densities in the point-count plots and found no difference. Dawson and Bull (1975) concluded that point counts at stations 200 m apart were about as accurate an index of abundance as transect counts. Ratowsky and Ratowsky (1979), however, concluded that the transect method was more efficient. Desante (1981) stated that users of point counts tended to overestimate density when it is low and underestimate density when it is high.

The point count method is sometimes used to compute absolute densities when distances to the observed birds are measured. Although that procedure is theoretically sound, it cannot be used to obtain a true density unless the birds do not move within the study area and one assumes that all birds are found doing each counting period. In addition, it is not necessary to know absolute densities in order to be able to make comparisons.

It is very difficult to gather enough data for valid comparisons under the best of conditions. Any method that does not use all of the time that is available could only be justified if it had a much higher degree of precision. Birds constantly move through the environment and modify their conspicuousness by changing their behavior. There is no reason to expect that consecutive counts of the same area would produce similar results. In fact, we have made a series of 30 consecutive 5-minute counts of an area and did not get the same result twice. Under these conditions, precision cannot be high except under unique circumstances and every effort should be made to ensure that sample size is as large as possible.

It would never be possible to gather as much point-count data as transect data in any given period of time. The point-count method is wasteful of observer time because of the non-observation time spent moving between sampling areas. We concluded that the primary concern of anyone attempting to assess abundance of communities of birds in the field in complex habitats must be to maximize sample size and therefore we recommend transect plots as the appropriate bird survey method in most situations.

Because diversity increases with sample size (Hair 1980), and because Wilhm (1970) showed that progressively pooled samples reach an asymptote, we devised a computer program to randomly select samples and to create diversity-area curves (Lester 1983). We generated these curves for the habitats mentioned above and could thereby evaluate where diversity comparisons could be made. We developed a procedure for estimating sample sizes required for determining stable species diversities. For this procedure we used random selection of plots by computer to develop synthetic communities and then calculated diversity-area curves for these communities. Objective criteria can be established for determining when adequate sampling has occurred. Diversity comparisons can be made by determining the variance in the synthetic communities with the jackknife procedure.

By establishing that asymptotes had been reached in computer generated synthetic communities randomly drawn from our samples, we found that adequate sampling occurred on transects in all seasons in "pure pine" and "pine-upland hardwood" habitats and in "sawtimber" plots. Insufficient data were available for testing specific habitats (stand-age combinations). "Upland hardwood-pine" needed 82 plots (62 ac) for stability in the winter and 145 (110 ac) in the summer. In situations where there are mixed habitats of various sizes, it would be very difficult to sample individual habitats that are large enough to determine a valid diversity because the required block sizes are not available or, when required block sizes are available, time is wasted moving from one block to another. Data from different types of neighboring habitats can be lumped together, but that is sure to result in non-comparable diversities because of unique habitat requirements of the constituent birds in the avian communities involved. Sampling of synthetic habitats and careful experimental design are necessary to properly test the "null hypothesis" of no difference between experimental units.

Within a given season, the number of plots required to obtain stable diversity is presumably a measure of habitat complexity. Differences in the required number could reflect habitat complexity differences among the types, such as in patterns of vegetational structure. Alternately, differential mixes of stand ages and, therefore, different mixes of vegetational structure among the types (Lester 1983) or a combination of factors could be responsible. Unfortunately, there were not enough plots in specific age-type-season combinations to test for diversity differences in a specific habitat, and the cause of the plot requirement differences cannot be evaluated for a single season. The difference in patterns between winter and summer in single habitats probably reflect more specific habitat requirements for breeding than for wintering and less movement of individuals between different stand ages during the summer. No differences were found in the required number of plots among the stand ages. This is another indication that habitat requirements for birds on the study areas are more specific for stand type than for stand age. If the sample sizes (degrees of freedom) were increased, additional significant differences could have been found.

Because of the scarcity of insectivores in the winter and the occurrence of large mobile flocks, the equitability component of species diversity (Tramer 1969) is almost surely lower then (Hamilton and Noble 1975:102). It is not surprising that the decrease is more noticeable in "pure pine" stands that were less complex than the "upland-hardwood-pine" stands. This is because many species in the winter feed on seeds that have remained from the previous season and seed abundance is higher in hardwood or mixed stands than pine stands (Hamilton and Noble 1975:102). In fact, there is a statistical difference between H in the winter in "pure pine" stands and "upland hardwood-pine" stands that is due to reduced species richness in winter in the pine stands (tab. 7).

Trends in diversity were much less variable and more in conformance with theory than trends in the other variables studied. Diversity values are related to habitat structure (MacArthur and MacArthur 1961) and are relatively independent of community changes that are unrelated to events on the study areas. Diversity values are thus of use when testing hypotheses that involve change or potential change in vegetational structure.

LITERATURE CITED

American Ornithologists' Union. 1983. Check-list of North American birds, 6th edition. Allen Press, Lawrence, Kansas. 877pp.

Brillouin, L. 1962. Science and information theory. Academic Press, New York. 351pp.

Byrd, N. A.,and C. E. Lewis. 1976. Managing southern pine forests to produce forage for beef cattle. U. S. Forest Serv., State and Private For., Ga. Forest Manage. Bull. 5pp.

Dawson, D. G. 1981. Counting birds for a relative measure (index) of density. Pages 12-16 *in* C. J. Ralph and J. M. Scott, eds. Estimating numbers of terrestrial birds. Stud. Avian Biology 6. Allen Press, Lawrence, Kansas.

____________, and P. C. Bull. 1975. Counting Birds in New Zealand forests. Notornis 22:101-109.

Desante, D. F. 1981. A field test of the variable circular-plot technique in a California coastal scrub breeding bird community. Pages 177-185 *in* C. J. Ralph, and J. M. Scott, Eds. Estimating numbers in terrestrial birds. Stud. Avian Biol. 6. Allen Press, Lawrence, Kansas.

Ellsworth, S. W. 1983. Mammalian abundance indices in the loblolly-shortleaf pine, upland hardwood forest type of central Louisiana. M.S. Thesis, Louisiana. State University, Baton Rouge. 188pp.

Hair, J. D. 1980. Measurement of ecological diversity. Pages 269-275 *in* S. D. Schemnitz, ed. Wildlife Management Techniques Manual. The Wildlife Society, Washington D. C. 686pp.

Hamilton , R. B., S. W. Ellsworth, and J. C. Smith. 1987. Mammalian use of habitat in the loblolly-shortleaf pine type of Louisiana. [elsewhere in the volume]. 12pp.

Hamilton, R. B., and R. E. Noble. 1975. Plant succession and interactions with fauna. Pages 96-114 *in* D. R. Smith, tech. coor. Proceedings of the symposium on management of forest and range habitats for nongame birds. USDA For. Serv. Gen. Tech. Rep. WO-1. Tucson, Arizona.

Heltshe, J. F., and D. W. Bitz. 1979. Comparing diversity measures in sampled communities. Pages 133-144 *in* J. F. Grassle, G. P. Patil, W. Smith, and C. Taillie, eds. Ecological diversity in theory and practice. Int. Coop. Publ. House. Fairland, Maryland.

Helwig, J. T., and K. A. Council, eds. 1979. SAS user's guide. SAS institute, Raleigh, N> C> 494pp.

Lester, G. D. 1983. Sample size requirements for computing avian species diversities in mixed pine-upland hardwood forest in Central Louisiana. M.S. Thesis, Louisiana State University, Baton Rouge. 171pp.

MacArthur, R. H., and J. W. MacArthur. !961. On bird species diversity. Ecology 42:594-598.

Margalef, D. R., 1958. Information theory in ecology. Gen. Syst. 3:36-71.

Peet, R. K. 1974. The measurement of species diversity. Pages 114-118 *in* C. J. Ralph and J. M. Scott, eds. Estimating numbers of terrestrial birds. Stud. Avian Biology 6. Allen Press, Lawrence, Kansas.

Pielou, E. C. 1975. Ecological Diversity. John Wiley and Sons, New York. 165pp.

Radford, A. E., H. E. Ahles, and C. R. Bell. 1968. Manual of the vascular flora of the Carolinas. Univ. N. Carolina Press, Chapel Hill. 1183pp.

Ratowsky, A. V., and D. A. Ratowsky. 1979. A comparison of counting methods to obtain bird numbers. Notornis 26:53-61.

Reed, D. P. 1981. Understory vegetative yield in the loblolly pine-shortleaf pine-upland hardwood fores type, Louisiana. M.S. Thesis, Louisiana State University, Baton Rouge. 257pp.

Shannon, C. E., and W. Weaver. 1949. The mathematical theory of communication. Univ. of Illinois Press, Urbana. 177pp.

Tramer, E. J. 1969. Bird species diversity: components of Shannon's formula. Ecology 50:927-929.

Wilhm, H. L. 1970. Effect of sample size on Shannon's formula. Southwestern Nat. 14:441-445.

Zahl, S. 1977. Jackknifing, an index of diversity. Ecology 58:907-913.

Loblolly-Shortleaf Pine Type Discussion

The following questions and responses are the summarized and edited discussion of pertinent ideas expressed during the workshop. While every effort was made to retain the substance and intent of responses, we may have inadvertently altered the intent of the respondent. In many cases, responses to a question came from several individuals; individuals are identified only by paragraph separation. This procedure is followed for all subsequent discussion sections.

Question

What are the effects of forest management on wildlife species relative to tree stand ages or classes?

Response

Bird communities differ in different stand ages or classes. Seedling stands (1-2 year-old pines) have abundant granivorous bird populations in winter; however, numbers may be high or low in spring depending upon previous site preparation or other management. Sapling stands normally have an abundance of birds during the breeding season but lower numbers in winter. Insect population levels and degree of tree thinning will influence abundance of bird species in sawtimber stands as well as younger stands.

In Louisiana, amphibians and reptiles were most abundant in sawtimber while mammals were more abundant in grassy regeneration and sapling stands.

In Texas, herps were more abundant in seedling and sapling stands compared to pole stands, but sawtimber stands also had relatively abundant herps.

Wildlife diversity is dependent on vegetation stratification. There will be a good diversity of birds if management provides a good diversity of ground, midstory, and overstory canopy layers. Tree stand size is also important; 40-acre clearcuts may be good for deer, but there are some sensitive wildlife species that require larger openings.

Question

Would the differences in availability of water on the Texas and Louisiana areas explain herp abundance differences between the two studies?

Response

Herps are linked to the water source in winter but not during spring. However, Texas herp numbers were still higher in spring than in Louisiana. Also, there were some lizards and snakes in seedling and sapling stands that were not found elsewhere. The prairie kingsnake, for instance, prefers a grassy-type understory and was found in a large clearcut area.

Question

Did cattle influence herp, bird, or mammal populations on the study areas?

Response

There were three lizard species found more abundantly in the Louisiana loblolly-shortleaf pine type where there were no cattle; in the longleaf-slash pine type these same lizard species were found more in sawtimber stands, which cattle tended to avoid.

There was a noticeable difference on the Louisiana longleaf-slash pine type between grazed and ungrazed range units. There was more frequent prescribed burning where cattle grazed, which kept ground vegetation down and brush out; this management was probably good for the red cockaded woodpecker and maybe Bachman sparrows, and may have impacted other species positively or negatively.

Question

What are the effects of uneven- and even-age loblolly pine management on mammals and herps?

Response

The amphibian and reptile data for Louisiana indicate that it is best to leave the sawtimber, but this is not so for mammals.

Uneven-age management, with its greater vegetation stratification, will result in higher species diversity. However, some species will be affected positively, others negatively.

Question

Are game animals (rabbits, quail, squirrel, deer) limited by environmental constraints (low soil fertility, low forage yield, poor forage quality) more than by human use or activity? Does grazing actually impact game populations if they are not limited environmentally?

Response

Experinece in Texas indicates environmental factors are generally more limiting. Woodcock, squirrels, doves, quail, etc. are probably not limited by human use or activity. Deer are probably more limited by human use.

From the historical viewpoint, areas managed for grazing tend to have little or no midstory. The midstory was not removed by grazing alone but by a combination of grazing, timber stand improvement, and prescribed burning. Furthermore, there is often heavy hunting pressure that can reduce game populations; consequently, biological management strategies need to be accompanied by sociological considerations.

In Louisiana, deer appear limited by human pressure--primarily poaching. Free-ranging dogs may also be impacting deer and rabbits. If poaching could be reduced, we could better manage game populations.

In multiple-use management, it is impossible to maximize all resources (timber, livestock, wildlife, etc.) at the same time. Within limits, we understand the impact of vegetation stratification on diversity of birds and mammals. Using simple range management practices (manipulation of stocking rates and season of use), we can use livestock to manage vegetation on forest range to benefit some wildlife species. Livestock can be used to attain and maintain certain stratifications, mosaics, or other vegetation variety for wildlife enhancement. In some cases, grazing may have a negative effect, but it can have a positive or at least neutral impact with management. However, several biological and social attributes affect the total and we need to develop models of all factors and optimize the best combination of resource products.

Question

Is the greatest conflict in multiple use management social or biological?

Response

Most groups or individuals tend to be single purpose--either deer, rabbits, cattle, or timber. Generally, we know how to manage the resources but are less knowledgeable in managing the people that use the resources; that is where the biggest problems arise.

Cattle grazing in conjunction with other management practices does change the environment to some degree; whether it is good, bad, or indifferent depends on you, your ideas, and concepts, and how they agree with others in the social framework. Managers have a tough job to evaluate and prescribe management.

Question

Since 100-150 year or older stands were not sampled in the SEP, can these data be used to understand species and community composition changes under longer rotation lengths? Also, was species composition information recorded by stand size classes or other criteria?

Response

Most plants were identified to species and composition by stand size classes were summarized in most original reports. However, for the sake of brevity, we have grouped species into woody, grasses, vines, forbs, and legumes. Greater detail will be available in these proceedings and in the original Forest Service office reports.

In the Texas study, where stands are 50-60 years old, the site is successionally moving towards hardwoods, but from a pine management standpoint, the general tendency is to perpetuate the pine culture through use of fire or mechanical means; this is a value judgement by society. From an environmental standpoint, the bottom line is whether site productivity (soil, watershed, site potential, etc.) is adversely affected. The watershed papers deal with some of the effects of clearcutting, site preparation, and grazing on soil erosion, fertility, etc. It is critical to know the factors that cause a site to degrade and that reduce the management options on that site. Southern forests have been subjected to considerable disturbance, but the land is very resilient or the forests would probably have been totally destroyed long ago. The shortage of old growth stands, especially hardwoods, becomes a societal question. Managers of National Forests are seeing increased interest from environmental groups and the public in general for old age or mature hardwood or pine-hardwood forests.

LONGLEAF-SLASH PINE TYPE

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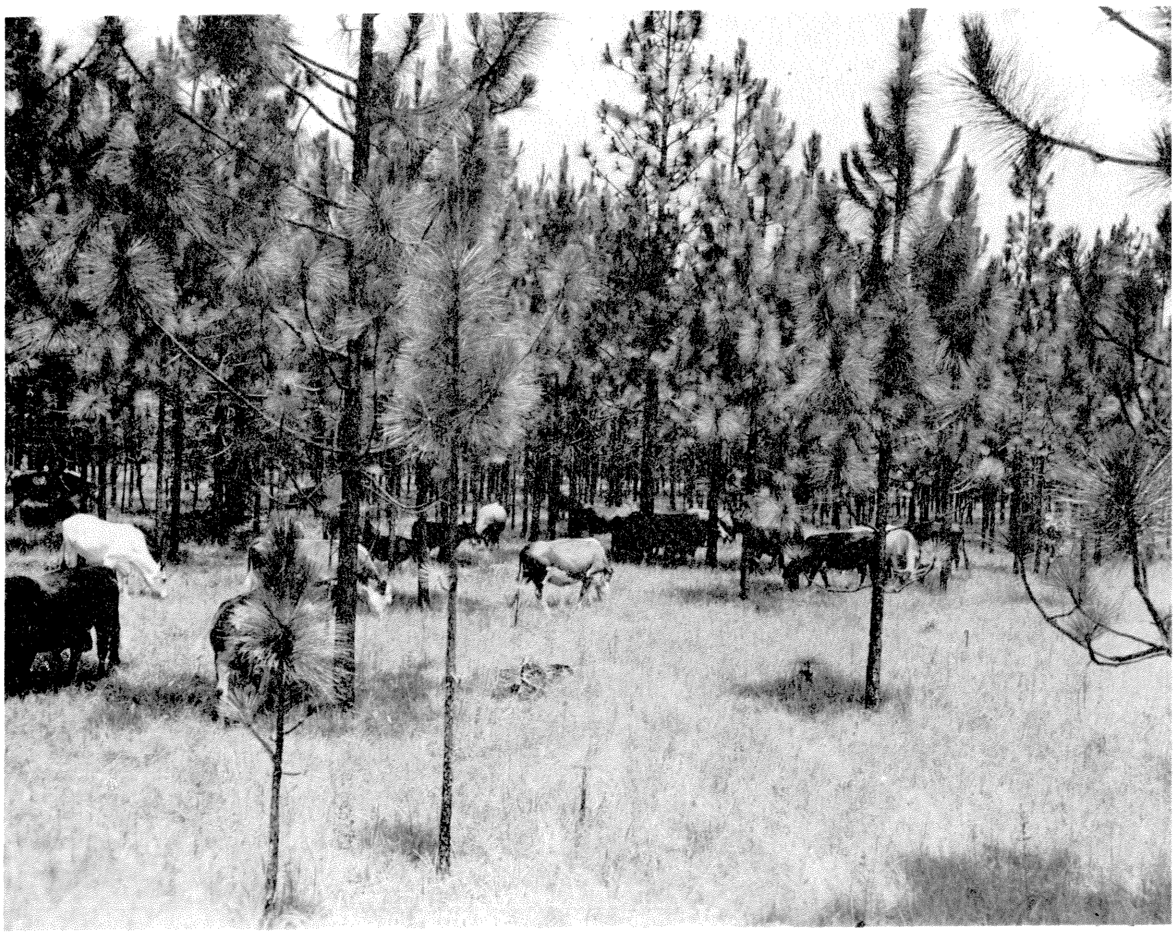
The longleaf-slash pine-bluestem vegetation type, extending from northwestern Florida and southern Alabama to eastern Texas, and occupying the Western and Central Gulf Coastal Plain, includes about 8 million acres. The longleaf-slash pine-wiregrass type, dominant vegetation type of the pine flatwoods in Florida, southern Georgia, and South Carolina, occupies approximately 20.5 million acres.



Detailed Vegetative Description of the Longleaf-Slash Pine Type, Vernon District, Kisatchie National Forest, Louisiana

Henry A. Pearson, Harold E. Grelen, Bernie R. Parresol, and Vernon L. Wright

Abstract.--This study was part of the Southern Evaluation Project initiated in 1978 in Louisiana, Mississippi, Florida, and Texas. Plotless sampling was used to inventory tree overstory (stems more than 1 in d.b.h.), circular milacre plots were used for midstory trees and shrubs (stems 1 in or less d.b.h. and more than 5 ft high), and circular 9.6-ft^2 plots were used to measure herbage and browse (up to 5 ft). Soil taxonomic descriptions were verified at each sampling location. Malbis (5,219 acre) and Guyton (1,206 acre) soil series predominated on the area, and longleaf (Pinus palustris) and slash (P. elliottii) pines were the most abundant trees. Pinehill bluestem (Schizachyrium scoparium var divergens), swamp sunflower (Helianthus augustifolius), and waxmyrtle (Myrica cerifera) and blackberry (Rubus spp.) were the most abundant grass, forb, and browse, respectively. The overstory trees averaged 62 ft^2/acre basal area, with 49-percent canopy cover and 11 in d.b.h. Snags averaged 0.6/acre, with an average of 1.2 cavities per snag. Herbage yields averaged 744 lb/acre on the four range units, and browse averaged 175 lb/acre. Herbage yields ranged from 120 to over 1,110 lb/acre on the different soils, and browse ranged from 125 to 300 lb/acre.

INTRODUCTION

The Southern Evaluation Project (SEP) was initiated in 1978 at three locations in the longleaf-slash pine (Pinus palustris - P. elliottii) type (Louisiana, Mississippi, and Florida) and two in the loblolly-shortleaf pine (P. taeda - P. echinata) hardwood type (Texas and Louisiana). This study was companion to four other inventories of forest vegetation in those four States. The objectives of the study were to (1) describe quantitatively and qualitatively the vegetation of four selected units in the SEP and (2) relate these inventories of vegetation to the major soils of the area. This report provides a detailed description of the longleaf-slash pine type in the SEP in Louisiana. The data were collected in 1979 and 1980 and provide base parameters of vegetation for manipulating, managing, and/or evaluating timber, livestock, and wildlife.

STUDY AREA

The study area (fig. 1) was located approximately 30 mi southeast of Leesville, Louisiana, on the Fullerton Allotment, Vernon Ranger District, Kisatchie National Forest (Yurkunas 1984). The 6,785-acre study area, adjacent to Fort Polk Military Reservation, was comprised of four range units (RU's) having five major soil series (USDA Soil Conservation Service 1979).

The area is characterized by gently rolling topography intersected by numerous drainages. Elevations range from 150 to 350 ft above sea level. Little Sixmile Creek, a tributary of Sixmile Creek, flows through the area. Overstory vegetation consists mainly of longleaf and slash pine, with a bluestem (Andropogon spp., Schizachyrium spp.) and panicum (Panicum spp., Dichanthelium spp.) grass understory. Prescribed burning is a common management tool used on the area and is usually accomplished on a 3-year rotation.

Normal annual rainfall is 54 in, with an average annual temperature of 66°F (Hunter 1985). The frost-free season is about 270 days, from late-February through November (Nelson and Zillgitt 1969). July and August are the hottest months

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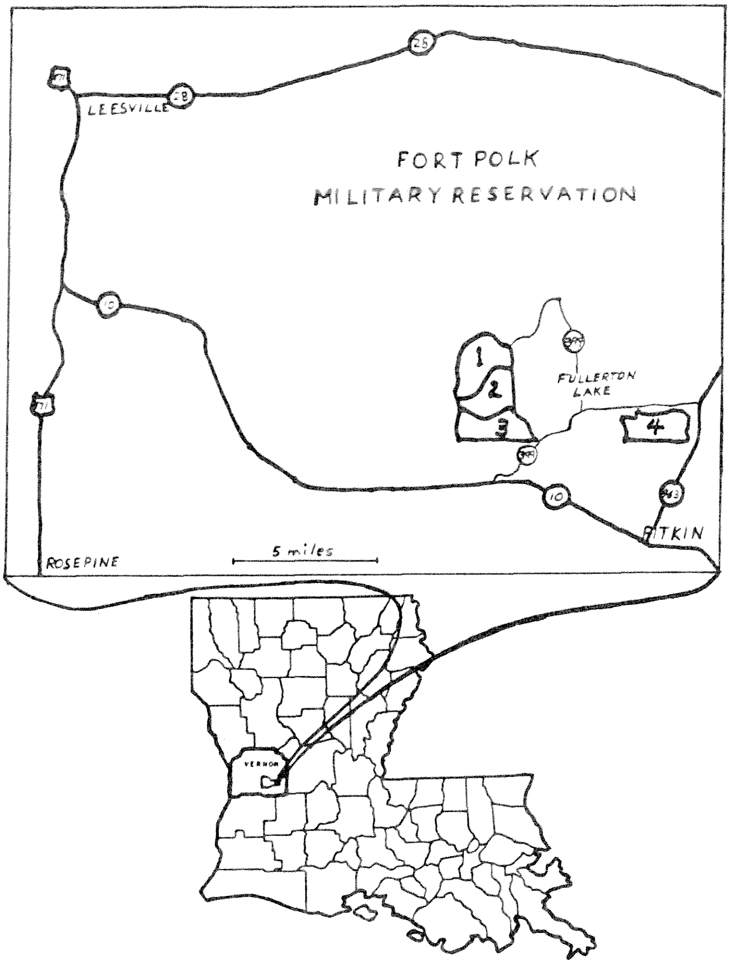

Figure 1.--The study area, Vernon Ranger District, Kisatchie National Forest, Louisiana, showing four range units

(82°F), with December and January being the coldest months (51°F). Annual precipitation during 1979 at McNary weather station was 73 in, with nearly 25 in occurring from May through September; the 1980 precipitation was 55 inches, with 18 in occurring from May through September.

Area soils are mainly the Malbis fine sandy loam series (5,219 acres), a fine-loamy, siliceous, thermic Plinthic Paleudult, and Guyton series (1,206 acres), a fine-silty, siliceous, thermic Typic Glossaqualf (USDA Soil Conservation Service 1979). Other soil series of minor importance include Beauregard very fine sandy loam (186 acres), Susquehanna very fine sandy loam (49 acres), and Cahaba very fine sandy loam (125 acres). None of the samples of vegetation were taken on the Susquehanna soil series.

Grazing history--Cattle had free access to the Fullerton Allotment from 1967 to 1977. In 1977 the allotment was cross-fenced into four RU's (Hunter 1985). Each RU contained 1,300 to 2,300 acres. Control of animal stocking rates and grazing systems was not initiated on the sites until 1981 when watershed studies were installed on the three grazed RU's (1, 2, and 3). From 1967 through 1980, cattle stocking rates averaged 37 acres/animal unit (AU). Thereafter, RU's 1 and 3 were grazed continually from March 1 to November 15 and deferred from November 16 to February 28. RU 2 was continuously grazed yearlong. RU 4 was not grazed after 1980. A contiguous RU east of the three grazed units was used during the winter by cattle deferred from RU's 1 and 3; it also served as a reserve pasture for other livestock. Consequently, grazing on the study areas before and during the present inventories reflect the average stocking rate of 37 acres/AU under yearlong continuous grazing (Hunter 1985).

From 1981 through 1983, livestock were stocked at a yearly average of 47 acres/AU. The yearlong continuously grazed range (RU 2) was stocked at 32 acres/AU, and the seasonally used ranges (RU's 1 and 3) were stocked at 38 and 48 acres/AU, respectively (Hunter 1985). The continuously grazed range (RU 2) was grazed 3.5 months longer than the seasonally grazed units.

Silvicultural history.--Two silvicultural management harvest methods (seedtree harvesting and thinning) were practiced on the area from 1977 through 1982 (Hunter 1985). Seedtree harvesting removed most of the pines. Trees left as a seed source were chosen for phenotype, spacing, and cone producing characteristics. After harvesting, the tracts and stands were site-prepared with a drum chopper to remove residual stems and then broadcast-burned.

Thinning harvest was done to enhance production by reducing competition among pines. One third of the area was prescribed-burned every year. Pines with red-cockaded woodpecker cavities were protected from harvest and managed as prescribed by USDA Forest Service regional guidelines (USDA Forest Service 1985).

METHODS AND PROCEDURES

Scientists from Texas A & M University, Louisiana State University, Mississippi State University, University of Florida, and Southern Forest Experiment Station participated in development of common guidelines for sampling and measuring vegetation on the SEP. These guidelines were followed in making measurements and are described in detail below.

Soil Survey.--An order 2 soil survey was conducted on the Louisiana longleaf-slash pine site by the USDA Soil Conservation Service (SCS), Alexandria, Louisiana (Kilpatrick 1987, USDA Soil Conservation Service 1979). Soil taxonomic descriptions were verified at each location where vegetation was sampled.

Sampling Design and Intensity.--Permanent sappling points were systematically located 200 ft apart along lines in each of the four RU's (Yurkunas 1984). Initial points on lines were randomly located 100 to 300 ft from the south end of each unit. North-south lines were 1,500 ft apart, with the initial line randomly located 100 to 750 ft from the southwest corner of each unit. No sampling points were located closer than 100 ft of the boundary fences. Permanent sampling points were marked with metal stakes (3/8-in rod) and tree blazing. Compass line and points were located on soil maps.

Sample Frequency and Duration.--Herbage and browse were measured during winter (January and February 1980), spring (April and May 1980), and fall (September through November 1979 and 1980). In spring and winter, only forage botanical composition and use were measured; all forage measurements described in this paper under herbage and browse are fall measurements. Tree, snag, and cavity measurements were taken from February through August 1980.

Point Sampling and Plot Size.--Plotless sampling was used to inventory tree overstory (stems more than 1 in d.b.h.). Midstory trees and shrubs (stems 1 in or less d.b.h. and more than 5 ft high) were measured on circular milacre plots centered on the permanent sampling location (fig. 2). Herbage and browse (up to 5 ft) were measured on a predetermined circular 9.6-ft^2 plot centered 42 in from the permanent sampling location. Both herbage and browse were measured on the selected plots comprising each cluster.

Taxonomic Nomenclature.--Plant names and symbols followed those developed by SCS (USDA Soil Conservation Service 1971, 1982). Other reference manuals included Hitchcock (1950), Radford et al. (1968), Correll and Johnston (1970), or others as needed. Scientific and common names of all plant species or groups identified in the SEP study are listed in the final study report (Pearson et al. 1984).

Overstory Tree Measurements and Classification.--The tree stand at each sampling location was recorded as nonstocked with pine, regeneration (pines 3 years old or younger), saplings (pines more than 3 years old to 4 in d.b.h.), poles (pines 4 to 9 in d.b.h.), or sawtimber (pines more than 9 in d.b.h.).

Pine basal area (square feet per acre) was measured using a 10-basal-area factor prism. Tree diameter at 4.5 ft above ground level (d.b.h.) of prism-recorded trees was measured with a diameter tape. Heights of dominant and co-dominant pines were measured with a clinometer. Tree age was determined from increment borings (cores) of the dominant and co-dominant trees or from National Forest tree planting records. Canopy cover was estimated with a spherical densiometer (Lemmon 1956). Hardwoods were measured for tree basal area, canopy cover, d.b.h., age, and height by the same methods described for pines. Trees per acre (T/A) of hardwoods and pines was determined with the equation

$$T/A = \frac{BAF}{0.005454(d.b.h.)^2},$$

where BAF is the basal area factor, and d.b.h. is the diameter at breast height in inches. The number of snags occurring within a 1/2-chain radius (0.0785 acre) of the permanent sampling point was defined as any standing dead tree or part of a dead tree at least 10 in d.b.h. and 10 ft tall. All tree species within 1/2-chain of the permanent sampling point were recorded.

Midstory Tree, Shrub, and Vine Measurements.--Trees (stems 1 in or less d.b.h.), shrubs, and vines more than 5 ft high were measured for percentage of canopy cover and height (ft) by species and number of species occurring on the milacre plots. Because only two plots had measurable midstory, these parameters were not included in these results.

Browse.--The current year's growth of trees, shrubs, and vines within 5 ft of the ground (browse) was measured on 9.6-ft^2 plots systematically located near permanent sampling points (fig. 2). Total browse weight (pounds/acre) and foliage ground cover (percent) were estimated on each plot; 20 percent of the plots were clipped (double sampling technique) to determine ovendry weight adjustments (Society for Range Management 1986). Current year's growth of all species was clipped and weighed collectively.

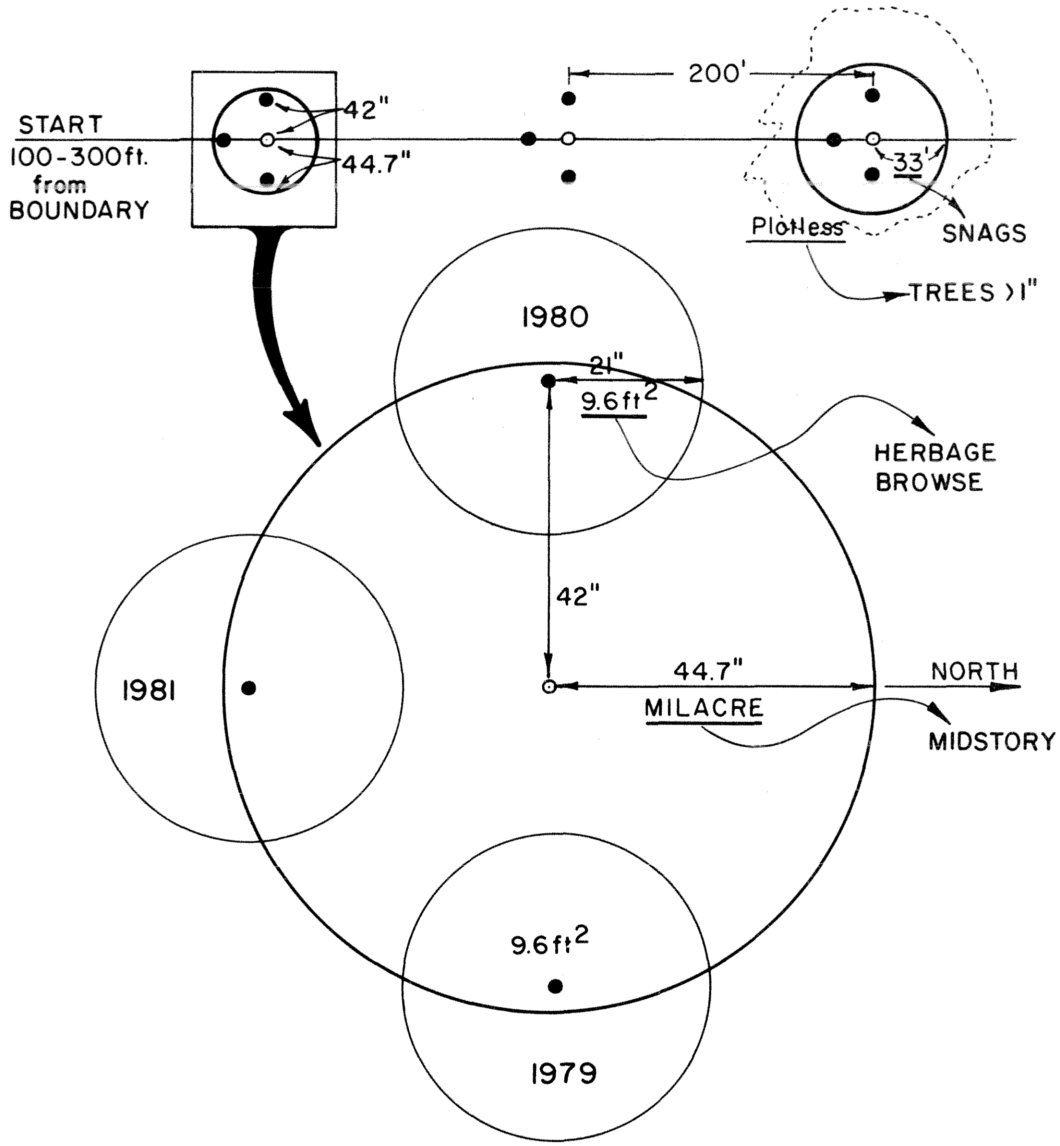

Figure 2.--Plots, clustered around sampling location, for measuring trees, herbage, browse, and snags.

Percentage of botanical composition of browse was estimated for each species making up 10 percent or more of the foliage ground cover. Presence only was recorded for species having less than 10 percent. Species comprising more than 10 percent and those present were used to calculate percentage of botanical composition for species by cover.

Degree of browsing on woody species was recorded in five categories: None; very light--difficult to find browse plants on plot, less than 10 percent of plants or plant portions browsed; light--infrequent evidence of browsing on plot, generally 10 to 35 percent of plants or plant portions browsed; moderate--frequent evidence of browsing, generally 35 to 70 percent of plants or plant portions browsed; and heavy--extensive evidence of plant portions browsed.

Herbage--Herbage (grasses, grasslikes, and forbs) was measured on 9.6-ft^2 plots systematically located near the permanent sampling points (fig. 2); these were the same plots used for browse measurements. Total herbage weight (pounds/acre), foliage ground cover (percent), and basal cover (percent) were estimated on each plot; 20 percent of the plots were clipped (double sampling technique) to determine ovendry weight adjustments. Current year's growth of all species was clipped to a 1-in stubble and weighed collectively.

Percentage of botanical composition of herbage was estimated for each species making up 10 percent of more of the foliage ground cover. Species having less than 10 percent cover were recorded as present. Species comprising more than 10 percent and those present were used to calculate percentage of botanical composition by cover.

Degree of grazing on the herbage species was recorded in five categories: None; very light--difficult to find grazed plants on plot, less than 10 percent of plants or plant portions grazed; light--infrequent evidence of grazing on plot, generally 10 to 35 percent of plants or plant portions grazed; moderate--frequent evidence of grazing, generally 35 to 70 percent of plants or plant portions grazed; and heavy--extensive evidence of grazing, generally more than 70 percent of plants or plant portions grazed.

Analysis.--Regression analyses were used to evaluate relationships among variables such as soils, trees, herbage, and browse. Both linear and nonlinear regression models were tested for the best fit. Analyses of variance were used to test differences among range units, soils, and other parameters. Statistical significance was accepted at the 0.05 probability level. Forage yields are reported in the text with standard error of the means. Regression equations are reported showing the reduction in variation due to regression (r^2) with the standard error of estimate ($Sy \cdot x$).

RESULTS

Overstory

A total of 650 sample locations were measured for tree overstory, snags, and cavities. Five percent of the study area was open or without measurable trees; the RU's ranged in openness from 2 to 12 percent (RU 1, 12 percent; RU 2, 5 percent; and RU's 3 and 4, 2 percent).

Most of the timber stand acreage was stocked with sawtimber (66 percent), with considerably less acreage in poles (9 percent), seedlings and saplings (14 percent), and regeneration (9 percent); only 1 percent of the acreage was nonstocked according to the 1979 silvicultural stand prescription summaries for the Vernon District. Longleaf and slash pines were the dominant tree species, encompassing 74 to 85 percent of the acreage on the four RU's. Hardwoods occupied 6 to 15 percent of the acreage, with loblolly pine occupying 3 to 14 percent of the area.

Trees.--Longleaf and slash pines were the most common tree species on the study area, including pines or hardwoods, comprising 73 percent of all the trees (76 percent of the trees tallied on RU 1, 80 percent on RU 2, 56 percent on RU 3, and 85 percent on RU 4). RU 3 also had 13-percent occurrence of loblolly pine at the sampling locations, whereas other units had 8 percent or less loblolly pine. Occurrence of shortleaf pine was less than 1 percent on any of the units.

Overstory trees averaged 62 ft^2/acre basal area, with 49 percent canopy cover and 11 in d.b.h. (table 1). There was 0.6 snag/acre, with 1.2 cavities per snag or 0.7 cavity/acre. Pines averaged 26 stems/acre, 50 ft^2/acre basal area, and 34 percent canopy cover, with dominant and co-dominant pines averaging 13 in d.b.h., 45 years of age, and 71 ft tall. Hardwoods averaged 69 stems/acre, 12 ft^2/acre basal area, and 15 percent canopy cover, with dominant and co-dominant hardwoods averaging 10 in d.b.h., 34 years old, and 54 ft tall (Pearson et al. 1984). Average basal area of pines on the four RU's ranged from 43 to 63 ft^2/acre, while hardwoods ranged from 4 to 20 ft^2/acre; canopy cover for pines and hardwoods ranged from 29 to 43 and 9 to 21 percent, respectively. Average d.b.h., age, height, and density of pines on the four RU's ranged from 12 to 14 in, 43 to 47 years, 70 to 73 ft, and 21 to 31 trees/acre; hardwoods ranged from 8 to 11 in, 15 to 73 years, 43 to 60 ft, and 49 to 105 trees/acre, respectively.

Table 1.--Summary of plant characteristics for the four range units within the longleaf-slash pine-bluestem range type, Vernon District, Kisatchie National Forest, Louisiana

Characteristic	Range unit 1	2	3	4	Avg.
OVERSTORY (Pine/Hardwood Trees)					
Canopy cover (%)	49	47	50	52	49
Basal area (ft^2/acre)	61	56	63	67	62
d.b.h. (in/tree)	11	12	13	10	11
Density (No.trees/acre)	125	74	80	136	104
Age (yr) of dominants	33	59	47	29	42
Height (ft) of dominants	61	63	65	57	62
Snags (No./10 acres)	5	4	8	6	6
Cavities (No./10 acres)	8	7	11	2	7
Species (No.)	18	14	20	15	17
UNDERSTORY (Herbage/Browse)					
Herbage yield (lb/acre)	671	724	761	821	744
Woody yield (lb/acre)	169	159	153	219	175
Total yield (lb/acre)	840	883	914	1,040	919
Utilization (%)	21	21	18	14	19

Overstory tree basal area ranged from 54 to 84 ft^2/acre on major soils, and canopy cover ranged from 43 to 75 percent (table 2). Pine basal area, canopy cover, d.b.h., and age were similar on the Beauregard (52 ft^2/acre, 39 percent, 14 in, 40 years) and Malbis (54 ft^2/acre, 36 percent, 13 in, 45 years) soils but were somewhat different on the Cahaba (39 ft^2/acre, 21 percent, 14 in, 32 years) and Guyton (22 ft^2 acre, 10 percent, 16 in, 61 years) soils (table 3).

Basal Area-Canopy Cover Relationships.--Tree basal area and canopy cover regression lines were compared for five overstory types, hardwood, hardwood-pine, slash pine, loblolly pine, and longleaf pine, because foresters manage hardwood and pine stands differently. The data were sufficient only to warrant regression equations above 30-percent canopy cover. Regressions for the basal area-canopy cover relationships of loblolly and longleaf pine were not significantly different and therefore were pooled as one relationship (Pearson et al. 1984). Slash pine regressions were significantly different from the loblolly and longleaf pine regressions. The reduction in variation due to regression was quite low for the hardwoods (13 percent) and the loblolly and longleaf pines (20 percent); therefore, equations are not beneficial for predictive purposes. Only for slash pine was the reduction in variation due to regression (55 percent) somewhat adequate for predicting basal area from canopy cover. The equation for slash pine was

$$BA = 14.493 + 1.721\ CC,$$

where BA is basal area in square feet/acre and CC is canopy cover in percent with a $Sy \cdot x$ of 24 ft^2/acre.

Understory

Altogether, 625 sample locations were measured each fall (1979 and 1980) for herbage and browse understory. During spring (1980), 217 locations were measured, but during winter (1980) only 196 locations were measured. Data reported in this paper include only the fall measurements of herbage and browse.

Herbage and Browse Species.--Pinehill bluestem (*Schizachyrium scoparium* var. *divergens*) and low panicum (*Dichanthelium* spp.) species were the most prevalent grasses on the area. Swamp sunflower (*Helianthus angustifolius*) was the most prevalent forb, and waxmyrtle (*Myrica cerifera*) and blackberry (*Rubus* spp.) were the most common browse. Tephrosia (*Tephrosia* spp.) was the most prevalent legume. Altogether, 279 species or species groups were measured on the plant locations. These included 48 grasses, 1 grasslike group, 8 ferns and mosses, 26 legumes, 56 composites, 74 other forbs, and 66 woody species. More than 320 species or species groups were observed on the area (Pearson et al. 1984).

Herbage and Browse Foliage Ground Cover.--Percentage of ground cover for grasses (48 percent) was highest for pinehill bluestem (20 percent), slender bluestem (*Schizachyrium tenerum*) (5 percent), cutover muhly (*Muhlenbergia expansa*) (5 percent), and low panicums (5 percent) (table 4). Browse foliage ground cover (13 percent) exceeded or equaled 2 percent only for waxmyrtle (3 percent) and blackberry (2 percent). Average percentage of herbage and browse ground cover for the four RU's ranged from 44 to 53 percent for the various forage classes (Pearson et al. 1984). Percentage of ground cover for herbage and browse was highest on Beauregard and Guyton soils (61 percent), lowest on Cahaba (40 percent), and intermediate on Malbis (46 percent).

Table 2.--Summary of plant characteristics for major soils within the longleaf-slash pine-bluestem range type, Vernon District, Kisatchie National Forest, Louisiana

Characteristic	Soil				
	Beauregard	Malbis 1%-3%	Malbis 3%-8%	Cahaba	Guyton
OVERSTORY (Pine/Hardwood Trees)					
Canopy cover (%)	45	43	54	62	75
Basal area (ft^2/acre)	55	54	68	76	84
d.b.h. (in/tree)	14	12	13	13	12
Density (No. trees/acre)	58	78	105	85	86
Age (yr) of dominants	40	36	48	32	67
Height (ft) of dominants	[illegible]	57	63	68	72
Snags (No./10 acres)	0	4	4	0	23
Cavities (No./10 acres)	0	4	7	0	31
Species (No.)	5	14	16	13	19
UNDERSTORY (Herbage/Browse)					
Herbage (lb/acre)	1,152	863	661	120	378
Woody (lb/acre)	183	125	213	201	300
Total yield (lb/acre)	1,335	988	874	321	678

Table 3.--Average basal area (ft^2/acre) and d.b.h. (in) for tree species by soil series [1/]

Species	Soil: Beauregard BA	Beauregard d.b.h.	Malbis 1-3% BA	Malbis 1-3% d.b.h.	Malbis 3-8% BA	Malbis 3-8% d.b.h.	Cahaba BA	Cahaba d.b.h.	Guyton BA	Guyton d.b.h.	Weighted average [2/] BA	Weighted average [2/] d.b.h.
Acer rubrum					1.3	3.8	1.1	3.2	5.7	6.5	0.9	5.4
Carya tomentosa					0.1	11.5					0.1	11.5
Cornus florida			0.1	5.3	0.5	3.4	2.2	5.4			0.2	4.2
Fagus grandifolia									0.1	16.3	0.1	16.3
Ilex coriacea									0.8	4.7	0.1	4.7
I. opaca					0.1	8.0			0.2	2.0	T	5.0
Liquidambar styraciflua	2.7	8.7	0.7	8.1	3.6	8.9	3.3	10.2	10.5	8.1	2.5	8.5
Lyonia lucida									0.2	1.8	T	1.8
Magnolia virginiana					0.5	16.4	1.1	17.4	11.7	11.3	1.3	11.9
Nyssa aquatica									0.3	20.0	T	20.0
N. sylvatica			0.3	6.9	0.9	6.6	4.4	13.3	23.5	11.6	2.8	10.9
Persea borbonia					0.1	6.4			0.3	8.3	T	7.7
Pinus echinata			0.1	6.0	0.1	11.1					T	7.7
P. elliottii	27.3	14.9	13.8	10.1	15.5	12.4			7.7	13.6	13.8	11.2
P. palustris	24.0	13.6	34.2	13.4	34.3	14.0	3.3	17.3	9.3	15.9	31.1	13.7
P. taeda	0.7	4.6	2.9	14.4	7.1	12.9	35.6	13.5	4.7	17.7	4.6	13.9
Quercus alba			0.1	7.8			1.1	12.3	0.2	14.8	0.1	10.7
Q. falcata	0.7	13.0	0.7	12.9	2.1	13.4	14.4	14.2	1.0	14.7	1.3	13.5
Q. falcata var. *pagodifolia*									0.2	8.8	T	8.8
Q. incana			T	14.7							T	14.7
Q. marilandica			1.1	10.5	1.5	9.7	1.1	15.0			1.1	10.3
Q. nigra			0.1	11.5			1.1	15.8	6.5	13.4	0.7	13.3
Q. stellata			0.4	7.8	0.9	8.2	3.3	8.1	0.5	9.5	0.6	8.1
Symplocos tinctoria					0.1	3.6	3.3	10.3			0.1	8.6
Toxicodendron vernix									0.2	1.4	T	1.4
Vaccinium stamineum			0.0	2.7							T	2.7
TOTAL	55.3		54.3		68.3		75.6		84.0		61.5	
Weighted average [2/]		13.9		12.4		12.7		13.0		11.9		12.5

[1/] T = < 0.05 ft^2/acre.

[2/] average d.b.h. are weighted by acreage.

Herbage and Browse Weights.--Herbage (grasses and forbs) and browse weights were correlated with foliage ground cover and ocular weight estimates; regression equations and correlation coefficients show the herbage estimates to be slightly more accurate than the browse estimates. Weight estimates corrected with double sampling were used to determine forage yields on the herbage and browse plots. Herbage yields were best determined from herbage weight estimates by the regression equation

$$H = (0.905\ HW)10,$$

where H is herbage yield in pounds/acre and HW is estimated herbage weights in grams/9.6-ft^2 plot. Reduction in variation due to regression was 75 percent with a Sy·x of 29 lb/acre. Herbage yields were also determined from estimates of herbage foliage ground cover, but less accurately than with weight estimates by the equation

$$H = (15.0 + 0.015\ (HC)^2)10,$$

where HC is percentage of herbage foliage ground cover; the variation due to regression was 65 percent with a Sy·x of 34 lb/acre. Herbage yield equations were determined from 247 double-sample plots.

Browse yields (current year's growth) were best determined from woody plant foliage ground cover by the regression equation

$$B = (3.7 + 0.931\ WC)10,$$

where B is browse yield in pounds/acre and WC is percentage of woody plant foliage ground cover. The reduction in variation due to regression was 54 percent with a Sy·x of 16 lb/acre. Browse yield was determined nearly as well from browse weight estimates:

$$B = (7.4 + 0.531\ BW)10,$$

where BW is estimated browse weight in grams/9.6-ft^2 plot. The reduction in variation due to regression was 53 percent with a Sy·x of 17 lb/acre. Browse yield equations were determined from 141 double-sample plots.

Table 4.--Average percent foliage ground cover during fall (1979 and 1980) for forage class, genera, and species[1/]

Genera/Species	Ground cover	Genera/Species	Ground cover
GRASSES (total)	47.8	**LEGUMES (total)**	**1.5**
Andropogon spp. (5)	1.7	*Desmodium* spp. (4)	0.2
Aristida spp. (2)	1.9	*Galactia* spp. (2)	0.3
Axonopus affinis	2.9	*Lespedeza* spp. (7)	0.1
Dichanthelium spp.	4.8	*Stylosanthes biflora*	0.3
Eragrostis spp. (3)	0.7	*Tephrosia* spp. (2)	0.4
Gymnopogon spp. (2)	0.5	Other legumes (10)	0.2
Muhlenbergia expansa	4.5	**MISCELLANEOUS FORBS (total)**	**2.4**
Panicum spp. (4)	3.0	*Acalypha gracilans*	0.2
Paspalum spp.(7)	1.0	*Diodia* spp. (2)	1.0
Schizachyrium scoparium	20.2	*Euphorbia corollata*	0.1
var. *divergens*		*Oxalis* spp. (2)	0.1
S. tenerum	5.0	*Rhexia* spp. (4)	0.1
Other grasses (16)	1.6	*Ruellia humilis*	0.1
GRASSLIKES (total)	1.4	*Scutellaria* spp. (2)	0.1
FERNS AND MOSSES (total)	0.5	*Tragia* spp. (2)	0.2
Pteridium aquilinum	0.4	Other miscellaneous forbs (59)	0.5
var. *pseudocaudatum*		**BROWSE (total)**	**13.1**
Other ferns & mosses (7)	0.1	*Acer rubrum*	0.7
COMPOSITES (total)	3.1	*Ascyrum* spp. (2)	0.2
Aster spp. (3)	0.4	*Gelsemium sempervirens*	0.8
Eupatorium spp. (7)	0.5	*Liquidambar styraciflua*	0.9
Gnaphalium spp. (2)	0.1	*Myrica* spp. (2)	3.2
Helianthus angustifolius	1.0	*Pinus* spp. (4)	0.4
Heterotheca spp. (3)	0.2	*Quercus* spp. (7)	0.6
Liatris spp. (5)	0.1	*Rubus* spp.	2.1
Rudbeckia spp. (2)	0.1	*Smilax* spp. (6)	0.3
Solidago spp. (4)	0.3	*Toxicodendron* spp. (3)	0.2
Other composites (27)	0.4	*Vaccinium* spp. (5)	0.7
		Other browse (36)	3.0

1/ Numbers in parentheses refer to identified species.

Herbage and Browse Yields.--Herbage yields on the area averaged 744 ± 44 lb/acre (table 1). Yields varied among the four RU's, with the lowest in RU 1 (671 ± 47 lb/acre), highest in RU 4 (821 ± 48 lb/acre), and intermediate in RU's 2 (724 ± 41 lb/acre), and 3 (761 ± 40 lb/acre). Yields were not significantly different among the four RU's. Browse yields were 169 ± 19, 159 ± 15, 153 ± 13, and 219 ± 21 lb/acre in RU's 1, 2, 3, and 4, respectively. Browse yields were significantly higher in RU 4 than in the other three units, which were not different from each other.

Overstory tree basal area reduced herbage yields but did not appreciably affect browse yields (table 5). On Malbis soils, for which there were sufficient samples for comparison, herbage yields were significantly less under tree stands of 100 ft^2/acre or more basal area than under tree stands having less basal area (Pearson et al. 1984). Herbage yields averaged 814 lb/acre for the lower tree basal areas (less than 100 ft^2/acre) and 390 the Malbis soils, which differed only in percentage of slope, with higher yields (213 lb/acre) on the 3- to 8-percent slopes than on the 1- to 3-percent slopes (125 lb/acre) (table 2). Analysis of the interactions between overstory basal area and tree type showed that longleaf pine with basal areas of 60 to 99 ft^2/acre had significantly less browse (106 lb/acre) than basal areas greater than 100 ft^2/acre (164 lb/acre). The Beauregard soil series produced the highest average herbage yields across all tree densities, with 1,152 lb/acre, while Cahaba yielded the least herbage (120 lb/acre) (table 2). Browse yields were greatest on Guytons soil (300 lb/acre) and least on Malbis soil with a 1- to 3-percent slope (125 lb/acre). Guyton soil without trees actually produced the highest herbage yields (1,549 lb/acre), and this same soil with a tree basal area of less than 20 ft^2/acre produced the most browse (738 lb/acre). The longleaf pine type had the highest herbage yields (885 lb/acre) under trees, while the hardwood-pine type had the highest browse yields (291 lb/acre).

Comparisons among overstory types (longleaf pine, slash pine, and hardwood-pine) on Malbis soil with a 3- to 8-percent slope and basal area of 60 to 99 ft^2/acre showed that herbage yields of the hardwood-pine (354 lb/acre) were significantly less than those of the two pine types (801 lb/acre).

Table 5.--Average fall (1979 and 1980) herbage and browse yields for various ranges of tree basal area

Basal area	Herbage	Browse	Total
ft^2/acre	-----------lb/acre-----------		
0	1,036	129	1,165
1-19	896	176	1,072
20-59	955	169	1,124
60-99	710	165	875
>100	309	207	516

Browse yields were lowest on longleaf pine (143 lb/acre), intermediate on hardwood-pine (184 lb/acre), and highest on slash pine (286 lb/acre), probably due to the burning schedule. The longleaf pine type had been burned more often and more recently, but the younger slash pine had been protected from burning.

Yields on the Malbis soil with a 3- to 8-percent slope and Guyton soil with a basal area of 60 to 99 ft^2/acre in the hardwood-pine type showed no differences for herbage (289 lb/acre) but significant differences for browse; browse yields were 184 lb/acre and 465 lb/acre, respectively. The wetter Guyton soil apparently provided a better site for woody plant growth. Herbage and browse yields were not different between the two hardwood types (hardwood, hardwood-pine) on the Guyton soils under a constant tree basal area of 60 to 99 ft^2/acre. Herbage yields averaged 163 lb/acre and browse averaged 363 lb/acre.

LITERATURE CITED

Correll, D. S.; Johnston, M. C. 1970. Manual of the vascular plants of Texas. Renner, TX: Texas Research Foundation. 1,881 p.

Hitchcock, A. S. 1950. Manual of the grasses of the United States. Chase, Agnes, ed. 2d rev. Misc. Publ. 200. Washington, DC: U.S. Department of Agriculture. 1,051 p.

Hunter, T. K., Jr. 1985. Assessment of intensive silvicultural practices and livestock grazing on watershed parameters, Kisatchie National Forest, Louisiana. College Station, TX: Texas A & M University. 87 p. M.S. thesis.

Kilpatrick, W. W. 1987. Soils of the loblolly/shortleaf and longleaf/slash pine project: Grant and Vernon Parishes, Louisiana. In: Proceedings, 1987 Southern Evalution Project workshop; 1987 May 26-27; Long Beach, MS: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station; [in press].

Lemmon, P. E. 1956. A spherical densiometer for measuring forest overstory density. Forest Science. 2:314-320.

Nelson, T. C.; Zillgitt, W. M. 1969. A forest atlas of the South. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station and Southeastern Forest Experiment Station. 27 p.

Pearson, H. A.; Grelen, H. E.; Rollins, D. A.; Parresol, B. R. 1984. Vegetation inventory in the longleaf-slash pine type, Vernon Parish, Louisiana. Final Report FS-SO-1701-3.20. Pineville, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 75 p.

Radford, A. E.; Ahles, H. E.; Bell, C. R. 1968. Manual of the vascular flora of the Carolinas. Chapel Hill, NC: University of North Carolina Press. 1,183 p.

Society for Range Management. 1986. Range research: basic problems and techniques. Cook, C. W.; Stubbendieck, J., eds. Denver, CO: Society for Range Management. 317 p.

U. S. Department of Agriculture, Forest Service. 1985. Wildlife Habitat Management Handbook. FSH-2609.23R. Atlanta, GA: U.S. Department of Agriculture, Forest Service, Southern Region. R-8 Amendment #13.

U. S. Department of Agriculture, Soil Conservation Service. 1971. National list of scientific plant names. Washington, DC: U.S. Department of Agriculture, Soil Conservation Service. 281 p.

U. S. Department of Agriculture, Soil Conservation Service. 1979. Soil survey of the range management research units, Vernon Parish. Alexandria, LA: U.S. Department of Agriculture, Soil Conservation Service. 26 p.

AMPHIBIANS AND REPTILES OF LONGLEAF-SLASH PINE STANDS IN CENTRAL LOUISIANA

Kenneth L. Williams and Keith Mullin[1]

Abstract.--Amphibians and reptile species composition and abundance were surveyed on four study areas, each 1300-2300 ac, on the Vernon Ranger District, Kisatchie National Forest, in central Louisiana, from August 1979 to May 1981. Four stand size classes (habitats) were sampled within each study area--regeneration, sapling, poletimber, and sawtimber. A variety of census methods were used, including walking transects and fence arrays with pitfalls and funnel traps. Sawtimber stands exhibited the most herpetofauna diversity. Amphibians were not abundant in any stand type. Reptiles were more abundant, but with the exception of three species of lizards, probably not abundant enough to serve as good indicators of habitat change resulting from grazing.

INTRODUCTION

Four study sites were located in the southern part of the Vernon Ranger District, Kisatchie National Forest, Vernon Parish, Louisiana. Three sites are located north of Cravens (Route 10) and one site (no. 4) is north of Pitkin. The overall study area is approximately 6785 acres divided into four fenced sites ranging from 1300 to 2300 acres (Fig. 1). The study sites have been impacted by scheduled burns, military activity, cattle grazing and girtling of hardwoods. Elimination of hardwoods was most noticable in pine dominated creek bottoms.

The overstory is predominately longleaf pine (Pinus palustris) and slash pine (Pinus elliottii) forest. Longleaf pine is a fire resistant species and is considered to be a fire dependant species.

The studies were approached with two main objectives: to determine the kinds of amphibians and reptiles occurring in the four types of habitat, and (2) to obtain quantitative data for each habitat type,'which could be utilized in later phases of the study. The overall purpose was to obtain data fulfilling the above two objectives and then utilize this data in later studies to evaluate the effects of cattle grazing on occurrence and abundance.

Due to United States Forest Service timber management practices, the forest is in various stages of development ranging from clearcut areas of varying sizes up through mature pine stands. For sampling purposes, four stand size classes were recognized:

1. Regeneration: "recently site prepared, with or without young pine seedlings."
2. Saplings: trees up to 4 inches dbh.
3. Poletimber: trees from 4 inches to 10 inches dbh.
4. Sawtimber: trees 10 inches or more in dbh, most would be classified as immature sawtimber.

Amphibians and reptiles are common animals in this area of Louisiana. Within this area piney woods are probably the least desirable habitat for many amphibians and reptiles (see the list below for species that occur/or may occur in the region of Louisiana where the study areas are located). The numbers following each species are 1=obtained in study, 2=known to occur in immediate similar habitat, but not obtained in present study, 3=not recorded from general area, but very likely occurs, and 4=range maps show it occurring in this area, but not likely in study area due to lack of suitable habitat.

Species (Amphibia)	Category
Amphiuma tridactylum	4
Siren intermedia	3
Necturus beyeri	4

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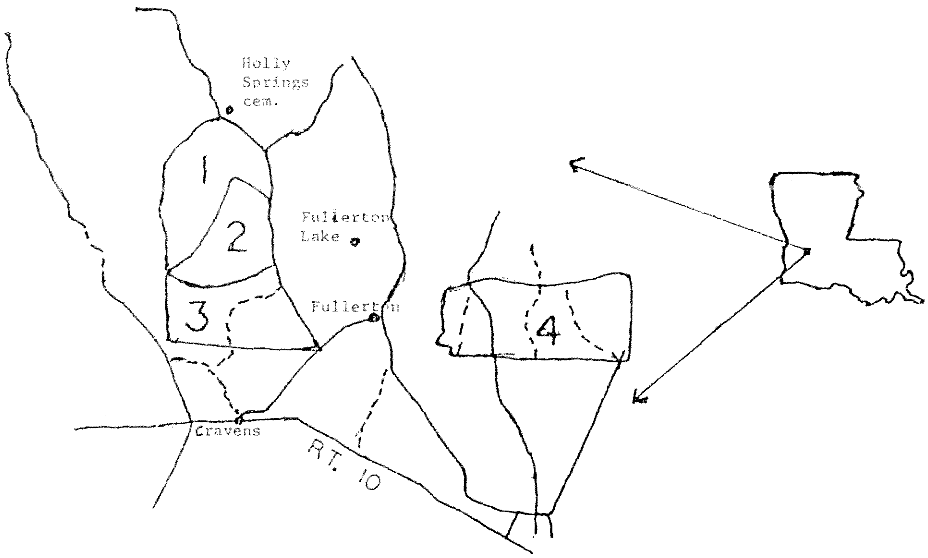

Figure 1. Location of the Vernon Ranger District Study sites, Vernon Parish, Louisiana. (Scale one-half inch=one mile)

Species	Category
Notophthlamus viridescens	4
Ambystoma talpoideum	3
Ambystoma texanum	3
Ambystoma maculatum	3
Ambystoma opacum	3
Desmognathus auriculatum	4
Plethodon glutinosus	4
Eurycea quadridigitata	1
Scaphiopus holbrooki	1
Gastrophryne carolinensis	1
Bufo woodhousei	1
Bufo valliceps	1
Hyla crucifer	1
Hyla cinerea	1
Hyla versicolor	1
Hyla squirella	3
Pseudacris triseriata	1
Acris crepitans	1
Rana clamitans	1
Rana catesbeiana	2
Rana sphenocephala	1
Rana areolata	4

Species (Reptilia)	Category
Alligator mississipiensis	4
Macroclemys temmincki	4
Chelydra serpentina	3
Sternotherus odoratus	3
Sternotherus carinatus	4
Kinosternon subrubrum	3
Graptemys pseudogeographica	4
Graptemys kohni	4
Chrysemys picta	4
Chrysemys concinna	4
Chrysemys floridana	4
Chrysemys scripta	4
Terrapene carolina	1
Trionyx muticus	4

Species	Category
Trionyx spinifer	4
Anolis carolinensis	1
Sceloporus undulatus	1
Scincilla lateralis	1
Eumeces fasciatus	1
Eumeces laticeps	1
Eumeces anthracinus	1
Cnemidophorus sexlineatus	1
Ophiosaurus attenuatus	1
Nerodia erythrogaster	4
Nerodia rhombifera	4
Nerodia cyclopion	4
Regina rigida	4
Regina grahami	3
Thamnophis sirtilis	1
Thamnophis proximus	3
Virginia striatula	3
Storeria occipitomaculata	1
Storeria dekayi	1
Heterodon platyrhinos	2
Diadophis punctatus	3
Opheodrys aestivus	3
Farancia abacura	4
Coluber constrictor	1
Masticophis flagellum	1
Pituophis melanoleucus	3
Elaphe obsoleta	1
Elaphe guttata	1
Cemophora coccinea	1
Lampropeltis triangulum	4
Lampropeltis calligaster	1
Lampropeltis getulus	1
Tantilla gracilis	3
Agkistrodon piscivorus	1
Agkistrodon contortrix	1
Sistrurus miliarius	1
Crotalus horridus	3
Micrurus fulvius	3

Hardwoods allowed to develop along creek bottoms provide more diversity, and kinds and numbers of organisms, including amphibians and reptiles, increase. Many of the species in the above list are absent (code 4) because of a lack of permanent water (except for some man-made ponds). However, as this study indicated, piney woods can sustain a moderate variety of amphibians and reptiles and in a few cases, large populations. The water in the areas, in addition to the ponds, includes only a few intermittant streams. Several species were found only around these meager water sources.

Amphibians and reptiles are basically second or third level consumers in the food chain. They likely are important links in the food web of the piney woods studied.

METHODS AND PROCEDURES

The sampling techniques were as follows:

I. Straight line transects were established and walked. Shrubs and trees (6 ft. or lower) were checked for herpetofauna (especially the lizards Anolis and Sceloporus), and ground cover was watched, especially for the lizards Scincella and Cnemidophorus. In addition debris (logs mainly) within 10 yards on either side of the transect were rolled over or if rotten "pulled apart" and searched for amphibians and reptiles.

Each transect was located within a specific habitat type and was searched for a recorded amount of time. A compass was used to maintain a straight line.

II. The other primary method used was a drift fence with associated five gallon buckets (sunk in soil) and funnel traps (Campbell and Christman, 1982, Fig. 2). The traps were randomly established in each of the habitat types and maintained throughout the study.

III. Other census methods were occasionly used with varying success. However, they did allow the addition of several species that would not have been otherwise recorded. These methods were:

1. Accidental observation while moving through the area, often from one trap site to another.
2. Driving the roads at night during warmer months. When a specimen was discovered in this manner, the type of habitat closest was recorded.
3. At the beginning of the study, quadrats were randomly set up and walked for a set amount of time. This procedure was discontinued and the transect method (I above) was substituted. The time involved in establishing randomly located quadrats was prohibitive.

The study sites were visited an average of twice a month. Usually two to two two and one-half days were spent in the area each trip. The exception was during very cold weather the visits were less frequent, especially in January. Most of the visits were made by the authors.

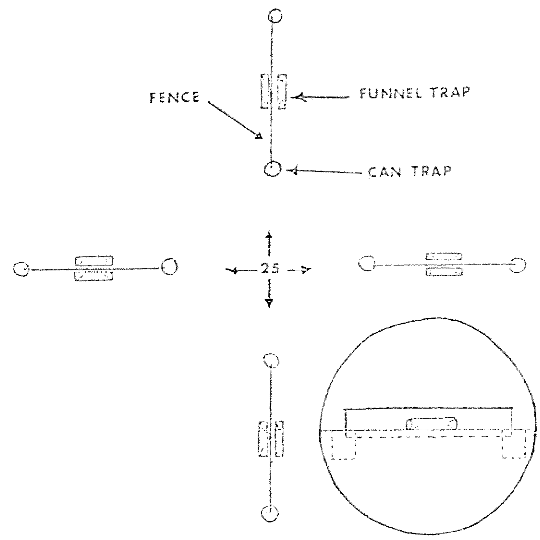

Figure 2. Diagram of drift-fence trap.

Sawtimber was the most abundant habitat; sapling stands were second in abundance. Poletimber and regeneration habitats were less available. Consequently sampling efforts, by necessity, were greater in sawtimber and sapling stands. For all comparisons given here, data are expressed as mean/unit effort (i.e., number per trap-night or per hour searched).

We used Conant (1975) and occasionly Keiser and Wilson (1979) for species identification. Nomenclature follows Conant (1975) except for watersnakes, where Nerodia was used instead of Natrix.

RESULTS AND DISCUSSION

Collections revealed surprising diversity of amphibians given the general lack of available water sources (Table 1). Amphibians were most abundant in sawtimber, uncommon in poletimber, and virtually absent in sapling and regeneration. Several factors undoubtedly account for this: (1) presence or absence of water, and (2) shaded cover. Both factors were most frequent in sawtimber. Also, certain species were only/or more frequently found along transects, where they crossed creeks. One species (Scaphiopus holbrooki) was collected on the road during a heavy rain.

Overall, amphibians occurred in such limited numbers and restricted habitats that they would be of little value as indicators of habitat change resulting from site disturbance. The narrow-mouth toad (Gastrophryne carolinensis) might be a possible exception for sawtimber stands.

Reptiles (Table 2) were more numerous and in

Table 1. Number of amphibians trapped or encountered (parenthesis value).

Species	Sawtimber[1]	Pole[1]	Sapling[1]	Regeneration[2]
Eurycea quadridigitata	9(3)	0(2)	0(0)	0(0)
Scaphiopus holbrooki	0(1)	0(0)	0(0)	0(0)
Gastrophryne carolinensis	12(6)	0(0)	0(0)	1(1)
Bufo woodhousei	0(2)	0(0)	0(0)	0(0)
Bufo valliceps	0(1)	0(0)	0(0)	0(0)
Acris crepitans	0(7)	0(2)	0(0)	0(0)
Pseudacris triseriata	0(+)	0(+)	0(0)	0(0)
Hyla cinerea	0(1)	0(0)	0(0)	0(0)
Hyla crucifer	0(2)	0(0)	0(0)	0(0)
Hyla versicolor	0(1)	0(0)	0(0)	0(0)
"frogs"	11(0)	0(0)	0(0)	0(0)
Rana clamitans	1(5)	0(0)	0(0)	0(1)
Rana catesbeiana	0(1)	0(0)	0(0)	0(0)
Rana sphenocephala	3(15)	4(0)	0(0)	0(0)
Totals	36(56)	4(5)	0(0)	1(2)

[1] The data for trapping results represents the totals for 142 trap nights. The data for transect walks represents 70 hours total time.

[2] The data for trapping results represents the totals for 70 trap nights. The data for transect walks represents 35 hours total time.

most cases, less related to water availability and consequently more useful as indicators for later comparative purposes. Lizards were the most abundant reptile group. With the possible exception of box turtles (Terrapene carolina) only certain lizards seem to be abundant (i.e., observable) enough to be useful as indicator species. The three most abundant lizards were the fence lizard (Sceloporus undulatus), the ground skink (Scincella lateralis), and the American anole (Anolis carolinensis). Although Anolis carolinensis and Sceloporus undulatus are found in all habitat types, many records in sapling and regeneration (especially Anolis) were obtained as the transect passed near an isolated hardwood (often black-jack oak).

Table 2. Number of reptiles trapped or encountered (parenthesis value).

Species	Sawtimber[1]	Poles[1]	Sapling[1]	Regeneration[2]
Terrapene carolina	4(6)	2(1)	3(7)	5(0)
Sceloporus undulatus	67(15)	3(4)	1(0)	2(0)
Anolis carolinensis	25(9)	3(2)	1(0)	3(0)
Scincella lateralis	68(20)	4(7)	3(1)	2(0)
Eumeces fasciata	0(1)	0(0)	0(0)	0(0)
Eumeces laticeps	0(2)	0(0)	0(0)	0(0)
Eumeces anthracinus	3(0)	0(0)	2(0)	0(0)
Ophiosaurus attenuatus	0(0)	1(0)	0(0)	0(0)
Coluber constrictor	3(3)	0(1)	1(2)	4(0)
Masticophis flagellum	0(2)	0(0)	0(0)	0(1)
Elaphe obsoleta	1(0)	0(0)	3(1)	0(0)
Elaphe guttata	0(2)	0(0)	0(0)	0(0)
Lampropeltis getulus	0(3)	0(0)	0(1)	0(0)
Lampropeltis calligaster	1(0)	0(1)	0(0)	0(0)
Cemophora coccinea	1(0)	0(0)	0(0)	0(0)
Storeria dekayi	1(0)	0(0)	1(0)	0(0)
Storeria occipitomaculata	1(0)	0(0)	0(0)	0(0)
Thamnophis sirtilis	1(1)	0(0)	0(0)	0(0)
Agkistrodon contortrix	1(6)	1(2)	0(1)	0(0)
Agkistrodon piscivorus	1(22)	0(3)	2(0)	0(0)
Sistrurus miliarius	2(0)	1(1)	0(1)	0(0)
Totals	180(88)	15(22)	17(14)	16(1)

[1] The data for trapping results represents the totals for 142 trap nights. The data for transect walks represents 70 hours total time.

[2] The data for trapping results represents the totals for 70 trap nights. The data for transect walks represents 35 hours total time.

Distribution of the three most common lizards was compared by stand size classes and forest types (Table 3). The loblolly-shortleaf pine site had two areas, with a more uniform occurence among stand size classes. We attribute these differences to more hardwoods and ground cover at Catahoula and the presence of cattle at Vernon. Regeneration was not extensive enough in either area to be sampled adequately.

Table 3. Occurences (%) of the three most common lizards by stand size classes for loblolly-shortleaf (Catahoula) and longleaf-slash pine (Vernon) sampling areas (Catahoula data from Williams and Mullin, 1987).

Species	SAWTIMBER	POLE	SAPLING	REGEN.
Anolis				
Vernon	79	10	3	8
Catahoula	33	29	33	5
Scincella				
Vernon	84	10	4	2
Catahoula	68	28	3	1
Sceloporus				
Vernon	89	8	1	2
Catahoula	62	19	17	2

Scincella lateralis may be the best candidate of the three lizards for monitoring grazing effects. It was the most abundant, lives primarily on the ground under pine or leaf litter, limbs and log debris, and would be subject to the trampling of cattle. Brooks (1967), Johnson (1953), and Turner (1961) give considerable information on the ground skink both on its habitat and density.

As with amphibians reptiles were more abundant in sawtimber where there was more shade and vegetation structural diversity; however, the difference between stand size classes were not as apparent as with amphibians. Snakes were not observable enough by trapping or transect observations to be useful as indicators unless perhaps, all species were lumped.

Interestingly, two of the most commonly encountered snake species copperheads and cottonmouths were poisonous. Many of the cottonmouth (Agkistrodon piscivorus) records were obtained in late summer along drying creeks, but several were taken in traps a considerable distance from water. Copperheads (Agkistrodon contortrix) were active primarily at night and most records were obtained while driving roads. The most abundant harmless snake was the buttermilk snake or racer (Coluber constrictor). It was one of the few species in fair abundance in all four stand size classes. The box turtle (*Terrapene carolina*) was also found in all four areas.

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LITERATURE CITED

Brooks, G.R. 1967. Population ecology of the ground skink, *Lygosoma laterale* (Say). Ecol. Monog. 37(2): 71-87.

Campbell, H.W., and S.P. Christman. 1982. Field techniques for herpetofaunal community analysis, pp. 193-200 *in* Herpetological communities (N.J. Scott, ed.). U.S. Dept. Interior, Fish and Wildlife Service. Wildlife Res. Rept. 13.

Conant, R. 1975. A field guide to reptiles and amphibians of eastern and central North America. Second ed., H.M. Co. xviii + 429 pp.

Johnson, R.M. 1953. A contribution to the life history of the lizard *Scincella laterale* (Say). Tulane Stud. Zool. 1(2): 1-27.

Keiser, E.D., and L.D.Wilson. 1979. Checklist and key to the amphibians and reptiles of Louisiana. Lafayette Nat. Hist. Mus. Bull. 1, 49 pp.

Turner, F.B. 1960. Estimation of a Louisiana population of the skink *Lygosoma laterale*. Ecology 41(3); 574-577.

Williams, K.L., and K. Mullin. 1987. Amphibians and reptiles of loblolly-shortleaf pine stands in central Louisiana. This volume.

MAMMALS OF LONGLEAF-SLASH PINE STANDS

IN CENTRAL LOUISIANA

KEITH MULLIN AND KENNETH L. WILLIAMS[1]

Abstract.--Four study areas of between 1300 to 2300 acres each, in Vernon Ranger District, Kisatchie National Forest, in central Louisiana, were sampled for mammals from June 1980 through December 1981. Four stand types were sampled within the study areas--regeneration, sapling, poletimber and sawtimber. A variety of sampling techniques were utilized including trapping, drift fence-pitfalls, and scent posts. Sawtimber exhibited the most diversity, sapling was next, followed by poletimber. The two primary sampling methods, Sherman or snap traps, and drift fence-pitfall traps provided information on different portions of the small mammal fauna. Species richness, diversity (Sherman-Weiner), and evenness were calculated separately for trapline and drift fence-pitfall data for each stand class. Similarity of species was calculated for each stand-age class combination. Abundance indices based on all captures were calculated as catch per unit effort for each stand-age class.

INTRODUCTION

Cattle grazing is one aspect of the U.S. Forest Service's multiple-use forest management plan for National Forests in the southern United States. The effects of grazing on the diversity and abundance of mammals is not clearly understood. Mammals are an important part of the ecosystem. They fill a wide variety of niches in the southern forest; herbivore, insectivore, carnivore, and omnivore. Any major effects on the forest ecosystem should be reflected in mammalian diversity and abundance at some level. This would be particularly true for small mammals because of their limited locomotor abilities in response to a change in their habitat.

The Forest Service's management plans usually include a harvest of timber and reforestation on selected rotations. There is a continum of tree stand ages because of this, which could have a confounding effect on mammal populations.

The objective of this study was to provide pretreatment data (i.e., no grazing) on mammalian diversity and abundance in four representative age class stands of longleaf pine (*Pinus palustris*) and/or slash pine (*Pinus elliottii*) in Louisiana.

The study took place on four study sites in the Vernon Ranger District, Kisatchie National Forest, central Louisiana. Each treatment stand was classified as one of the following stand-age classes: 1) sawtimber, more than 10 inches dbh, 2) poletimber (poles), 4 to 10 inches dbh, 3) sapling, less than 4 inches dbh, and 4) regeneration, no pine or seedlings. Descriptions, locations and sizes of each treatment stand can be found in Williams and Mullin (1987).

Some treatment stands were subjected to scheduled control burns. Military activity (trucks, tanks etc.) from nearby Fort Polk Army base occurred on most of the treatment stands throughout the study. Cattle grazing also occurred on the treatment stands during the study because fences were frequently cut or gates were left open.

A variety of animal species are found in the area where the study was conducted. We extracted a list of mammals from Lowery (1974) which according to his range maps occur in this area. The list is given below with the following category designations: 1=obtained or seen in our study, 2=known to occur in immediate area, but not obtained in our study areas, 3=likely occurs, but not obtained in study area or adjacent areas, and 4=range maps show it as occurring in this area, but not likely

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due to lack of suitable habitat.

Species	Category
Didelphis virginiana	1
Blarina brevicauda	1
Cryptotis parva	1
Scalopus aquaticus	3
Myotis austroriparius	3
Nycticeius humeralis	1
Lasiurus intermedius?	3
Lasiurus seminolus	3
Lasiurus borealis	1
Eptesicus fuscus	3
Pipistrellus subflavus	1
Plecotus rafinesquii	1
Tadarida braziliensis	2
Dasypus novemcinctus	1
Sylvilagus floridanus	1
Sylvilagus aquaticus	1
Sciurus carolinensis	1
Sciurus niger	1
Glaucomys volans	1
Geomys bursarius	1
Perognathus hispidus	1
Oryzomys palustris	4
Reithrodontomys humilis	3
Reithrodontomys fulvescens	1
Peromyscus gossypinus	1
Peromyscus leucopus	1
Ochrotomys nuttalli	1
Sigmodon hispidus	1
Neotoma floridana	3
Microtus pinetorum	1
Ondatra zibethicus	4
Rattus rattus	4
Rattus norvegicus	4
Mus musculus	3
Myocastor coypus	4
Canus latrans	1
Canus rufus (probably hybrids)	1
Vulpes fulva	1
Urocyon cinereoargenteus	1
Procyon lotor	1
Mustela frenata	3
Mustela vison	1
Mephitis mephitis	1
Lutra canadensis	4
Lynx rufus	2
Odocoileus virginianus	1

METHODS AND PROCEDURES

The study took place from 1 June 1980 to 31 December 1981. The study area was visited during two to two and one-half day periods twice each month. The following methods were used to determine the presence of mammal species in the entire study area or on a selected stand-age class and to quantify relative abundance for selected species.

The following sampling techniques were utilized during this study:

1) Trapping. Trap lines were laid out in each of the stand-age classes for two to four nights each month from September 1980 to April 1981. Trapping was abandoned after April due to lack of results in warm weather. Fire ants probably contributed greatly to this. Trapping effort in each stand-age class was approximately proportional to availability. A trap line consisted of stations placed 15 yards apart in a straight line. A station was a Sherman live trap and a Museum Special snap trap baited with a mixture of rolled oats and peanut butter. Traps were set just prior to sunset and checked at first light the following day. All animals were identified, standard measurements taken, and removed from the study area. Trap lines were placed in a new area each time. Total trapping effort was 4085 trap nights. Large live traps were set in a non-systematic manner in a limited way. These traps were baited with apples, dog food, or sardines. Animals obtained (racoons and opossums) were identified and released.
2) Drift fence-pitfall traps. Traps built for a related reptile and amphibian study (see Williams and Mullin, 1987 for details) were found to be effective for small mammals. Because of this success, additional drift fence-pitfall traps were built. The number of traps in each stand-age class was proportional to availability. Fifteen traps were operational for varying amounts of time from May 1980 to August 1981 for a total of 269 trap months. Traps were checked twice each trip (usually 4 times a month)and all captured animals were identified and removed.
3) Scent posts. Scent posts were established with a cleared area of soil one yard in radius. These were kept clear and the post was usually scented with canid scent. Scent posts were examined each morning for tracks. It was usually impossible to distinguish between species of foxes, rabbits and squirrels, thus we simply clumped them into a general category (i.e., foxes, rabbits, and squirrels).
4) Bat shooting and netting. Mist nets were stretched across ponds and logging roads. A variety of net sizes and heights were tryed in the stand-age classes. Bats were also shot near twilight in similar areas. In addition we searched for resting bats under all bridges in the study areas.

5) General observations. Any mammal seen in the study areas during our general movements, found dead or otherwise identified were recorded.

Names and identification of mammals were based on Lowery (1974). Track identification was based on Murie (1974).

Species richness, diversity (Shannon-Wiener), and evenness (Krebs, 1972) were calculated separately for trapline data and drift fence-pitfall results for each stand-age class. Similarity of species (Odum, 1971) was calculated for each stand-age combination. Abundance indices based on all captures were calculated as catch per unit effort for each stand-age class.

RESULTS AND DISCUSSION

The two primary sampling methods, Sherman or snap traps (SST) and drift fence-pitfall traps (DFPT), sampled different portions of the small mammal fauna. Specimens from SST were 68% Peromyscus spp. while 63% of the DFPT specimens were shrews. Since we do not know how results from the two methods relate to each other it was necessary to present results from both methods.

Overall eight species were sampled using both methods (Table 1). SST captured all eight. DFPT did not capture Ochrotomys nuttalli or Peromyscus gossypinus. Sawtimber was the stand-age class richess is species, all eight were captured. Regeneration was the poorest in species (Table 1). Even though there was no significant difference species richness among stand-age classes (X^2=.77, P>.05) differences would probably be expected (Table 2). The regeneration areas were relatively homogenous in habitat structure when compared to the other areas and this should have limited the number of species. Based on Lowery's (1974) habitat descriptions species such as Reithrodontomys fulvescens, O. nutalli, and P. gossypinus should not have been captured in the regeneration and indeed they were not.

Table 1. The total number of species captured in, A-Sherman or snap traps, B-drift fence traps, and C- combined in the four stand-age classes.

	Sawtimber	Poles	Saplings	Regeneration
A	6	4	5	5
B	8	4	5	0
C	8	6	7	5

Lowery's (1974) distribution map for Microtus pinetorum showed that it was outside of the range of the study area. M. pinetorum was thought to be relatively uncommon where it did occur in the state. The vole, however, was captured in each stand-age class during the study and it made up 20% of the captures from DFPT. This range extension is documented in detail by Williams, et al. (1980).

Both trapping methods showed sawtimber to be the most diverse and even with poles second in both categories (Table 3).

The distribution of overall captures from DFT was significantly different across the four stand-age classes (X^2=12.29, P<.05). More specimens than expected were captured in the two younger stands, sapling and regeneration. The results from SST were also significant (X^2=11.17, P<.05). However more than expected were captured in the older stand-age classes. These results are also reflected in the relative abundance

Table 2. Percent similarity of species between stand-age classes.

	Sawtimber	Poles	Sapling
Poles	86		
Sapling	93	92	
Regeneration	77	91	83

Table 3. The Shannon-Wiener species diversity index (H), and evenness (e), (range 0-1) for the two trapping methods.

	Sawtimber	Poles	Saplings	Regeneration
	Drift fence traps			
H	1.13	0.63	0.96	0.91
e	.71	.57	.70	.66
	Sherman or snap traps			
H	1.65	1.05	1.32	0.0
e	.85	.76	.82	.0

indices (Table 4).

Shrews were ubiquitous, high numbers were captured in each stand-age class. Peromyscus gossypinus and Ochrotomys nuttalli while placed in the sawtimber class were usually captured near hardwood areas. The other species captured were relatively uniform in both presence and abundance across the stand-age classes.

Table 4. Number of specimens of each species captured in each stand-age type class. The first number in each column is from the drift fence traps and the second from Sherman or snap traps.

Species	Sawtimber	Poles	Sapling	Regeneration
Cryptotis parva or Blarina brevicauda	30-4	18-2	28-4	14-0
Microtus pinetorum	16-3	4-0	6-0	3-0
Reithrodontomys fulvescens	9-4	1-2	9-1	0-0
Sigmodon hispidus	1-1	0-0	1-4	1-0
Peromyscus leucopus	1-12	0-15	0-11	2-0
Peromyscus gossypinus	0-12	0-6	0-0	0-0
Ochrotomys nuttalli	0-2	0-0	0-0	0-0
Total	57-38	23-25	44-22	20-0
Abundance Index [1]	50-28	33-28	79-15	67-0

1/ Total number of specimens divided by trapnights (X 100) for Sherman or snap traps, or trap months (X 10) for drift fence traps.

Three species of bats, Pipistrellus subflavus, Lasiurus borealis, and Nycticeus humeralis were accounted for in the study areas by shooting. Most were shot on a pipeline through sawtimber. This pipeline created a natural flying corridor and aided in shooting so these bats are not necessarily associated with sawtimber. Specimens of Plecotus rafinesquii were located resting under bridges in the study area. The mist netting of bats was unsuccessful.

All other species of mammals except two which should have been captured in longleaf-slash pine stands based on Lowery's (1974) range maps and habitat descriptions were accounted for in the study area. This was done by tracks at scent posts or on dirt roads, animals found dead, or incidental observations. The exceptions were

Table 5. Total number of larger mammals observed by tracks or other means.

Species	Sawtimber	Poles	Saplings	Regeneration
Didelphis virginiana	5	2	1	-
Dasypus novemcinctus	34	2	-	-
Sylvilagus floridanus	1	1	2	4
Sylvilagus aquaticus	1	1	2	4
"rabbits" (tracks)	16	4	1	2
Sciurus carolinensis	1	2	-	-
Sciurus niger	21	2	1	-
"squirrels" (tracks)	26	2	-	-
Glaucomys volans	1	-	-	-
Canus latrans	9	-	1	-
Canus rufus	4	-	-	-
Vulpes fulva	-	1	-	-
Urocyon cinereoargenteus	2	-	-	-
"foxes" (tracks)	8	2	-	-
Procyon lotor	6	-	-	-
Mustela vison	2	-	-	-
Mephitis vison	5	-	-	-
Odocoileus virginianus	28	8	9	1
Totals	170	26	19	11

Mustela frenata and Reithrodontomys humilis both of which are thought to be extremely rare in the area. See Table 5 for a list of the larger mammals obtained or observed in the study area.

LITERATURE CITED

Krebs, C.J., 1972. Ecology: The experimental analysis of distribution and abundance. Harper and Row, Publ., Inc.

Lowery, G.H., Jr. 1974. The mammals of Louisiana and its adjacent waters. Louisiana State Univ. Press.

Murie, O.J. 1974. A field guide to animal tracks. H.M. Co. 2nd ed.

Odum, E.P. 1971. Fundamentals of ecology. 3rd ed. W.B. Saunders Co., Philadelphia.

Williams, K.L., and K. Mullin. 1987. Amphibians and reptiles of longleaf-slash pine stands in central Louisiana. This volume.

Williams, K.L., D.T.Stalling, and J. Scarborough. 1980. Range extension of the woodland vole in west-central Louisiana. Louisiana Acad. Sci. 43: 12-14.

Avian Use of Habitats in the Longleaf-Slash Pine

Forests of Louisiana

Robert B. Hamilton and Vincent G. Yurkunas

Abstract.--Birds were counted in consecutive plots along transects in four study areas, three grazed and one ungrazed. The differences in abundance, richness and species composition that were found among study areas and seasons were related to habitat differences among areas and the transitory nature of avian communities.

INTRODUCTION

Longleaf pine (*Pinus palustris*)[1] and slash pine (*P. elliottii*) are important commercial species throughout the Southeast (USDA 1965). Together they are the dominant species in a widespread plant community inhabited by a variety of wildlife species. Except for game birds (Stoddard 1931, Stoddard 1963, Rosene 1969, and Holbrook 1973) and endangered species (Thompson 1971), little is known about habitat requirements of birds in "longleaf-slash pine" forests.

The applicability of studies of avian communities in other pine types such as "loblolly" (*P. taeda*) (Noble and Hamilton 1975), "slash" (Johnson and Landers 1982), "loblolly-shortleaf" (*P. echinata*) (Quay 1947, Johnston and Odum 1956, Dickson and Segelquist 1977 and 1979), and "pitch pine-oak" (*P. rigida* and *Quercus* spp.) (Conner et al. 1979) to bird habitat relationships in the "longleaf-slash" type is not known. Baseline data are needed by managers on bird habitat relationships for this specific forest type. This study, a part of the USDA Forest Service's Range Evaluation Project to promote sound multiple-use management of southern forested land (Pearson 1979:1), was designed to provide these baseline data.

The first phase of the study plan was to gather pre-treatment baseline data on soils, water, vegetation, and wildlife. Areas were then to be exposed to varying levels of cattle grazing pressure including an ungrazed control and three grazing intensities. Third, the measures taken in the first phase were to be repeated and the effects of the varying levels of grazing intensity were to be evaluated. This study was to be part of the first phase of the overall investigation.

This approach presupposes that study areas are equivalent with respect to the variables being measured; *i.e.* each study area would initially have the same pattern of distribution and abundance of birds as all of the others and the areas would remain similar throughout time if no treatment were made. This assumption is required for any study that compares the effects of treatments on different areas. However, this assumption apparently does not hold for the areas reported on here. Each study area is unique and consists of a variety of stand ages and types as well as various distributions of these in space. Even management activity varied among the study areas. Birds are not scattered at random and their distribution is not independent of the environment. Because each species has its own requirements, the birds present at any location depend on ambient conditions, and as conditions change the bird communities change (Hamilton and Noble 1975). Species composition and abundance change with succession (Shugart and James 1973, Johnston and Odum 1956) and, particularly relevant in this case, the age of pine stands (Noble and Hamilton 1975). Patterns of abundance are affected by the presence of edge (see Hamilton and Noble 1975) as well as the size of habitat blocks (see Harris 1984). Diversity, a measure that combines the concepts of species richness (number of species) and relative abundances of each species present, is used often to describe avian communities. Diversity changes with succession (see Hamilton and Noble 1975) and is primarily affected by vegetative structure (foliage height diversity) (MacArthur and MacArthur 1961, MacArthur 1964, Schoener 1974). Foliage volume (Balda 1969), percent vegetation cover (Karr and Roth 1971), plant species diversity (Tomoff 1974) and snag density (Conner 1978) have all been shown to affect avian diversity in some situations. Diversity will not be measured directly in this paper (see Hamilton and Lester 1987) but the factors mentioned above should all affect the bird communities in the study areas and the relative abundance of the species that constitute the communities.

We attempted to ascertain whether achievable methods of assessing the composition of bird communities at the study area level can be sufficient for future analysis of treatment effects. In addition, we attempted to determine the desirability of using habitat information that is readily available to foresters, and the general knowledge of habitat requirements of birds to explain any differences of avian abundance patterns among study areas.

[1] Scientific and common names of plants follow Radford et al. (1968).

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The study areas have endured many years of burning, harvesting, and grazing. Cattle were removed from three of four study areas prior to this study and thus, to a small degree, the effects of cattle grazing can be evaluated in this pretreatment phase by comparing avian communities in the grazed and ungrazed study areas.

Specific objectives are to determine:

1) Seasonal status of birds in the "longleaf-slash" type.

2) Habitat relationships of birds in the "longleaf-slash" type.

3) Differences in avian abundance between grazed and ungrazed study areas.

4) Differences in avian abundance among the ungrazed areas.

We are grateful to those who helped make this study possible. The field work was financed by the U.S. Forest Service and the LSU Agricultural Center and Louisiana Agricultural Experiment Station. Most of the field work was done by Vincent Yurkunas and the data on bird habitat relations were used in his thesis. Dr. Robert E. Noble assisted in the collection of the supplemental vegetation data. Dr. James P. Geaghan and his student, Susan M. Peterman, of the Experimental Statistics Department of Louisiana State University helped with statistical design and programming. We appreciate the help of Forest Service employees, especially Dr. Henry Pearson, who conceived the Range Evaluation Project and provided vegetation data from the study area for our use. The Louisiana Department of Wildlife and Fisheries provided living accommodations near the study area.

STUDY AREA

Four study areas, each approximately 2000 ac in extent, in west-central Louisiana were utilized. Areas 1,2, and 3 are adjacent to each other (n to s) and about 5 mi west of Area 4. Area 3 is approximately 2 mi west of Fullerton (Yurkunas 1984).

The study areas, consisting of flatlands interspersed with gently rolling hills and meandering streams, are in the Vernon Ranger District of the Kisatchie National Forest, Vernon Parish, Louisiana. The forests are primarily the "longleaf-slash pine" type of all ages, with some hardwoods interspersed, especially in the stream bottoms.

Sampling was done along transects that passed through the vegetation sampling points used by Pearson (1979). These points are spaced every 200 ft on n-s lines, 1500 ft apart. The location of the origin of the initial vegetation transect in each study area was randomly determined. Plotless sampling of vegetation had been done previously and prism-recorded trees have been identified and measured with a dbh tape. Plot centers have been marked with metal stakes and the adjacent trees have been blazed.

FWe established 75 additional vegetation points to connect the existing transects in appropriate places to facilitate bird sampling. By adding the additional points, we were able to increase the representativeness of our sample and maintain the desired lengths that were convenient to passable roads. In each study area, two avian sampling transects were placed congruent with existing vegetation transects, except for interconnecting segments. Avian transects were easily accessible and consisted of a mixture of stand and age types that were representative of the study areas.

Stand-Age Classes

We utilized three stand age classes that were based on the height of the tallest tree. The tallest trees in "sapling" plots were 6 m (20 ft) or less. The tallest trees in "pole" plots were between 6 m and 20 m (20 ft to 50 ft) high and those in sawtimber plots were 20 m (50 ft) or more.

Stand Types

We used three stand types based on the percent of prism-recorded trees with a dbh of 1 in or more. "Hardwood" plots had 75% or more hardwood trees, "pine" plots had 75% or more pine trees, and "mixed" plots had less than 75% of each.

Ecological Description

The most abundant trees were longleaf pine, slash pine, loblolly pine (*P. taeda*), blackgum (*Nyssa sylvatica*), sweetgum (*Liquidambar styraciflua*), southern red oak (*Quercus falcata*), sweetbay (*Magnolia virginiana*), blackjack oak (*Q. marilandica*), red maple (*Acer rubrum*), and water oak (*Q. nigra*). Three genera of grasses made up most of the ground cover: *Andropogon*, *Panicum*, and *Paspalum*. The pines were mainly on the ridges and flatlands with the grasses and the two most common shrubs, waxmyrtle (*Myrica cerifera*) and blackberry (*Rubus* spp.) made up the majority of the understory. Hardwoods were mainly in the bottoms and near water.

We considered nine combinations of stand type and age in our study areas as distinct habitats. The study areas consisted of a mixture of interspersed habitats with pine types tending to predominate except near bottoms where hardwoods were more common. The ages and sizes of the interspersed stands depended on past management (tab. 1 and fig. 1).

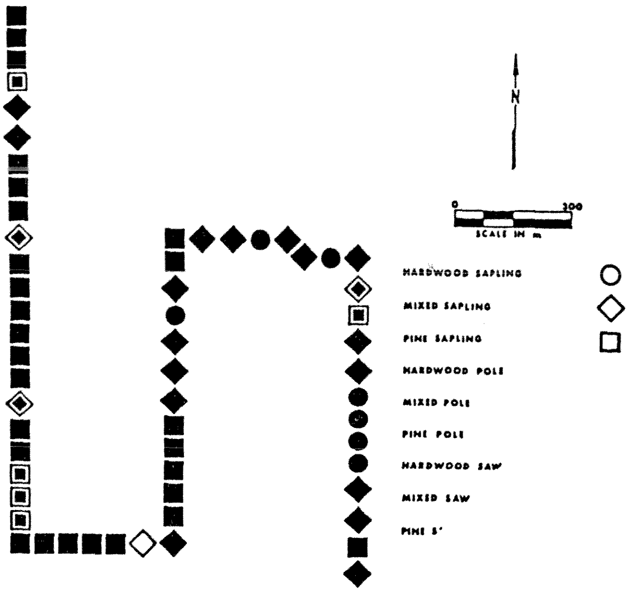

Figure 1.-- Diagrammatic map of habitats on a typical transect, transect 3W, Vernon Ranger District, Kisatchie National Forest, Vernon Parish, Louisiana.

Habitats we identified were

Hardwood Sapling.--These tended to be linear stands located primarily in bottoms where streams crossed or were small blocks isolated in upland pine stands. The saplings were generally close together.

Mixed Sapling.--This habitat was usually found isolated or clumped in upland areas and was unevenly distributed among transects. Trees were generally farther apart than in "hardwood sapling" stands.

Pine Sapling.--Most stands of this habitat were clumped in upland areas but the habitat was sometimes present as a transition between habitats. Trees were spaced farther apart than trees in the preceding habitats. Blackberry thickets were common in this habitat in Area 4.

Hardwood Pole.-- This habitat occurred primarily near stream bottoms, as a transition among habitats. Trees were close together and a vine and hardwood understory was usually present.

Mixed Pole.--This is another habitat that was present at transitions in bottoms but additionally occurred at transitions in upland areas. Trees were farther apart than in "hardwood pole" plots.

Pine Pole.-- Most stands of this habitat were clumped together in upland areas. Trees were spaced close together and the canopy was closed. Ground cover was sparse. Slash pine plantations were often of the age to be assigned to this habitat.

Hardwood Sawtimber.--Most stands of this habitat were clumped along stream bottoms, but a few small stands were in upland areas. Tree density varied among areas. A sparse hardwood and vine understory was present.

Mixed Sawtimber.--Plots of this habitat were located in all segments of the study area. Trees were generally closely spaced. This habitat usually had well developed understory and ground cover layers.

Pine Sawtimber.--This habitat was mostly clumped in uplands and the trees were widely spaced. Ground cover often contained grasses as well as hardwood saplings, shrubs and forbs. This was the most common habitat on the study areas.

Table 1.-- Number of plots in each habitat, by transect, Vernon Ranger District, Kisatchie National Forest, Vernon Parish, Louisiana, 1981-1982

	Transect								
Habitat	1W	1E	2W	2E	3W	3E	4W	4E	Total
Hard sap	1	2	1	0	0	0	1	0	5
Mixed sap	0	1	0	1	1	0	11	0	14
Pine sap	3	21	0	14	0	0	11	8	57
Hard pole	1	1	0	1	0	1	0	0	4
Mixed pole	0	1	0	0	3	1	0	0	5
Pine pole	2	3	0	0	5	5	0	22	37
Hard saw	11	0	9	3	7	8	4	0	42
Mixed saw	12	3	4	7	17	12	4	2	61
Pine saw	30	28	46	34	27	33	29	28	255
Total	60	60	60	60	60	60	60	60	480

The interspersion of habitats along the transects was variable (fig. 1, e. g.). The relative proportions of each habitat differed among transects (tab. 1), but in each area the habitat distribution of the transects roughly approximated the habitat distribution of the corresponding study area. Clumps of some types, such as "hardwood" and "mixed" plots, tended to be relatively small because of their locations at edges or in flood plains of small intermittent streams. These habitats could be considered to be entirely affected by edge (tab. 2). Pine types tended to occur in larger clumps because of the prevailing management practices.

Block size did not vary much with age (tab. 2). Only the pine stands were managed and they were the prevailing type in all of the transects so block sizes of the three stand ages were approximately the same; differences were probably due to sample error.

Table 2.-- Mean number of plots/clump in the habitats of the study areas, Vernon Ranger District, Kisatchie National Forest, Vernon Parish, Louisiana, 1981-1982

	Type			
	Hardwood	Mixed	Pine	Mean
Sapling	1.00	1.75	3.80	2.71
Pole	1.00	1.00	2.85	2.09
Sawtimber	1.62	1.56	4.64	2.98
Mean (study area)	1.46	1.54	4.22	2.82

Table 3.-- Mean number of plots/clump, by age and type, in the four study areas, Vernon Ranger District, Kisatchie National Forest, Vernon Parish, Louisiana, 1981-1982

	Area			
Plot class	1	2	3	4
Sapling	2.55	3.20	1.00	2.82
Pole	1.14	1.00	1.36	7.33
Sawtimber	2.71	2.50	2.54	4.79
Hardwood	1.45	1.27	1.45	2.50
Mixed	1.42	1.20	1.70	1.70
Pine	3.34	4.95	3.18	6.13
Mean	2.45	3.00	2.26	4.29

There were substantial differences among areas, however, both in the relative proportions of each habitat sampled (tab. 1) and in the block sizes of some of the habitats (tab. 3), especially in Area 4 where habitats tended to be larger. Area 4 was separate from the other three Areas and apparently had been managed somewhat differently. Maps of habitat type distribution along each transect have been prepared and are available (Yurkunas 1984:fig. 16-23).

The forests in the region of the study have been managed for "pine sawtimber" for many years. Hardwoods have been excluded through burning. Recreational use is light to moderate, with hunting being the prime recreational activity. Although the study plan was to investigate areas in a pre-grazing situation, Areas 1-3 were being grazed during the study and had been for many years. Grazing pressure was unevenly distributed in time and space. Timber harvesting and thinning were conducted in Areas 1-3 immediately prior to the study. The regeneration method employed is usually seedtree. Prescribed burning is conducted on a 3-yr rotation to stimulate grass growth. During the winter of our study, parts of Areas 1-3 were burned. On Area 4, there was no harvesting, grazing or burning immediately before or during this study, but Area 4 had been grazed up to the year before our study.

METHODS

Transects

We connected some of the vegetation point centers to form eight continuous transects (two/area), each 12,000 ft. long (60 points). Birds were counted as an observer walked the line. Because plot types along the lines were not arranged in a discernible pattern (see fig. 1), the transects were analyzed as a series of consecutive plots, each of a specific type.

Two groups of four transects (one/area) each were randomly selected. These groups were sampled on alternate months. Within a group the order of sampling was random; the direction of travel was alternated throughout the study.

The number of birds/plot was the experimental unit that was analyzed with appropriate tests. The number of birds/plot is a density index rather than a true density (Caughley 1977). All birds were probably not detected and the true density is thus somewhat higher than we report.

We estimated that we could hear and see the birds present at a distance of 75 m (246 ft) and used this distance as the distance from the transect line to the plot boundary. Total plot width was thus 150 m (500 ft). The length of each plot was 200 ft, and each plot had an area of 2.3 acres. The vegetative sampling points were the centers of each plot, and vegetation at the center was attributed to the entire plot.

Sampling Seasons

We divided the year into 6 seasons for this analysis:

1) January-February, winter with little migration;

2) March April, bulk of spring migration and residents begin breeding;

3) May-June, peak of resident breeding and late spring migration;

4) July-August, post-breeding dispersal and early fall migrations;

5) September-October, peak of autumn migration;

6) November-December, primarily late fall migrants and wintering birds present.

For statistical tests, the relatively stable seasons "1", winter, and "3", breeding were used.

Statistical Methods

Density (#/plot) of birds was analyzed as a dependent variable as were species richness and abundance. Season, stand type, stand age, transect, and study area were the independent variables. We compared species richness, abundance, and density among areas with an Analysis of Variance and Duncan's Multiple Range Test (Steele and Torrie 1980).

To make comparisons among habitats we used a multivariate analysis of variance (MANOVA) using a model with a factorial arrangement for stand type and stand age and a split-plot arrangement for season. Alpha was 0.05 when we tested for all the species lumped together. Alpha of 0.1 was used when testing individual models because of the relatively small sample sizes involved.

Computations were made, using programs from the Statistical Analysis System (SAS) (Helwig and Council 1979), on an IBM 3033 Computer at the Systems Network Computer Center, Louisiana State University,

Field Methods

Birds were counted along the selected transect from dawn to about 30 minutes later. Binoculars were used to aid visual identification. All birds that were detected (singing, nesting, foraging, etc,) within an estimated 75 m (250 ft) of the transect lines were counted. The appropriate sample plot, for those birds not perpendicular to the transect line, also had to be determined. Three minutes were allowed to traverse each plot. No counts were made when it was raining. It took approximately 3 hrs. to sample each transect.

RESULTS AND DISCUSSION

Weather

The mean maxima and minima temperatures in the summer of 1981 were about 2½F warmer than average (tab. 4). There was only 1 day, in July 1981, with a maximum exceeding 100½ F. Most of the study period was also drier than usual (tab. 4).

Abundance

A total of 83 species were found on the study areas. The density of the 73 species that were found during the counting periods included in this report varied greatly among species and study areas. (tab. 5). The most abundant species was the Yellow-rumped Warbler (scientific names for all species not given elsewhere are listed in tab. 5), with a maximum density of 100/100 plots in Area 3 in the winter. Next was the American Robin with a maximum density of 79.6/100 plots in Area 1 in the winter. Both species are flocking species and are often quite abundant. In the breeding season the highest density was 16.7/100 plots for Northern Cardinals in Area 3. Next was 15.0/100 plots for Blue Jay also in Area 3. There were many species found only occasionally in both seasons (tab. 5). A species that was surprisingly abundant was Bachman's Sparrow with densities from 7.9 to 12.5/100 plots during the breeding season. This species is rather inconspicuous, except for when it is singing, and lower observed winter densities were probably due to the lack of singing at that time. Many ornithologists consider the Bachman's Sparrow to be rare and a threatened species. The endangered Red-cockaded Woodpecker was relatively common in all seasons. All other species were as expected except densities were much lower than in the corresponding study in the "loblolly, shortleaf pine-upland hardwood" forests to the east (Hamilton and Lester 1987).

Table 4.-- Weather data at Leesville, Louisiana, approximately 33 km NW of the study areas, for the period 19511973 (NOAA 1975) and for the study period, Jul.1981-Jun.1982 (Ruffner 1980)

	Mean daily Max. (°C)		Mean daily Min (°C)		Mean precipitation (cm)	
Month	Avg	Study	Avg	Study	Avg	Study
Jul	92.8	94.5	69.8	72.0	5.28	4.67
Aug	92.7	94.9	68.7	70.3	3.70	1.20
Sept	88.5	89.3	64.0	61.5	3.66	2.36
Oct	80.8	78.5	52.5	56.0	2.99	4.99
Nov	70.0	73.3	44.2	47.3	4.13	2.71
Dec	62.8	60.4	39.6	36.9	5.98	2.75
Jan	60.8	61.9	37.9	37.4	4.21	2.61
Feb	64.2	59.0	39.9	37.9	4.76	4.84
Mar	71.1	71.9	45.9	52.8	4.21	3.35
Apr	78.6	74.7	54.9	54.4	5.20	6.50
May	84.7	85.2	60.6	60.6	5.16	4.01
Jun	90.5	91.5	66.7	68.0	4.17	5.22

The number of individuals in summer and winter was highest in Area 3 and second highest in Area 4 (tab. 6). This was probably due to the habitat differences among the areas (tab. 1). Area 3 had more "hardwood" and "mixed sawtimber" plots than the other areas. These types had well-developed understory and ground cover layers as well as high vegetational diversity. The shrub and ground cover layers in Area 4 were more developed in each plot type than in other areas because of the lower intensity of management and the lack of grazing. Abundance was higher in winter than in summer. Differences in abundance among areas were larger in the summer than in the winter. This is as expected because mobility of birds is reduced in summer due to nesting and increased in winter as flocks move from place to place.

Ten species were found in the study but not during the periods covered in table 5.

Common Name2[2]	Scientific name
Broad-winged Hawk	*Buteo platypterus*
American Woodcock	*Scolopax minor*
Barred Owl	*Strix varia*
Eastern Screech-Owl	*Otus asio*
Chuck-will's-widow	*Caprimulgus carolinensis*
~~Winter Wren~~	~~*Troglodytes troglodytes*~~
Sedge Wren	*Cistothorus platensis*
Black-and-white Warbler	*Mniotilta varia*
Rose-breasted Grosbeak	*Pheucticus ludovicianus*
Eastern Meadowlark	*Sturnella magna*

Species Richness

Species richness did not differ as much as abundance among areas (tab. 6). Species richness would be affected by the habitat variety among the areas and we attempted to make that similar (tab. 1). However, when richness/plot (a type of diversity) was tested among areas, similar patterns held as for number of individuals (tab. 6). Because all areas had good mixes of habitats that would attract a variety of species but Areas 3 and 4 had more of the highly stratified habitat types and should have higher diversities (tab. 1) and Areas 3 and 4 had higher richness/plot (tab. 6), the importance of vegetational structure is reinforced.

[2] Common and scientific names of birds are from the AOU Check-list (1983)

Composition and Relative Density

Seventeen species were common to all areas in the summer (tab. 5). The number of species exclusive to an area in the summer varied from none in Area 2 to five in Area 3 (tab. 5). In the winter, the number of exclusives ranged from one in Area 2 to five in Area 4 (tab. 5). Again the community is affected by larger habitat complexity in areas 3 and 4; sampling error may also have contributed to these patterns.

Table 5.--Density values (#/100 plots) for 73 species of birds on four study areas in summer 1981 and winter 1982

Common Name	Scientific Name	Summer 1981				Winter 1982			
		Area 1	Area 2	Area 3	Area 4	Area 1	Area 2	Area 3	Area 4
Cattle Egret	*Bubulcus ibis*	0.4	---	---	---				
Wood Duck	*Aix sponsa*					---	---	0.4	---
Black Vulture	*Coragyps atratus*	0.4	---	---	0.8	---	---	2.1	7.1
Turkey Vulture	*Cathartes aura*	---	---	0.4	---	0.8	---	0.4	0.4
Red-shouldered Hawk	*Buteo lineatus*	---	---	0.4	---				
Red-tailed Hawk	*Buteo jamaicensis*					0.4	0.4	---	0.4
American Kestrel	*Falco sparverius*	0.4	1.7	---	0.4	---	---	---	0.4
Northern Bobwhite	*Colinus virginianus*	---	1.2	3.3	3.3	4.6	---	---	---
Mourning Dove	*Zenaida macroura*	---	0.8	1.7	6.7	---	---	0.4	2.5
Yellow-billed Cuckoo	*Coccyzus americanus*	1.7	1.2	3.3	1.2				
Common Nighthawk	*Chordeiles minor*	0.4	---	---	0.8				
Chimney Swift	*Chaetura pelagica*	1.2	1.7	---	0.8				
Red-headed Woodpecker	*Melanerpes erythrocephalus*	0.4	1.2	---	1.2				
Red-bellied Woodpecker	*Melanerpes carolinus*	---	2.1	5.0	3.8	0.8	2.5	2.5	1.2
Yellow-bellied Sapsucker	*Sphyrapicus varius*					1.2	---	0.8	0.4
Downy Woodpecker	*Picoides pubescens*					---	---	0.4	---
Hairy Woodpecker	*Picoides villosus*	---	---	0.8	---				
Red-cockaded Woodpecker	*Picoides borealis*	1.7	3.3	1.2	2.9	3.3	2.1	0.8	2.9
Northern Flicker	*Colaptes auratus*	0.8	2.9	4.6	4.2	---	3.3	2.5	2.9
Pileated Woodpecker	*Dryocopus pileatus*	0.4	0.4	---	---	---	0.8	---	---
Eastern Wood-Pewee	*Contopus virens*	0.8	0.4	4.2	2.5				
Acadian Flycatcher	*Empidonax virescens*	0.8	0.4	5.4	---				
Eastern Phoebe	*Sayornis phoebe*					2.1	0.4	1.2	0.4
Great Crested Flycatcher	*Myiarchus crinitus*	2.1	2.1	5.4	2.5				
Eastern Kingbird	*Tyrannus tyrannus*	0.4	---	2.1	5.8				
Purple Martin	*Progne subis*	0.4	---	---	1.2				
Barn Swallow	*Hirundo rustica*	---	---	0.4	0.4				
Blue Jay	*Cyanocitta cristata*	7.1	7.9	15.0	7.5	0.4	---	0.4	1.2
American Crow	*Corvus brachyrhynchos*	2.5	---	---	2.9	---	---	0.8	1.2
Carolina Chickadee	*Parus carolinensis*	5.0	2.9	3.8	5.0	3.8	5.8	6.7	4.2
Tufted Titmouse	*Parus bicolor*	4.2	3.8	7.9	0.8	1.7	2.1	3.3	0.8
Red-breasted Nuthatch	*Sitta canadensis*					0.4	---	---	---
White-breasted Nuthatch	*Sitta carolinensis*					0.4	---	---	---

Table 5.--Density values (#/100 plots) for 73 species of birds on four study areas in summer 1981 and winter 1982--Continued

Common Name	Scientific Name	Summer 1981				Winter 1982			
		Area 1	Area 2	Area 3	Area 4	Area 1	Area 2	Area 3	Area 4
Brown-headed Nuthatch	*Sitta pusilla*	2.1	8.3	8.8	10.0	8.3	5.0	11.2	18.8
Brown Creeper	*Certhia americana*					0.4	2.5	---	---
Carolina Wren	*Thryothorus ludovicianus*	5.4	8.3	9.6	5.4	0.8	5.4	1.2	2.5
Golden-crowned Kinglet	*Regulus satrapa*					3.3	0.8	5.0	---
Ruby-crowned Kinglet	*Regulus calendula*					11.7	7.9	11.7	6.7
Blue-gray Gnatcatcher	*Polioptila caerulea*	0.8	1.2	2.5	---				
Eastern Bluebird	*Sialia sialis*	0.8	0.8	3.3	1.7	1.2	3.8	5.0	2.9
Hermit Thrush	*Catharus guttatus*					1.2	0.4	0.4	---
Wood Thrush	*Hylocichla mustelina*	0.8	1.7	3.3	---				
American Robin	*Turdus migratorius*					79.6	49.6	65.8	34.2
Gray Catbird	*Dumetella carolinensis*	---	---	0.4	---	---	---	---	0.4
Northern Mockingbird	*Mimus polyglottos*	---	---	0.8	0.8				
Brown Thrasher	*Toxostoma rufum*	---	0.4	0.4	---				
Cedar Waxwing	*Bombycilla cedrorum*					2.1	13.3	20.0	7.1
White-eyed Vireo	*Vireo griseus*	0.4	2.1	3.8	1.7				
Yellow-throated Vireo	*Vireo flavifrons*	---	0.4	0.8	---				
Red-eyed Vireo	*Vireo olivaceus*	0.4	---	3.8	---				
Orange-crowned Warbler	*Vermivora celata*					---	0.4	0.4	---
Yellow rumped Warbler	*Dendroica coronata*					48.3	54.6	100.0	97.1
Yellow-throated Warbler	*Dendroica dominica*	---	---	0.8	---				
Pine Warbler	*Dendroica pinus*	3.8	4.6	6.7	3.3	5.0	7.9	5.4	5.8
Prairie Warbler	*Dendroica discolor*	0.8	---	---	---				
Common Yellowthroat	*Geothlypsis trichas*	---	---	---	3.8				
Hooded Warbler	*Wilsonia citrina*	0.8	0.8	4.6	---				
Yellow-breasted Chat	*Icteria virens*	1.2	---	0.4	7.1				
Summer Tanager	*Piranga rubra*	3.8	2.5	7.9	2.5				
Northern Cardinal	*Cardinalis cardinalis*	1.0	9.2	16.7	6.2	2.1	1.2	3.8	0.8
Blue Grosbeak	*Guiraca caerulea*	0.8	---	0.8	1.2				
Indigo Bunting	*Passerina cyanea*	0.8	---	---	---				
Rufous-sided Towhee	*Pipilo erythrophthalmus*	0.4	---	---	5.8	---	---	---	2.5
Bachman's Sparrow	*Aimophila aestivalis*	8.8	12.1	7.9	12.5	2.5	5.0	0.4	5.0
Chipping Sparrow	*Spizella passerina*	1.7	2.9	3.3	2.9	4.6	6.7	1.7	2.5
Field Sparrow	*Spizella pusilla*	0.4	---	---	---	0.8	---	---	---
Song Sparrow	*Melospiza melodia*					---	---	---	2.1
Swamp Sparrow	*Melospiza georgiana*					---	---	---	2.5
White-throated Sparrow	*Zonotrichia albicollis*					2.9	0.4	2.1	2.9
Dark-eyed Junco	*Junco hyemalis*					2.9	0.8	0.4	6.2
Brown-headed Cowbird	*Molothrus ater*	0.8	---	2.1	1.2	---	---	16.7	---
Orchard Oriole	*Icterus spurius*	2.1	---	0.4	3.3				
American Goldfinch	*Carduelis tristis*					1.2	8.8	54.6	1.7

Table 6.-- Numbers of species, species per plot, individuals, and individuals per plot for Areas 1-4, Kisatchie National Forest, Vernon Parish, Louisiana, in summer and winter, 1981-1982

	Species			Individuals		
	#	#/plot	Gp	#	#/plot	Gp
SUMMER						
Area 1	40	0.67	-A	188	0.78	-A
Area 2	30	0.76	-A	215	0.90	-A
Area 3	39	1.35	-B	370	1.54	-B
Area 4	36	1.05	-C	299	1.05	-C
F-values		21.310			15.297	
p		0.005			0.005	
WINTER						
Area 1	30	0.70	-A	478	1.99	-A
Area 2	26	0.79	-A	461	1.92	-A
Area 3	32	0.99	-B	789	3.29	-B
Area 4	32	1.09	-B	547	2.28	-AB
F-values		6.441			2.794	
p		0.005			0.050	

[1] Within a season, numbers followed by the same letters are not significantly different from each other (ANOVA and Duncan's Multiple Range test, P<0.05)

The relative densities of 18 species varied among areas in the summer (tab. 7). The species that were more common in Area 3 (Acadian Flycatcher, Blue Jay, Red-eyed Vireo, Hooded Warbler, Summer Tanager, and Northern Cardinal) are all species of the canopy or sub-canopy of "hardwood" or "mixed" forests. Those species preferring Area 4 (Eastern Kingbird, Common Yellowthroat, Yellow-breasted Chat, and Rufous-sided Towhee) are birds of the understory (kingbirds perch on top of low vegetation) and most prefer thick undergrowth. These data support the habitat hypotheses mentioned earlier.

In the winter, relative densities of eight species differed among areas (tab. 8). Habitat differences, thus, do not seem to be as pronounced in the winter as the summer. The reasons why some species prefer some areas in the winter are more varied than the reasons for preferences in the summer. Swamp Sparrows and Song Sparrows prefer Area 4 and utilize brushy, shrubby undergrowth. Yellow-rumped Warblers were most abundant on Areas 3 and 4 and utilize a well-developed midstory. The nuthatches were more prevalent in Area 4 because of the many "pine pole" plots there. Brown-Creepers prefer large trees and there was more sawtimber on Area 2 (tab. 1)

Table 7.-- Statistics for species with significant differences in relative density among study areas, Kisatchie National Forest, Vernon Parish, Louisiana, in summer, 1981-1982

Species	F	p	Area 1	2	3	4
Northern Bobwhite	3.095	0.050	A[1]	AB	B	B
Mourning Dove	5.244	0.005	A	A	A	B
Red-bel. Woodpecker	4.346	0.005	A	AB	B	B
Eastern Wood-Pewee	3.381	0.025	A	A	B	AB
Acadian Flycatcher	9.562	0.005	A	B	A	A
Eastern Kingbird	6.500	0.005	A	A	A	B
Blue Jay	2.842	0.050	A	A	B	A
Tufted Titmouse	4.614	0.005	AB	AB	A	B
Wood Thrush	3.062	0.050	A	AB	B	A
White-eyed Vireo	2.368	0.100	A	AB	B	AB
Red-eyed Vireo	6.583	0.005	A	A	B	A
Common Yellowthroat	7.727	0.005	A	A	A	B
Hooded Warbler	6.733	0.005	A	A	B	A
Yellow-breasted Chat	10.480	0.005	A	A	A	B
Summer Tanager	3.950	0.010	A	A	B	A
Northern Cardinal	3.605	0.025	A	A	B	A
Rufous-sided Towhee	11.529	0.005	A	A	A	B
Orchard Oriole	3.562	0.025	AB	A	A	B

[1] Determined by using ANOVA and Duncan's Multiple Range test (P<0.050); areas having the same letter are not significantly different.

Table 8.-- Statistics for species with significant differences in relative density among study areas, Kisatchie National Forest, Vernon Parish, Louisiana, in winter, 1981-1982

Species	F	p	Area 1	2	3	4
Brown-headed Nuthatch	4.74	0.005	A[1]	A	A	B
Brown Creeper	3.78	0.025	A	B	A	A
Carolina Wren	3.22	0.025	A	B	A	AB
Yellow-rumped Warbler	3.92	0.010	A	A	B	B
Bachman's Sparrow	3.81	0.010	AB	A	B	A
Song Sparrow	2.89	0.050	A	A	A	B
Swamp Sparrow	3.08	0.050	A	A	A	B
American Goldfinch	3.07	0.050	A	A	B	A

[1] Determined using ANOVA and Duncan's Multiple Range test (P<0.050); areas having the same letter are not significantly different.

Species Habitats

The habitat utilization patterns of all species that were found more than 14 times were tested. Out of the 83 species encountered, 40 met the numerical abundance criterion and *in toto* accounted for about 95% of the bird observations.

We tested all nine habitats and consequently sample sizes were often not large enough to allow significant differences to be detected. The patterns found usually were in agreement with what is known about the habitats of each bird species involved. Significantly different stand type, and stand age preferences for the 40 species shown in table 9 are underlined.

Table 9.-- Seasonal status, stand type and age preferences of the 40 most abundant bird species observed in the study areas, Vernon Ranger District, Kisatchie National forest, Vernon Parish, Louisiana, 1981-1982

Species	Seasonal status[2]	Preference[1]	
		St type	St age
Black Vulture	PR	M	4
Northern Bobwhite	PR	H	3
Mourning Dove	PR	H	4
Yellow-billed Cuckoo	SR	M	4
Red-headed Woodpecker	UN	P	3
Red-bellied Woodpecker	PR	M	4
Red-cockaded Woodpecker	PR	M	3
Northern Flicker	PR	H	4
Eastern Wood-Pewee	SR	M	2
Acadian Flycatcher	SR	M	3
Great Crested Flycatcher	SR	H	3
Eastern Kingbird	SR	P	2
Blue Jay	PR	M	2
American Crow	PR	P	4
Carolina Chickadee	PR	M	3
Tufted Titmouse	PR	M	2
Brown-headed Nuthatch	PR	P	4
Carolina Wren	PR	H	3
Golden-crowned Kinglet	WR	M	4
Ruby-crowned Kinglet	WR	M	3
Blue-gray Gnatcatcher	SR	M	4
Eastern Bluebird	PR	M	2
Wood Thrush	SR	H	4
American Robin	WR	P	4
Cedar Waxwing	WR	M	3
White-eyed Vireo	SR	H	3
Yellow-rumped Warbler	WR	P	2
Pine Warbler	PR	P	3
Hooded Warbler	SR	M	4
Yellow-breasted Chat	SR	P	2
Summer Tanager	SR	H	3
Northern Cardinal	PR	M	3
Rufous-sided Towhee	PR	H	2
Bachman's Sparrow	PR	M	2
Chipping Sparrow	PR	P	4
White-throated Sparrow	WR	H	2
Dark-eyed Junco	WR	M	2
Brown-headed Cowbird	PR	M	4
Orchard Oriole	SR	M	2
American Goldfinch	WR	P	3

[1] PR = permanent resident, SR = summer resident, WR = winter resident, UN = unknown.

[2] Stand type preferences: H = Hardwood, M = Mixed, P = Pine; Stand Age preferences: 2 = Sapling, 3 = Pole, 4 = sawtimber.

In some cases, seasonal behavioral changes as well as sample error can contribute to unexpected patterns. Thus, the Red-cockaded Woodpecker is a permanent resident but its apparent abundance varied within the year in a way not directly related to density changes brought about by mortality or natality. Its habitat utilization changed seasonally between pole and sawtimber stands (fig. 2). We over-sampled pole plots, especially slash pine plantations; they were rare in the study area, but because we wanted to know what birds were using them we included them in our transects where possible. Any species that preferred "pine-pole" stands would have an apparently higher density than one utilizing "pine sawtimber" and the estimated density of the Red-cockaded Woodpecker thus shifted as its habitat preferences shifted.

We analyzed the habitat relations and prepared figures to graphically depict the habitat usage of the 40 most common species and will comment on several of them here. All can be found in Yurkunas (1984).

Density of all birds together differed significantly among seasons, utilization of stand types and ages varied seasonally, utilization of stand ages varied seasonally, and density varied among transects.

Mourning Dove.--Density of Mourning Doves differed significantly among transects ($p < 0.0628$). This species feeds in grasses and the ground cover of grasses seemed much more extensive in the ungrazed Area, Area 4.

Red-cockaded Woodpecker.--Surprisingly, Red-cockaded Woodpeckers were encountered at higher densities in pole plots than in sawtimber ones (fig. 2). This species was especially conspicuous before and after the breeding season and had a significantly different abundance between seasons ($p < 0.0342$). It is a social species so often clans or family groups were encountered. Any encounters of a group in pole plots greatly affected the mean density because of the scarcity of pole plots on the transects.

Acadian Flycatcher.--The density of this species varied among transects ($p < 0.0671$) and was highest in the clumped "hardwood" and "mixed" plots concentrated in the stream bottoms of transect 3E. The habitat utilization pattern (fig. 3) was affected by structure and the lack of resolution in our habitat classification. This species utilizes hardwood midstory trees 20-40 ft high and often located near water (Hamel et al. 1982). In the "mixed pole" stands these were predominantly canopy trees and in "hardwood sawtimber" stands they were in the subcanopy.

Tufted Titmouse.--Tufted Titmice prefer mixed and hardwood plots (tab. 4) and used the habitat differently among seasons types and seasons ($p < 0.0066$) (fig. 4). It was never found in "pine pole" plots.

White-eyed Vireo.--Density shifts of this species varied seasonally among habitats ($p < 0.0003$) (fig. 5). The shifting patterns of habitat utilization of this species well illustrates the complexities of trying to characterize habitats.

Yellow-rumped Warbler.--This species is a winter resident (tab. 9) that seems to utilize all habitats extensively (fig. 6).

Yellow-breasted Chat.--Chats are summer residents (tab. 9) that almost exclusively occupy "sapling" stages except during spring migration when they can be found in "mixed pole" habitats (fig. 7).

Rufous-sided Towhee.--Towhees prefer hardwood and sapling plots (tab. 9), but show an interesting seasonal pattern of occupying "mixed sapling" plots at all seasons except during the breeding season (fig. 8).

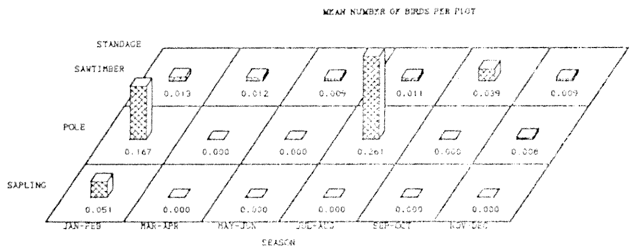

Figure 2.-- Density of Red-cockaded Woodpeckers by stand age and season.

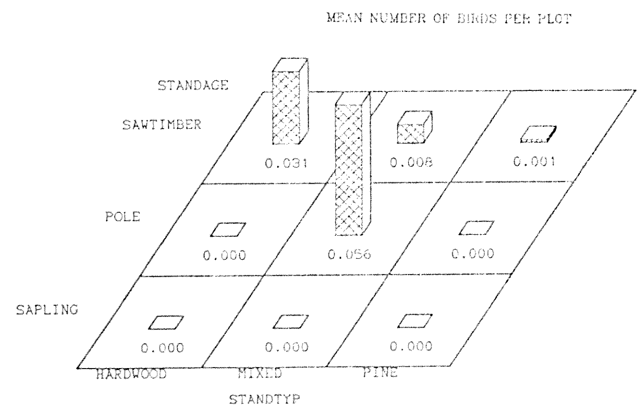

Figure 3.-- Density of Acadian Flycatchers by stand type and stand age.

SUMMARY

Seasonal and habitat relations, with respect to nine stand-age combinations, of 73 species of birds are described for the longleaf-slash pine forests of west-central Louisiana. The information presented conforms to that available in the literature except that shifts in stand-age preference with season were noted.

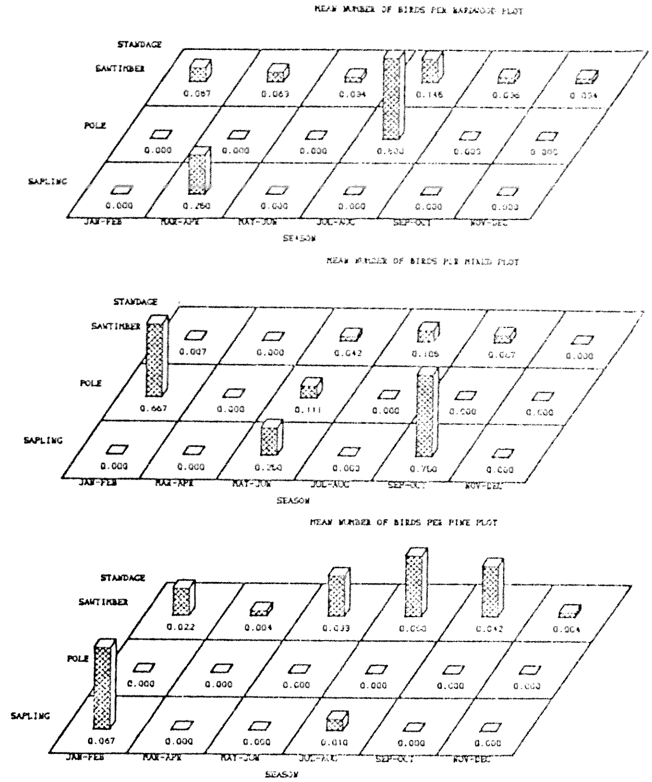

Figure 4.-- Density of Tufted Titmice by stand type, stand age, and season.

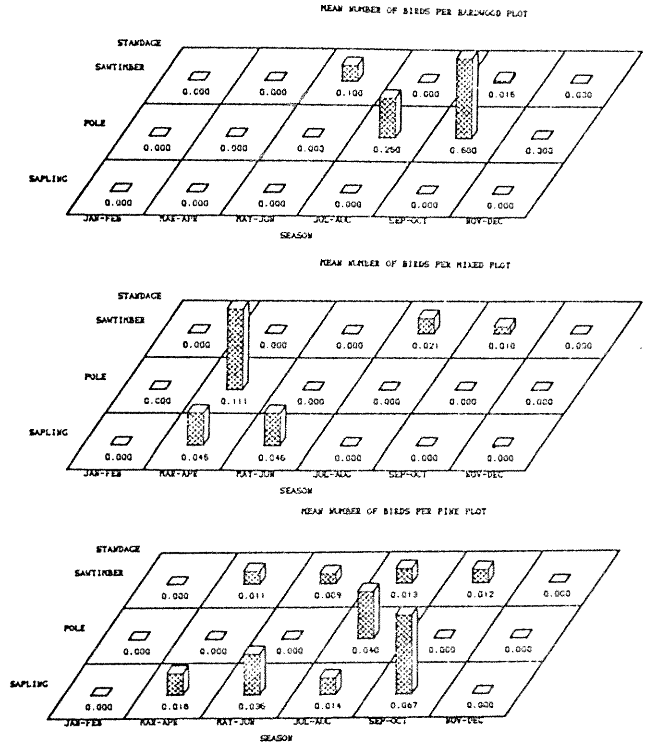

Figure 5.-- Density of White-eyed Vireos by stand type, stand age, and season.

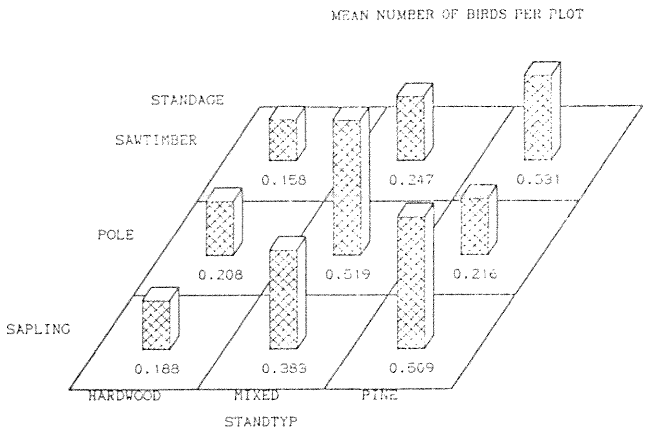

Figure 6.-- Density of Yellow-rumped Warblers by stand type, and stand age.

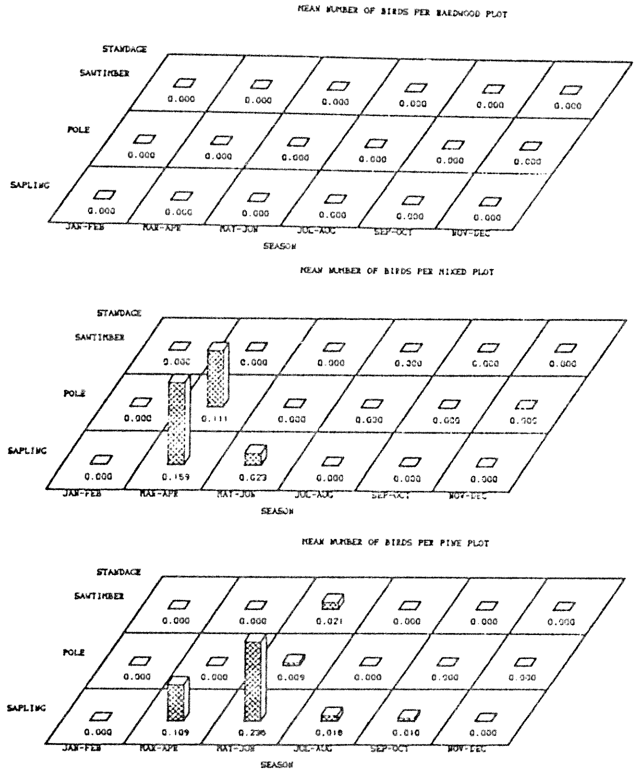

Figure 7.-- Density of Yellow-breasted Chats by stand type, stand age, and season.

The four study areas differed in the relative proportions of the nine habitat types in the avian transects as well as the mean size of the habitat clumps. Management was different in Area 4 than in the other three areas. Area 4 was the only ungrazed area and some of the management differences among areas, such as time since the last controlled burn, may have been related to the difference in grazing practices. Subjectively, we felt that vegetation structure was noticeably different in the ungrazed Area 4. Unfortunately the vegetation measurements were taken prior to our study when grazing was still occurring on Area 4. The differences noted were so obvious, however, that it reinforces the concern that many have about the possible effects of grazing.

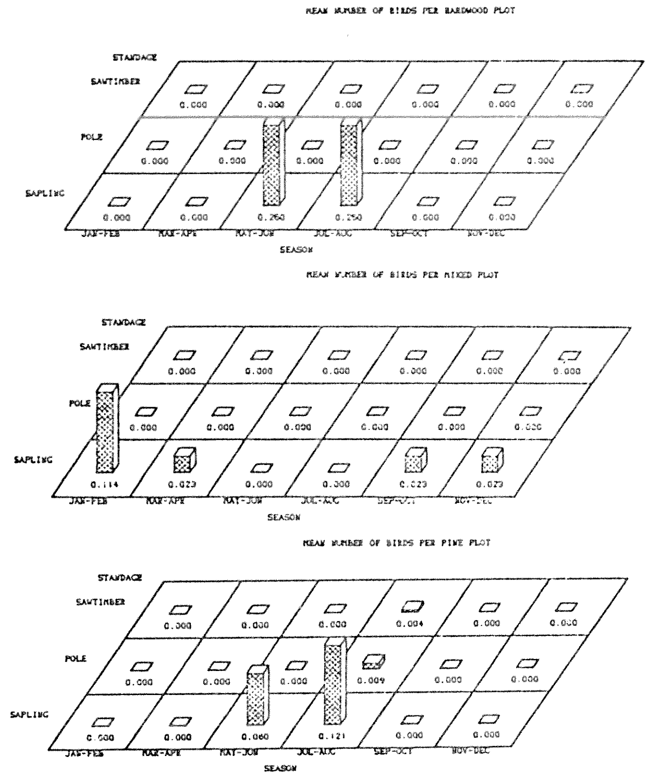

Figure 8.-- Density of Rufous-sided Towhees by stand type, stand age, and season.

Density varied from a high of 100 birds/100 plots for the American Robin in winter to a low of 0.4/100 plots for many species. There were significant differences in numbers of individuals among areas (even among the grazed areas) as well as significant differences in the mean number of species/plot (a type of diversity). The grazed Area 3 and the ungrazed Area 4 held the most individuals and the most species/plot. These differences were due to structural differences among areas. Structural differences in Area 4 were related to the lack of grazing and those in Area 3 were due to a disproportionate number of the complex "hardwood" and "mixed" habitat types. Abundance differences were more pronounced in the summer than in the winter.

Species that occurred exclusively in one area were again concentrated in Areas 3 and 4.

Densities varied among areas in ways that corresponded to the known habitat requirements of the birds involved and the structural differences among the areas.

Habitat utilization patterns were tested specifically for the 40 most common species. Even though sample sizes were low, statistical differences were found for 20 species. Again these differences corresponded with the structure of the vegetation and the known habitat requirements of the birds. The complexity of any future experimental design and analysis is increased because utilization patterns change seasonally. There were many differences found in avian utilization among the areas that were related to habitat structure and complexity. Because of this it would not be possible to compare areas with different treatments in the future unless the areas were perfectly matched in habitat composition, which is extremely unlikely.

The ungrazed area seemed to be structurally different than the other areas in the quantities of ground and shrub vegetation and there were corresponding changes in avian usage. These changes were apparent even though grazing had occurred up to 2 years prior to our study. Some of the structural differences were apparently related to a difference in the amount of control burning on the areas. We do not know if this difference was related directly to cattle grazing or not.

The structure of the vegetation governs the diversity of birds present to a great extent. Any management change that modifies structure will modify the avian community. The desirability of any changes must be evaluated by the manager but changes can be predicted if structural changes are known.

LITERATURE CITED

American Ornithologists' Union. 1983. Checklist of North American Birds, 6th edition. Allen Press, Lawrence, Kansas. 877pp.

Balda, R. P. 1969. Foliage use of birds of the oak-juniper woodland and Ponderosa pine forest in southeastern Arizona. Condor 71:399-412.

Caughley, G. 1977. Analysis of vertebrate populations. John Wiley & Sons. New York. 234pp.

Conner, R. N. 1978. Snag management for cavity nesting birds. Pages 120-128 *in* R. M. DeGraaf, tech. cord. Proceedings of the Workshop on Management of Southern Forests for Nongame Birds. USDA For. Serv. Gen. Tech. Rep. SE-14. Asheville, North Carolina.

______, J. W. Via, and I. D. Prather. 1979. Effects of pine-oak clearcutting on winter and breeding birds in southwestern Virginia. Wilson. Bull 91:301-316.

Dickson, J. G., and C. A. Segelquist. 1977. Winter bird populations in pine and pine-hardwood forest stands in east Texas. Proc. Ann. Conf. Southeast. Assoc. Fish and Wildl. Agen. 31:134-137.

Dickson, J. G., and C. A. Segelquist. 1979. Breeding bird populations in pine and pine-hardwood forests in Texas. J. Wildl. Manage. 43.549-555.

Hamel, P. B., H. E. Legrand, Jr., M. R. Lennartz, and S. A. Gauthreaux, Jr. 1982. Bird-habitat relationships on southeastern forest lands. USDA For. Serv. Gen. Tech. Rep. SE-22. Asheville, North Carolina. 417pp.

Hamilton, R. B., and G. D. Lester. 1987. Bird habitat use and its measurement on the Catahoula District of the Kisatchie National Forest, Louisiana. [elsewhere in this volume] pp.

______, and R. E. Noble. 1975. Plant succession and interactions with fauna. Pages 96-114 *in* D. R. Smith, tech. coor. Proceedings of the Symposium on Management of Forest and Range Habitats for Non game Birds. USDA For. Serv. Gen. Tech. Rep. WO-1. Tuscon, Arizona.

Harris, L. D. 1984. The fragmented forest. The University of Chicago Press, Chicago. 211pp.

Helwig, J. T., and K. A. Council, eds. 1979. SAS user's guide. SAS Institute, Raleigh, N. C. 494pp.

Holbrook, H. L. 1973. Management of Wild Turkey habitat in southern forest types. Pages 245-252 *in* G. C. Sanderson and H. C. Schultz, eds. Wild Turkey Management: current Problems and Programs. Univ. of Missouri Press, Columbia.

Johnson, A. S., and J. L. Landers. 1982. Habitat relationships of summer resident birds in slash pine flatwoods. J. Wildl. Manage. 46:416-428.

Johnston, D. W., and E. P. Odum. 1956. Breeding bird populations in relation to plant succession on the Piedmont of Georgia. Ecology 37:50-62.

Karr, J. R., and R. R. Roth. 1971. Vegetation structure and avian diversity in several new World areas. Amer. Natur. 105:423-435.

MacArthur, R. H. 1964. Environmental factors affecting bird species diversity. Am. Nat. 98:387-397.

______, and J. W. MacArthur. 1961. On bird species diversity. Ecology 42:594-598.

National Oceanic and Atmospheric Administration (NOAA). 1975. Climate at Leesville. Louisiana. Climatography of the United States No. 20. Environ. Data Serv., Nat. Climatic Center, Asheville, North Carolina. 4pp.

Noble, R. E., and R. B. Hamilton. 1975. Bird populations in even-aged loblolly pine forests of southeastern Louisiana. Proc. Ann. Conf. Southeast. Assoc. Game and Fish Comm. 29:441-450.

Pearson, H.. A. 1979. Vegetation inventory in the longleaf-slash pine type, Vernon Parish, Louisiana. USDA For. Serv, Study Plan 4210 FS-SO-1701-3.20. Alexandria, Louisiana. 17pp.

Quay, T. L. 1947. Winter birds in upland plant communities. Auk 64:382-388.

Radford, A. E., H. E. Ahles, and C. R. Bell. 1968. Manual of the vascular flora of the Carolinas. Univ. of North Carolina Press, Chapel Hill. 1,183pp.

Rosene, W. 1960. The Bobwhite Quail: its life and management. Rutgers Univ. Press, New Brunswick, New Jersey. 418pp.

Ruffner, J. 1980. Climates of the states. Gale Research Co., Detroit. Vol 1:?

Schoener, T. W. 1974. Resource partitioning in ecological communities. Science 185:27-39.

Shugart, H. H., Jr., and D. James. 1973. Ecological succession of breeding bird populations in northwestern Arkansas. Auk 90:62-70.

Steele, R. G. D., and J. H. Torrie. 1980. Principles and procedures of statistics: a biometrical approach. McGraw-Hill, New York. 633pp.

Stoddard, H. L. 1931. The Bobwhite Quail, its habits, preservation and increase. Charles Scribner's Sons, New York. 559pp.

________. 1931. Maintenance and increase of the eastern Wild Turkey on private lands of the coastal plain of the deep southeast. Tall Timbers Res. Stn. Bull. 3. Tallahassee, Florida. 49pp.

Thompson, R. L. 1971. The ecology and management of the Red-cockaded Woodpecker: proceedings of a symposium. Bur. Sport Fish. and Wildl. and Tall Timb. Res. Stn., Tallahassee, Florida. 188pp.

Tomoff, C. S. 1974. Avian species diversity in desert scrub. Ecology 55:396-403.

USDA Forest Service. 1965. Silvics of forest trees. USDA For. Serv. Agric. Handb. 271. Washington, D. C. 762pp.

Yurkunas, V. G. 1984. Seasonal status and habitat relationships of birds in longleaf-slash pine forests. M.S. Thesis. Louisiana State University, Baton Rouge. 163pp.

CROSS-COUNTRY TRACK STATIONS FOR INDEXING WILDLIFE POPULATIONS

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Abstract: Track stations were systematically deployed over 4 range units (about 225 ha each) of the Palustris Experimental Forest in central Louisiana. Track frequencies for small, exclusively resident wildlife increased significantly from spring to fall and track frequencies of cattle were associated with changes made in cattle numbers during the study period. Cross-country track sampling provides a means to monitor wildlife populations on relatively small, roadless tracts of forested land and provide land managers a means to monitor species presence and changes in animal populations or activity levels.

Southern forests are valued as habitat for a variety of wildlife species. Proper management can not take place without knowing how wildlife populations respond to management practices. However, wildlife population densities vary naturally among localities and influences of different land uses are difficult to measure (Johnson 1982). Scientific management of game is possible only when changes in populations can be monitored; thus improved measures of relative population densities are badly needed.

Track stations are a population indicator that can be deployed over large areas and can provide useful indices for comparing population densities with little effort compared to mark-recapture methods (Linhart and Knowlton 1975). Track stations can be used to simultaneously index a variety of species. The traditional procedure is to establish track stations (or scent stations) along secondary roads; however, this may not effectively sample the land area without bias. In addition, availability and distribution of secondary roads usually differs among areas. Population indices used for monitoring changes over regions, such as track counting or nightlighting along roads, are not useful for monitoring populations on small blocks of land, which are often essentially roadless. Further, use of off-road vehicles is often restricted in forested habitat. A population indexing method is needed that is relatively simple, inexpensive in cost and time, requires little technical expertise, and can be used on relatively small, roadless tracts of forested habitat. The technique should be unaffected by preconceptions as to the relative abundance of wildlife on an area.

In theory, there is a relationship between track densities and population densities of wildlife (Caughley 1977). For example, populations of rabbits (*Sylvilagus* spp.) generally increase by 300% to 500% from spring to fall (Allen 1954) and their track densities may increase similarly. However, field testing of this relationship is difficult. The objective of this study was to examine the utility of cross-country deployment of track stations for monitoring wildlife population densities in southern pine forests.

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the U. S. Man and the Biosphere Program (MAB-3) supporting management of grazing lands.

STUDY AREA

This study was conducted from February through October 1982 on the Palustris Experimental Forest in central Louisiana. Second growth longleaf pine (*Pinus palustris*), and planted stands of slash (*P. elliottii*) and loblolly (*P. taeda*) pines existed on the area. Four forested range units varying from 218 to 239 ha were studied. Range units (Northeast-NE, Northwest-NW, Southwest-SW, and Southeast-SE) were used for cow-calf operations and stocked with 19, 29, 32, and 32 cows with 16, 27, 29, and 28 calves born from December through March, respectively. Calves remained with the cows until mid-August. One bull serviced each herd from February 20 through July 1, 1982. Cattle were removed from the NE range unit during the July sampling period.

Understory vegetation on the area was primarily bluestem grasses (*Andropogon* spp., *Schizaskyrium* spp.) and other herbaceous plants (Clary 1979, Johnson and Pearson 1981). Shrubs were not abundant due to a long history of prescribed burning. About one-third of each grazing unit was rotationally prescribed burned each winter to remove rough cover and provide green forage for early spring grazing. Topography of the area is flat with slight relief.

METHODS

During winter of 1981-1982, 10 transects were established on each of the four range units. On 3 units, transects were located about 140 m apart and track stations were deployed at 160 m intervals along each transect for a total of 100 stations per unit. Track stations on the other unit were deployed at 80 m intervals for a total of 200 stations. To reduce influences from surrounding land, no track station was placed closer than 80 m from the range unit boundary.

Track stations were established by removing sod and vegetation from a 1 m^2 area with a potato rake. During the sampling periods (February-May, July, and October, 1982), soil was raked on each station to provide loose soil for recording tracks of animals. All 500 stations were prepared during the same day, and tracks were recorded during the following day. The presence or absence of tracks was recorded for each station and results were expressed as percent frequency of occurrence for each species identified.

The application of frequency sampling for comparing relative population densities of animals has been described by Caughley (1977). There is a direct relationship between relative track frequencies and relative track densities. The relationship between frequency and density of tracks is described by:

$$F = 1 - e^{-d},$$

where F is frequency of plots with track occurrence divided by the total plots sampled, e is the natural logarithm, and d is track density. Under the assumption that animals were distributed at random over the grazing units, the relationship was used to estimate track densities (number (n)/ha) for each species recorded on track stations.

Although there are presently few published reports, most investigators use a scent to attract predators to stations (Brady 1978, Morrison 1981, Knowlton and Tzilkowski 1979, Hon 1979). The widespread interest in the use of scented stations was probably stimulated by the 17-state study on coyote density reported by Linhart and Knowlton (1975). However, responses of different wildlife to scents vary. Some species seem attracted to scent while others seem repelled (Bullard et al. 1978, Roughton and Bowden 1979, Turkowski et al. 1979). During February and May sampling periods, we compared results from unscented stations to results from stations scented with a liquid made from fermented eggs (Bullard et al. 1978). About 1 ml of scent was placed on the soil in the middle of alternate stations after raking. Responses to scented and unscented stations were evaluated using chi-square procedures where the expected relative track frequency of occurrence was 50% of the total responses for each species recorded.

We had no previous knowledge as to how track densities vary among days. During July, we recorded tracks for 3 days in 2 units to estimate average track densities and variation among track densities for each grazing unit. The purpose was to determine how many days of sampling might be required to obtain data for statistically comparing animal densities among grazing treatments. We used the sample standard deviations to estimate the number of sampling days needed to determine statistical differences at specific confidence levels.

The 4 range units were used as replicates for the study. Track densities for each wildlife species were averaged among units and compared between seasons by Student's t tests. Track densities were averaged among days for the July samples and differences among range units were statistically evaluated with Student's t tests. We assumed that the average change in rabbit (*Sylvilagus floridanus* and *S. aquaticus*) population density from spring to fall would significantly increase and tested the hypothesis that relative track densities reflected this expectation.

Because cattle populations were known, we compared their track densities among range units and seasons to determine whether relative track densities reasonably reflected relative differences in population densities. The relationship between populations of cattle and cattle track densities was evaluated with linear regression procedures.

RESULTS

Wet soil conditions limited the use of some track stations, but from 75% to 90% of the stations were usable during each sampling period. Tracks recorded on stations were from cattle and 11 wildlife taxa: armadillo (*Dasypus novemcinctus*), rabbits, white-tailed deer (*Odocoileus virginianus*), squirrels (*Sciurus* spp.), raccoon (*Procyon lotor*), opossum (*Didelphis virginianus*), bobcat (*Lynx rufus*), coyote (*Canis latrans*), foxes (*Urocyon cinereargenteus* and/or *Vulpes vulpes*), bobwhite (*Colinus virginianus*), and wild turkey (*Meleagris gallopavo*). Wildlife track densities in the grazing unit with 200 track stations were similar to track densities in the 3 units with 100 stations each. Bobcat tracks occurred only on scented track stations and none of the species were affected by scent (Table 1). Predators generally respond to scent but since the bobcat densities represent only 3 occurrences, these data are inconclusive regarding their influence.

Table 1. Track densities for animals on the Palustris Experimental Forest compared between scented and unscented stations for February and May 1982.

Species	Scented[1/] (399)[2/]	Unscented (447)
Cattle	0.055	0.083
Armadillo	0.043	0.056
Raccoon	0.005	0.007
Rabbit	0.023	0.034
Deer	0.003	0.007
Bobcat	0.008	0
Opossum	0.005	0.002
Squirrel	0.003	0.002

[1/] A liquid made from fermented eggs (Bullard et al. 1978).

[2/] Number of plots sampled.

Cattle track densities were significantly associated with population densities ($r = 0.83$, $p < 0.05$). Data from February were not used in the analysis because cattle activity was confounded by use of supplemental winter pastures during this period. Cattle population density (C) in numbers of cows and calves per range unit can be estimated from percent track frequency (T) by the regression equation: $C = 9.05 + 3.49T$. The coefficient of determination was 69%.

Tracks for some species such as bobwhite, wild turkey, bobcat, coyote, white-tailed deer, raccoon, and opossum occurred infrequently, and densities were not different among units or seasons (Tables 2 and 3). Tracks of these species usually occurred on only 1 or 2 of the 500 stations during each sampling period. Tracks of foxes, armadillos, squirrels, and rabbits occurred more frequently. Average track densities for armadillos and rabbits were higher in October than in February (Table 2). Squirrel tracks were not detected in February but densities were higher in October than in May (Table 2). Tracks of foxes were not detected during February or May but were present during July and October.

Track densities of wild animals did not differ statistically among the 4 grazing units when data were averaged among seasons. Averages from 3 days during July were not significantly different among the 2 grazing units for armadillos ($p > 0.05$). Track densities for foxes and squirrels were each significantly higher in one grazing unit compared to the other ($P < 0.05$). Track densities of rabbits were significantly higher in the NE range unit compared to the NW unit, but at least 5 sampling days would have been needed to detect statistically significant differences at the 0.05 level (Table 3).

Approximately 150 man-hours were required for establishment of all 500 stations. About 10 hours were required to prepare 100 stations for sampling tracks and about 7 hours to record data the following day. The 200 station unit required about 14 hours for preparation and about 8 hours for recording data. More time was needed during July (≈ 12 hrs. for 100 and 16 hrs. for 200 stations) because of high temperatures and humidity which required workers to rest more often, but daylight was sufficient to allow preparation of 200 stations during 1 day.

DISCUSSION

Armadillos, rabbits, and squirrels may be considered exclusive residents because their range is much smaller than the areas contained in each grazing unit. Foxes, deer, bobcats, and coyotes generally range over larger areas and because their tracks were infrequent, we regarded these species as transient residents on the grazing units.

Table 2. Mean (± SE) track densities for wild animals on the Palustris Experimental Forest, 1982.

Species	Sampling Period			
	February	May	July	October
Armadillo	.019 ± .013	.080 ± .023	.067 ± .010	.105 ± .034
Rabbit	.015 ± .008	.037 ± .009	.028 ± .011	.050 ± .019
White-tailed deer	.001 ± .001	.008 ± .005	.017 ± .010	.003 ± .003
Squirrel	0	.005 ± .003	.017 ± .008	.022 ± .012
Raccoon	.001 ± .001	.012 ± .008	0	.009 ± .012
Opossum	0	.005 ± .003	0	.003 ± .003
Bobcat	0	.009 ± .005	.011 ± .006	.003 ± .003
Fox	0	0	.023 ± .017	.028 ± .005
Coyote	0	0	.004 ± .002	.003 ± .003
Bobwhite	0	0	.002 ± .002	0
Wild turkey	0	0	.001 ± .001	0

Table 3. Mean (± SE) track densities for animals on 2 range units of the Palustris Experimental Forest sampled 3 consecutive days during July 1982.

Species	Track Density	
	NW Range Unit	NE Range Unit
Cattle[1/]	0.116 ± 0.013	0
Armadillo	0.068 ± 0.034	0.061 ± 0.021
Rabbit[2/]	0.029 ± 0.016	0.056 ± 0.019
Bobcat	0	0.025 ± 0.017
Fox[3/]	0.004 ± 0.004	0.075 ± 0.032
Squirrel[3/]	0.029 ± 0.019	0.006 ± 0.006
Coyote	0.004 ± 0.004	0.006 ± 0.006
Bobwhite	0.007 ± 0.007	0
Deer	0.018 ± 0.007	0.006 ± 0.006
Wild Turkey	0.004 ± 0.004	0

[1/] Cattle not present in NE unit during sampling period.

[2/] Significantly different at the 0.10 level.

[3/] Significantly different at the 0.05 level.

Use of Scent

Although scent is intended for increasing the occurrence of predator tracks, our data suggest that fermented egg scent has no significant influence on the proportion of stations that might contain tracks of herbivorous or omnivorous wildlife. Because of the extra effort required, use of fermented egg scent is not warranted. On the other hand, other scents may have been more effective, especially for predators.

Interpretation of Data

Track densities represent relative changes in animal populations or activity within an area of measurement. For instance, the October rabbit track densities (0.050) increased more than 300% compared to February (0.015). This increase may represent increases in rabbit populations, increase in rabbit activity within the units or a combination of both. Increases in track density from winter to fall were about 400% and 500% for squirrels and armadillos, respectively. Activities of many animals differ among seasons and are probably affected by habitat quality. Therefore, care must be taken to minimize these sources of variation in any sampling scheme. On the other hand, these sources of variation are probably no greater for cross-country sampling than for road sampling. Unfortunately, there is no practical way to conduct track station studies over large blocks of land with known populations of wildlife. However, the significant relationship of track densities with known cattle densities, and the expected spring to fall increases in rabbit, squirrel, and armadillo track densities support the contention that cross-country track stations can provide an index to changes in population densities.

Because of the flat topography and forest range management, habitat on the 4 grazing units was more homogeneous and more similar than would be found in most forests. It is reasonable to presume that wildlife population densities would also be more similar among the 4 grazing units than among land units with greater differences. The detection of differences in rabbit and squirrel track densities between the 2 grazing units sampled for 3 consecutive days supports the contention that cross-country track stations can provide a reasonably sensitive index of population density changes and differences among areas, especially for comparison of very different habitats or land management practices.

Sampling Season and Intensity

The fact that track densities were highest during October corresponds to the assumption that population densities of wildlife are generally highest following the spring-summer reproductive season. The data may also reflect changes in movements; but the rabbit track density reasonably reflected the expected population increase. Increases for armadillos and squirrels also appeared biologically reasonable. Sampling during fall in the southeastern United States provides the highest track densities and the best opportunity for comparing densities among different wildlife populations or monitoring annual changes in game populations.

For armadillo, rabbit, and squirrel, track densities varied among seasons by 58%, 32%, and 72%, respectively for the unit (SE) with 200 sampling stations. For the 3 units with 100 stations each, average variation was 75%, 94%, and 98%, respectively. In addition, track densities for the 3 resident species generally increased from spring to fall for the SE unit but trends were more variable for the other 3 units (Table 4). Although not conclusive, these data suggest that higher sampling intensities provide more reliable indices of population changes. However, when 100 of the 200 stations from the SE unit were selected at random, track densities for the 3 species were not significantly different from track densities determined using all 200 stations according to chi-square analyses. Further study is required to determine whether the higher density of stations exposes more of the animals to sampling and provides a better index of population density. If this hypothesis is correct, then fewer sampling days would be required to obtain data for statistically evaluating population differences between sampling units compared to using a lower density of stations.

Table 4. Track densities for resident wildlife on range units of the Palustris Experimental Forest, 1982.

Species	Sample period	Range Unit NE (100)[1/]	NW (100)	SW (100)	SE (200)
Armadillo	Feb	0	.020	0	.055
	May	.022	.079	.134	.085
	Jul	.061	.068	.045	.095
	Oct	.052	.100	.067	.202
Rabbit	Feb	.030	0	0	.030
	May	.022	.045	.061	.021
	Jul	.056	.029	0	.027
	Oct	.104	.033	.015	.047
Squirrel	Feb	0	0	0	0
	May	0	.011	0	.007
	Jul	.006	.029	0	.034
	Oct	.039	0	0	.047

[1/]Number of plots sampled.

We suggest sampling for about 5 days during any period in order to obtain replicates for statistical comparisons of treatments. Two hundred track stations per section are recommended for describing changes in population densities. However, 100 stations will provide a reasonable index although data may be less precise.

Predators and other transient wildlife must be sampled over much larger areas than are required for smaller less mobile species. We have performed cross-country track station sampling for deer studies on two 1000 ha areas of mixed loblolly pine-hardwood in southcentral Louisiana. Deer track frequencies were about

17% and 27% in October for the 2 areas, respectively (unpublished data). Comparison of these data with the low track frequencies for deer on the Palustris Experimental Forest suggests that the size of area needed to conduct a study with track stations is related to the size of the population it supports as well as the species. In addition, deer density on the southcentral Louisiana area with the lower track frequency was estimated to be about 1 per 11 ha of habitat while deer density on the area with the higher track frequency was estimated to be about 1 per 9 ha of habitat. These data further support the contention that cross-country track stations can be used to detect differences in wildlife population densities.

SUMMARY

Cross-country deployment of track stations provides a reasonable method for indexing populations of wildlife. Population relationships can be indexed regardless of the distribution of roads. In comparison to sampling along roads, cross-country data represent populations inhabiting all portions of an area. Sampling along roads probably provides adequate representation of wildlife inhabiting western rangelands; however, topography in the southern United States results in most roads being constructed on ridges. Roads do not often allow unbiased, adequate sampling in bottomlands. In addition, vegetation associated with roadsides is often different from that which generally covers a forested area, so data collected along roads may be biased and lead to erroneous indicators of actual population changes. The cross-country method combines reasonable theoretical rationale with practical constraints of sampling.

Outside of cattle, there is no basis to compare tracks of animals with known populations. Consequently, only relative changes in population or changes in activity levels are possible from these data. However, the data (1) establishes that there are certain species of wildlife on the area, (2) show that the presence of these species vary, and (3) indicate that over time, certain species fluctuate in number or activity level. The cross-country track station sampling system has the advantages of being easy to employ with little effort and it is easy to understand.

LITERATURE CITED

Allen, D. L. 1954. Our Wildlife Legacy. Funk and Wagnalls Co. 422 p.

Brady, J. R. 1978. Preliminary results of bobcat scent station transects in Florida. Florida Game and Freshwater Fish Comm. unpublished report. 3 p.

Bullard, R. W., S. A. Shumake, D. L. Campbell, and F. J. Turkowski. 1978. Preparation of a synthetic fermented egg coyote attractant and deer repellant. J. Agric. Food Chem. 26:160-163.

Caughley, G. 1977. Analysis of vertebrate populations. John Wiley and Sons, New York. 235 p.

Clary, W. P. 1979. Grazing and overstory effects on rotationally burned slash pine ranges. J. Range Manage. 32:264-266.

Hon, T. 1979. Relative abundance of bobcats in Georgia: survey techniques and preliminary results. Pages 104-107 in Nat. Wildl. Fed. Sci. and Tech. Ser. 6, Proc. Bobcat Res. Conf.

Johnson, M. K. 1982. Response of small mammals to livestock grazing in southcentral Idaho. J. Range Manage. 35:51-53.

Johnson, M. K., and H. A. Pearson. 1981. Esophageal, fecal and exclosure estimates of cattle diets on a longleaf pine-bluestem range. J. Range Manage. 34:232-234.

Knowlton, F. F., and W. M. Tzilkowski. 1979. Trends in bobcat visitations to scent survey lines in western United States, 1972-1978. Pages 8-13 in Nat. Wildl. Fed. Sci. and Tech. Ser. 6. Proc. Bobcat Res. Conf. 137 p.

Linhart, S. B., and F. F. Knowlton. 1975. Determining the relative abundance of coyotes by scent station lines. Wildl. Soc. Bul. 3:119-124.

Morrison, D. W. 1981. Evaluation of specific variables for a scent survey in north central Louisiana. M.S. thesis, Louisiana State University, Baton Rouge, 35 p.

Roughton, R. D., and D. C. Bowden. 1979. Experimental design for field evaluation of odor attractants for predators. Pages 249-254 in J. R. Beck, ed., Vertebrate pest control and management, Am. Soc. Testing and Materials, Philadelphia, PA. 328 p.

Turkowski, F. J., M. L. Popelka, B. B. Green, and R. W. Bullard. 1979. Testing the responses of coyotes and other predators to odor attractants. Pages 255-269 in J. R. Beck, ed., Vertebrate pest control and management. Am. Soc. Testing and Materials, Philadelphia, PA. 328 p.

Soils of Study Area in Harrison and Stone Counties, Mississippi

Rex E. Davis

Abstract.--The soils of the study area developed in the Citronelle, Graham Ferry, and Pascagoula formations of the lower coastal plain. These soils include Ultisols, Inceptisols, Entisols, Histosols, and Alfisols. Natural fertility is relatively low in most of the soils because of high rainfall, temperature, and the nature of the parent material. Soil drainage ranges from excessive to very poor depending mainly on topographic position.

This is an attempt to give an analysis of soils and landscapes in the designated study area for the Southern Evaluation Workshop. It is designed to give a baseline environmental setting upon which vegetation can be superimposed.

STUDY AREA

The study area consists of all or portions of sections 21, 22, 23, 24, T4S, R11W, and sections 19, 20, 21, 22, and 23, T4S, R10W in Stone County. In Harrison County all or portions of sections 25, 26, and 28, T4S, R11W and sections 26, 27, 28, 29, 30, 31, 32, 33, 34, T4N, R10W and sections 3, 4, and 5, T5N, R10W were studied. The area is in the Saucier Creek, Tuxachaney Creek, and Big Foot Creek drainage areas.

Elevation of the area ranges from 80 to just over 200 feet above mean sea level. The landscape consists of poorly drained nearly level flats to rolling and steep hillsides and gently sloping ridgetops. Floodplains range in width up to 1,500 feet and are dominated by poorly drained soils. Excessively drained natural levees occur along larger streams that have well defined channels.

In higher elevations of interfluvial areas soils are developed in the Citronelle formation. The Citronelle formation is a terrace deposit believed to be of fluvial origin.[1] These soils are dominated by loamy sand, sandy loam, and loam. Some of the loamy sands are believed to be eolian sands caused by "blow-outs".

1/ Brown, Glen Francis; Foster, Velora Meek; Adams, Robert Wynn [and others]. In: Geology and Ground-Water Resources of the Coastal Area in Mississippi; Mississippi State Geological Survey; 1944: 32-66.

The soils are McLaurin, Lucy, Poarch, and Eustis. Permeability ranges from moderate to rapid causing these soils to be drier than those of lower elevations. Soils that developed within the Citronelle formation are well drained or excessively drained. Vegetation is characterized by Longleaf pine, Huckleberry, and Yaupon.

The Graham Ferry formation is located below the Citronelle and above the Pascagoula formation and is considered to be deltaic in origin consisting of both fluvial and marine or brackish deposits.[1]

The Pascagoula formation outcrops at lower elevations. It is dominated by clays of deltaic or estaurine origin.[1]

The soils formed in the Graham Ferry and Pascagoula formations are generally poorly drained through moderately well drained and have clayey or fine loamy subsoils. Landscapes are most nearly level to rolling. Many wet weather seeps occur along the contact between the Citronelle formation and the material below.

CLIMATE

The climate is subtropical with warm summers and alternately warm and cold winters. The average daily maximum temperature is 58 degrees F. The average highest annual temperature is 98 degrees F and the average lowest annual temperature is 20 degrees F.

The average annual precipitation is 62.3 inches most of which falls during the summer months.[2]

2/ U.S. Department of Agriculture, Soil Conservation Service. In: Soil Survey of Harrison County Mississippi, 1975. 73-77.

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VEGETATION

Vegetation is an important tool in making soil surveys. One generally recognizes certain species as good soil indicator plants. Soil drainage, texture, parent material, and degree of erosion are important soil factors that relate to plant communities. Titi, pitcher plants, swamp bay, and many rushes and sedges are good indicators of poorly drained soils. Wax myrtle and certain galberries are good indicators of somewhat poorly and moderately well drained soils. Yaupon, dogwood, and huckleberry are good indicators of well drained soils. Sawtooth palmetto, bluejack oak, and turkey oak are good indicators of excessively drained soils. Some of these plants will occur on adjacent drainage classes but their abundance determines whether or not they are good indicators.

METHODS AND PROCEDURES

The procedures for making this soil survey are the same used for the National Cooperative Soil Survey. Location and intensity of the field observations were dictated by the position on the landscape and parent material. Observations were made by hand auger and hydraulic probe to the depth of 5 feet (1.5m) in normal mapping. Typical pedons were described for each map unit. Additional pedons were described to support the typical pedons.

The Harrison County part of the study area is part of the Harrison County, Mississippi, Soil Survey. The Stone County part was contracted to the Soil Conservation Service by the Forest Service in 1979. Later this was incorporated into the Stone County, Mississippi, Soil Survey.[3]

RESULTS AND DISCUSSION

Soils of the Area

The soils of the study area developed in coastal plain sediments that are low in inherent fertility. Most of them have a low cation exchange capacity and low base saturation level. Exceptions are soils of the Susquehanna series, which are Alfisols, and flood plain soils that have a high level of organic matter. The drainage class and topographic position of each soil series follows:

SERIES	DRAINAGE CLASS	TOPOGRAPHIC POSITION
Atmore	poor	upland depressions
Escambia	somewhat poor	stream terraces
Eustis	somewhat excessive	upland
Harleston	moderately well	upland and terrace
Jena	well	natural levee
Lucy	well	upland
Malbis	well or moderately well	upland
McLaurin	well	upland
Nahunta	somewhat poor	flood plain
Nugent	excessive	natural levee
Poarch	well or moderately well	upland
Ponzer	very poor	flood plain
Saucier	moderately well	upland
Smithton	poor	flood plain
Susquehanna	somewhat poor	upland

Classification of the soils in the study area is listed below.[4]

Atmore	Plinthic Paleaquult, coarse loamy siliceous thermic
Escambia	Plinthaquic Paleudult, coarse loamy siliceous thermic
Eustis	Psammentic Paleudult, sandy siliceous thermic
Harleston	Aquic Paleudult, coarse loamy siliceous thermic
Jena	Fluventic Dystrochrept, coarse loamy siliceous thermic
Lucy	Arenic Paleudult, loamy siliceous thermic

3/ U.S. Department of Agriculture, Soil Conservation Service. Soil Survey of Designated Portion of Desoto National Forest in Stone County, Mississippi. [Unpublished report]. 1979.

4/ U.S. Department of Agriculture. Soil Taxonomy: A Basic System of Soil Classification for Making and Interpreting Soil Surveys. Soil Conservation Service, U.S.D.A. Handbook 436, 754pp., illus.

Malbis	Plinthic Paleudult, fine loamy siliceous thermic
McLaurin	Typic Paleudult, coarse loamy siliceous thermic
Nahunta	Aeric Paleaquult, fine silty siliceous thermic
Nugent	Typic Udifluvent, sandy siliceous thermic
Poarch	Plinthic Paleudult, coarse loamy siliceous thermic
Ponzer	Terric Medisaprist, loamy mixed dysic thermic
Saucier	Plinthaquic Paleudult, fine loamy siliceous thermic
Smithton	Typic Paleudult, coarse loamy siliceous thermic
Susquehanna	Vertic Paleudalf, fine montmorillonitic thermic

Vegetation in the Longleaf-Slash Pine Forest, Biloxi District, Desoto National Forest, Mississippi

Aberdeen W. Stewart and George A. Hurst

Abstract.--Vegetation was studied on 4 areas on the Biloxi District, Desoto National Forest, Mississippi. Percent plant occupancy on line transects ranged from 53-73% and averaged 61.7%. A total of 153 species of plants was found. Basal area averaged 72 ft^2/ac, pine (Pinus spp.) height averaged 71 ft, pine age averaged 45 yrs, canopy cover averaged 23%, and number of stems averaged 592/ac. Of 44 tall brush (≦ 1 in. DBH, > 5 ft) species, Ilex coriacea and I. vomitoria were the most numerous. Low brush (< 5 ft) species numbered 84. Estimated current annual growth (dry weight) of low brush averaged 147 lb/ac and Ilex glabra, I. vomitoria, I. coriacea, Cornus florida, and Vaccinium elliottii were the most prominant species. Forage species numbered 103 and forage [grass, forbs, legumes, vines, and woody (up to 5 ft)] averaged 755 lb/ac in July, 1979 and 305 lb/ac in January, 1980. Less than 12% of the variation in forage and low brush weights was explained by overstory conditions. Forage weight was inversely related to percent canopy cover and low brush weight.

INTRODUCTION

The Longleaf (Pinus palustris) - slash pine (P. elliottii) forest type forms the western part of the longleaf pine belt and comprises about 5 million ac. This forest has produced good forage and timber simultaneously.

Mississippi State University, other institutions, the Soil Conservation Service, and the U. S. Forest Service conducted the Southern Evaluation Project (SEP) to study livestock, wildlife, forage, and timber relationships in the southern forest, and the impacts of these resources on recreation and watershed. The ultimate goal of SEP is to promote sound multiple-use management of southern forested public lands.

Vegetative and soil components of an area provide the basis on which much of management must depend. This study involved a vegetation survey and objectives were to (1) describe quantitatively and to determine differences among vegetation on 4 selected units in the SEP, Desoto National Forest and (2) evaluate relationships among parameters such as overstory, tall brush, low brush, and white-tailed deer (Odocoileus virginianus) forage.

STUDY AREA

Four areas in Harrison and Stone counties, Mississippi, on the Biloxi District, Desoto National Forest were selected and fenced by the Forest Service. The areas were in the rolling uplands of the Southern Lower Coastal Plain. Common soils series included Atmore, Bibb, Escambia, Eustis, Lucy, Malbis, Poarch, Saucier, and Smithton. Textures are generally well-drained, loamy sands to fine, sandy loams.

Normal annual rainfall for the general area is 57 in. and the average annual temperature is 66°F. A mild climate persists with the frost-free season being 259 days.

Forest stands were mostly natural, open-grown stands of longleaf and slash pine with the exception of several plantings of slash pine. A detailed description of the forest can be found in Stewart (1981). The Forest Service has used late winter controlled burning, on a 3-year rotation, as a general practice for many years. Cattle grazed most of the area prior to 1979.

The 4 areas (range units) varied from 2735 ac to 4135 ac and were located in Airey and Big Foot Allotments. Area 1 (2735 ac) was located in Forest Service compartment numbers 592, 593,

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594, and 595. Area 2 (3620 ac) was in compartments 574, 575, 617, and Area 3 (3396 ac) was located in compartments 570, 571, 572, 573, and 616. Area four (4135 ac) was located in compartments 566, 567, 568, and 569.

METHODS

In each of the 4 areas, 4 lines, 2640 ft long, were randomly established. Along each line, 9 systematically established, 330 ft apart, permanent sample points were located for a total of 144 sample points.

Line Transects

Species composition, frequency of occurrence, and percent occupancy were obtained by the line-intercept method (Canfield 1941). Transect lines were established in July, 1979 on sampling points 4 and 8 of each line for a total of 32 transects. A transect was 20 ft long and was bisected by the sample point center. The tape, divided into 0.1 ft intervals, was stretched 2 ft above ground at a 90-degree angle to the main line direction. Plants that occurred directly under the tape were identified and their linear occupancy was recorded. Species were grouped into plant categories: grass, forb, vine, shrub, tree, sedge, rush, and fern. Bare ground and debris were also recorded. Percent occupancy was the percentage of the total line occupied by a category. Frequency of occurrence was the number of times a plant category occurred.

Overstory

Overstory tree data were obtained in July, 1979, from 144 sample points. Stand data at each sample point was recorded as (1) nonstocked or regeneration, pines up to and including 3 yrs old, (2) saplings, pines more than 3 yrs old to 4 in. DBH, (3) poles, pines 4 to 9 in. DBH, or (4) sawtimber, pines more than 9 in. DBH.

From the sample point, pine and hardwood trees were measured for (1) basal area using a 10 factor prism, (2) DBH of prism-recorded trees with a DBH tape, (3) height of 1 dominant or codominant tree with a clinometer, and (4) tree age of 1 dominant or codominant tree from increment bores. Percent canopy cover was estimated.

Number of snags, dead trees at least 3.6 in. DBH, within a 33 ft radius of the sample point were recorded. Numbers of individual tree species within a 33 ft radius were also recorded.

Tall Brush

Tree, shrub, and vine data were obtained near peak biomass in July 1979. On milacre plots located at the sample point, percent canopy cover and canopy height in ft (to top of crown) for each species were estimated for trees, shrubs, and vines with stems 1 in. or less DBH and heights greater than 5 ft. Numbers of individuals by species were counted.

Low Brush

Low brush (browse) data were obtained in July of 1979 and 1980. On milacre plots located at the sample point, total current year's growth of trees, shrubs, and vines within 5 ft of the ground was estimated. Percent foliage ground cover was estimated. Browse species were estimated as greater or less than 10% of total composition. Degree of browsing on woody species was recorded in 5 categories (1-5); none; very light, difficult to find browsed plants on plot, less than 10%; light, infrequently find browsing on the plot, generally 10-35%; moderate, frequent evidence of browsing, generally 35-70%; heavy, extensive evidence of browsing, generally more than 70% of the plants browsed.

Forage

Forage (grasses, grasslikes, forbs, and browse) data were obtained in July of 1979 and near minimal biomass in January, 1980, using the ranked-set sampling technique (Halls and Dell 1966). One cluster of 3 circular plots (hoops) 42 in. in diameter (9.62 ft^2) were placed at arms length near each sample point, 1 plot to the left, 1 plot to the right, and 1 plot directly in front of the observer. High, medium, and low ranks were assigned to the hoops for each sample according to an occular estimation of forage dry weight (current annual growth) in each plot. High, medium, and low plots were sampled in succession until 3 plots of each category were obtained for a total of 9 sample points per line. Forage weight was estimated within each plot to a height of 5 ft from ground level.

During July, 1980 forage species were estimated as a percentage based on dry weight. Degree of grazing was recorded as in 1979, as well as percent of basal herbaceous ground cover, foliage ground cover, leaf litter cover, bare ground cover, and rock cover were estimated.

Soils

Soil data were obtained in July, 1980 by Rex E. Davis of the USDA, SCS, Hattiesburg, MS. Soil samples were taken near the sample point using a tubular bucket type soil auger. Soil types consisting of series and texture were identified for each sample point.

Statistical Analysis

Statistical analyses were conducted by Dr. Walter J. Drapala, Dept. of Experimental Statistics, Miss. Agric. and Forestry Experiment Station, Mississippi State Univ. Analysis of variance and multiple regression programs were used to analyze overstory, low brush, and forage data. Duncan's New Multiple Range Test was used to test for differences among means.

RESULTS

Species Composition

A total of 153 plant species was found on transects on the 4 areas. There were 74 species of forbs (48%), 23 grasses, 19 shrubs, 11 vines, 11 trees, 9 sedges, 4 rushes, and 2 ferns. A2 (85) and A3 (87) contained the greater numbers of species while A1 (55) and A4 (58) had fewer species.

Line Transects

Total plant occupancy vaired from 53 (A4) to 73% (A2), and averaged 61.7%. Debris, shrubs, and grasses had the highest occupancy percentages (Table 1).

Overstory

Basal area for A1-4 (nsd, $P > 0.05$) averaged 72 ft^2/ac (Table 2). Basal area ranged from 29 ft^2/ac on A2, line 3, to 127 ft^2/ac on A4, line 3. Trees tallied for basal area averaged 66% pine. Pine tree height on A 1-4 (significantly lower on A2 ($P < 0.05$) averaged 71 ft. Hardwood tree height averaged 57 ft. Pine tree age for A1-4 averaged 45 yrs and was significantly lower on A2 because of several young plantations being present. Hardwood age averaged 49 yrs. Canopy cover averaged 23% and was lowest (11%) on A2.

Number of stems (nsd, $P > 0.05$) averaged 592/ac, and ranged from 146/ac (A4, line 1) to 1,086/ac (A2, line 2).

A total of 49 overstory species was recorded and the major species, based on percent of stems were *Pinus elliottii* (13.6), *P. palustris* (12.1), *Ilex vomitoria* (11.3), *Cliftonia monophylla* (9.3), *Cornus florida* (7.1), *Cyrilla racemiflora* (6.4), *Magnolia virginiana* (5.8), *Ilex coriacea* (5.2), *Myrica cerifera* (4.9), and *Nyssa sylvatica* (4.2).

Number of snags averaged 10/ac and ranged from 0 (A1, lines 1 and 2) to 33/ac (A3, line 3).

Table 1.--Average plant frequency, occupancy, and percent occupancy by category on line transects in longleaf - slash pine forests, Desoto National Forest, July 1979

Plant category	Freq. 1/	Occ. 2/	%Occ. 3/
Grass	17.8	3.8	19.1
Forb	11.0	1.8	8.8
Vine	5.2	1.0	4.8
Shrub	16.5	4.6	22.7
Tree	3.2	0.8	4.3
Sedge	1.4	0.2	1.1
Rush	0.2	0.1	0.1
Fern	0.1	0.1	0.1
Unknown	0.5	0.3	1.3
Total			61.7
Bare ground	0.3	0.2	0.9
Debris	15.7	7.7	38.5

1/Frequency = number of times a plant category occurred.
2/Occupancy = length (ft) of line transect occupied by a plant category.
3/Percent occupancy = % of line transect occupied by a plant category.

Table 2.--Averages of overstory tree measurements by study area and line, Desoto National Forest, Stone and Harrison Counties, MS, July 1979

Study area	Line	Basal area ft^2/ac	Basal area % pine	Height (ft) Pine	Height (ft) Hdwood	Age (yrs) Pine	Age (yrs) Hdwood	Canopy cover (%)	No. Stems/ac	No. Snags/ac
1	1	74	57	71	44	45	26	29	862	0
	2	49	61	49	42	23	60	8	627	0
	3	50	64	75	65	51	60	17	287	7
	4	49	82	82	--	52	--	13	544	6
	Mean	56a[1/]	66	69a	50	43ab	48	17ab	580a	3
2	1	72	85	66	--	40	--	16	444	18
	2	93	40	57	46	30	46	18	1086	13
	3	29	77	62	--	55	--	3	436	0
	4	36	94	38	--	22	--	8	651	3
	Mean	58a	74	56b	46	37a	46	11a	654a	9
3	1	109	55	84	--	64	--	33	866	16
	2	86	55	73	--	40	--	31	914	14
	3	83	40	74	--	39	--	30	712	17
	4	71	67	71	56	47	43	17	313	3
	Mean	87a	54	76a	56	47b	43	28bc	701a	13
4	1	71	97	85	74	56	57	35	146	7
	2	83	54	82	--	53	--	33	224	4
	3	127	56	92	--	58	--	41	696	33
	4	71	64	71	--	41	--	27	670	21
	Mean	88a	68	82a	74	52b	57	34c	434a	16
Total Mean		72	66	71	57	45	49	23	592	10

[1/] Means for basal area, pine height, pine age, canopy cover, and number of stems significantly different, P > 0.05, if not followed by the same small letter.

Tall Brush and Vines

Tall brush and vines (≦ 1 in. dbh, >5 ft high) species numbered 44. Areas 1 and 2 contained 26 and 28 species, while A3 and A4 contained 19 and 16 species, respectively.

Canopy height for the 4 areas averaged 8.4 ft and ranged from 6 to 20 ft. Predominant species were Cephalanthus occidentalis, Gelsemium sempervirens, Ilex vomitoria, Liriodendron tulipifera, Quercus incana, Rhus radicans, Smilax glauca, S. laurifolia, S. rotundifolia, Vaccinium arboreum, and Vitis rotundifolia.

Percent ground cover, based on canopy cover at ground level, averaged 6.48 for the 4 areas. Cliftonia momophylla (1.03%), Ilex coriacea (1.63%), and I. vomitoria (1.08%) had the highest ground cover.

Number of stems averaged 634/ac and most prevalent species were Acer rubrum (20/ac), Cliftonia monophylla (62/ac), Cornus florida (22/ac), Ilex coriacea (263/ac), I. vomitoria (91/ac), Magnolia virginiana (18/ac), and Symplocos tinctoria (20/ac). Area 1 averaged 695, A2 531, A3 625, and A4 665/ac.

Low Brush

Low brush (≦ 5 ft high) species averaged 80 (July 1979) and 84 (July 1980) on the 4 areas. Ilex glabra, I. vomitoria, I. coriacea, Cornus florida, and Vaccinium elliottii were the most prominant species. Average estimated low brush weight (July 1979 and 1980) on the 4 areas was 147 lbs/ac (Table 3).

Low brush weights were significantly greater (P < 0.05) on A1 for 1979, but there was nsd (P > 0.05) among areas for 1980.

Degree of browsing was between none and light for the 4 areas, ranging from 1.22 to 2.33. Assuming desirable deer browse weight was a maximum of 80% of total low brush weight, browse ranged from 101 to 147 lbs/ac and averaged 118 lb/ac in July 1979.

Table 3.--Average estimated low brush weight (lbs/ac), by study area and line, Desoto National Forest, Stone and Harrison Counties, MS, July 1979 and 1980

Area	Line	July 1979	July 1980	Mean
1	1	184	110	147
	2	150	115	133
	3	348	125	237
	4	201	235	218
	Mean	221a[1/]	146c	184
2	1	90	136	113
	2	97	209	153
	3	100	111	106
	4	91	178	135
	Mean	94b	158c	126
3	1	119	174	147
	2	200	128	164
	3	99	173	136
	4	90	107	99
	Mean	127b	145c	136
4	1	92	138	115
	2	125	150	138
	3	60	204	132
	4	98	270	184
	Mean	94b	191c	143

1/Means for July 1979 and then 1980 significantly different, $P < 0.05$, if not followed by the same small letter.

Forage

Forage species (grass, forb, legume, vine, and woody ≤ 5 ft high) numbered 103 on the 4 areas. Area 4 contained the greatest number of species (63) followed by A3 with 53, and A1 and 2 had 51 each. Average estimated forage weight for July, 1979 was 755 lbs/ac (Table 4), and was 305 lbs/ac in January, 1980. Only those portions of the current annual growth which were considered palatable (selected forage) to deer or cattle were estimated. The wood category averaged 71% of the total estimated forage weight in July, 1980 (Table 5).

Table 4.--Average estimated forage weight (lbs/ac) by study area and line, Desoto National Forest, Stone and Harrison Counties, MS, July 1979 and January 1980

Area	Line	July 1979	January 1980
1	1	292	238
	2	763	134
	3	834	115
	4	983	257
	Mean	696a[1/]	191
2	1	752	---
	2	736	367
	3	675	305
	4	1261	276
	Mean	856a	306
3	1	782	479
	2	766	577
	3	961	314
	4	566	161
	Mean	769a	317
4	1	537	271
	2	701	burned
	3	1037	512
	4	505	519
	Mean	695a	406

1/Means for July 1979 significantly different $P \leq 0.05$, if not followed by the same small letter.

Table 5.--Average percent of estimated weight (July 1980) and estimated forage weight (July 1979) by plant category, Desoto National Forest, and Harrison Counties, MS

Plant category	% of Weight	lbs/ac
Grass	7.71[1/]	58[2/]
Forb	8.38	66
Legume	1.15	9
Vine	11.35	85
Woody	71.38	537
Total	100.00	755

1/Based on estimated weight, 9.6 ft^2 plots, July 1980.
2/Based on percent of July, 1980, estimated weight.

Basal herbaceous ground cover was greatest (0.95%) for A4 (Table 6). Foliage ground cover was between 23% on A3 and 30% on A2. Leaf litter cover was the greatest cover component, occupying 63% of A3 and A4, to 82% A2. Bare ground cover was more than twice as great on A3 (13%) as on any other area. Rock cover was negligible. Degree of grazing was none to light.

Table 6.--Average estimated basal herb cover, foliage ground cover, degree of grazing, leaf litter cover, bare ground cover, and rock cover by area, Desoto National Forest, Stone and Harrison Counties, MS, July 1979

	Area			
	1	2	3	4
Basal herb ground cover (%)	0.50	0.22	0.53	0.95
Foliage ground cover (%)	28.78	29.83	23.17	26.21
Degree of grazing (1-5)[1/]	1.31	1.57	1.47	1.13
Leaf litter cover (%)	80.36	82.36	62.81	63.22
Bare ground cover (%)	5.40	5.89	12.75	2.42
Rock cover (%)	0.03	0.00	0.03	0.00

[1/] 1 = none; 2 = very light; 3 = light; 4 = moderate; 5 = heavy.

Vegetative Relationships

Multiple regression analyses were performed on the overstory, low brush, and forage components of the study areas with a low measure of success probably due to the open nature of the longleaf - slash pine stands. Height and age were most closely related ($r^2 = .60$), followed by basal area and percent cover ($r^2 = .53$). Less than 12 percent of the variation in forage and low brush weights was explained by overstory conditions. Overstory components were lower on A1 and A2 because 14 and 17%, respectively, of the sampling points were in pine plantations younger than 37 years (Table 7). Forage weight showed a strong inverse relationship to percent canopy cover and, to a lesser degree, basal area. This trend was similar to the results of Halls and Schuster (1965), Wiggers et al. (1978), and Hurst et al. (1979). Low brush weight was positively related to percent canopy cover. Low brush and forage weights were inversely related due to a measure of overlap in space occupation.

Deer Browse

Assuming desirable browse weight was a maximum of 80% of total low brush weight, browse ranged from 101-147 lbs/ac, and averaged 118 lbs/ac. Much of the browse was Ilex which was found to be heavily used by deer in South Mississippi (Mitchell 1980).

Soils

Soils ranged from somewhat excessively drained to very poorly drained and 19 series were found on the 4 areas (Table 8).

LITERATURE CITED

Canfield, R. H. Application of the line interception method in sampling range vegetation. J. For. 39:388-394; 1941.

Halls, L. K. and T. R. Dell. Trial of ranked-set sampling for forage yields. For. Sci. 12:22-26; 1966.

_____, and J. L. Schuster. Tree-herbage relations in pine-hardwood forests of Texas. J. For. 63:282-283; 1965.

Hurst, G. A., D. C. Guynn, and B. D. Leopold. Correlation of forest characteristics with white-tailed deer forage. Proc. Ann. Conf. S. E. Assoc. Fish and Wildl. Agencies 33:48-55; 1979.

Mitchell, W. A. Evaluation of white-tailed deer and cattle diets in two southeastern pine forests. Ph.D. dissertation, Dept. of Biological Sciences, Miss. St. Univ., Miss. State, MS; 1980. 236 p.

Stewart, A. W. Vegetative inventory and white-tailed deer forage on the Desoto National Forest, Miss. M.S. Thesis, Dept. Wildl. and Fish., Miss. St. Univ., Miss. St., MS; 1981. 122 p.

Warren, R. C., and G. A. Hurst. Ratings of plants in pine plantations as white-tailed deer food. Information Bull. 18, Miss. Agricul. and For. Exper. Sta., Miss. St. Univ.; 1981. 14 p.

Wiggers, E. P., D. L. Robinette, J. R. Sweeny, R. F. Harlow, and H. S. Hill, Jr. Predictability of deer forages using overstory measurements. Proc. Ann. Conf. S. E. Assoc. Fish and Wildl. Agencies 32:187-194; 1978.

Table 7.--Average overstory, forage, and low brush measurements in pine plantations, Desoto National Forest, Stone and Harrison Counties, MS, July 1979

Plantation age (yrs)	Type[1/]	Basal Area (ft^2/ac)	Height (ft)	Cover (%)	No. Stems (/ac)	Forage (lbs/ac)	Low Brush (lbs/ac)
≦ 3	SL	13	20	5	408	948	160
11-16	SL,LL	40	31	13	832	715	132
19-25	SL	53	32	9	628	1324	169
37	LL	40	64	2	624	650	191

1/ SL = slash pine; LL = longleaf pine.

Table 8.--Average percent soil series by study area, Desoto National Forest, Stone and Harrison Counties, MS, July 1980

		Area			
Series	Texture	1	2	3	4
Alaga	loamy sand	2.8	--	--	5.6
Atmore	find sandy loam	--	11.1	13.9	--
Bibb	silt loam	2.8	--	--	--
	sandy loam	2.8	--	--	2.8
	fine sandy loam	--	2.8	8.3	--
	loam	--	2.8	--	--
Borrow area		--	5.6	--	--
Escambia	fine sandy loam	--	13.9	11.1	11.1
	sandy loam	--	--	--	2.8
Eustis	loamy sand	19.4	--	--	--
Harleston	fine sandy loam	--	2.8	2.8	--
Johnston	muck	--	--	2.8	--
Lucy	loamy sand	11.1	--	8.3	--
Malbis	fine sandy loam	11.1	5.6	8.3	2.8
McLaurin	fine sandy loam	5.6	--	--	--
	loamy sand	2.8	--	2.8	--
Plummer	loamy sand	--	--	--	2.8
Poarch	loamy sand	5.6	--	--	2.8
	fine sandy loam	11.1	16.7	2.8	33.3
Ruston	fine sandy loam	2.8	--	--	--
	loamy sand	--	--	--	2.8
Saucier	loamy sand	2.8	--	--	--
	fine sandy loam	5.6	19.4	2.8	8.3
Smithton	fine sandy loam	--	13.9	33.3	25.0
Susquehannah	silt loam	2.8	--	2.8	--
	fine sandy loam	--	5.6	--	--
Troup	loamy sand	8.3	--	--	--
Wagram	loamy sand	2.8	--	--	--

Amphibians and Reptiles on Longleaf-Slash Pine Forests in Southern Mississippi

Henry A. Pearson, Renne R. Lohoefener, and James L. Wolfe

Abstract.--Amphibians and reptiles were sampled during 1980-1982 on more than 20 square miles of the Biloxi Ranger District, DeSoto National Forest, in Southern Mississippi. Five stand classes or habitats (regeneration, saplings, poles, sawtimber, and bayheads) were sampled within each of four management units. The diverse fauna were measured by several survey methods, including active searches--both diurnal and nocturnal, permanent line transects, anuran calls after or during rainfall, pit-fall traps, and funnel trap stations.

Highest numbers of salamander species and individuals were recorded on bayheads. Toad and frog species diversities were similar among all stand types, but numbers of individuals were higher on bayheads. Species diversities of turtles and lizards were also similar across stand types; highest individual counts of lizards occurred in poletimber stands, but relatively high counts occurred in all stands. Snake species diversity, individuals, and frequency were lowest on regeneration areas.

INTRODUCTION

The longleaf-slash pine forest association covers more than 17 million acres of the lower Gulf Coastal Plain from Texas to Florida (Shiflet 1980). It is important for commercial timber and livestock production and is a unique biological community. In Mississippi, this forest association makes up 1.3 million acres and is the predominant forest type of the Pine Hills and Lower Coastal Plain physiographical provinces (Lowe 1921, Cross et al. 1974, Lohoefener and Altig 1983).

This herpetological study for the Southern Evaluation Project, Biloxi Ranger District, DeSoto National Forest-Mississippi, was conducted during 1980, 1981, and 1982 (Wolfe and Lohoefener 1980, Lohoefener 1981, 1982b). The objective of this study was to describe the amphibian and reptile abundance and diversity within five forest stand classes in the longleaf-slash pine type study area in Mississippi. Forest stand classes (habitats) studied were regeneration (clear-cuts), saplings, poles, sawtimber, and bayheads (Wolfe and Lohoefener 1983).

STUDY AREA

The study area, subdivided into four management units, was located in northern Harrison and southern Stone counties, Mississippi (Wolfe and Lohoefener 1983). The topography consisted of gently rolling hills dissected by small streams (some intermittent) that were bordered by narrow zones of hardwoods (Wolfe and Lohoefener 1983). Longleaf pine (*Pinus palustris*) and slash pine (*P. elliottii*), occurring in various stages of succession from regeneration to mature trees, were the dominant overstory trees. The understory consisted of bluestem grasses (*Andropogon* spp., *Schizachyrium* spp.), panicums (*Panicum* spp., *Dicanthelium* spp.), wiregrass (*Aristida stricta*), yaupon (*Ilex vomitoria*), blackberries (*Rubus* spp.), gallberry (*Ilex glabra*, *I. coriacea*), and a variety of forbs and other plants (Stewart 1981). Control burning was routinely practiced at 3- to 5-year intervals.

METHODS AND PROCEDURES

In 1980, four forest stand classes or habitats (regeneration--pines 3 years old or younger, saplings--pines more than 3 years old and up to 4 in d.b.h.; poles--pines 4 to 9 in d.b.h., and sawtimber--pines more than 9 in d.b.h.) were studied in two management units. In 1981, studies were expanded to four management units and five habitats; bayheads (baygalls), mesic-hydric hardwood habitats were added. This created a total of 20 study areas.

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Several census methods were used. Because little of the habitat within the management units was suitable for salamanders, the 1980 surveys did not concentrate on salamanders, noting them only when found incidental to the surveys. The 1981 and 1982 surveys included all terrestrial herpetofauna in each of the five habitat types; aquatic amphibians were also censused in selected streams, and gopher tortoises were censused throughout the four management areas. Amphibians and reptiles were surveyed during 17 days (March-June) in 1980, 40 days (April-June) in 1981, and 48 days (March-September) in 1982.

Active Searches

Both diurnal and nocturnal searches were made along approximately 1300-ft-long permanent line transects bisecting each stand type (Wolfe and Lohoefener 1980, Lohoefener 1981, 1982b). Lizards were counted along each transect during late morning and late afternoon, while snakes were counted during the day and at night. Debris within 33 feet on either side of the transect line was searched. During nocturnal searches, a light with a red acetate cover was used so that the herpetofauna would not be alarmed.

Anuran Call Census

Anurans (toads and frogs) were surveyed by call counts from 7:30 p.m. to midnight after or during rainfall--when they are most active. However, dryness during spring of 1982 hampered these surveys. Portable equipment was used to record the more complex calling aggregations for later identification. Periodic stops were made along the transects and a 90° directional parabolic reflector was held in each of the four cardinal directions for 2 minutes while vocalizations were recorded.

Pit-fall Traps

Twenty-five gallon cans were buried flush with the soil surface in each of the forest stands. A total of 500 cans were buried for this study. The gallon can was found to be most useful with the ground skink (Scincella lateralis). These cans were replaced in 1982 with deeper cans (5-gallon buckets) to ensure that some herpetofauna did not escape.

Funnel Traps

One trap station with three funnel traps (Lohoefener 1981) was established in each stand. The traps were used in conjunction with two 50-ft long polyethelene fences placed at a 30° angle. A central trap was placed where the fences joined and one trap was placed at the outer end of each 50-ft fence. Traps were placed in shallow trenches so the protruding PVC pipe entrance was flush with the ground. In 1982, the trap stations were modified to include four 30-ft drift fences in a zigzag layout using both the pit-fall and funnel traps (Loehoefener 1982b).

Toads and Frogs

Anurans could not be censused uniformly because of the lack of precipitation; consequently, the results are biased to sites with standing water, which was not uniform across study areas. Some anurans were added to the species lists by active search techniques, funnel traps, and--to a less extent--the pitfall traps. Anuran call censuses were the most reliable technique.

Salamanders

Most salamanders were found by active searches. No salamanders were taken in the pitfall traps, but a few were taken in bayheads in the funnel traps. Active search techniques are the most valuable for this component of the herpetofauna.

Turtles

All turtle data, except for one eastern box turtle (Terrapene carolina) and one stinkpot turtle (Sternotherus odoratus), were the result of active diurnal searches. The gopher tortoise (Gopherus polyphemus) is a herbivore that primarily feeds on grasses. Due to the gopher tortoise's rarity and possible future endangered or threatened status, each management unit was searched for burrows of this species (Lohoefener 1982a). Gopher tortoise burrows were counted only if active.

Lizards

Some species of lizards are common and readily observable. All the census methods described earlier were used in collecting lizards. The pitfall traps were most useful to capture the ground skink; however, the funnel traps were the most successful for all lizards.

Snakes

Early in spring, diurnal searches were most successful in censusing snakes. By mid-May, nocturnal searches and the use of the funnel traps replaced diurnal searches because the snakes sought shelter from the heat of day. The funnel traps were most useful for snakes, especially on the bayheads.

RESULTS AND DISCUSSION

Two classes of herpetofauna were found in the study area, each class including two orders (Amphibia: Caudata and Anura; Reptilia: Testudinata and Squamata). Each of these were represented by several families and species.

Toads, frogs, and lizards occurred more frequently than salamanders, turtles, and snakes in the five stand types (table 1). Bayheads had a greater number of salamander species than the drier upland sites (table 2). A total of 61 herpetofaunal species were found on the area. The number of species was fairly similar among stand types, varying from a low of 33 species in the regeneration type to a high of 38 species in

Table 1.--Percent frequency of occurrence of amphibians and reptile species occurring in five habitats of a longleaf-slash pine forest in Mississippi 1/

	Regeneration	Saplings	Pole	Sawtimber	Bayheads	Average
Salamanders	0.5	0	1.5	2.0	8.8	2.6
Toads and Frogs	6.9	8.0	8.0	8.0	8.4	7.9
Turtles	1.3	2.5	0.6	2.5	2.3	1.8
Lizards	8.1	9.7	11.7	10.6	8.7	9.8
Snakes	2.3	2.7	3.7	2.8	3.3	3.0

1/ Percent frequency is the number of species encountered divided by the total number of locations.

Table 2.--Number of amphibian and reptile species occurring in five habitats of a longleaf-slash pine forest in Mississippi

	Regeneration	Saplings	Pole	Sawtimber	Bayheads	Total
Salamanders	1	0	2	1	5	5
Toads and Frogs	13	13	11	13	12	16
Turtles	2	2	1	1	3	4
Lizards	7	9	6	6	6	9
Snakes	10	14	15	15	12	27
Totals	33	38	35	36	38	61

bayhead and sapling type. Numbers of all herpetofauna were more abundant on pole sites than the other sites due to the high counts of lizards (table 3). Lizards were least abundant on bayheads; toads, frogs, and salamanders were most abundant on bayheads. Total numbers of species occurring on the four management units within the five habitats are recorded in table 3 from three study reports (Wolfe and Lohoefener 1980, Lohoefener 1981, 1982b).

Salamanders

Five species of salamanders were found (Desmognathus auriculatus, Eurycea longicauda, Eurycea quadridigitatus, Plethodon glutinosus, and Notophthalmus viridescens louisianensis). It is not surprising that most of the salamanders were found in the bayhead areas because of those areas' moist environment. In most instances, the other habitats were too sandy and dry and provided little cover for salamanders. Slimy salamanders (P. glutinosus) located in immature sawtimber were found in depressions with deciduous shrubbery and abundant leaf litter. Only one central newt (N. v. louisianensis) was found while searching for amphibians.

More species of salamanders may occur on the study area than were found, because the months of February and March are usually the best times to find salamanders and the 1981 surveys were not begun until April. Also, the spring of 1981 was unusually dry, and probably many species of salamanders did not emerge from the winter refuges.

Toads and Frogs

During the 1980 survey, March data were more valuable than June data in quantifying anurans. No new species were encountered in June and population levels were lower than in March. This was probably due to the dry weather depressing the vocalizations rather than an actual drop in individuals present.

Anurans must have water in their life-cycles. Ponds throughout these habitats usually contain water during the spring months. During the spring drought of 1981, however, little breeding of anurans took place except in the bayheads. Bayheads serve as reservoirs for anurans during these dry times and help to maintain populations that can expand in wetter years or seasons. The spring of 1982 was comparatively wet and produced the highest anuran counts.

Table 3.--Total numbers of amphibians and reptile counted, 1980-1982

Species	Regeneration	Sapling	Poletimber	Sawtimber	Bayheads
	#	#	#	#	#
Class Amphibia					
Order Caudata					
Family Plethodontidae					
Desmognathus auriculatus Southern dusky salamander					1
Eurycea longicauda Long-tailed salamander			1		8
Eurycea quadridigitatus Dwarf salamander					13
Plethodon glutinosus Slimy salamander	3		5	13	14
Family Salamandridae					
Notophthalmus viridescens Central newt					1
TOTAL SALAMANDERS (59)	3	0	6	13	37
Order Anura[1/]					
Family Bufonidae					
Bufo terrestris Southern toad	23	9p[1/]	9	21p	25pm[2/]
Bufo woodhousei Common toad	6	6p	8p	3	4p
Family Hylidae					
Acris gryllus Southern cricket frog	5	2p	4	2p	36p
Hyla avivoca Bird voiced tree frog		p		1	
Hyla cinerea Green tree frog					4p
Hyla crucifer Peeper tree frog	8	2	2p	2p	28p
Hyla fermoralis Pine woods tree frog	2	p	1p	1p	1p
Hyla gratiosa Barking tree frog	1	p			4p
Hyla squirella Squirrel tree frog	1	p	1p	p	m
Hyla versicolor Gray tree frog	3	2	12p	3p	4p
Pseudacris nigrita Southern chorus frog	5	2	2	2	
Pseudacris triseriata Chorus frog				1	
Family Microhylidae					
Gastrophryne carolinensis Eastern narrow mouthed toad	7	4p	4p	5p	3p
Family Pelobatidae					
Scaphiopus holbrooki Eastern spadefoot toad	1				

Table 3.--(continued)

Species	Regeneration	Sapling	Poletimber	Sawtimber	Bayheads
	#	#	#	#	#
Family Ranidae					
<u>Rana clamitans</u> Green frog	2	4	2	1	7p
<u>Rana sphenocephala</u> Southern leopard frog	1	2	1p	1p	9pm
TOTAL TOADS AND FROGS (312 pm)	65	33p	46p	43p	125pm
Class Reptilia					
Order Testudinata					
Family Emydidae					
<u>Terrapene carolina</u> Eastern box turtle	1	2		5	1
Family Kinosternidae					
<u>Kinosternon subrubrum</u> Eastern mud turtle					1
<u>Sternotherus odoratus</u> Stinkpot turtle					1
Family Testudinidae					
<u>Gopherus polyphemus</u> Gopher tortoise	2	5	1		
TOTAL TURTLES (19)	3	7	1	5	3
Order Squamata					
Suborder Lacertilia					
Family Anguidae					
<u>Ophisaurus ventralis</u> Eastern glass lizard	1	1			
Family Iquanidae					
<u>Anolis carolinensis</u> Green anole	7	13m	51m	29m	24m
<u>Sceloporus undulatus</u> Fence lizard	28	28m	42	23m	24
Family Scincidae					
<u>Eumeces anthracinus</u> Coal skink		1			
<u>Eumeces fasciatus</u> Five-lined skink	4	1	6	2	18
<u>Eumeces inexpectatus</u> Southeastern skink	5	10	17	3	6
<u>Eumeces laticeps</u> Broad-headed skink	1	m	m	2	1
<u>Scincella lateralis</u> Ground skink	103	85m	139m	104m	61m

Table 3.--(continued)

Species	Regeneration	Sapling	Poletimber	Sawtimber	Bayheads
	#	#	#	#	#
Family Teidae					
Cnemidophorus sexlineatus Six-lined race runner		7			
TOTAL LIZARDS (847m)	149	146m	255m	163m	134m
Suborder Serpentes					
Family Colubridae					
Carphophis amoenus Worm snake				2	
Cemophora coccinea Scarlet snake	2	1	2	3	3
Coluber constrictor Black racer	11	20	16	11	13
Diadophis punctatus Ringneck snake			2	1	2
Elaphe guttata Corn snake					2
Elaphe obsoleta Rat snake	1	1	3	2	
Farancia abacura Mud snake					1
Heterodon platyrhinos Eastern hognose snake	2	1			
Heterodon simus Southern hognose snake			2		
Lampropeltis getulus Speckled king snake	4	2	5	4	6
Lampropeltis triangulum Scarlet kingsnake		2			
Masticophis flagellum Eastern coachwhip	1	1	2		
Nerodia fasciata Banded water snake					1
Opheodrys aestivus Rough green snake		1	2	2	4
Pituophis melanoleucus Black pine snake			1	1	
Regina rigida Glossy water snake		1			
Rhadineae flavilota Pine woods snake	1			4	
Storeria dekayi Brown snake		1		1	
Tantilla coronata Southeastern crowned snake		2	1		
Thamnophis sauritus Ribbon snake			1		2
Thamnophis sirtalis Eastern garter snake	1	2		1	2
Virginia valeriae Smooth earth snake			1	1	
Virginia striatula Rough earth snake	2	2	7	3	1

Table 3.--(continued)

Species	Regeneration	Sapling	Poletimber	Sawtimber	Bayheads
	#	#	#	#	#
Family Elapidae					
Micrurus fulvius Coral snake			1		
Family Viperidae					
Agkistrodon contortrix Southern copperhead				1	
Agkistrodon piscivorus Eastern cottonmouth			1		1m
Crotalus adamanteus Eastern diamondback	3	3	2	1	
TOTAL SNAKES (193m)	28	40	49	38	38m
GRAND TOTAL HERPETILES (1430 pm)	248	226pm	357pm	262pm	337pm

1/ p--refers to more than a few anurans present.

2/ m--refers to many individuals present.

The 16 species of anurans recorded during the study probably represent the species breeding at the time of study. Since the bayheads had some form of water present throughout the study period, a great diversity or number of anurans was expected in these areas. Similarly, it is not surprising that the upland areas had fewer numbers of anurans. The sapling, pole, and sawtimber areas seemed to have anurans directly proportional to the amount of cover and the amount and duration of water available. Areas that had a greater diversity of anurans also had more water and cover.

The southern toad (Bufo terrestris) and common toad (B. woodhousei fowleri) were found to be evenly distributed throughout the four range units, with the southern toad being most common. The southern toad was commonly found vocalizing near small puddles in the sandy soils. The eastern spadefoot toad (Scaphiopus holbrooki) was found only in regeneration areas while the eastern narrow-mouthed toad (Gastrophryne carolinensis) occurred in all the forest stand classes.

The green (Rana clamitans), southern leopard (R. sphenocephala), and southern cricket (Acris gryllus) frogs were found in all the forest stand classes. Also, several tree frogs--peeper (Hyla crucifer), pine woods (H. fermoralis), squirrel (H. squirella), and gray (H. versicolor)--were in all forest stands. The bird-voiced (H. avivoca), green (H. cinerea), and barking (H. gratiosa) tree frogs were found in some forest stands but not all; however, all were found in bayheads. The chorus frogs (Pseudacris nigrita and P. triseriata feriarum) were found only on the upland stands but not in bayheads.

Turtles

None of the water courses in the study areas was stable enough or of sufficient magnitude to support aquatic turtles. All turtles found were terrestrial (Terrapene, Gopherus) or semi-aquatic (Kinosternon, Sternotherus). The eastern boxturtle is fairly ubiquitous, and in this study, was found more or less uniformly throughout the stand types. The gopher tortoise was found in sapling, pole, and regeneration areas. All gopher tortoises were isolated individuals; usually healthy gopher tortoise populations occur in colonies (Lohoefener 1982a). However, the pole, regeneration, and one of the sapling areas formed a continuum in location. Isolated tortoises do not become part of the reproductive pool. Unless these tortoises disperse, the population will likely die out. The stinkpot turtle and eastern mud turtle (Kinosternon subrubrum) require water yearlong and were found only in the bayhead areas. They both may be more common in these habitats than the survey revealed.

Lizards

As indicated by the results of this study, the green anole (Anolis carolinensis), fence lizard (Sceloporus undulatus), and ground skink tolerate these habitats. The green anole prefers shaded areas (Behler and King 1979). Both the green anole and fence lizard increase as density of vegetation increases. The ground skink needs ground cover, such as leaf litter, to survive. Because of their ubiquitousness, the ease with which they were captured in pit-fall and funnel traps, and the numbers in which they occur, the ground skink may be a good lizard species for monitoring habitat changes.

The broad-headed skink (Eumeces laticeps); five-lined skink (E. fasciatus), both common in mesic areas, and southeastern skink (E. inexpectatus), common in xeric areas (Behler and King 1979), were found in the bayheads as well as in all the upland forest stand classes. Coal skinks (E. anthracinus pluvialis) were found only in sapling stands. Most of the skinks were captured in the funnel traps.

The eastern glass lizard (Ophisaurus ventralis) was probably more abundant than reflected in this survey. It is secretive by nature and usually occurs in suitable ground cover and mesic conditions, but it was found only in regeneration and sapling stands. The six-lined racerunner (Cnemidophorus sexlineatus) prefers dry, sunny, open woodlands on well-drained soils (Behler and King 1979) and was found only in sapling stands.

Snakes

The black racer (Coluber constrictor priapus) was the most commonly observed snake in this study. It occupies a wide range of habitats and is both diurnal and nocturnal. Its habit of sunning make it easy to locate (or observe). The racer was found in 14 of the 20 study areas in all forest stand classes and probably occurred in all 20. The speckled kingsnake (Lampropeltis getulus holbrooki), also found in all forest stand classes, was common, being found in 6 of the 20 areas. Its large, slow movement, and diurnal activity make it readily observable. The scarlet kingsnake (L. triangulum elapsoides) was found only in sapling stands. The scarlet snake (Cemophora coccinea copei) was found in all forest stand classes.

The ringneck (Diadophis punctatus), brown (Storeria dekayi wrightorum), worm (Carphophis amoenus), smooth earth (Virginia valeriae), and rough earth (V. striatula) snakes were probably more common than records indicated because they are difficult to find. They are semi-fossorial forms and usually most common in mesic conditions under leaf litter and fallen wood (Behler and King 1979). These were found by searching (turning over and going through places of refuge) or they were caught in the funnel traps. The dry spring of 1981 probably forced these snakes underground.

The rough green snake (Opheodrys aestivus) is usually more abundant than reflected in these surveys. It is a semi-arboreal species that seems to prefer mesic environments and consequently was more frequent in the bayheads. The green coloration and arboreal habits made it difficult to find this species.

The eastern cottonmouth (Agkistrodon piscivorus) was a common snake, especially in the wetter bayheads. The banded water snake (Nerodia fasciata) and glossy water snake (Regina rigida) were the only water snakes recorded; the banded water snake occurred in bayheads while the glossy water snake occurred in sapling stands. The only mud snake (Farancia abacura reinwardti) noted was during a nocturnal search of a bayhead area. This snake is usually associated with water and was only expected to be found in the bayhead areas.

The small number of eastern coachwhips (Masticophis flagellum) captured or observed indicates that they are uncommon in the study area. They usually prefer dry upland habitats and were found in regeneration, sapling and pole stands. The black pine snake (Pituophis melanoleucus lodingi) was found in pole and sawtimber stands; this species prefers open, dry pine uplands (Behler and King 1979). The corn snake (Elaphe guttata) and rat snake (E. obsoleta spiloides) are usually most common in areas where forest and agriculture mix. The corn snake was found only in bayheads while the rat snake was found in all the upland forest classes. The pine woods (Radineae flavilota) and southeastern crowned (Tantilla coronata) snakes were found in all upland sites, while the ribbon (Thammophis sauritus) and eastern garter (T. sirtalis) snakes were found in uplands and bayheads The eastern hognose (Heterodon platyrhinos) and southern hognose (H. sinus) snakes were found only in regeneration, sapling and pole stands.

The southern copperhead (Agkistrodon contortrix) was rare, being found only in a hilly sawtimber stand. Possibly the study area was too sandy for the copperhead. The eastern diamondback rattlesnake (Crotalus adamanteus) was the most abundant of the poisonous snakes. As temperatures increased in the spring, it became more nocturnal; it was found in regeneration, sapling, pole and sawtimber stands. The gopher tortoise was also found in similar areas and may be habitat associated. Only one coral snake (Micrurus fulvius) was found in a pole stand.

LITERATURE CITED

Behler, J. L.; King, F. W. 1979. The Audubon Society field guide to North American reptiles and amphibians. New York, N.Y.: Alfred A. Knopf, Inc. 719 p.

Cross, R. D.; Wales, R. W. eds. 1974. Atlas of Mississippi. Jackson, MS: University Press.

Lohoefener, R. R. 1981. Herpetological studies, Southern Evaluation Project, DeSoto National Forest, Mississippi. USDA Forest Service Final Rpt. P.O. #40-7B82-1-22291. Pineville, LA. 58 p.

Lohoefener, R. R. 1982a. Gopher tortoise ecology and land-use practices in southern DeSoto Nationa Forest, Harrison County, Mississippi. In: Franz, R., Brant, R. J. eds. The gopher tortoise and its sandhill habitat: Proceedings, 3rd annual Gopher Tortoise Council meeting; 1982, October 30; Tallahassee, FL: Tall Timbers Research Station. 50-74.

Lohoefener, R. R. 1982b. Amphibians and reptiles on five habitats, DeSoto National Forest, Mississippi. USDA Forest Service Final Rpt. FS-SO-1701-1.350. Pineville, LA. 41 p.

Lohoefener, R. R.; Altig, R. 1983. Mississippi herpetology. Bull. Mississippi State University Research Center 1: 1-66.

Lowe, E. N. 1921. Topographic and floristic regions of Mississippi. Geol. Survey Bull. 17. Mississippi State, MS: Mississippi State Geological Survey. 29-57.

Shiflet, T. N. 1980. What is the resource. In: Child, R.; Byington, E. K. eds. Proceedings, Southern forest range and pasture: Proceedings of a symposium; 1980 March 13-14; New Orleans, LA. Morrilton, AR: Winrock International Livestock Training Center; 17-28.

Stewart, III, A. W. 1981. Vegetative inventory and white-tailed deer forage on the DeSoto National Forest. Mississippi State, MS: Mississippi State University. M.S. thesis. 122 p.

Wolfe, J. L.; Lohoefenner, R. R. 1980. Inventory of amphibians and reptiles on two range units of the range evaluation project, DeSoto National Forest. USDA Forest Service Final Rpt. FS-SO-1701-4.17. Pineville, LA. 22 p.

Wolfe, J. L.; Lohoefenner, R. R. 1983. The small fauna of a longleaf-slash pine forest in southern Mississippi. Journal Mississippi Academy of Science 28: 37-47.

Inventory of Mammals and Birds on Bigfoot and Airey

Grazing Allotments of the DeSoto National Forest, Mississippi

Mark K. Johnson[1]

Abstract.--Birds and mammals were inventoried by sampling methods during 1979 and 1980 in 4 adjoining grazing units of the DeSoto National Forest, Mississippi. Seasonal differences were not observed in mammalian community composition. Seasonal differences in avian community composition were attributed to seasonal migrations of several species. However, relative abundance of Canids was much higher in late winter compared to mid-summer. This difference was presumably due to use and loss of dogs by hunters.

INTRODUCTION

There are about 7 million ha of longleaf (*Pinus palustris*) - slash (*P. elliotti*) pine forest types in the Gulf Coastal Plain from Texas to Florida (Shiflet 1980). This forest type has had a long and recently erratic grazing history. Present uses of National forests include grazing by livestock but there is little knowledge as to effects of livestock grazing on wildlife species in the longleaf-slash pine habitat. The purpose of this work was to provide baseline data on relative abundance of birds and mammals in 4 adjacent grazing allotments in this forest type in order to detect future changes in wildlife populations associated with a plan to study livestock grazing management practices.

METHODS

Four management units comprising over 21 sections (13,886 acres) in the southern part of the DeSoto National Forest, Mississippi, were sampled for birds, small mammals, and medium-sized mammals during 1979 and 1980 (Fig. 1). Specific units compared were in the Bigfoot grazing allotment (units 1-3) and the Airey grazing allotment (unit 4). The forest was dominated by longleaf and slash (*Pinus palustris*) and *elliottii*) pine. Understory vegetation was dominated by bluestem grasses (*Andropogon* spp.) and wiregrass (*Aristida* spp.). Dominant shrubs included yaupon (*Ilex vomitoria*) and gallberry (*I. glabra*). Results from 2 additional years of small mammal inventory in relation to habitat types was reported by Wolfe and Lohoefner (1983).

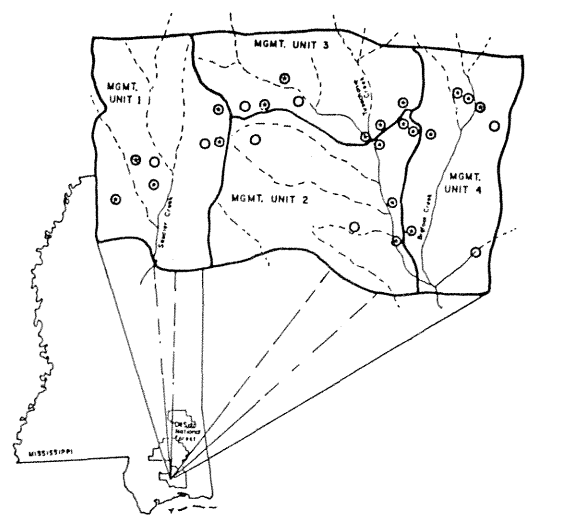

Figure 1. Location of study area showing locations of grazing management units and small mammal sampling sites. Open circles were sampled during 1979; circles with stars were sampled during 1981-82.

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Table 1. Average (± SD) density (d) and percent frequency (%) for birds on the DeSoto National Forest, Mississippi during July 1979. Averages were computed from 4 areas. Density is number of birds per sample station.

Species	d	% f
Bobwhite (Colinus viginianus)	0.5 ± 0.1	38 ± 11
Yellow billed cuckoo* (Coccyzus americanus)	0.7 ± 0.1	58 ± 12
Blue jay (Cyanocitta cristata)	1.1 ± 0.2	77 ± 6
Common crow (Corvus brachyrhychos)	1.4 ± 0.2	80 ± 8
Fish crow* (Corvus ossifragus)	0.2 ± 0.1	17 ± 7
Tufted titmouse* (Parus bicolor)	0.8 ± 0.1	62 ± 8
Carolina wren (Thryothorus ludovicianus)	0.7 ± 0.2	48 ± 16
Red-eyed vireo* (Vireo olivaceus)	0.3 ± 0.2	26 ± 12
Northern Cardinal (Cardinalis cardinalis)	1.2 ± 0.2	74 ± 10
Wood thrush* (Hylocichla mustelina)	0.2 ± 0.2	18 ± 9
Great crested flycatcher* (Myiarchus criuitus)	0.6 ± 0.2	52 ± 16
White-eyed vireo* (Virio griseus)	0.5 ± 0.2	40 ± 11
Yellow-throated vireo* (Virio flavifrons)	0.1 ± 0.1	15 ± 8
Kentucky warbler* (Oporornis formosus)	0.2 ± 0.2	13 ± 7
Rufous-sided towhee (Pipilo erythrophthalmus)	1.1 ± 0.4	66 ± 13
Hooded warbler* (Wilsonia citrina)	0.6 ± 0.2	39 ± 9
Pileated woodpecker (Dryocopus pileatus)	0.5 ± 0.1	44 ± 5
Brown thrasher (Toxostoma rufum)	0.3 ± 0.2	24 ± 9
Red-bellied woodpecker* (Melanerpes carolinus)	0.4 ± 0.2	39 ± 20
Brown-headed nuthatch* (Sitta pusilla)	0.3 ± 0.2	19 ± 12
Purple martin* (Progne subis)	0.2 ± 0.1	20 ± 6
Carolina chickadee* (Parus carolinensis)	0.2 ± 0.1	17 ± 5
Summer tanager* (Piranga rubra)	0.1 ± 0.1	12 ± 3
Downy woodpecker (Picoides pubescens)	< 0.1	1 ± 4
Pine warbler* (Dendroica pinus)	0.5 ± 0.3	44 ± 12
Yellow-breasted chat* (Icteria virens)	0.5 ± 0.5	38 ± 32
Ruby-throated hummingbird* (Archilochus colubris)	< 0.1	2 ± 2
Prairie warbler* (Dendroica discolor)	0.2 ± 0.2	14 ± 2
Red-shouldered hawk* (Buteo lineatus)	< 0.1	7 ± 4
Indigo bunting* (Passerina cyanea)	< 0.1	4 ± 5
Bachman's sparrow* (Aimophila aestivalis)	0.3 ± 0.2	20 ± 14
Blue-gray gnatcatcher* (Polioptila caerulea)	0.1 ± 0.2	8 ± 11
Chimney swift* (Chaetura pelagica)	< 0.1	3 ± 3
Eastern kingbird* (Tyrannus tryannus)	< 0.1	2 ± 4
Common flicker* (Colaptes auratus)	0.1 ± 0.3	16 ± 16
Orchard oriole* (Icterus spurius)	< 0.1	1
Hairy woodpecker* (Picoides villosus)	< 0.1	3 ± 2

Table 1. Continued.

Species	d	% f
Eastern wood pewee* (Contopus virens)	< 0.1	8 ± 10
Blue grosbeak* (Guiraca caerulea)	< 0.1	11 ± 14
Cattle egret* (Bubulcus ibis)	0.1 ± 0.7	1
Mourning dove* (Zenaida macroura)	0.2 ± 0.2	18 ± 16
Chuck-will's-widow* (Caprimulgus carolinensis)	< 0.1	3 ± 2
Barn swallow* (Hirundo rustica)	0.1 ± 0.2	9 ± 7
Common yellowthroat* (Geothypis trichas)	0.2 ± 0.2	20 ± 18
Bank swallow* (Hirundo rusticus)	< 0.1	6 ± 7
Eastern bluebird* (Sialia sialis)	0.1 ± 0.2	14 ± 13
Common grackle* (Quiscalus quiscula)	0.2 ± 0.2	10 ± 11
Red-headed woodpecker (Melanerpes erythrocephalus)	< 0.1	5 ± 6
Green heron* (Butorides striatus)	< 0.1	1
Broad-winged hawk* (Buteo platypterus)	< 0.1	5 ± 6
Barred owl* (Strix varia)	< 0.1	6 ± 9
Swainson's warbler* (Limnothlypis swansonii)	< 0.1	1
Red-winged blackbird* (Agelaius phoeniceus)	< 0.1	2 ± 3
Brown-headed cowbird* (Molothrus ater)	< 0.1	1
Common nighthawk* (Chordeiles minor)	< 0.1	1

*These species were not detected in mid-winter sampling plots. Additional species found during winter were White-throated Sparrow (Zonotrichia, American Goldfinch (Carduelis tristis), Eastern Phoebe (Sayornis phoebe), Field Sparrow (Spizella pusilla), Robin (Turdus migratorius), Ruby-crowned Kinglet (Regulus calendula), Chipping Sparrow (Spizella passerina), Myrtle Warbler (Dendroica coronata), Sparrow Hawk (Falco sparverius), Brown Creeper (Certhia americana), and Hermit Thrush (Catharus guttatus).

Breeding Bird Studies

Bird data were recorded from each of 5 transect lines in each of the 4 allotments for a total of 20 transect lines. Breeding bird data were recorded in July 1979. On each transect line, 5 sampling stations located about 1300 m apart were each sampled once. Data were recorded from each sampling station for one 15-minute period either by tape recorder, direct observation or both. Data were compared among direct observation, monaural tape recorder and stereo tape recorder methods for 69 stations. All stations were sampled between 5:45 a.m. and 10:30 a.m.

Small Mammal Studies

Small mammal trap lines were sampled from May 9 - 26, 1979. Traps were checked daily and all animals removed. Two sampling lines, each with 25 stations, were used in each of the 4 areas for a total of 8 lines and 200 trapping stations. A total of 3600 trap nights was used in the sampling. Trap stations were 20 m apart and each station included a pitfall trap (sunken one-gallon tin can) and a large Sherman live trap. Traps were baited with a mixture of 80 percent oat flakes, 10 percent peanut butter, and 10 percent sardines in peanut oil. Trapping sessions lasted for 18 days with all lines run concurrently.

Medium-sized Mammal Studies

During July 1979 and January 1980, 1000 scent-posts were sampled for a total of 2000 scent-post nights. Scent posts were 1 m^2 circular areas along secondary roads and were cleaned with a rake the day before sampling. The center of each scent-post was baited with a small stick soaked with fox urine as an attractant. Scent posts were distributed at 250-m intervals with 50 stations in each of the 4 land units. Each station was sampled for 5 consecutive nights each season. All wildlife tracks that occurred were recorded the following day. Data are reported as relative frequency of occurrence.

RESULTS

Breeding-Bird Studies

The average ($\pm$ SD) 15-minute sampling station produced 17.6 $\pm$ 6.6 birds when recorded by observer, 14.3 $\pm$ 3.4 when recorded by stereo tape and 10.8 $\pm$ 3.7 when recorded by monaural tape. Two bird species were recorded that were not previously known to nest as far south in Mississippi. A Louisiana Waterthrush was found at the Highway 67 bridge over Saucier Creek and a Swainson's Warbler was found during July in a swampy portion of area IV (Airey Allotment). Nests were not found but the presence of singing males suggested that the birds were probably breeding in the area. Eastern Wood Pewees and Kentucky Warblers, thought to be rare in the area, were common (Table 1). There were no significant differences among the 4 sampling areas in July.

Small Mammal Studies

Cotton mice accounted for most of the small mammals captured (Table 2). Other mammals captured during the study were southeastern shrew, short-tailed shrew, least shrew and cotton rat. However, with more intensive sampling Wolfe and Lohoefner (1983) also captured golden mice (*Ochotomys nuttalli*), harvest mice (*Reithrodontomys humulis*), wood rats (*Neotoma floridana*), rice rats (*Oryzomys palustris*), pine voles (*Microtus pinetorum*) and house mice (*Mus musculus*). Data for the original survey were not sufficient for evaluation of relative abundance of most species among the 4 areas. However, species composition and abundance of cotton mice was similar among the 4 study units. With the additional work, Wolfe and Lohoefner (1983) failed to find significant differences among the 4 units in small mammal abundance or species richness.

Table 2. Number of small mammals trapped on DeSoto National Forest during a 18-day period, May 1979.

	Area			
Species	I	II	III	IV
Southeastern shrew (*Sorex Longirostris*)	1	1	2	0
Short-tailed shrew (*Blarina brevicauda*)	0	6	3	1
Least shrew (*Cryptotis parva*)	0	0	2	1
Cotton mouse (*Peromyscus gossypinus*)	18	18	20	21
Cotton rat (*Sigmodon hispidus*)	0	0	1	0

Medium-Sized Mammal Studies

During July 1979 and January 1980, tracks from canids, skunks, armadillos, bobcats, deer, rabbits, squirrels, racoons, opossums and domestic cats were found in the scent-post stations (Table 3). Relative abundance of tracks from different species was similar among the 4 study units. Domestic cat and opossum tracks were not detected in July, and tracks from canids were significantly more abundant in January. Tracks from other species were more abundant in January than in July but differences were not significant. We presume that the higher number of dog tracks found in January was from use and loss of dogs by hunters.

Table 3. Relative ($\bar{X} \pm$ SD) frequency of tracks in scent-post stations on the DeSoto National Forest.

Species	July 1979 (%)	January 1980 (%)
Canids (*Canis* spp.)	3.8 ± 2.4	32.3 ± 13.2
Skunks (*Mephitus mephitus*)	1.1 ± 0.9	1.6 ± 1.2
Armadillos (*Dasypus novemcinctus*)	6.4 ± 4.0	9.1 ± 2.1
Bobcats (*Felis rufus*)	2.3 ± 1.2	0.6 ± 0.7
Deer (*Odocoileus virginianus*)	3.4 ± 2.0	4.1 ± 1.5
Rabbits (*Sylvilagus* spp.)	2.3 ± 1.3	4.0 ± 2.2
Squirrels (*Sciurus* spp.)	1.7 ± 0.9	6.0 ± 3.3
Racoons (*Procyon lotor*)	1.1 ± 0.7	1.6 ± 1.3
Opossum (*Didephis marsupialis*)	- - -	1.6 ± 0.9
Domestic cat (*Felis domesticus*)	- - -	0.4 ± 0.6

CONCLUSIONS

Data from the inventory of birds and mammals on the DeSoto National Forest suggest that there are no significant differences in bird and mammal communities among the 4 pastures. Future sampling to detect differences due to experimental treatments would probably be best for birds and mammals if performed in summer. However, small mammal sampling should be done in early summer (May) and with greater intensity than was done in the present study. However, winter sampling would also be adequate for detecting differences but less likely to be well-coordinated if graduate research associates are used via university grants because of their usual coursework assignments.

LITERATURE CITED

Shiflet, T. N. 1980. What is the resource? Pages 17-28 *In* R. Child and E. K. Byington (eds.). Proc. Southern Forest Range and Pasture Symposium. New Orleans, Louisiana, March 13-14, 1980.

Wolfe, J. L., and R. Lohoefner. 1983. The small mammal fauna of a longleaf-slash pine forest in Southern Mississippi. J. Miss. Acad. Sci. 28:37-47.

The Small Mammal Fauna of a Longleaf-Slash Pine Forest in Southern Mississippi

James L. Wolfe and Ren Lohoefener

Abstract.--Four management units comprising over 51 square km (20 square mi) in the southern part of DeSoto National Forest, Mississippi, were sampled for small mammals over a four-year period. Trap lines, consisting of 25 pitfalls and 25 traps, were used for 18 days per session. Five sessions were conducted over the period, accounting for a total of 28,800 trap-station days. Three sessions (10,800 trap-station days) were nonspecific with relation to habitat. Two sessions (18,000 trap-station nights) sampled 5 habitat (regeneration areas, seedling and sapling areas, poletimber, sawtimber and bayheads) equally.

Bayheads yielded the greatest numbers of small mammals; regeneration areas produced the fewest. The pine forest types were similar, but poletimber produced slightly more small mammals than the others. Year to year fluctuation in total captures was significant. A geobotanical ranking scale was found useful in characterizing habitat preferences of individual species.

The cotton mouse (*Peromyscus gossypinus*) accounted for 78% of the small mammal sample. Other species taken, in decreasing order of abundance, were *Cryptotis parva*, *Sigmodon hispidus*, *Sorex longirostris*, *Blarina carolinensis*, *Ochrotomys nuttalli*, *Reithrodontomys humulis*, *Neotoma floridana*, *Oryzomys palustris*, *Microtus pinetorum* and *Mus musculus*.

INTRODUCTION

Much of the lower Gulf Coastal Plain is composed of the longleaf (*Pinus palustris*)-slash (*P. elliottii*) pine forest type which extends from Texas to Florida. Its area is estimated at about seven million hectares (Shiflet 1980). It is a major forest community of the southeast, important in commercial timber production and as a unique biological community. In Mississippi, this forest association is predominant in the Pine Hills and Lower Coastal Plain physiographical provinces (Lowe 1921; Cross et al. 1974; Lohoefener and Altig 1983).

Hamilton and Cook (1940) stated "...small mammals, long considered only as unfavorable species, are an unrecognized asset in forest management." This statement referred to their value as insect predators, their position in the food web, and to the role of their burrows in aeration and hydration of the soil. More recently, their importance as the critical agents of dispersal for spores of hypogeous, mycorrhizal forest fungi has been documented (Maser et al. 1978). Given the symbiotic relationship between mycorrhizal fungi and higher plants (Marks and Kozlowski 1973; Sanders et al. 1975) small mammals undoubtedly contribute to forest productivity and are of considerable economic value.

In addition to their aesthetic and indirect economic value, small mammals can be useful indicators of changes in ecosystem structure. Several characteristics of this faunal element make it well suited for environmental analysis. Habitat orientation and locomotory adaptations include semiaquatic, fossorial, arboreal and terrestrial. Insectivores, carnivores, omnivores and several classes of herbivores are represented. Thus, certain components of this fauna are sensitive to

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almost any type of habitat alteration. An additional consideration is that small mammals are much less vagile than birds and larger mammals, and are thus more representative to specific habitat type. Small mammals have been shown to constitute over 90% of the diet of some raptorial birds (Craighead and Craighead 1969; Jemison and Chabreck 1962). Mammalian carnivores often prey heavily on small mammals (Hamilton and Whitaker 1979). There are approximately a dozen species of small mammals (shrews, mice, and rats) which would be expected to exist in DeSoto National Forest (Wolfe 1971; Kennedy et al. 1974; Hall 1981). Our study contributes to a characterization of this assemblage.

METHODS

The study area, situated in northern Harrison and southern Stone counties, Mississippi is shown in fig. 1. It is within the boundaries of DeSoto National Forest. Topographically it consists of gently rolling pinelands dissected by small streams (some intermittent) bordered by narrow zones of hardwoods. The understory of the pine forest is dominated by bluestem grasses (*Andropogon* spp.) and wiregrass (*Aristida* spp.). Dominant shrubs include yaupon (*Ilex vomitoria*) in upland areas and gallberry (*Ilex glabra*) in lower, less well drained areas (Stewart 1981). Understory throughout the study area is relatively sparse, as control burning is routinely practiced at three to five year intervals.

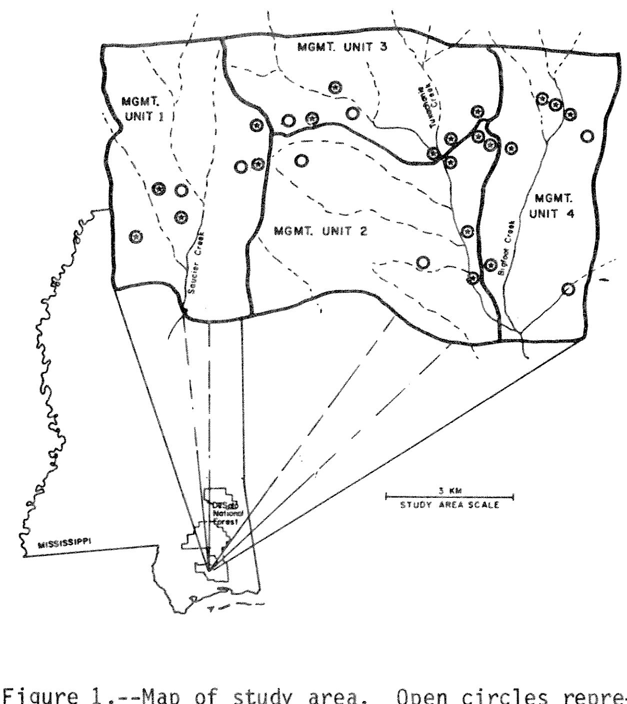

Figure 1.--Map of study area. Open circles represent sampling sites during 1979-80; circles with stars sampling sites during 1981-82.

The mammal sampling was divided into two phases. In the early phase (1979-80) two traplines were used in each of four forest range management units which ranged from about 1100 to 1700 ha in area. Traplines were superimposed on Stewart's (1981) randomly established vegetation sampling transects. Although situated predominantly in mature pine forests, traplines frequently passed through more than one major plant association and were designated as nonhabitat-specific. These lines were trapped in May, 1979, December-January 1980 and May 1980. During this phase of study geobotanical data were recorded for each trapping station. These data were analyzed in relation to mammal captures. Geobotanical analysis is discussed in more detail in the results sections.

During the second phase of sampling (1981-82) twenty traplines were used, five in each of the four management units. Within each unit, five habitat types were sampled. This habitat-specific sampling regime provided data on five habitats with four replicates of each. These lines were sampled in May 1981 and May 1982.

Specific habitats sampled during 1981-82 included clearcuts (regeneration areas), seedlings and saplings, poletimber, sawtimber, and bayheads. The first four refer to pine and represent timber stand classifications used by the U. S. Forest Service. Bayheads are areas of mesic-hydric hardwoods along small watercourses where sweetbay (*Magnolia virginiana*) is often dominant. Stewart (1981) presents a more detailed (botanical and physical) description of these classifications.

Traplines consisted of 25 stations with a 20m interval between stations. During 1979-80, each station included a pitfall trap (sunken one-gallon tin can) and a large Sherman live trap. During 1981-82, Museum Special snap traps were alternated with live traps. Traps were baited with a mixture of 80 percent oat flakes, 10 percent peanut butter, and 10 percent sardines in soybean oil. Sampling sessions consisted of 18 consecutive days with all lines run concurrently.

RESULTS

Seven hundred sixty-six small mammals representing 11 species were captured. Total sampling effort was 28,800 trap-station days. Species collected, in decreasing order of abundance were: cotton mouse (*Peromyscus gossypinus*), least shrew (*Cryptotis parva*), cotton rat (*Sigmodon hispidus*), southeastern shrew (*Sorex longirostris*), short tailed shrew (*Blarina carolinensis*), golden mouse (*Ochrotomys nuttalli*), harvest mouse (*Reithrodontomys humulis*), wood rat (*Neotoma floridana*), rice rat (*Oryzomys palustris*), pine vole (*Microtus pinetorum*), and house mouse (*Mus musculus*). The relative abundance of small mammals based on our total sample is shown in Table 1. Juvenile opossums (*Didelphis virginiana*) and cottontail rabbits (*Sylvilagus floridanus*) were trapped occasionally but are not included in our analyses.

Table 1.--Numbers of mammals captured in DeSoto National Forest. The Nonspecific column is based on three sampling sessions in 1979-80 which were not segregated by habitat. Specific habitats were sampled in 1981 and 1982

Species	Totals	Nonspecific	Regeneration	Saplings	Poletimber	Sawtimber	Bayheads
Peromyscus gossypinus	594	376	16	26	64	42	70
Cryptotis parva	51	11	10	7	8	12	3
Sigmodon hispidus	30	9	6	8	2	4	1
Sorex longirostris	25	8	0	2	6	1	8
Blarina carolinensis	22	13	0	4	1	1	3
Ochrotomys nuttalli	12	16	0	0	0	0	4
Reithrodontomys humulis	20	4	1	4	2	1	0
Neotoma floridana	5	4	0	0	0	0	1
Oryzomys palustris	4	4	0	0	0	0	0
Microtus pinetorum	2	2	0	0	0	0	0
Mus musculus	1	0	1	0	0	0	0
TOTAL	766	447	34	51	83	61	90

Table 2 presents data on the total number of animals and species (species richness) captured in the late spring (May) of four consecutive years. As can be seen, year to year fluctuations in abundance are significant ($X^2 = 8.08$, $P < .05$). The most productive year produced 3.9 times as many animals per effort as the least productive year. Compared to an average abundance of 11.8 percent, annual fluctuations ranged from 3.4 percent to 61.8 percent, with a mean of 32.5 percent.

Sampling effort in all management units was equal and simultaneous. Thus total captures over the four year period and species richness can be compared. This provided a measurement (Table 3) of uniformity of distribution over a large (5,619 ha, about 51 sq km) geographic area of similar habitat.

While total captures appeared lower in unit I, a Chi-square test did not detect a significant overall difference among units ($X^2 = 6.64$, $.05 < P < .10$). However, units II, III, and IV were very close (table 3). Thus, most of the Chi-square value was derived from the low number of captures in unit I, suggesting a possible lower abundance of small mammals in that area. There was no significant difference in species richness among units ($X^2 = .75$, $P > .25$).

Although the difference between years in absolute numbers taken was significant, distribution through habitats was similar in 1981 and 1982 and years were combined in an analysis of habitat differences. There was a highly significant difference between habitats ($X^2 = 29.1$, $P < .001$) in numbers taken (table 4).

Table 2.--Fluctuations in number of animals and species collected in late spring of four consecutive years. The index is total captures/number of lines

Year	Species richness	Total captures	Traplines	Abundance index
1979	5	98	8	12.2
1980	9	153	8	19.1
1981	7	98	20	4.9
1982	7	221	20	11.1

Table 3.--Total captures and species richness by management unit

Item	Management unit I	II	III	IV
Species richness	7	10	8	7
Total captures	165	203	213	196

Table 4.--Numbers of small mammals captured by habitat type

Year	Regeneration	Saplings	Poletimber	Sawtimber	Bayheads
1981	14	12	27	19	26
1982	20	39	56	42	64
TOTAL	34	51	83	61	90

Table 5.--Habitat characteristics and rankings assigned

Characteristic	Rank
Soil Drainage	
Xeric	0
Mesic	2
Grass Abundance (expressed as % ground cover)	
0 - 25	1
26 - 50	2
51 - 75	3
76 - 100	4
Litter abundance (only dead plant material as % ground cover)	
0 - 25	1
26 - 50	2
51 - 75	3
76 - 100	4
Other vascular plants	
Absent	0
Present	1
Abundant	2
Dominant tree type	
Pines	-2
Hardwoods	2
Woody vegetation growth form	
Sapling pines only	-2
Mature pines only	-1
Pines and deciduous shrubs	0
Mature hardwoods only	1
Mature hardwoods and shrubs	2
Shrubs only	3

The sample of Peromyscus gossypinus was sufficient for a separate analysis of habitat preference. We assumed that no interaction between management units and habitats existed and a two-way ANOVA without replication was performed. A significant habitat effect on P. gossypinus captures was indicated ($F = 5.79$, $P < .01$). Differences among management units was not significant ($F = 1.27$, $P > .25$). This mouse was taken most frequently in mature forests, especially bayheads (table 1).

A series of botanical and physical parameters were analyzed in relation to small mammal abundance (table 5). The scale was designed to provide a xeric-mesic gradient. Rankings were based on a summation of measurements taken within a 2.5 m radius of each trapping station during the 1979-80 trapping sessions. Low geobotanical scores indicate dry, open, well-drained habitats. Higher scores indicate a progression toward forests with increasing understory and little accumulation.

Kendall's Tau Rank Correlation (Conover 1971) was used to assess the relationships between mammal captures and geobotanical class. Total captures of all species was independent of geobotanical habitat ranking ($K = .035$, test value = 1). This result would be expected if individual species were adapted to different zones along the gradient. In tests of individual species, only P. gossypinus captures were significantly correlated with geobotanical ranking ($K = .195$, test value = 3772, $P < .025$).

Table 6.--Results of interfaced Chi-square test for relationship of small mammal captures to habitat characteristics as indicated by geobotanical ranking

Mammal Species	Geobotanical Class[1/] 4	5	6	7	8	9	10	11	Overall
Peromyscus gossypinus	*-	ns	ns	***+	***+	ns	*-	***	***
Ochrotomys nuttalli	ns	ns	ns	ns+	ns+	ns	ns	ns	*
Reithrodontomys humulis	ns	ns	ns+	ns	ns	ns	ns	ns	ns
Sigmodon hispidus	ns	ns	ns	ns	ns+	ns	ns	ns	ns
Neotoma floridana	ns	ns	ns	ns	ns	ns+	ns	ns	ns
Oryzomys palustris	ns	ns	ns	ns	ns+	ns	ns+	ns	ns
Sorex longirostris	ns	ns	ns	ns	ns+	ns	ns	ns	ns
Blarina carolinensis	ns-	ns	ns	ns	**	ns	ns	ns	***
Cryptotis parva	ns	ns+	ns	ns+	ns	ns	ns	ns	**
Mus musculus	ns	ns	ns+	ns	ns	ns	ns	ns	ns
TOTAL									***

1/ ns = not significant, *= significant at .05 alpha, **= significant at .01 alpha, ***= significant at .001 alpha, += more than expected, -= less than expected

In an effort to establish the location of individual species on the geobotanical gradient, an interfaced Chi-square analysis (Conover 1971) was performed (table 6).

More P. gossypinus was captured at the middle and high (mesic/hydric) rankings than expected and less were captured at the low (xeric) ranking than expected. More O. nuttali, S. hispidus, N. floridana, O. palustris, and S. longirostris were captured at the middle rankings than were expected. B. carolinensis was most abundant at stations of middle ranking and less abundant than expected at stations of low ranking. C. parva was captured most often at the drier trapping stations. Overall, lowest densities and diversities seemed to occur at both ends of the scale--xeric and hydric.

DISCUSSION

The most common species in the forests we sampled was P. gossypinus, comprising 78 percent of all captures. The study area was within the geographic range of its sibling species, P. leucopus. Our sample was a homogenous population of P. gossypinus--like individuals. Studies on these two species have been numerous (Wolfe and Linzey 1977; Lohmeier 1981) and their evolutionary relationship is complex.

While P. gossypinus was most abundant in mesic to hydric habitats, it was also the most common species in relatively open pine forests. This species shows a strong preference for pine mast (Hatchell 1964) and in May was frequently found in areas that had burned the previous winter. Layne (1974) noted that this is a pioneering species in the reinvasion of burned pinelands.

Three shrews, C. parva, B. carolinensis, and S. longirostris comprised a significant (13%) portion of the fauna. Cryptotis occupied more open, xeric areas, while Sorex tended toward more mesic, forested habitats. Blarina was ubiquitous.

Cotton rats, S. hispidus, typically occupied areas of dense ground cover. In certain parts of their range they are numerous in pine forests with dense understory (Layne 1974). They were much less common in the areas we sampled than would be expected on the basis of available suitable habitat. Dramatic long-term population fluctuations have been reported for this species (Odum 1955; Cameron and Spencer 1981) but we would have expected sampling over four years to detect at least one period of high density.

Next in abundance were O. nuttalli and R. humulis. Ochrotomys preferred closed forests or heavy brush while Reithrodontomys was found in grassy ground cover such as occurs in regeneration areas and open forests.

Woodrats, N. floridana, were not common and occurred only in swamps and bayheads. The semi-aquatic rice rat, O. palustris, was equally rare. The pine mouse, M. pinetorum is essentially subterranean and difficult to capture. We took only two in the course of the study. The relative remoteness of our study areas accounts for the fact that no old world rats (Rattus) and only one house mouse (Mus) were taken.

The results of our sampling indicates that the small mammal fauna is relatively uniform over a large geographic area of predominantly longleaf-slash pine forest. This uniformity was somewhat surprising as the areas we sampled were different in burning history and grazing intensity.

Year to year fluctuations were pronounced and should be taken into account in any attempt to assess a small mammal population over a limited time frame. Seasonal differences undoubtedly occur, but as we had only one winter sample, seasonality could not be evaluated.

Bayheads were the best overall small mammal habitats and likely act as crucial refuges in times of timber harvest, site preparation, and burning. Regeneration areas provided to be the poorest small mammal habitat. This was unexpected as early successional areas often have high populations. Two factors may be involved. First, cotton rat populations were extremely low, and this species is the most common inhabitant of early successional areas. Secondly, ground cover on the regeneration areas we sampled developed at an atypically slow rate. Three of the four areas were sandy, dry, and relatively open. Grazing may have been a factor. The pine forests, from saplings to sawtimber were statistically similiar, although the poletimber areas seemed to have a disproportionately large number of captures.

Meaningful comparisons of abundance based on similar studies in southeastern pine forests are difficult because of differences in methodologies and because of the significance of year to year fluctuations. However, relative abundance of species should be less affected by these problems. Unfortunately, few published studies have provided quantitative data on small mammals in southeastern pine forests. This may be because pine forests are generally perceived as poor small mammal habitat (Golley et al. 1965). Shadowen (1963) found a loblolly (P. taeda)-shortleaf (P. echinata) pine forest in northern Louisiana to be dominated by O. nuttalli, with P. gossypinus about half as abundant. Blarina brevicauda (= carolinensis) was intermediate between the two. Reithrodontomys fulvescens and M. pinetorum were present but rare. Hatchell (1964) working in the same area and habitat found Blarina equal to O. nuttalli in numbers and about two-thirds as many P. gossypinus. Also R. fulvescens was somewhat more common than in the Shadowen (1963) study. Atkeson and Johnson (1979) found S. hispidus to be the most common mammal in young loblolly pine plantations in Georgia. Second in abundance was P. leucopus. M. musculus, R. humulis, and O. nuttalli were also taken. Layne (1974) found S. hispidus, C. parva, P. gossypinus, R. humulis, Rattus rattus, and O. palustris, in order of abundance, in a Florida pine flatwoods. Sigmodon comprised 77 percent of all captures.

LITERATURE CITED

Atkeson, T. D.; Johnson, A. S. 1979. Succession of small mammals on pine plantations in the Georgia piedmont. American Midland Naturalist 101: 385-392.

Cameron, G. N.; Spencer, S. R. 1981. Sigmodon hispidus. Mammalian Species 158: 1-9.

Conover, W. J. 1971. Practical nonparametric statistics. New York: Wiley.

Craighead, J. J.; Craighead, F. C., Jr. 1969. Hawks, owls, and wildlife. New York: Dover. (Originally published in 1956 by Wildlife Management Institute).

Cross, R. D.; Wale, R. W. eds. 1974. Atlas of Mississippi. Jackson, MS: University Press of Mississippi.

Golley, F. B.; Gentry, J. R.; Caldwell, L. D. [and others]. 1965. Number and vareity of small mammals on the AEC Savannah river plant. Journal of Mammalogy 46: 1-18.

Hall, E. R. 1981. The mammals of North America, Vols. I and II. New York: Wiley Interscience.

Hamilton, W. J., Jr.; Cook, D. B. 1940. Small mammals and the forest. Journal of Forestry 38: 468-473.

Hamilton, W. J., Jr.; Whitaker, J. O., Jr.; 1979. Mammals of the Eastern United States. 2nd ed. Ithaca, New York: Cornell University Press.

Hatchell, G. E. 1964. Small mammal species and populations in the loblolly-shortleaf pine forest type of Louisiana. Res. Pap. SO-10. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. p. 1-12.

Jemison, E. S.; Chabreck, R. H. 1962. Winter barn owl foods in a Louisiana coastal marsh. Wilson Bulletin 74: 95-96.

Kennedy, M. L.; Randolph, K. N.; Best, T. L. 1974. A review of Mississippi mammals. Nat. Sci. Res. Instute, Eastern New Mexico State University, Studies in Natural Science 2: 1-36.

Layne, J. N. 1974. Ecology of small mammals in a flatwoods habitat in north-central Florida, with emphasis on the cotton rat (Sigmodon hispidus). American Museum of Novitates 2544: 1-48.

Lohoefener, R.; Altig, R. 1983. Mississippi herpetology. Bulletin. Mississippi State University Research Center 1: 1-66.

Lohmeir, L. M. 1981. Behavioral comparison between sympatric and allopatric Peromyscus leucopus and Peromyscus gossypinus. Mississippi State, MS: Mississippi State University. Ph. D. dissertation.

Lowe, E. N. 1921. Topographic and floristic regions of Mississippi. Mississippi State Geological Survey Bulletin 17: 29-57.

Marks, G. C.; Kozlowski, T. T. 1973. Ectomycorrhizae: their ecology and physiology. New York: Academic Press.

Maser, C.; Trappe, J. H.; Nussbaum, R. A. 1978. Fungal-small mammal interrelationships with emphasis on Oregon coniferous forests. Ecology 59: 799-809.

Odum, E. P. 1955. An eleven year history of a Sigmodon population. Journal of Mammalogy 36: 368-378.

Sanders, F. B., Mosse, B.; Tinker, P. B. 1975. Endomycorrhizae. London: Academic Press.

Shadowen, H. E. 1963. A live-trap study of small mammals in Louisiana. J. Mammalogy 44: 103-108.

Shiflet, T. N. 1980. What is the resource? In: Child, R.; Byington, E. K. eds. Southern forest range and pasture resources: Proceedings of a symposium; 1980, March 13-14. New Orleans, LA. Morrilton, AR: Winrock International. p. 17-18.

Stewart, A. W., III. 1981. Vegetative inventory and white-tailed deer forage on the DeSoto National Forest Mississippi. Mississippi State, MS: Mississippi State University. M. S. Thesis.

Wolfe, J. L. 1971. Mississippi land mammals. Jackson, MS: Mississippi Museum of Natural Sciences.

Wolfe, J. L.; Linzey, A. V. 1977. Peromyscus gossypinus. Mammalian Species 70: 1-5.

Fish Diversity and Abundance in Streams of the

DeSoto National Forest in Mississippi

Henry A. Pearson, James L. Wolfe, and Renne R. Lohoefenner

Abstract.--Twenty-six species of fish representing 11 families were collected and identified during a 1981 survey of four Southern Evaluation Project units on the DeSoto National Forest.

INTRODUCTION

In the Western United States, improper grazing practices have been shown to alter the character of natural water; this can easily lead to altered fish populations (Platts 1978). It has been hypothesized that land management practices such as grazing or timber harvesting can alter fish populations by: (1) increasing sedimentation, (2) altering channel characteristics, (3) increasing the level of solar radiation, (4) altering the amount of organic debris in the water, (5) modifying the substrate, and (6) changing the amount of terrestrial and aquatic invertebrate biomass in the water.

In October, 1981, a survey was performed in the four Southern Evaluation Project units of the Airey Allotment, Biloxi Ranger District, DeSoto National Forest, Mississippi. The objective of the survey was to document species of fish in the natural drainages and obtain an estimate of their abundance. This information can serve as a base for future evaluations of the impact of various land management practices.

STUDY AREA

Fish collecting sites were located on Saucier, Wolf, Bigfoot, Tuxachanie, Bridge, and several unnamed streams traversing four management units of the DeSoto National Forest (Wolfe and Lohoefener 1983). Stream depth was usually less than 3 ft, with widths varying from 10 to 50 ft; sampled stream length varied from 150 to 350 ft. Legal descriptions of sample sites, road numbers, and stream names are listed in table 1. Sufficient water was not found in the interiors of management units 1 and 3 (fig. 1). However, water was present just off these units along FS 401 and FS 402; fish collected at those sites (1-1, 1-2, 1-4, 3-2, 3-3, and 3-4) were probably representative of fish that would have been in the interiors of units 1 and 3 during wetter years or seasons.

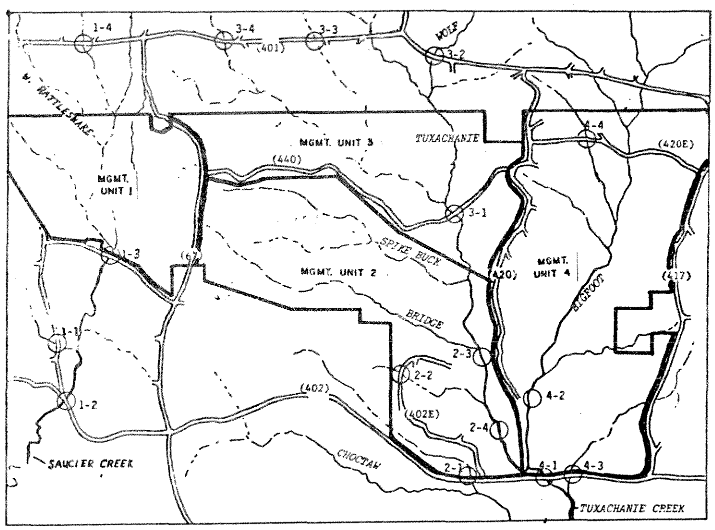

Figure 1.--Fish collecting sites (circles), access roads (in parentheses), and named streams in DeSoto National Forest, Mississippi.

Water and bottom substrates were characterized on each site (table 2). The streams at collection sites 1-2, 1-4, 2-4, 4-1, and 4-2 were clear and flowing (lotic), with sand or gravel substrates. Sites 2-2, 1-1, 1-4, 3-3, and 4-4 were characterized by clear or stained (colored) water that most likely occurred intermittently during dry seasons. Site 3-1 was similar to these five but had firmer channel substrates and water was found here throughout the year. Sites 1-3, 2-3, and 3-4 were typified by still (lentic) shallow water over a soft substrate with some deep holes present. Sites 2-1 and 4-3 had intermittent bodies of deeper water over a soft substrate.

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Table 1--Fish sample locations, DeSoto National Forest, Stone and Harrison Counties, Mississippi

Site	Location (Intersection)
1-1	Unnumbered road and unnamed creek in T.4S, R.11W, Sec. 34.
1-2	Road 402 and Saucier Creek in T.5S, R.11W, Sec. 3.
1-3	Unnumbered road and Saucier Creek in T.5S, R.11W, Sec. 27.
1-4	Road 401 and unnamed creek in T.4S, R.11W, center Sec. 15.
2-1	Road 402 and unnamed creek in T.5S, R.10W, Sec. 5.
2-2	Road 402E and unnamed creek in T.4S, R.10W, jct. Secs. 31 and 32.
2-3	Bigfoot Horse Trail and Bridge Creek in T.4S, R.10W, Sec. 32.
2-4	Natural waterfall on the Tuxachanie Creek about 165 ft north of the confluence of the Bigfoot Creek in T.5S, R.10W, Sec. 4.
3-1	Road 440 and Tuxachanie Creek in T.4S, R.10W, Sec. 29.
3-2	Road 401 and Wolf Creek in T.4S, R.10W, Sec. 17.
3-3	Road 401 and Tuxachanie Creek in T.4S, R.10W, Sec. 18.
3-4	Road 401 and unnamed creek in T.4S, R.11W, Sec. 13.
4-1	Road 402 and Tuxachanie Creek in T.5S, R.10W, Sec. 4.
4-2	Bigfoot Creek about 115 ft north of its confluence with Tuxachanie Creek in T.5S, R.10W, Sec. 4.
4-3	Road 402 and in unnamed creek in T.5S, R.10W, jct. Secs. 3 and 4.
4-4	Road 420E and Bigfoot Creek in T.4S, R10W, Sec. 22.

Table 2.--Water and substrata characteristics of streams sampled

	Water						Bottom strata				
	Depth		Shallow	Deep				Aquatic		Debris	
Site	Min.	Max.	(<1.0 ft)	(>1.0 ft)	Type	Quality	Streambed	plants	Roots	Fine	Large
	----Feet----		------Percent-------								
1-1	1.0	2.5	60	40	lentic	stained	sand	x	x	x	
1-2	0.3	2.5	75	25	lotic	clear	sand/gravel			x	x
1-3	0.2	3.3	20	80	lentic	stained	clay	x	x	x	
1-4	0.8	4.9	30	70	lotic	clear	sand/gravel	x	x	x	
2-1	0.3	2.5	10	90	lentic	clear	clay			x	x
2-2	0.7	2.0	05	95	lentic	clear	clay	x	x	x	
2-3	0.8	6.5	10	90	lentic	turbid	clay		x	x	
2-4	0.2	3.3	65	35	lotic	clear	sand/clay	x	x	x	
3-1	0.1	4.9	40	60	lotic	clear	gravel/clay		x	x	
3-2	0.7	6.5	30	70	lotic	stained	clay	x	x	x	
3-3	0.3	3.3	10	90	lentic	turbid	clay	x	x	x	
3-4	0.7	4.9	10	90	lentic	turbid	clay	x	x	x	
4-1	0.2	3.3	70	30	lotic	clear	sand/gravel		x	x	
4-2	0.2	2.5	90	10	lotic	clear	sandy			x	
4-3	1.0	3.3	05	95	lentic	turbid	clay	x	x	x	x
4-4	0.8	1.6	05	95	lentic	stained	gravel	x	x	x	

METHODS AND PROCEDURES

Fish sampling was accomplished during 2 days, October 5 and October 12, 1981. October 5 was a sunny and calm day; October 12 was a cloudy and calm day. Water temperature throughout the collection period was 24 ± 2 °C.

Fish were collected by electrofishing and dip netting. A backpack electroshocker with a gas powered generator was used (Model BP-1C, Coffelt Electronics Co., Inc., Englewood, CO) with direct current at about 150 watts (400 volts). All sites were electrofished. Usually the streams were so laden with snags and debris that a seine could not be used. In the two instances when seining was used (table 3), no species of fish were collected that had not been previously collected by electrofishing. Collected fish were field-fixed in 10-percent formalin; these fish were later washed and preserved in 40-percent isopropyl alcohol and stored at the Mississippi State University Research Center, National Space Technology Laboratory Station, Mississippi.

References used to name and identify fishes collected during this survey were: Blair and others (1968), Cook (1959), Douglas (1974), Eddy and Underhill (1969), Lee and others (1980), and Smith-Vaniz (1968).

RESULTS AND DISCUSSION

Twenty-six species of fish representing 11 families were collected (table 4). Most species had been reported earlier from Mississippi (Seehorn 1975); some had not been previously reported. Sorensen's index was used to obtain similarity values (Odum 1971). Management units 2 and 4 were the most similar in terms of fish species collected from drainage waters (table 5). This was as expected, because both are part of the Tuxachanie Creek watershed. Management units 1 and 2 were second in terms of fish similarity; Saucier Creek and Tuxachanie Creek, which traversed the two units, were of similar quality. Other management units had similar fish indexes. Comparison of fish diversity among sites showed sites 2-2 and 3-1 to have the greatest similarity (63 percent) (table 6). Ten sites had fish species' similarity indexes of 40 percent or greater, while 9 sites had no similarity.

COLLECTED FISH SPECIES

Representative specimens were collected from 11 fish families; some species were found on all four management units and a few were found on only one unit (table 4). The following sections list the species collected by family along with other pertinent information.

Family Petromyzontidae

One lamprey larva (ammocoete) was collected in management unit 2 that could not be identified to species; it was probably *Ichthyomyzon gagei*, the southern brook lamphrey. Four species of lampreys may be found in Mississippi waters: parasitic chestnut lamprey (*I. castaneus*), parasitic silver lamprey (*I. unicuspis*) (known only from the Mississippi River), and two nonparasitic forms--the southern brook lamprey and least brook lamprey (*Lampetra aepyptera*).

Family Anguillidae

Two specimens of American eel (*Anguilla rostrata*) were collected: one in management unit 1 and one in management unit 4. This eel is a catadromous species that moves into freshwater prior to an oceanic migration. Eels were often observed but rarely collected.

Table 3.--Stream sample methods

Site	Date sampled in 1981	Seining		Electrofishing			
						D.C.	
		Area	Time	Area	Time	Watts	Volts
		ft^2	minutes	ft^2	minutes		
1-1	5 Oct	--	--	118	25	150	400
1-2	12 Oct	--	--	4304	35	150	400
1-3	5 Oct	--	--	968	20	150	400
1-4	12 Oct	--	--	269	15	150	350
2-1	5 Oct	--	--	108	15	280	400
2-2	5 Oct	--	--	226	20	140	400
2-3	5 Oct	--	--	215	25	150	400
2-4	12 Oct	430	10	1130	40	125	400
3-1	12 Oct	--	--	269	15	150	350
3-2	12 Oct	--	--	377	20	150	400
3-3	12 Oct	--	--	646	25	175	350
3-4	12 Oct	--	--	194	15	150	400
4-1	5 Oct	1400	15	4412	45	150	400
4-2	12 Oct	--	--	1184	20	150	500
4-3	12 Oct	--	--	807	20	125	400
4-4	5 Oct	--	--	301	35	150	400

Table 4.--Numbers of fish collected at the 16 study sites in the 4 management units

Species	Study Site Number															
	1-1	1-2	1-3	1-4	2-1	2-2	2-3	2-4	3-1	3-2	3-3	3-4	4-1	4-2	4-3	4-4
Ichthyomyzon spp. Lamprey		1														
Anguilla rostrata American eel		1														1
Esox americanus Redfin pickerel				1		3			3	4	1			1	1	2
Notropis roseipinnis Cherryfin shiner		7	12					13					24	1		
N. signipinnis Flagfin shiner		1	1	4				3	1					3		
N. texanus Weed shiner								7					30	2		
Erimyzon sucetta Lake chubsucker	1	1	3	2		3	2					1		1	1	
Moxostoma poecilurum Blacktail redhorse								1					3			
Ictalurus natalis Yellow bullhead				1		1								1		
Noturus funebris Black madtom													1			
N. leptacanthus Speckled madtom								2					1	1		
Aphredoderus sayanus Pirate perch							1			1	1				1	
Fundulus notatus Blackstrip topminnow			3				3									1
F. notti Starhead topminnow	5				2	4		1	1	8		9	1		1	
F. olivaceous Blackspotted topminnow		28				2		7	2		1		18	8		2
Labidesthes sicculus Brook silverside			7					20			1		20			1
Elassoma zonatum Pygmy sunfish												1			1	
Lepomis gulosus Warmouth		1								1	2	1	2	1	5	
L. macrochirus Bluegill				1						1						
L. marginatus Dollar sunfish			1			1										
L. megalotis Longear sunfish		6					1	1	4			1	15		8	
L. punctatus Spotted sunfish	1					2		2	1		2					2
Lepomis sp. Juvenile sunfish	1	7				1		3		5		1		10		2
Micropterus punctulatus Spotted bass		1														
Etheostoma proeliare Cypress darter													1	1		
E. swaini Gulf darter		1						1								
Percina nigrofasciata Blackbanded darter		2														
TOTAL (417)	8	57	27	9	2	17	7	61	12	20	8	14	116	30	18	11

Table 5.--Comparison by Sorensen's index of similarity[1/] of fish species collected in the four management units

Management Unit	Management Unit 2	3	4
1	72	58	67
2		64	79
3			62

1/ Odum (1971).

Table 6.--Comparison of sites by Jaccard's index of similarity1/ of fish from the 16 collecting sites

Site	Site 1-2	1-3	1-4	2-1	2-2	2-3	2-4	3-1	3-2	3-3	3-4	4-1	4-2	4-3	4-4
1-1	07	13	17	33	43	14	33	50	13	13	29	08	09	29	11
1-2		13	06	00	19	14	33	20	13	13	29	16	40	20	19
1-3			10	00	08	25	20	09	20	09	20	06	25	09	18
1-4				00	38	14	00	25	25	11	11	00	18	25	10
2-1					14	00	08	17	17	00	17	10	00	17	00
2-2						10	27	63	30	30	30	13	33	30	40
2-3							07	25	25	11	25	08	08	43	10
2-4								14	13	13	13	47	31	13	27
3-1									20	33	33	23	25	50	30
3-2										33	33	07	25	50	18
3-3											09	23	25	25	30
3-4												23	25	50	08
4-1													27	23	13
4-2														25	23
4-3															08

1/ Mueller-Dombois and Ellenberg (1974).

Family Esocidae

Sixteen pickerel of two subspecies (*Esox americanus americanus* and *E.a. vermiculatus*) were collected.

Family Cyprinidae

The cherryfin shiner (*Notropis roseipinnis*) is common in small Coastal Plain streams that flow over a sand or gravel substrate. Fifty-seven cherryfin shiners were collected in three of the four management units. The flagfin shiner (*N. signipinnis*) prefers larger streams and is more common in stained water. Thirteen flagfin shiners were collected in all four management units. The weed shiner (*N. texanus*) was found in larger streams with sandy substrates; 39 were collected from 2 range units.

Family Catostomidae

Of the 15 *Erimyzon* spp. adults collected, all were lake chubsuckers (*E. sucetta*). They were found in all range units. Although many juvenile *Erimyzon* spp. were collected, some may have been sharpfin chubsuckers (*E. tenuis*). However, most specimens were taken in still (lentic) water--a characteristic of *E. sucetta*. Chubsuckers may be a good indicator of habitat quality because they are intolerant of stream siltation (Boschung and others 1983).

The blacktail redhorse (*Moxostoma poecilurum*) is most common in medium-sized streams with gravel bottoms. Only four redhorses were collected in two management units.

Family Ictaluridae

The yellow bullhead (*Ictalurus natalis*) is commonly found in small, vegetated bodies of clear water. Three bullheads were collected in three of the four management units. The black madtom (*Norturus funebris*) is not common but may be taken in small lotic streams that have sandy to gravelly bottoms. Only one black madtom was collected in management unit 4. The speckled madtom (*N.*

leptacanthus) tends to be more common than the black madtom in much the same habitat.

Family Aphredoderidae

The pirate perch (Aphredoderus sayanus) is common in slow or still waters with abundant aquatic plant cover. A total of four pirate perch were collected from three management units.

Family Cyprinodontidae

The blackstripe topminnow (Fundulus notatus) and blackspotted topminnow (F. olivaceous) are difficult to identify. The presence or absence of the predorsal stripe was found to be the most consistent character and seemed to separate the species in about the expected ratios (Brown 1956). Fundulus notatus and F. olivaceous both prefer lotic streams, but the latter tends to be more common in the clearer, faster flowing streams that have a hard substrate (Boschung et al. 1983). Seven blackstripe topminnows were collected from 3 management units while 68 blackspotted topminnow were collected from all 4 units.

The starhead topminnow (F. notti) is a common topminnow in still to slow-moving streams and can be found with a variety of substrates. Thirty-two starheads were collected from all four management units.

Family Atherinidae

The brook silverside (Labidesthes sicculus) is an abundant surface fish of clear, warm, slow-flowing waters. Forty-nine were collected in the 4 management units.

Family Centrarchidae

The banded pygmy sunfish (Elassoma zonatum) prefers clear, still water that is heavily vegetated. We collected only two. The warmouth (Lepomis gulosus) is common in most waters but prefers a lentic water with a soft bottom and vegetation. Thirteen were collected. The bluegill (L. macrochirus) is ubiquitous but prefers clear lentic water with vegetation; only two were collected. The dollar sunfish (L. marginatus) is much less common than L. gulosus or L. macrochirus; it prefers swamps and lentic waters. Only two were collected. The longear sunfish (L. megalotis) was the most common sunfish collected; 36 were collected in slow flowing streams. The spotted sunfish (L. punctatus) is usually fairly common in lentic to slow moving waters with dense cover, but only 10 were collected.

Juvenile sunfish that had not developed diagnostic characters were included in the category Lepomis spp. A total of 30 juveniles were collected.

The spotted bass (Micropterus punctulatus) prefers clear streams with deep pools. Only one spotted bass was collected.

Family Percidae

The cypress darter (Etheostoma proeliare) is most common in lowland streams with some backwater areas, detritus, and a soft substrate. Only two were collected. The gulf darter (E. swaini) is usually found in clear lotic streams with riffles and a gravelly or sandy substrate; two were collected. The blackbanded darter (Percina nigrofasciata) is most common in lotic, clear streams that have gravel bottoms and riffles; two were collected.

SUMMARY

The diversity of fish species found in streams at the selected sites in the four management units of the Southern Evaluation Project, DeSoto National Forest, Mississippi, were sampled during a 2-day time period. A total of 417 specimens were collected, representing 11 families, 16 genera, and 26 species of fish. Several species of darters (Percidae) that had been previously collected at these sites were not collected. There was no way to be sure that all species present were collected.

The minnows or shiners (Notropis spp.), chubsuckers (Erimyzon spp.), madtoms (Noturus spp.), both blackspotted topminnow (Fundulus olivaceous) and blackstripe topminnow (F. notatus), and darters (Etheostoma spp. and Percina spp.) are the most valuable indicators of habitat quality change. Particular attention should be given to these genera when conducting future surveys.

LITERATURE CITED

Blair, W. F.; Blair, A. P.; Brodkorb, P.; [and others]. 1968. Vertebrates of the United States. New York: McGraw-Hill Book Co. p. 22-165.

Boschung, H. T., Jr.; Williams, J. D.; Gotshall, D. K. [and others]. 1983. The Audubon Society field guide to North American fishes, whales, and dolphins. New York: Alfred A. Knopf, Inc. 850 p.

Brown, J. L. 1956. Identification and geographic variation of the cyprinodont fishes Fundulus olivaceous and Fundulus notatus. Tulane Studies Zoology and Botanical 7: 119-134.

Cook, F. A. 1959. Freshwater fishes in Mississippi. Jackson: Mississippi Game and Fish Commission. 239 p.

Douglas, N. H. 1974. Freshwater fishes of Louisiana. Baton Rouge, LA: Claitor's Publishing Division. 443 p.

Eddy, S.; Underhill, J. C. 1969. How to know the freshwater fishes. Dubuque, IA: Wm. C. Brown Co. Publ. 215 p.

Lee, D. S.; Gilbert, C. R.; Hocutt, C. H.; [and others], eds. 1980. Atlas of North American freshwater fishes. N.C. Biological Survey Publ. 1980-12. Raleigh: N.C. State Museum of Natural History. 854 p.

Mueller-Dombois, Dieter; Ellenberg, Heinz. 1974. Aims and methods of vegetation ecology. New York: John Wiley and Sons. 547 p.

Odum, E. P. 1971. Fundamentals of Ecology. 3rd ed. Philadelphia, PA: W. B. Saunders Company. 574 p.

Platts, W. S. 1978. Livestock interactions with fish and their environments: a symposium summary. Cal-Neva Wildl. Transactions 1978: 92-96.

Seehorn, M. E. 1976. Fishes of Southeastern National Forests. In: Rogers, W. A., ed. Proceedings, 29th annual Southeastern Association Game and Fish Commissioners conference; 1975 October 12-15; St. Louis, MO. Columbia, SC: Southeastern Association of Game and Fish Commissioners; p. 10-27.

Smith-Vaniz, W. F. 1968. Freshwater fishes of Alabama. Montgomery, AL: Paragon Press. 211 p.

Wolfe, J. L.; Lohoefener, R. 1983. The small mammal fauna of a longleaf-slash pine forest in Southern Mississippi. Journal of Mississippi Academy of Science 28(5): 37-47.

Soils and Vegetation of the Longleaf/Slash Pine Forest Type, Apalachicola National Forest, Florida

George W. Tanner

ABSTRACT.--A 12,800 ac study site within the longleaf/slash pine type, Apalachicola National Forest, was surveyed to characterize overstory and understory vegetation. Seven major forest types and 17 soil series were delineated. Longleaf pine forest type occurred on 31.0% of the area while planted slash pine occurred on 23.6% of the area. Planted slash pine stands were grouped into three age categories: 9-18 yr, 19-38 yr and over 40 yr old. Titi and cypress areas, considered nongrazeable forest types, occurred on 30.0% of the area. The remaining area was in natural slash pine and savanna. Rutledge and Surrency soils were entirely associated with titi and cypress drainages and comprised 31.1% of the study site. Otherwise, Bladen (21.9%), Dunbar (14.2%), Dothan (10.0%) and Leefield (9.3%) were the major soil series.

Most longleaf stands had been commercially thinned to about 50 to 60 ft^2/ac. In these stands, mean tree age was approximately 62 years old with mean tree height of 66 ft. Growth of planted slash pine tended to be best on the wetter, Bladen soil series than on moderately or well drained soils. Natural slash pine and savanna sites generally were sparsely wooded. Snag (2.4/ac) and cavity (1.6/ac) densities were greatest in longleaf pine stands on Albany soil.

Frequent prescribed burns have kept a hardwood midstory from developing. Gallberry, runner oaks, greenbriers, and saw-palmetto were the most common understory shrubs and produced approximately 200 to 300 lb/ac where they occurred. Herbaceous biomass reached maximum values (approximately 2,500 lb/ac) within natural slash and savanna sites. A large portion of this forage was comprised of pineland threeawn and beakrush. Biomass production on these sites tended to decrease following the establishment of planted slash pine stands on them. Longleaf pine sites, though lower in herbaceous biomass, usually had a much richer assemblage of forage species.

INTRODUCTION

The rapidly increasing human population in the United States and World is placing higher demands on food and fiber products. Pine forests in the southern portion of the United States are well known or utilized for their fiber producing potential but are lesser known or utilized for their red meat producing potential. Much of this forested region has an understory component that is amenable to grazing and browsing, but little of it is being utilized for red meat production. Therefore, on 25 September 1978, the Chief of the Forest Service approved the Range Evaluation Project, a project designed to determine the grazing potential within the major coniferous

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forest types in the south and to monitor the effects of livestock production on various edaphic, hydrologic, floral and faunal components of the forest ecosystems. Efforts of the study reported herein addressed the floral component. The purpose of the project was to inventory the understory and overstory vegetation on a 13,000 ac area of longleaf/slash pine forest within the Apalachicola National Forest (ANF). The work was conducted under Cooperative Agreement No. 19-306 between the U.S. Forest Service and the University of Florida.

OBJECTIVES

The overall goal of this study was to inventory the vegetation on the Apalachicola National Forest study site prior to the installation of four grazing treatments. To accomplish this goal the following objectives were formulated:

1) To delineate the major plant communities based on overstory, forest type and soil series, and
2) To quantitatively describe species composition and cover of overstory and understory components, age, height and dbh of trees, and current year's growth of browse and herbage.

STUDY AREA DESCRIPTION

Location

This study was conducted along the western boundary of the Apalachicola National Forest (ANF) in Liberty County, Florida (Figure 1). Specifically, permanent study plots were located in U.S. Forest Service compartments 26, 27, 28, 29, 67, 69 and 72. The compartments were located in Townships 3 and 4 South and Ranges 8 and 7 West and comprised approximately 12,800 ac. This area is approximately 20 mi south of Bristol, Florida along State Road 12.

Forest types and soil series had been mapped previously by the U.S. Forest Service (Fig. 2-6). Map codes for the forest type (denominator) and soil series (numerator) designations are given in Tables 1 and 2, respectively.

Climate

Total rainfall was quite variable during the 3-yr span of this study. In 1979, two hurricanes passed near Florida in the month of September which resulted in 18 in of rainfall being recorded in Blountstown, Florida with 72.7 in for the annual total. No other major rainfall event occurred during the study period. Total rainfall decreased in 1980 and 1981 with 51.2 and 48.4 in, respectively. Low rainfall in April and June 1981 augmented the droughty conditions on the study site.

Air temperatures in this region usually are mild in the winter to hot in the summer. Periodic freezing temperatures associated with cold fronts are common during the winter months. July and August usually are the hottest months with air temperatures occasionally reaching 100°F.

Table 1. Code for forest type on ANF study site, Liberty County, Florida.

	Forest Type	Denominator on map code
I.	High Pineland (A. longleaf B. slash)	
	a. Turkey Oak Phase	11 A,B
	b. Bluejack Oak Phase	12 A,B
	c. Mixed Oak Phase	13 A,B
II.	Pine-Palmetto Flatwoods	
	a. Longleaf Pine Phase	21
	b. Slash Pine Phase	22
III.	Savannahs	
	a. Verbisina Phase	31
	b. Pleea Phase	32
	c. Hypericum Phase	33
IV.	High Pineland Depression	
	a. Hardwood Phase	51
	b. Holly Phase	52
	c. Cypress-Black Gum Phase	53
	d. Black Gum Phase	54
V.	Titi Swamps	
	a. Titi Phase	61
	b. Pine Titi Phase	62
VI.	Bay Swamps	
	a. Sweet Bay Phase	71
	b. Mixed Bay Swamps Phase	72
VII.	Cypress Swamps	
	a. Cypress Domes	81
	b. Cypress Black-Gum Phase	82
	c. Cypress Stringers	83
VIII.	Southern Mixed Hardwood Forest	90
IX.	River Swamps	
	a. Hydric Hardwood Swamp	101
	b. Cypress Gum Swamps	102
X.	Loblolly Pine Forest	120
XI.	Longleaf Flat	130
XII.	Slash Pine Flat	140
XIII.	Pine Plantation	150

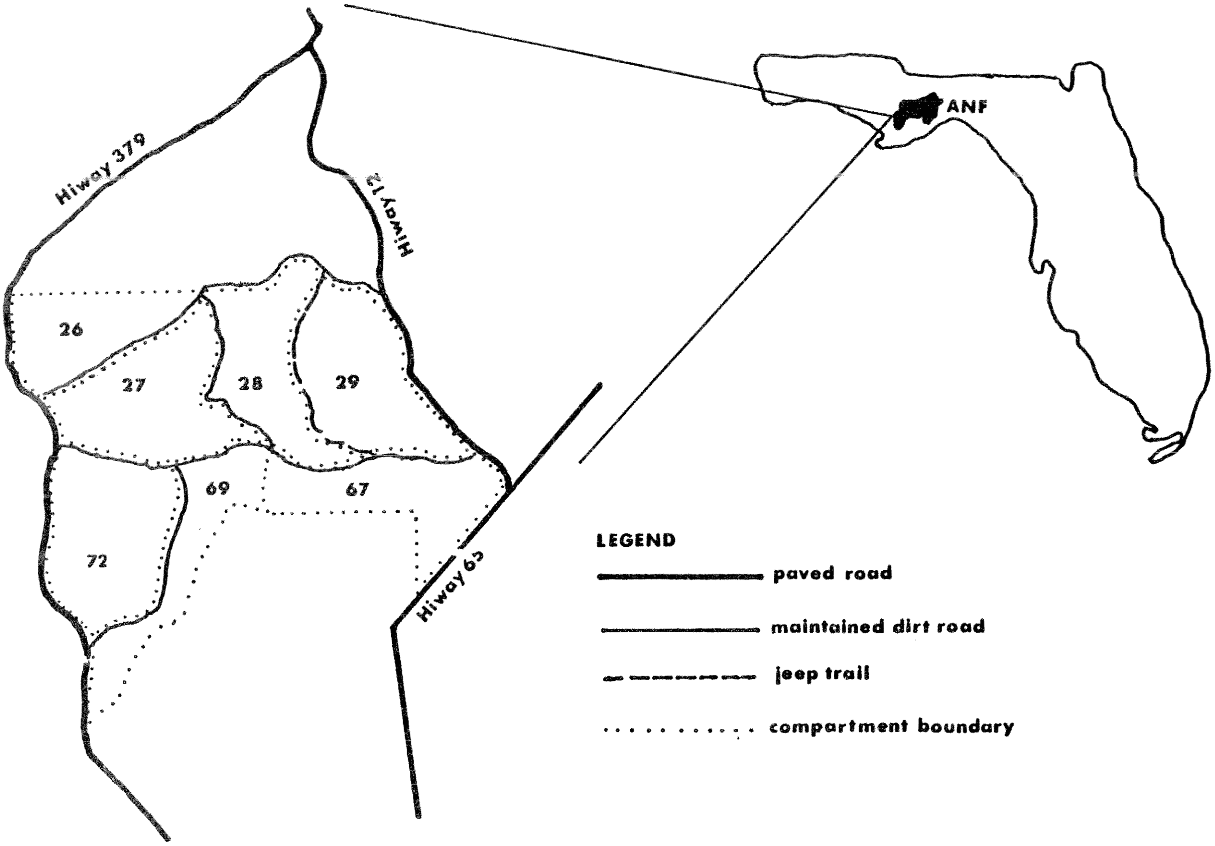

Figure 1. Location of the Apalachicola National Forest study site, Liberty County, Florida.

Geology and Soils

Geology of the ANF region was described in depth by Clewell (1971). The study site for this project and the entire ANF lies within the Gulf Coastal Lowlands land form. This land form has been divided into two physiographic units based on topography: the Apalachicola Coastal Lowlands and the Woodville Karst Plain. The study site was located in the former unit.

The bedrock of this unit is limestock and dates no later than to the early Miocene. This limestone reaches depths of approximately 200 feet near the Apalachicola River. Positioned above the bedrock, various Miocene clastics are found. Surface soils are derived from Pleistocene sands. Although the Apalachicola Coastal Lowlands are higher in elevation than the Woodville Karst Plain, they are more swampy due to a perched water table above the impenetrable bedrock.

Seventeen soil series were identified on the study area (Table 3). These soils typically have sandy loam or loamy sand surface horizons. Soils other than the well drained series have moderate amounts of clay material in the B horizons. Variation in drainage classifications ranged from very poorly drained to excessively drained. More detailed descriptions of these soil series are presented in the Appendix.

The two very poorly drained soil series, Rutledge and Surrency, comprised 30.1% of the entire study area (Table 3). These soils were restricted to drainages. Within the Compartment 28-29 pastures, these soils comprised 43.2% of the area.

Bladen soils (poorly drained) were the next two most dominant series, covering 21.9% of the area overall. This series occurred mostly in the Compartment 72 and 26-27 pastures, 39.5% and 47.2%, respectively. The "somewhat poorly drained" soils, mainly of the Leefield and Dunbar series, generally were uniformly distributed throughout the four pastures. "Well drained" soils were least prevalent in the Compartment 67-69 pasture, totaling only 6.5% of the area.

Forest Types

Forest type delineations were according to Clewell's (1971) descriptions. Seven major overstory forest types were located within the study area (Table 3). Clearcuts were not identifiable from the maps, however approximately 100 acres in Compartment pasture 28-29 and 200 acres in Compartment pasture 26-27 were clearcut immediately prior to this study.

Within the entire study area, natural longleaf pine (29.1%), planted slash pine (23.6%)

Table 2. Code for soil types on ANF study sites, Liberty County, Florida.

Soil Series	Numerator on map code	Drainage[1]
Rutledge Series	01	VPD
Surrency Series	02	VPD
Dorovan/Pamlico Muck	03	VPD
Osier	11	VPD
Coxville & Rains	13	PD
River Swamp	14	PD-SWP
Humaqueptic Psammaquents	21	PD
Plummer	22	PD
Bladen	23	PD
Chipley	31	SPD
Leon	32	PD
Talquin	33	SPD
Albany	34	SPD
Leefield	35	SPD
Dunbar	36	SPD
Sapelo	37	PD
Blanton	38	MWD
Ortega	40	WD
Foxworth	41	MWD
Kershaw	42	ED
Troup	43	WD
Fuquay	44	WD
Dothan	45	WD
Faceville	46	WD
Alpin	47	WD-ED

[1]VPD = very poorly drained, PD = poorly drained, SPD = somewhat poorly drained, MWD = moderately well drained, WD = well drained, ED = excessively drained.

and titi swamps (23.2%) were the most dominant forest types (Table 3). Not all forest types were equally distributed among the four pastures. The remaining areas of longleaf-oak stands were found only on well and excessively drained soils and existed only in Compartment pastures 28-29 and 67-69. Approximately 450 ac of this forest type had been clearcut and planted to slash pine in Compartment pasture 28-29. Longleaf stands occurred throughout the study area but were most predominant in Compartment pastures 28-29 (1,356 ac) and 67-69 (1,174 ac). Seventy-three percent of all natural slash pine acreage was located in Compartment pasture 26-27. Planted slash pine stands also occurred throughout the study area, however, this forest type was most predominant in Compartment pastures 26-27 (28.1%) and 72 (42.3%). The savanna community, though small in acreage, is unique to this area of Florida and the ANF. The majority of this community that remained on the study site was located in Compartment pasture 72.

Titi swamps occupied 42.8 and 31.9% of Compartment pastures 28-29 and 67-69, respectively. Cypress swamps, though usually small in total acreage, were associated with the drainage standards. Their linear and/or dendritic configuration may cause problems in grazing distribution.

Each natural forest type generally was found to be strongly associated with two or three soil series. Although longleaf stands occurred on 10 of the 17 soil series, the majority of this forest type occurred on Leefield and Dunbar soils. Longleaf-oak stands were restricted solely to the very dry, deep sands. Approximately 80% of natural slash stands and 97% of the savanna was on Bladen soils. The major portion of both titi and cypress swamps was on Surrency soils.

Slash pine plantations were found on 11 of the 17 soil series. However, the majority of planted slash pine acreage was on Dunbar (40%) and Bladen (37%) soils.

VEGETATION SAMPLING

Design and Intensity

Vegetation sampling was restricted to areas of natural pine or planted pine, clearcuts to be planted to pine and a savanna. Titi and cypress swamps, the other two major communities on the study site, were not sampled since they provided very little herbaceous forage and/or were quite impenetrable by man or beast. Therefore, it was felt that these two communities would receive limited use by livestock. Clearcuts were site prepared for planting during this study. Permanent plot markers were destroyed, therefore data from these plots are incomplete.

Within those communities being inventoried, eight soil types were sampled. These eight soils represented three general drainage classifications: poorly drained, somewhat poorly drained, and moderately to excessively well drained.

Sampling Frequency and Duration

Herbage and browse were sampled during winter (Jan-Feb 1980), spring (April-May 1980) and fall (Oct-Nov 1980 and August 1981). In spring and winter, only species composition and utilization of Herbage and Browse were measured; all vegetation measurements were recorded during the fall sampling periods.

Sampling Techniques, Measurements and Descriptions

Overstory Trees

Overstory trees (stems more than 1 in DBH) were sampled by a plotless technique around each sample point. Pines were measured for 1) basal area in ft^2/ac using a ten-factor prism, 2) DBH of prism-recorded trees with a DBH tape, 3) height of a representative dominant tree with a clinometer, and 4) tree age from increment boring of the nearest tree within the northwestern quadrant at each sample point in natural stands or from U.S. Forest Service records within plantations. Snags, defined as any dead tree more than 10 ft tall and 10 inches DBH, were counted within a 33 ft radius of each sample point.

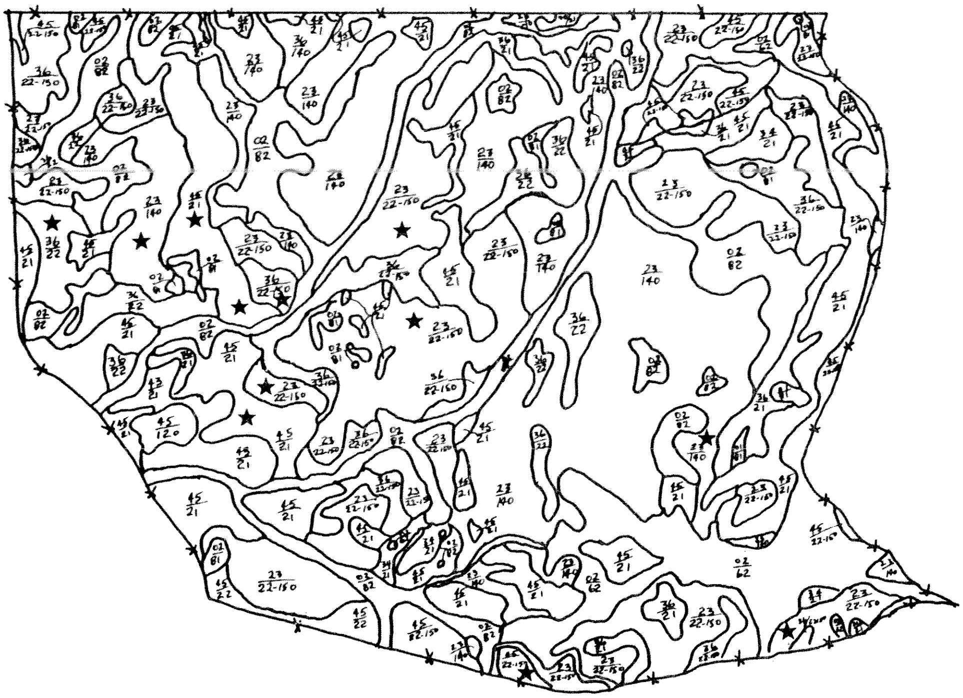

Figure 2. Forest type and soil series combinations (see Table 2 and 3 for codes) on Compartments 26 and 27, ANF study site, Liberty County, Florida. Stars indicate vegetative sample locations.

Figure 3. Forest type and soil series combinations (see Tables 2 and 3 for codes) on Compartments 28 and 29, ANF study site, Liberty County, Florida. Stars indicate vegetative sample locations.

Table 3. Overall total area (acres) and proportion (%) of overstory forest type - soil series combinations on the entire ANF study site, Liberty County, Florida.

Soil Series	Drainage[2] Class	Forest Type[1] LL-O	LL	NS	PS	Sav	Titi	Cypress	Total
		(Acres [Proportional])							
Rutlege	VPD						876 (6.8)	6 (T)	882 (6.9)
Surrency	VPD						2095 (16.4)	869 (6.8)	2964 (23.2)
Bladen	PD			1146 (9.0)	1123 (8.8)	529 (4.1)			2798 (21.9)
Plummer	PD			98 (0.8)	24 (0.2)	14 (0.1)			136 (1.1)
Sapelo	PD		21 (0.2)		21 (0.2)				42 (0.3)
Chipley	MWD				45 (0.4)				45 (0.4)
Talquin	PD		113 (0.9)						113 (0.9)
Albany	SPD		403 (3.1)		38 (0.3)				441 (3.4)
Leefield	SPD		1190 (9.3)						1190 (9.3)
Dunbar	SPD		463 (3.6)	141 (1.1)	1207 (9.4)				1811 (14.2)
Leon	SPD		13 (0.1)	19 (0.1)	63 (0.5)				95 (0.7)
Blanton	MWD	20 (0.2)	266 (2.1)		39 (0.3)				325 (2.5)
Foxworth	MWD	184 (1.4)			69 (0.5)				253 (2.0)
Dothan	WD		1156 (9.0)	24 (0.2)	103 (0.8)				1283 (10.0)
Troup	WD	33 (0.3)	83 (0.6)						116 (0.9)
Fuquay	WD		10 (0.1)						10 (0.1)
Kershaw	ED				294 (2.3)				294 (2.3)
Total		237 (1.9)	3718 (29.1)	1428 (11.1)	3026 (23.6)	543 (4.2)	2971 (23.2)	875 (6.8)	12,798

[1]LL-O = longleaf pine- oak, LL = longleaf pine, NS = natural slash pine, PS = planted slash pine, Sav = Savanna, Titi = Titi Swamp, Cypress = Cypress swamp.
[2]See Table 2.

Midstory Trees, Shrubs and Vines

Midstory trees, shrubs and vines (stems $\leq$ 1 in DBH and > 5 ft high) were measured within circular milacre plots (radius = 44.7 in) centered on each sample plot. Species within this category were measured for canopy cover (%) and height (ft) by species. Also, the number of measured plants of each species was recorded.

Browse

The current year's growth of trees, shrubs, and vines within 5 feet of the ground (browse) was measured on a 9.6 ft^2 circular plot randomly located in the immediate vicinity of each permanent sample point. The center of the 9.6 ft^2 plot was located 65.7 in from permanent plot centers. Foliar cover of each browse species was ocularly estimated. Species with less than 10% cover were recorded as present. Current year's growth of each browse species with greater than 10% canopy cover was collected (clipped) separately, oven dried, and weighed to determine production (lbs/ac) and percent botanical composition by weight. A three dimensional clip was used.

Herbage (grasses, grasslikes and forbs) were measured within 2, 2.7 ft^2 quadrats randomly located at each sample point. Total herbage weight (lb/ac) for each species rooted in the quadrat was determined by clipping and weighing in the field. A selected number of samples was returned to the lab, dried at 60°C for 48 hr and weighed for dry weight conversions. Foliar cover of species with greater than 10% cover was ocularly estimated. Other herbage species were listed as present. Also, areal cover of litter and bareground was ocularly estimated on each quadrat.

RESULTS

Overall Species Composition

Taxonomic nomenclature followed Radford, Ahles and Bell (1968) for forbs and woody plants. Hitchcock (1935) was used for grasses.

Fourteen tree species were encountered within the sample forest type soil series combinations of the entire ANF study site (Table 4). Longleaf pine stands had nine species encountered. Bladen soils had the least number of tree species while the drier soils had more species. Several oak species were common on the drier soils.

Shrub species were more diverse and common than trees. Thirty-one shrub species were recorded on the ANF study site (Table 4). Gallberry (Ilex glabra) was the most ubiquitous shrub species, occurring to some degree in all forest type - soil series combinations except PS9--Chipley. Bedding of Bladen soils in PS9 and PS19 stands appeared to be responsible for the increased occurrence of gallberry over NS sites. PS39 sites were not bedded and gallberry was not as common. Gallberry occurrence appeared to be diminishing on Dunbar soils planted to slash pine. This trend was not as evident on Dothan soils.

Figure 4. Forest type and soil series combinations (see Tables 2 and 3 for codes) on Compartment 72, ANF study site, Liberty County, Florida. Stars indicate vegetative sample locations.

Shrub occurrence generally was much less frequent on Balden soil than on the other, much drier soils. Shrub species most common on Bladen soils were St. John's-wort (Hypericum fasciculatum) and blackberry (Rubus spp.). On the drier soils, excluding the excessively drained Kershaw series, runner oaks, gallberry and dwarf huckleberry (Gaylussacia dumosa) were most common. Longleaf pine occurs naturally on these soils. Clearcutting, site preparing and planting these sites appeared to initially increase blackberry and ground blueberry occurrence but decrease gallberry and wax myrtle (Myrica cerifera) occurrence.

Only nine vine species were recorded on the ANF study site, five of which were Smilax species (Table 4). Smilax bona-nox was the most common vine.

Forty-two grass species were recorded within the entire ANF study site (Table 4). Pineland threeawn (Aristida stricta), commonly called wiregrass, was the most ubiquitous grass species occurring in all forest type - soil series combinations. Low panicums, a complex of several Dichanthelium species, also occurred in all study sites. Site preparation (chopping and bedding) did not have apparent deleterious effects on wiregrass abundance. Cabanis (Andropogon cabanisii) and broomsedge (A. virginicus) were the most common bluestems. Elliot bluestem (A. gyrans) was found mostly on drier soils. Big bluestem (A. gerardii), a very desirable grass, was measured only in longleaf pine stands. Other decreaser grass species encountered on the ANF study site were yellow (Sorghastrum nutans) and lopsided Indian grass (S. secundum), switchgrass (Panicum virgatum) and maidencane (P. hemitomon).

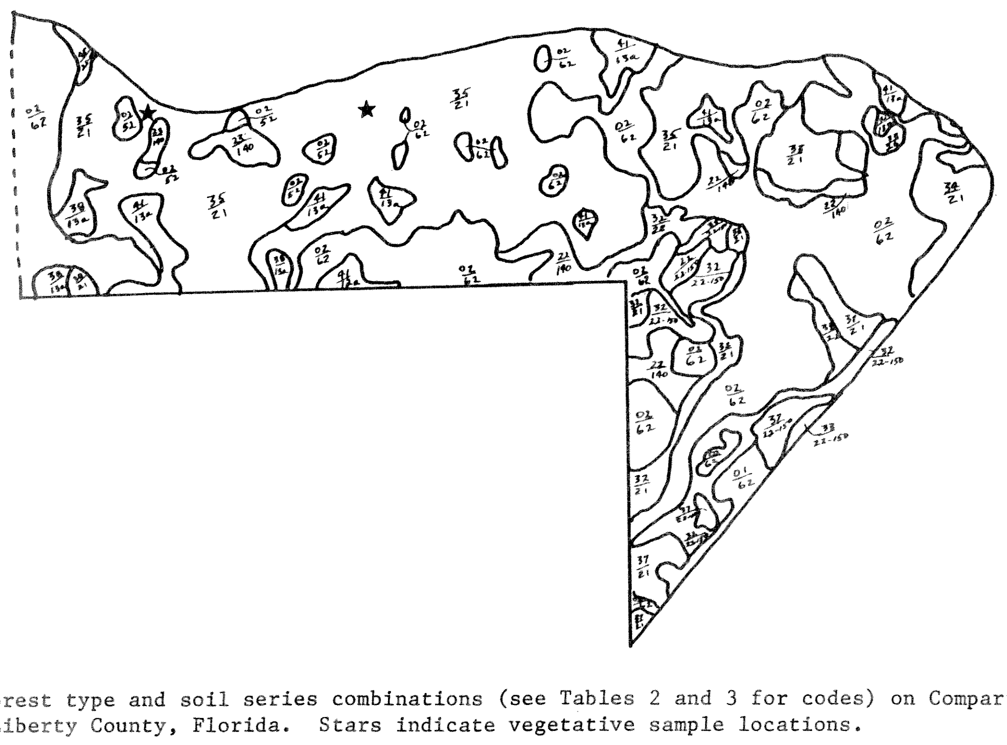

Figure 5. Forest type and soil series combinations (see Tables 2 and 3 for codes) on Compartment 67, ANF study site, Liberty County, Florida. Stars indicate vegetative sample locations.

Table 4. Number of species encountered within sampled forest type-soil series combinations within the entire ANF study site, Floria.

	Forest type-Soil series[1]																				
	LL						NS			PS9					PS19				PS39	SAV	CC	Overall
	AL	LE	DU	BT	DO	Total	BL	DU	Total	BL	CH	DU	KE	Total	BL	DU	DO	Total	BL	BL	DO	Total
Trees	2	4	2	2	7	9	1	0	1	1	3	3	5	7	4	3	2	8	4	1	2	14
Shrubs	13	12	8	12	24	26	13	5	14	17	7	16	14	28	15	15	13	19	11	5	11	31
Vines	4	7	4	3	8	8	2	0	2	1	3	1	6	6	4	5	2	7	1	0	1	9
Grasses	13	14	8	8	27	32	20	8	21	17	7	26	14	30	18	17	11	24	14	13	16	42
Grasslikes	3	4	4	3	4	5	7	4	9	4	0	8	4	9	5	5	3	6	3	3	3	11
Forbs	25	24	12	19	45	58	32	13	34	24	15	31	21	48	28	20	13	36	24	16	19	78
Legumes	7	10	4	7	10	11	0	0	0	1	4	3	7	8	6	8	5	8	2	0	6	12
Ferns	1	1	0	1	1	1	0	0	0	1	1	1	1	1	0	1	2	1	1	0	0	2
Other	3	1	1	2	3	3	2	1	2	3	2	3	3	3	3	3	2	3	3	3	2	3

Forest types:
LL = longleaf pine, NS = Natural slash pine, PS9 = Planted slash pine 9-80 yr old, PS19 = Planted slash pine 19-38 yr old, PS39 = Planted slash pine greater than 39 yr old, Sav = Savanna, CC = clearcut. Soil series: AL = Albany, BL = Bladen, BT = Blanton, CH = Chipley, DO = Dothan, DU = Dunbar, KE = Kershaw, LE = Leefield.

Cyperus, *Rynchospora* and *Scleria* species groups were the most common grasslikes encountered (Table 4). These species were seldom in flower therefore impossible to distinguish at the specific level. Grasslike species tended to be more common on the wetter Bladen soil series.

Forbs comprised the largest species group among the vegetation (Table 4). A total of 78 forb species or species groups were distinguished. Grasslike goldaster (*Pityopsis graminifolia*) was the most ubiquitous single species, occurring to some degree in all forest type - soil series combinations. The *Aster* and *Solidago* species groups also were recorded throughout the study area.

Native legume species were scattered throughout the study area but generally were not very common (Table 4). Pencil flower (*Stylosanthes biflora*) and *Tephrosia* spp. were two of the more common legume species. Bladen soils tended to have the fewest legumes present.

Only two fern species were recorded. Bracken fern (*Pteridium aquilinum*) was very abundant in the longleaf pine stands and in slash pine stands planted on the drier soils. Mushroom species were scattered throughout the ANF study site but were never very common.

Overstory Tree Parameters

For the entire ANF study site, mean tree age within sampled longleaf pine stands ranged from 56 to 78 years old (Table 5). Trees on natural slash pine sites usually were very scattered. However, one natural slash pine site in this study had a good stand of trees, averaging 24 years old. This stand may have been artificially seeded but not recorded on USFS files. Planted slash pine sites were segregated into three age groups of approximately 12, 23, and 40 years old.

Tree height was quite uniform in the longleaf pine stands, averaging between 63 and 70 ft (Table 5). Tree height of planted slash pine was affected by soil type. Minor increases in height occurred on the drier soils, while averaging tree height on Bladen soil showed about a 20 percent increase between the age categories. These increases of tree height on Bladen soils by planted slash pine resulted in taller trees (43 ± 9 ft) by age 23 than of slash pine in a natural stand (35 ± 3ft).

Average DBH within the longleaf pine stands ranged between 10.4 and 12.3 in, but was only 8.0 in the younger natural slash pine stand (Table 5). Planted slash pine on Bladen soils had larger mean DBH measurements than the drier soils for both PS9 and PS19 age groups. Mean DBH measurements for slash pine on Bladen soils apparently did not increase through time between PS19 and PS39 soils.

Most of the longleaf pine stands, had been commercially thinned and stumped. Basal area ranged from 38 to 71 ft^2/ac among the five soil series on which longleaf was sampled (Table 5). The maximum value was inflated due to unthinned longleaf stands on Leefield soils in Compartments 67-69. Mean basal area in the forested natural slash pine stand was 72 ft^2/ac.

A large disparity of mean basal area existed among the soil series in PS9 stands, ranging from 22 to 75 ft^2/ac. Chipley and Kershaw soils are very dry and not conductive to planted slash pine growth. Mean basal area of PS19 trees on Bladen soils was less than in PS9 stands. This change may have been due to death or to an original lower stocking rate. Mean basal area of PS19 stands on Dunbar and Dothan soils was about 50% greater than on Bladen soils. Mean basal area in PS39--Bladen stands was 14% greater than PS19--Bladen stands.

Overstory canopy cover of longleaf pine stands was uniform among the soil types, ranging from 41 to 49% (Table 5). The natural slash pine stand had an average 58% canopy cover. The relationship of average canopy cover among PS9 forest type - soil series combination was similar to basal areas estimates among those stands. The lowest canopy cover means were on Chipley and Kershaw soils 36 and 50%, respectively. Mean canopy cover within planted slash pine stands on

Table 5. Overall mean tree age, height, dbh, basal area, canopy cover, snag density, and cavity density within respective standard deviations, of dominant overstory trees within the sampled forest type - soil series combinations of the entire ANF study site, Florida.

Forest Type[1]	Soil Series	Age (Yr)	Height (ft)	DBH (in)	Basal Area (ft^2/ac)	Canopy Cover (%)	Snags (no./ac)	Cavities (no./ac)
LL	Albany	62	64	12.3	46	41	2.4	1.6
	Leefield	54	70	10.4	71	49	0.4	0.0
	Dunbar	78	63	12.9	57	49	0.0	0.0
	Blanton	60	66	12.0	38	41	1.4	0.0
	Dothan	56	69	11.7	57	46	1.4	0.2
NS	Bladen	24	35	8.0	72	58	0.6	0.0
PS9	Bladen	13	36	6.4	75	62	-	-
	Chipley	11	30	4.5	22	36	-	-
	Dunbar	13	26	5.0	75	63	-	-
	Kershaw	11	26	3.8	36	50	-	-
PS19	Bladen	23	43	7.0	56	66	-	-
	Dunbar	24	30	6.4	83	61	-	-
	Dothan	23	32	6.8	87	70	-	-
PS39	Bladen	40	53	7.1	64	55	0.5	0.0

[1]LL = Longleaf pine; NS = Natural slash pine; PS9 = Planted slash pine 9-18 years old; PS19 = Planted slash pine 19-38 years old; PS39 = Planted slash pine greater than 39 years old.

Bladen soils was similar among the three age categories.

This survey did not encounter many snags or cavities (Table 5). None were found in planted slash pines younger than 39 years old nor within the savannas. Of those snags and cavities tallied, the majority were in longleaf pine stands. Snag density ranged from 0.0 to 2.4/ac. Many of the snags had no cavities, probably indicating a short-lived existence of snags on this study area.

Snag density was affected by several factors. First, the requirement of a 10" dbh excluded some standing dead trees as the mean dbh of the dominant trees within the longleaf stands was about 12 in. Secondly, frequent fire causes many dead trees to burn and fall. And finally, several snags were found pushed down by stumping crews.

Future snag surveys should use belt transects and should make some record of fallen trees. Reptiles and amphibians make up a large component of Florida wildlife; therefore, fallen snags provide a significant amount of cover for these species.

Midstory

The midstory component was defined as trees, shrubs, and vines with stems greater than 1 in dbh and more than 5 ft in height. Vegetation meeting these requirements was virtually non-existent within the sampled forest type - soil series combinations. Absence of a midstory component was due to frequent prescribed burns designed and implemented to retard development of that stratum.

Understory Parameters

Browse cover was generally greater in longleaf pine than among the other forest types with browse cover on Dunbar soils (6%) being the exception (Table 6). Within slash pine stands, browse cover was greatest in PS39 sites on Dothan soils (21%). Average browse cover never exceeded 13% on the somewhat poorly drained Bladen soil. Herbage coverage was greatest within the natural slash pine forest type, averaging 74% and 126% on Bladen and Dunbar soils, respectively. Herbage coverage within the longleaf pine forest type was lowest on Leefield soils (26%) due mainly to recent prescribed burning in some areas and long-term lack of fire in other areas. Herbage coverage averaged 90% in the nearly treeless savanna.

Overall average browse biomass was highest in natural slash pine-- Dunbar (782 lb/ac) and clearcut--Dothan (397 lb/ac) forest type-soil series combinations (Table 7). In both stands, gallberry was the dominant browse species. Gallberry also contributed a large proportion of the total browse biomass in the longleaf pine stands. In addition, several species of oaks contributed significantly to browse biomass in longleaf stands and in planted slash pine in dry soils. Growth of blackberry, as well as gallberry, is stimulated by soil disturbance associated with site preparation and bedding.

Longleaf pine stands typically had more browse species present, but biomass production was limited due to frequent prescribed burning. Runner oaks, dwarf huckleberry, ground blueberry (Vaccinium myrsinites) and greenbrier had rapid

Table 6. Average areal cover of browse, herbage, bareground and litter within sampled forest types soil series combinations of the entire ANF study site, Florida. Data were collected October - November 1980 and August 1981.

		Forest type[1]						
Soil series	Parameter	LL	NS	PS9	PS19	PS39	Sav	CC
		%						
Bladen	Browse		5	6	13	4	9	
	Herbage		74	44	39	39	90	
	Bareground		2	2	3	0	3	
	Litter		20	51	36	44	7	
Chipley	Browse			13				
	Herbage			42				
	Bareground			20				
	Litter			17				
Albany	Browse	32						
	Herbage	48						
	Bareground	6						
	Litter	22						
Leefield	Browse	28						
	Herbage	26						
	Bareground	5						
	Litter	55						
Dunbar	Browse	6	12	16	6			
	Herbage	37	126	39	37			
	Bareground	0	0	T	0			
	Litter	51	0	51	56			
Blanton	Browse	18						
	Herbage	54						
	Bareground	13						
	Litter	14						
Kershaw	Browse			15				
	Herbage			22				
	Bareground			13				
	Litter			51				
Dothan	Browse	29			21			25
	Herbage	48			33			64
	Bareground	1			0			10
	Litter	29			27			13

[1]LL = Longleaf pine, NS = Natural slash pine, PS9 = Planted slash pine 9-18 yr old, PS19 = Planted slash pine 19-38 yr old, PS39 = Planted slash pine greater than 39 yr old, Sav = Savanna, CC = clearcut.

Table 7. Average forage biomass within sampled forest type-soil series combinations of the entire ANF study site, Florida. Data were collected October - November 1980 and August 1981.

Soil series	Forage class	LL	NS	PS9	PS19	PS39	Sav	CC
		--------	--------	--------	lb/ac	--------	--------	--------
Bladen	Browse		40	38	180	39	47	
	Herbage		1908	741	1643	1158	1875	
Chipley	Browse			114				
	Herbage			807				
Albany	Browse	271						
	Herbage	993						
Leefield	Browse	328						
	Herbage	596						
Dunbar	Browse	124	397	125	63			
	Herbage	920	2604	778	734			
Blanton	Browse	151						
	Herbage	999						
Kershaw	Browse			122				
	Herbage			192				
Dothan	Browse	269			191			721
	Herbage	1155			2336			1472

[1]LL = Longleaf pine, NS = Natural slash pine, PS9 = Planted slash pine 9-18 yr old, PS19 = Planted slash pine 19-38 yr old, PS39 = Planted slash pine greater than 39 yr old, Sav = Savanna, CC = Clearcut.

regrowth following fire and comprised a large portion of the browse biomass longleaf pine.

Average herbage biomass estimates were greater on natural slash pine - Dunbar and PS19-Dothan sites, 2604 and 2336 lb/ac, respectively (Table 7). Beakrush was the most significant contributor on natural slash pine - Dunbar sites, while pineland threeawn was the dominant herbage species on PS19-Dothan sites. Among longleaf pine stands, herbage biomass was lowest on Leefield soils. Pineland threeawn was not decimated by the site preparation methods used on this study's planted slash pine sites.

Browse and herbage biomass yields were regressed against the respective foliar cover estimates within each sampling quadrat. Browse cover (BC) accounted for 48% of the variation in browse weight (BW) and is described by the following equation:

$$BW = 13.4 + 9.9 (BC).$$

Likewise, herbage cover (HC) accounted for 50% of the variation in herbage weight (HW) and is described by the following equation:

$$HW = 68.0 + 17.4 (HC).$$

LITERATURE CITED

Clewell, A. F. 1971. The vegetation of the Apalachicola National Forest: an ecological perspective. Final Report, Contract No. 38-2249, USDA Forest Service, Atlanta, Ga. 152 p.

Hitchcock, A. S. 1935. Manual of the grasses of the U.S. (2nd ed. A. Chase). USDA Misc. Publ. 200, 1040 p., Revised 1951 by Agnes Chase.

Radford, A. F., H. E. Ahles, and C. R. Bell. 1968. Manual of the vascular plants of the Carolinas. The Univ. of North Carolina Press, Chapel Hill. 1183 p.

Figure 6. Forest type and soil series combinations (see Tables 2 and 3 for codes) on Compartment 69, ANF study site, Liberty County, Florida. Stars indicate vegetative sample locations.

APPENDIX

Description of those soil series found on the ANF study site, Liberty County, Florida.

RUTLEDGE SERIES

The Rutledge series is a member of the sandy, siliceous, thermic family of Typic Humaquepts. These soils typically have black loamy sand upper A horizons more than 6 inches thick, very dark gray loamy sand lower A horizons and grayish brown mottled sand C horizons.

Range in Characteristics: Reaction is very strongly acid to extremely acid throughout the soil. The A horizon is sand, fine sand, loamy sand, or loamy fine sand.

Drainage and Permeability: Very poorly drained. The water table is at or near the surface for long periods of the year, and ponding is common. Runoff is very slow or ponded. Permeability is rapid throughout.

SURRENCY SERIES

The Surrency series is a member of the loamy, siliceous, thermic family of Arenic Umbric Paleaquults. These soils have black sand A1 horizons, grayish brown A2 horizons 20 to 40 inches thick, and mottled grayish brown loamy B horizons.

Range in Characteristics: Texture of the A horizon is loamy sand or sand 20 to 40 inches thick. Texture of the Bt horizons is sandy loam to sandy clay loam. Reaction of the B horizon is very strongly acid to strongly acid.

Drainage and Permeability: Very poorly drained. The water table is at the surface for long periods of the year, and ponding is common. The permeability is rapid in the A horizon and moderate in the B horizon.

BLADEN SERIES

The Bladen series is a member of the clayey, mixed, thermic family of Typic Ochraquults. These soils have loamy A horizons, gray, fine-textured, Bt horizons containing mottles of yellowish-brown, strong brown, and shades of red, and a seasonally high water table.

Range in Characteristics: Bladen soils are strongly acid to very strongly acid in all horizons unless limed. The principal surface soil textures are sandy loam, fine sandy loam, loam, and clay loam; loamy fine sand and loamy sand are minor textures. Texture of the Bt horizon is centered on clay, but sandy clay is within the range of the series.

Drainage and Permeability: Poorly drained; permeability is slow to very slow. In most years depth to the water table is less than 15 inches for periods of 2 to 6 months. Some areas are flooded annually for periods of 1 to 2 months.

PLUMMER SERIES

The Plummer series is a member of the loamy, siliceous, thermic family of Grossarenic Paleaquults which consist of deep, poorly drained, moderately permeable soils that formed in sandy and loamy sediments of marine terraces. These soils are on level or depressional landscapes and along poorly defined drains of the Coastal Plain. They are saturated in winter, spring, and sometimes into summer. Slope is dominantly 1 percent or less, but ranges up to 5 percent.

Range in Characteristics: Reaction of all horizons ranges from extremely acid to strongly acid. The A horizon is sand, fine sand, or loamy sand. The Bt horizon is sandy loam or sandy clay loam.

Drainage and Permeability: Plummer soils are poorly drained; runoff is slow and permeability is moderately rapid in the sandy A horizon and moderate in the subsoil. A water table is above the surface or within 15 inches of the surface for very long periods, mainly in midwinter and spring; depressional phases are ponded for 6 to 12 months each year.

SAPELO SERIES

The Sapelo series is a member of the sandy, siliceous, thermic family of Ultic Haplaquods which consist of poorly drained, nearly level soils that have a fine sand upper sequence of horizons with a black A1 horizon, light gray A2 horizon, very dark brown and dark brown Bh horizon, pale yellow A'2 horizon, and a light gray sandy clay loam B'tg horizon. Slopes range from 0 to 2 percent.

Range in Characteristics: Reaction ranges from extremely acid to strongly acid. The A horizon is sand or fine sand. The B horizon is sandy loam, fine sandy loam, loam, clay loam, or sandy clay loam.

Drainage and Permeability: Poorly drained; slow runoff, moderate permeability. The water table is at 15 to 30 inches for 2 to 4 months during most years.

CHIPLEY SERIES

The Chipley series is a member of the thermic family of coated Aquic Quartzipsamments which consists of deep, moderately well-drained, rapidly permeable soils that formed in thick deposits of sandy marine sediments. They are on nearly level to sloping upland landscapes in the lower Coastal Plain. Slopes range from 0 to 8 percent.

Range in Characteristics: Texture is sand or fine sand to depths of 80 inches or more. Reaction ranges from extremely acid through medium acid in all A horizons except where limed and from very strongly acid to slightly acid in the C horizon.

Drainage and Permeability: Moderately well-drained; slow runoff; rapid permeability. These soils have seasonal water tables between depths of 20 to 40 inches for 2 to 4 months during most years.

TALQUIN SERIES

The Talquin series is a member of the sandy, siliceous, thermic family of Entic Haplaquods which consists of deep, poorly drained, moderate to moderately rapid permeable sandy soils that formed in thick beds of sandy marine sediments. They are on broad, nearly level lower Coastal Plain flatwoods. Slopes range from 0 to 2 percent.

Range in Characteristics: Texture is sand or fine sand to depths of 80 inches or more. Reaction ranges from extremely acid to strongly acid.

Drainage and Permeability: Talquin soils are poorly drained. Runoff is slow. Permeability is rapid in the A horizon and moderate to moderately rapid in the Bh horizon. The water table is within depths of 10 inches for 1 to 3 months during periods of high rainfall and within depths of 20 to 40 inches for 9 months or more during most years.

ALBANY SERIES

The Albany series is a member of the loamy, siliceous, thermic family of Grossarenic Paleudults which consists of somewhat poorly drained soils that formed in Coastal Plain deposits of sandy material underlain by loamy sediments. Permeability is rapid in the thick sandy surface horizon and moderate in the loamy subsoil. Slopes range from 0 to 5 percent.

Range in Characteristics: Reaction ranges in the Ap or A1 horizon from extremely acid to slightly acid and in the A2 and B horizons from very stronly acid to medium acid. Texture of the A horizon is sand, fine sand, loamy sand, or loamy fine sand. Texture of the Bt horizon is sandy loam or sandy clay loam.

Drainage and Permeability: Somewhat poorly drained; seasonally high water table is within 12 to 30 inches of the surface for 1 to 4 months yearly. Permeability is rapid in the sandy horizons and moderate in argillic horizons. Runoff is slow. In some areas, flooding is possible under abnormal conditions.

LEEFIELD SERIES

The Leefield series is a member of the loamy, siliceous, thermic family of Arenic Plinthaquic Paleudults. These soils have thick loamy sand surfaces over somewhat gleyed, loamy Bt horizons that have soft plinthite in their lower part.

Range in Characteristics: Reaction is very strongly acid in all horizons, except where the soil has been limed. The A horizon is loamy sand or sand in texture. The texture of the B horizon is sandy clay loam or sandy loam.

Drainage and Permeability: Somewhat poorly drained with slow runoff and slow internal drainage. A perched water table at depths less than 30 inches is present for several months during the year. Permeability is moderate in the upper part and moderately slow in the lower part.

DUNBAR SERIES

The Dunbar series is a member of the clayey, kaolinitic, thermic family of Aeric Paleaquults.

These soils have dark gray sandy loam A horizons, brown and gray clayey Bt horizons, and light gray sandy clay C horizons at a depth of more than five feet.

Range in Characteristics: The soil is strongly to very strongly acid, except where it is limed. The A horizon is typically sandy loam and ranges from loam to loamy sand. The Bt horizon commonly is sandy clay, but it ranges from clay loam to clay.

Drainage and Permeability: Somewhat poorly drained. Runoff and internal drainage are slow. Permeability is slow. Undrained areas are saturated to within less than 1 foot on the surface for significant periods every year.

LEON SERIES

The Leon series is a member of the sandy, siliceous, thermic family of Aeric Haplaquods which consists of somewhat poorly drained, sandy soils that have a weakly cemented Bh horizon within 30 inches of the surface. These soils formed in thick deposits of sandy marine sediments and are on nealry level to gently sloping landscapes. Slopes range from 0 to 5 percent.

Range in Characteristics: Texture is sand or fine sand to depths of 80 inches or more. Reaction ranges from extremely to strongly acid in each horizon.

Drainage and Permeability: Leon soils are somewhat poorly drained. Runoff is slow. Permeability is rapid in the A horizons and moderate to moderately rapid in the Bh horizons. The water table is at depths of 10 to 40 inches for periods of more than 9 months during most years. It is at depths of less than 10 inches for one to 4 months during periods of high rainfall and recedes to depths of more than 40 inches during very dry seasons.

BLANTON SERIES

The Blanton series is a member of the loamy, siliceous, thermic family of Grossarenic Paleudults which consists of deep, moderately well-drained, moderately permeable soils that formed in sandy and loamy marine or eolian deposits. They are on nearly level to strongly sloping upland landscapes in the Coastal Plain. Slopes range from 0 to 12 percent.

Range in Characteristics: Texture of the A horizon is sand, fine sand, loamy sand, or loamy fine sand, and reaction ranges from very strongly acid to medium acid. The Bt horizon is sandy loam, fine sandy loam, or sandy clay loam.

Drainage and Permeability: Moderately well-drained; moderate permeability; rapid internal drainage; slow runoff. A perched water table above the B2t horizon is within depths of 60 to 72 inches for 1 to 3 months in most years and below 72 inches the remainder of the year. It rises above 60 inches briefly in some years.

FOXWORTH SERIES

The Foxworth series is a member of the thermic family of coated Typic Quartzipsamments which consists of deep, moderately well-drained, very rapidly permeable soils that formed in thick deposits of sandy marine or aeolian sediments. These are on broad, nearly level and gently sloping uplands and sloping sideslopes. They are saturated below depths of about 40 inches in winter and early spring. Water runs off the surface very slowly. Slope ranges from 0 to 8 percent.

Range in Characteristics: Thickness of sand exceeds 80 inches and texture is sand or fine sand throughout. Reaction ranges from very strongly acid to medium acid throughout.

Drainage and Permeability: Moderately well-drained. Runoff is very slow. Permeability is very rapid. A water table fluctuates between depths of 40 to 72 inches below the soil surface for 1 to 3 months during most years and 30 to 40 inches for less than 30 cumulative days in some years.

DOTHAN SERIES

The Dothan series is a member of the fine-loamy, siliceous, thermic family of Plinthic Paleudults which consists of deep, well-drained, moderately slowly permeable soils that formed in thick unconsolidated medium to fine textured sediments of the Coastal Plain. These soils are on broad, nearly level to strongly sloping uplands. Slopes range from 0 to 12 percent.

Range in Characteristics: Soil reaction is medium to very strongly acid throughout, except where the surface has been limed. Texture of the A horizon is sandy loam, fine sandy loam, loamy fine sand, or loamy sand. Texture of the B horizon is sand loam, sand clay loam, or clay loam and ranges to include sandy clay in the lower poriton of the Bt horizon.

Drainage and Permeability: Well-drained. Runoff and internal drainage are medium. Permeability is moderate in the B21t and B22t horizons and moderately slow in the horizons with plinthite.

TROUP SERIES

The Troup series is a member of the loamy, siliceous, thermic family of Grossarenic Paleudults. These soils have thick brownish sandy A horizons and red loamy Bt horizons.

Range in Characteristics: Reaction of all horizons is strongly acid or very strongly acid. Texture of the A horizon is sand or loamy sand. Thickness ranges from 40 to 72 inches. Texture of the Bt horizon is sandy loam or sandy clay loam.

Drainage and Permeability: Well-drained. Runoff is slow. Permeability is moderate to moderately rapid.

FUQUAY SERIES

The Fuquay series is a member of the loamy, siliceous, thermic family of Arenic Plinthic Paleudults. These soils have thick A horizons of loamy sand or sand textures 20 to 40 inches thick. These are underlain by loamy Bt horizons that have plinthite in the lower part.

Range in Characteristics: Reaction is very strongly acid or strongly acid throughout, except where limed. The A horizon is loamy sand, sand, or loamy fine sand. Texture of the Bt horizon is centered on sandy clay loam.

Drainage and Permeability: Well-drained. A perched water table occurs above the plinthic zone briefly during wet periods. Internal drainage is medium. Permeability is moderate in the upper part of the B horizon and slow in the lower part.

KERSHAW SERIES

The Kershaw series is a member of the thermic family of uncoated Typic Quartzipsamments and consists of deep, excessively drained, very rapidly permeable soils that formed in thick sandy deposits. These soils are on smooth uplands and dune-like landscapes and have slopes ranging from 2 to 15 percent.

Range in Characteristics: Reaction ranges from medium acid to very strongly acid. Texture is coarse sand, sand, or fine sand to a depth of more than 80 inches.

Drainage and Permeability: Excessively drained; slow runoff; very rapid permeability. Depth to seasonal water table is more than 120 inches.

Comparison of Vertebrate Wildlife Communities in Longleaf Pine and Slash Pine Habitats in North Florida

Ronald F. Labisky and Julie A. Hovis

Abstract--Birds, herpetofauna, and small mammals were surveyed on a 5,181-ha (12,797-acre) research site within natural longleaf (*Pinus palustris*) and planted slash pine (*Pinus elliottii* var. *elliotti*) habitats in the Apalachicola National Forest, Florida, during 1980 and 1981. Densities of breeding and wintering birds averaged 100.9 birds/km^2 (0.4 birds/acre) and 136.2 birds/km^2 (0.6 birds/acre), respectively, for 1980 and 1981. Densities of birds were greater ($P < 0.05$) in longleaf than in slash pine during both breeding and wintering periods. Species richness and species diversity of birds differed ($P < 0.05$) between the 2 habitat types, being greater in longleaf pine. Thirty-nine species of amphibians and reptiles, totaling 726 individuals, were captured during spring and fall surveys in 1980 and 1981. Herpetofaunal species diversity and biomass differed ($P < 0.05$) between habitats, being greater for longleaf than slash pine. Five species of small mammals, totaling 198 individuals, were captured during the spring and fall periods of 1980 and 1981. Neither capture success, species diversity, nor biomass of small mammals differed ($P < 0.05$) between longleaf and slash pine habitats. Birds, herpetofauna, and small mammals generally favored longleaf pine habitats over slash pine habitats, which, in light of the substantive diminishment (> 80%) of longleaf pine in Florida during the past 3 decades, raises concern for the future of these vertebrate groups in the pinelands of north Florida.

INTRODUCTION

The Multiple Use-Sustained Yield Act of 1960 mandated that all public lands be managed concurrently for grazing, wildlife, recreation, and timber (Pearson 1974). Subsequently, land managers on national forests have begun to develop management strategies that consider the total forest environment. It is now recognized that a well-balanced ecosystem approach to multiple-use management must include all components of the forest community--plants and animals, game and nongame, vertebrates and invertebrates, soil, climate, and other environmental factors (Clawson 1975, Siderits and Radtke 1977). Yet, the successful implementation of such all-encompassing management practices is a complex procedure that hinges on the ability of various land-management groups to integrate successfully their individual goals and objectives (Lewis 1973, Pearson 1974).

In the southern United States, where approximately 65% of the nation's pulpwood is produced (Southern Forest Institute 1977), emphasis traditionally has been placed on maximizing timber-harvest yields. In recent years, however, an expanding human population, coupled with the public's rising interest in environmental quality, has placed increased demands on the southern pine forests--not only for timber production, but also for beef production, wildlife, recreation, and wilderness. As a result, forest managers in the South have turned increasingly to sophisticated multiple-use planning to meet these growing and often conflicting demands (Lewis 1973).

The compatibility of cattle grazing with other southern pine forest uses is a controversial and, as of yet, largely unresolved issue. One aspect of this controversy, the effect that cattle grazing has on wildlife, has centered mainly on a few selected game species, particularly the white-tailed deer (*Odocoileus virginianus*) (Goodrum and Reid 1955; Lay 1967, 1969; Veteto et al. 1971; Pearson and Sternitzke 1976, 1978; Lay and Murry 1978; Mitchell 1980; Thill and Martin 1979). No study to date has

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attempted to assess the impact that cattle grazing has on the total wildlife community. As a result, the interrelationships among cattle, wildlife, and timber in southern pine forests are not understood clearly, a situation that has seriously precluded the implementation of sound resource management strategies.

The Southern Evaluation Project, approved by the Chief, U.S. Forest Service, in 1978, was designed to evaluate impacts of timber, wildlife, and range management on the biological, physical, and socio-economic components of National Forests in the South. To achieve this goal, study areas were established in Texas, Louisiana, Mississippi, and Florida. The initial phase of the comprehensive project was to obtain pretreatment baseline inventories on the study areas. The present study, conducted in 1980 and 1981, reports the abundance and species composition of birds, herpetofauna, and small mammals within natural longleaf pine and planted slash pine habitats on the Apalachicola National Forest, Florida.

STUDY AREA

The study was conducted on the western section (T3S, 4S; R7W, 8W) of the Apalachicola National Forest, which is located in the Florida Panhandle southwest of Tallahassee. Bounded on the east by Florida Highway 12 and on the west by Florida Highway 379, the 5,181-ha (12,797-acre) research site consisted of 7 contiguous U.S. Forest Service management compartments: 26, 27, 28, 29, 67, 69, and 72 (Fig. 1). These compartments were subject to ongoing forest management practices (e.g., prescribed burning and timber harvesting) throughout the study period. Major forest types present on the area included: natural longleaf pine (31%), planted slash pine (24%), titi (*Cliftonia monophylla* and *Cyrilla* spp.) thickets (23%), natural slash pine (11%), pondcypress (*Taxodium distichum* var. *nutans*) and tupelo (*Nyssa* spp.) swamps (7%), and savannas (4%) (Tanner and Terry 1982).

The research site is approximately 18 m (59 ft) above sea level and has a generally flat terrain. Soils range from very poorly drained to extremely dry, with the Surrency, Bladen, Dothan, and Leefield series being the most common (Tanner and Terry 1982). The mean annual temperature and precipitation for the area are 20 C (68 F) and 149 cm (59 in), respectively (National Oceanic and Atmospheric Administration 1978). Rainfall and temperature data for the 2-year study period,

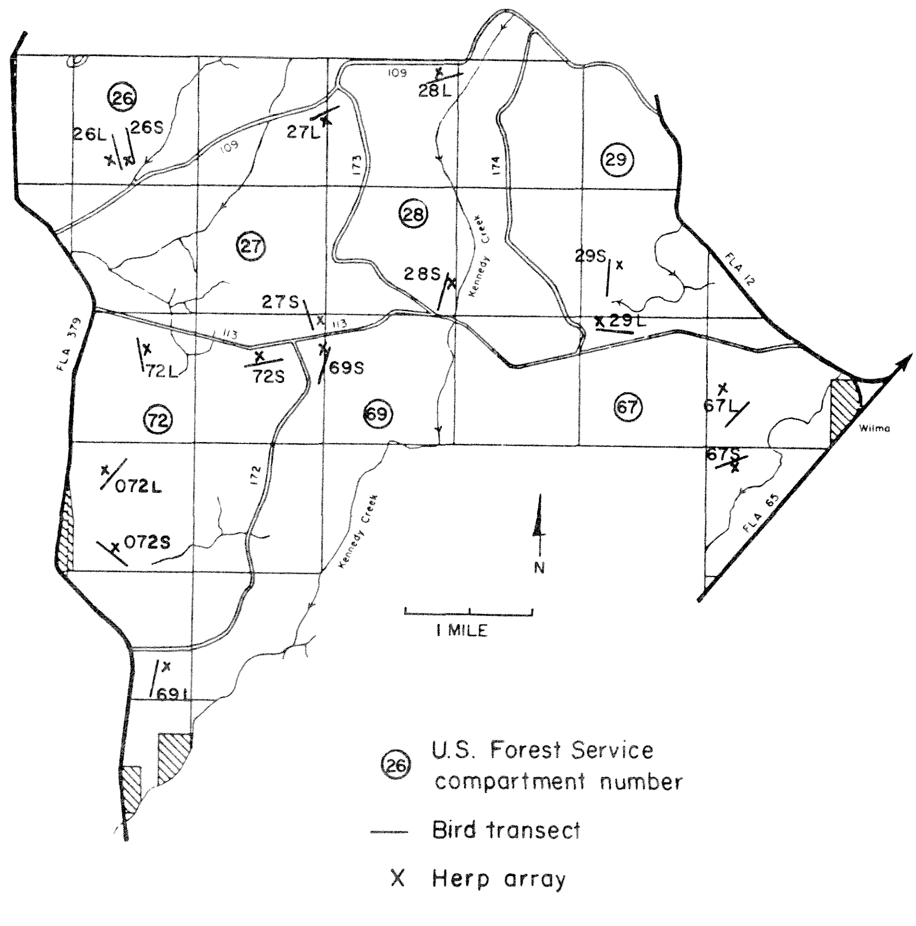

Fig. 1. Location of faunal sampling sites within natural longleaf (L) and planted slash (S) pine habitat types, Apalachicola National Forest, Florida, 1980 and 1981.

1980-1981, were obtained from the weather station in Blountstown, Florida, which is located approximately 32 km (20 miles) northwest of the research site (Fig. 2).

The 7 management compartments comprising the research site were grouped into 4 treatment pastures, each 900 ha (2,223 acres) or larger, for the subsequent evaluation of 4 different levels of range management: pasture A - compartments 26 and 27; pasture B - compartments 28 and 29; pasture C - compartments 67 and 69; and pasture D - compartment 72, which was divided into 2 sections, designated as 72 and 072. In each of the 4 pastures, 2 natural longleaf pine and 2 planted slash pine stands were selected for indepth faunal surveys (Fig. 1, Table 1). Thus, a total of 16 forest stands served as sites for censusing bird, herpetofaunal, and small mammal communities on the study area.

METHODS

Sampling Design and Procedures

Birds.--Bird populations were censused using the fixed-width strip transect method (Conner and Dickson 1980). Four, 500-m (1,640-ft) transects were established in each of the 4 treatment pastures, with 2 transects being located in natural longleaf pine habitat and 2 in planted slash pine habitat (Fig. 1).

Four bird censuses were conducted on the research site--2 during the breeding season (10-18 May 1980, 7-14 May 1981), and 2 during the wintering season (11-19 December 1980, 7-18 December 1981). Each transect was censused on 5 different days within the first 4 hours post-sunrise during each sampling period. The order in which transects were censused was varied to minimize time-of-day biases in bird detectability. Bird observations (sight or call) were recorded only within the 20-m (66 ft) zone extending from each side of the transect. Each bird observed was identified to species, and its location in the census strip was recorded. These data were used to determine the density (number of individuals observed/km^2), species richness (number of species observed), species diversity (H') (Shannon and Weaver 1949), and biomass (kg) of birds observed within each strip transect during each of the 4 sampling periods. Biomass values were estimated using mean standard weights of individual species as reported in the literature (Appendix A.1).

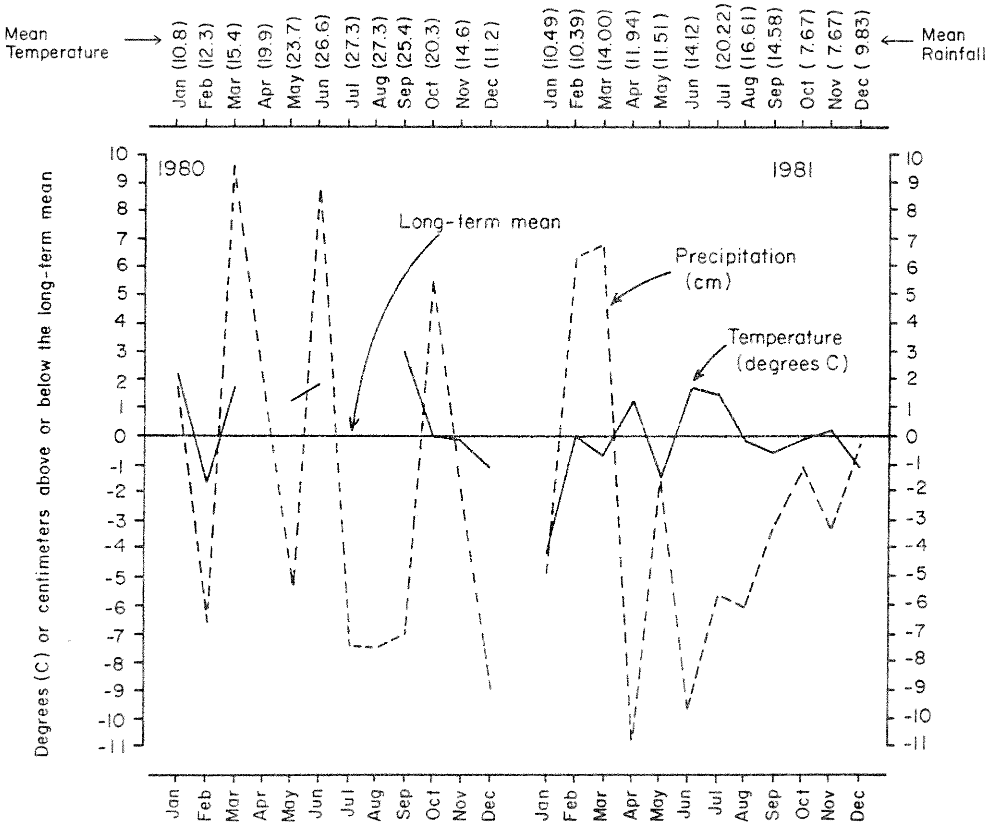

Fig. 2. Departures from long-term mean monthly measurements of temperature and precipitation, Apalachicola National Forest study area, 1980 and 1981. Long-term means of temperature (top left) and precipitation (top right) are for the period 1941-1970. Temperature measurements for April, July, and August, 1980, were not available. All data are for Blountstown, Florida (U.S. Department of Commerce 1980, 1981), which is located approximately 32 km (20 miles) northwest of the study area.

Table 1. Characteristics of forest stands containing the 16 faunal sampling sites, Apalachicola National Forest, Florida, 1980 and 1981.

Management compartment and pasture	Stand characteristics[a/]					
	Habitat type[c/]	Stand number	Size (ha)	Age (years)	Soil type[d/]	Soil wetness rank[e/]
26A	LP	08	477	54	Dothan	2
	SP	09	104	10	Dunbar	4
27A	LP	10	101	109	Dothan	2
	SP	02	79	10	Bladen	5
28B	LP	05	230	48	Leefield	4
	SP	18	104	19	Albany	4
29B	LP	04	358	57	Leefield	4
	SP	06	37	11	Kersaw	1
67C	LP	06	247	88	Dothan	2
	SP	02	1930	23	Dunbar	4
69C	LP	07	89	103	Dothan	2
	SP	09	27	16	Dunbar	4
72D	LP	04	1806	63	Leefield	4
	SP	07	289	17	Leon	5
072D	LP	19	180	88	Dunbar	4
	SP	07	128	24	Dunbar	4

a/ Obtained from U.S. Forest Service, Apalachicola Ranger District (unpublished data).

b/ Compartments followed by the same letter comprise a pasture; compartment 72 was divided into 2 sections, designated as 72 and 072.

c/ LP = natural longleaf pine; SP = planted slash pine.

d/ See Tanner and Terry (1982) for complete description of soil series.

e/ Soil wetness rank: 0 = xeric, 5 = saturated.

Herpetofauna.--Herpetofauna were sampled using an array-type trapping system (Campbell and Christman 1977). Each array consisted of 4, 7.6-m (25-ft) metal drift fences (30 cm [12 in] above ground in height), positioned in a plus-shaped pattern with a central separation of 15 m (49 ft). Four funnel traps, constructed of aluminum-screen wire, were positioned along each of the 4 drift fences, which provided for a total of 16 traps per array. Within each of the 4 treatment pastures, 2 arrays were placed in natural longleaf pine habitat and 2 in planted slash pine habitat (Fig. 1).

Arrays were operative for 8 consecutive weeks during 4 seasonal trapping periods: spring 1980 (13 March - 15 May); fall 1980 (3 September - 1 November); spring 1981 (29 March - 20 May); and fall 1981 (4 September - 30 October). Arrays were checked weekly during operation. Captured animals were identified to species, weighed (g), and measured -- snout to vent length (mm). The date of capture, location of trapping-array (pasture, compartment, and habitat type), and funnel-trap number (1-16) in which the animal was captured were recorded also. Herpetofaunal specimens were deposited in the Florida State Museum, Gainesville, Florida. Trapping results were used to determine the number of individuals captured per array during each of the 4 trapping periods. In addition, species richness (number of species captured), species diversity (H') (Shannon and Weaver 1949), and biomass (g) of herpetofauna were determined.

Small Mammals.--Small mammals were sampled using removal-trapping. Four traplines, 2 in natural longleaf pine habitat and 2 in planted slash pine habitat, were established in each of the 4 treatment pastures parallel to the corresponding bird census transect (Fig. 1). Each trapline consisted of 25 trap-stations, spaced at 15-m (49-ft) intervals. A trap-station was comprised of 1 Sherman live-trap and 1 museum special (snap trap) placed approximately 1 m apart. All traps were baited with a mixture of peanut butter and oatmeal; the area immediately surrounding each trap was dusted with a carbamate (Sevin) to prevent ants from eating the bait and/or a captured animal.

Traplines were operative for 4 consecutive nights during 4 seasonal trapping periods: spring 1980 (13-17 May); fall 1980 (25-29 October); spring 1981 (21-24 May); and fall 1981 (22-26 October). Traplines were checked daily during operation and the status (sprung-capture, sprung-no capture, or operative) of each trap was recorded. Each captured small mammal was sacrificed, identified to species, weighed (g), sexed, and measured (right ear, right hind foot, tail, and total body length in mm). Also recorded were the date of capture, location of trapline (pasture, compartment, and habitat type), number of trap-station (1-25), and type of trap (Sherman or snap) in which each animal was captured. A representative sample of each species was deposited in the Florida State Museum, Gainesville, Florida.

For each of the 4 trapping periods, the number of trap-nights per trapline was adjusted to account for traps accidentally sprung by falling leaves, rain, or animals that avoided capture. Because these traps may have been operative for some portion of the trapping period, one-half the number of traps accidentally sprung was subtracted from the number of traps originally set to obtain an adjusted trap-night statistic. Subsequently, capture success (%) was calculated for each trapline by dividing the total number of individuals captured by the adjusted number of trap-nights and then multiplying this value by 100. The species richness (number of species captured), species diversity (H') (Shannon and Weaver 1949), and biomass (g) of small mammals captured per trapline were determined also for each trapping period.

Data Analysis

All data were analyzed by analysis of variance (least squares) procedures (Table 2). The effects of habitat, compartment, season, and year were tested using the General Linear Models (GLM) procedure of the Statistical Analysis System (SAS) (Helwig and Council 1979). All statistical tests were performed at a predetermined level of probability ($\underline{P}$=0.05) at the Northeast Regional Data Center, University of Florida, Gainesville, Florida.

Median estimates (i.e., geometric means) reported for log-transformed data (Table 2) were obtained by calculating the antilog of the symetrically-distributed, transformed data; 68% minimum and maximum range values were obtained by calculating the antilog of the mean minus the standard deviation and the antilog of the mean plus the standard deviation of the transformed data, respectively. Similarly, median estimates reported for data subjected to an arcsine-square root transformation were obtained by first squaring the mean of the transformed data, and then calculating the sine of this value; 68% minimum and maximum range values were obtained by squaring the mean minus the standard deviation and the mean plus the standard deviation of the transformed data, and then calculating the sine of these values, respectively (R. C. Littell, pers. commun.).

RESULTS

Birds

A total of 759 birds, representing 53 species, was observed during breeding and wintering censuses in 1980 and 1981 (Table 3, Appendices A. 1-A.3). Irrespective of habitat

Table 2. Parameters and types of transformations used to statistically analyze data collected on bird, herpetofaunal, and small mammal populations, Apalachicola National Forest, Florida, 1980 and 1981.

Population	Parameter	Transformation
Birds[a/]	Density (birds/km^2)	log (base 10)
	Species richness (number of species)	log (base 10)
	Species diversity (H')[b/]	None
	Biomass (kg)	log (base 10)
Herpetofauna	Number of individuals	log (base 10)
	Species richness (number of species)	log (base 10)
	Species diversity (H')	None
	Biomass (kg)	log (base 10)
Small mammals	Capture success	Arcsine-square root
	Species richness (number of species)	log (base 10)
	Species diversity (H')	None
	Biomass (kg)	log (base 10)

[a/]Assumptions: (1) all birds present within the census strip were observed; (2) detectability of birds was equal between habitat types (natural longleaf and planted slash pine) and between seasons (spring and fall); and (3) detectability and identification of encountered birds were equal among observers.

[b/]Shannon-Weiner index of species diversity (Shannon and Weaver 1949).

Table 3. Relative frequency of occurrence of bird species observed during breeding (May) and wintering (December) censuses, Apalachicola National Forest, Florida, 1980 and 1981. Data were derived from a strip transect (40 m X 500 m) located in both natural longleaf and planted slash pine habitats in each of the 8 compartments.

	% frequency of occurrence								
	Longleaf pine			Slash pine			Subtotal		
Species[a]	Breeding	Wintering	Subtotal	Breeding	Wintering	Subtotal	Breeding	Wintering	Total
Pine warbler	22 (53)[b]	20 (59)	21(112)	14 (11)	7 (10)	9 (21)	20 (64)	16 (69)	18(133)
Yellow-rumped warbler	0 (0)	14 (42)	8 (42)	0 (0)	27 (39)	17 (39)	0 (0)	19 (81)	11 (81)
Brown-headed nuthatch	14 (35)	5 (14)	9 (49)	13 (10)	0 (0)	4 (10)	14 (45)	3 (14)	8 (59)
American robin	0 (0)	8 (22)	4 (22)	0 (0)	26 (37)	16 (37)	0 (0)	14 (59)	8 (59)
Red-cockaded woodpecker	11 (27)	4 (13)	7 (40)	3 (2)	1 (2)	2 (4)	9 (29)	3 (15)	6 (44)
Sedge wren	0 (0)	11 (32)	6 (32)	0 (0)	6 (9)	4 (9)	0 (0)	9 (41)	5 (41)
Red-bellied woodpecker	7 (17)	<1 (2)	4 (19)	16 (13)	0 (0)	6 (13)	9 (30)	<1 (2)	4 (32)
Bachman's sparrow	9 (23)	2 (6)	5 (29)	1 (1)	<1 (1)	<1 (2)	7 (24)	2 (7)	4 (31)
House wren	0 (0)	7 (19)	4 (19)	0 (0)	8 (11)	5 (11)	0 (0)	7 (30)	4 (30)
Great crested flycatcher	8 (19)	0 (0)	4 (19)	12 (10)	0 (0)	4 (10)	9 (29)	0 (0)	4 (29)
Ruby-crowned kinglet	0 (0)	3 (9)	2 (9)	0 (0)	7 (10)	4 (10)	0 (0)	4 (19)	3 (19)
Chipping sparrow	0 (0)	6 (17)	3 (17)	0 (0)	1 (2)	<1 (2)	0 (0)	4 (19)	3 (19)
White-throated sparrow	0 (0)	6 (18)	3 (18)	0 (0)	0 (0)	0 (0)	0 (0)	4 (18)	2 (18)
Northern bobwhite	6 (14)	0 (0)	3 (14)	0 (0)	0 (0)	0 (0)	4 (14)	0 (0)	2 (14)
Summer tanager	3 (7)	0 (0)	1 (7)	8 (6)	0 (0)	3 (6)	4 (13)	0 (0)	2 (13)
Yellow-bellied sapsucker	0 (0)	3 (9)	2 (9)	0 (0)	<1 (1)	<1 (1)	0 (0)	2 (10)	1 (10)
Blue jay	2 (5)	0 (0)	<1 (5)	5 (4)	0 (0)	2 (4)	3 (9)	0 (0)	1 (9)
American crow	<1 (1)	0 (0)	<1 (1)	9 (7)	<1 (1)	4 (8)	2 (8)	<1 (1)	1 (9)
Eastern bluebird	1 (3)	2 (6)	2 (9)	0 (0)	0 (0)	0 (0)	<1 (3)	1 (6)	1 (9)
Rufous-sided towhee	<1 (2)	<1 (1)	<1 (3)	3 (2)	3 (4)	3 (6)	1 (4)	1 (5)	1 (9)
Red-headed woodpecker	2 (6)	0 (0)	1 (6)	1 (1)	0 (0)	<1 (1)	2 (7)	0 (0)	<1 (7)
Blue-gray gnatcatcher	2 (6)	<1 (1)	1 (7)	0 (0)	0 (0)	0 (0)	2 (6)	<1 (1)	<1 (7)
Eastern phoebe	0 (0)	2 (5)	<1 (5)	0 (0)	<1 (1)	<1 (1)	0 (0)	1 (6)	<1 (6)
Swamp sparrow	0 (0)	2 (6)	1 (6)	0 (0)	0 (0)	0 (0)	0 (0)	1 (6)	<1 (6)
Downy woodpecker	0 (0)	1 (3)	<1 (3)	1 (1)	0 (0)	<1 (1)	<1 (1)	<1 (3)	<1 (4)
Pileated woodpecker	<1 (2)	0 (0)	<1 (2)	3 (2)	0 (0)	<1 (2)	1 (4)	0 (0)	<1 (4)
Eastern wood-pewee	2 (4)	0 (0)	<1 (4)	0 (0)	0 (0)	0 (0)	1 (4)	0 (0)	<1 (4)
Carolina wren	0 (0)	<1 (2)	<1 (2)	1 (1)	<1 (1)	<1 (2)	<1 (1)	<1 (3)	<1 (4)
Solitary vireo	0 (0)	0 (0)	0 (0)	0 (0)	3 (4)	2 (4)	0 (0)	<1 (4)	<1 (4)
Palm warbler	0 (0)	0 (0)	0 (0)	0 (0)	3 (4)	2 (4)	0 (0)	<1 (4)	<1 (4)
Blue grosbeak	2 (4)	0 (0)	<1 (4)	0 (0)	0 (0)	0 (0)	1 (4)	0 (0)	<1 (4)
Eastern kingbird	1 (3)	0 (0)	<1 (3)	0 (0)	0 (0)	0 (0)	<1 (3)	0 (0)	<1 (3)
Fish crow	<1 (2)	0 (0)	<1 (2)	1 (1)	0 (0)	<1 (1)	<1 (3)	0 (0)	<1 (3)
Tufted titmouse	0 (0)	0 (0)	0 (0)	4 (3)	0 (0)	1 (3)	<1 (3)	0 (0)	<1 (3)
Common yellowthroat	0 (0)	<1 (1)	<1 (1)	1 (1)	<1 (1)	<1 (2)	<1 (1)	<1 (2)	<1 (3)
Wood duck	<1 (2)	0 (0)	<1 (2)	0 (0)	0 (0)	0 (0)	<1 (2)	0 (0)	<1 (2)
Wild turkey	<1 (1)	0 (0)	<1 (1)	1 (1)	0 (0)	<1 (1)	<1 (2)	0 (0)	<1 (2)
Hermit thrush	0 (0)	<1 (1)	<1 (1)	0 (0)	<1 (1)	<1 (1)	0 (0)	<1 (2)	<1 (2)
Northern mockingbird	0 (0)	0 (0)	0 (0)	0 (0)	1 (2)	<1 (2)	0 (0)	<1 (2)	<1 (2)
Northern cardinal	<1 (2)	0 (0)	<1 (2)	0 (0)	0 (0)	0 (0)	<1 (2)	0 (0)	<1 (2)
Song sparrow	0 (0)	1 (2)	<1 (2)	0 (0)	0 (0)	0 (0)	0 (0)	<1 (2)	<1 (2)
Common grackle	<1 (1)	0 (0)	<1 (1)	1 (1)	0 (0)	<1 (1)	1 (2)	0 (0)	<1 (2)
Red-shouldered hawk	0 (0)	0 (0)	0 (0)	0 (0)	<1 (1)	<1 (1)	0 (0)	<1 (1)	<1 (1)
Mourning dove	0 (0)	0 (0)	0 (0)	0 (0)	<1 (1)	<1 (1)	0 (0)	<1 (1)	<1 (1)
Yellow-billed cuckoo	0 (0)	0 (0)	0 (0)	1 (1)	0 (0)	<1 (1)	<1 (1)	0 (0)	<1 (1)
Barred owl	0 (0)	0 (0)	0 (0)	0 (0)	<1 (1)	<1 (1)	0 (0)	<1 (1)	<1 (1)
Chuck-will's-widow	0 (0)	0 (0)	0 (0)	1 (1)	0 (0)	<1 (1)	<1 (1)	0 (0)	<1 (1)
Hairy woodpecker	0 (0)	<1 (1)	<1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	<1 (1)	<1 (1)
Carolina chickadee	<1 (1)	0 (0)	<1 (1)	0 (0)	0 (0)	0 (0)	<1 (1)	0 (0)	<1 (1)
Brown thrasher	<1 (1)	0 (0)	<1 (1)	0 (0)	0 (0)	0 (0)	<1 (1)	0 (0)	<1 (1)
Northern parula	<1 (1)	0 (0)	<1 (1)	0 (0)	0 (0)	0 (0)	<1 (1)	0 (0)	<1 (1)
Field sparrow	0 (0)	0 (0)	0 (0)	0 (0)	<1 (1)	<1 (1)	0 (0)	<1 (1)	<1 (1)
Orchard oriole	<1 (1)	0 (0)	<1 (1)	0 (0)	0 (0)	0 (0)	<1 (1)	0 (0)	<1 (1)
Total number of birds	100(243)	100(291)	100(534)	100 (80)	100(145)	100(225)	100(323)	100(436)	100(759)
Total number of species	27	24	43	21	23	37	33	32	53

[a] After Eisenmann (1982).

[b] Numbers in parentheses represent number of birds observed.

type, compartment, season, or year, the 5 most frequently observed species were the pine warbler (18%), yellow-rumped warbler (11%), brown-headed nuthatch (8%), American robin (8%), and red-cockaded woodpecker (6%). Twenty-seven (51%) of the species observed were year-round residents, 11 (21%) were summer residents, and 15 (28%) were winter residents (Appendix A.1). The density of birds observed -- habitat types, seasons, and years combined, was 118.6 birds/km^2 (0.5 birds/acre).

Habitats.--Forty-three species of birds, totaling 534 individuals, were observed in natural longleaf pine habitat (Table 3). Of these, the 5 most frequently observed species were the pine warbler (21%), brown-headed nuthatch (9%), yellow-rumped warbler (8%), red-cockaded woodpecker (7%), and sedge wren (6%). In comparison, 37 species, totaling 225 individuals, were observed in planted slash pine habitat, the 5 most common being the yellow- rumped warbler (17%), American robin (16%), pine warbler (9%), red-bellied woodpecker (6%), and house wren (5%).

Sixteen bird species were observed only in natural longleaf pine, 10 were observed only in planted slash pine, and 27 were observed in both habitat types (Table 3). Species observed exclusively in longleaf pine were the white-throated sparrow, northern bobwhite, eastern bluebird, blue-gray gnatcatcher, swamp sparrow, eastern wood-pewee, blue grosbeak, eastern kingbird, wood duck, northern cardinal, song sparrow, hairy woodpecker, Carolina chickadee, brown thrasher, northern parula, and orchard oriole. Species observed exclusively in slash pine were the solitary vireo, palm warbler, tufted titmouse, northern mockingbird, red-shouldered hawk, mourning dove, yellow-billed cuckoo, barred owl, chuck-will's widow, and field sparrow.

The density of birds observed within natural longleaf pine habitat, seasons and years combined, was 166.9 birds/km^2 (0.7 birds/acre). The comparable density for planted slash pine habitat was 70.3 birds/km^2 (0.2 birds/acre).

Mean bird density, mean species richness, and mean species diversity were substantially greater for natural longleaf than planted slash pine during each of the 4 sampling periods (Table 4). Differences in mean biomass between habitat types, however, were variable among sampling periods (Table 4).

Because significant ($P < 0.05$) habitat-compartment interactions occurred for both species richness and species diversity (Table 5), further analysis of these parameters with respect to habitat type was precluded. However, no significant ($P > 0.05$) habitat interactions occurred for either bird density or biomass, thereby allowing comparisons of these 2 parameters between habitat types to be made irrespective of compartment, season, or year. These comparisons showed that bird density differed ($P < 0.05$) between habitat types, with the estimated median value being greater for natural longleaf than for planted slash pine (Table 6). In contrast, biomass did not differ ($P > 0.05$) between the 2 habitat types.

Seasons.--Thirty-three species of birds, totaling 323 individuals, were observed during the breeding season (Table 3); the 5 most frequently observed species were the pine warbler (20%), brown-headed nuthatch (14%), red-bellied woodpecker (9%), red-cockaded woodpecker (9%), and great crested flycatcher (9%). In comparison, 32 species, totaling 436 individuals, were observed during the wintering season, the 5 most common being the yellow-rumped warbler (19%), pine warbler (16%), American robin (14%), sedge wren (9%), and house wren (7%). Twenty bird species were observed only during the breeding season, 21 only during the wintering season, and 12 during both seasons (Table 3). Densities of breeding and wintering birds, habitat types and years combined, were 100.9 birds/km^2 (0.4 birds/acre) and 136.2 birds/km^2 (0.6 birds/acre), respectively.

Significant ($P < 0.05$) season-year interactions occurred for each parameter tested -- density, species richness, species diversity, and biomass (Table 5). Consequently, further analyses were restricted to seasonal comparisons within years. These comparisons revealed that bird density differed ($P < 0.05$) between seasons in both 1980 and 1981 (Table 7). In 1980, the estimated median value for bird density was greater for wintering than breeding populations, whereas, in 1981, the reverse trend occurred.

Table 4. Density, species richness (number of species), species diversity, and biomass of birds observed per transect within natural longleaf and planted slash pine habitats during breeding (May) and wintering (December) censuses, Apalachicola National Forest, Florida, 1980 and 1981. All means were based on data derived from 8 transects.

	Longleaf pine				Slash pine			
	1980		1981		1980		1981	
Parameter	Breeding	Wintering	Breeding	Wintering	Breeding	Wintering	Breeding	Wintering
Density (birds/km^2)								
Mean	147.5	260.0	156.2	103.8	33.8	141.2	66.2	40.0
SD	63.9	147.4	97.2	186.5	25.6	195.8	40.0	36.2
Species richness								
Mean	6.8	6.9	7.0	3.0	2.1	4.2	3.8	1.6
SD	3.0	2.2	3.5	2.7	1.2	2.8	1.4	0.7
Species diversity (H')								
Mean	1.6	1.5	1.6	0.7	0.7	1.0	1.2	0.3
SD	0.6	0.2	0.5	0.7	0.4	0.7	0.4	0.4
Biomass (kg)								
Mean	1.1	0.6	0.8	0.2	0.2	0.6	1.1	0.1
SD	1.3	0.5	0.7	0.3	0.2	0.8	1.6	0.2

Table 5. Results of analysis of variance procedures for bird population parameters, Apalachicola National Forest, Florida, 1980 and 1981.

		Parameter			
Factor[a]	df	Density (birds/km^2)[b]	Species richness (number of species)[b]	Species diversity (H')	Biomass (kg)[b]
H	1	*[c]	*	*	NS
C	7	NS	*	*	NS
H*C	7	NS	*	*	NS
S	1	NS	*	*	*
H*S	1	NS	NS	NS	NS
Y	1	NS	*	*	NS
H*Y	1	NS	NS	NS	NS
S*Y	1	*	*	*	*

[a] H = habitat; C = compartment; S = season; Y = year.

[b] Analysis was executed on log (base 10) transformed data.

[c] Significance of F values: * = $P < 0.05$; NS = $P > 0.05$.

Although species richness, species diversity, and biomass did not differ ($P > 0.05$) between breeding and wintering populations in 1980, they did differ ($P < 0.05$) in 1981 (Table 7). The estimated median values for species richness and biomass were greater for the breeding than the wintering population in 1981. Similarly, the actual mean value for species diversity was greater for the breeding than the wintering population in 1981.

Herpetofauna

A total of 726 amphibians and reptiles, representing 39 species, was captured during spring and fall trapping periods in 1980 and 1981 (Table 8, Appendices B.1-B.3). Irrespective of habitat type, compartment, season, or year, the 5 most frequently captured species were the ground skink (33%), six-lined racerunner (10%), racer (7%), scarlet snake (5%), and smooth earth snake (5%). Twenty-three (59%) of the 39 herpetofaunal species captured were terrestrial, 8 (20%) were semi-aquatic, 4 (10%) were arboreal, 3 (8%) were aquatic, and 1 (3%) was fossorial (Appendix B.1).

Habitats.--Thirty-five species of herpetofauna, totaling 377 individuals, were captured in natural longleaf pine habitat (Table 8). Of these, the 5 most frequently captured species were the ground skink (27%), six-lined racerunner (12%), scarlet snake (8%), racer (5%), and smooth earth snake (4%). In comparison, 32 species, totaling 349 individuals, were captured in planted slash pine habitat, the 5 most common being the ground skink (40%), racer (8%), six-lined racerunner (7%), green anole (7%), and smooth earth snake (6%).

Table 6. Comparative analysis of bird density and biomass for natural longleaf and planted slash pine habitats, spring and fall censuses combined, Apalachicola National Forest, Florida, 1980 and 1981. All medians were based on data derived from 32 transects.

Parameter	Longleaf pine	Slash pine	F-test[a]
Density (birds/km^2)[b]			
Median	108.5	39.2	*
Range (68%)	36.4-319.5	12.0-123.6	
Biomass (kg)[b]			
Median	0.6	0.4	NS
Range (68%)	0.1-1.3	0.0-1.1	

[a] * = $P < 0.05$; NS = $P > 0.05$.

[b] Analysis was executed on log (base 10) transformed data.

Table 7. Comparative analysis of seasonal aspects of bird populations, Apalachicola National Forest, Florida, 1980 and 1981. All medians/means were based on data derived from 16 transects.

Parameter	1980 Breeding season	1980 Wintering season	1980 F-test[a]	1981 Breeding season	1981 Wintering season	1981 F-test[a]
Density ($birds/km^2$)[b]						
Median	51.1	124.5	*	81.7	34.8	*
Range (68%)	11.7-212.6	39.2-390.8		34.8-190.3	11.2-103.8	
Species richness (number of species)[b]						
Median	3.5	4.9	NS	4.7	1.9	*
Range (68%)	1.3-7.8	2.5-8.9		2.6-8.2	0.8-3.7	
Species diversity (H')						
Mean	1.2	1.3	NS	1.4	0.5	*
SD	0.7	0.6		0.5	0.6	
Biomass (kg)[b]						
Median	0.5	0.5	NS	0.7	0.2	*
Range (68%)	0.0-1.3	0.1-1.2		0.1-1.8	0.0-0.4	

[a] * = $P < 0.05$; NS = $P > 0.05$.

[b] Analysis was executed on log (base 10) transformed data.

Seven herpetofaunal species were captured only in natural longleaf pine, 4 were captured only in planted slash pine, and 28 were captured in both habitat types (Table 8). Those species captured exclusively in longleaf pine were the oak toad, slender glass lizard, eastern mud turtle, five-lined skink, eastern hognose snake, southern hognose snake, and pine snake. Those species captured exclusively in slash pine were the mole salamander, little grass frog, southern chorus frog, and brown snake.

The mean number of amphibians and reptiles captured per array within natural longleaf pine during the spring of 1980 was nearly twice that captured within planted slash pine (Table 9). Differences in the mean abundance of herpetofauna between habitats during the fall of 1980 and the spring and fall of 1981 were much less pronounced, but favored slash pine. Mean species richness and mean species diversity were greater in longleaf than slash pine during the spring and fall of 1980 and the spring of 1981, whereas the reverse relationship occurred in the fall of 1981 (Table 9). Mean herpetofaunal biomass was greater in longleaf pine during the spring of 1980 and 1981, and greater in slash pine during the fall of 1980 and 1981 (Table 9).

No significant ($P > 0.05$) interaction between habitat and compartment effects, habitat and season effects, or habitat and year effects was determined for any of the parameters tested -- abundance, species richness, species diversity, and biomass (Table 10). As a result, statistical comparisons between natural longleaf and planted slash pine habitats were made irrespective of compartment, season, or year. These comparisons showed that neither the number of individuals captured nor the number of species captured differed ($P > 0.05$) between habitat types; however, the actual mean value for species diversity and the estimated median value for biomass were higher for natural longleaf than planted slash pine (Table 11).

<u>Seasons</u>.--Thirty-six species of herpetofauna, totaling 503 individuals, were captured during the spring (Table 8); the 5 most frequently captured species were the ground skink (35%), six-lined racerunner (12%), scarlet snake (7%), racer (6%), and broadhead skink (5%). In contrast, 33 species, totaling 223 individuals, were captured in fall, the 5 most common being the ground skink (30%), smooth earth snake (10%), racer (8%), green anole (7%), and dwarf salamander (5%).

Six herpetofaunal species were captured only during spring, 3 were captured only during fall, and 30 were captured during both seasons (Table 8). Those species captured exclusively during spring were the eastern mud turtle, mole salamander, southern chorus frog, eastern and southern hognose snake, and brown snake. Those species captured exclusively during fall were the little grass frog, five-lined skink, and pine snake. No significant ($P > 0.05$)

Table 8. Relative frequency of occurrence of herpetofaunal species captured during spring (March-May) and fall (September-October) censuses, Apalachicola National Forest, Florida, 1980 and 1981. Data were derived from a 16-trap array operated in both natural longleaf and planted slash pine habitats in each of the 8 compartments.

	% frequency of occurrence								
	Longleaf pine			Slash pine			Subtotal		
Species[a/]	Spring	Fall	Subtotal	Spring	Fall	Subtotal	Spring	Fall	Total
Ground skink	27 (74)[b/]	28 (29)	27(103)	44(100)	32 (39)	40(139)	35(174)	30 (68)	33(242)
Six-lined racerunner	15 (41)	6 (6)	12 (47)	9 (20)	2 (3)	7 (23)	12 (61)	4 (9)	10 (70)
Racer	6 (17)	3 (3)	5 (20)	7 (15)	12 (14)	8 (29)	6 (32)	8 (17)	7 (49)
Scarlet snake	11 (31)	<1 (1)	8 (32)	2 (5)	0 (0)	1 (5)	7 (36)	<1 (1)	5 (37)
Smooth earth snake	2 (5)	10 (10)	4 (15)	4 (8)	10 (12)	6 (20)	3 (13)	10 (22)	5 (35)
Green anole	3 (7)	2 (2)	2 (9)	4 (10)	12 (14)	7 (24)	3 (17)	7 (16)	5 (33)
Broadhead skink	5 (15)	<1 (1)	4 (16)	4 (8)	0 (0)	2 (8)	5 (23)	<1 (1)	3 (24)
Eastern narrowmouth toad	3 (8)	7 (7)	4 (15)	2 (5)	2 (3)	2 (8)	3 (13)	4 (10)	3 (23)
Dwarf salamander	1 (4)	5 (5)	2 (9)	2 (5)	5 (6)	3 (11)	2 (9)	5 (11)	3 (20)
Southern leopard frog	3 (8)	7 (7)	4 (15)	<1 (1)	2 (2)	<1 (3)	2 (9)	4 (9)	2 (18)
Southern toad	2 (5)	0 (0)	1 (5)	5 (11)	<1 (1)	3 (12)	3 (16)	<1 (1)	2 (17)
Eastern ribbon snake	1 (4)	0 (0)	1 (4)	4 (9)	2 (2)	3 (11)	3 (13)	<1 (2)	2 (15)
Pigmy rattlesnake	1 (3)	4 (4)	2 (7)	<1 (1)	4 (5)	2 (6)	<1 (4)	4 (9)	2 (13)
Eastern glass lizard	<1 (2)	2 (2)	1 (4)	2 (4)	3 (4)	2 (8)	1 (6)	3 (6)	2 (12)
Eastern coral snake	1 (3)	4 (4)	2 (7)	<1 (2)	2 (3)	1 (5)	<1 (5)	3 (7)	2 (12)
Slimy salamander	3 (8)	<1 (1)	2 (9)	<1 (2)	0 (0)	<1 (2)	2 (10)	<1 (1)	2 (11)
Southeastern five-lined skink	1 (4)	3 (3)	2 (7)	<1 (2)	<1 (1)	<1 (3)	1 (6)	2 (4)	1 (10)
Eastern fence lizard	<1 (2)	4 (4)	2 (6)	1 (3)	<1 (1)	1 (4)	<1 (5)	2 (5)	1 (10)
Common garter snake	2 (6)	0 (0)	2 (6)	1 (3)	<1 (1)	1 (4)	2 (9)	<1 (1)	1 (10)
Flatwoods salamander	<1 (2)	0 (0)	<1 (2)	1 (3)	2 (2)	1 (5)	<1 (5)	<1 (2)	<1 (7)
Oak toad	1 (4)	2 (2)	2 (6)	0 (0)	0 (0)	0 (0)	<1 (4)	<1 (2)	<1 (6)
Corn snake	1 (4)	<1 (1)	1 (5)	<1 (1)	0 (0)	<1 (1)	<1 (5)	<1 (1)	<1 (6)
Ornate chorus frog	<1 (1)	<1 (1)	<1 (2)	<1 (1)	2 (2)	<1 (3)	<1 (2)	1 (3)	<1 (5)
Eastern box turtle	<1 (1)	2 (2)	<1 (3)	<1 (2)	0 (0)	<1 (2)	<1 (3)	<1 (2)	<1 (5)
Slender glass lizard	1 (3)	2 (2)	1 (5)	0 (0)	0 (0)	0 (0)	<1 (3)	<1 (2)	<1 (5)
Southern cricket frog	<1 (1)	<1 (1)	<1 (2)	<1 (1)	<1 (1)	<1 (2)	<1 (2)	<1 (2)	<1 (4)
Eastern mud turtle	1 (4)	0 (0)	1 (4)	0 (0)	0 (0)	0 (0)	<1 (4)	0 (0)	<1 (4)
Coachwhip	1 (3)	0 (0)	<1 (3)	0 (0)	<1 (1)	<1 (1)	<1 (3)	<1 (1)	<1 (4)
Ringneck snake	<1 (1)	<1 (1)	<1 (2)	0 (0)	<1 (1)	<1 (1)	<1 (1)	<1 (2)	<1 (3)
Scarlet kingsnake	<1 (1)	0 (0)	<1 (1)	<1 (1)	<1 (1)	<1 (2)	<1 (2)	<1 (1)	<1 (3)
Glossy crayfish snake	<1 (1)	<1 (1)	<1 (2)	<1 (1)	0 (0)	<1 (1)	<1 (2)	<1 (1)	<1 (3)
Mole salamander	0 (0)	0 (0)	0 (0)	<1 (2)	0 (0)	<1 (2)	<1 (2)	0 (0)	<1 (2)
Little grass frog	0 (0)	0 (0)	0 (0)	0 (0)	2 (2)	<1 (2)	0 (0)	<1 (2)	<1 (2)
Southern chorus frog	0 (0)	0 (0)	0 (0)	<1 (1)	0 (0)	<1 (1)	<1 (1)	0 (0)	<1 (1)
Five-lined skink	0 (0)	<1 (1)	<1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	<1 (1)	<1 (1)
Eastern hognose snake	<1 (1)	0 (0)	<1 (1)	0 (0)	0 (0)	0 (0)	<1 (1)	0 (0)	<1 (1)
Southern hognose snake	<1 (1)	0 (0)	<1 (1)	0 (0)	0 (0)	0 (0)	<1 (1)	0 (0)	<1 (1)
Pine snake	0 (0)	<1 (1)	<1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	<1 (1)	<1 (1)
Brown snake	0 (0)	0 (0)	0 (0)	<1 (1)	0 (0)	<1 (1)	<1 (1)	0 (0)	<1 (1)
Total number of amphibians and reptiles	100(275)	100(102)	100(377)	100(228)	100(121)	100(349)	100(503)	100(223)	100(726)
Total number of species	33	26	35	29	23	32	36	33	39

[a/]After Collins et al. (1982).

[b/]Numbers in parentheses represent number of amphibians and reptiles captured.

season-habitat interactions occurred for any of the 4 parameters tested. A significant ($P < 0.05$) interaction did occur, however, between season and year with respect to the number of individuals captured. Although this interaction was not significant ($P > 0.05$) for other parameters tested, 2 separate sets of statistical comparisons, 1 for each year of the study, were made in order to maintain consistency in data analysis. These comparisons showed that the abundance, species richness, and biomass of captured herpetofauna differed ($P < 0.05$) between seasons in both 1980 and 1981 (Table 12), with the estimated median value for each of these parameters being greater for spring than fall in both years. Species diversity differed ($P < 0.05$) between seasons in 1980, but not ($P > 0.05$) in 1981. Yet, in both years, the value for actual mean species diversity was greater for spring than fall.

Small Mammals

A total of 198 small mammals, representing 5 species, was captured during spring and fall of 1980 and 1981 (Table 13, Appendices C.1 and C.2). The species composition of the sample was: cotton mouse, 47%; cotton rat, 44%; least shrew, 8%; southern short-tailed shrew, 1%; and house mouse, 1%.

A steady decline in capture success occurred during the 2-year study period, with capture success being greatest in the spring of 1980 (3.4%) and least in the fall of 1981 (0.6%) (Appendices C.1 and C.2). Total capture success for the area, habitats, seasons, and years combined, was 1.6%.

Habitats.--Four species of small mammals, totaling 106 individuals, were captured in natural longleaf pine habitat (Table 13). The cotton rat was the most frequently captured (47%) species. In comparison, 4 species, totaling 92 individuals, were captured in planted slash pine habitat, with the cotton mouse being the most frequently captured (51%) species. The house mouse was captured only in natural longleaf pine, whereas

Table 9. Abundance, species richness (number of species), species diversity, and biomass of herpetofauna captured per array within natural longleaf and planted slash pine habitats during spring (March-May) and fall (September-October) censuses, Apalachicola National Forest, Florida, 1980 and 1981. All means were based on data derived from 8 arrays.

	Longleaf pine				Slash pine			
	1980		1981		1980		1981	
Parameter	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
Number of individuals								
Mean	16.4	6.6	18.0	6.1	9.4	8.8	19.1	6.4
SD	7.5	2.1	6.1	3.8	4.8	8.0	9.1	4.7
Species richness								
Mean	7.5	4.6	7.8	3.4	5.4	4.0	5.2	3.9
SD	3.2	1.7	1.7	1.8	2.4	2.3	1.7	2.3
Species diversity (H')								
Mean	1.6	1.3	1.6	0.9	1.4	1.0	1.0	1.2
SD	0.5	0.5	0.2	0.6	0.6	0.7	0.3	0.5
Biomass (g)								
Mean	351.8	64.8	403.5	126.8	110.5	137.4	180.5	138.9
SD	320.2	107.6	244.6	237.9	92.3	231.4	125.4	231.8

the southern short-tailed shrew was captured only in planted slash pine. Capture success in natural longleaf pine and planted slash pine, seasons and years combined, was 1.8% and 1.5%, respectively.

Mean capture success and mean biomass of small mammals were greater in natural longleaf than planted slash pine during spring and greater in planted slash pine than natural longleaf pine during fall of both 1980 and 1981 (Table 14). Mean species richness and mean species diversity were greater in longleaf than slash during the fall of 1980 and the spring of 1981 (Table 14); the reverse relationship occurred during the spring of 1980 and the fall of 1981.

Because a significant ($P < 0.05$) habitat-compartment interaction occurred for species richness (Table 15), further statistical analysis of this parameter was precluded. No significant ($P > 0.05$) habitat interactions occurred, however, for capture success, species diversity, or biomass. Thus, habitat comparisons of these 3 parameters were made irrespective of

Table 10. Results of analysis of variance procedures for herpetofaunal population parameters, Apalachicola National Forest, Florida, 1980 and 1981.

Factor[a]	df	Number of individuals[b]	Species richness (number of species)[b]	Species diversity (H')	Biomass (g)[b]
H	1	NS[c]	NS	*	*
C	7	NS	*	*	NS
H*C	7	NS	NS	NS	NS
S	1	*	*	*	*
H*S	1	NS	NS	NS	NS
Y	1	NS	NS	NS	NS
H*Y	1	NS	NS	NS	NS
S*Y	1	*	NS	NS	NS

[a] H = habitat; C = compartment; S = season; Y = year

[b] Analysis was executed on log (base 10) transformed data.

[c] Significance of F values: * = $P < 0.05$; NS = $P > 0.05$.

Table 11. Comparative analysis of herpetofaunal abundance, species richness (number of species), species diversity, and biomass for natural longleaf and planted slash pine habitats, spring and fall censuses combined, Apalachicola National Forest, Florida, 1980 and 1981. All medians/means were based on data derived from 32 transects.

Parameter	Longleaf pine	Slash pine	F-test[a]
Number of individuals [b]			
Median	9.5	8.2	NS
Range (68%)	4.4-19.8	3.2-19.0	
Species richness[b]			
Median	5.2	4.1	NS
Range (68%)	2.9-9.0	2.2-7.2	
Species diversity (H')			
Mean	1.4	1.1	*
SD	0.6	0.5	
Biomass (g)[b]			
Median	99.7	65.2	*
Range (68%)	21.4-451.4	14.5-281.1	

[a] * = $P < 0.05$; NS = $P > 0.05$.

[b] Analysis was executed on log (base 10) transformed data.

Table 12. Comparative analysis of seasonal aspects of herpetofaunal populations, Apalachicola National Forest, Florida, 1980 and 1981. All medians/means were based on data derived from 16 transects.

	1980			1981		
Parameter	Spring	Fall	F-test[a]	Spring	Fall	F-test[a]
Number of individuals						
Median	10.8	6.3	*	17.1	5.0	*
Range (68%)	5.2-21.7	3.0-12.5		10.8-26.8	2.1-10.7	
Species richness (number of species)[b]						
Median	5.9	3.9	*	6.2	3.2	*
Range (68%)	3.2-10.1	2.2-6.6		4.3-8.9	1.7-5.6	
Species diversity (H')[c]						
Mean	1.5	1.1	*	1.3	1.0	NS
SD	0.6	0.6		0.4	0.6	
Biomass (g)[b]						
Median	134.3	32.9	*	189.0	50.0	*
Range (68%)	45.9-389.6	5.8-168.6		54.0-656.2	12.1-197.3	

[a] * = $P < 0.05$; NS = $P > 0.05$.

[b] Analysis was executed on log (base 10) transformed data.

Table 13. Relative frequency of occurrence of small mammal species captured during spring (May) and fall (October) censuses, Apalachicola National Forest, Florida, 1980 and 1981. Data were derived from a 375-m, 25-station transect, with 1 live trap and 1 snap trap per station, operated in both natural longleaf and planted slash pine habitats in each of the 8 compartments.

	% frequency of occurrence								
	Longleaf pine			Slash pine			Subtotal		
Species[a/]	Spring	Fall	Subtotal	Spring	Fall	Subtotal	Spring	Fall	Total
Cotton mouse	38 (29)[b/]	57 (17)	43 (46)	56 (31)	43 (16)	51 (47)	46 (60)	49 (33)	47 (93)
Cotton rat	56 (42)	27 (8)	47 (50)	38 (21)	43 (16)	40 (37)	48 (63)	36 (24)	44 (87)
Least shrew	5 (4)	16 (5)	9 (9)	6 (3)	11 (4)	8 (7)	5 (7)	13 (9)	8 (16)
Southern short-tailed shrew	0 (0)	0 (0)	0 (0)	0 (0)	3 (1)	1 (1)	0 (0)	2 (1)	< 1 (1)
House mouse	1 (1)	0 (0)	< 1 (1)	0 (0)	0 (0)	0 (0)	< 1 (1)	0 (0)	< 1 (1)
Total number of small mammals	100 (76)	100 (30)	100(106)	100 (55)	100 (37)	100 (92)	100(131)	100 (67)	100(198)
Total number of species	4	3	4	3	4	4	4	4	5

a/ After Jones et al. (1982).

b/ Numbers in parentheses represent number of small mammals captured.

compartment, season, or year. These comparisons showed that neither capture success, species diversity, nor biomass differed ($P > 0.05$) between natural longleaf and planted slash pine habitat types (Table 16).

Seasons.--Four species of small mammals, totaling 131 individuals, were captured during spring; the cotton rat was the most frequently captured (48%) species. In comparison, 4 species, totaling 67 individuals, were captured during fall, with the cotton mouse being the most frequently captured (49%) species. The house mouse was captured only during spring, whereas the southern short-tailed shrew was captured only during fall. Spring capture success was 2.1%; fall capture success was 1.1%.

No significant ($P > 0.05$) interactions occurred between season and habitat or between season and year for any population parameter (Table 15). Consequently, statistical comparisons between spring and fall were made irrespective of habitat or year. These comparisons showed that each of the 4 parameters -- capture success, species richness, species

Table 14. Capture success, species richness, species diversity, and biomass of small mammals trapped per transect within natural longleaf and planted slash pine habitats during spring (May) and fall (October) censuses, Apalachicola National Forest, Florida, 1980 and 1981. All means were based on data derived from 8 transects.

	Longleaf pine				Slash pine			
	1980		1981		1980		1981	
Parameter	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
Capture success (%)								
Mean	3.8	1.5	1.3	0.5	3.1	1.8	0.5	0.7
SD	3.6	1.4	1.2	0.4	2.1	1.7	0.5	0.7
Species richness (number of species)								
Mean	1.6	1.2	1.5	0.8	1.9	1.1	0.8	0.9
SD	1.1	0.9	1.2	0.5	1.1	1.0	0.7	0.8
Species diversity (H')								
Mean	0.4	0.2	0.3	0.0	0.6	0.1	0.1	0.3
SD	0.4	0.3	0.4		0.4	0.1	0.3	0.4
Biomass (g)								
Mean	423.0	117.5	130.2	31.4	264.1	192.8	70.8	38.4
SD	428.2	77.4	151.9	37.9	188.0	265.5	78.6	43.0

Table 15. Results of analysis of variance procedures for small mammal population parameters, Apalachicola National Forest, Florida, 1980 and 1981.

Factor[a]	df	Capture success (%)[b]	Species richness (number of species)[c]	Species diversity (H')	Biomass (g)[c]
H	1	NS[d]	NS	NS	NS
C	7	*	*	NS	*
H*C	7	NS	*	NS	NS
S	1	*	*	*	*
H*S	1	NS	NS	NS	NS
Y	1	*	*	*	*
H*Y	1	NS	NS	NS	NS
S*Y	1	NS	NS	NS	NS

a/ H = habitat; C = compartment; S = season; Y = year.

b/ Analysis was executed on arcsine-square root transformed data.

c/ Analysis was executed on log (base 10) transformed data.

d/ Significance of F values: * = $P < 0.05$; NS = $P > 0.05$.

diversity, and biomass -- differed ($P < 0.05$) between seasons (Table 17). Estimated median values for capture success, species richness, and biomass were greater for spring than fall. Similarly, the actual mean value for species diversity was greater for spring than fall.

DISCUSSION

Birds

In general, there is a paucity of information regarding year-round bird populations in longleaf and slash pine habitats. Most studies have concentrated on breeding (Johnston and Odum 1956, Dickson et al. 1980) or wintering populations (Emlen 1978, Engstrom and James 1981), but rarely on both (Repenning and Labisky 1985). The total of 53 species recorded on the Apalachicola National Forest in this study, however, was comparable to year-round species accounts reported for similar pine habitats in Florida: 49 species (Hirth and Marion 1979), 53 species-- also on the Apalachicola National Forest (Repenning and Labisky 1985), 69 species (Engstrom 1980a, 1980b), and 78 species (Rowse 1980). Thus, pine habitats

Table 16. Comparative analysis of small mammal capture success, species diversity, and biomass for natural longleaf and planted slash pine habitats, spring and fall censuses combined, Apalachicola National Forest, Florida, 1980 and 1981. All medians were based on data derived from 32 transects; the means for H' were based on data from 27 and 23 transects in longleaf and slash pine, respectively.

Parameter	Longleaf pine	Slash pine	F-tests[a]
Capture success (%)[b]			
Median	1.4	1.2	NS
Range (68%)	0.2-3.5	0.2-3.0	
Species diversity (H')			
Mean	0.2	0.3	NS
SD	0.4	0.3	
Biomass (g)[c]			
Median	46.9	32.2	NS
Range (68%)	4.8-394.2	2.1-355.4	

a/ * = $P < 0.05$; NS = $P > 0.05$.

b/ Analysis was executed on arcsine-square root transformed data.

c/ Analysis was executed on log (base 10) transformed data.

Table 17. Comparative analysis of seasonal aspects of small mammal populations, Apalachicola National Forest, Florida, 1980 and 1981. All medians were based on data derived from 32 transects; the means for H' were based on data from 26 and 24 transects in spring and fall, respectively.

Parameter	Spring	Fall	F-tests[a]
Capture success (%)[b]			
Median	1.7	0.9	*
Range (68%)	0.3-4.3	0.2-2.2	
Species richness (number of species)[c]			
Median	1.2	0.8	*
Range (68%)	0.4-2.5	0.2-1.8	
Species diversity (H')			
Mean	0.4	0.1	*
SD	0.4	0.2	
Biomass (g)[c]			
Median	62.1	24.2	*
Range (68%)	5.5-610.8	2.0-212.4	

in Florida support a relatively diverse group of bird species on an annual basis.

Habitats.--Bird density differed ($P < 0.05$) between habitat types on the Apalachicola National Forest, with more birds being observed in natural longleaf than in planted slash pine stands. The differential avian use of the 2 pine habitats is probably attributable to differences in vegetative structure and/or stand age. Harris et al. (1975) and Repenning and Labisky (1985) found that the abundance, species richness, and species diversity of birds in north Florida were greater in mature natural stands of longleaf pine than in younger stands of planted slash pine, the differences being due to the higher degree of structural diversity exhibited by the longleaf stands. Similarly, Noble and Hamilton (1976) concluded that mature natural pine stands in southeastern Louisiana supported more numbers and species of birds than younger loblolly pine (*P. taeda*) plantations because the older stands had a more abundant and diversified vegetative strata. Although the vegetation within the pine habitats censused on the Apalachicola National Forest was not evaluated empirically, natural longleaf stands appeared structurally more diverse than planted slash pine stands. Not only were stands of natural longleaf greater in age than those of planted slash pine, but they seemed also to offer a set of vegetative features not available in the younger slash pine stands (e.g., snags, thick ground cover, and an open canopy). Thus, mature natural stands of longleaf, due to their structural diversity, are seemingly capable of supporting a greater abundance of birds than younger stands of planted slash pine.

Seasons.--Wintering bird populations in the southeastern United States typically are larger than breeding bird populations (Noble and Hamilton 1976, Ortego et al. 1978, Dickson and Noble 1978, Harris 1980, Rowse 1980, Repenning and Labisky 1985). Findings from the Apalachicola National Forest supported this generalization in 1980, when the density of wintering birds exceeded that of breeding birds. In 1981, however, the trend was reversed, as the density of breeding birds exceeded that of wintering birds. This between-year inconsistency in seasonal bird populations on the Apalachicola National Forest was due primarily to the scarcity and/or absence of several common winter migrants in 1981 (e.g., American robin, ruby-crowned kinglet, sedge wren, and house wren). Notably, low populations of wintering birds were reported throughout Florida in 1981 (Stevenson 1982). The relatively low density, species richness, species diversity, and biomass of birds recorded during the winter of 1981 was very likely related to a reduced availability of food resources. Rainfall was markedly below average throughout the spring, summer, and fall of 1981, resulting in severe drought conditions throughout Florida. This drought condition undoubtedly depressed fruit and seed production, thereby reducing the potential food supply for the contingent of birds that normally winter in Florida. Findings for the Apalachicola National Forest strongly suggest that mature stands of natural longleaf pine represent an important habitat for breeding and wintering bird populations. Consequently, maintenance of the current avifaunal community in north Florida will be dependent, in part, on the future availability of natural stands of longleaf pine.

Herpetofauna

The catalog of herpetofaunal species presented for the Apalachicola National Forest does not constitute a complete inventory of all amphibians and reptiles occurring in the Apalachicola River drainage basin. Means (1977) reported that the Apalachicola basin supported at least 108 herpetofaunal species; only 39 species were recorded in this study. One possible explanation for the reduced number of herpetofaunal species captured on the Apalachicola National Forest centers on the drift-fence/funnel-trap array system utilized in the study. The technique has an inherent bias in that it tends to select for small, ground-dwelling animals (Campbell and Christman 1977). Other animals, such as large snakes or turtles, will not fit in the traps, and, consequently, are not captured. Arboreal species, although captured occasionally, also are selected against. Furthermore, because the arrays were not located near creeks, cypress ponds, or other areas of standing water, many aquatic species were not represented. Nonetheless, standardized drift-fence trapping systems have been proven effective in providing data on relative abundance and diversity of herpetofaunal communities (Gibbons and Semlitsch 1981, Campbell and Christman 1977).

Habitats.--It is axiomatic, within certain limitations, that a positive correlation exists between the diversity of habitat and the diversity of vertebrate fauna. Yet, despite the homogeneity often associated with southeastern pine-flatwood monocultures (Williams 1972), findings for the Apalachicola National Forest indicated that longleaf and slash pine habitats are capable of supporting a relatively high diversity of herpetofauna (39 species) when compared with seemingly more diverse habitats within Florida. For example, Campbell and Christman (1977), operating drift-fence arrays in 18 different habitat types, collected 43 species of reptiles and amphibians. Similarly, using drift-fence arrays in north Florida, White (1983) found 29 species of herpetofauna along a slash pine/meadow ecotone, Vickers et al. (1985) reported 38 species from diverse cypress pond/flatwood habitats, and Enge and Marion (1986) captured 45 species on a pine flatwoods site. The relatively high species richness found in pine habitats on the Apalachicola National Forest probably was due to between-stand heterogeneity, as substantial differences in habitat components such as stand age, soil type, canopy closure, stand density, and ground cover structure and composition occurred among the 16 herpetofaunal trapping sites.

Neither the abundance nor species richness of herpetofauna on the Apalachicola National Forest differed ($P > 0.05$) between natural longleaf and planted slash pine habitat types, which suggested that pine-type had little influence on the species composition and distribution of herpetofaunal communities. Caution must be exercised, however, when making such a broad generalization about such a diverse and complex group of animals. Although habitats are generally defined and characterized by their major vegetative components, microhabitats play a dominant role in determining the presence, and abundance, of herpetofauna (Kiester 1971, Inger and Colwell 1977). An increase in ground-level structural diversity (e.g., fallen logs and branches, stumps, rocks) provides a greater number of available microhabitats for wildlife (Maser et al. 1979), and partitioning of these available microhabitats permits the coexistance of a greater number of species. Therefore, any attempt to determine the suitability of a given area to herpetofauna should include an assessment of available microhabitats, such as ground-level diversity, litter depth and composition, and proximity to aquatic areas. Consequently, the inference that herpetofaunal communities do not differ between natural longleaf and planted slash pine habitats may be premature, inasmuch as variables affecting microhabitat diversity were not considered in this study. Clearly, a research design that is sensitive to "fine-grained" habitat variables is needed to evaluate the relative value of longleaf and slash pine habitats to herpetofauna.

Seasons.--The number of amphibians and reptiles captured on the Apalachicola National Forest differed ($P < 0.05$) between seasons in both 1980 and 1981, the abundance of herpetofauna being greater during spring than fall. Given the ectothermic physiology of these animals, such seasonal fluctuations in herpetofaunal populations are not surprising. Other studies have shown that the abundance, distribution, dispersal, and breeding activity of various herpetofaunal species is influenced frequently by climate-related environmental factors such as temperature and rainfall (Bider 1968, Gibbons and Bennett 1974, Wygoda 1979). The relatively high number of amphibians and reptiles captured during spring probably was due to a favorable set of climatic conditions (i.e., above-average rainfall and moderate temperatures), which caused an increase in daily movements and/or population abundance. Conversely, the relatively low number of individuals captured during the fall was probably the result of a less favorable set of climatic conditions (i.e., below-average rainfall and elevated temperatures), which diminished daily movements and/or population abundance.

This study suggests that herpetofaunal populations on the Apalachicola National Forest may be governed as much by weather factors as by habitat type. Preliminarily, however, longleaf pine appears to support a more diversified community of herpetofauna, and, therefore, warrants further consideration in assessing the habitat requirements.

Small Mammals

Means (1977) listed 16 species of terrrestrial small mammals as occurring in the Apalachicola River drainage basin. That only 5 of these species were captured during this study probably was due, at least in part, to the fact that trapping was limited to longleaf and slash pine habitats. Pine habitats are intermediate in species richness of small mammals when compared with other Florida habitat types (Layne 1974, Florida Game and Fresh Water Fish Commission 1976). More species of small mammals likely would have been captured had additional habitat types, such as titi thickets, cypress swamps, or upland hardwoods, been sampled.

Nonetheless, the species composition and species richness of small mammals captured on the Apalachicola National Forest were comparable to those reported for similar pine habitats throughout Florida. As in this study, the cotton mouse and cotton rat generally were the 2 most common pine-inhabiting species, whereas the total number of species captured in pinelands typically ranged from 1 to 5 (Layne 1974, Florida Fresh Water Fish and Game Commission 1976).

Small mammal capture success rates reported for pine habitats throughout Florida reflect considerable variation -- 0.1% (U.S. Fish and Wildlife Service 1978); 1.4% (Harris et al. 1975); 1.6% (this study); 2.3% (Layne 1974); and 3.2% (Florida Game and Fresh Water Fish Commission 1976). The low capture success in this study was probably related to severe drought conditions that occurred during the spring, summer, and fall of 1981. Other studies have shown that lack of rainfall, by reducing the quantity and quality of available forage plants, adversely affects small mammal populations (Layne 1974). As a result, the reproductive effort of breeding-age adults often is lowered, which subsequently causes a decline in population abundance (McCarley 1954, Odum 1955). The steady decrease in capture success observed in this study followed this drought-related pattern, and thereby, further substantiated that a close relationship exists between climatic conditions and the dynamics of small mammal populations.

Habitats.--Findings for the Apalachicola National Forest revealed that small mammal capture success did not differ ($P > 0.05$) between natural longleaf and planted slash pine habitat types. Comparable studies conducted in Florida, however, have indicated that capture rates were considerably lower in slash pine plantations than in natural longleaf pine stands (Harris et al. 1975, Florida Game and Fresh Water Fish Commission 1976). These varying findings may have been due to habitat differences other than pine type. Numerous researchers have found that the distribution and abundance of small mammal populations are governed, to a large extent, by the structure of understory and ground-level vegetation (Dambach 1944, Pearson 1959, Shure 1970, Layne 1974, M'Closkey 1975, M'Closkey and Lajoie 1975, Hanley and Page 1982). Consequently, assessing the differences in "microhabitats" and/or forest management practices that affect these microhabitats, such as site preparation (Umber and Harris 1975, Harris et al. 1975, White et al. 1976) or prescribed burning (Arata 1959, Layne 1974), may be more relevant considerations when comparing small mammal populations between habitat types than overstory species composition.

Seasons.--Capture success differed ($P < 0.05$) between seasons on the Apalachicola National Forest; small mammals were more abundant during spring than fall. This seasonal difference was principally the result of fluctuations in cotton mouse and cotton rat populations, inasmuch as these 2 species accounted for 91% of all small mammals captured on the study area. Substantially more cotton mice and cotton rats were captured during the spring (60 and 63, respectively) than the fall (33 and 24, respectively). Comparable studies have shown that cotton mouse populations typically are larger during spring than fall (Pournelle 1952, McCarley 1954). In contrast, cotton rat abundance generally has been found to be lower during spring than fall (Odum 1955). Yet, as previously mentioned, the drought that occurred during 1981 probably affected the normal breeding behavior of small mammals on the study area, and thereby may have caused the low abundance of cotton rats in fall.

In summary, pine-type, at least in the years of this study, appeared to influence the abundance and species composition of spring and fall populations of small mammals less than did weather. These findings give rise to the speculation that, given a favorable set of climatic conditions, both natural longleaf and planted slash pine habitats on the Apalachicola National Forest might be capable of supporting a greater abundance of small mammals than observed in this study.

ASSESSMENT

The comparative inventory statistics for birds, herpetofauna, and small mammals in longleaf pine and slash pine habitats on the Apalachicola National Forest revealed that abundance, species richness, species diversity, and biomass for the 3 groups (with the exception of species diversity of small mammals) tended to be greater in longleaf pine than in planted slash pine. Additionally, Repenning and Labisky (1985) documented that planted slash pine in north Florida does not provide habitat suitable for maintaining the breeding bird community of natural longleaf pine forest. Collectively, these data suggest that longleaf pine is a critically important wildlife habitat in Florida. Notably, however, the acreage of longleaf pine forest in Florida was decreased by 84% in the three decades between 1950 and 1980 (McCormick 1950, Bechtold and Knight 1982), which evinces a critical reduction in prime pineland habitat for many vertebrate wildlife species. Thus, efforts not only to maintain but also to increase the current acreage of longleaf pine forest constitute an appropriate strategy for enhancing vertebrate wildlife resources in Florida.

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LITERATURE CITED

Arata, A. A. 1959. Effects of burning on vegetation and rodent populations in a longleaf pine turkey oak association in north central Florida. Q. J. Florida Acad. Sci. 22:94-104.

Bechtold, W. A., and H. A. Knight. 1982. Florida's forests. U.S. Dep. Agric., For. Serv. Resour. Bull. SE-62. 84pp.

Bider, J. R. 1968. Animal activity in uncontrolled terrestrial communities as determined by a sand transect technique. Ecol. Monogr. 38:269-308.

Campbell, H. W., and S. P. Christman. 1977. Techniques for herpetofaunal community analysis. Joint Annual Meeting of the Herpetological League and Society for the Study of Amphibians and Reptiles, Lawrence, Kans., Aug. 1977.

Clawson, M. 1975. Compatibilities and incompatibilities in multiple uses of forests. Trans. North Am. Wildl. and Nat. Resour. Conf. 40:157-167.

Clench, M. H., and R. C. Leberman. 1978. Weights of 151 species of Pennsylvania birds analyzed by month, age, and sex. Bull. Carnegie Mus. Nat. Hist. 5:1-87.

Collins, J. T., R. Conant, J. E. Huheey, J. L. Knight, E. M. Rundquist, and H. M. Smith. 1982. Standard common and current scientific names for North American amphibians and reptiles. 2nd ed. Soc. Study Amphibians and Reptiles Herp. Circ. 12. 29 pp.

Conner, R. N., and J. G. Dickson. 1980. Strip transect sampling and analysis for avian habitat studies. Wildl. Soc. Bull. 8:4-10.

Dambach, C. A. 1944. A ten-year ecological study of adjoining grazed and ungrazed woodlands in northeastern Ohio. Ecol. Monogr. 14:255-270.

Dickson, J. G., and R. E. Noble. 1978. Vertical distribution of birds in a Louisiana bottomland hardwood forest. Wilson Bull. 90:19-30.

______, R. N. Conner, and J. H. Williamson. 1980. Relative abundance of breeding birds in forest stands in the Southeast. South. J. Appl. For. 4:174-179.

Eisenmann, E., chrm. 1982. Thirty-fourth supplement to the American Ornithologists' Union check-list of North American birds. Supplement to Auk 99(3). 16 pp.

Emlen, J. T. 1978. Density anomalies and regulatory mechanisms in land bird populations on the Florida peninsula. Am. Nat. 112:265-286.

Engstrom, T. 1980a. Mature longleaf pine forest (census 15). Am. Birds 34:29-30.

Enge, K. M., and W. R. Marion. 1986. Effects of clearcutting and site preparation on herpetofauna of a north Florida flatwoods. For. Ecol. Manage. 14 (1986):177-192.

______. 1980b. Mature longleaf forest (census 64). Am. Birds 34:61.

Engstrom, R. T., and F. C. James. 1981. Plot size as a factor in winter bird-population studies. Condor 83:34-41.

Florida Game and Fresh Water Fish Commission. 1976. Cross Florida barge canal restudy report: wildlife study. Vol. 4. Dep. Army, Corps of Eng., Jacksonville, Fla. 437 pp. (Mimeo).

Gibbons, J. W., and D. H. Bennett. 1974. Determination of anuran terrestrial activity patterns by a drift fence method. Copeia 1974:236-243.

______, and R. D. Semlitsch. 1981. Terrestrial drift fences with pitfall traps: an effective technique for quantitative sampling of animal populations. Brimleyana 7:1-16.

Goodrum, P., and V. H. Reid. 1955. Deer versus livestock on Gulf Coast range. Proc. Southeast. Assoc. Game and Fish Comm. 8:83-85.

Graber, R. R., and J. W. Graber. 1962. Weight characteristics of birds killed in nocturnal migration. Wilson Bull. 74:74-88.

Hanley, T. A., and J. L. Page. 1982. Differential effects of livestock use on habitat structure and rodent populations in Great Basin communities. California Fish and Game 68:160-173.

Harris, L. D. 1980. Forest and wildlife dynamics in the Southeast. Trans. N. Am. Wildl. and Nat. Resour. Conf. 45:307-322.

______, L. D. White, J. E. Johnston, and D. G. Milchunas. 1975. Impact of forest plantations on north Florida wildlife and habitat. Proc. Southeast. Assoc. Game and Fish Comm. 28:659-667.

Helwig, J. T., and K. A. Council, eds. 1979. SAS user's guide, 1979 edition. SAS Inst. Inc., Cary, N.C. 494 pp.

Hirth, D. H., and W. R. Marion. 1979. Bird communities of a south Florida flatwoods. Florida Scient. 42:142-151.

Inger, R. F., and R. K. Colwell. 1977. Organization of contiguous communities of amphibians and reptiles in Thailand. Ecol. Monogr. 47:229-253.

Johnston, D. W., and E. P. Odum. 1956. Breeding bird populations in relation to plant succession on the Piedmont of Georgia. Ecology 37:50-62.

Jones, J. K., Jr., D. C. Carter, H. H. Genoways, R. S. Hoffmann, and D. W. Rice. 1982. Revised checklist of North American mammals north of Mexico, 1982. Occas. Pap. Mus., Texas Tech. Univ. 80:6-19.

Kiester, A. R. 1971. Species density of North American amphibians and reptiles. Syst. Zool. 20:127-137.

Klimkiewicz, M. K., and C. S. Robbins. 1978. Standard abbreviations for common names of birds. N. Am. Bird Bander 3:16-25.

Lay, D. W. 1967. Deer range appraisal in eastern Texas. J. Wildl. Manage. 31:426-432.

_____. 1969. Foods and feeding habits of white-tailed deer. Pages 8-13 in L. K. Halls, ed. White-tailed deer in the southern forest habitat. U.S. Dep. Agric., For. Serv., South. For. Exp. Stn., Nacogdoches, Tex.

_____, and R. E. Murry, Sr. 1978. Comments on browse inventories in Louisiana -- Pearson and Sternitzke. J. Wildl. Manage. 42:169-171.

Layne, J. N. 1974. Ecology of small mammals in a flatwoods habitat in north-central Florida, with emphasis on the cotton rat (Sigmodon hispidus). Am. Mus. Novitates 2544:1-48.

Lewis, C. E. 1973. Integrating management of forest and range resources. Pages 69-78 in Range resources of the southeastern United States. Am. Soc. Agron. Spec. Publ. 21.

M'Closkey, R. T. 1975. Habitat succession and rodent distribution. J. Mammal. 56:950-955.

_____, and D. T. Lajoie. 1975. Determinants of local distribution and abundance in white-footed mice. Ecology 56:467-472.

McCarley, W. H. 1954. Fluctuations and structure of Peromyscus gossypinus populations in eastern Texas. J. Mammal. 35:526-532.

McCormick, J. F. 1950. Forest statistics for Florida, 1949. U.S. Dep. Agric., For Serv., Southeast. For. Exp. Stn. Release 36. 70 pp.

Maser, C., R. G. Anderson, K. Cromack, Jr., J. T. Williams, and R. E. Martin. 1979. Dead and down woody material. Pages 78-95 in J. W. Thomas, ed. Wildlife habitats in managed forests: the Blue Mountains of Oregon and Washington. U.S. Dep. Agric., For. Serv., Agric. Handbook 553. Washington, D.C.

Means, D. B. 1977. Aspects of the significance to terrestrial vertebrates of the Apalachicola River drainage basin, Florida. Florida Marine Res. Publ. 26:37-67.

Mitchell, W. A. 1980. Evaluation of white-tailed deer and cattle diets in two southeastern pine forets. Ph.D. Thesis. Mississippi State Univ., Mississippi State. 236 pp.

National Oceanic and Atmospheric Administration. 1978. Climates of the states, Vol. 1. Gale Res. Co., Detroit, Mich. 602 pp.

Noble, R. E., and R. B. Hamilton. 1976. Bird populations in even-aged loblolly pine forests of southeastern Louisiana. Proc. Southeast. Assoc. Game and Fish Comm. 29:441-450.

Norris, R. A., and D. W. Johnston. 1958. Weights and weight variations in summer birds from Georgia and South Carolina. Wilson Bull. 70:114-129.

Odum, E. P. 1955. An eleven year history of a Sigmodon population. J. Mammal. 36:368-378.

Ortego, B., R. B. Hamilton, and R. E. Noble. 1978. Bird usage by habitat types in a large freshwater lake. Proc. Southeast. Assoc. Game and Fish Comm. 30:627-633.

Palmer, R. S., ed. 1976. Handbook of North American birds, Vol. 3. Yale Univ. Press, New Haven, Conn. 560 pp.

Pearson, H. A. 1974. Range and wildlife opportunities. Pages 19-27 in Proc. symposium of management of young pines. U.S. Dep. Agric., For. Serv., South. and Southeast. Exp. Stn. 349 pp.

_____, and H. S. Sternitzke. 1976. Deer browse inventories in the Louisiana coastal plain. J. Wildl. Manage. 40:326-329.

_____, and _____. 1978. Response to comments by Daniel W. Lay and Robert E. Murry, Sr. J. Wildl. Manage. 42:171-172

Pearson, P. G. 1959. Small mammals and old field succession on the Piedmont of New Jersey. Ecology 40:249-255.

Poole, E. L. 1938. Weights and wing areas in North American birds. Auk 55:511-517.

Pournelle, G. H. 1952. Reproduction and early post-natal development of the cotton mouse, Peromyscus gossypinus gossypinus. J. Mammal. 33:1-20.

Repenning, R. W., and R. F. Labisky. 1985. Effects of even-age timber management on bird communities of the longleaf pine forest in northern Florida. J. Wildl. Manage. 49:1088-1098.

Rohwer, S., and J. Butler. 1977. Ground foraging and rapid molt in the chuck-will's-widow. Wilson Bull. 89:165-166.

Rowse, L. A. 1980. Avian community composition of a north Florida flatwoods. M. S. Thesis. Univ. Florida, Gainesville. 69 pp.

Shannon, C. E., and W. Weaver. 1949. The mathematical theory of communication. Univ. Illinois Press, Urbana. 117 pp.

Shure, D. J. 1970. Ecological relationships of small mammals in a New Jersey barrier beach habitat. J. Mammal. 51:267-278.

Siderits, K., and R. E. Radtke. 1977. Enhancing forest wildlife habitat through diversity. Trans. N. Am. Wildl. Conf. 42:425-434.

Southern Forest Institute. 1977. Basic forest statistics for the thirteen southern states. Southern Forest Institute, Atlanta, Ga. (Fact sheet.)

Stevenson, H. M. 1982. Florida region. Am. Birds 36:286-289.

Stewart, P. A. 1937. A preliminary list of bird weights. Auk 54:324-332.

Tanner, G. W., and W. S. Terry. 1982. Vegetation inventory in the longleaf/slash pine forest type, Apalachicola National Forest, Florida. Sch. For. Resour. Conserv., Univ. Florida, Gainesville. 242 pp.

Thill, R. E., and A. Martin, Jr. 1979. Deer and cattle diet overlap in Louisiana pine-hardwood forests: preliminary findings. Proc. Southeast. Assoc. Game and Fish Comm. 33:64-71.

Umber, R. W., and L. D. Harris. 1975. Effects of intensive forestry on succession and wildlife in Florida sandhills. Proc. Southeast. Assoc. Game and Fish Comm. 28:686-693.

U.S. Department of Commerce. 1980. Climatological data: Florida. Climatological Data (Asheville, N.C.) 84(13):1-15.

_____. 1981. Climatological data: Florida. Climatological Data (Asheville, N.C.) 85(13):1-15.

U.S. Fish and Wildlife Service. 1978. Osceola National Forest phosphate extraction and processing: impacts on federally listed threatened or endangered and other species of concern. Natl. Fish and Wildl. Lab., Gainesville Field Stn., Gainesville, Fla. 414 pp. (Mimeo.)

Veteto, G., R. Hart, Jr., and E. Davis. 1971. Browsers or grazers. Texas Parks and Wildl. 29(3):13-15.

Vickers, C. R., L. D. Harris, and B. F. Swindel. 1985. Changes in herpetofauna resulting from ditching of cypress ponds in coastal plains flatwoods. For. Ecol. Manage. 11(1985):17-29.

White, D. J. 1983. The herpetofaunal community of an abrupt forest edge in north Florida. M.S. Thesis. Univ. Florida, Gainesville. 37 pp.

White, L. D., L. D. Harris, J. E. Johnston, and D. G. Milchunas. 1976. Impact of site preparation on flatwoods wildlife habitat. Proc. Southeast. Assoc. Game and Fish Comm. 29:347-353.

Williams, L. E., Jr. 1972. Pine monoculture vs. wildlife values. Florida Nat. 45:25-26.

Wygoda, M. L. 1979. Terrestrial activity of striped mud turtles, *Kinosternon baurii* (Reptilia, Testudines, Kinosternidae) in west-central Florida. J. Herpetol. 13:469-480.

Appendix A.1. Common name, scientific name, abundance status, and body weight for bird species observed within census transects, Apalachicola National Forest, Florida, 1980 and 1981.

Common name[a]	Scientific name[a]	Abundance status[b]	Body weight (g)	Body weight reference[c]
American robin	*Turdus migratorius*	C	74.87	1
Barred owl	*Strix varia*	A	510.00	2
Blue-gray gnatcatcher	*Polioptila caerulea*	B	5.87	4
Blue grosbeak	*Guiraca caerulea*	B	27.18	4
Blue jay	*Cyanocitta cristata*	A	90.00	3
Brown-headed nuthatch	*Sitta pusilla*	A	9.93	4
Brown thrasher	*Toxostoma rufum*	A	66.00	1
Carolina chickadee	*Parus carolinensis*	A	9.01	4
Chuck-will's widow	*Caprimulgus carolinensis*	B	119.60	7
Common grackle	*Quiscalus quiscula*	A	103.52	8
Common yellowthroat	*Geothlypis trichas*	A	11.85	5
Crow, American	*Corvus brachyrhynchos*	A	482.75	1
Crow, fish	*Corvus ossifragus*	A	273.50	2
Eastern bluebird	*Sialia sialis*	B	32.55	3
Eastern kingbird	*Tyrannus tyrannus*	B	38.50	3
Eastern phoebe	*Sayornis phoebe*	C	20.00	1
Eastern wood-peewee	*Contopus virens*	B	13.82	4
Great crested flycatcher	*Myiarchus crinitus*	B	33.09	4
Hermit thrush	*Catharus guttatus*	C	29.50	2
Mourning dove	*Zenaida macroura*	A	130.00	2
Northern bobwhite	*Colinus virginianus*	A	186.77	1
Northern cardinal	*Cardinalis cardinalis*	A	42.37	1
Northern mockingbird	*Mimus polyglottos*	A	49.33	4
Northern parula	*Parula americana*	B	11.85	2
Orchard oriole	*Icterus spurius*	B	23.00	2
Red-shouldered hawk	*Buteo lineatus*	A	804.00	2
Ruby-crowned kinglet	*Regulus calendula*	C	6.73	2
Rufous-sided towhee	*Pipilo erythrophthalmus*	A	41.75	1
Solitary vireo	*Vireo solitarius*	C	16.75	2
Sparrow, Bachman's	*Aimophila aestivalis*	A	18.34	4
Sparrow, chipping	*Spizella passerina*	C	13.50	2
Sparrow, field	*Spizella pusilla*	C	12.10	2
Sparrow, song	*Melospiza melodia*	C	20.70	3
Sparrow, swamp	*Melospiza georgiana*	C	17.00	2
Sparrow, white-throated	*Zonotrichia albicollis*	C	27.50	3

Appendix A.1. Continued

Common name[a/]	Scientific name[a/]	Abundance status[b/]	Body weight (g)	Body weight reference[c/]
Summer tanager	Piranga rubra	B	29.53	4
Tufted titmouse	Parus bicolor	A	22.50	2
Warbler, palm	Dendroica palmarum	C	10.20	5
Warbler, pine	Dendroica pinus	A	11.90	1
Warbler, yellow-rumped	Dendroica coronata	C	15.50	2
Wild turkey	Meleagris gallopavo	A	3897.00	2
Wood duck	Aix sponsa	A	658.00	6
Woodpecker, downy	Picoides pubescens	A	26.75	1
Woodpecker, hairy	Picoides villosus	A	72.00	1
Woodpecker, pileated	Dryocopus pileatus	A	260.77	2
Woodpecker, red-bellied	Melanerpes carolinus	A	67.50	1
Woodpecker, red-cockaded	Picoides borealis	A	43.50	4
Woodpecker, red-headed	Melanerpes erythrocephalus	A	68.50	1
Wren, Carolina	Thryothorus ludovicianus	A	18.67	4
Wren, house	Troglodytes aedon	C	11.00	2
Wren, sedge	Cistothorus platensis	C	8.30	5
Yellow-bellied sapsucker	Sphyrapicus varius	C	51.15	8
Yellow-billed cuckoo	Coccyzus americanus	B	61.00	2

a/ After Eisenmann (1982).

b/ Status: A = year-round resident; B = summer resident; C = winter resident.

c/ References: 1 = Stewart (1937); 2 = Poole (1938); 3 = Stegeman (1955); 4 = Norris and Johnston (1958); 5 = Graber and Graber (1962); 6 = Palmer (1976); 7 = Rohwer and Butler (1977); 8 = Clench and Leberman (1978).

Appendix A.2. Number (N) and density (birds/km^2) of birds observed during breeding season (May) censuses, Apalachicola National Forest, Florida, 1980 and 1981. Data were derived from a strip transect (40 m x 500 m; 131 ft x 1,640 ft) located in both natural longleaf and planted slash pine habitats in each of the 8 compartments; each transect was censused 5 times.

	Longleaf pine		Slash pine	
Species	1980	1981	1980	1981
Blue-gray gnatcatcher				
N	2	4	0	0
Density	2.5	5.0		
Blue grosbeak				
N	0	4	0	0
Density		5.0		
Blue jay				
N	1	4	0	4
Density	1.2	5.0		5.0
Brown-headed nuthatch				
N	5	30	0	10
Density	6.2	37.5		12.5
Brown thrasher				
N	1	0	0	0
Density	1.2			
Carolina chickadee				
N	1	0	0	0
Density	1.2			

Appendix A.2. Continued.

	Longleaf pine		Slash pine	
Species	1980	1981	1980	1981
Chuck-will's widow				
N	0	0	0	1
Density				1.2
Common grackle				
N	1	0	1	0
Density	1.2		1.2	
Common yellowthroat				
N	0	0	0	1
Density				1.2
Crow, American				
N	0	1	2	5
Density		1.2	2.5	6.2
Crow, fish				
N	0	2	0	1
Density		2.5		1.2
Eastern bluebird				
N	2	1	0	0
Density	2.5	1.2		
Eastern kingbird				
N	1	2	0	0
Density	1.2	2.5		
Eastern wood-peewee				
N	1	3	0	0
Density	1.2	3.8		

Appendix A.2. Continued.

Species	Longleaf pine 1980	Longleaf pine 1981	Slash pine 1980	Slash pine 1981
Great crested flycatcher				
N	9	10	5	5
Density	11.2	12.5	6.2	6.2
Northern bobwhite				
N	9	5	0	0
Density	11.2	6.2		
Northern cardinal				
N	2	0	0	0
Density	2.5			
Northern parula				
N	1	0	0	0
Density	1.2			
Orchard oriole				
N	0	1	0	0
Density		1.2		
Rufous-sided towhee				
N	2	0	0	2
Density	2.5			2.5
Sparrow, Bachman's				
N	9	14	0	1
Density	11.2	17.5		1.2
Summer tanager				
N	0	7	3	3
Density		8.8	3.8	3.8
Tufted titmouse				
N	0	0	2	1
Density			2.5	1.2
Warbler, pine				
N	40	13	9	2
Density	25.0	16.2	11.2	2.5
Wild turkey				
N	1	0	0	1
Density	1.2			1.2
Wood duck				
N	0	2	0	0
Density		2.5		
Woodpecker, downy				
N	0	0	1	0
Density			1.2	
Woodpecker, pileated				
N	1	1	0	2
Density	1.2	1.2		2.5
Woodpecker, red-bellied				
N	8	9	3	10
Density	10.0	11.2	3.8	12.5
Woodpecker, red-cockaded				
N	20	7	0	2
Density	25.0	8.8		2.5
Woodpecker, red-headed				
N	1	5	0	1
Density	1.2	6.2		1.2
Wren, Carolina				
N	0	0	1	0
Density			1.2	
Yellow-billed cuckoo				
N	0	0	0	1
Density				1.2

Appendix A.2. Continued.

Species	Longleaf pine 1980	Longleaf pine 1981	Slash pine 1980	Slash pine 1981
Total				
N (individuals)	118	125	27	53
Density (birds/km)	147.5	156.2	35.8	66.2
N (species)	21	20	9	18
Species diversity (H')[a/]	1.6	1.6	0.7	1.2
Biomass (kg)[b/]	8.88	6.72	1.71	8.98

a/ Shannon-Weiner index of species diversity (Shannon and Weaver 1949); mean values are reported.

b/ Biomass was estimated using mean-standard weights of individual species as reported in the literature (Appendix A.1).

Appendix A.3. Number (N) and density (birds/km^2) of birds observed during wintering season (December) censuses, Apalachicola National Forest, Florida, 1980 and 1981. Data were derived from a strip transect (40 m x 500 m; 131 ft x 1,640 ft) located in both natural longleaf and planted slash pine habitats in each of the 8 compartments; each transect was censused 5 times.

Species	Longleaf pine 1980	Longleaf pine 1981	Slash pine 1980	Slash pine 1981
American robin				
N	22	0	37	0
Density	27.5		46.2	
Barred owl				
N	0	0	0	1
Density				1.2
Blue-gray gnatcatcher				
N	0	1	0	0
Density		1.2		
Brown-headed nuthatch				
N	11	3	0	0
Density	13.8	3.8		
Common yellowthroat				
N	1	0	1	0
Density	1.2		1.2	
Crow, American				
N	0	0	1	0
Density			1.2	
Eastern bluebird				
N	4	2	0	0
Density	5.0	2.5		
Eastern phoebe				
N	5	0	1	0
Density	6.2		1.2	
Hermit thrush				
N	1	0	1	0
Density	1.2		1.2	

Appendix A.3. Continued.

Species	Longleaf pine 1980	Longleaf pine 1981	Slash pine 1980	Slash pine 1981
Mourning dove				
N	0	0	0	1
Density				1.2
Northern mockingbird				
N	0	0	2	0
Density			2.5	
Red-shouldered hawk				
N	0	0	1	0
Density			1.2	
Ruby-crowned kinglet				
N	9	0	10	0
Density	11.2		12.5	
Rufous-sided towhee				
N	0	1	4	0
Density		1.2	5.0	
Solitary vireo				
N	0	0	2	2
Density			2.5	2.5
Sparrow, Bachman's				
N	5	1	0	1
Density	6.2	1.2		1.2
Sparrow, chipping				
N	17	0	0	2
Density	21.2			2.5
Sparrow, field				
N	0	0	1	0
Density			1.2	
Sparrow, song				
N	2	0	0	0
Density	2.5			
Sparrow, swamp				
N	6	0	0	0
Density	7.5			
Sparrow, white-throated				
N	18	0	0	0
Density	22.5			
Warbler, palm				
N	0	0	0	4
Density				5.0
Warbler, pine				
N	34	25	10	0
Density	42.5	31.2	12.5	
Warbler, yellow-rumped				
N	22	20	20	19
Density	27.5	25.0	25.0	23.8
Woodpecker, downy				
N	1	2	0	0
Density	1.2	2.5		
Woodpecker, hairy				
N	1	0	0	0
Density	1.2			
Woodpecker, red-bellied				
N	0	2	0	0
Density		2.5		
Woodpecker, red-cockaded				
N	4	9	2	0
Density	5.0	11.2	2.5	

Appendix A.3. Continued.

Species	Longleaf pine 1980	Longleaf pine 1981	Slash pine 1980	Slash pine 1981
Wren, Carolina				
N	2	0	1	0
Density	2.5		1.2	
Wren, house				
N	18	1	11	0
Density	22.5	1.2	13.8	
Wren, sedge				
N	21	11	8	1
Density	26.2	13.8	10.0	1.2
Yellow-bellied sapsucker				
N	4	5	0	1
Density	5.0	6.2		1.2
Total				
N (individuals)	208	83	113	32
Density (birds/km^2)	160.0	103.8	141.2	40.0
N (species)	21	13	17	9
Species diversity (H')[a]	1.5	0.7	1.0	0.3
Biomass (kg)[c]	4.67	1.70	5.22	1.13

a/ Shannon-Weiner index of species diversity (Shannon and Weaver 1949); mean values are reported.

b/ Biomass was estimated using mean-standard weights of individual species as reported in the literature (Appendix A.1).

Appendix B.1. Common name, scientific name, and dominant mode of life for herpetofaunal species captured in trapping arrays, Apalachicola National Forest, Florida, 1980 and 1981.

Common name[a/]	Scientific name	Dominant mode of life[b/]
Coachwhip	*Masticophis flagellum*	T
Frog, little grass	*Limnaaedus ocularis*	SA
Frog, ornate chorus	*Pseudacris ornata*	SA
Frog, southern chorus	*Pseudacris nigrita*	SA
Frog, southern cricket	*Acris gryllus*	SA
Frog, southern leopard	*Rana sphenocephala*	SA
Green anole	*Anolis carolinensis*	AR

Appendix B.1. Continued.

Common name[a/]	Scientific name	Dominant mode of life[b/]
Lizard, eastern fence	Sceloporus undulatus	AR
Lizard, eastern glass	Ophisaurus ventralis	T
Lizard, slender glass	Ophisaurus attenuatus	T
Pigmy rattlesnake	Sistrurus miliarus	T
Racer	Coluber constrictor	T
Salamander, dwarf	Eurycea quadridigitata	SA
Salamander, flatwoods	Ambystoma cingulatum	T
Salamander, mole	Ambystoma talpoideum	F
Salamander, slimy	Plethodon glutinosus	T
Scarlet kingsnake	Lampropeltis triangulum	T
Six-lined racerunner	Cnemidophorus sexlineatus	T
Skink, broadhead	Eumeces laticeps	AR
Skink, five-lined	Eumeces fasciatus	T
Skink, ground	Scincella lateralis	T
Skink, southeastern five-lined	Eumeces inexpectatus	T
Snake, brown	Storeria dekayi	SA
Snake, common garter	Thamnophis sirtalis	SA
Snake, corn	Elaphe punctatus	T
Snake, eastern coral	Micrurus fulvius	T
Snake, eastern hognose	Heterodon platyrhinos	T
Snake, eastern ribbon	Thamnophis sauritus	SA

Appendix B.1. Continued.

Common name[a/]	Scientific name	Dominant mode of life[b/]
Snake, glossy crayfish	Regina rigida	A
Snake, pine	Pituophis melanoleucus	T
Snake, ringneck	Diadophis punctatus	T
Snake, scarlet	Cemophora coccinea	T
Snake, smooth earth	Virginia valeriae	T
Snake, southern hognose	Heterodon simus	T
Toad, eastern narrowmouth	Gastrophryne carolinensis	T
Toad, oak	Buto quercicus	T
Toad, southern	Bufo terrestris	T
Turtle, eastern box	Terrapene carolina	T
Turtle, eastern mud	Kinosternon subrubrum	A

a/ After Collins et al. (1982).

b/ Dominant mode of life designations: A = aquatic; AR = arboreal; F = fossorial; SA = semi-aquatic; T = terrestrial.

Appendix B.2. Census statistics for herpetofauna captured per array during spring (March-May) censuses, Apalachicola National Forest, Florida, 1980 and 1981. Data were derived from a 16-trap array operated in both natural longleaf and planted slash pine habitats in each of the 8 compartments for 8 consecutive weeks.

	Longleaf pine		Slash pine	
Species	1980	1981	1980	1981
Coachwhip				
N	1	2	0	0
Mean	0.1	0.2		
SD	0.4	0.7		
Frog, ornate chorus				
N	1	0	1	0
Mean	0.1		0.1	
SD	0.4		0.4	

Appendix B.2. Continued.

Species	Longleaf pine		Slash pine	
	1980	1981	1980	1981
Snake, glossy crayfish				
N	1	0	1	0
Mean	0.1		0.1	
SD	0.4		0.4	
Snake, ringneck				
N	0	1	0	0
Mean		0.1		
SD		0.4		
Snake, scarlet				
N	13	18	3	2
Mean	1.6	2.2	0.4	0.2
SD	1.4	1.4	0.5	0.5
Snake, smooth earth				
N	0	5	2	6
Mean		0.6	0.2	0.8
SD		0.5	0.5	1.8
Snake, southern hognose				
N	0	1	0	0
Mean		0.1		
SD		0.4		
Toad, eastern narrowmouth				
N	7	1	3	2
Mean	0.9	0.1	0.4	0.2
SD	1.1	0.4	1.1	0.5
Toad, oak				
N	4	0	0	0
Mean	0.5			
SD	0.8			
Toad, southern				
N	4	1	9	2
Mean	0.5	0.1	1.1	0.2
SD	1.1	0.4	2.2	0.7
Turtle, eastern box				
N	1	0	2	0
Mean	0.1		0.2	
SD	0.4		0.5	
Turtle, eastern mud				
N	4	0	0	0
Mean	0.5			
SD	0.9			

Appendix B.3. Census statistics for herpetofauna captured per array during fall (September-November) censuses, Apalachicola National Forest, Florida, 1980 and 1981. Data were derived from a 16-trap array operated in both natural longleaf and planted slash pine habitats in each of the 8 compartments for 8 consecutive weeks.

Species	Longleaf pine		Slash pine	
	1980	1981	1980	1981
Coachwhip				
N	0	0	0	1
Mean				0.1
SD				0.4
Eastern box turtle				
N	2	0	0	0
Mean	0.2			
SD	0.5			
Frog, little grass				
N	0	0	2	0
Mean			0.2	
SD			0.5	
Frog, ornate chorus				
N	1	0	2	0
Mean	0.1		0.2	
SD	0.4		0.5	
Frog, southern cricket				
N	1	0	1	0
Mean	0.1		0.1	
SD	0.4		0.4	
Frog, southern leopard				
N	7	0	1	1
Mean	0.9		0.1	0.1
SD	1.1		0.4	
Green anole				
N	2	0	3	11
Mean	0.2		0.4	1.4
SD	0.5		1.1	3.1
Lizard, eastern fence				
N	2	2	0	1
Mean	0.2	0.2		0.1
SD	0.5	0.7		0.4
Lizard, eastern glass				
N	0	2	2	2
Mean		0.2	0.2	0.2
SD		0.5	0.5	0.5
Lizard, slender glass				
N	1	1	0	0
Mean	0.1	0.1		
SD	0.4	0.4		
Pigmy rattlesnake				
N	4	0	3	2
Mean	0.5		0.4	0.2
SD	0.8		0.7	0.5

Appendix B.2. Continued.

Species	Longleaf pine 1980	Longleaf pine 1981	Slash pine 1980	Slash pine 1981
Frog, southern chorus				
N	0	0	1	0
Mean			0.1	
SD			0.4	
Frog, southern cricket				
N	1	0	1	0
Mean	0.1		0.1	
SD	0.4		0.4	
Frog, southern leopard				
N	7	1	1	0
Mean	0.9	0.1	0.1	
SD	1.2	0.4	0.4	
Green anole				
N	6	1	3	7
Mean	0.8	0.1	0.4	0.9
SD	2.1	0.4	0.7	1.1
Lizard, eastern fence				
N	1	1	1	2
Mean	0.1	0.1	0.1	0.2
SD	0.4	0.4	0.4	0.5
Lizard, eastern glass				
N	0	2	1	3
Mean		0.2	0.1	0.4
SD		0.7	0.4	0.7
Lizard, slender glass				
N	3	0	0	0
Mean	0.4			
SD	0.7			
Pigmy rattlesnake				
N	1	2	0	1
Mean	0.1	0.2		0.1
SD	0.4	0.5		0.4
Racer				
N	10	7	8	7
Mean	1.2	0.9	1.0	0.9
SD	1.0	0.6	1.8	0.8
Salamander, dwarf				
N	3	1	5	0
Mean	0.4	0.1	0.6	
SD	1.1	0.4	0.7	
Salamander, flatwoods				
N	2	0	3	0
Mean	0.2		0.4	
SD	0.7		0.7	
Salamander, mole				
N	0	0	2	0
Mean			0.2	
SD			0.7	

Appendix B.2. Continued.

Species	Longleaf pine 1980	Longleaf pine 1981	Slash pine 1980	Slash pine 1981
Salamander, slimy				
N	3	5	0	2
Mean	0.4	0.6		0.2
SD	0.7	0.9		0.7
Scarlet kingsnake				
N	0	1	0	1
Mean		0.1		0.1
SD		0.4		0.4
Six-lined racerunner				
N	18	23	4	16
Mean	2.2	2.9	0.5	2.0
SD	3.9	3.7	1.4	5.3
Skink, broadhead				
N	3	12	0	8
Mean	0.4	1.5		1.0
SD	0.5	1.9		2.4
Skink, ground				
N	27	47	16	84
Mean	3.4	5.9	2.0	10.5
SD	2.7	6.0	1.6	8.8
Skink, southeastern five-lined				
N	2	2	2	0
Mean	0.2	0.2	0.2	
SD	0.7	0.5	0.5	
Snake, brown				
N	0	0	1	0
Mean			0.1	
SD			0.4	
Snake, common garter				
N	2	4	1	2
Mean	0.2	0.5	0.1	0.2
SD	0.5	0.8	0.4	0.5
Snake, corn				
N	1	3	0	1
Mean	0.1	0.4		0.1
SD	0.4	0.5		0.4
Snake, eastern coral				
N	1	2	0	2
Mean	0.1	0.2		0.2
SD	0.4	0.5		0.5
Snake, eastern hognose				
N	1	0	0	0
Mean	0.1			
SD	0.4			
Snake, eastern ribbon				
N	3	1	4	5
Mean	0.4	0.1	0.5	0.6
SD	0.7	0.4	0.8	1.2

Appendix B.3. Continued.

Appendix B.3. Continued.

	Longleaf pine		Slash pine	
Species	1980	1981	1980	1981
Racer				
N	0	3	7	7
Mean		0.4	0.9	0.9
SD		0.7	1.0	1.0
Salamander, dwarf				
N	5	0	6	0
Mean	0.6		0.8	
SD	0.9		0.9	
Salamander, flatwoods				
N	1	0	0	2
Mean	1			0.2
SD	0.4			0.7
Scarlet kingsnake				
N	0	0	0	1
Mean				0.1
SD				0.4
Six-lined racerunner				
N	2	4	2	1
Mean	0.2	0.5	0.2	0.1
SD	0.5	0.8	0.7	0.4
Skink, broadhead				
N	1	0	0	0
Mean	0.1			
SD	0.4			
Skink, five-lined				
N	1	0	0	0
Mean	0.1			
SD	0.4			
Skink, ground				
N	15	14	33	6
Mean	1.9	1.8	4.1	0.8
SD	2.1	2.3	6.3	1.8
Skink, southeastern five-lined				
N	2	1	0	1
Mean	0.2	0.1		0.1
SD	0.5	0.4		0.4
Snake, common garter				
N	0	0	1	0
Mean			0.1	
SD			0.4	
Snake, corn				
N	1	0	0	0
Mean	0.1			
SD	0.4			
Snake, eastern coral				
N	1	3	1	2
Mean	0.1	0.4	0.1	0.2
SD	0.4	0.7	0.4	0.5
Snake, eastern ribbon				
N	0	0	1	1
Mean			0.1	0.1
SD			0.4	0.4
Snake, glossy crayfish				
N	0	1	0	0
Mean		0.1		
SD		0.4		
Snake, pine				
N	0	1	0	0
Mean		0.1		
SD		0.4		
Snake, ringneck				
N	1	0	0	1
Mean	0.1			0.1
SD	0.4			0.4
Snake, scarlet				
N	1	0	0	0
Mean	0.1			
SD	0.4			
Snake, smooth earth				
N	1	9	5	7
Mean	0.1	1.1	0.6	0.9
SD	0.4	2.0	1.2	1.4
Toad, eastern narrowmouth				
N	0	7	0	3
Mean		0.9		0.4
SD		1.4		0.7
Toad, oak				
N	1	1	0	0
Mean	0.1	0.1		
SD	0.4	0.4		
Toad, southern				
N	0	0	0	1
Mean				0.1
SD				0.4

Appendix C.1. Census statistics for small mammals captured per transect during spring (May) censuses, Apalachicola National Forest, Florida, 1980 and 1981. Data were derived from a 375-m (1,230-ft), 25-station transect, with 1 live trap and 1 snap trap per station, operated in both natural longleaf and planted slash pine habitats in each of the 8 compartments for 4 consecutive nights.

	Longleaf pine		Slash pine	
Species	1980	1981	1980	1981
Cotton mouse (*Peromyscus gossypinus*)				
N	20	9	29	2
Mean	2.5	1.1	3.6	0.2
SD	2.4	1.1	3.1	0.5
Cotton rat (*Sigmodon hispidus*)				
N	33	9	15	6
Mean	4.1	1.1	1.9	0.8
SD	4.5	1.7	1.9	0.9
House mouse (*Mus musculus*)				
N	0	1	0	0
Mean		0.2		
SD		0.5		
Least shrew (*Cryptosis parva*)				
N	2	2	3	0
Mean	0.2	0.2	0.4	
SD	0.5	0.5	0.5	

Appendix C.2. Census statistics for small mammals captured per transect during fall (October) censuses, Apalachicola National Forest, Florida 1980 and 1981. Data were derived from a 375-m (1,230-ft), 25-station transect, with 1 live trap and 1 snap trap per station, operated in both natural longleaf and planted slash pine habitats in each of the 8 compartments for 4 consecutive nights.

	Longleaf pine		Slash pine	
Species	1980	1981	1980	1981
Cotton mouse (*Peromyscus gossypinus*)				
N	15	2	12	4
Mean	1.9	0.2	1.5	0.5
SD	2.2	0.7	1.8	1.1

Appendix C.2. Continued.

	Longleaf pine		Slash pine	
Species	1980	1981	1980	1981
Cotton rat (*Sigmodon hispidus*)				
N	6	2	14	2
Mean	0.8	0.2	1.8	0.2
SD	0.7	0.5	3.2	0.5
Least shrew (*Cryptosis parva*)				
N	1	4	0	4
Mean	0.1	0.5		0.5
SD	0.4	0.8		0.8
Southern short-tailed shrew (*Blarina carolinensis*)				
N	0	0	1	0
Mean			0.1	
SD			0.4	

Longleaf-Slash Pine Type Discussion

Question

Were understory vegetation data collected by pine type similar to Florida collections? Also, are natural savannas in Florida being converted to pine plantations with bedding and chopping?

Response

About 60% of the Louisiana area had longleaf pine and 20% slash pine; only one area in Mississippi had any slash pine plantations. The workshop reports do not distinguish between the pines since understory vegetation characteristics did not appear different. However, the basic data records the understory for each specific overstory type.

The savanna sites in Florida are currently protected and are not being planted to slash pine.

The Florida data indicate greater wildlife diversity in natural longleaf pine stands compared with slash pine plantations. This does not suggest that longleaf pine plantations will be more diverse than slash pine plantations.

In Mississippi, some bedding is being done; however, prior to bedding, sites are reviewed by the Forest Service botanist to determine if sensitive plants (threatened, endangered, etc.) exist on the sites. Bogs are essentially protected from all site preparation activities.

Question

Can comments regarding discrepancies in areas grazed in Louisiana be resolved?

Response

Originally (1979-80) when vegetation measurements were made, all 4 study areas were grazed by cattle; grazing was discontinued on area 4 by the time of the wildlife measurements (1981-82). Areas 1, 2, and 3 were grazed during all measurements.

Question

Did sawtimber in the Louisiana study have a mosaic pattern with a lot of edge that may have influenced the wildlife numbers?

Response

The sawtimber had a more diverse habitat with abundant understory growth, down logs, and litter for amphibians and reptiles.

In Florida, there are distinct islands of longleaf pine in wet areas and Bladden soils but only the larger tracts of contiguous stands were sampled for wildlife to avoid the edge effect.

In Mississippi there were several herpetafauna that were considered as transients that normally would not have been expected in a particular stand class. During dry periods, some species were found apparently moving toward water.

Question

Have the Southeast National Forests ever been considered from the standpoint of biological islands providing refuge for biological diversity--especially as related to disease outbreaks, droughts, or other disaster?

Response

The National Forest planning effort recognizes this diversity and will continue to support habitat diversity on those biological islands. As we learn more about the biological interrelationship, planning and action will continue to improve maintenance of biological diversity.

Question

Why did herbage production average 1100 lb/ac at zero basal area (BA), then decrease in the next higher BA class, but then increase in the next higher BA class?

Response

This was probably due to sampling error. Differences in herbage yield were not statistically different for the lower BA classes. Herbage yields above 100 ft^2/acre BA were significantly less than those below 100 ft^2/acre BA.

Question

What is the normal occurrence of legumes in the botanical composition where an area has a history of fire and grazing? Also, what recovery period or opportunity is there for legumes to return to these areas?

Response

Some work in Mississippi indicates that legumes may not increase with continued burning, even in the absence of cattle. Even with disking there was no increase in legumes--presumable because there was no seed source. Legumes could be seeded but they would disappear in a few years without control of other competition.

Further north, the legume seed source is not a problem. Just disk, plow, chop, or crush, and then burn and legumes respond fantastically.

Question

How critical are legumes in the longleaf type for quail populations?

Response

Pine seed is excellent for quail but you cannot depend on it as the main winter quail food. Where food plots are well distributed and legumes abundant, you can expect 1 to 4 birds/acre. You will not get a quail/acre in the longleaf pine-wiregrass type without habitat improvements.

Question

Are there differences in quail populations due to size or period of burn and length of rotation between burns? Large areas on the National Forest are usually burned because of economics and practicality.

Response

A 200-300 acre burn interspersed with nonburned areas would be great. A mosaic of burned areas, some cool, some hot, with cover scattered around for escape would be ideal. Annual burns in Alabama were compared to burns where cover was left; quail survival rates have been better where cover was left. The most critical time for quail is from just after an early March burn until the vegetation cover grows back in June. The burning pattern (mosaic) is important to provide cover.

WATERSHEDS, SOCIOECONOMICS, AND FOREST PESTS

Moderators:

Robert C. Joslin
Kisatchie National Forest
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and

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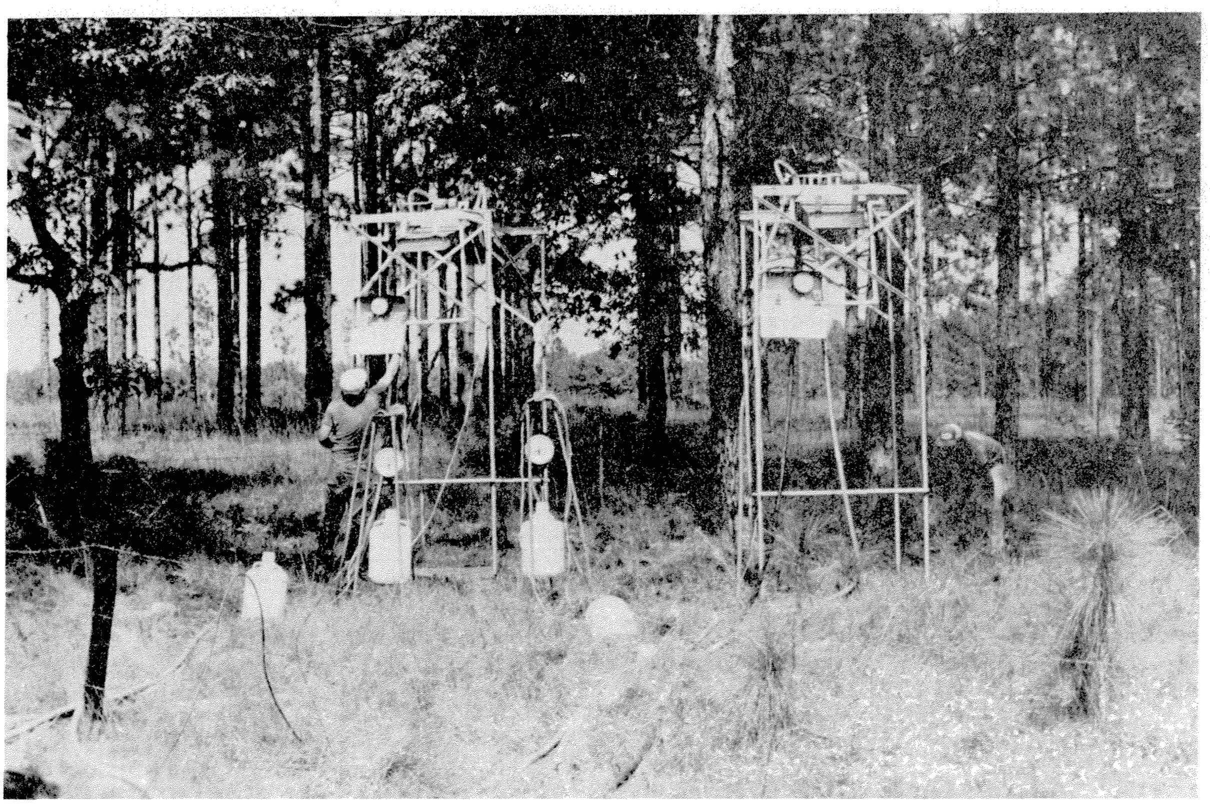
The big challenge facing forestry in the South is to maintain an acceptable forest environment while managing for timber, livestock, wildlife, and recreation. The Clean Water Act requires identification and control of activities that contribute to nonpoint source pollution. Socioeconomic factors are little understood components of traditional southern agriculture especially as they relate to forestry and livestock grazing. Interrelationships among range, wildlife, and tree pests are not fully understood. The implications of insects and diseases that attack trees are important considerations for forest range management.



Storm Flow and Sediment Loss from Intensively Managed Forest Watersheds in East Texas

W. H. Blackburn, J. C. Wood, H. A. Pearson, and R. W. Knight[1/]

Abstract.--Five small (12-acre) forested watersheds in East Texas were instrumented in December 1980 to determine the effect of forest harvesting, mechanical site preparation, and livestock grazing on storm flow, peak discharge rate, and sediment loss. After three years of pre-treatment calibration, four of the watersheds were treated as follows: (1) clearcutting followed by roller chopping; (2) clearcutting followed by shearing, and windrowing; (3) clearcutting followed by shearing, windrowing, and rotational grazing; and (4) clearcutting followed by shearing, windrowing, and continuous grazing. Clearcut harvesting and all site preparation treatments significantly increased storm flow, peak discharge rates, and sediment losses over the undisturbed watershed. Properly stocked livestock grazing appeared to have little impact on sediment loss or storm flow. Sediment losses from these intensively managed watersheds, even though significantly greater, were within the range of sediment losses from undisturbed watersheds in the Southeast, below the range of losses from mechanically prepared watersheds elsewhere, and well below potential losses from pasture and cropland. Roller chopping, and shearing and windrowing are recommended as environmentally sound forest practices on watersheds with slopes up to 8 percent.

INTRODUCTION

Current and projected water shortages for Texas make the water-rich, commercial forestlands of East Texas extremely important to the State's future growth and development. However, little is known in Texas about the influence of intensive forest practices or livestock grazing on sediment loss or storm flow.

The Southern States are currently producing more than half of the nation's wood supply with demands expected to increase timber production in the next 20 years. The challenge facing forestry in the South is to develop technology and management to meet this increased demand while maintaining an acceptable forest environment in the face of increased taxes and rising costs of labor, equipment, and energy. The intensive forest management practices of harvesting, site preparation, and livestock grazing have been identified as potential sources of declining site productivity and nonpoint pollution. The Clean Water Act (PL 92-500 and PL 95-217) requires identification and control of silvicultural and livestock grazing activities that contribute to nonpoint source pollution.

Because of: (1) the long history of woodland overgrazing; (2) poorly designed studies to evaluate proper livestock grazing; and (3) lack of forest hydrology research that applies to grazing, the conservation-minded public continues to perceive forest grazing as an urgent environmental problem (Adams 1975, Johnson 1952, Lee 1980, Patric and Helvey 1986). Most studies in the eastern United States have evaluated only the impacts of heavy continuous grazing or have misused soil loss prediction equations such as the Universal Soil Loss Equation to evaluate forest

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grazing (Blackburn 1984, Patric and Helvey 1986). Dissmeyer (1976) using his First Approximation of Suspended Sediment (FASS) method to evaluate soil loss in the Southeast stated that overgrazing of woodlands is clearly a major source of soil erosion.

Forest management activities have the potential to influence storm-flow amount and timing. The first year following site preparation near Alto, Texas, storm flow was significantly greater from watersheds that had been clearcut, followed by shearing, windrowing, and burning (5.7 inch) than from watersheds that were clearcut, followed by roller chopping and burning (3.3 inch). Storm flow from the latter treatment was greater than from the undisturbed watersheds (1.1 inch) (Blackburn and others 1986). Storm flow decreased from the site-prepared watersheds after the first post-treatment year, but was still greater during the fourth post-treatment year from the sheared (2.4 inch) and chopped (1.4 inch) watersheds than from the undisturbed (0.6 inch) watersheds.

The natural sediment loss from undisturbed forest varies with location, soil, geology, vegetation, watershed size, and season. Research in the Southeast has demonstrated that natural erosion rates from undisturbed forestland are low, ranging from a trace to 640 lb/acre/year (Beasley 1982, Schrieber and others 1980, Yoho 1980). First year sediment losses were greater from the sheared watersheds (2,620 lb/acre) at Alto, Texas than from the chopped (22 lb/acre) or undisturbed (29 lb/acre) watersheds (Blackburn and others 1986). Although second-year sediment losses were greatly reduced from the sheared watersheds, they remained greater than the chopped or undisturbed watersheds for at least four years.

The objective of this study was to assess the impact of clearcut harvesting, mechanical site preparation, and livestock grazing on soil erosion, storm flow, and sediment loss.

STUDY AREA

The study site consisted of five 12-acre instrumented watersheds located about 35 miles east of Lufkin, Texas on the Angelina National Forest in western San Augustine County. The study area is characterized by gentle rolling topography intersected with numerous drainages. Slopes range from 1 to 8 percent. Overstory vegetation prior to harvesting was predominantly loblolly pine (*Pinus taeda* L.), longleaf pine (*Pinus palustris* P. Mill.), shortleaf pine (*Pinus echinata* P. Mill), red oak (*Quercus falcata* var. *falcata* Michx.), and sweetgum (*Liquidambar styraciflua* L.). The watersheds are located in the northern part of the Yegua geologic formation which is mainly acid stratified sandstone and shale with some areas underlain by variable amounts of siltstone. The soils are of the Cuthbert or Kirvin series, which are classified as clayey, mixed, thermic typic Hapludults. They have a fine-textured, sandy loam A horizon up to 10 inches thick, and a clay-textured B horizon. Both soil series are found extensively throughout East Texas and much of the southern Coastal Plain. Mean annual temperature is 66 °F with an average frost-free season of 246 days. Normal annual precipitation of 48 inches is fairly well-distributed throughout the year (NOAA 1981) with slightly more precipitation occurring during April, May, November, December, and January.

METHODS AND PROCEDURES

Treatments

The five watersheds were instrumented in 1980 and stream flow monitoring began in January 1981. Calibration relationships were developed from January 1981 through October 1983 between four treatment watersheds and one control watershed (Table 1).

Harvesting of an 80-acre clearcut in conjunction with watershed 1 began October 26, 1983 and ended December 28, 1983. Approximately 15 percent of the upper portions of watersheds 2, 3, and 4 was harvested in conjunction with another 76-acre clearcut beginning October 19, 1983 and ending November 10, 1983. The remaining portions of watersheds 2, 3, and 4 were clearcut between May 22, 1984 and June 25, 1984. Watershed 2 was roller chopped on October 9, 1984. Approximately 50 percent of watershed 1 was sheared between November 11, 1984 and December 10, 1984. The remaining half was sheared and windrowed between May 20, 1985 and May 31, 1985. Shearing and windrowing of watershed 3 and 4 took place, for the most part, between May 31, 1985 and June 12, 1985. All silvicultural practices were performed under the direction of the Angelina Ranger District and followed "state-of-the-art methods" in compliance with Forest Service policy.

Forty longhorn cattle with some calves under 6 months of age grazed the study area's approximately 1,400 acres for six weeks beginning August 1, 1984. The overall stocking rate was about 23 acres/Animal Unit Month (AUM). Livestock were excluded from watersheds 2, 3, and 5 by electric fences. Although approximately 1,400 acres were available for livestock grazing during this six-week period, animals concentrated on the two clearcut areas.

Watershed 1 and the adjacent clearcut area was grazed continuously for four months under a moderate stocking rate (2.5 acres/AUM) beginning July 1, 1986 and ending October 31, 1986. Watershed 4 and the adjacent clearcut area was grazed in a manner which simulated one-pasture of an eight-pasture intensive rotation grazing system. Periods of grazing were dependent on forage availability, quality, and plant physiological stage. After each grazing period, cattle were removed and the pasture was allowed to rest. Rest periods were determined as the equivalent time that would be required to rotationally graze seven additional pastures of equal size and carrying capacity. During 1986

Table 1.--Schedule of silvicultural and livestock grazing treatments as applied to the five experimental watersheds, Angelina National Forest, Texas

Watershed	Undisturbed	Clearcut	Site Preparation	Grazed
1	Jan. 1, 1981 to Oct. 26, 1983	Oct. 26, 1983 to Dec. 28, 1983	Sheared/windrowed 50%, Nov. 11, 1984 to Dec. 10, 1984 50%, May 20, 1985 to May 31, 1985	Continuous July 1, 1986 to Oct. 31, 1986 (2.5 acre/AUM)
2	Jan. 1, 1981 to Oct. 19, 1983	15%, Oct. 19, 1983 to Nov. 10, 1983 85%, May 22, 1984 to June 25, 1984	Roller chopped Oct. 9, 1984	None
3	Jan. 1, 1981 to Oct. 19, 1983	15%, Oct. 19, 1983 to Nov. 10, 1983 85%, May 22, 1984 to June 25, 1984	Sheared/windrowed May 31, 1985 to June 12, 1985	None
4	Jan. 1, 1981 to Oct. 19, 1983	15%, Oct. 19, 1983 to Nov. 10, 1983 85%, May 22, 1984 to June 25, 1984	Sheared/windrowed May 31, 1985 to June 12, 1985	Rotation July 1-6, 1986 Aug. 18-25, 1986 Oct. 22-31, 1986 (2 acres/AUM)
5	Jan. 1, 1981 to Dec. 30, 1986	None	None	None

watershed 4 underwent three grazing periods with a comparative stocking rate of about 2 acres/AUM: (1) a six-day grazing period from July 1 to July 6 with a 42 day rest; (2) an eight-day grazing period from August 18 to August 26 with a 56 day rest; and (3) a 10-day grazing period from October 22 to October 31 followed by winter deferment of approximately five months.

Precipitation was measured in Forester type rain gauges located in a network that has one gauge for each five acres. Rainfall intensity and duration were obtained from recording rain gauges (Belfort Weighing). The erosion index (EI) of individual storms was calculated using the procedure outlined by Wischmeier and Smith (1978). Storm flow volume and rate were measured with three-foot H-flumes equipped with FW-1 Type water level recorders. Flume approach sections were 12 feet long. Suspended sediment samples were collected at each flume with a Coshocton wheel sampler coupled to a splitter constructed from four-inch PVC water pipe. The water samples collected by the Coshocton wheel (about 0.5 percent of total flow) were further divided by a factor of 10 as they flowed through the splitter. The water samples were collected in 50-gallon chemically inert containers. Homogeneous subsamples were collected for laboratory analysis usually within one day following each runoff event.

Coarse sediments were collected in a 20 x 68 x 9 inch drop box located at the front of the approach section to each flume. A subsample was collected, oven-dried at 221 °F, weighed, and multiplied by the volume of sediment deposited. Suspended sediment was determined by vacuum-filtering one quart subsamples of the Coshocton wheel water sample through 1.78×10^{-5} inch filters, oven drying at 221 °F, and weighing. Total sediment loss was the product of the discharge weighted-Coshocton wheel samples and drop box samples, expressed in lb/acre.

Ground cover was measured by point-sampling (Levy and Madden 1933) at 8-inch intervals along twenty-five, 65-foot transects distributed in a stratified random pattern. Surface cover was classified as litter, slash, live vegetation, rock, or mineral soil. If mineral soil was exposed, it was recorded as non-eroded, interrill or rill erosion, or deposition.

Due to the extreme variability in rain storm frequency, size, intensity, and duration, and, more importantly, the response of each experimental watershed to these variations, statistical analysis of rainfall data was separated into two parts: (1) events without storm flow from the undisturbed watershed; and (2) events with storm flow from the undisturbed watershed. In both cases, regression models were used to test for treatment differences in storm flow and sediment loss. In the first case, where storm flow did not occur from the undisturbed watershed, regression models for watershed responses of storm flow, and sediment loss were fit with watershed and treatment effects. In the second case, where storm flow did occur from the undisturbed watershed, the same regression models were used and the undisturbed watershed was included as a covariate in the model. All storm flow response variables were adjusted using a natural log transformation in order to fulfill the assumption of normality necessary for the statistical procedures used in this analysis.

RESULTS AND DISCUSSION

Ground Cover

Prior to treatment, mean ground cover for the five watersheds was 92 percent mulch, 3 percent slash, and 3 percent live vegetation (Table 2). Mineral soil was exposed on 2 percent of the watersheds with no evidence of rill or interrill erosion.

After site preparation, in August 1985, mineral soil was exposed on 8.1 percent of the chopped watershed, 37.5 percent of the sheared watershed, and 30.9 and 31.3 percent of the sheared/grazed watersheds. Herbaceous vegetation, slash and mulch covered most of the site prepared watersheds after two growing seasons. Exposed mineral soil was reduced to 10 percent or less by October 1986 on the sheared and sheared/grazed watersheds and to 8.1 percent by August 1985 on the chopped watershed.

Precipitation

Annual precipitation was above normal for all six years of the study (NOAA 1981) (Table 3). Although above normal precipitation occurred during 1981 and 1985, they were the drier of the six years and 1982 and 1986 were the wettest years.

Precipitation during 1986 was above normal for all months except January and March, but during 1985 precipitation was above normal for only five months (Fig. 1). Variation in rainfall amount, intensity, duration, and frequency of occurrence caused considerable variation in storm flow. Most precipitation events were too small or too infrequent to generate storm flow. Because of high evapotranspiration and low antecedent soil moisture, larger, more frequent rainfall events were necessary during late spring and summer than during late fall and winter to generate storm flow. As a result of these conditions, only one storm flow event occurred during 1981.

The largest rainfall event (8.8 inch) occurred on November 22, 1986. Rainfall events of 3.5 to 3.9 inches occurred on October 9, 1982, August 3, 1983, February 11, 1984, October 29, 1985, and September 21, 1986.

Storm Flow

Storm flow from the watersheds was influenced by: (1) antecedent soil moisture conditions; (2) rainfall amount, intensity, and duration; and (3) watershed conditions such as size, shape, slope, vegetation, ground cover, and soil.

One storm flow event occurred during 1981, with 20 and 21 events during 1982 and 1983, respectively. Pre-treatment annual storm flow expressed as a percentage of precipitation averaged less than 0.5 percent in 1981 compared to 9.4 percent in 1982 and 10.6 percent in 1983. Storm flow after various stages of harvesting, site preparation, and livestock grazing averaged 21.4 percent of precipitation in 1985 and 26.7 percent of precipitation in 1986.

Rainfall events generated storm flow from at least one watershed 43 times during 1984, 26 times during 1985, and 39 times during 1986. From 1984 through 1986 the sheared/windrowed watershed generally yielded the greatest storm flow and mean peak discharge rate (Table 3) followed by sheared/rotationally grazed, chopped, sheared/continuously grazed, and undisturbed watersheds.

Storm flow for each treated watershed was cumulated and plotted against the cumulated counterpart for the undisturbed watershed (Fig. 2). Clearcut harvesting resulted in significant increases ($p < .05$) in storm flow relationships relative to pre-harvesting. Clearcut harvesting reduced evapotranspiration and increased soil moisture available to stream flow. Forest floor disturbance associated with harvesting may have reduced soil infiltration rates, thus increasing overland flow.

The effects of site preparation, either shearing/windrowing, or roller chopping on storm flow, although dwarfed by the sharp increases already resulting from clearcut harvesting, were significant. The additional increases in storm flow resulting from site preparation were probably due to the further reduction in standing vegetation and additional soil surface disturbance. The increase in storm flow following forest harvesting and/or site preparation follows a generalized pattern that has been repeatedly documented (Blackburn and others 1986, Douglas 1983, Hewlett 1979, Hornbeck 1975). Storm flow and peak discharge rates tended to be greater from the sheared watersheds than from the chopped watershed. This was probably due to the greater soil disturbance (Table 1) associated with the shearing/windrowing treatment than with the chopping treatment.

Roller chopping tended to reduce storm flow by covering the ground with a protective layer of litter and slash, and by increasing microrelief, the result of roller chopper blade depressions.

Table 2.--Pre- and post-treatment watershed groundcover (%) and erosion (%), Angelina National Forest, Texas

	Pre-treatment (1981-1983) All Watersheds	Post-treatment August 1985 Chopped (WS 2)[1/]	Sheared (WS 3)	Sheared/ Pregrazed (WS 4)	Sheared/ Pregrazed (WS 1)	October 1986 Chopped (WS 2)	Sheared (WS 3)	Sheared/ Grazed (WS 4)	Sheared/ Grazed (WS 1)
Mulch	92	1.8	1.3	3.5	4.6	13.3	8.8	10.4	12.0
Slash	3	70.0	57.6	55.6	48.6	26.8	17.3	17.5	19.8
Seedlings, Woody	t[2/]	1.6	0.6	1.2	1.9	4.0	2.1	0.9	3.6
Vine	t	0.6	t	0.3	1.4	2.8	0.1	0.3	0.9
Forb	t	1.9	0.6	1.4	2.6	2.8	3.8	2.3	2.8
Grass like	t	0.3	t	0.5	t	0.8	0.3	2.4	t
Grass	3	16.0	2.4	7.1	9.7	47.7	57.6	61.0	50.8
Mineral Soil	2	8.1	37.5	30.9	31.3	2.1	8.8	5.2	10.1
No Erosion	2	8.0	37.0	30.4	31.3	1.9	5.1	4.0	8.7
Deposition	0	0.1	0.2	0.5	0	0.2	0.7	0.4	1.1
Rill	0	0	0.3	0	0	0	0	0	0
Interrill	0	0	0	0	0	0	3.0	0.8	0.2

1/ WS = watershed.

2/ t = trace.

Table 3.--Annual pre- and post-treatment[1/] precipitation, storm flow, mean peak discharge rate, and sediment loss by watershed (1981-1986), Angelina National Forest, Texas

Parameter	Treatment	Watershed	Pre-treatment 1981	1982	1983	Post-treatment 1984	1985	1986
Precipitation (inch)	Undisturbed	5	48.7	66.2	56.3	53.4	52.5	65.1
	Chopped	2	49.4	65.2	57.4	52.8	49.4	64.8
	Sheared	3	48.8	64.2	56.9	51.8	48.4	63.3
	Sheared/Grazed, Rotation	4	48.8	64.2	56.9	51.8	48.4	63.3
	Sheared/Grazed, Continuous	1	48.1	62.4	56.3	51.8	47.4	61.5
Storm flow (inch)	Undisturbed	5	<0.1	5.8	5.1	3.4	1.4	5.6
	Chopped	2	0.2	5.3	5.3	8.8	8.2	15.6
	Sheared	3	0.2	9.0	8.3	13.5	14.0	21.0
	Sheared/Grazed, Rotation	4	<0.1	4.8	5.7	9.5	10.6	15.7
	Sheared/Grazed, Continuous	1	<0.1	5.9	6.2	10.1	9.6	15.4
Peak Discharge Rate (cfs)	Undisturbed	5	0.4	0.9	0.6	0.6	0.2	1.2
	Chopped	2	0.6	0.9	0.8	1.0	1.4	1.3
	Sheared	3	0.6	0.9	0.7	1.3	1.8	1.6
	Sheared/Grazed, Rotation	4	0.3	0.8	0.7	1.2	1.5	1.4
	Sheared/Grazed, Continuous	1	0.2	0.8	0.9	1.2	1.3	1.2
Sediment Loss (lb/acre	Undisturbed	5	1.8	80.6	38.6	32.2	18.0	244.8
	Chopped	2	2.0	38.4	58.2	151.4	76.3	150.4
	Sheared	3	2.4	90.2	70.1	272.7	164.6	158.4
	Sheared/Grazed, Rotation	4	11.4	37.1	30.6	92.8	106.8	275.4
	Sheared/Grazed, Continuous	1	*	35.9	37.4	95.4	73.9	99.3

1/ The chopped watershed was harvested during November and December 1983 and site prepared on October 9, 1984. Harvesting was completed on the sheared watersheds during May and June 1984 and were site prepared during May and June 1985.

* No sample collected.

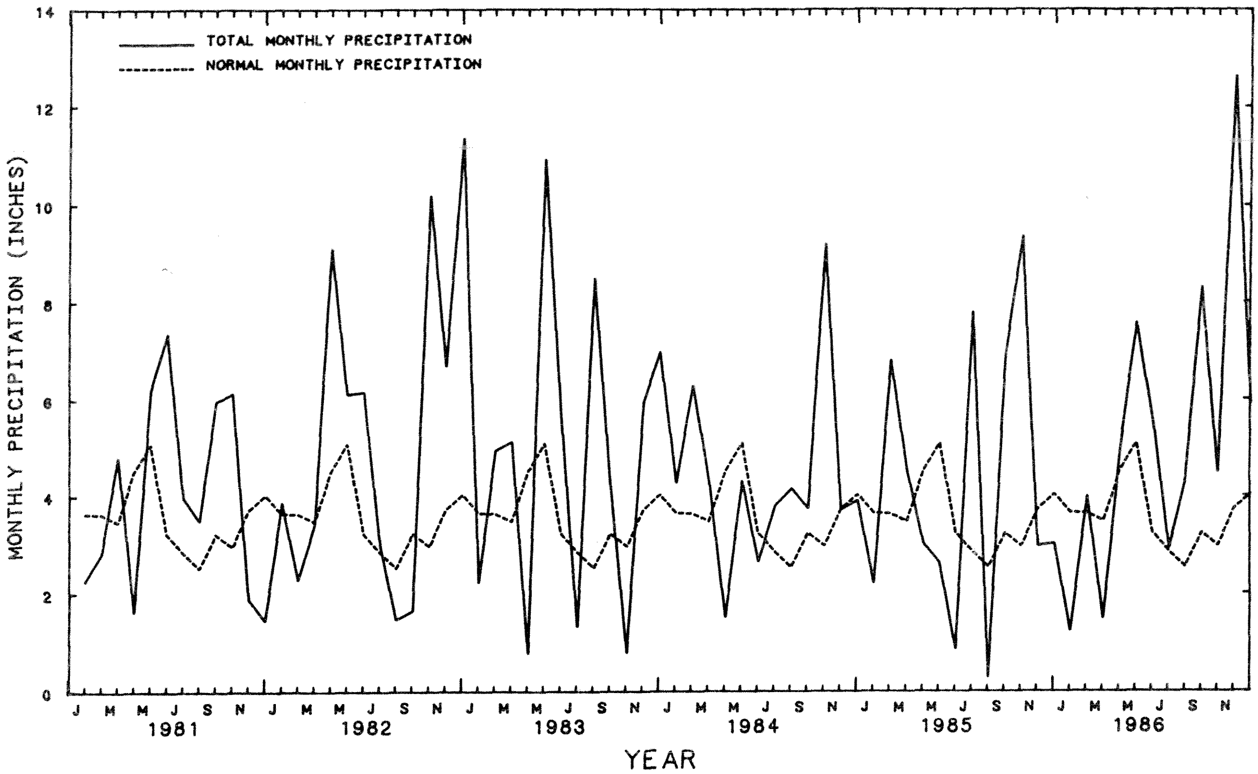

Figure 1.--Total monthly and normal monthly precipitation for the study period, Angelina National Forest, Texas.

These factors were apparently quite effective in reducing storm flow and peak discharge rates of the smaller rainfall events but had little influence on the larger events. Livestock grazing had no significant impact on storm flow.

Sediment

Annual sediment loss during the three pre-treatment years was generally less than 89 lb/acre from each watershed (Table 3). Sediment loss from the undisturbed watershed ranged from 0.8 to 244 lb/acre; sediment loss from the treated watersheds ranged from 74 to 275 lb/acre. These values are well within the range of sediment loss (trace to 640 lb/acre) reported for southeastern undisturbed forested watersheds (Yoho 1980). Periodic flushing of sediment collected in the stream channel as a result of bank sloughing, rodents, small mammal or insect activity accounts for most of the occasional high sediment loss from undisturbed watersheds. These channel activities and the increased storm flow probably accounted for most of the sediment lost from the treated watersheds.

Sediment loss was significantly increased by clearcut harvesting and site preparation (Fig. 3). However, total cumulative sediment loss during the six years of this study ranged from less than 342 to 758 lb/acre, just over the range of annual sediment loss reported for undisturbed forested watersheds in the Southeast (Yoho 1980). The lowest cumulative sediment loss occurred from the clearcut, sheared, windrowed, and continuously grazed watershed, not from the undisturbed watershed.

The watersheds were most susceptible to soil erosion and sediment loss after clearcut harvesting or site preparation when the greatest amount of mineral soil was exposed and before herbaceous plants vegetate the areas. The largest single rainfall event occurred on March 20, 1985, nine months after harvesting watersheds 2-4 and five months after roller chopping watershed 2. Storm flow and peak discharge rates for all mechanical treatments exceeded rates on the untreated watershed (Table 4). Sediment losses, however, were small from all watersheds. Approximately one month after the shearing and windrowing treatment was completed on watersheds 1, 3, and 4, and nine months after the roller chopping treatment on watershed 2, storm flow, peak discharge rate, and sediment loss from a 3.4-inch rain storm (July 16, 1985) were again greater from all treated watersheds than from the undisturbed watershed. Absolute sediment loss values were low (0.5-36 lb/acre) from all watersheds. Sediment loss from site-prepared watersheds continued to decline with time.

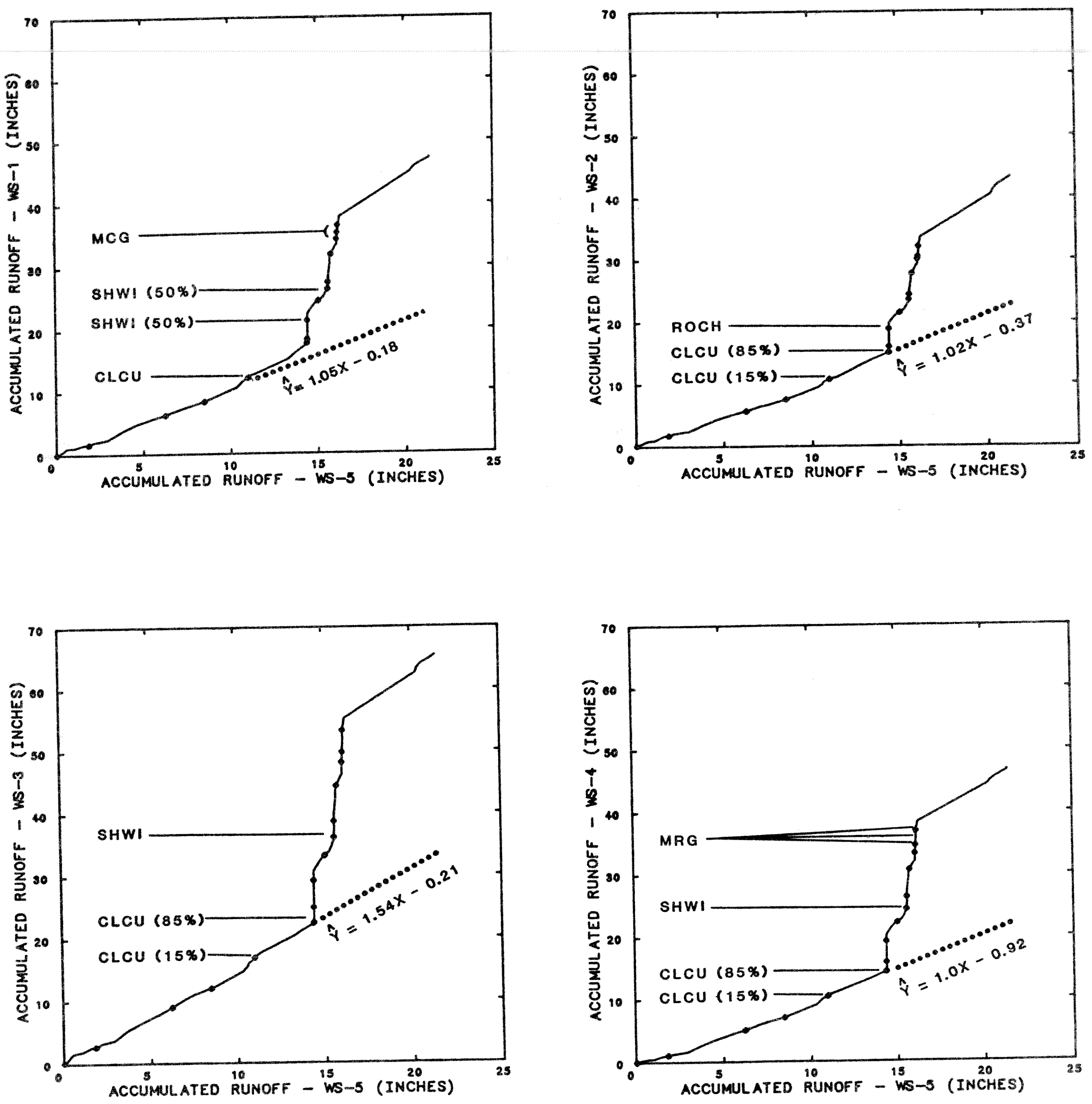

Figure 2.--Accumulated storm flow relationships between the undisturbed watershed (WS-5) and the four treated watersheds, with occurrences of clearcut harvesting (CLCU), roller chopping (ROCH), shearing and windrowing (SHWI), moderate continuous grazing (MCG), moderate rotational grazing (MRG), and pre-treatment relationships noted, Angelina National Forest, Texas, 1981-1986.

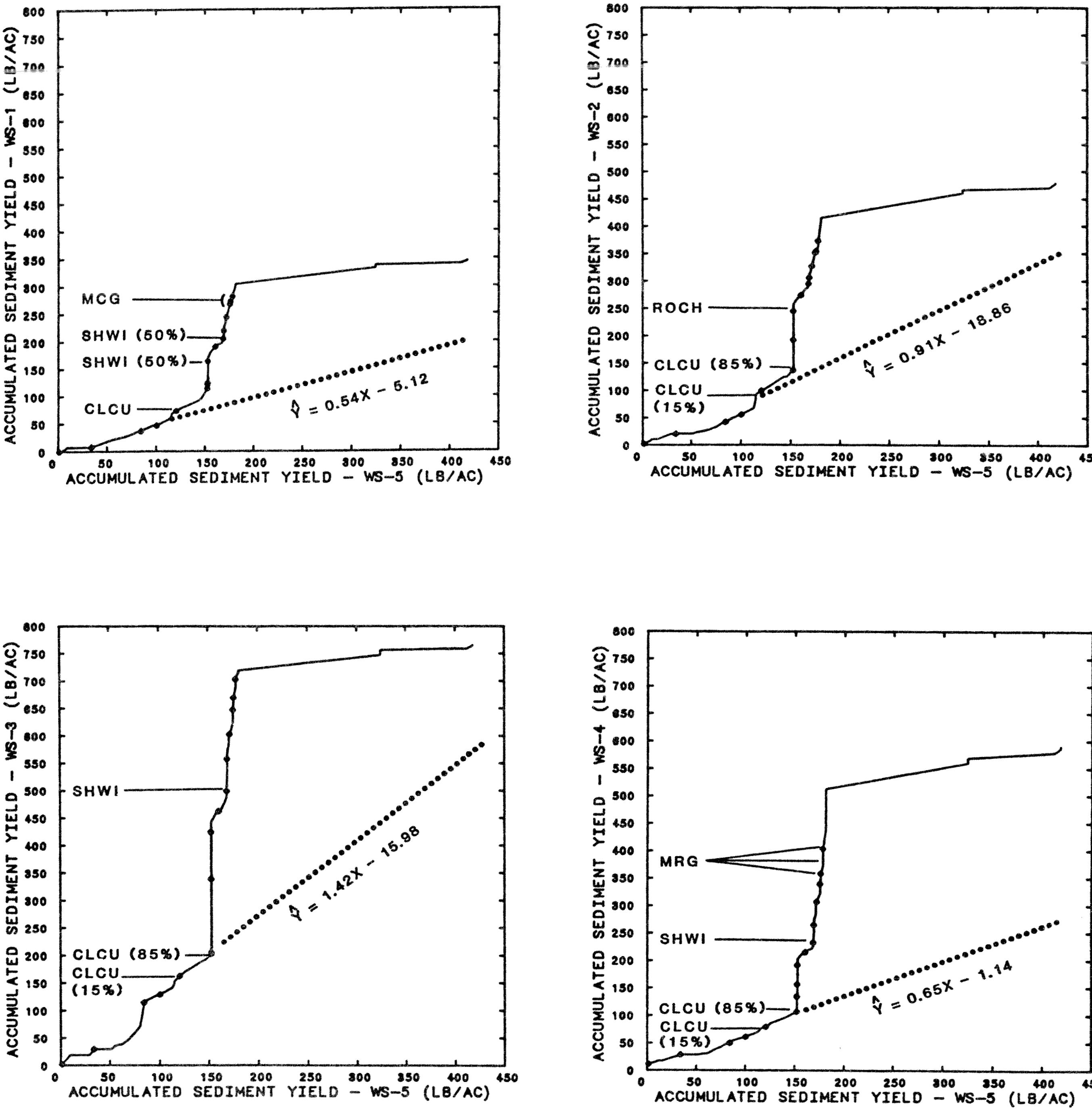

Figure 3.--Accumulated sediment loss relationships between the undisturbed watershed (WS-5) and the four treated watersheds with occurrences of clearcut harvesting (CLCU), roller chopping (ROCH), shearing and windrowing (SHWI), moderate continuous grazing (MCG), moderate rotational grazing (MRG), and pre-treatment relationships noted, Angelina National Forest, Texas, 1981-1986.

Table 4.--Post-treatment (1985, 1986) storm flow, peak discharge rate and sediment loss by treatment for selected large rainfall events, Angelina National Forest, Texas

Treatment	Watershed	Storm Flow (inches)	Annual Storm Flow (percent of total)	Peak Discharge Rate (cfs)	Sediment Loss (lb/acre)	Annual Sediment Loss (percent of total)
March 20, 1985, Precipitation[1/] = 2.1 in, 5.9 h duration, EI[2/] = 1,952 ft-tons/ac, Maximum I_{30} = 1.1 in/h						
Undisturbed	5	0.2	5	0.4	3.2	18
Chopped	2	0.9	10	3.8	4.8	6
Harvested	3	1.1	8	3.9	14.0	8
Harvested	4	0.9	9	3.2	2.8	3
Harvested/50% Sheared	1	0.9	9	3.5	2.1	3
July 16, 1985, Precipitation = 3.4 in, 2.8 h duration, EI = 8,748 ft-tons/ac, Maximum I_{30} = 5.6 in/h						
Undisturbed	5	<0.1	2	0.5	0.5	3
Chopped	2	0.8	10	10.8	11.5	15
Sheared	3	1.8	13	30.8	35.8	22
Sheared	4	1.6	15	21.6	20.0	19
Sheared	1	0.9	9	11.1	12.8	17
October 29, 1985, Precipitation = 3.7 in, 27 h duration, EI = 1,100 ft-tons/ac, Maximum I_{30} = 0.5 in/h						
Undisturbed	5	0.1	7	0.2	1.9	10.6
Chopped	2	2.0	24	2.2	10.2	13.4
Sheared	3	3.0	21	2.9	19.4	11.8
Sheared	4	2.4	22	2.5	9.8	9.2
Sheared	1	2.4	25	2.5	10.9	14.8
November 7, 1986, Precipitation = 2.3 in, 30 h duration, EI = 3,267 ft-tons/ac, Maximum I_{30} = 1.6 in/h						
Undisturbed	5	0.5	8	0.6	2.7	1.1
Chopped	2	1.1	7	2.2	37.7	25.1
Sheared	3	1.4	7	4.4	10.9	6.9
Sheared/Grazed, Rotation	4	1.1	7	4.6	31.8	11.6
Sheared/Grazed, Continuous	1	1.0	6	2.8	19.7	19.8
November 23, 1986, Precipitation = 8.8 in, 68 h duration, EI = 10,522 ft-tons/ac, Maximum I_{30} = 1.5 in/h						
Undisturbed	5	4.0	7	10.5	143.1	58.5
Chopped	2	6.9	44	11.6	44.8	29.8
Sheared	3	7.2	34	14.1	27.5	17.4
Sheared/Grazed, Rotation	4	6.0	37	13.1	47.3	17.2
Sheared/Grazed, Continuous	1	7.1	46	12.2	29.0	29.2

1/ Mean storm precipitation of the five watersheds.

2/ I_{30} = Maximum 30 minute intensity, EI = Erosion Index.

One week after the livestock grazing season (November 7, 1986), a 2.3 inch rain storm increased storm flow and peak discharge rate above the undisturbed watershed, but only small sediment losses (10.9-37.7 lb/acre) occurred from the treated watersheds. The largest rain storm event (8.8 inch) during the six year study occurred on November 23, 1986 after all treatments were in place and livestock grazing was completed for the season. Storm flow and peak discharge rates remained high with the greatest sediment loss (143 lb/acre) occurring from the undisturbed watershed. This was the result of bank sloughing, probably caused by rodent activity, and the large storm. Sediment loss continued to remain low from the treated watersheds. The greatest sediment loss (47 lb/acre) from the treated watersheds during this storm was from the clearcut, sheared, windrowed, and rotationally grazed watershed.

The high stocking density of the intensive rotational grazed watershed appeared to increase livestock trailing and the potential for disturbance to stream channels, thus increasing the potential sediment loss over the moderately stocked continuously grazed watershed.

SUMMARY

Undisturbed forests are generally characterized by having low storm flow and sediment loss. Large, intense storms are responsible for most of the sediment lost from both undisturbed and disturbed forest (Beasley 1979, Blackburn and others 1986, Greer 1971).

Clearcut harvesting resulted in significant increases in storm flow, peak discharge rates, and sediment loss for both small storms (storm flow not occurring from the undisturbed watershed) and large storms (storm flow occurring from the undisturbed watershed). This is mainly attributed to the removal of protective overstory vegetation which reduces evaporation and increases soil moisture available to stream flow. Harvesting may also disturb the forest floor, thus reducing infiltration rate and increasing overland flow.

For small storms roller chopping was particularly effective in reducing peak discharge rate, storm flow, and sediment loss by covering the ground with a protective layer of litter and slash, and by increasing microrelief via the roller chopper blade depressions. Shearing and windrowing, on the other hand, resulted in greater storm flow and sediment loss. The excessive surface soil disturbances from shearing, together with the movement of debris into windrows, exposed the soil to raindrop impact which breaks soil aggregates into smaller particles. These particles are easily detached and may leave the site and/or clog larger soil pores. As a result infiltration is reduced and surface runoff is increased, thus augmenting the potential for further loss of sediment.

For large storms, roller chopping and shearing/windrowing treatments resulted in greater storm flow peak discharge rate and sediment loss than clearcut harvesting. This is mainly attributed to the removal of the remaining standing vegetation which further reduced evapotranspiration and increased soil moisture available to storm flow. The benefits of the increased depression storage capacity created by roller chopping were only slightly effective in reducing storm flow and sediment loss from the larger storms. As a result, both roller chopping and shearing/windrowing treatments were similar in their response to the larger rainfall events.

Clearcut harvesting and mechanical site preparation of gentle sloping (< 8 percent) watersheds in East Texas increased storm flow, peak discharge rates, and sediment loss over undisturbed watersheds. The sediment losses from these intensively managed watersheds were within the range of sediment losses from undisturbed watersheds in the Southeast, below the range of losses from mechanical site prepared watersheds elsewhere, and well below potential losses from pasture and cropland (Yoho 1980, Loehr 1974). A study by Blackburn and others (1986) near Alto, Texas indicated that roller chopping is an effective forest soil conservation practice for watersheds having slopes up to 25 percent. Shearing and windrowing had little impact on sediment loss from gentle (< 8 percent) sloping watersheds and appear to be a sound forest soil conservation practice for gentle sloping watersheds.

Although one year's data is not enough to determine the impact of livestock grazing on forest soil and water resources, it appears that properly stocked livestock grazing has little impact on sediment loss or storm flow. However, there is a potential for increased stream channel instability and sediment losses caused by the high stocking density of intensive rotation grazing systems.

LITERATURE CITED

Adams, S. N. Sheep and cattle grazing in forests: A review. Journal of Applied Ecology. 12: 143-152; 1975.

Beasley, R. S. Intensive site preparation and sediment losses on steep watersheds in the Gulf Coast Plain. Soil Science Society of America Journal. 43: 412-417; 1979.

Beasley, R. S. Water quality in south Arkansas forests. Paper presented at environmentally sound water and soil management symposium, Irrigation and Drainage Division of the American Society of Civil Engineers, Orlando, FL; 1982.

Blackburn, W. H. Impact of grazing intensity and specialized grazing systems on watershed characteristics and response. In: Developing strategies for rangeland management; National Research Council/National Academy of Sciences; Westview Press; 1984: 927-983.

Blackburn, W. H.; Wood, J. C.; DeHaven, M. G.; Stormflow and sediment losses from site-prepared forestland in East Texas. Water Resources Research. 22: 776-784; 1986.

Dissmeyer, G. E. Erosion and sediment from forested land uses, management practices and disturbances in the southeastern United States. In: Proceedings of Third Federal Interagency Sedimentation Conference; NITS Publication; 1976: PB-245100:1/140-1/148.

Douglas, J. E. The potential for water yield augmentation from forest management in the Eastern United States. Water Resources Bulletin. 19: 351-358; 1983.

Greer, J. O. Effect of excessive-rate rainstorms on erosion. Journal of Soil and Water Conservation. 5: 196-197; 1971.

Hewlett, J. D. Forest water quality--An experiment in harvesting and regenerating Piedmont forest, Ga. Forestry Research Paper; School of Forestry Research; University of Georgia; Athens; 1979.

Hornbeck, J. W. Streamflow response to forest cutting and revegetation. Water Resources Bulletin. 11: 1257-1260; 1975.

Johnson, E. A. Effect of farm woodland grazing on watershed values in the southern Appalachian mountains. Journal of Forestry. 50: 109-113; 1952.

Lee, R. Forest Hydrology. New York: Columbia University Press; 1980. 349 p.

Levy, E. G.; Madden, E. A. The point method of pasture analysis. New Zealand Journal of Agriculture. 43: 267-279; 1933.

Loehr, R. C. Characteristics and comparative magnitudes of nonpoint sources. Journal of Water Pollution Control Federation. 46: 1849-1872; 1974.

National Oceanic and Atmospheric Administration. Climatological data. NOAA Environmental Data and Information Service; Vol. 86. Asheville, NC; 1981.

Patric, J. H.; Helvey, J. D. Some effects of grazing on soil and water in the eastern forest. NE-GTR-115. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1986. 25 p.

Schreiber, J. D.; Duffy, P. D; McClurkin, D. C. Aqueous- and sediment-phase nitrogen yields from five southern pine watersheds. Soil Science Society of America Journal. 44: 401-407; 1980.

Wischmeier, W. H.; Smith, D. D. Predicting rainfall erosion losses: A guide to conservation planning. Agricultural Handbook No. 537. Washington, DC: U.S. Department of Agriculture; 1978.

Yoho, N. S. Forest management and sediment production in the South--A review. Southern Journal of Applied Forestry. 4: 27-36; 1980.

Assessment of Silvicultural and Grazing Treatment Impacts on Infiltration and Runoff Water Quality of Longleaf-Slash Pine Forest, Kisatchie National Forest, Louisiana

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Abstract.--The impact of intensive silviculture, extensive silviculture, moderate continuous livestock grazing and no livestock grazing on infiltration and runoff water quality were evaluated using a rainfall simulator over an 11 ft^2 plot. Study sites were located in the Vernon District of the Kisatchie National Forest, Louisiana. Overall, infiltration and runoff water quality were significantly greater from areas under extensive silviculture and no livestock grazing than from areas under intensive silviculture and livestock grazing. Although some statistical significances were observed between treatments, differences were small and no alarming decreases in infiltration or runoff water quality resulted from any of the applied treatments. This research strongly indicates that the silvicultural and livestock grazing practices applied had minimal impacts on the soil and water resources of the study area, under the prevailing climatic soil and vegetation conditions.

The Southeastern forest provides numerous natural resources important not only to the local regions but to the country as a whole. Currently, this region is producing half of the nation's wood supply, with wood demands expected to double by the year 2000, resulting in a projected 70% increase in wood production within the Southeastern region (Ursic 1975). Also, potential range forage production in the South is greater than in other range areas within the United States (Grelen 1978). Approximately 28 million cattle are utilizing this forage resource, with 14 million head being beef cows and replacement heifers. The Southeast contains 25% of all cattle and calves in the United States and 33% of all beef cows and replacement heifers. Since little is known concerning the impacts of silvicultural and livestock grazing practices on water quality, water yield or site productivity in the Southeast, it is extremely important to assess these impacts, to provide forest managers with the knowledge necessary to make sound resource management decisions.

Intensive forest harvesting and site preparation practices have been identified as causing potential declines in site productivity and as a source of non-point pollution. Harvesting and site preparation increase the potential for sediment loss by disturbing the protective surface layers of the forest floor. Compaction and destruction of surface soil structure and macropore space cause an increase in surface runoff, thus increasing the sediment production potential (Dixon 1975, Lull 1959, Moehring and Rawls 1970). Disturbing the protective vegetation and litter opens the soil to raindrop impact, which breaks soil aggregates into smaller particles. These particles are more easily detached and may leave the site in runoff, and/or may clog larger soil pores, thus reducing infiltration and increasing surface runoff (Edwards and Larson 1969). Removal of vegetation and litter also reduces resistance to overland flow and increases water velocity, which in turn increases the carrying-power of runoff (Douglass 1975).

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The long history of woodland grazing and poorly designed studies to evaluate proper livestock management has given the grazing animal a bad image in Eastern forestry (Lee 1980, Johnson 1952, Adams 1975). Livestock grazing influences an area by: 1) decreasing protection cover, thus increasing the impact of raindrops and overland flow, 2) reducing soil organic matter and soil aggregation, 3) increasing soil surface crusting, and 4) increasing runoff and erosion (Blackburn 1984).

The objective of this study was to assess the impact of intensive silviculture, extensive siviculture, continuous livestock grazing and no grazing on infiltration and runoff water quality.

STUDY AREA DESCRIPTION

The study area was located approximately 30 miles southeast of Leesville, Louisiana on the Fullerton Allotment, Vernon Ranger District, Kisatchie National Forest. Normal annual rainfall is 54.3 inches and the average annual temperature is 65.8°F. The average frost-free season is 245 days, from the end of March to mid-November. July and August are the hottest months (81.9°F), with December and January being the coldest months (51.1°F).

Gentle rolling topography, intersected by numerous drainages, characterize the area. Elevations range from 180 to 443 feet above sea level. Vegetation consists mainly of a longleaf pine (Pinus palustris) overstory and a bluestem (Andropogon sp.) and panicum (Panicum sp.) grass understory. Study site soils are of the Malbis series, which is a fine-loamy, silicous, thermic Plinthic Paleudult. Soils are deep and moderately well drained and occur on side slopes and gently sloping ridgetops.

METHODS

Study sites were sampled in June and August/September of 1982-1984, and for a final time in September of 1985. A rainfall simulator similar to the one described by Meyer and Harman (1979) was used to determine infiltration and runoff water quality over an 11 ft^2 plot. In order to reduce variability attributable to antecedent soil water content, the plots were pre-wet by applying four inches of water at a rate of four in/h from a mist-type nozzle under a plastic cone four feet above the soil. The plots were then covered with plastic to reduce evaporation. When plots were at or near field capacity (approximately 24 hours later), simulated rainfall was applied at a rate of five in/h to insure runoff from all plots. Runoff from each plot was regularly pumped into tared containers. At each 5 minute interval during the simulated rainfall event the cumulative runoff was weighed and mean infiltration rate (in/h) was calculated by determining the difference between applied rainfall and the quantity of runoff. Upon termination of each simulated rainfall event, a thoroughly agitated one quart subsample and an 18 ounce whirl-pac subsample were collected. The one quart subsample was filtered through a #1 Whatman filter paper, dried at 221°F for 24 hrs and weighed, converted to sediment production in lb/acre, and used as an index of erosion. The 18 ounce whirl-pac sample was frozen and later analyzed for part per billion (ppb) concentrations of total unfiltered nitrogen and total phosphates.

The study pastures underwent one of two silvicultural management practices, i.e. seedtree harvesting or thinning. Seedtree harvesting was considered an intensive silvicultural practices and involved the removal of most trees, leaving 17 to 25 ft^2 basal area per acre. Trees were left as a seed source and were chosen based on phenotype, spacing and cone producing characteristics. After harvesting, the areas were site prepared using a drum chopper or rake harrow (a railroad tie with spikes 3 to 4 inches long dragged behind a tractor) and broadcast-burned to remove extraneous stems and debris. Once pine seedlings were established, all remaining seed trees were harvested. Forest thinning was treated as an extensive silvicultural practice with minimal management conducted over a large area. Thinning was done to improve growth of remaining pines, to enhance browse and mast for wildlife production and to improve herbaceous production for livestock by removing part of the surrounding overstory. One third of the thinned area was prescribed-burned every year in a rotational sequence to remove excessive undergrowth and reduce fuel loads. Silvicultural study sites were located with seed tree harvest and thinning treatments adjacent to each other. Treatment dates for each study site are summarized in Table 1.

Table 1.--Study site silvicultural treatment schedules, Vernon District, Kisatchie National Forest, Louisiana

Study Site	Seedtree harvest	Thinning
1	February 1980	March 1978
2	February 1982	March 1978
3	February 1980	March 1980
4	February 1980	March 1980
5	February 1977	March 1980
6	February 1977	March 1980

Prior to the study from 1967 to 1977, cattle had free access to the allotment, and stocking rates averaged 3.1 acre/animal unit month (ac/aum). In 1977 the allotment was cross-fenced into four pastures; however, grazing sequences were not initiated until 1981. Six study sites were located, with two sites in each of three pastures varying in size from 1322 to 1668 acres (Pearson and others 1987). Four study sites were located in pastures grazed seven months continuously from April 1 to October 31. The two remaining study sites were located in a pasture grazed continuously yearlong. All study sites were grazed at a stocking rate of 3.5 to 4.0 ac/aum (Pearson and others 1987). Livestock exclosures were constructed in 1982; however, construction was not completed until after the first sampling period and just prior to the second sampling period. For this reason both sampling periods in 1982 were treated as grazed conditions.

Initially three grazing treatments (seasonal continuous grazing, yearlong continuous grazing and no grazing) were analyzed for statistical differences. In the final analyses, however, seasonal and yearlong continous grazing treatments were analyzed together as one grazing treatment. This was done for three reasons: 1) no statistical evidence was found to indicate a significant difference between the two grazing treatments, 2) Forest Service stocking rates were based on ac/aum, which includes a time factor to correct stocking rates, appropriately, for seasonal or yearlong use, and 3) separation of the two grazing treatments only decreased the degrees of freedom and weakened the strength of the statistical analyses.

Experimental treatments evaluated were: seedtree harvesting (intensive silvicultural); forest thinning (extensive silviculture); continuous livestock grazing; and no livestock grazing. A stripping or crisscross analysis of variance was used to test for treatment differences by sample date and for all sample dates combined. Significant differences were discussed at the 95 percent level of confidence. Since the two silvicultural treatments were not found to be statistically different at the two grazing treatment levels, treatments were separated and significant differences pertain only to silvicultural means or grazing means. For each sample date, 48 individual plots were sampled when six replications and two subsamples were employed (2 grazing treatments x 2 silvicultural treatments x 6 replications x 2 subsamples).

RESULTS AND DISCUSSION

Silviculture

Infiltration rate means for extensive silviculture versus intensive silviculture were not found to be statistically different for any of the individual sampling dates (table 2). Individual sampling dates all had higher infiltration rate means for extensive silviculture, which contributed to the significantly higher combined mean across all sampling dates. Combined infiltration rate means were 2.05 in/h for extensive silviculture and 1.69 in/h for intensive silviculture.

Sediment production was somewhat variable across sampling dates, but, in general, more sediment production occurred from intensive silviculture than from extensive silviculture (table 3). The intensive silviculture mean of August 1984 (186.7 lb/ac), together with the intensive silviculture combined overall mean (141.6 lb/ac) were found to be significantly greater than respective means (96.8 and 102.7 lb/ac) from extensive silviculture.

Table 2.--Mean infiltration rate (in/h) by sampling date and for all sample dates combined, Vernon District, Kisatchie National Forest, Louisiana

Sample Date	Intensive Silviculture	Extensive Silviculture	Livestock Grazing	No Livestock Grazing
June 1982	1.73a[1]	1.89a	1.81	--[2]
Sept. 1982	1.73a	1.95a	1.84	--
June 1983	1.75a	2.30a	1.86a	2.18a
Aug. 1983	1.47a	1.63a	1.56a	1.54a
June 1984	1.80a	2.13a	1.77a	2.15a
Aug. 1984	1.39a	2.00a	1.68a	1.71a
Sept. 1985	1.99a	2.30a	1.80b	2.48a
Combined Mean	1.69b	2.05a	1.76b	2.01a

1/ Silviculture or grazing treatment means by sample date and combined across all sample dates, followed by the same letter, are not significantly different, P<.05.
2/ No sample date treatment mean.

Table 3.--Mean sediment production (lb/ac) by sampling date and for all sample dates combined, Vernon District, Kisatchie National Forest, Louisiana

Sample Date	Intensive Silviculture	Extensive Silviculture	Livestock Grazing	No Livestock Grazing
June 1982	44.5a[1]	48.3a	46.4	--[2]
Sept. 1982	278.7a	244.8a	261.8	--
June 1983	64.7a	73.6a	77.1a	61.2a
Aug. 1983	199.1a	142.4a	218.5a	122.2b
June 1984	42.7a	61.8a	56.6a	47.9a
Aug. 1984	186.7a	96.8b	124.6a	158.9a
Sept. 1985	186.3a	61.1a	178.4a	74.5b
Combined Mean	141.6a	102.7b	138.8a	92.8b

1/ Silviculture or grazing treatment means by sample date and combined across all sample dates, followed by the same letter, are not significantly different, P<.05.
2/ No sample date treatment means.

Individual sampling date unfiltered total nitrogen concentration means were found to be significantly higher only from intensive silviculture (2775 ppb) and not significantly higher from extensive silviculture (1327 ppb) for the August 1984 sample date (table 4). Combined means across all sample dates were found to be significantly higher from intensive silviculture (1777 ppb) than from extensive silviculture (1403 ppb). Overall, intensive silviculture resulted in higher runoff levels of unfiltered total nitrogen.

Total phosphate concentration means were consistently higher from intensive silviculture across individual sampling dates (table 5). The individual sampling date of August 1984, and the combined mean across sample dates, were found to have significantly higher total phosphate concentrations from intensive silviculture. Total phosphate means were 233 and 209 ppb from intensive silviculture, and 136 and 178 ppb from extensive silviculture from August 1984 and combined sample dates, respectively.

Table 4.--Mean total unfiltered nitrogen concentrations (ppb) by sample date and for all sample dates combined, Vernon District, Kisatchie National Forest, Louisiana

Sample Date	Intensive Silviculture	Extensive Silviculture	Livestock Grazing	No Livestock Grazing
June 1982	--[1/]	--	--	--
Sept. 1982	980a[2/]	1227a	1103	--
June 1983	1204a	1640a	1519a	1324a
Aug. 1983	3112a	2227a	2767a	2616a
June 1984	1691a	1558a	1677a	1571a
Aug. 1984	2775a	1327b	2401a	1632b
Sept. 1985	1243a	694a	1123a	813a
Combined Mean	1777a	1403b	1643a	1514b

1/ No sample date treatment mean.
2/ Silviculture or grazing treatment means by sample date and combined across all sample dates, followed by the same letter, are not significantly different, P<.05.

Table 5.--Mean total phosphate concentration means (ppb) by sampling date and for all sample dates combined, Vernon District, Kisatchie National Forest, Louisiana.

Sample Date	Intensive Silviculture	Extensive Silviculture	Livestock Grazing	No Livestock Grazing
June 1982	--[1/]	--	--	--
Sept. 1982	402a[2/]	424a	413	--
June 1983	136a	140a	148a	128a
Aug. 1983	166a	172a	176a	163a
June 1984	136a	98a	117a	116a
Aug. 1984	233a	136b	178a	196a
Sept. 1985	189a	111a	177a	123a
Combined Mean	209a	178b	229a	144a

1/ No sample date treatment means.
2/ Silviculture or grazing treatment means by sample date and combined across all sample dates, followed by the same letter, are not significantly different, P<.05.

In general, intensive silvicultural treatments displayed a trend of lower infiltration rates and decreased runoff water quality when compared to extensive silvicultural treatments. Runoff water quality appears to follow closely with infiltration, in that the larger treatment differences in individual sampling date infiltration rates were also the dates with larger runoff water quality differences between treatments. The lower infiltration rates and runoff water quality resulting from intensive silviculture are mainly attributed to the surface soil disturbances caused by clearcutting and site preparation, and to the subsequent removal of protective surface layers of vegetation and litter.

Grazing

For individual sample dates, the September 1985 sample period was the only date where mean infiltration rate was significantly higher for non-grazed areas than for grazed areas (table 2). The combined infiltration rate mean for the non-grazed areas was 2.01 in/hr and was significantly higher than the mean of 1.76 in/hr for the grazed areas.

Mean sediment production was significantly greater from the grazed areas than from the non-grazed areas for August 1983 and September 1985 (table 3). When sample dates were observed over time, the combined sediment production mean from non-grazed areas was significantly lower than from grazed areas.

Total unfiltered nitrogen concentration means for individual sample dates were consistently higher from the grazed areas than from the non-grazed areas, which contributed to the significant difference found for combined means (table 4). Although only a small difference was apparent between the combined total nitrogen mean of 1643 ppb for grazed areas and 1514 ppb for non-grazed areas, differences were nonetheless significant. The August 1984 sampling date was the only individual sampling date with significantly higher total nitrogen concentrations in runoff from grazed areas (2401 ppb) than from non-grazed areas (1632 ppb).

Total phosphate concentration means were low and no significant differences were found between grazing treatments (table 5). Phosphate concentrations in runoff were generally higher from the grazed areas; however, differences between treatments were not significant. The combined total phosphate mean across sample dates was 229 ppb for grazed areas and 144 ppb for non-grazed areas.

Generally, a trend existed for lower infiltration and decreased runoff water quality from grazed areas than from non-grazed areas. As with silvicultural responses, runoff water quality followed closely with infiltration, in that sample dates with large treatment differences in infiltration rates usually had corresponding treatment differences in runoff water quality. Influences of livestock grazing on infiltration and runoff water quality were probably mainly a result of the removal of protective vegetative cover and surface soil disturbances from trampling.

SUMMARY

Infiltration rates and runoff water quality displayed a pattern of decreasing infiltration and increasing sediment production as the seasons progressed from spring to fall. This was mainly attributed to freezing and thawing, soil drying, microorganism activity and soil surface sealing from raindrop impact, all occurring as the seasons progress (Bertoni and others 1958, Musgrave 1955).

Overall, infiltration and runoff water

quality were significantly greater from areas under extensive silviculture or no livestock grazing, than from areas under intensive silviculture or continuous livestock grazing. It is important to note that although significant decreases in infiltration and runoff water quality resulted from intensive silviculture and continuous grazing, these decreases were small and did not represent any drastic changes to the soil and water resources of the study area. The primary impacts attributable to silvicultural or grazing treatments are predominantly related to the degree of disturbance resulting from either practice.

The decrease in infiltration and runoff water quality following intensive silviculture is primarily due to the removal of protective vegetation and the disturbances in surface soil conditions which invariably follow intensive harvesting and site preparation operations. Resulting decreases in infiltration and runoff water quality are short-lived, and diminish as revegetation and site recovery occur.

Decreased infiltration and runoff water quality resulting from livestock grazing are mainly due to the removal of protective plant cover and to surface soil trampling. These effects cannot be completely eliminated without eliminating grazing of livestock and wildlife, altogether. However, the adverse effects of livestock grazing can be minimized with wise and judicious livestock management. This means that heavy continuous grazing should be avoided and moderate stocking rates or use should be maintained. Since very little research has been conducted on the influence of livestock grazing, particularly specialized systems, on the soil and water resources of the Southern pine forest, the potential impacts livestock may have are poorly understood. Thus, it is important that research be conducted to determine the best or most optimum level of livestock grazing, in conjunction with various silvicultural practices, in order to successfully integrate the multiple-use concept, vital to forest management objectives.

This research strongly indicates that, under the prevailing climatic, soil and vegetation conditions, the silvicultural and livestock grazing practices applied had minimal impact on soil and water resources of the study area.

LITERATURE CITED

Adams, S.N. Sheep and cattle grazing in forests: A review. Journal of Applied Ecology. 12:143-152; 1975.

Bertoni, J., W.E. Larson and W.D. Shrader. Determination of infiltration rates on Marshall silt loam from runoff and rainfall records. Soil Science Society of America Proceedings. 22:550-558; 1958.

Blackburn, W.H. Impact of grazing intensity and specialized grazing systems on watershed characteristics and response. In: Developing strategies for rangeland management; National Research Council/National Academy of Sciences; Westview Press; 1984:927-983.

Dixon, R.M. Infiltration control through soil surface management. In: Watershed Management: Proceedings of American Society of Civil Engineering Irrigation and Drainage Division; Logan, UT; 1975.

Douglass, J.E. Southeast forest and the problem of non-point sources of water pollution. In: Proceedings of a Southeastern Regional Conference; Virginia Water Resources Research Center, Blacksburg, VA; 1975.

Edwards, W.M. and W.E. Larson. Infiltration of water into soils as influenced by surface soil development. Transactions of the American Society of Agricultural Engineers; 12(4):463-470; 1969.

Grelen, H.E. Forest grazing in the South. Journal of Range Management. 31:244-250; 1978.

Johnson, E.A. Effect of farm woodland grazing on watershed values in the southern Appalachian mountains. Journal of Forestry. 50:109-113; 1952.

Lee, R. Forest Hydrology. New York: Columbia University Press; 1980. 349 p.

Lull, H.W. Soil compaction on forest and rangelands. Forest Service Misc. Publ. 768: U.S. Department of Agriculture; 1959. 33 p.

Meyer, L.D. and W.C. Harmon. Multiple intensity rainfall simulator for erosion research on row sideslopes. Transactions of the American Society of Agricultural Engineers; 22:100-103; 1979.

Moehring, D.M. and I.W. Rawls. Detrimental effects of wet weather logging. Journal of Forestry. 68:166-167; 1970.

Musgrave, G.W. How much rain enters the soil? In: Alfred Stefferud eds. Water: Agric. Yearb. Washington DC: U.S. Department of Agriculture Government Printing Office; 1955:151-159.

Pearson, H.A., H.E. Grelen, B.R. Parresol and V.L. Wright. Longleaf-slash pine type, Vernon District, Kisatchie National Forest, LA. In: Proceedings of the 1987 Southern Evaluation Workshop; 1987 May 26-27; Longbeach MS. New Orleans LA; Southern Forest Experiment Station. In Press.

Ursic, S.J. Harvesting southern forests: A threat to water quality? In: Non-point sources of water pollution: Proceedings of a Southeastern Regional Conference; Virginia Water Resources Research Center, Blacksburg VA; 1975.

Sediment Production from Long-term Burning of a Longleaf Pine-Bluestem Association

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Abstract.--A mobile, spray-nozzle type rainfall simulator (2.9, 4.4, and 5.0 in/hr for 45 min) was used to determine long-term effects of prescribed burning on surface cover and sediment production from a longleaf pine/bluestem association in Louisiana. Treatments represented biennially-applied winter, spring, or summer burns on an upland sandy loam site; and annual winter or spring, and biennial winter or spring burns on a bottomland silt loam site with associated unburned controls. Immediate effects of burning were to remove soil surface cover, exposing soil to raindrop impacts. Burning the sandy loam site during winter and spring significantly increased sediment production from 10.76 ft^2 rainfall simulation plots and exposed mineral soil throughout the treatment-year growing season when compared to unburned control plots. Rapid recovery of the herbaceous understory reduced differences among treatments by growing season end and stabilized sediment production within ten months. Effects of long-term prescribed burning of sandy loam and silt loam sites did not persistently increase sediment production when compared to unburned plots one and two years post-treatment, respectively.

INTRODUCTION

Fire is one of the most important ecological factors in the longleaf pine (*Pinus palustris* Mill.) region. Much valid evidence indicates that fire is the main factor responsible for perpetuation and maintenance of longleaf pine in its typical forest stands (Garren 1943). In the longleaf pine type, most wildfires do not generally create conditions as in other timber types. With rapid decay limiting total fuel buildup, most fires remain at the surface, with longleaf pine exhibiting particularly effective fire resistance (Heyward 1938).

Recognition of these conditions forms the basis of prescribed burning, acknowledged by silviculturalists as an accepted management technique in the southern pine forest region (Bruce 1947). Burning, whether prescribed or accidental, may affect the watershed through removal of the protective soil cover and alteration of soil physical and chemical properties. With regard to its frequency and intensity, burning has the potential to accelerate erosion, increase overland flow, decrease water-holding capacity, reduce soil fertility, and degrade stream water quality.

Intense research interest has been focused upon the influence of burning on hydrologic parameters, particularly in areas with severe flooding potential or where the maintenance of long-term site productivity is essential. Much work has been published on the effects of fire on soil (Burns 1952, Wells and others 1979), water (Tiedemann and others 1979), shifts in vegetative composition (Lotan and others 1981), and ecosystem

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function (Ahlgren and Ahlgren 1960). Numerous studies have been confined to either comparison of frequent burning with complete fire protection or the observation of the effects of a single severe fire. Study site specificity and conflicting results tend to inhibit the making of generalized inferences. In many cases, the effects of burning have been confounded with other silvicultural and/or range improvement practices. Few research projects have dealt with the effects of long-term maintenance burning seasonally applied on sediment production and surface cover conditions, exclusive of other treatments.

Sediment production rates, contingent upon fire intensity, soil properties, and surface cover conditions, may vary following a fire. Sediment losses from undisturbed watersheds in southern and southeastern forests are inconsequential (Yoho 1980). However, Blackburn and others (1986) found sheared, windrowed, and burned watersheds in east Texas to produce more sediment than roller-chopped and burned and undisturbed watersheds four years after treatment. Sediment losses following these site preparation techniques were significantly different between treatments, but were small and below Soil Conservation Service tolerable levels. Pye and Vitousek (1985) showed erosion on chop and burn plots to be negligible under loblolly pine.

Small but significant increases in suspended sediment occurred from maximum disturbance and site preparation consisting of tree-length harvesting, slash burning, windrowing, soil bedding, and machine planting of poorly drained pine flatwoods of northcentral Florida (Riekerk 1985). Sediment production from treated watersheds was not significant during the first post-treatment year.

Lear and others (1985) studying soil and nutrient export from clearcut loblolly watersheds found two preharvest, low-intensity prescribed fires had no effect on discharge water quality. Harvesting after the third prescribed fire significantly increased sediment concentration and export. Treatment differences in sediment yield were greater on clearcut, crushed, burned, and contour ripped when compared to undisturbed watersheds in the Ouachita Mountains of eastern Oklahoma during the first through third, but not the fourth post-treatment years (Miller 1984). The overall effects of harvest practices and site preparation on suspended sediment levels was small and short-lived, however.

The objective of this study was to determine the treatment-year and long-term effects of biennial prescribed burning at three seasonsonsediment production and surfacecover conditions in a longleaf pine/bluestem association.

STUDY AREA

Field research was conducted in a 250 ac stand of longleaf pine on the Palustris Experimental Forest approximately 33 mi south of Alexandria, Lousiana. The research location is typical of longleaf pine/bluestem (Schizachyrium spp.) sites. Elevation of the study site varies from 130 to 295 ft with slopes ranging from 1 to 30 percent. The area has a humid, subtropical climate with a mean annual temperature of 77^{o}F with an average growing season of 300 days. The average annual rainfall is 57 in with growing season peaks in April, May, and July. Study site soils have predominantly sandy loam surface and clay loam subsurface horizons developed on Columbian deposits laid down during the Quaternary period of the Pleistocene. Little forest floor is present; instead there is a vigorous ground cover composed largely of perennial grasses.

Sandy loam unit

In 1962 sixteen 10,000 ft^2 plots were established on an ungrazed site representative of the longleaf pine/bluestem range. The site gradient ranged from dry ridgetop to moist lower slope (Grelen and Epps 1967, Grelen 1975) dominated by the Ruston soil series, which is a member of the fine-loamy, siliceous, thermic family of Typic Paleudults. It is classified as a Woodland Suitability Group 2o1, rangesite 4, with a fine sandy loam topsoil of about 11 in. Overstory vegetation consists of longleaf pine with a relative abundance of southern waxmyrtle (Myrica cerifera L.), shining sumac (Rhus copallina L.), American beautyberry (Callicarpa americana L.), and blackjack oak (Quercus marilandica Muenchh.). Herbaceous dominants include pinehill bluestem (Schizachyrium scoparium v. divergens Nash), slender bluestem (Schizachyrium tenerum Nees), and broomsedge bluestem (Andropogon virginicus L.).

Silt loam unit

In 1973 fifteen 10,000 ft^2 plots were established on a second ungrazed area with little site gradient. Soils consisted of a poorly drained Beauregarde silt loam, a member of the fine-silty, siliceous thermic family of Plinthaquic Paleudults. This series is classified as a Woodland Suitability Group 2w8, rangesite 2, with low permeability and plinthite in the subsurface horizons. Overstory dominants included waxmyrtle, blackjack oak, sweetgum (Liquidamber styraciflua L.), black tupelo (Nyssa sylvatica Marsh.), and other moist-site hardwoods. Bluestems dominate the understory, with scattered panicum species (Panicum spp. and Dicanthelium spp. Gould) and paspalums (Paspalum spp.)

METHODS AND PROCEDURES

Treatments

The upland sandy loam site has remained ungrazed since 1955 (Grelen 1975). In 1962, all pines, hardwoods, and shrubs were removed from study plots. Initially, four treatments consisting of annual burns in winter (March 1), spring (May 1), summer (July 15), and mechanical removal of vegetation were installed in a randomized block design. Beginning in 1964, burning treatments were scheduled biennially, and the summer burning date changed to July 1. Mechanical removal of vegetation was discontinued after March 1963 and these unburned plots constituted the controls. Treated plots were burned in 1982 as part of the normal biennial cycle. Standing fine fuel was clipped and mulch was collected from eight randomly located 2.7 ft^2 plots prior to each burning date (Table 1). Fire temperatures were approximated using "Tempil" tablets set at 4 in aboveground and at the mineral soil surface (Silen 1956).

In 1968 loblolly pines (Pinus taeda L.) were girdled prior to direct seeding of longleaf pines on the silt loam unit. The area had been burned and grazed in 1970. During 1973 three replications of annual and biennial March 1 and May 1 burning treatments were installed in a completely randomized design. Since 1973, all fires have been set within four days of target date (Grelen 1978). All fires on both units were burned with headfires except when hazardous burning conditions made backfires necessary. In 1980 annual winter and spring burning treatments were reassigned as triennial burns, thereby precluding treatment during 1982.

Rainfall Simulation

Rainfall simulation sample plots were superimposed on the burning treatments of the sandy loam unit treated in 1982. Within each burning replication eight randomly assigned subplots 25 ft by 50 ft were delineated to represent sampling dates for simulated rainfall. For a specific date within each subplot two 10.76 ft^2 simulated rainfall/runoff plots was placed at random unless severely restricted by access or the occurrence of macropores. It was assumed that sampling during the treatment year would allow evaluation of short-term effects, while 1983 sampling dates would permit quantification of the effects of long-term biennial burning. Dates of prescribed burning treatment and watershed evaluation were as follows:

Table 1.--Fire and fuel variables during the 1982 prescribed burning treatment in a longleaf pine/pinehill bluestem association near Alexandria, Louisiana

		Mean fuel load (lb/ac)[1]			Fire temperature (°F)		
Season	Replication	Grass	Forb	Mulch	Soil surface	6 in above-ground	Mean fire speed (sec/ft)
Winter (March 1)	A	2402	181	1948	500	500	13
	B	1324	206	6143	500	600	18
	C	802	207	5100	300	600	3
	D	1351	353	2332	600	600	24
Spring (May 3)	A	1434	773	11135	400	600	17
	B	1172	38	14074	500	600	31
	C	1604	22	9825	500	600	16
	D	1558	210	9296	200	700	33
Summer (July 1)	A	4092	101	1546	300	600	13
	B	3192	74	9706	300	500	20
	C	1920	74	13341	200	500	22
	D	4547	273	9628	150	300	27

1/ Winter fuel loads are estimates based upon aboveground standing crop sampling 1 year after treatment.

Treatment	Evaluation date	
	Pre-burn	Post-burn
Sandy loam		
Winter burn (March 1982)	None	4-30-82[1/]
Spring burn (May 1982)	4-30-82	5-30-82
Summer burn (July 1982)	5-30-82	7-15-82
None		8-15-82
None		10-15-82
Longterm effects		5-30-83
Longterm effects		9-15-83
Silt loam		
Longterm effects	None	6-07-82
Longterm effects	None	10-20-82

[1/] Each date represents evaluation of all replications of all treaments and unburned control plots.

Selected dates incorporate seasonal differences (i.e. growing season versus dormancy). Rainfall/runoff plots were similarly superimposed on the treatment plots of the silt loam unit. Sampling dates represented an attempt to elicit long-term burning effects for the annual and biennial treatments incorporating seasonal differences.

A multiple-intensity rainfall simulator produced rainfall at three intensities over a 45 min storm duration to the fixed area rainfall simulation plots (Meyer and Harmon 1979). Intensities included 2.9 in/h, 4.4 in/h and 5.0 in/h representing 25-year, 35-year, and 50-year return period storms, respectively. Rainfall simulation plots were prewet with 37 gal of water using an elliptical mist-type nozzle sprinkler to standardize antecedent soil moisture conditions.

Suspended sediment was determined by vaccum-filtering a 0.3 gal subsample through a No. 1 Whatman filter, and oven-drying at 221°F for 24 h. The sample was weighed, runoff volume-weighted, converted to sediment yield in lb/ac, and used as an index of sheet erosion (Blackburn 1975).

Ocular estimates of plot cover were made using a 10.76 ft^2 frame gridded into 0.11 ft^2 squares. Surface cover consisted of shrubs (less than 3.3 ft height), grasses, forbs, litter, and bare ground. Standing crop was measured by clipping grasses, low shrubs, and forbs at the mineral soil surface. Vegetative standing crop and raked surface litter was air-dried at 140°F for 48 h and weighed.

Antecedent soil moisture and soil bulk density were determined for each rainfall simulation plot at 2 and 4 in depths utilizing the gravimetric and core methods, respectively (Black 1965). Surface soil samples were collected following rainfall simulation for laboratory analysis of particle size distribution (Bouycoucos 1962), aggregate stability, and percent organic matter (Black 1965).

Small plot characteristics and sediment production residual mean squares were tested for skewness and kurtosis (Box and others 1978). Where required, Log_{10}, reciprocal, or reciprocal-square root transformations were applied to satisfy the assumption of normality required for the statistical analyses used in this study. An analysis of variance (ANOV) was applied to sediment production data for each treatment to elicit possible differences among treatment means ($P<0.05$). Where appropriate, Student-Newman-Keuls (SNK) mean separation test for equal cell sizes was applied to the data. Simple linear correlation analysis was employed to determine the degree of association of measured variables with sediment production. Multiple regression, utilizing a modified forward stepwise technique, was applied to specify the best linear variable combination influencing sediment production.

RESULTS AND DISCUSSION

Sandy Loam Unit

Surface Cover Responses.--Short- and long-term vegetation responses to burning have shown consistent shifts in dominance to resistant longleaf pine and herbaceous species on the sandy loam unit (Grelen 1975). Burning has effectively reduced growth of susceptible noncommercial and commercial woody plants. Restriction of prescribed burning resulted in a dense overstory of shrub and tree species with concomitant heavy litter component. This overstory restricted herbaceous growth to scattered canopy openings. Maintenance burning stimulated production of an herbaceous understory in all treated plots. Scattered longleaf pines provided inherent variation in the degree of litter accumulation on burned plots.

Vegetal and mulch surface cover alleviates raindrop impact on bare mineral soil, thereby reducing soil aggregate breakdown, slaking, suspension and transport of soil particles. These cover conditions can be integrated into the percent exposed bare soil (Table 2) which can be used as an index to the potential for raindrop impact effects. Bare soil exposure from winter burning during 1982 was significant for four months post-treatment when compared to unburned controls. Spring burning treatments produced 71.4 percent bare soil exposure during the first month after burning, and contained significantly more exposed bare soil through August, 1982. Similarly, summer burning reduced ground cover to 52.4 percent, exposing bare soil through August, 1982. End-of-growing season sampling (October 1982) showed evidence for considerable vegetation and mulch cover response, resulting in a reduction of exposed mineral soil to undisturbed levels. Bare soil exposure one year post-treatment was similar to unburned control plots.

Table 2.--Mean bare ground (%) by burning treatment and sample date, sandy loam site in a longleaf pine/pinehill bluestem association near Alexandria, Louisiana

	Burning treatments[1/]							
	Winter March 1, 1982		Spring May 3, 1982		Summer July 1, 1982		Unburned control	
Evaluation dates	$\bar{X}$	$S_{\bar{X}}$	$\bar{X}$	$S_{\bar{X}}$	$\bar{X}$	$S_{\bar{X}}$	$\bar{X}$	$S_{\bar{X}}$
April 30, 1982	32.50[a]	5.90	0.12[b]	0.12	1.75[b]	1.22	0.88[b]	0.64
May 30, 1982	33.12[b]	5.76	71.38[a]	7.10	5.38[c]	2.21	3.00[c]	1.00
July 15, 1982	21.00[b]	3.62	31.75[b]	5.09	48.62[a]	7.84	0.25[c]	0.16
August 15, 1982	8.12[b]	2.31	15.62[a]	2.74	17.12[a]	2.72	2.25[b]	1.61
October 15, 1982	5.50[a]	3.52	9.25[a]	2.62	6.62[a]	1.78	0.25[a]	0.25
May 30, 1983	4.50[a]	2.28	2.75[a]	1.52	4.38[a]	0.65	3.12[a]	0.91
September 15, 1983	3.75[ab]	1.11	2.50[b]	0.33	5.38[a]	1.15	1.75[b]	0.53

[1/] Means followed by the same letter within each row are not significantly different ($P<0.05$) according to analysis of variance and Student-Newman-Keuls multiple range test.

Relative soil exposure rates from seasonal burning have implications for management of a sandy loam site. Winter-burned treatments had exposed mineral soil during winter and spring precipitation periods prior to spring vegetative regrowth. The potential for raindrop impact-induced sediment transport from intensive storm events existed during this time. Spring burning exposed mineral soil for a shorter period before spring and summer regrowth compensated for treatment effects. Summer burning exposed mineral soil for the least amount of time, but eliminated longleaf pine over the long-term (Grelen 1975). Mineral soil exposure was checked by vegetative regrowth on all treated plots by growing season end. This study provided no evidence to support perpetual changes in mineral soil exposure resulting from biennial burning of the sandy loam unit.

Sediment Production.--Sediment production in runoff from rainfall simulator plots was significantly greater after the 1982 winter and spring burns when compared to unburned plots (Table 3). By the end of the 1982 growing season, mean sediment production from these treatments was elevated but not significantly greater than sediment yielded from unburned controls.

Sediment output from treatment-year summer burning was lower relative to spring- or winter-burned plots. The summer burn, which occurred under relatively moist conditions (0.7 in of precipitation during the previous week), produced sediment at levels similar to unburned controls during the first post-treatment month.

During the 1983 sampling period, no difference in sediment production was observed between treatments. Analysis of covariance, using antecedent soil moisture as covariable, did not control additional variability to the point of altering ANOV results.

Increased sediment production immediately after a burning treatment corresponds to the findings of Roundy and others (1978), Ueckert and others (1978), and Knight and others (1983). Removal of the heavy litter load through burning tended to stimulate grass and forb production. This stimulation response observed in 1983, seemed to compensate for the lack of a protective mulch cover.

Predicated upon the sediment production data from burned plots, there may be no significant differences in sediment transport compared to unburned controls within ten months after treatment. Results show an absence of long-term changes in sediment production, and resiliency of a longleaf pine site to perturbation by biennial burning. Accelerated sediment movement immediately after burning appears short-lived and follows the degree of mineral soil exposure.

Factors Influencing Sediment Production.--Rainfall simulation plot variables that exercised the greatest influence on sediment production were percent of bare ground exposed ($r=0.43$), grass cover ($r=-0.46$), grass standing crop ($r=-0.44$), litter cover ($r=-0.42$), total surface sand ($r=-0.44$), surface silt ($r=0.47$), during the 1982 treatment year. In 1983, physical soil parameters antecedent soil moisture at the 2 and 4 in depths (r=0.621 and r=0.682 respectively), 2 in bulk density (r=0.57), surface silt (r=0.65), and surface clay (r=0.42) were important. Surface cover variables appeared to influence sediment as a result of removal by burning. In the post-treatment year, vegetation had returned and physical soil variables replaced cover variables in importance, accounting for up to 46 percent of the variation in sediment production. The importance of antecedent moisture indicates inconsistent prewetting of rainfall simulation plots.

Predictive equations with sediment production as dependent variable were determined by stepwise multiple regression analysis (P<0.15). These predictive models were used to provide insight into probable causative relationships relative to sediment production. Regressor variables have been defined as follows:

Number	Variable	Unit of measure
Y1	Sediment production	lb/ac
X1, X2	Bulk density (2 in, 4 in)	lb/in^3
X3, X4	Soil moisture	%
X5	Organic matter content	%
X6	Aggregate stability	%
X7	Total sand	%
X8	>0.08 in fraction	%
X9	0.04-0.08 in fraction	%
X10	0.02-0.04 in fraction	%
X11	0.01-0.02 in fraction	%
X12	0.008-0.01 in fraction	%
X13	>0.008 in fraction	%
X14	Total clay	%
X15	Total silt	%
X16	Grass cover	%
X17	Forb cover	%
X18	Litter cover	%
X19	Bare ground cover	%
X20	Grass standing crop	lb/ac
X21	Forb standing crop	lb/ac
X22	Litter accumulation	lb/ac
X23	Depth to clay loam	in

Significant variables in the regression equations for sediment production reflected soil profile factors or soil cover conditions that resulted from either burning treatments or from inherent, preburn differences among treatments. Fire temperatures recorded during treatment suggested that burning regardless of season, primarily affected surface litter and standing crop, but may have been too cool at the surface to produce physical soil changes (DeBano and others 1977).

The lack of protective cover was important in predicting sediment production in runoff after burning (Table 4). Percent of bare soil exposed (X19) to the impact of raindrops provided one of the principal predictive variables for suspended sediment during treatment-year and 1983 sampling periods. Other consistently important variables included 2 in bulk density (X1), percent grass cover (X16), and surface silt (X15).

Silt Loam Unit

Surface Cover Response.--Prescribed burning, whether annual or biennial selectively removed broadleaf woody species and susceptible conifers. Restriction of burning on the silt loam unit produced a closed canopy of small diameter trees (Grelen 1978). At the time of surface cover and sediment production evaluation, two years had elapsed since the last burning treatment. Percent bare ground exposed was not significantly different among treatment plots when sampled during the 1982 inactive year in the prescribed burning cycle (Table 5). These results provided no evidence for perpetually greater exposed soil as a result of annual or biennial burning treatments.

Sediment Production.--Sediment yield from simulated rainfall plots was not increased as the result of any prescribed burning treatment on this unit (Table 6). A non-significant trend for greater sediment occurred on the unburned plots during both sampling periods. These plots tended to saturate and float off considerable suspended organic material mixed with mineral sediment. Additional error control using >0.08 in sand fraction as a covariate did not improve the detection of treatment differences. Although considered erodible, results showed the Beauregarde silt loam unit was not likely to yield substantial sediment on level terrain two years post-treatment.

Factors Influencing Sediment Production. The >0.08 in sand fraction was correlated but inversely proportional to sediment production (r=0.44). The presence of large-diameter sand grains in the surface horizon would promote infiltration at the expense of runoff-transported sediment. No other rainfall simulation plot variables were correlated with suspended sediment.

Litter accumulation (X22) associated with unburned control plots was important in predicting sediment production from the silt loam unit (Table 7). Surface texture variables total silt (X15) and sand fractions (X8, X11) may have affected sediment transport by influencing runoff, or altering the puddling efficiency of the surface horizon.

SUMMARY

Tiedemann and others (1979) and Glendening and others (1961) have reported sediment yield increases of ten and two hundred-fold, respectively, following western wildfire on steep slopes with slow vegetative cover response. In contrast, southern and southeastern pine forest are extremely resilient environments. Frequent prescribed burning has reduced the incidence of wildfire, slopes are rolling to level, and soil-protecting vegetation recovers quickly. Although the southern forest has a great potential for soil loss from intensive storm events, this resiliency results in short-lived effects and

Table 3.--Mean sediment production (lb/ac) from 10.76 ft rainfall simulation plots, initially at field capacity, sandy loam site initially in a longleaf pine/pinehill bluestem association near Alexandria Louisiana

	Burning treatments 1/ 2/							
	Winter March 1, 1982		Spring May 3, 1982		Summer July 1, 1982		Unburned control	
Evaluation dates	X	S_X	X	S_X	X	S_X	X	S_X
April 30, 1982	181.38a(a)	63.28	43.36b(b)	22.32	24.60b(b)	10.04	72.84b(b)	39.96
May 30, 1982	191.46a(a)	52.08	355.53a(a)	210.86	45.32b(b)	12.66	83.42b(b)	25.64
July 15, 1982	63.72a(a)	21.20	270.23a(a)	136.46	161.24a(a)	49.13	99.31a(a)	50.72
August 15, 1982	1625.37a(a)	588.82	1424.40a(a)	219.31	984.29ab(ab)	238.75	505.80b(b)	159.40
October 15, 1982	1819.94a(a)	433.35	1762.97a(a)	252.30	1077.54a(a)	508.37	802.40a(a)	290.35
May 30, 1983	196.77a(a)	54.54	168.50a(a)	54.20	196.25a(a)	67.30	148.55a(a)	52.16
September 15, 1983	238.95a(a)	132.62	161.96a(a)	33.11	155.10a(a)	64.89	125.74a(a)	42.55

1/ Means followed by the same letter within each row are not significantly different ($P<0.05$) according to analysis of variance and Student-Newman Keuls multiple range test.
2/ Means followed by the same letter in parentheses within each row are not significantly different at $P<0.05$) according to analysis of covariance, antecedent soil moisture (2 in depth) as a covariate, and Student-Newman-Keuls multiple range test.

Table 4.--Sediment production regression models by sampling date with all treatments combined, sandy loam site in a longleaf pine/pinehill bluestem association near Alexandria, Louisiana

Sampling date	Regression equation 1/	Coefficient of determination (R^2)
April 30, 1982	$Y = -2.7448 + 0.0685(X19)^2 + 0.0996(X15) + 30.8482(X23)$	0.543
May 30, 1982	$Y = 6.8322 - 0.0188(X16) - 2.9569(X8)$	0.208
July 15, 1982	$Y = 14.5069 + 0.0187(X19) - 3.4387(X14) - 0.0657(X12)$	0.402
August 15, 1982	$Y = -0.6928 - 3.2833(X1) + 0.0381(X19) + 0.4561(X17) + 5.7701(X2) + 3.2719(X8)$	0.660
October 15, 1982	$Y = 12.2734 + 0.0373(X19) - 0.0179(X18) - 2.0321(Xg) - 0.0799(X13) - 30.6170(X23)$	0.379
May 30, 1983	$Y = -0.4496 + 2.2063(X1) + 0.0531(X19) - 0.0157(X16) - 0.7331(X5) + 0.2471(X4)$	0.766
September 15, 1983	$Y = 2.4329 + 0.0677(X15)$	0.428

1/ All models significant at $P<0.15$.

Table 5.--Mean sediment production (lb/ac) from 10.76 ft rainfall simulation plots for seasonal burning treatments and unburned controls by sampling date, silt loam soil initially at field capacity, in a longleaf pine/pinehill bluestem association near Alexandria, Louisiana

	Collection dates 1/ 2/			
	June 7, 1982		October 20, 1982	
Burning treatments	X	S_X	X	S_X
Unburned control	$119.25^{a(a)}$	50.98	$690.61^{a(a)}$	200.06
Winter annual	$82.98^{a(a)}$	25.88	$493.86^{a(a)}$	73.99
Spring annual	$56.83^{a(a)}$	17.71	$464.90^{a(a)}$	95.42
Winter biennial	$95.85^{a(a)}$	26.80	$677.16^{a(a)}$	183.60
Spring biennial	$59.71^{1(a)}$	19.99	$639.71^{a(a)}$	301.35

1/ Means followed by the same letter within each column are not significantly different (P<0.05) according to analysis of variance and Student-Newman-Keuls multiple range test.
2/ Means followed by the same letter in parentheses within each column are not significantly different (P<0.05) according to analysis of covariance, >0.08 in sand fraction as a covariate, and Student-Newman-Keuls multiple range test.

export levels within published criteria for soil loss and water quality (Lear and others 1985).

Biennial burning of the sandy loam unit for 22 years has maintained dominance by longleaf pine and fire-tolerant grasses and forbs. Prescribed burning in 1982 may not have produced enough heat to alter soil structure. Burning removed soil surface cover, exposing plots to raindrop impact and the potential for surface sealing, increased runoff and concomitant sediment production.

Short-term effects of treatment-year burning were increases in sediment production from winter- and spring-burned plots. This was mainly attributed to the removal of protective surface soil cover and exposure of mineral soil to raindrop impact. Winter-burned plots had exposed mineral soil for a longer period than other treatments prior to the inception of spring growth. The potential for increased sediment transport from intensive storm events existed during this period. Significant sediment was moved from winter-burned rainfall simulation plots as the result of an interaction between wet surface soil conditions and dislodgement by raindrops. This circumstance provided a sediment source and runoff as a conveyance mechanism. Sediment production for both treatments was similar to unburned controls at the end of the growing season. Vegetative cover for both winter and spring treatments was restored quickly (within ten months) and compensated for mulch removed by burning. Knight and others (1983) have found a similar compensatory relationship for sediment yield under a burning/herbicide treatment regime in Texas.

The summer treatment occurred under atypically wet conditions, exposing less mineral soil than either winter or spring treatments. Sediment production from the summer-burned plots was similar to unburned controls. By the end of the treatment-year growing season, no treated plots were producing significantly more sediment than unburned plots.

It was assumed that rainfall simulation sampling of the sandy loam unit in 1983 measured the effects of longterm burning. Results provided no evidence for perpetual effects of burning on sediment production for treated plots when compared to unburned controls.

Table 6.--Mean bare ground (%) by burning treatment and sample date, silt loam site in a longleaf pine/pinehill bluestem association near Alexandria, Louisiana

	Collection dates 1/			
	June 7, 1982		Oct 20, 1982	
Burning treatments	X	S_X	X	S_X
Unburned control	2.83^{a}	2.46	0.17^{a}	0.17
Winter annual	2.50^{a}	1.54	1.33^{a}	0.61
Spring annual	2.83^{a}	1.64	1.00^{a}	0.36
Winter biennial	1.50^{a}	0.81	1.33^{a}	0.49
Spring biennial	7.83^{a}	2.65	2.33^{a}	0.76

1/ Means followed by the same letter within each column are not significantly different (P<0.05) according to analysis of variance and Student-Newman-Keuls multiple range test.

Table 7.--Sediment production regression model by sampling date all treatments combined, soil initially at field capacity. Silt loam site in a longleaf pine/pinehill bluestem association near Alexandria, Louisiana

Sampling date	Regression equation[1/]	Coefficient of determination (R^2)
June 7, 1982	Y = 4.4373 + 15.3669(X22) - 0.5489(X11)	0.235
October 20, 1982	Y = 2.5005 + 0.0283(X15) + 3.7874(X8) + 0.4125(X11)	0.397

[1/] All models significant at P<0.15.

Prescribed burning in the longleaf pine/bluestem association on a silt loam soil selectively removed broadleaf woody species and susceptible conifers independent of burning cycle and season. All plots contained nearly complete surface cover available for intercepting raindrop energy. Sediment production was limited to organic matter and small amounts of mineral soil floated from mulch layers beneath undisturbed control plots. Repeated burning did not significantly increase sediment production when compared with control plots. The potential for soil loss may be great immediately after burning a highly erosive silt loam site. However, assuming a rapid recovery of the vegetation and typically flat terrain, stabilization of the site should occur quickly without perpetual soil losses.

Variables influencing sediment production in a longleaf pine/bluestem association include bare ground exposed, grass cover and standing crop, litter cover, surface sand, and surface silt during the treatment year; antecedent soil moisture, bulk density, surface silt, and surface clay during the 1983 post-treatment year.

Severe wildfires may drastically affect vegetation and soil, resulting in alteration of hydrologic parameters and processes. Prescribed burning under the environmental conditions existing in the southern forest is not likely to have appreciable effects on sediment production. Fire temperatures are not extreme and consumption of forest floor biomass is relatively small. Humidity, temperature, and length of growing season interact to promote rapid recovery of surface cover. Sediment yields are restricted to relatively short periods when bare soil is exposed. These losses could be managed by spring burning, as summer burning eliminates longleaf pine seedlings (Grelen 1975). Application of prescribed burning on a biennial cycle provides adequate time for plant and litter cover to return to preburn levels. Although burning has greatly shifted community composition, perpetual effects of 22 years of biennial burning on sediment production from a sandy loam soil and 10 years of annual and biennial burning on sediment yield from a silt loam soil are not evident.

LITERATURE CITED

Ahlgren, I. F.; Ahlgren, C. E. Ecological effects of forest fires. Botanical Review. 26: 483-583; 1960.

Black, C. A. (Ed.). Methods of soil analysis. American Society of Agronomy Series No. 9; 1965. 1572 p.

Blackburn, W. H. Factors influencing infiltration and sediment production of semi-arid rangelands in Nevada. Water Resources Research. 11: 929-937; 1975.

Blackburn, W. H.; Wood, J. C.; DeHaven, M. G. Stormflow and sediment losses from site-prepared forestland in East Texas. Water Resources Research. 22(5): 776-784; 1986.

Bouycoucos, G. J. Hydrometer method improved for making particle size analysis of soil. Agronomy Journal. 54: 464-465; 1962.

Box, G. E. P.; Hunter, W. G.; Hunter, J. S. Statistics for experimentors. John Wiley & Sons, New York, NY; 1978. 392 p.

Bruce, D. Thirty-two years of annual burning in longleaf pine. Journal of Forestry. 45: 809-814; 1947.

DeBano, L. F.; Dunn, P. H.; Conrad, C. F. Fire's effect on physical and chemical properties of chaparral soils. Symposium on the Environmental Consequences of Fire and Fuel Management in Mediterranean Ecosystems: Stanford University, Palo Alto, CA; 1977. p. 65-74.

Garren, K. H. Effects of fire on vegetation of the southestern United States. Botanical Review. 9: 617-654; 1943.

Glendening, G. E.; Pase, C. P.; Ingebo, P. Preliminary hydrologic effects of wildfire in chaparral. Proceedings of the Fifth Annual Watershed Symposium: Tucson, AZ; 1961. 4 p.

Grelen, H. E. Vegetative response to twelve years of seasonal burning on a Louisiana longleaf pine site. U. S. Department of Agriculture Forest Service Research Note SO-192. Southern Forest Experiment Station, Pineville, LA; 1975. 4 p.

Grelen, H. E. May burns stimulate growth of longleaf pine seedlings. U. S. Department of Agriculture Forest Service Research Note SO-234. Southern Forest Experiment Station, Pineville, LA; 1978. 4 p.

Grelen, H. E.; Epps, E. A. Season of burning affects herbage quality and yield on pine-bluestem range. Journal of Range Management. 20(1): 31-33; 1967.

Heyward, F. Soil temperatures during forest fires in the longleaf pine region. Journal of Forestry. 36: 478-491; 1938.

Knight, R. W.; Blackburn, W. H.; Scifres, C. J. Infiltration rates and sediment production following herbicide/fire brush treatments. Journal of Range Management. 36: 154-157; 1983.

Lear, D. H. van; Douglass, J. E.; Cox, S. K.; Ausspurger, M. K. Sediment and nutrient export in runoff from burned and harvested pine watersheds in the South Carolina piedmont. Journal of Environmental Quality. 14(2): 169-174; 1985.

Lotan, J. E.; Alexander, M. E.; Arno, S. F.; French, R. E.; Longdon, O. G.; Loomis, R. M.; Norum, R. A.; Rotheimel, R. C.; Schundt, W. C.; van Wagendonk, J. Effects of fire on flora. U. S. Department of Agriculture General Technical Report WO-16; 1981. 34 p.

Meyer, L. D.; Harmon, W. C. Multiple-intensity rainfall simulator for erosion research on row sideslopes. Transactions of the American Society of Agricultural Engineers. 22(1): 100-103; 1979.

Miller, E. L. Sediment yield and stormflow response to clear-cut harvest and site preparation in the Ouachita Mountains. Water Resources Research. 20(4): 471-475; 1984.

Pye, J. M.; Vitousek, P. M. Soil and nutrient removals by erosion and windrowing at a southeastern U. S. Piedmont site. Forest Ecology and Management. 11(3): 145-155, 1985.

Reikerk, H. Water quality effects of pine flatwoods silviculture. Journal of Soil and Water Conservation. 40(3): 306-309; 1985.

Roundy, B. A.; Blackburn, W. H.; Eckert, R. E., Jr. Influence of prescribed burning on infiltration and sediment production in the pinyon-juniper woodland, Nevada. Journal of Range Management. 31: 250-253; 1978.

Silen, R. R. Use of temperature pellets in regeneration research. Journal of Forestry. 54: 311-312; 1956.

Tiedemann, A. R.; Conrad, C. E.; Dietrich, J. M.; Hornbuk, J. W.; Megahan, W. F.; Viereck, L. A.; Wade, D. D. Effects of fire on water: a state-of-knowledge review. U. S. Department of Agriculture Forest Service General Technical Report WO-10; 1979. 28 p.

Ueckert, D. N.; Wigham, T. L.; Spears, B. M. Effects of burning on infiltration, sediment and other soil properties in a mesquite-tobosagrass community. Journal of Range Management. 31: 420-425; 1978.

Wells, C. G.; Campbell, R. E.; DeBano, L. F.; Lewis, C. E.; Fredricksen, R. L.; Franklin, E. C.; Froelich, R. C.; Dunn , P. M. Effects of fire on soil. U. S. Department of Agriculture Forest Service General Technical Report WO-7; 1979. 34 p.

Yoho, N. S. Forest management and sediment production in the South--A review. Southern Journal of Applied Forestry. 4: 27-36; 1980.

Social Aspects of Southern Forest Grazing

John H. Peterson, Jr.

Major factors affecting potential expansion of forested grazing were identified in a pilot study using historical research, demographic trends and in-depth interviews with cattle men and Forest Service personnel.

INTRODUCTION

The Southern Evaluation Project approved by the Chief of the U.S. Forest Service in 1978 is one of the first efforts to scientifically evaluate multiple use of management of southern forest lands for both food and fiber production. Forested grazing of cattle in the southeast United States is viewed by many southern foresters and animal scientists as an undesirable survival of earlier practices associated with southern frontier subsistence agriculture. Forested grazing is often approached as a problem which will be eliminated as older farmers retire and are replaced by younger, better educated farmers who will convert land usage to more intensive mono-crop production. Cattle would be concentrated on improved pastures while improved timber management would convert forested lands to tree crops.

The trend to more intensive mono-crop production of cattle and timber in the South is parallel to developments taking place in many areas of the world. Economic benefits and management practices have been examined primarily from the perspective of a single scientific discipline such as forestry or animal science. There has been little scientific assessment of more traditional forest grazing practices, and little effort to develop scientific approaches to management of forested grazing in the Southeast. Indeed, southern forested grazing is a phenomenon which, until recently, has received little attention from social historians, social scientists, or resource scientists. This is ironic since in recent years integrated production systems of forests and crops or improved grazing are attracting increased attention in many parts of the world.

The Southern Evaluation Project

Efforts to better understand scientifically the possibilities of forested grazing are relatively new to the South, and have been undertaken primarily by the U.S. Forest Service. Although foresters and animal scientists tend to view forested grazing as an undesirable tradition practice, the U.S. Census of Agriculture indicated that in 1978 50% of farm forests in Mississippi were grazed, Forest grazing is permitted by many of the major timber companies holding larger tracts of land. But this is viewed as a traditional practice which is continued to maintain good relations with the surrounding population. In simpler terms, it is cheaper for the timber companies to try to regulate the grazing to prevent damage to the timber than to try to control losses from woods arson which often accompanies attempts to eliminate grazing. Although interest in improved management of forest grazing has been expressed in recent years by both timber companies and regional foresters, the first major study of forest grazing in the Southeast was undertaken by the U.S. Forest Service.

The U.S. Forest Service has long recognized that population increases result in greater competition for the use of land and that this requires that the nation's forest and rangeland needs to respond to multiple needs including livestock, timber and wildlife. The USDA Forest Service (1972) made a nationwide study of grazing potential with predictions concerning livestock grazing of forested lands and interactions with other resources. The Resources Planning Act of 1974, the Resources Conservation Act of 1977, the National Forest Management Act of 1976, as well as the earlier Multiple Use Sustained Yield Act of 1960 provided the legislative basis for multiple use management of forest and rangelands.

To carry out the intent of these acts and to evaluate multiple use interactions in the South, the Southern Evaluation Project was conceived, and the Chief of the Forest Services approved the project in September 1978. The objectives were:

1. evaluate impacts of timber, wildlife and range management alternatives from a biological, physical, economic, and social standpoint;

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2. provide appropriate technology transfer;
3. demonstrate selected management strategies on an operational scale.

The Social Assessment Study

The responsibility for drafting a social assessment framework was given to Mississippi State University through a cooperative research contract in the summer of 1981. Because of the broad nature of the project, an interdisciplinary team was established consisting of an archaeologist, an historian, a cultural geographer (demography), and a social anthropologist. The initial assignment was to carry out a preliminary social reconnaissance of the Mississippi test area and from this draw up a research plan for the collection of baseline data on all sites which would also permit the measurement of social changes resulting from the project (Snow and Peterson 1981).

The archaeological component of the research was deemed required by applicable federal law and consisted of a reconnaissance of the study area by a Mississippi State University archaeologist cooperating with the U.S. Forest Service archaeologist for the State of Mississippi (Marshall 1981).

The historical element in the study was included because forested grazing is a well-established traditional practice and it is probable that perspectives on traditional forest grazing will affect the perceptions and responses to modern forms of extensive and intensive forest grazing. Further, the six study areas represent a significant diversity in recent settlement or population history and also a diversity in recent grazing history. For these reasons it seemed essential for intersite comparisons that baseline data include a brief historical element (Atkinson and Peterson 1981).

The historian, geographer and anthropologist conducted preliminary interviews with local individuals knowledgeable about grazing practices in the study area. The historian supplemented historical documentation with oral history interviews with persons with long grazing experience, while the geographer and anthropologist supplemented interviews with an analysis of available statistical data on the study area (Snow 1982).

The primary purpose of the preliminary research was only to ascertain availability of data sources for further study. Therefore, any conclusions must be very tentative. Because of cutback in funds, the social assessment phase never went beyond the pilot study and research design phase (Peterson 1982). Thus the research I report represents a preliminary view of only the Mississippi test site which was never intended to be a complete research project. With this in mind, we will summarize certain aspects of southern forested grazing as they appear in the Mississippi study area.

HISTORICAL ORIGINS OF SOUTHERN FOREST GRAZING

Before examining the current status of forested grazing in the DeSoto National Forest, it is useful to renew the historical origins of southern forest grazing.

Early Cattle Herding in the Southeast

Cattle were initially introduced into the Southeast by the Spanish, and formed the basis of the wild herds encountered later on the Atlantic coastal plain by the English colonists (Towne and Wentworth 1955). Not only was the established cattle stock on the mainland significantly derived from the Iberian longhorns, but cattle-keeping practices such as open range grazing, roundups, branding and marking, horsemanship, and overland drives to market were also derived from those practices on the Iberian peninsula. Latin American cattle ranching was transferred directly from Iberia (Bishko 1952) and Anglo-American ranching practices indirectly through the migration of British West Indies colonists to the mainland, the English herding industry having displaced the earlier Spanish cattle industry on those Atlantic Islands (Gray 1933). While relatively unresearched, it would also appear that the open ranging of cattle on unimproved common lands in the southeast also has a strong antecedent in the grazing practices of the Welch and Scotch-Irish who formed the bulk of the settlers in the U.S. southeast.

These grazing practices predominated in the early settlement period in the interior backwoods of the new southern colonies with back country settlements serving as suppliers of the coastal settlements (Vance 1935). The well-known Revolutionary battlefield, the Cowpens in the Carolina Piedmont, is the most conspicuous example of this widely-established practice. A description of backwoods cattle practices as observed in the North Carolina Piedmont in 1783-84 show strong continuity into this century:

> With the most careless handling domestic cattle have increased with the greatest rapidity. It is nothing uncommon for one man to own 100 or more head of horned cattle; some count their herds by the thousands, all running loose in the swamps. By penning up the calves, and throwing out a little corn every day to the dams, the milch cows have been accustomed to come up to the dwelling-house from time to time to be milked. For each farm, the black cattle, sheep, and hogs are distinguished by special earmarks; horses are branded. Each planter's own peculiar mark is registered by law, and is thus legitimate proof of ownership, and extinguishment or falsification of these marks is treated as felony. There is little beef salted for export; what is salted is said not to keep

> well, and to grow hard and lank. In general, the beef is of no especial goodness in any of the provinces south of Pennsylvania and Maryland; the cattle themselves small and thin. . . . large herds are driven up from the farther regions to Pennsylvania, and there fed for the Philadelphia market. Out of the woods and thin as they are, one head with another is sold to the cattle-handlers at 3 to 6 Spanish dollars; and to the owner, has been at so little trouble and expense, this is almost clear gain (Stephenson 1954).

The extensive cattle herding practiced in the early years has been described as the time when a true cattle kingdom existed in the southeast. In southeastern Mississippi, Israel (1970) has shown that a decline in the cattle industry began shortly after 1840, and by 1860 the end of the early cattle kingdom was near. By the latter date, the human population had increased to the point where much former public domain land had been sold to settlers, thereby restricting its free use by the herders. In order to cultivate crops settlers burned and cut the extensive cane breaks which provided winter forage, and many types of non-winter forage vegetation had been destroyed due to many years of overgrazing and/or excessive burning (Moore 1958). Contributing to the decline in the piney woods areas was the increase during the 1840s and 1850s of subsistence pursuits based on lumber, tar, and turpentine, uses of the land which further reduced the open range (Hickman 1962).

While the increased agricultural population and beginnings of forest industry did restrict the expanse of open range, this was a gradual process. In most areas local tracts of open range continued to be available until well after the Civil War, even in prime agricultural areas. Young's (1961) study of land use following Indian removal indicates that even in DeSoto County in northeast Mississippi, where 90 percent of the soil was "loess" or "brown loam," approximately one-quarter of the land was still held by absentee owners as late as 1860. Both the landowner's own forested acreage and these "unoccupied" tracts continued to be used for grazing. In areas not well suited for agricultural use, such as south Mississippi, the percentage of lands not owned by local owners was much higher and the continued use of forested grazing was more extensive.

The Clear-Cutting Era and Its Repercussions

In many areas of the southeast the early lumber industry depended solely on natural streams for the transportation of logs to sawmills. In the late 19th century, however, a significant increase in railroad construction began, providing a more efficient and economical method of transportation. At the same time, the demand for southern wood was increasing because of depletion of the northern forests. These circumstances resulted in a tremendous boom in sawmill construction along the railroads as the centuries-old virgin timber began to be extensively cut. By 1900 numerous large lumber companies were in operation wherever virgin timber still existed, which was primarily in areas with poor agricultural soils or where the terrain was unsuitable for agriculture. By the early 1930s the virgin forests of the South were practically gone. The large lumber companies closed down operations as an area was denuded, leaving behind them vast wastelands of stumps. At the same time wildfires ravaged the cut-over lands, destroying the new seedlings which otherwise would have reforested the land naturally. These annual fires, however, removed obstacles to grass growth, resulting in millions of acres of open range conducive for grazing. Knowing the benefits of fire to grazing, many of the fires were intentionally set by livestock farmers. Grazing at this time was still poorly managed and few government restraints were attempted. In addition to cattle, hogs and sheep were also grazed, animals which were quite detrimental to young seedlings (Grelen 1978).

In 1891 Congress gave the President power to create forest reserves (later becoming National Forests), a measure which ultimately led to reforestation of much of the cut-over land not suitable for agriculture. Attempts to reforest the areas were initially hindered by grazing and the accompanying, deliberately-set annual fires, but by 1927 most southern states had outlawed forest arson and had created forestry agencies to enforce fire prevention. Opposition to laws restricting the open range resulted in continued woods arson by persons opposed to interference with the traditional open range (Grelen 1978; Lee 1980).

After World War II, most of the cut-over lands that had formerly belong to the exploitive timber companies had been purchased by large, stable timber companies which strove to regenerate the pine forests through planting and direct seeding. Regeneration and the desire to protect the private and governmental investments brought about an increase in the number of fences and stricter enforcement of stock laws. Better fire protection efforts, as well as prescribed burning in young plantations further promoted the regeneration of the forests. As a result of forest regeneration, the grass forage underneath the pines decreased, forcing many individuals to reduce their livestock herds or even sell out. In the early 1960s, intensified efforts were made in the National Forests to promote better management of grazing in order to protect the total environment, including vegetation, wildlife, soils, and water (Grelen 1978).

Southern Forest Grazing Today

In comparing the early herding practices to modern times, the termination of open range because of enforced stock laws is the most significant change. No longer can vast numbers of cattle, sheep, and hogs roam unrestrained in the forests as they did until well into the 20th century. Another significant change, caused by environmental modifications and better cattle-keeping practices, concerns the cessation of winter grazing without supplemental feeding. Unlike today, many cattle were once allowed to graze year-round without supplemental feeding because of the presence of evergreen cane, a vegetation type that once existed in abundance, but is scarce today. When abundant, the cane provided winter forage for cattle when the other types of vegetation died or became dormant. Today cattle are usually taken out of the forests during the winter and fed, but some farmers prefer to leave them in the forest during the winter while also providing them with hay and other feed. In regard to sheep, the stock laws seem to be the primary reason why once extensive holdings of sheep by farmers have not generally been reduced to small holdings kept around the farmhouse for home use. With the disappearance of the open range, farmers could no longer graze large holdings on the reduced territory available to them on the public lands.

CONTEMPORARY FOREST GRAZING IN THE DESOTO NATIONAL FOREST

From these general observations on southern forest grazing, we now direct our attention to forest grazing in the DeSoto National Forest in 1981. First, however, it is necessary to briefly examine the specific study area.

The Mississippi Study Area

The Mississippi study area lies in the southern portion of DeSoto National Forest, 22 miles north of Gulfport on the Mississippi Coast and 50 miles south of Hattiesburg, the nearest large town to the north. The DeSoto National Forest was established in 1936 and today comprises some 500,000 acres. The sandy soils of this portion of the Gulf Coastal Plain are generally poorly suited for agriculture. Prior to the 20th century, economic pursuits in the area were primarily cattle farming, sheep raising, lumbering, and naval stores. Even today only about 25% of the land area surrounding the study area is in farms and a much smaller proportion is in crop land. DeSoto National Forest is currently one of two in Mississippi where grazing or the potential for grazing is significant for the local economy.

History of Grazing in the Study Area

Historical documentation on traditional grazing in this region is very poor. Forested grazing is mentioned in the historical record primarily in the context of development of railroads, the port at Gulfport, the timber industry, and later highways. Usually such information is on the negative impacts of traditional practices on opportunities for development. Historical studies of the timber industry (Hickman 1962) and local histories (Lang 1936) mention forested grazing, but usually as a side issue.

The clearest picture of traditional grazing comes from oral history interviews. One 60-year-old man, living adjacent to the study area, introduced us to his father who remembered the earlier days of open range grazing. He recalled times when you could drive cattle from Gulfport to Hattiesburg without being bothered by roads or fences. This was a time when you could stand on your porch and see the land in all directions not being blocked in by the trees. Cattle were taken to market by driving them to the coast, but sheep were mostly driven to a place in Harrison County on the Biloxi River called Woolmarket.

Increased control of fire and reseeding of the land was carried out following acquisition by the government, and state and federal laws and regulations eventually resulted in the demise of the open range and a significant reduction in livestock numbers. The landowners today holding grazing permits for National Forest lands do not seem to resent the coming of highways and fences, national commercial forests. But older newspaper editorials suggest that this acceptance of the modern landscape was once strongly opposed. While most local residents do not recall the coming of fences and the initial permit system, they do recall the stock reduction carried out more recently through limitation of permits and numbers of allowable cattle per permittee. Prior to 1963, livestock grazing in the forest was largely uncontrolled. Excessive numbers of cattle and sheep were allowed to graze, resulting in substantial damage to all resources. Presently, grazing areas and numbers of cattle permitted are tightly controlled by the Forest Service, but problems stemming from various factors are limiting the use of the forest for grazing.

Grazing of sheep is no longer significant, but in the 1940s and 1950s some farmers were grazing sheep herds as large as 1,000 or more in the National Forest. Those farmers who have sheep today own only a few, and these are kept around the farm for food rather than for wool production. Although most individuals stated that they ceased raising sheep because dogs were killing so many of them, a more realistic and underlying reason appears to be that the demise of the open range and the grazing fees made it impractical, if not impossible, to raise sheep in large numbers. At present there seems to be no thought given by any of the permittees to attempt large-scale sheep raising again.

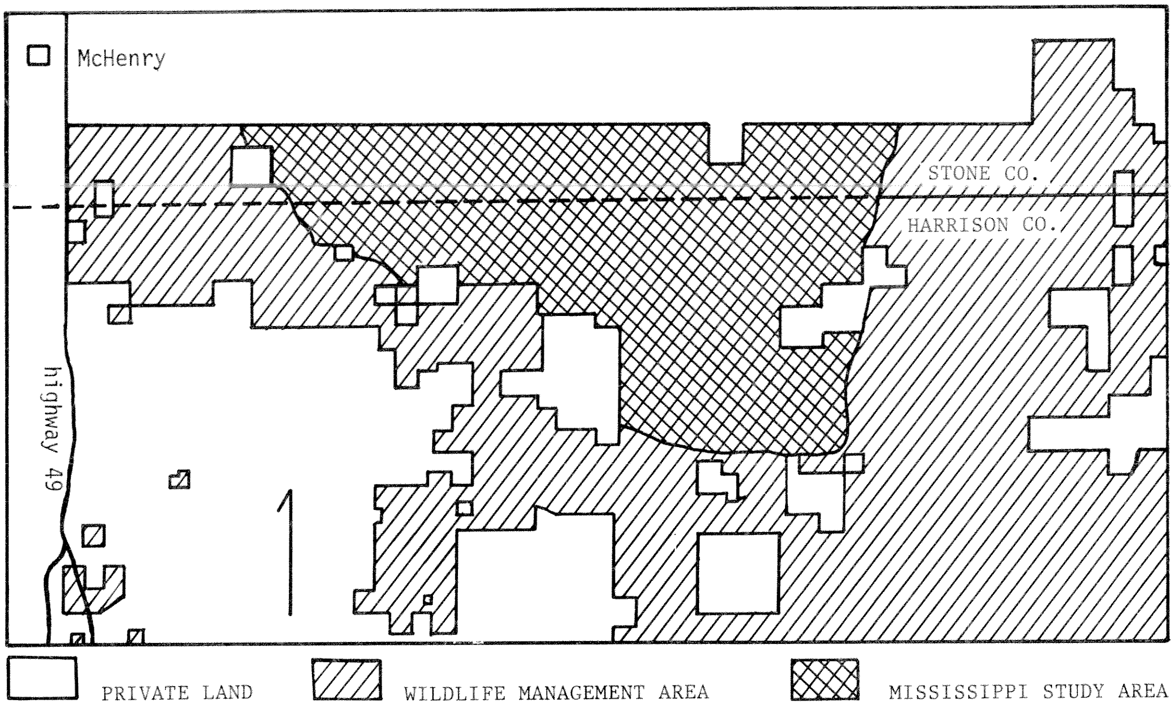

Figure 1.--Mississippi study area DeSoto National Forest.

Types of Grazing Operations

The DeSoto National Forest lands in south Mississippi do not constitute a solid block of land, as is more typical in the western United States. Nor do the residents having grazing permits for the National Forest lands resemble the ranchers grazing the western National Forests. DeSoto National Forest resembles a checkerboard with numerous small farmsteads scattered through the forests. The Biloxi Ranger District, in which the study area is located, had about 35 persons with grazing permits in 1981. Most of these permittees ran only about 30 head of cattle. Each permittee was required to pay $.62 a head per month, build and maintain fences (furnished by the Forest Service), and see that each of his cattle are ear-tagged by Forest Service personnel. Numbers of cattle a farmer can run on a certain area are controlled by the Forest Service in order to prevent damage to the total environment. Watering ponds in grazing areas without natural water are constructed by the Forest Service.

In August 1981, a field reconnaissance was conducted by Mississippi State University in the DeSoto National Forest for the purpose of gathering base line data for planning more in-depth future socio-economic studies of grazing potential in southern forests. Following is a summary of this data as obtained through interviews with nine permittees or former permittees residing on the north, south, and east sides of the study area. The nine interviewees appear to be a valid sample of the different classes of cattle grazer in the area. All but one of the present or past grazers are between 55 and 70 years of age, and have 50 or more years experience in cattle raising. The remaining permittee, who is 76 years of age, stopped cattle grazing about 10 years ago. Seven of the individuals are white and two are black.

Farmers tend to have somewhat of a proprietary attitude toward grazing rights in lands adjacent to their own holdings. Approximately seven farmsteads are located immediately adjacent to the study area (Figure 1). It is probably that these landowners would feel that they have first call to any more extensive grazing rights in the study area. This is partially a result of practical considerations on the part of the permitees as will be discussed below.

Among the individuals interviewed there were three types of cattle farmers. First, there were two full-time cattle farmers with 100 or more cattle which constitute their primary source of income. These farmers are very appreciative of the Forest Service grazing lands, for without them they would not be able to conduct large-scale cattle farming and would either have to rely on other sources of income or have a lower standard of living. In addition to the Forest Service land, they also graze on commercial timber company holdings. Both of these individuals are running cattle on some of the better areas for grazing in that permanent water-sources (creeks) are present. One of these individuals stated that the present Forest Service grazing program is the best ever and does not need to be changed. He also stated that he puts his cattle in the forest on April 1st and in six weeks they are "mud fat." These individuals seem to put the advantages of using the non-owned grazing lands above the problems and disadvantages that are faced by all the permittees. These individuals are the ones most likely to benefit from an expanded grazing program in the National Forests since they have the capital, the time, and are young enough to adapt to a more intensive operation.

In addition to the full-time cattle farmers, there are two types of part-time cattle farmers. These are similar in that neither of them derive their primary income from their cattle operations. One type of part-time cattle grazer is the older farmer who is semi-retired, but who keeps cattle as a source of supplemental income. In many cases these individuals previously managed more cattle, but no longer have the ability or interest to continue to do so. Similar to these semi-retired farmers in orientation toward their cattle is the younger individual who has a job in a nearby town, but who continues a part-time farming and cattle operation for supplemental income. These individuals have a family tradition of cattle raising. Unlike their fathers who depended upon it for a livelihood, their primary source of income is from jobs or businesses in nearby cities. One such individual, for example, owns several business establishments in Gulfport. A hired hand living on the old home place looks after his cows, but the owner comes out once or twice a week to check on things and just to be with his cows.

The part-time cattle operators, whether semi-retired or holding a non-farm job, have certain characteristics in common. They generally lack the ability to significantly increase their cattle-management effort either because of age or because of the demands of their primary occupation. As a result they tend to find the problems resulting from other human activities more acute. Further, in most cases, since their cattle operation is secondary in terms of income, they do not view their cattle as a major source of income. For many it is a second or even special purpose income. Cattle are sold when a down payment is needed on a new pickup truck, or other special cash needs arise. Thus cattle are partially income and partially like money in the bank. The personal desire to have cattle apart from any financial gain is also an important factor for these individuals. In most cases, these individuals could not invest either more time or capital in an expanded intensive cattle operation, even if people problems were reduced.

The proprietary attitude toward grazing rights in lands adjacent to private holdings was mentioned earlier. This partially reflects the fact that most holders of grazing permits are not interested in transporting cattle to a grazing area not near their farms.

The Cattlemen View People Problems

While all cattlemen recognize the same "people" problems, the larger owners feel these problems are manageable. Smaller operators seem to feel these problems more acutely. Four individuals interviewed once had medium cattle holdings. But finding the problems intolerable, they have discontinued grazing on non-owned land and reduced their holdings.

Invariably the primary reason given for not renewing their permits was the "people" problem, but other factors were usually given also. These individuals complained about the increasing numbers of people using the forest. Since cattle are presently being tagged, all individuals interviewed are concerned about liability if one of their cows should get out and be hit by a car. The difficulty here arises from the not-infrequent cases where people leave down gaps or cut fences, problems which the farmer cannot control. Other people-related problems include chasing of cattle on motorcycles (in some instances cows have been run to death), shooting cattle and sometimes butchering them on the spot, and stealing cattle. Some individuals blame the Forest Service for not doing enough to alleviate these problems by educating the public through such measures as putting up signs warning people that cattle are present and that gaps should not be left open. Some of the farmers were particularly aggravated by the Forest Service timber contractors leaving the fences unrepaired after cutting them to get into an area and also leaving fences down after letting trees fall on them. The timber contractors are required by the Forest Service to repair the fences. According to the cattle farmers, contractors do not always repair fences and, often, when they do so, it is done in such a sloppy manner that they fall apart again. These problems are of great concern to all permittees, but some persons interviewed stated that they would resume Forest Service grazing if the people problem could be solved.

Permittee Fees

Most holders of grazing permits did not object to permittee fees. There were some exceptions, but these seemed unrelated to the economics of the grazing operations since one of the strongest complaints came from one of the more wealthy permittees who was clearly not raising cattle for profit. On the other hand, one of the poorer permittees, a black man about 60 years of age, had no objection to the fees possibly because he grazes all year around and does not feed his cattle during the winter as do the others. As a result, however, his cattle get very poor and weak during the winter, according to one of the forest rangers.

Grazing in the Immediate Area

One of the drawbacks to more widespread

grazing in the forest is that most cattle farmers are generally not inclined toward transporting cattle to a grazing area not near their farms. No interviews were conducted with non-grazing cattle farmers living long distances from the forest, so attitudes toward long-distance transport among those farmers were not ascertained. All the present permittees live near their grazing areas on the fringe of the forest. Most farmers apparently prefer to have their cattle nearby so they can keep an eye on them. The people problem discussed above is a significant factor in this attitude. But some of the farmers do not have the equipment to transport cattle, even if they wanted to, and are not financially able to purchase necessary trucks. One of the large cattle raisers indicated he would be interested in transporting cattle to an area removed from his residence if grazing permits were available. The other large operator said he would consider it. One ex-grazer said he would not only resume grazing, but would also be willing to transport if the people problem could be solved. In view of these favorable attitudes toward transporting cattle to other grazing locations by larger cattle farmers, there may be a potential interest in transport grazing among similar cattle farmers living outside the immediate forest area.

A factor in transporting voiced by the permittees concerns the habit that cattle have of wanting to return to the area where they were raised. Thus, those cows transported would have to be young ones, for old cows would constantly be trying to get out and return to their old territory. In view of the cut fences and open gates problem discussed above, this is obviously a real problem. It can readily be seen that all these problems would be most acute for those individuals whose cattle operation was only a part-time activity.

Other Forest Users

The perspective of holders of grazing permits on "human problems" has been discussed above. Naturally, the perspectives of these other forest users can be expected to differ greatly from that of cattlemen. Although time did not permit interviewing a representative sample of these other forest users, it is clear that their perspectives may differ quite markedly from that of the cattlemen. The Mississippi Study Area is a popular recreational area with both a horseback trail and a hiking trail traversing the area. In addition to individual recreationalists and organized local groups such as Boy Scouts, groups from as far away as the Sierra Club from New Orleans and the R.O.T.C. units from the University of Southern Mississippi make use of the area. Local cattlemen feel that the problem of closing gates is particularly attributable to the recreational use of the area by non-local residents who are unaware of the grazing program and potentially unsympathetic to the concept of grazing cattle in "natural" forested areas. Tire marks from trail bikes found in our visit to the study area clearly demonstrate this emerging new recreational use, which is probably at odds with both cattle grazing and more traditional forms of outdoor recreation.

Hunting is another form of recreation with potential conflicts for cattlemen. The potential conflict between cattle and deer for food is one of the more important biological aspects of the Southern Evaluation Program. But even if tests prove that conflict between cattle and wildlife for food is minimal, there remains the conflict between hunters and cattlemen. When cattlemen remove their cattle from the woods during the winter this conflict is somewhat minimized. But hunters tend to return to the same hunting camp year after year and perceive informal ownership of camp locations. As with other recreationists, an increasing number of hunters are apparently coming from the nearby urban areas of coastal Mississippi and represent an increasing human pressure on the land resources of the National Forests.

Not enough is known about these other forest users at the present to anticipate how their presence may affect forested grazing in the DeSoto National Forest. Certainly this is an important factor in determining the success of the grazing programs and must be taken into account in planning research and management plans.

Area Demographic Trends

The conflicts between recreational users and forested grazing make the study of demographic trends in the two county area surrounding the Mississippi study area of special importance (Snow and Peterson 1982). Only the major points of this study will be reviewed here. The Mississippi Gulf Coast was relatively underpopulated before 1920 (See Figure 2).

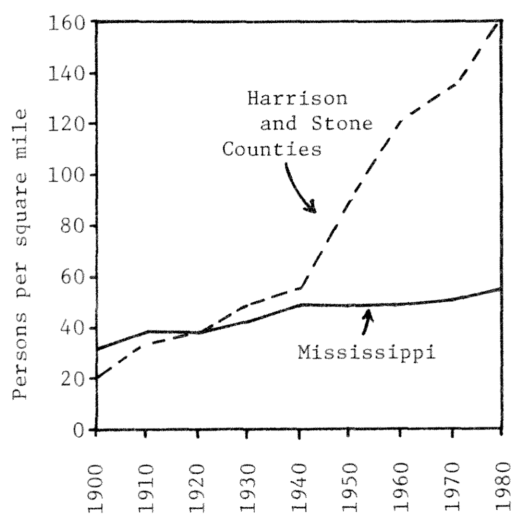

Figure 2.--Population density (Persons per square mile), 1850 - 1980).

Since the end of World War Two, Harrison and Stone Counties have experienced the rapid population growth characteristic of the entire Gulf Coast.

The majority of this growth through 1970 was in the urban population of the two county area as shown in Figure 3.

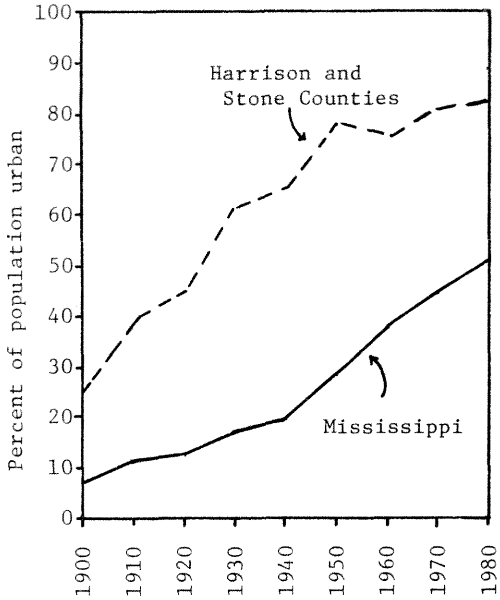

Figure 3.--Percentage of population urban, 1950 - 1980.

Between 1970 and 1980, the major population growth occurred in areas outside the major incorporated places. This suburbanization has been widely described as a retreat from urban areas into the surrounding countryside. As Table 1 indicates, between 1970 and 1980 the two major towns in the area, Biloxi and Gulfport remained almost static in population, while major growth occurred in the smaller towns and the unincorporated areas of coastal Harrison County. Stone County, inland from Harrison County and on the north or inland side of the Mississippi Study area, experienced a growth about the same percent of change as Harrison County. With only one small town, the growth in Stone County, like Harrison County, concentrated in the unincorporated areas along major transportation routes to the coast. Thus not only was the total population growing rapidly, but the population was shifting from the incorporated areas into the countryside closer to forested lands.

A further indication of this change is the rapidly decline of farm woodland as a percentage of the total land area in the two counties, as shown in Figure 4. In both Harrison and Stone County, individual farm woodlands have dropped from 13 to 16 percent of the total land area in the 1950s to 3 to 6 percent in the 1970s.

Table 1.--Population of incorporated places in Harrison and Stone counties 1970-1980

	1970	1980	Percent change 1970-1980
Harrison County			
Biloxi	48,486	49,311	1.7
Gulfport	40,791	39,676	-2.7
Long Beach	6,170	7,967	29.1
Pass Christian	2,979	5,014	68.3
Remainder of county	36,156	55,697	54.0
County total	134,582	157,665	17.2
Stone County			
Wiggins	2,995	3,205	7.0
Remainder of county	5,106	6,511	27.5
County total	8,101	9,716	19.9
Area Total	142,683	167,381	17.3

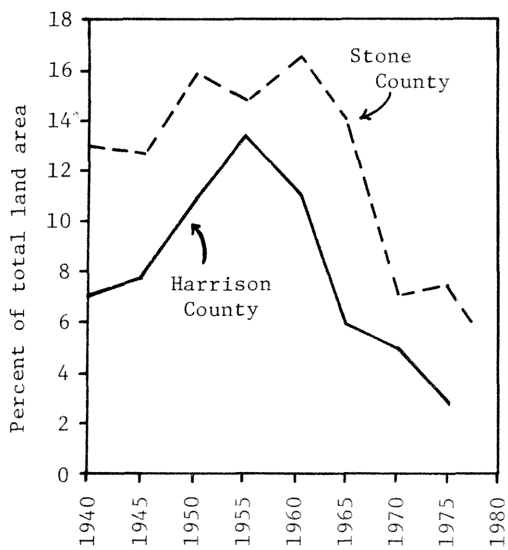

Figure 4.--Farm woodland as a percentage of total land area.

Implications of Demographic Trends

There are obvious and important implications in these demographic trends for the future of forested grazing in the southern half of the DeSoto National Forest in which the Mississippi study area is located. First, the level of recreational use can be expected to continue to dramatically increase. This use will increasingly be by non-local, urban residents who have little appreciation for forested grazing, and who lack knowledge of even the fundamentals of rural courtesy such as closing gates. Further the demand for both recreation and housing outside existing urban areas will result in high demand for forested land outside the National Forest. The sharp decline in farm forest land in the two county area already demonstrates this pressure. Except where land is made available for forested grazing in the National Forests or in commercial forests, no significant continuation of forested grazing is possible in the vicinity of the Mississippi study area. Both commercial forests and the National Forests will experience increasing demand for recreational purposes which conflict with forested grazing. Thus while the Mississippi study area is ideal ecologically for research on forested grazing, the demographic trends in the surrounding area indicate that such an experiment is probably doomed to failure in the longer run because of the pressure for human use. These conclusions about demographic trends apply only to the Mississippi study area.

The long-range possibilities of forested grazing in the Mississippi study area and other forested areas near population centers may be limited more by demographic considerations than by biological factors. Demographic trends and related non-forest, non-cattle, use of the forests would seem to be very important in considering the long-range possibilities of forested grazing in the Southern National Forests. In this regard, it is most unfortunate the limitations of funds prevented the expansion of this analysis to other study areas which could be expected to have quite different demographic characteristics.

IMPLICATIONS FOR FURTHER RESEARCH

There are some important implications to be noted from this preliminary view of current grazing operations. Since expanded grazing demands an increase in management time, many of the current holders of permits will be unable or unwilling to respond to a new opportunity. But since individuals currently holding grazing rights near their homesteads view this as a long-standing right, they may tend to resent bringing in an outsider to graze lands now or formerly being used by them. The study team was informed of a case in an adjacent state where an outsider was given a grazing permit, but significant difficulties with neighboring landowners led to his ceasing operations. Based on current information, one could anticipate that the most successful response to an experimental intensified grazing program would come from the current larger cattle operators in forest areas where grazing is now permitted. Smaller grazers would be less likely to respond to the opportunities and more likely to resent the bringing in of an outside operator. In forest areas where grazing has not been allowed in recent years, the selection of a non-resident for the grazing experiment would probably meet less opposition. Here since the criteria of local residence would not be a factor, the conditions for finding the best person to implement a cattle management program would be best. But while bringing in an outsider to a non-grazing area would best meet the cattle management objective, the possibilities that the experiment would be observed and perhaps duplicated by other grazers in the immediate area would be reduced.

The implementation of a successful intensified grazing program would seem most likely where grazing is currently permitted and where pressure from other human users is minimal. Where other human activity is high and where grazing has not been allowed under permit in recent years, a grazing program could be expected to have the maximum amount of "human problems."

Finally, the attitudes on the part of the U.S. Forest Service personnel may be the most important factor in the implementation of the grazing experiment. Cattlemen believe that many of the problems they face in forested grazing are under the control of Forest Service personnel. Without the support and understanding of Forest Service personnel, successful grazing programs would be difficult. Forest Service personnel in areas currently being grazed may be expected to have more experience with forested grazing than in areas where grazing has not been permitted in recent times. Thus without a major educational program for Forest Service personnel, an intensified grazing program may be easier to implement in areas already experiencing grazing.

PREDICTION FOR SUCCESSFUL GRAZING PROGRAMS

Given the above factors and assuming that no major unknown factor is found operative in the other research sites, it may be predicted that the more successful implementation of experimental programs in southern forested grazing will involve a site which has the following characteristics:

1. An ongoing grazing program recognized by other forest users and understood by Forest Service personnel.
2. Recruitment of permittees for the project from among local current grazers utilizing primarily successful larger grazers capable and wishing to expand operations.
3. An area in which competition from non-forestry, non-grazing users is minimal.

Where these factors are not present, the successful implementation of an experimental forest grazing project will seem to depend heavily on the education of both Forest Service personnel and other forest users as to the importance of the grazing program.

SIGNIFICANCE OF THIS RESEARCH

Although the social research component of the Southern Evaluation Project was minimal, it afforded the first effort to examine the social factors surrounding one of the least understood of traditional southern agricultural practices. A better multidisciplinary understanding of all aspects of forest grazing could have important consequences not only for combined food and fiber production from southern forests, but also could contribute scientific findings of value to other areas of the world. Certainly, the long persistence of southern forest forested grazing and the wide use of the practice today on private woodlands suggest that there are lessons to be learned which, if scientifically applied, could result in significantly higher production from southern forested lands.

REFERENCES

Atkinson, James R.; Peterson, John H., Jr. Preliminary report: historical and social trends in southern forest grazing, an overview based on historical sources and oral interviews for the southern evaluation project. Study No. 1701-1.650. Mississippi State University, C.A. 1981-40, 1981. 19 p.

Bishko, Charles J. The peninsular background of Latin American cattle ranching. The Hispanic American Historical Review. 32 (1962); 491-515; 1952.

Frome, Michael. Whose woods these are: the story of the national forests. Garden City, N.Y.: Doubleday and Co.; 1962.

Gray, Lewis C. History of agriculture in the southern United States to 1860. Washington, D.C.; Carnegie Institute of Washington; 1933: 567 p.

Grelen, Harold E. Forest grazing in the south. Journal of Range Management. 31 (4): 244-249; 1978.

Hansbrough, Thomas. Integrated use of the southern forest range: a sociological perspective. In: Child, R. Dennis and Byington, Everett N., eds. Southern forest range and pasture symposium. Morrilton, AK, Winrock International; 1980: 59-65.

Hickman, Nollie. Mississippi harvest: lumbering in the longleaf pine belt 1840-1915. Oxford, MS: The University of Mississippi; 1962 (pp. 14-27). 306 p.

Israel, Kenneth D. A geographical analysis of the cattle industry in southeastern Mississippi to 1860. Hattiesburg, MS: University of Southern Mississippi; 1970. Ph.D. dissertation. 123 p.

Kelley, Arthell, and Robert C. Spillman. Sequent occupancy of the piney woods of southeastern Mississippi, 1980 to 1976. The Mississippi Geographer. IV (1) pp. 25-40.

Lang, John H. History of Harrison County, Mississippi. Gulfport, Mississippi: The Dixie Press; 1936. 303 p.

Lee, J. Charles. Integrated use in the south: a biological perspective. In: Child, R. Dennis and Byington, Everet K., eds. Southern forest range and pasture symposium. Morrilton, Arkansas: Winrock International; 1980: 51-57.

Marshall, Richard A. Preliminary report: a cultural resource survey of study area 4, DeSoto National Forest, Mississippi. Study No. 1701-1.650. Mississippi State University, C.A. 1981-40, 1981. 30 p.

Moore, John H. Agriculture in ante-bellum Mississippi. New York: Bookman Associates; 1958 (p. 63). 268 p.

Pearson, Henry A. Livestock in multiple-use management of southern forest range. In: Child, R. Dennis and Byington, Everet K., eds. Southern forest range and pasture symposium. Morrilton, Arkansas: Winrock International; 1980: 75-88.

Peterson, John H., Jr., Final report: social assessment and cultural heritage component for the southern evaluation project. Study No. 1701-1.650. Mississippi State University, C.A. 1981-40, 1982.

Snow, Ronald W. Preliminary report: selected demographic and agricultural characteristics of Harrison and Stone Counties, Mississippi, an example of secondary base line data analysis for the southern evaluation project. Study No. 1701-1.650. Mississippi State University, C.A. 1981-40, 1982. 84 p.

Snow, Ronald W.; Peterson, John H. Jr., Preliminary report: social assessment and data collection framework for the southern evaluation project. Study No. 1701-1.650. Mississippi State University C.A. 1981-40, 1981. 49 p.

Stephenson, Wendall H. North Carolina's beef, pork and peltry trade. In a basic history of the old south. Princeton, N.J.: D. Van Nostrand Co., Inc.; 1954 (pp. 107-109). 192 p.

Towne, Charles W., and Edward Wentworth. Cattle and men. Norman: University of Oklahoma Press; 1955. 384 p.

U.S. Department of Agriculture, Forest Service. The nation's range resources - a forest range environmental study. Forest Resource Report No. 19. April, 1972.

Vance, Rupert B. Human geography of the south. Chapel Hill: Carolina Press; 1935. 596 p.

Young, Mary E. Redskins, ruffleshirts and rednecks. Norman: University of Oklahoma Press; 1961. 217 p.

Aggregate Economic Impact of Implementing Forest Grazing of Beef Cattle in the Southern United States

G. K. Lundgren, J. R. Conner and H. A. Pearson

Abstract.--Projected increases in the demand for grazable forage for beef cattle could potentially be met by utilizing Southern U.S. forests in conjunction with pulp-sawtimber rotations. Aggregate impact estimates of implementing beef cattle production in southern forests are obtained using TECHSIM, an economic simulation model of the U.S. agricultural economy. Results indicated that total welfare would be increased by implementation while producers of beef, pork and sheep could expect real decreases in the net returns for their products.

INTRODUCTION

It has been projected that the demand for animal unit months[1/] (AUM's) of forage from grazing lands in the U.S. will increase 50% by the year 2000 (Forest-Range Task Force 1972). Thus, there arises a need to search for an alternative source of feed for livestock use. There are several strategies which would produce the projected demand for AUM's. One such strategy lies in extensive use of the forest-range environment in the Southern United States.

An estimated 1.2 billion acres, or 63% of the total land area in the 48 conterminous United States, is in forest-range environment. Sixty-nine percent of this, or 835 million acres, was grazed by livestock in 1970. Nearly 100 million acres of pine and oak-pine forest land in the southeast are potentially available for livestock production with almost a quarter of a billion acres available when pasture, cropland and hayland are added to the livestock forage resource (Shiflet, 1980).

Lundgren, et al., (1983) conducted a feasibility study of grazing cattle on four timber management regimes in the South. The timber management alternatives included a 30-year rotation without thinning, a 30-year rotation with thinning to 70 square feet of basal area per acre in year 15, a 40-year rotation with thinnings in years 15 and 27, and a 60-year rotation with thinnings in years 15, 25, 35, and 48. A moderately stocked, year-long grazing strategy was practiced on each timber management alternative. Positive economies were indicated for the alternatives, the highest being the 40-year rotation with thinnings.

Returns for grazing cattle on forested lands may be further increased by the implementation of a rotational grazing management system. It has been hypothesized that systems such as the Merrill four-pasture system and the Savory grazing method, or short-duration grazing, may result in stocking rate increases of 25 to 100 percent (Merrill, 1954; Savory and Parsons, 1980). In order to evaluate the application of grazing systems in forest grazing, an analysis of a year-long continuous and four rotational grazing systems were conducted (Lundgren et al., 1984). Each grazing management system was evaluated using a 40-year timber rotation with thinnings in years 15 and 27. Three levels of stocking were analyzed for each system. Results showed that if the short duration system would allow at least a 75% increase in herd size over the continuously grazed system, the opeator would be justified in choosing it. If not, the four-pasture, one herd system should be considered because it was estimated to produce the next highest rate of return at all levels of stocking.

These studies indicate that individual firms currently owning forest land in the South could expect positive rates of return on investments in

[1/] An animal unit month is the amount of forage required to support one mature 1,000 lb. cow, or the equivalent, for one month based on an average daily forage consumption of 26 lbs. of dry matter per day.

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beef cattle production enterprises on their forest lands used in long-term rotations with periodic thinning. However, these analyses only considered firm level costs and prices.

The objectives of this study were to examine the aggregate economic effect of beef cattle grazing in conjunction with a 40-year pulp-sawtimber rotation assuming three levels of implementation in the southern U.S., 50, 75, and 100 percent of total southern forest lands used for cattle grazing. The impacts were estimated for the target year 1990.

METHODS

The aggregate impact estimates used herein were developed by using TECHSIM, a simulation model of the U.S. agricultural economy (Collins, 1980; and Collins and Taylor, 1983). The impact of implementing beef cattle grazing of southern forest lands was introduced into the model as a small reduction in the average cost of production of fed and non-fed beef cattle in the U.S. The source of the lower costs was the reduction in land costs associated with that portion of the total U.S. beef cattle herd grazing southern forest lands under the alternative implementation assumptions. The implementation assumptions--50, 75, and 100--resulted in respectively larger reductions in average cost of production. It should be noted, however, that a 100 percent implementation would amount to about 3.5 percent of the U.S. beef cow herd receiving an approximate 10 percent reduction in the cost of production. Thus, the impact on the average cost of production for the total U.S. beef cow herd is only about a .35 percent decrease.

RESULTS AND DISCUSSION

Total welfare, as a result of a 50, 75, or 100 percent implementation of forest grazing in the U.S., will increase by the year 1990. However, total welfare, reflecting the combined benefits accruing to consumers and producers in the U.S., is less than the final consumers' surplus (the benefits accruing to all consumers in the U.S.) because of the negative impact on the producers' and wholesalers' surplus (the benefits accruing to all production and wholesale firms in the U.S.) (Table 1.)

The reason for the loss in producers' and wholesalers' surplus is readily apparent when one examines the vertical effects (effect on different phases of the beef industry) and horizontal effects (effect on alternative livestock enterprises) of implementation of forest grazing in the U.S. At each level of implementation, fed

Table 1.--Estimated aggregate changes in consumers' surplus, total welfare and beef related industries resulting from forest grazing of cattle for target year 1990

	Units	50% Implementation	75% Implementation	100% Implementation
Total livestock final				
Consumer surplus	Mil $	2758.88	4150.57	5550.93
Total welfare	Mil $	2398.60	3579.46	4770.90
Vertical effects				
Cattle				
Fed beef				
net returns	$/head	-13.86	-20.74	-27.57
Non-fed beef				
net returns	$/head	-10.54	-15.75	-20.92
Calves placed on feed	Mil head	.72	1.09	1.47
Farm price	$/cwt	-2.89	-4.32	-5.74
Retail price	$/cwt	-9.61	-14.38	-19.12
Horizontal effects				
Sheep				
Net returns	$/head	-.69	-1.04	-1.38
Supply	Mil lbs	-.80	-1.25	-1.70
Farm price	$/cwt	-1.40	-2.10	-2.79
Retail price	$/cwt	-5.47	-8.18	-10.89
Pork				
Net returns	$/head	-1.29	-1.93	-2.57
Supply	Mil lbs	-16.27	-24.37	-32.44
Farm price	$/cwt	-1.19	-1.79	-2.38
Retail price	$/cwt	-3.78	-5.67	-7.57

beef, non-fed beef, pork, and sheep net returns all decrease.

Increased production at the cow-calf level had the effect on the vertically different levels of the beef industry of increasing the number of calves placed on feed and the number of non-fed cattle sold to slaughter. This increase in supply of beef, not being offset by a compensating increase in demand, caused the decrease in farm level and retail level prices.

The horizontal effects among competing livestock enterprises are shown in the substitution effect. As beef becomes less expensive at the retail level and consumers switch their meat purchases to beef, competing livestock enterprises such as sheep and pork experience a decrease in price levels which result in a commensurate decrease in the number supplied.

The aggregate effect of implementing cattle grazing in conjunction with pulp-sawtimber rotations would be a slightly lower internal rate of return on investments than was estimated for a single firm by the Lundgren, et al. studies (1983, 1984). However, the general conclusions reported in those studies should remain valid.

The implications for U.S. agricultural producers and consumers of implementing this technology (i.e., grazing cattle in conjunction with pulp-sawtimber rotations in the Southern Pine forests) are similar to those of most agricultural production technologies which increase efficiency of agricultural production. That is, society in general gains because consumers receive substantial benefits (more beef at lower prices in this case). This gain for consumers, however, is generally earned through losses in net revenues by producers. In this case, most livestock producers would experience farm level price reductions for their products of about 2.5 percent for beef and 1.5 percent for pork; assuming that the practice is implemented on 50 percent of the Southern Pine forests by 1990.

LITERATURE CITED

Collins, G. S., III. An econometric simulation model for evaluating aggregate economic impacts of technological change on major U.S. field crops. College Station, Tx: Texas A&M University; 1980. 263 p. Ph.D. dissertation.

Collins, G. S., III and C. R. Taylor. TECHSIM: a regional field crop and national livestock econometric simulation model. Agricultural Economics Research. 35(2): 1-18; 1983.

Lundgren, G. K., J. R. Conner and H. A. Pearson. An economic analysis of forest-grazing on four timber management situations. Southern Journal of Applied Forestry. 7(3): 119-124; 1983.

Lundgren, G. K., J. R. Conner and H. A. Pearson. An economic analysis of five forest-grazing management systems in the southeastern United States. Misc. Pub. 1551. College Station, Tx: Texas Agricultural Experiment Station; 1984. 7 p.

Forest-Range Task Force. The nation's range resources - a forest-range environmental study. Forest Research Report 19. USDA, Forest Service; 1972. p. 147.

Merrill, Leo B. A variation of deferred rotation grazing for use under southwest range conditions. Journal of Range Management. 7:152-154; 1954.

Savory, A., and D. D. Parsons. The savory grazing method. Rangelands. 2:235-237; 1980.

Shiflet, T. N. What is the resource. In: Proceedings, Southern Forestry Range and Pasture Research Symposium; March 13-14; New Orleans, La; 1980: p. 17-28.

The Interrelationships Among Management of Forested Range, Tree Pests, and Wildlife

William H. Sites

Abstract.--Notes that interrelationships between the management of forested range, tree pests, and wildlife have never been fully studied. Considers positive and negative impacts of forested range management on tree pests. Discusses the relationship between tree pests, cattle grazing, and wildlife populations which are generally localized.

INTRODUCTION

To the aspects of vegetation, grazing, and wildlife discussed at this workshop, I would like to add yet another consideration--the management implications of insects and diseases that attack trees. These are very important considerations for both range and timber management.

Many factors influence the spread and severity of insects and disease attacks on forest trees. Among them are weather, soil, past and present timber management practices, changes in plant species composition, and the previous land use. I will discuss a few management practices and how they affect pest populations.

My paper is not based on a designed study. Rather, it examines the practices of combined range and timber management for possible impacts on insects and diseases, and vice versa. We did conduct some general surveys to determine the relative distribution of some important pest problems.

The interrelationships among management of forested range and the many insects and diseases that attack trees have never been fully studied. However, many practices common in range and timber management are reflected in pest problems and are well know. I will discuss some of the more important ones here so that those managing for range and timber can optimize both resources.

THE INFLUENCE OF CATTLE MANAGEMENT PRACTICES ON TREE INSECT AND DISEASE POPULATIONS

Fire

As with other treatments, fire can have positive and negative impacts on pest incidence in trees. The use of fire to improve forage also controls brown-spot disease (caused by *Scirrhia acicola* [Dearn.] Sigg.) of longleaf pine (*Pinus palustris* Mill.) seedlings. Fire also offers good control of fruiting bodies of annosus root rot fungus (caused by *Heterobasidion annosum* [Fr.] Bret. [formerly *Fomes annosus*]) on the two most common hosts, loblolly (*Pinus taeda* L.) and slash (*Pinus elliottii* Engelm. var. *elliottii*) pines (Froelich and others 1978). While fire does not reduce the level of root disease already established in the stand, inoculum that would be otherwise available for infecting newly thinned stands is reduced. Similar indirect control of southern fusiform rust (caused by *Cronartium quercuum* [Berk.] Miyabe ex Shirai *f. sp. fusiforme*) with fire is accomplished by helping to control oak, the alternate host. In diseased stands, fire results in severe damage and mortality to galled stems in rust- infected stands and can also create unbleachable char (Belcher and others 1977), making wood fiber unsuitable for paper.

Southern pines are resistant to fire when they are mature, but seedlings and saplings can be killed outright. Furthermore, fire damage to stems and surface roots can invite attack by *Ips* beetles (*Ips* spp.) and the southern pine sawyer

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(*Monochamus titillator* [Fab.]) (Dixon and others 1984) or, in the case of older trees, can result in the development of root and butt rot caused by *Polyporus schweinitzii* Fr. The risks to the timber resource associated with fire are mainly from high-intensity fire or fire in regeneration. Low-intensity fires, typical of controlled burns, have more positive than negative impacts on pine stands beyond the sapling stage, and they certainly do improve forage quality.

Tree Spacing

The wide tree spacings that are suggested for improved forage production can also have positive and negative influences on tree diseases. Annosus root rot spreads rapidly in thinned slash, loblolly, and shortleaf pines (*Pinus echinata* Mill.) through root grafts and contacts between residual trees and stumps that become infected. This is particularly troublesome in plantations. Increasing distance between trees can reduce this means of spread (Kuhlman and others 1976).

Some debate exists over the relationship between tree spacing and damage from fusiform rust. Wider spacings may tend to increase damage from fusiform rust on loblolly and slash pines, because they result in poorer pruning of limbs with active galls that are close enough to the main stem to grow to and infect it. In addition, wider spacing reduces the number of stems per acre and is thought to increase the negative impact on yields from outright mortality and nonmerchantable, infected stems in moderately infected stands (Phelps and Czabator 1978). Belcher and others (1977), however, indicate that the close spacing results in significantly less growth of individual trees, smaller sizes of intermediate and end products, and delayed removal of rust-infected trees from the stand.

Depending on growth, stand characteristics, and level of infection, either of these theories may apply. Without a detailed analysis of the stand, considering growth, stand characteristics, and level of infection, it would be difficult to argue that wider spacing does or does not pose a conflict between grazing and timber production, unless the site is underutilized.

Fertilization and Cultivation

Pasture fertilization and cultivation can increase fusiform rust losses in slash pines (Balthis and Anderson 1944, Dinus and Schmidtling 1971). Although we normally think of increased tree vigor as retarding disease development, the reverse is actually true for fusiform rust on slash pines (Dinus and Schmidtling 1971, Hughes and Jackson 1962). Fertilized trees are much more prone to the disease, and trees that are cultivated as well as fertilized are the most rust sensitive (Dinus and Schmidtling 1971, Lewis and others 1972). Similar research tests on loblolly pines did not reveal similar increases in rust incidence (Dinus and Schmidtling 1971).

The effects of fertilization on root diseases are not known, but they are certainly less significant than for fusiform rust. For annosus root rot, soil texture and texture-related characteristics appear to be the most significant factor (Kuhlman and others 1976).

Fertilization of 92 slash pine families resulted in a significant increase in infection from the pitch canker fungus (*Fusarium moniliforme* Sheld. var. *subglutinans* Wollenw. and Reink.) (Lowarts and others 1985). Application of high rates of nitrogen and phosphorus fertilizer caused increased mortality in already infected trees (Fisher 1981).

The results of studies on the effects of fertilization on southern pine beetle attacks have been inconclusive (Haines and others 1976, Moore and Layman 1978). However, damage from the southern pine coneworm (*Dioryctria amatella* [Hulst]) was increased in fertilized slash pines (Hughes and Jackson 1962, Lewis and others 1983).

A significant conflict between grazing and tree management objectives arises with fertilization and cultivation of slash pines. Incidences of southern fusiform rust and southern pine coneworm in slash pine plantations are increased by these practices. In addition, since root rot fungi can enter via root wounds, any cultivation practice that causes root injury could result in an increase of these diseases.

Seedling and Site Selection

Planting stock should be selected carefully. To reduce disease potential, nursery stock should always be free of disease. This is particularly important in reducing losses to and limiting the spread of fusiform rust. To obtain the most resistant trees, seed source is very important. Livingston Parrish, Louisiana, has traditionally been considered an excellent source for loblolly pines resistant to fusiform rust. Slash pines from southern Mississippi also appear to have greater rust resistance (Wells and Lora 1974). Recently, Powers and Matthews[1] field tested loblolly pines from Livingston Parrish (LP), Angelina County, Texas (TX), and Clark County, Arkansas (AK). The TX and AK sources were more resistant than the LP.

Recent advances in screening for rust resistance in seeds from slash and loblolly seed orchards also provide a source of increased

[1]Powers, H.R., Jr. and F.R. Matthews. USDA Forest Service, Southeastern Forest Experiment Station, Athens, GA (unpublished)

rust-resistant stock. Powers and Matthews found that loblolly and slash from a mixture of clones being considered for placement in a rust-resistant orchard also performed very well.

Some pine species are more resistant than others to diseases and insects. Longleaf pines are more resistant than slash or loblolly pines to annosus root rot, southern fusiform rust, and bark beetles, and should be planted where site conditions are proper for it (Kuhlman and others 1976). Shortleaf pine (Pinus echinata Mill.) is also resistant to fusiform and should be considered, within its range, especially in high-hazard areas (Phelps and Czabator 1978). Although new information, as yet unpublished, will further delineate fusiform rust hazard zones, fusiform incidence maps were published by Phelps in 1973 for slash and loblolly pines. These and revisions of them should always be considered by managers when areas are planted. In high-hazard zones, resistant sources and species should be given a high priority.

For annosus root rot, low- and high-hazard sites can be identified (Kuhlman and others 1976). The sites with lowest hazard are in the Gulf and Atlantic Coastal Plains. These soils have poor internal drainage, high seasonal water tables, and subhorizons with a plastic consistency. A second low-hazard soil occurs in the rolling terrain of the upper Coastal Plains and Piedmont, where the soils are dry and have a heavy clay content within 12 inches of the surface.

High-hazard sites are generally those where soils are deep, sandy, and well drained (Kuhlman and others 1976); typical of the sandhills region. Timber management practices, particularly thinning practices, can be responsible for spread of annosus root rot.

Concentration Area

Cattle concentrate at feeding stations and ponds or other watering areas. The soil disturbance and compaction alone may reduce tree vigor. Root injuries provide infection courts for root disease fungi, such as H. annosum. Low vigor or injured trees may also attract southern pine beetle, which can subsequently spread to other areas that have not been directly influenced by livestock.

THE INFLUENCE OF TIMBER MANAGEMENT PRACTICES ON INSECT AND DISEASE POPULATIONS

In addition to fire and fertilizer application, which have already been discussed, other practices designed to improve tree growth can influence insect and disease risks.

Thinning

Thinning in either plantations or natural stands improves tree growth and increases forage production. Thinning generally reduces disease and insect impacts through salvage removal of diseased stems, as in the case of fusiform rust. Since thinning increases vigor of the trees that are left, it also reduces the threat from pests like southern pine beetle, if the residuals are not damaged by soil compaction or logging injuries.

However, damage by annosus root rot is often increased by thinning (Powers and Verrall 1962, Rishbeth 1951). If there is a source of spores, the fungus can spread to fresh stumps and then to live trees (Hodges 1969). Spores landing on freshly cut stump surfaces germinate and colonize the stump and root system. They can then infect surrounding trees via root grafts and contacts. Several surrounding trees may contact roots of one infected stump and be infected by it. Thus, wider spacings to reduce thinnings would benefit both disease management and forage production.

In addition to spacing, annosus root rot can be controlled by: 1) thinning from April to August south of the 34th parallel where air and stump temperatures may be hot enough to kill spores; 2) applying borax to the stump surface immediately after felling, if there is no annosus in the stand; or 3) applying a spore suspension of the competing fungus, Phlebia gigantea [Fr.] Donk., to the stump surfaces. This fungus competes with H. annosum, decaying the stump before H. annosum can utilize it for a food base. It should be noted that thinning during the hottest part of the year has some drawbacks. Thinning operations typically run for extended periods of time, and weather conditions are not always so extreme to effectively control annosus spores. Further, bark beetles may be attracted to damaged trees and slash in larger numbers at this time of year, thus increasing the risk of outbreaks. These trade-offs make the other annosus control options more attractive.

Rotations

Short rotations of 25 years (Byrd and others 1984) will reduce the impact from most insects and diseases, particularly annosus root rot that can be made worse by thinning. Trees grow rapidly through age 25 and suffer less than older trees from attack by bark beetles or root rots.

THE DIRECT INFLUENCE OF CATTLE ON FOREST INSECTS AND DISEASES

A key question is whether cattle directly influence insect and disease attacks on trees. Cattle are, of course, not susceptible to tree diseases, and trees are not subject to cattle diseases. The question is, therefore, whether cattle do things that influence the attack of insects and diseases on trees or that influence their spread from tree to tree.

Some noticeable trends have emerged during other surveys. In Mississippi and Georgia, two loblolly pine stands growing on low-hazard sites were severely infected with H. annosum. Fruiting structures of the fungus were numerous and grew from injured surface roots. In both locations, the injuries closely resembled those made by cattle. Basal and surface root wounds are very prone to infection by this fungus, though freshly cut stump surfaces are considered the primary method by which stands become infected.

In Flagler and Volusia Counties in Florida, slash pine saplings were infected with the pitch canker fungus at places where limbs were broken by grazing cattle[1]. Broken lateral branches provide infection courts for this fungus.

Where annosus root rot was observed, the cattle had been concentrated and root injuries were common. More dispersed grazing would probably result in less injury and subsequent infection. Thus, I foresee a problem with H. annosum only in places where cattle are concentrated, such as at supplemental feed stations or watering areas. In the case of pitch canker, I believe that damage or injury potential decreases as the trees grow and the number of lower limbs decline.

THE INFLUENCE OF FORESTS INSECTS AND DISEASES ON OTHER VEGETATION, CATTLE AND WILDLIFE

The insects and diseases that attack trees do not attack other vegetation. Their influence on lesser vegetation is largely on the creation of openings, resulting from tree mortality (Maine and others 1980). The size and distribution of these openings are the most important factors. Edge is created, snags are made available for cavity nesting birds and animals, understory plants that can be used by cattle and wildlife are stimulated, and in the case of insect pests like bark beetles, the pest is a food supply itself.

Southern pine beetle outbreaks result in contiguous openings that can encompass a few to several hundred acres, while annosus root rot centers are smaller. Pitch canker disease, when epidemic, also can create small openings of several trees, but these are usually even smaller and less abundant than those caused by annosus root rot. Openings created by southern pine beetle have the greatest potential impact on grazing by increasing forage. However, Leuschner and Maine (1980) reported that a study conducted on the Trinity District of the Davy Crockett National Forest revealed that, in general, openings caused by southern pine beetle are of little benefit to cattle grazing.

Fusiform rust is randomly distributed in stands and resultant mortality creates single-tree openings that alter spacial relationships of trees only slightly. Significant impacts from rust are expected only when infection levels and rust associated mortality are extremely high. Epidemics of any of these pests effectively eliminate timber management opportunities through mortality, reduced volume growth, or product-degrading deformities.

In the best known case of an interaction between a tree disease and wildlife, the heart rot fungus, Phellinus pini (Thore: Fr.) Pilat [formerly Fomes pini (Thore)], causes heartwood decay that softens the wood for easier removal by the red-cockaded woodpecker in nest cavity preparation (Hooper and others 1980). Phellinus pini causes extensive decay only in pines that are approaching maturity or are fully mature. Since harvesting has reduced this class of growing stock, many federal, state, and private organizations have invoked protection programs to retain adequate nesting.

Tree insects and diseases have other influences on wildlife. Southern pine beetle itself is food for woodpeckers (Kroll and others 1980) Other nongame bird species and some predators may enjoy improved habitat and food as a result of southern pine beetle. Small mammal and finch populations increase in newly cut pine stands (Edwards 1978). This successional change would be similar to that caused by southern pine beetle-induced mortality.

Changes in turkey habitat, as a result of southern pine beetle, are regarded as negligible (Leuschner 1980). The impacts on squirrels are also low in pure pine stands, but southern pine beetle can have a positive impact on white-tailed deer populations (Maine and others 1980). Those authors estimated that 1 acre of a southern pine beetle spot yielded 14.5 additional deer-days of food. The positive impact also included increased woodland edge. Leuschner (1980) also estimates that there is a positive influence on quail habitat with increased edge.

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[1]L. David Dwinell, Pathologist, USDA Forest Service, Southeastern Forest Experiment Station, Athens, GA (personal communication)

The effects on fish, small mammals (mice, shrews, etc.), and large mammals (opossums, skunks, etc.) are poorly understood. Leuschner (1980) states that a "negligible net impact is assumed, based again on lack of evidence rather than evidence of no effect."

The impact of tree diseases on other vegetation and wildlife is even less understood. Diseases like fusiform rust kill individual trees. Many trees in a stand may be affected, but not in centers like those created by southern pine beetle or annosus root rot. Thus, the increased open area and edge effect of fusiform rust mortality are difficult to assess. Effects may be significant only where tree losses are very high.

Annosus root rot on the other hand does affect trees in groups due to its underground spread via root grafts and contacts. The potential for impacts on ground cover and wildlife should be similar to those of small southern pine beetle spots.

SURVEY OF SOUTHERN EVALUATION PROJECT PLOTS

In 1978 and 1979, general insect and disease surveys were conducted in three of the five plots in the Southern Evaluation Project. They included Texas, Mississippi, and Florida sites. In addition, a plot in Louisiana was partially surveyed. The surveys consisted of 1-mile transects begun at points along the perimeter. A record was kept of the insects and diseases observed. Pests specifically targeted in the survey were Ips engraver beetles, southern pine beetle, and black turpentine beetle (*Dendroctonus terebrans* Oliv.); annosus root rot, fusiform rust, pitch canker disease, and heart rot (caused by *P. pini*). This list includes the major pests that affect managed pine timber. At the time, a more detailed survey was not possible.

By far the most significant problem observed was fusiform rust. It was present in all locations where loblolly and slash pines occurred. In only one case, in Mississippi, did the root rot fungus *H. annosum* occur.

After grazing treatments have been imposed for sufficient time to permit pest problems to develop, new surveys probably should be considered. If disease problems develop, the possible relationships to grazing should be analyzed.

LITERATURE CITED

Balthis, R.F.; Anderson, D.A. Effects of cultivation in a young slash pine plantation on the development of *Cronartium* cankers and forked trees. Journal of Forestry. 42:926-927. 1944.

Belcher, H.J.; Craft, W.J., Jr.; Erickson, W.D.; Ward, R.H. Fusiform rust management strategies in practice: plantation management. In: management of fusiform rust in southern pines: proceedings of a symposium; 1977 December 7-8; Gainesville, FL: University of Florida Press; 1977: 158-163.

Byrd, Nathan A.; Lewis, Clifford E.; Pearson, Henry A. Management of southern pine forests for cattle production. Gen. Rep. R8-GR4. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Region; 1984. 21 pp.

Dinus, R.J.; Schmidtling, R.C. Fusiform rust in loblolly and slash pines after cultivation and fertilization. Res. Pap. SO-68. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station; 1971. 10 pp.

Dixon, Wayne N.; Corneil, Jeffrey A.; Wilkinson, Robert C.; Foltz, John L. Using stem char to predict mortality and insect infestation of fire-damaged slash pines. Southern Journal of Applied Forestry. 8(2):85-88; 1984.

Edwards, Malcolm G. Raptor management. In: Proceedings of the workshop: management of southern forests for nongame birds; 1978 January 24-26; Atlanta, GA. Gen. Tech. Rep. SE-14. Asheville, NC: U.S. Department of Agriculture, Forest Service; 1978: 129-134.

Fisher, R.F.; Garbett, W.S.; Underhill, E.M. Effects of fertilization on healthy and pitch canker-infected pines. Southern Journal of Applied Forestry. 15(2):77-70; 1981.

Froelich, R.C.; Hodges, C.S., Jr.; Sackett, S.S. Prescribed burning reduces severity of annosus root rot in the South. Forest Science 24(1):93-100; 1978.

Haines, L. Wayne; Haines, Sharon G.; Liles, Frank T., Jr. Effects of fertilization on susceptibility of loblolly pine to the southern pine beetle. Tech. Rep. 58. Raleigh, NC: School of Forest Resources, North Carolina State University; 1976. 55 pp.

Hodges, Charles S. Modes of infection and spread of *Fomes annosus*. Annual Review of Phytopathology 7:247-266; 1969.

Hooper, Robert G.; Robinson, Andrew F., Jr.; Jackson, Jerome A. The red-cockaded woodpecker: notes on life history and management. Gen. Rep. SA-GR9. Atlanta, GA: U.S. Department of Agriculture, Forest Service, Southeastern Area, State and Private Forestry; 1980. 8 pp.

Hughes, Ralph H.; Jackson, Jerome A. Fertilization of young slash pine in a cultivated plantation. Stn. Pap. 148. U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1962. 14 pp.

Kroll, James C.; Conner, Richard N.; Fleet, Robert R. Woodpeckers and the southern pine beetle. Agric. Handb. 564. Pineville, LA: U.S. Department of Agriculture, Forest Service, Combined Forest Pest Research Project; 1980. 19 pp.

Kuhlman, E.G.; Hodges, C.S., Jr.; Froelich, R.C. Minimizing losses to Fomes annosus in the southern United States. Res. Pap. SE-151. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1976. 16 pp.

Leuschner, William A. Impacts of the southern pine beetle. In: Thatcher, Robert C.; Searcy, Janet L.; Coster, Jack E.; Hertel, Gerard D., eds. The southern pine beetle. Tech. Bull. 1631. Washington, DC: U.S. Department of Agriculture, Forest Service. 1980:137-151 (p. 146-150).

Leuschner, William A.; Maine, John D. Estimating the southern pine beetle's grazing impact. ESA Bulletin. 26(2):117-120; 1980.

Lewis, Clifford E.; McCormick, W.C.; White, W. Eaton. Cultivation, grazing, insects, and disease affect yield of slash pine planted in sod. Res. Note SE-174. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1972. 8 pp.

Lewis, Clifford; Burton, Glenn W.; Monson, Warren G. [and others]. Integration of pines, pastures, and cattle in south Georgia, USA. Agroforestry Systems. 1:277-297; 1983.

Lowerts, G.A.; Zoerb, M.J., Jr.; Pait, J. Resistance to the development of pitch canker in open-pollinated slash pine families. In: Proceedings, 18th southern forest tree improvement conference; 1985 May 21-23; Long Beach, MS: Southern Tree Improvement Committee; 1985:334-340.

Maine, John D.; Leuschner, William A.; Tipton, Alan R. A qualitative assessment of southern pine beetle's wildlife impact. FWS-1-80. Blacksburg, VA: School of Forestry and Wildlife Resources, Virginia Polytechnic Institute and State University; 1980. 54 pp.

Moore, G.E.; Layman, H.F. Attempts to increase resistance of loblolly pines to bark beetles by fertilization. Res. Note SE-260. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1978. 4 pp.

Phelps, William R. Fusiform rust incidence survey, 1971-73. Atlanta, GA: U.S. Department of Agriculture, Forest Service, Southeastern Area, State and Private Forestry; 1973. 31 pp.

Phelps, W.R.; Czabator, F.L. Fusiform rust in southern pines. For. Insect and Dis. Leafl. 26. Washington, DC: U.S. Department of Agriculture, Forest Service, Southeastern Area, State and Private Forestry; Revised 1978. 7 pp.

Powers, Harry R., Jr.; Verrall, Arthur F. A closer look at Fomes annosus. Forest Farmer. 21(8):8-9, 16-17. 1962.

Rishbeth, J. Observations on the biology of Fomes annosus, with particular reference to East Anglian pine plantations. II spore production, stump infection, and saprophytic activity in stumps. Annals of Botany. 15:1-22; 1951.

Wells, O.O.; Lora, Mary E. Faster growing, healthier trees. Forests and People. 24(3):17-18, 36-38. 1974.

Watersheds, Socioeconomics, and Forest Pests Discussion

Question

For continuity at the local level, would there be merit in keeping a key person, such as a silviculturist or other resource person, on the District for longer time periods?

Response

The Forest Service presently has longer tenure (3 to 5 years) for district personnel than in the past mainly for two reasons: (1) economic effects on the employee and (2) continuity in the job. There is also a need to balance the need for continuity with the need for career development. As the employee moves to higher levels of management, it is important to have experienced different situations; consequently, everyone cannot remain in a location.

Question

Did the economic projections for livestock production pertain to all forested land in the South or just to National Forest lands?

Response

The study was designed for implementation on all suitable forested land (pine types) in the South and included both public and private lands.

Question

Did the study consider moving cow herds from pasture to the forest-range or were the herds increased? Was the economic benefit reflecting lower production or lower cost of production?

Response

The cow herd size was increased on forest-range irrespective of pasture herd movements; however, this could be accomplished by moving animals from pasture to forest-range to reduce cattle numbers in pasture. The model assumption using forest-range resulted in reductions in cost of production. A shift from pasture to forest-range would reduce cost but not increase beef supply, while additional cows on the forest-range should increase the beef supply, which could further aggrevate market surpluses.

Question

Would there be a regional shift in cow herds from West to East?

Response

A shift would occur only if cost reductions were great enough; however, the maximum cost reductions for the U. S. (based on the model) would be too small to cause regional shifts.

Question

Did the cost reductions include going through the feedlot?

Response

The reduction was realized because of decreases in the cow-calf production costs prior to the feedlot.

Question

Was the cost of additional management (such as fencing) included in the economic analysis?

Response

The cost for facilities and operation included fences, corrals, water, supplemental feeds, and other expenses in using the forest-range resource.

Question

Was the cost per AUM computed for the forest-range? Could this information provide some information regarding the controversy over grazing fees on National Forest and private lands?

Response

The cost per animal could be calculated from the basic data but would have to be tied back to specific situations for determining grazing fees. The present economic model was not designed for that purpose.

Comments

It is suggested that sediment from small plots be reported in grams or kg per m^2 rather than kg/ha. We are talking about soil movement from small plots and not necessarily erosion. Erosion reflects impoverishment of the site and what it does to water quality. Water quality should be in terms of sediment concentration and not yields that normalizes the data. For example, a base rate for loblolly pine from East Texas through the Piedmont is about 14 lb/acre-inch runoff, which gives wide rates of sediment production in tons/acre depending on the year and runoff.

Response

Similar small plot data have been reported for 15 years in lb/acre or kg/ha. It is not that important whether it is reported in lb/acre or g/m^2. It is a relative rate and basically used as an index and not as a loss.

For comparisons, sediment yields off agricultural lands (which are measured in tons/acre) far exceed the small amounts from forestry or grazing of woodlands. For example, on large watersheds in northern Florida (Bradford Forest), the sediment, water, and nutrient yields off the actual watersheds were found to be minor from forest regeneration practices.

APPENDIXES

Anderson, M. E. 1981. Song dialects and syllable structure as related to the environment of three east Texas cardinal populations. Nacogdoches, TX: Stephen F. Austin State University; 77 p. M.S. thesis.

Anderson, M. E.; Conner, R. N. 1985. Northern cardinal song in three forest habitats in eastern Texas. Wilson Bulletin. 94(4): 436-449.

Baggett, S. C. 1983. A comparison of two avian census methods: strip transect and fixed circular plot. Nacogdoches, TX: Stephen F. Austin State University; 68 p. M.S. thesis.

Booth, L. M. 1980. Reproductive success of the Cardinal in relation to territory size and anthropod availability in three eastern Texas forests. Nacogdoches, TX: Stephen F. Austin State University; 34 p. M.S. thesis.

Byrd, N. A.; Lewis, C. E.; Pearson, H. A. 1984. Management of southern pine forests for cattle production. Gen. Rep. R-8-GR4. Atlanta, GA: U.S. Department of Agriculture, Forest Service, Region 8; 22 p.

Byrd, N. A.; Pearson, H. A.; Byington, E. N.; Halverson, S. D.; Lewis, C. E.; Johnson, M. K. 1984. Integrate grazing with timber management. Forest Farmer. 43(3): 20-21.

Conner, R. N.; Anderson, M. E.; Dickson, J. G. 1986. Relationships among territory size, song, and nesting success of northern cardinals. The Auk. 103: 23-31.

Conner, R. N.; Dickson, J. G.; Williamson, J. H. 1983. A comparison of breeding bird census techniques with mist netting results. Wilson Bulletin. 95(2): 276-280.

Dickson, J. G.; Conner, R. N.; Williamson, J. H. 1983. An evaluation of techniques for marking cardinals. Journal of Field Ornithology. 54(4): 41-42.

Dobrowolski, J. P. 1985. Soil hydrologic changes and nutrient flux following long-term burning of a longleaf pine-bluestem association. College Station, TX: Texas A & M University; 367 p. Ph.D. dissertation.

Ehrhart, R. L. 1981. Vegetational features of cardinal territories and nest sites in three east Texas forests. Nacodgoches, TX: Stephen F. Austin State University; 90 p. M.S. thesis.

Ehrhart, R. L.; Conner, R. N. 1986. Habitat selection by the Northern Cardinal in three eastern Texas forest stands. Southwest Naturalist. 31(2): 191-199.

Ellsworth, S. W. 1983. Mammalian abundance indices in the loblolly-shortleaf pine, upland hardwood forest type of central Louisiana. Baton Rouge, LA: Louisiana State University; 188 p. M.S. thesis.

Hagedorn, C.; Watson, V. H.; Knight, W. E. 1980. Forage legumes in a forested environment. In: Child, R. Dennis; Byington, Evert K., ed. Southern forest range and pasture resources: Proceedings of the symposium; 1980 March 13-14; New Orleans, LA. Morrilton, AR: Winrock International Livestock Research and Training Center; 143-145.

Haney, Jr., H. L. 1980. Economics of integrated cattle-timber land use. In: Child, R. Dennis; Byington, Evert K., ed. Southern forest range and pasture resources: Proceedings of the symposium; 1980 March 13-14; New Orleans, LA. Morrilton, AR: Winrock International Livestock Research and Training Center; 165-183.

Hinton, J. Z. 1981. Vegetation, edaphic and topographic interrelationships in an East Texas forest. College Station, TX: Texas A & M University; 78 p. M.S. thesis.

Hovis, J. A. 1982. Population biology and vegetative requirements of the red-cockaded woodpecker (<u>Picoides borealis</u>) in Apalachicola National Forest, Florida. Gainesville, FL: University of Florida; 56 p. M.S. thesis.

Hovis, J. A.; Labisky, R. F. 1985. Vegetative associations of red-cockaded woodpecker colonies in Florida. Wildlife Society Bulletin. 13(3): 307-314.

Howell, J. W. 1981. Nutritive value of eastern little bluestem and sweetgum as influenced by canopy condition and soil. College Station, TX: Texas A & M University; 87 p. M.S. thesis.

Hunter, T. K. 1985. Assessment of intensive silvicultural practices and livestock grazing on watershed parameters, Kisatchie National Forest, Louisiana. College Station, TX: Texas A & M University; 87 p. M.S. thesis.

Johnson, M. K.; Davis, L. G. 1983. Potentials for forest grazing in the southeastern United States. International Tree Crops Journal. 2(1982): 121-131.

Lohoefener, R. 1982. Gopher tortoise ecology and land-use practices in southern DeSoto National Forest, Harrison County, Mississippi. In: Franz, R., Brant, R. J. eds. The gopher tortoise and its sandhill habitat: Proceedings, 3rd annual Gopher Tortoise Council meeting; 1982 October 30; Tallahassee, FL. Tallahassee, FL: Tall Timbers Research Station; 50-74.

Lohoefener, R.; Wolfe, J. 1984. A "new" live trap and a comparison with a pit-fall trap. Herp Review. 15(1): 25.

Lundgren, G. H.; Conner, J. R.; Pearson, H. A. 1983. An economic analysis of forest grazing on four timber management situations. Southern Journal of Applied Forestry. 7(3): 119-124.

Lundgren, G. H.; Conner, J. R.; Pearson, H. A. 1984. An economic analysis of five forest-grazing management systems in the Southeastern United States. Tex. Agric. Exp. Stn. MP-1551. College Station, TX: Texas Agricultural Experiment Station; 8 p.

Pearson, H. A. 1981. The southern evaluation project: a status report. In: Lohoefener, Ren; Lohmeier, Lynne; Johnston, Gail, eds. The future of gopher tortoise habitats: Proceedings, 2nd annual Gopher Tortoise Council meeting; 1981 November 14; Jackson, MS. Jackson, MS: Mississippi Museum of Natural Sciences; 35-43.

Porter, M. L.; Labisky, R. F. 1986. Home range and foraging habitat of red-cockaded woodpeckers in Northern Florida. Journal of Wildlife Management. 50(2): 239-247.

Rakowitz, V. A. 1983. Comparison of the herpetofauna of four different-aged stands in the loblolly-shortleaf pine-hardwood ecosystem of east Texas. Nacogdoches, TX: Stephen F. Austin State University; 127 p. M.S. thesis.

Reed, D. P. 1981. Understory vegetative yield in the loblolly pine-shortleaf pine upland hardwood forest type, Louisiana. Baton Rouge, LA: Louisiana State University; 257 p. M.S. thesis.

Repenning, R. W. 1983. Effects of even-age timber management on bird communities of the longleaf pine forest in north Florida. Gainesville, FL: University of Florida; 41 p. M.S. thesis.

Repenning, R. W.; Labisky, R. F. 1985. Effects of even-age timber management on bird communities of the longleaf pine forest in northern Florida. Journal of Wildlife Management. 49(4): 1088-1098.

Smith, J. C. 1983. Community structure of small mammals in a southern pine forest, with comment on multivariate niche' analysis. Baton Rouge, LA: Louisiana State University; 61 p. M.S. thesis.

Stewart, A. W. 1981. Vegetative inventory and white-tailed deer forage on the DeSoto National Forest. Mississippi State, MS: Mississippi State University; 122 p. M.S. thesis.

Watson, V. H.; Hagedorn, C.; Knight, W. E.; Pearson, H. A. 1984. Shade tolerance of grass and legume germplasm for use in the southern forest range. Journal of Range Management. 37(3): 229-232.

Watson, V. H.; Pearson, H. A.; Knight, W. E.; Hagedorn, C. 1984. Cool season forages for use in pine forests. In: Linnartz, N. E.; Johnson, M. K. Agroforestry in the southern United States: 33rd annual forestry symposium; 1984 April 4-5; Baton Rouge, LA. Baton Rouge, LA: Louisiana State University; 79-88.

Westman, W. W. 1980. Economic guidelines for adding beef cattle to pine-timbered range in the south. Blacksburg, VA: Virginia Polytechnic Institute and State University; 178 p. M.S. thesis.

White, D. J. 1983. The herpetofaunal community of an abrupt forest edge in North Florida. Gainesville, FL: University of Florida; 37 p. M.S. thesis.

Whiting, R. M.; Fleet, R. F.; Pearson, H. A. 1983. Implementing and maintaining a system to monitor small mammal and bird populations. In: Bell, John F., Atterbury, Toby, eds. Renewable resource inventories for monitoring changes and trends: Proceedings of the international conference; 1983 August 15-19; Corvallis, OR. SAF 83-14. Bethesda, MD: Society of American Foresters; 420-423.

Wolfe, J. L.; Lohoefener, R. 1983. The small mammal fauna of a longleaf-slash pine forest in southern Mississippi. Journal Mississippi Academy of Science. 28(5): 37-47.

Wood, J. M. 1982. Nutritive value of deer browse related to soil and overstory characteristics in north Florida pine plantations. Gainesville, FL: University of Florida; 139 p. M.S. thesis.

Wood, J. M.; Tanner, G. W. 1985. Browse quality response to forest fertilization and soils in Florida. Journal of Range Management. 38(5): 432-435.

Yurkunas, V. G. 1984. Seasonal status and habitat relationships of birds in longleaf-slash pine forests. Baton Rouge, LA: Louisiana State University; 163 p. M.S. thesis.

The following is a list of presentations made at various meetings.

Anderson, M. E.; Conner, R. N.
Dialects and syllable structure of three East Texas cardinal populations. Annual meeting Wilson Ornithological Society 1982 May; Blacksburg, VA.

Byrd, N. A.
Private land grazing on forest lands. Annual meeting of Southern Section, Society for Range Management; 1981 December 11; Gulfport, MS.

Conner, R. N.; Anderson, M. E.; Dickson, J. G.
Relationships among cardinal (Cardinalis cardinalis) territory size, vegetation, song, and nesting success. Annual meeting American Ornithologists Union, 1982 October; Chicago, IL.

Conner, R. N.; Dickson, J. G.; Williamson, J. H.
Comparisons of two census techniques and mist net captures. Annual meeting Wilson Ornithological Society, 1982 May; Blacksburg, VA.

Dobrowolski, J. P.; Blackburn, W. H.; Grelen, H. E.
Infiltration rates and water quality of longleaf pine/bluestem range following 22 years of seasonal burning. 37th annual meeting of the Society for Range Management; 1984 February 12-17; Rapid City, SD. Denver, CO: Society for Range Management.

Howell, J. W.; Stuth, J. W.
The effect of canopy and soil on the nutritive value of eastern little bluestem. 36th annual meeting of the Society for Range Management; 1983 February 14-17; Albuquerque, NM. Denver, CO: Society for Range Management.

Hovis, J. A.
Population biology and habitat characteristics of red-cockaded woodpeckers in northern Florida pine forests. Annual meeting of The Wilson Ornithological Society; 1982 May 6-9; Blacksburg, VA.

Hunter, T. K.; Blackburn, W. H.; Pearson, H. A.
Assessment of intensive silvicultural practices and livestock grazing on watershed parameters, Kisatchie National Forest, Louisiana. 37th annual meeting of the Society for Range Management; 1984 February 12-17; Rapid City, SD. Denver, CO: Society for Range Management.

Pearson, H. A.
Southern Forest Range Evaluation Project. Cooperative Multiple Use Southern Forest Range Workshop. 1980 October 7; Lufkin, TX.

Dolezel, R.
Soils of the forest-range project, Angelina National Forest, San Augustine County, Texas. Cooperative Multiple Use Southern Forest Range Workshop. 1980 October 7; Lufkin, TX.

Blackburn, W. H.
Assessment of livestock grazing and silviculture practices on water yields and quality, Angelina National Forest. Cooperative Multiple Use Southern Forest Range Workshop. 1980 October 7; Lufkin. TX.

Roath, L. R.
Grazing management strategies for forest grazing evaluation program. Cooperative Multiple Use Southern Forest Range Workshop. 1980 October 7; Lufkin, TX.

Whitson, R.
Economic feasibility of grazing management in East Texas. Cooperative Multiple Use Southern Forest Range Workshop. 1980 October 7; Lufkin, TX

Smeins, F. E.
Vegetation inventory in the loblolly-shortleaf pine type, Angelina National Forest, Texas. Cooperative Multiple Use Southern Forest Range Workshop. 1980 October 7; Lufkin, TX.

Fleet, R. R.
Effect of multiple-use forest range management on the herpetofauna. Cooperative Multiple Use Southern Forest Range Workshop. 1980 October 7; Lufkin, TX.

Whiting, R. M.; Fleet, R. R.
Inventories of birds and small mammals. Cooperative Multiple Use Southern Forest Range Workshop. 1980 October 7; Lufkin, TX.

Sites, W. H.
Survey of five grazing plots to determine the incident and damage caused by disease organisms and insects. Cooperative Multiple Use Southern Forest Range Workshop. 1980 October 7; Lufkin, TX

Byrd, N. A.
Application of results of the Southern Forest-Range Evaluation Study. Cooperative Multiple Use Southern Forest Range Workshop. 1980 October 7; Lufkin, TX.

Lundgren, G. K.; Conner, J. R.; Pearson, H. A.
Economics of forest land grazing; preliminary analysis. 1982 workshop on forest grazing for resource leaders; 1982 March 25; Auburn, AL.

Pearson, H. A.; Halverson, S. D.; Byrd, N. A.
Range management strategy evaluation in the south. 33rd annual meeting of the Society for Range Management; 1980 February 11-13; San Diego, CA. Denver, CO: Society for Range Management.

Pearson, H. A.; Halverson, S. D.; Byrd, N. A.
Forest range evaluation in southeastern United States. XIV International Grassland Congress; 1981 June 12-24; Lexington, KY.

Peterson, J. H.; Pearson, H. A.; Snow, R. W.
Social aspects of southern forest grazing: a pilot project. Annual meeting Society of Applied Anthropology; 1982 March 13; Lexington, KY.

Repenning, R. W.; Labisky, R. F.
Effects of even-age timber management on the breeding bird community of longleaf pine flatwoods. Annual meeting of The Wilson Ornithological Society; 1984 May 31-June 2; Wilmington, NC.

Wood, J. M.
Nutritive value of browse related to soil and overstory characteristics in north Florida pine plantations. 36th annual meeting of the Society for Range Management; 1983 February 14-17; Albuquerque, NM. Denver, CO: Society for Range Management.

Texas: Loblolly-Shortleaf Pine Type

Dolezel, R.; Holt, T. 1979. Angelina National Forest study area soil survey in San Augustine County, Texas. Nacogdoches, TX: USDA Soil Conservation Service. Soil Survey Report. 69 p.	CA-19-320[1/]
Smeins, F. E.; Hinton, J. Z. 1981. Vegetation inventory in the loblolly- shortleaf pine type, Angelina National Forest. College Station, TX: Texas A & M University. Progress Report. 142 p.	CA-19-304 1701-3.16
Smeins, F. E. 1982. Vegetation inventory in the loblolly-shortleaf pine type, Angelina National Forest. College Station, TX: Texas A & M University. Final Report. 38 p.	CA-19-304 1701-3.16
DeHaven, M.; Blackburn, W. H. 1980. Assessment of nonpoint source pollution from intensive forest practices in East Texas. College Station, TX: Texas A & M University. Progress Report. 37 p.	CA-19-341 1701-3.21 -1.121 -1.110 4201-1.121
Hunter, T. K.; Blackburn, W. H.; Knight, R. Weichert, A. T. 1981. Assessment of non-point source pollution from livestock grazing on intensive managed forest in the Southeast. College Station, TX: Texas A & M University. Progress Report. 57 p.	CA-19-341 1701-3.21 -1.121 -1.110 4201-1.121
Fuchs, C. R.; Gray, L. D. 1982. Soil survey of a small forested watershed on non-point source loading in San Angustine County, Texas. USDA Soil Conservation Service. Soil Survey Report. 45 p.	CA-19-341 1701-3.21 -1.121 -1.110 4201-1.121
Blackburn, W. H. 1982. Status report of cooperative watershed research projects between Texas Agricultural Experiment Station, Southern Forest Experiment Station and Angelina and Kisatchie National Forests. College Station, TX: Texas A & M University. Progress Report. 5 p.	CA-19-341 1701-3.21 -1.121 -1.110 4201-1.121
Blackburn, W. H. 1983. Resume of work accomplished. College Station, TX: Texas A & M University. Progress Report. 30 p.	CA-19-341 1701-3.21 -1.121 -1.110 4201-1.121
Hunter, T. K.; Blackburn, W. H.; Weichert, A. T.; Dobrowolski, J. P. 1983. Effect of forest site preparation and livestock grazing on stormflow and water quality in the southeast. College Station, TX: Texas A & M University. Texas Water Resources Institute. Interim Progress Report. 100 p.	CA-19-341 1701-3.21 -1.121 -1.10 4201-1.121
Dobrowolski, J. P.; Blackburn, W. H.; Grelen, H. E. 1985. Effects of long term burning on the hydrological and chemical properties of southeast forest soils. College Station, TX: Texas A & M University. Final Report. 370 p.	CA-19-341 1701-3.21 -1.121 -1.110 4201-1.121
Hunter, T. K.; Blackburn, W. H.; DeHaven, M. G.; Weichert, A. T. 1984. Assessment of nonpoint source pollution from intensive silvicultural practices and livestock grazing in southeast forests. College Station, TX: Texas Water Resources Institute, Texas A & M University. Interim Progress Report TR-132. 111 p.	CA-19-341 1701-3.211 -1.121 -1.110 4201-1.121
Hunter, T. K.; Blackburn, W. H.; Nieber, J. L.; DeHaven, M. G.; Weichert, A. T.; Awang, J. B.; Fazio, P. M.; Wood, J. C. 1984. Assessment of nonpoint source pollution from intensive silvicultural practices and livestock grazing in southeast forests. College Station, TX: Texas Agricultural Experiment Station. Texas A & M University. Annual Progress Report. 140 p.	CA-19-341 1701-3.211 -1.121 -1.110 4201-1.121

Blackburn, W. H.; Wood, J. C.; Weichert, A. T.; Fazio, P. M.; Neville, M. B. 1986. Assessment of water yield and quality from intensive silvicultural practices and livestock grazing in southeast forests. College Station, TX: Texas Agricultural Experiment Station, Texas A & M University. Annual Progress Report. 198 p. — CA-19-341; 1701-3.21; -1.121; -1.110; 4201-1.121

Blackburn, W. H.; Wood, J. C.; Pearson, H. A.; Weichert, A. T.; Fazio, P. M. 1986. Assessment of water yield and quality from intensive silvicultural practices and livestock grazing in southeast forests. College Station, TX: Texas Agricultural Experiment Station, Texas A & M University. Annual Progress Report. 223 p. — CA-19-341; 1701-3.21; -1.121; -1.110; 4201-1.121

Stuth, J. W.; Howell, J. 1982. Nutritive value of eastern little bluestem and sweetgum influenced by canopy and soil. College Station, TX: Texas Agricultural Experiment Station, Texas A & M University. Final Report. 92 p. — CA-19-339; 1701-3.22

Fleet, R. R. 1982. Effect of multiple-use forest range management on small animal population. Nacogdoches, TX: Stephen F. Austin State University. Final Report. 155 p. — CA-19-300; 1701-4.9

Whiting, R. M.; Fleet, R. R. 1985. Small animal population inventories on a mixed pine-hardwood forest of east Texas. Nacogdoches, TX: Stephen F. Austin State University. Final Report. 396 p. — CA-19-330; 1701-4.11

Conner, R. N.; Fisher, C. D.; Pearson, H. A. 1982. Inventory of cardinal song and nests in three differently aged mixed pine hardwood stands. Nacogdoches, TX: Stephen F. Austin State University. Final Report. 4 p. — 1701-4.10

Roath, L. R. 1981. Development of a grazing management plan for the forest grazing evaluation project, Angelina National Forest. College Station, TX: Texas A & M University. Progress Report. 23 p. — CA-19-373; 1701-1.770

Roath, L. R; Pearson, H. A. 1986. Forage utilization techniques. College Station, TX: Texas A & M University. Final Report. 41 p. — CA-19-373; 1701-1.770

Louisiana: Loblolly-Shortleaf Pine Type

Kilpatrick, W. W. 1979. Soil survey of the Range Management research units, Grant Parish. Alexandria, LA: USDA Soil Conservation Service. Soil Survey Report. 30 p. — CA-19-322

Noble, R. E.; Reed, D. P. 1981. Vegetation inventory in loblolly-shortleaf pine type near Dry Prong, LA. Baton Rouge, LA: Louisiana State University. Final Report. 257 p. — CA-19-305; 1701-3.17; PO#40-7B82-0-22211

Williams, K. L. 1982. Inventory of the species, diversity, and numbers of amphibians and reptiles on selected loblolly-shortleaf pine and longleaf-slash pine stands (pre-treatment phase). Natchitoches, LA: Northwestern State University. Final Report. 31 p. — CA-19-332; 1701-4.12

Hamilton, R. B.; Ellsworth, S. W.; Smith, J. C.; Lester, G. 1983. Bird and mammal evaluations on the Louisiana loblolly-shortleaf pine range project. Baton Rouge, LA: Louisiana State University. Final Report. 3 p. — CA-19-343; 1701-4.14

Louisiana: Longleaf-Slash Pine Type

Butler, L. 1979. Soil survey, Vernon, Kisatchie National Forest. Soil Conservation Service. Soil Survey Report. 26 p. — CA-19-322

Pearson, H. A.; Grelen, H. E.; Rollins, D. A.; Parresol, B. R. 1984. Soil vegetation correlation in the longleaf pine type of Louisiana. Alexandria, LA: Southern Forest Experiment Station. Final Report. 75 p. — PO#43-7B82-1-10628; 1701-3.20

Williams, K. L. 1982. Inventory of the species, diversity, and numbers of bians and reptiles on selected loblolly-shortleaf pine and longleaf-slash pine stands (pre-treatment phase). Natchitoches, LA: Northwestern State University. Final Report. 31 p. — CA-19-332; 1701-4.12

Louisiana: Longleaf-Slash Pine Type (continued)

Williams, K. L.; Mullin, K. 1982. Inventory of the species, diversity, and numbers of mammals on selected longleaf-slash pine stands. Natchitoches, LA: Northwestern State University. Final Report. 27 p.	CA-19-384 1701-4.18
Hamilton, R. B.; Yurkunas, V. G. 1984. Bird inventories of longleaf-slash pine forest, Vernon District, KNF. Baton Rouge, LA: Louisiana State University. Final Report. 163 p.	CA-19-398 1701-4.19
Johnson, M. K. 1983. Tracking station assessments. Baton Rouge, LA: Louisiana State University. Final Report. 14 p.	PO#40-7B82- 1-22577
Johnson, M. K. 1982. Track stations on the Palustris Experimental Forest. Baton Rouge, LA: Louisiana State University. January-February Progress Report. 3 p.	PO#40-7B82- 1-22577 1701-1.470
Johnson, M. K. 1982. Track stations on the Palustris Experimental Forest. Baton Rouge, LA: Louisiana State University. April-May Progress Report. 6 p.	PO#40-7B82- 1-22577 1701-1.470
Johnson, M. K. 1982. Track stations on the Palustris Experimental Forest. Baton Rouge, LA: Louisiana State University. July-August Progress Report. 2 p.	PO#40-7B82- 1-22577 1701-1.470
Johnson, M. K. 1982. Track stations on the Palustris Experimental Forest. Baton Rouge, LA: Louisiana State University. October-November Progress Report. 16 p.	PO#40-7B82- 1-22577 1701-1.470

Mississippi: Longleaf-Slash Pine Type

Davis, R. E. 1979. Soil survey of designated portion of DeSoto National Forest in Stone County, Mississippi. USDA Soil Conservation Service. Soil Survey Report. 49 p.	CA-19-321
Hurst, G. A.; Stewart, A. W.; Pearson, H. A. 1981. An inventory of vegetation in longleaf-slash pine type in Mississippi. Mississippi State, MS: Mississippi State University. Final Report. 122 p.	CA-19-303 1701-3.18
Johnson, M. K.; Perkins, C. J.; Wolfe, J. L.; Pearson, H. A. 1981. Baseline inventory of mammals and birds on DeSota National Forest. Mississippi State, MS: Mississippi State University. Final Report. 53 p.	CA-19-302 1701-4.8
Wolfe, J. L.; Lohoefener, R. R. 1980. Inventory of amphibians and reptiles on two range units of the range evaluation project, DeSota National Forest. Waveland, MS: Southern Ecology Laboratory. Final Report. 22 p.	PO#40-7B82- 9-10484 1701-4.17
Lohoefener, R. R. 1981. Herpetological studies, Southern Evaluation Project, DeSoto National Forest, Mississippi. NSTL Station, MS: National Space Technology Laboratories. Mississippi State University Research Center. Final Report 58 p.	PO#40-7B82- 1-22291
Lohoefener, R. R. 1982. Results of the herpetofauna census, Southern Evaluation Project, DeSoto National Forest, Mississippi. Mississippi State, MS: Mississippi State University. Final Report. 41 p.	PO#40-7B82- 2-22248 1701-1.350
Wolfe, J. L. 1981. Baseline inventory of small mammals on a National Forest Site in Mississippi. Waveland, MS: Southern Ecology Laboratory. Final Report. 13 p.	PO#40-7B82- 2-22325
Wolfe, J. L.; Lohoefener, R. R. 1982. Small mammals on five DeSoto National Forest, Mississippi. Mississippi State, MS: Mississippi State University. Final Report. 43 p.	PO#40-7B82- 2-22246 1701-1.450
Wolfe, J. L.; Lohoefener, R. R. 1981. Pretreatment assessment of fish diversity and relative abundance of four range units of the Southern Evaluation Project, DeSoto National Forest, Mississippi. Waveland, MS: Southern Ecology Laboratory. Final Report. 18 p.	PO#40-7B82- 1-22521
Watson. V. H.; Knight, W. H.; Pearson, H. A. 1981. Shade tolerance potential of grass and legume germplasm for use in the southern forest range. Mississippi State University, Agricultural Research Service, Forest Service. Final Report. 25 p.	CA-19-299 1701-2.4

Mississippi: Longleaf-Slash Pine Type (continued)

Hagedorn, C.; Knight, W. E. 1981. Evaluation of subclover in a forested environment. Mississippi State, MS: Mississippi State University. Final Report. 6 p.	CA-19-377 (CA-58-7B308-21)
Marshall, R. A. 1982. A cultural resource survey of study area 4, DeSoto NF, Mississippi. Mississippi State, MS: Mississippi State University. Preliminary Report. 30 p.	CA-19-81-40 1701-1.650
Snow, R. W. 1982. Selected demographic and agricultural characteristics of Harrison and Stone counties, MS, an example of secondary baseline data analysis for the SEP. Mississippi State, MS: Mississippi State University. Preliminary Report. 84 p.	CA-19-81-40 1701-1.650
Snow, R. W.; Peterson, J. H. 1981. Social assessment/cultural heritage data collection and analysis framework for the SEP. Mississippi State, MS: Mississippi State University. Preliminary Report. 49 p.	CA-19-81-40 1701-1.650
Atkinson, J. R.; Peterson, J. H., Jr. 1981. Historical and social trends in southern forest grazing. Mississippi State, MS: Mississippi State University. Preliminary Report. 19 p.	CA-19-31-40- 1701-1.650
Peterson, J. H.; Pearson, H. A. 1982. Social assessment and cultural heritage component for the SEP. Mississippi State, MS: Mississippi State University. Final Report. 205 p.	CA-19-81-40 1701-1.650

Florida: Longleaf-Slash Pine Type

Tanner, G. W.; Terry, W. S. 1982. Vegetation inventory in the longleaf-slash pine forest type, Apalachicola National Forest. Gainesville, FL: University of Florida. Final Report. 242 p.	CA-19-306 1701-3.19
Tanner, G. W.; Terry, W. S. 1982. Inventory of nutritional quality of major dietary components of domestic herbivores on the Apalachicola National Forest, Florida. Gainesville, FL: University of Florida. Final Report. 48 p.	CA-19-342 1701-3.23
Labisky, R. F.; Hovis, J. A.; Repenning, R. W.; White, D. J. 1983. Wildlife inventory on the Apalachicola National Forest, Florida. Gainesville, FL: University of Florida. Final Report. 171 p.	CA-19-340 1701-4.13

Support Studies

Sites, W. H. 1982. Disease and insect conditions in three (Angelina, Biloxi, and Apalachicola Ranger Districts) of five of the forest-range project plots. Asheville, NC: USDA Forest Service, Southeastern Area State and Private Forestry. Final Report. 3 p.	SEP-I&DS
Conner, J. R.; Lundgren, G. K. 1983. Economic consideration of livestock production in southern forests. College Station, TX: Texas A & M University. Final Report. 18 p.	CA-19-81-41 1701-1.670
Haney, H. L.; Westman, W. W. 1980. Economic guidelines for adding beef and cattle to timbered range in the South. Blacksburg, VA: Virginia Polytechnic Institute and State University. Final Report. 187 p.	CA-19-290 1701-3.15
Johnson, M. K. 1981. Multiple-use practices on some private land owners in the southeastern United States. Baton Rouge, LA: Louisiana State University. Tour Report. 11 p.	PO#40-7B82-1-22514
Byrd, N. A.; Pearson, H. A.; Byington, E. K.; Halverson, S. D.; Lewis, C. E.; Pint, W. E.; Johnson, M. K. 1981. Summary of ownerships visited during research needs discovery tour. Trip Report. 8 p.	PO#40-7B82-1-22514

1/ Study numbers refer to cooperative agreement (CA), purchase order (PO), project (1701, 4201) or SEP designations.

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The results of 43 research projects, which evaluate the flora, fauna, watersheds, socioeconomics, and forest pests located on the southern National Forests, were presented and discussed in 4 major categories: Management Outlook and Evaluation, Loblolly-Shortleaf Pine Type, Longleaf-Slash Pine Type, and Watersheds, Socioeconomics, and Forest Pests.