INTRODUCTION

TO PART IV

Nutrition is one of the fundamental relationships between animal and range. Nutrients provide the materials for matebalosim, with growth being the result of the conversion of nutrients into new body tissue, and activity the result of the release of energy from the forage. The characteristics of animals that determine amounts of forage needed include the physical characteristics of the animals, discussed in CHAPTERS 1 and 2, the activity and behavioral characteristics of the animals, discussed in CHAPTERS 3, 4, and 5, and basic physiological characteristics and efficienciencies, discussed in CHAPTERS 6, 7, 8, 9, and 10.

The material in the first 10 chapters is essential for when evaluating range relationships of wild ruminants, discussed in this PART IV, and weather and thermal relationships, discussed in PART V, in relation to the concept of carrying capacity, discussed in PART VI. An understanding of all of these basic biological relationhsips is essential to understanding the basis for management decisions (PART VII).

Free-ranging wild ruminants interact with range forage in a very fundamental way, ecologically. They not only eat forage, but they function as individuals, metabolizing nutrients, producing new tissue, and reproducing new individuals. Each animal survives ultimately as an individual, and the analyses thus far have focused on the individual. They also import the ragne as a group; that will be discussed in PART VI.

This PART IV focuses on range forage. The smallest unit describing forage has often been the plant as a member of a species. In this PART, the smallest unit used to describe forage is the cell and its parts. This level of analyses enables one to understand the basis for digestion and for changes in digestion through the annual cycle (Chapter 11). Food habits and forage preferences are also discussed (CHAPTER 12), followed by discussions of primary production and forage production (CHAPTER 13).

The lists of references that follow provide essential bibliographic information for general books and serials on several biological characteristics. These general references will be helpful in many of the UNITS that follow, but they are not listed again after each UNIT as the UNIT lists are limited to more specific articles of direct application to the material discussed in each UNIT.

REFERENCES, PART IV

FORAGE CHARACTERISTICS AND RANGE RELATIONSHIPS

BOOKS

TYPE	PUBL	CITY	PAGE	ANIM	KEY WORDS-----------------	AUTHORS/EDITORS--	YEAR
aubo	rokp	loen	597	cerv	deer of g. britain, irelan	whitehead,gk	1964
aubo	huho	nyny	426	od--	deer, antelope of america	caton,jd	1877
edbo	stac	hapa	668	od--	deer of north america	taylor,wp	1956
aubo	stac	hapa	128	od--	if deer are to survive	dasmann,w	1971
aubo	vipr	nyny	194	od--	deer of the world	whitehead,gk	1972
aubo	omcc	eail	107	odvi	the white-tailed deer	madson,j	1961
edbo	nhfg	conh	256	odvi	the white-tai deer, new ha	siegler,hr	1968
aubo	ucap	beca	567	odhe	a herd of mule deer	linsdale,jm; tomi	1953
aubo	oxup	loen	215	ceel	herd of red deer, behavior	darling,ff	1937
aubo	stac	hapa	386	ceel	elk of north america	murie,oj	1959
aubo	wiwe	eail	125	ceel	the elk	madson,j	1966
aubo	ucap	beca	209	ceel	tule elk	mccullough,dr	1971
aubo	utop	toon	280	alal	north american moose	peterson,rl	1955
aubo	macm	nyny	300	rata	bar-gr car of north canada	pike,w	1892
aubo	ukap	laka		rata	bar-ground carib, keewatin	harper,f	1955
aubo	qupr	oton	339	rata	migratory, barren-ground c	kelsall,jp	1968
aubo	stac	hapa	238	anam	the pronghorn antelope	einarsen,as	1948
aubo	utop	toon	957	bibi	the north american buffalo	roe,fg	1951
aubo	thcr	nyny	242	bibi	the buffalo	haines,f	1970
aubo	aakn	nyny	339	bibi	time of the buffalo	mchugh,t	1972
aubo	swap	atoh	374	bibi	the buffalo book, saga ani	dary,d	1974
aubo	uchp	chil	383	ov--	mt sheep, behavior, evolut	geist,v	1971
aubo	coup	itny	248	ov--	mt sheep, man, norther wil	geist,v	1975
aubo	usgp	wadc	242	ovca	the bighorn of death valley	welles,re; welle	1961
aubo	qupr	oton	166	obmo	muskoxen in canada	tener,js	1965
aubo	dalt	laen	271	dada	fal de: histor, distr, bio	chapman,d; chapma	1975

TYPE	PUBL	CITY	PAGE	ANIM	KEY WORDS------------------	AUTHORS/EDITORS--	YEAR
aubo	doup	nyny	318	many	americ anim; popular guide	stone,w; cram,we	1902
aubo	cscs	nyny	347	many	our big game	huntington,d	1904
aubo	cscs	nyny	1267	many	life hist northern animals	seton,et	1909
aubo	ropr	nyny	129	many	wildlife in alaska, ecolog	leopold,as; darli	1953
edbo	holt	nyny	264	many	records of n a big game an	boone & crockett	1958
aubo	ropr	nyny	547	many	mammals of north america	hall,er; kelson,k	1959
aubo	ucap	beca	586	many	wildlife of mexico	leopold,as	1959
aubo	vipr	nyny	304	many	wildlife in america	matthiessen,p	1959
aubo	repu	nyny	335	many	principals of mammalogy	davis,de; golley,	1963
aubo	blsp	loen	308	many	guide, study of productivi	golley,fb; buechn	1968
aubo	jhpr	bamd	769	many	mammals of the world	walker,ep; paradi	1968
aubo	whfr	sfca	458	many	wildlife ecology	moen,an	1973
aubo	utop	toon	438	many	the mammals of canada	banfield, awf	1974
aubo	repu	nyny	1023	dome	bioenergetics and growth	brody,s	1945
edbo	coup	itny	1463	dome	duke's physiol domest anim	swenson,mj	1970
aubo	wbsc	phpa	574		fundamentals of ecology	odum,ep	1971
aubo	dohr	stpa	361		biblio of quantita ecology	schultz,vll; ebe/	1976

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS------------------	AUTHORS----------	YEAR
MDCBA	5----	1	64	odvi	w-tailed deer of minnesota	erickson,ab; gunv	1961
MDCRA	14---	1	80	odvi	michigan white-tailed deer	jenkins,dh; bartl	1959
WCDBA	14---	1	282	odvi	white-tailed deer, wiscons	dahlberg,bl; guet	1956

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS------------------	AUTHORS----------	YEAR
AZWBA	3----	1	109	odhe	mule deer in arizona chapa	swank, wg	1958
CFGGA	8----	1	163	odhe	life hist, managemt, calif	taber,rd; dasmann	1958

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS------------------	AUTHORS----------	YEAR
UCPZA	88---	1	209	ceel	tule elk: hist, behav, eco	mccullough,dr	1969
WLMOA	16---	1	49	ceel	status, ecol, roosevel elk	harper,ja; harn/	1967
WLMOA	24---	1	66	ceel	the sun river elk herd	knight,rr	1970

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
NCANA	101--	1	436	alal	ecol, proc inter sym, pt 1	bedard,j	1974
NCANA	101--	437	735	alal	ecol, proc inter sym, pt 2	bedard,j	1974

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
BPURD	2----	1	215	rata	ecol, caribou, prudhoe bay	white,rg; thomso/	1975
CWRSB	38---	1	71	rata	biology, kaminuriak popula	dauphine,tc,jr	1976
UABPA	8----	1	82	rata	ecology, managment, sweden	skunke,f	1969
WMBAA	10A--	1	79	rata	prelim investigation, pt 1	banfield,awf	1954
WMBAA	10B--	1	112	rata	prelim investigation, pt 2	banfield,awf	1954
WMBAA	12---	1	148	rata	caribou, continued studies	kelsall,jp	1957
WMBAA	15---	1	145	rata	barrn gr carib, coop study	kelsall,jp	1960

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
AMNAA	43--2	257	354	anam	life hist, ecology, texas	buechner,hk	1950
JOMAA	3----	82	105	anam	the prong-horn	skinner,mp	1922

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
AMNAA	24--3	505	580	ov--	distribut, variat, no amer	cowan,imct	1940
AZWBA	1----	1	153	ov--	desert bighorn	russo,jp	1956
WLMOA	4----	1	174	ov--	united sta, past to future	buechner,hk	1960

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
AMNAA	56--2	297	324	ovca	ecology of mountain sheep	mccann,lj	1956
WGFBA	1----	1	127	ovca	wyoming bighorn study	honess,rf; frost,	1942
XNFSA	6----	1	242	ovca	th bighorn of death valley	welles,re; welles	1961

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CGFPA	8----	1	23	oram	liter review on ecology of	hibbs,ld	1966

OTHER PUBLICATIONS

Proceedings of the White-tailed Deer Disease Symposium
Proceedings of the White-tailed Deer in the Southern Forest Habitat Symposium
Transactions of the Annual Meeting of the Northeast Deer Study Group

Proceedings of the North American Moose Conference

Proceedings of the International Reindeer/Caribou Symposium

Proceedings of the Biennial Antelope States Workshop
Transactions of the Interstate Antelope Conference

Transactions of the North American Wild Sheep Conference
Transactions of the Desert Bighorn Council

Proceedings of the International Mountain Goat Symposium

Proceedings of the Annual Conference of Western Association of State Game & Fish Commissioners
Transactions of the Congress of the International Union of Game Biologists

LIST OF PUBLISHERS - PART IV

aakn	Alfred A. Knopf	New York	nyny
blsp	Blackwell Scientific Publications	London	loen
coup	Cornell University Press	Ithaca, NY	itny
cscs	Charles Scribner's Sons	New York	nyny
dalt	Dalton	Lavenheim, England	laen
dipr	Dial Press, The	New York	nyny
dohr	Dowden, Hutchinson & Ross	Stroudsburg, PA	stpa
doup	Doubleday, Pace, & Co.	New York	nyny
hocl	Hollis & Carter Ltd.	London	loen
holt	Holt	New York	nyny
huho	Hurd Houghton	New York	nyny
jhpr	John Hopkins Press	Baltimore, MD	bamd
macm	MacMillan Co.	New York	nyny
nhfg	New Hampshire Fish & Game Deptartment	Concord, NH	conh
omcc	Olin Mathieson Chem. Corp.	E. Alton, IL	eail
oxup	Oxford University Press	London	loen
qupr	Queen's Printer	Ottowa, Canada	oton
repu	Reinhold Publishing	New York	nyny
rokp	Routledge & K. Paul	London	loen
ropr	Ronald Press	New York	nyny
stac	The Stackpole Company	Harrisburg, PA	hapa
swap	Swallow Press	Athens, OH	atoh
thcr	Thomas Crowell Co.	New York	nyny
ucap	University of California Press	Berkely, CA	beca
uchp	University of Chicago Press	Chicago, IL	chil
ukap	University of Kansas Press	Lawrence, KA	laka
usgp	U. S. Government Printing Office	Washington D. C.	wadc
utop	University of Toronto Press	Toronto, Ontario	toon
vipr	Viking Press	New York	nyny
wbsc	W. B. Saunders Co.	Philadelphia	phpa
whfr	W. H. Freeman Co.	San Francisco, CA	sfca
wiwe	Winchester-Western Press	East Alton, Il	eail

GLOSSARY OF CODE NAMES, PART IV

Code names (CODEN) of Serials are defined in a GLOSSARY OF CODENS at the end of each CHAPTER. The GLOSSARY below includes the CODENS listed as Serials in this PART IV. It is a miniature version of the lists given at the ends of CHAPTERS.

AMNAA	American Midland Naturalist
AZWBA	Arizona Game and Fish Department Wildlife Bulletin (US)
BPURD	Biol. Pap. Univ. Alaska Spec. Rep.
CAFNA	Canadian Field Naturalist (Canada)
CFGGA	California Department of Fish and Game, Game Bulletin
CGFPA	Colorado Division of Game, Fish, and Parks Special Report
CWRSB	Canadian Wildlife Service Report and Management Bull. Series
JOMAA	Journal of Mammalogy
MDCBA	Minnesota Deptartment of Conservation Technical Bulletin
MDCRA	Michigan Department of Conservation Game Division Report
NATUA	Nature (England)
NCANA	Naturaliste Canadien, Le
UABPA	Proceedings of the Utah Academy of Sciences, Arts and Letters
UCPZA	University of California Publications in Zoology
WCDBA	Wisconsin Department of Natural Resources Technical Bulletin
WGFBA	Wyoming Game and Fish Commission Bulletin
WLMOA	Wildlife Monographs
WMBAA	Wildlife Management Bulletin
XNFSA	U S National Park Service Fauna of the National Parks of the United States, Fauna Series

THE BIOLOGY AND MANAGEMENT OF WILD RUMINANTS

CHAPTER ELEVEN

FORAGE CHARACTERISTICS AND THE DIGESTIBILITY OF PLANT TISSUE

by

Aaron N. Moen

Professor of Wildlife Ecology

Department of Natural Resources

College of Agriculture and Life Sciences

Cornell University

Ithaca, N.Y. 14853

and

Certified Wildlife Biologist

(The Wildlife Society)

Published by

CornerBrook Press
Box 106
Lansing, N.Y. 14882

Library of Congress Catalog Number 80-70984

CONTENTS OF CHAPTER ELEVEN

FORAGE CHARACTERISTICS AND THE DIGESTIBILITY OF PLANT TISSUE

CHAPTER 11. FORAGE CHARACTERISTICS AND THE DIGESTIBILITY OF PLANT TISSUE

Life on earth depends on the process of photoshynthesis. Plants are called primary producers, using light energy to synthesize carbon dioxide, water, and minerals into new plant material. Animals that eat plant materials are called primary consumers, and animals that eat the primary consumers are called secondary consumers. They are also dependent on plants even though they do not eat plant material directly.

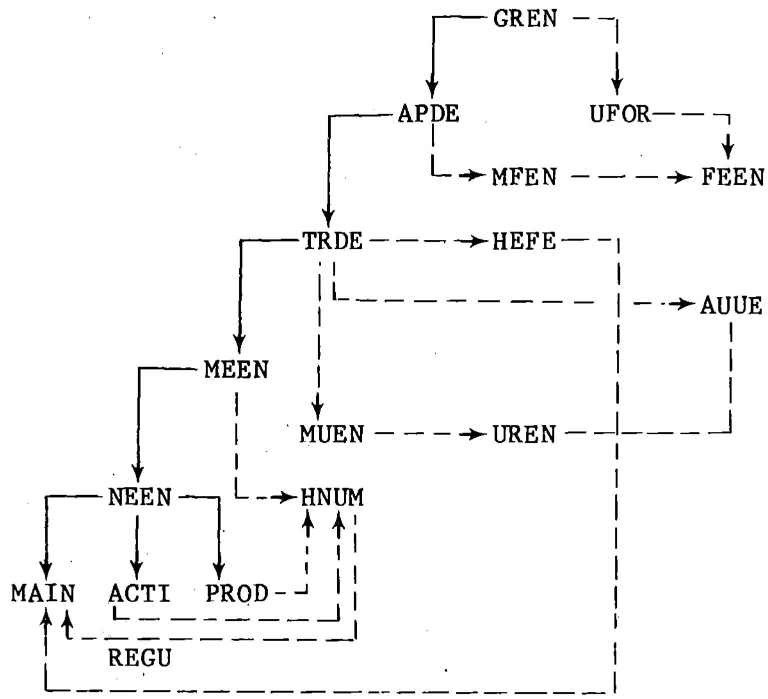
The nutrients in forage are the substrate for metabolic processes. The annual pattern of ecological metabolism reflects the timing and costs of metabolic processes that result in maintenance, growth, and reproduction in relation to the changing nutrient characteristics of the range forage over the annual cycle.

Metabolic patterns were discussed in CHAPTER 7. An understanding of these patterns is essential for an understanding of animal-range interactions. How can nutritive relations between animal and range be understood if the metabolic characteristics of the animals and nutritive characteristics of the range are not both known?

The nutrients in ingested food are partitioned into several pathways as food traverses the gastro-intestinal tract and nutrients are extracted and metabolized. This is so because mechanical, chemical, and metabolic processes are not 100% efficient. The idea of a process being less than 100% efficient implies a "waste," but that is not a good term for describing pathways in biological systems. Heat energy, for example, is part of the "waste" by microflora involved in rumen fermentation, but the heat dissipated by the microflora is useful to the host in the regulation of body temperature.

The efficiencies of nutrient pathways are related to specific nutrients and their specialized roles in physiological functions. There is a general pattern, however, beginning with the gross amount ingested, to the amount present in the urine and feces. Some of the forage is digested and metabolized, converted to body tissue, and then broken down and incorporated into urine and feces. Some of the fecal material is undigested forage residue, left intact from ingestion to defecation. Thus some ingested nutrients go through the gastrointestinal tract without being broken down and assimilated, and others are assimilated into new tissue that is broken down later and its constituents eliminated.

The major nutrient pathways of energy and protein are illustrated in the diagrams pages 2 and 4. Note that the basic format is very similar for the pathways of energy and protein breakdown from gross to net.



Definitions of the four-letter symbols are given below, and the categories on the upper left side of the flow diagram are discussed in the paragraphs that follow.

GREN = Gross energy
APDE = Apparent digestible energy
UFOR = Undigested forage residue
MFEN = Metabolic fecal energy
FEEN = Fecal energy
TRDE = True digestible energy
HEFE = Heat of fermentation
AUUE = Absorbed but unused urinary energy
MEEN = Metabolizable energy
MUEN = Metabolic urinary energy
UREN = Urinary energy
NEEN = Net energy
HNUM = Heat of nutrient metabolism
MAIN = Maintenance
ACTI = Activity
PROD = Production
REGU = Regulation

ENERGY

Energy is a very basic nutrient that is necessary for all of the life functions. The pathways of energy partitioning from gross to net are discussed in the paragraphs that follow.

Gross energy. The gross energy in any combustible material can be expressed in kcal per unit weight or kcal per unit volume. Firewood is sold on the basis of volume, where one cord = 128 cubic feet, equal to a stack 8 by 4 by 4 feet. Ther energy in this cord varies. A cord of white oak, a very dense wood, gives off 7,700,000 kcal when burned, and of white pine, a light porous wood, 4,100,000 kcal when burned.

The gross energy in a forage is the amount of energy released when that forage is completely oxidized in a bomb calorimeter (See Moen 1973: 172). It is an initial nutritive measurement of the energy in the product of primary production. The energy content per unit dry weight, or kcal per kg, is not widely different for different forages; 4500 KCAL PER KG is a good approximation of gross energy in many forages. Complete oxidation and the yield of gross energy is not necessarily related to the nutritive energy as a result of the biochemical functions in the gastrointestinal tract. The amount of energy available as a result of digestion is dependent on the effectiveness of the rumen microflora in breaking down the forage ingested and releasing the nutrients.

Apparent digestible energy. The apparent digestible energy is the gross energy in ingested food minus the energy in the feces. It is easily determined by measuring fecal energy and subtracting it from the gross energy, but it is of limited value since feces also contain tissues of metabolic origin. These tissues have been assimilated and broken down, and are not the same as undigested food residue. These two sources of fecal energy--undigested forage residue and metabolic fecal energy--must be separated before nutritive pathways can be quantified properly.

Apparent digestibility, expressed as a percent, may be calculated with the formula:

Apparent digestibility =
[(Intake energy - Fecal energy)/Intake energy] 100

True digestible energy. True digestible energy is determined by subtracting metabolic fecal energy from fecal energy, and subtracting that from gross energy. Metabolic products in the feces include such things as mucous, digestive juices, intestinal cell walls, bacteria, and protozoa. True digestibiligy, expressed as a percent, may be calculated with the formula:

True digestibility =
{[Intake energy - (Fecal energy - Metabolic fecal energy)]/Intake energy} 100

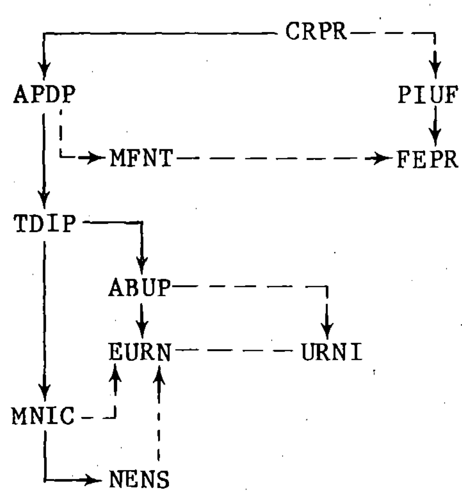
Numerically, true digestibility is greater than apparent digestibility.

Metabolizable energy. Metabolizable energy is that which is available for the nutrient metabolism that supports maintenance, activity, and production. It is the energy left after true digestible energy, heat energy of fermentation, energy in the methane, and urinary energy have been partitioned out of the gross energy. Methane, plus a few other gases in trace amounts, are produced in the digestive tract as a result of rumen fermentation. They are elimnated by eructation. The heat energy of fermentation is due to the exothermic metabolic reactions of rumen microflora. This heat energy contributes to the regulation of body temperature, and indirectly, at least, affects levels of activity and production.

Net energy. Net energy for maintenance, activity and heat production is the metabolizable energy less the heat of nutrient metabolism. It is a high-level distinction in the series of energy pathways, surpassed only by the further division into net energy for specific body functions, such as contraction of heart muscle, net energy for the muscular contraction necessary for walking, net energy for the growth of fetal tissue, and many other specific functions. These distinctions are beyond the considerations for wild ruminants in this book· metabolizable energy is the finest division division that will be applied directly to ecological situations.

PROTEIN

Ingested protein is partitioned into different sequences of metabolic processes just as energy is. Some is left intact as it traverses the gastrointestinal tract. Digested protein is broken down into amino acids and synthesized into new protein tissue. Some of this new tissue is in the form of rumen microflora, and some is new host tissue. The pathways are illustrated below.



Definitions of the four-letter symbols are given on the next page, and the categories on the upper left of the flow diagram are discussed in the paragraphs that follow.

CRPR = Crude protein
APDP = Apparent digestible protein
PIUF = Protein in undigested forage
MFNT = Metabolic fecal nitrogen
FEPR = Fecal protein
TDIP = True digestible protein
ABUP = Absorbed but unused protein
EURN = Endogenous urinary nitrogen
URNI = Urinary nitrogen
MNIC = Metabolizable nitrogenous compounds
NENS = Net nitrogen synthesized

Crude protein. Crude protein is the gross protein content of forage. It is an expression of the total protein in the forage, whether or not it may become metabolically available to a primary consumer.

Apparent digestible protein. The apparent digestible protein is the crude protein minus the protein in the feces. The feces, however, contain some protein of metabolic origin. Epithelial linings of the gastrointestinal tract, for example, are found in the feces. Thus the apparent digestible protein fraction of the crude protein is higher than the true digestible protein fraction.

True digestible protein. The true digestible protein fraction includes not only the undigested protein in the forage but also the fecal nitrogen of metabolic origin (MFEN). The true digestible protein fraction of the crude protein is higher than the apparent digestible protein, indicating that more protein was digested than at the apparent digestible protein level.

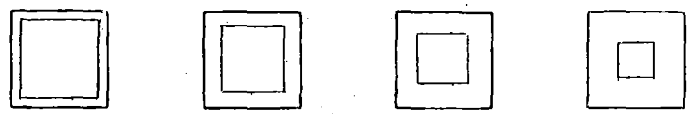
Metabolizable nitrogenous compounds. The nitrogenous compounds that actually end up being metabolized are available for synthesis, with some of the nitrogen ending up as endogenous urinary nitrogen (EURN) and some as net nitrogen synthesized (NENS) as new tissue. Endogenous urinary nitrogen is eliminated, though some is subject to resorption and recycling.

Net nitrogen synthesized. The nitrogen in the metabolizable nitrogenous compounds that actually ends up in new tissue represents the net nitrogen synthesized, becoming part of the protein tissue in the body.

FORAGE ANALYSES

An understanding of the nutrient pathways begins with an understanding of digestion. Food ingested must first be broken down into chemical forms that can be absorbed, metabolized, and synthesized. Since forage characteristics are very important in determining digestion, forage analyses are of definite interest.

What factors determine the digestibility of a forage for a ruminant animal? How does forage quality change as the range goes from the dormant winter condition, through various stages in phenology during the growing season, and back to the dormant winter condition? The nutritive use of the range by consumers ultimately occurs at the cellular and molecular level. Digestibilities are affected by the molecular structure of plant cell walls. Their complex molecular structure is hard to break down; the cell walls are often quite indigestible. Materials within the cell have fairly simple molecular structures, however, and are usually very digestible. Visualize the structure and volume of the cell wall in relation to the volume of intracellular space as the growing season passes. Cell walls of emerging plant tissues are thin, and as the tissues mature, the cell walls become thicker. The cell walls of mature tissues, especially structural tissues, are thick.



Tissue maturation - - →

As the cell walls increase in thickness, the amount of intracellular material decreases. Since highly lignified thick cells walls provide structural support to the plants, they also are an effective barrier to structural and chemical breakdown by rumen microflora. Since thicker cell walls are more resistant to chemical breakdown than thinner ones, the digestibility pattern over the annual cycle follows lplant maturation patterns; the general pattern of plant development at the cellular level is the basis for variations in digestibility.

A method of nutrient analyses called "Proximate analysis" has been used for over 100 years. Unfortanately, the results of this chemical method are not always closely aligned with the biological processes going on in the ruminant animal. Short (1966:163) states: "The proximate analysis of important species of deer browse has many times been shown to have little value in predicting how a deer digests a particular forage item." Why is this statement true? Because proximate analysis is an analysis of the chemical characteristics of forages, and these chemical characteristics are not always related to the digestion process of living organisms. These considerations are discussed further in Moen (1973:136-139).

How, then, should forage analyses be conducted to be of greatest value in evaluating nutritive relationships of wild ruminants? What factors determine the digestibility of a forage for a ruminant animal? How does forage quality change as the range goes from the dormant winter condition, through various stages in phenology during the growing season, and back to the dormant winter condition? Cell characteristics and digestibilities are considered in TOPIC 1. Chemical characteristics, sorted according to nutrients, genus and species of plants, and different plant parts are given in TOPIC 2. Diet digestibilities, determined by _in vivo_, _in vitro_, and calculations are given in TOPIC 3.

LITERATURE CITED

Moen, A. N. 1973. Wildlife Ecology. W. H. Freeman and Company, San Francisco. 458 pp.

REFERENCES, CHAPTER 11

FORAGE CHARACTERISTICS AND THE DIGESTIBILITY OF PLANT TISSUE

BOOKS

TYPE	PUBL	CITY	PGES	ANIM	KEY WORDS-----------------	AUTHORS/EDITORS--	YEAR
aubo	dvnc	nyny	427		the essential oils	guenther,e	1949
aubo	mopc	itny	1165	doru	feeds and feeding	morrison,fb	1956
aubo	mhbc	nyny	533	doru	animal nutrition	maynard,la; loosl	1962
edbo	acpr	nyny	618		biochemi, phenolic compnds	harborne,jb	1964
edbo	butt	wadc	480	doru	physiol of dig, rumin	dougherty,rw,ed	1965
aubo	agrc	loen	264	doru	nutr requi, farm livestock	smith,jab; armst/	1965
aubo	prha	ecnj	306	doru	princi of microbial ecolog	brock,td	1966
aubo	olbo	edsc	407	doru	animal nutrition	mcdonald,p; edwa/	1966
aubo	acpr	nyny	383		compar biochem, flavonoids	harborne,jb	1967
edbo	acpr	nyny	427	wiru	comparat nutri, wild anima	crawford,ma,ed	1968
edbo	nhfg	conh	256	odvi	p 182-196 deer nutrit stud	siegler,hr,ed	1968
aubo	whfr	sfca	753	doru	applied animal nutrition	crampton,ew; harr	1969
aubo	mhbc	nyny	613	doru	animal nutrition	maynard,la; loosl	1969
aubo	stmp	nyny	347		the cuticles of plants	martin,jt; junipe	1970
edbo	esli	edgb	549		trace elemnt metab in anim	mills,cf	1970
edbo	spve	nyny	214		integrated experime ecolog	heinz,e,ed	1971
aubo	cdch	coor	316	doru	digest physiology, nutritn	church,dc	1972
edbo	acpr	nyny	272	rumi	phytochemical ecology	harborne,jb	1972
book	nasc	wadc	772	doru	atlas nutrition data feed	NRC*	1972
edbo	acpr	nyny	3vol		chemis, biochem of herbage	butler,gw; baile	1973
aubo	long	loen	479	doru	animal nutrition	mcdonald,p; edwa/	1973
aubo	acpr	nyny	179		chemi of vegetable tannins	haslam,e	1974
edbo	acpr	nyny	1204		the flavonoids	harborne,jb; mab/	1975
edbo	acpr	nyny	326		chem & biochem plnt protns	harborne,jb; van	1975
aubo	acpr	nyny	243		introduc, ecolog biochemis	harborne,jb	1977
edbo	isup	amia	755	doru	forages; scien grsslnd agr	hughes,hdm; heat/	1977
edbo	acpr	nyny	435		biochem, plnt anim coevolu	harborne,jb	1978
edbo	acpr	nyny	718	hrbv	interact, plnt metabolites	rosenthal,ga; jan	1979

*National Research Council. Committee on Animal Nutrition. Subcommittee on Feed Composition

TOPIC 1. CELL CHARACTERISTICS AND DIGESTIBILITIES

What does a primary consumer, or herbivore, ingest? Forage, at the macroscopic level, but at the chemical level where digestion occurs, cells composed of many complex chemical compounds. The basic structural unit of the plant is the cell, and of the cell, the cell wall. The chemical compounds lending structural support to the cell wall include lignin, cellulose, hemicellulose, fiber-bound protein, and lignified nitrogenous compounds. These are often quite indigestible due to their complex molecular structures. Within the cell, bounded by the cell membrane and cell wall, there are lipids, sugars, organic acids, other water-soluble materials, pectin, starch, soluble proteins, and non-protein nitrogenous compounds called cell solubles. These are essentially 100% digestible.

Highly lignified cell walls, characteristic of mature and decadent plants, are quite indigestible. Thin cell walls, characteristic of young, growing plant tissue, are much more digestible. The ratio of cell wall: cell solubles forms the basis for forage digestibility, with other physical and chemical variables further influencing it. This basic relationship is discussed in UNIT 1.1: CELL COMPONENTS AND DIGESTIBILITIES.

Chemicals with inhibitory effects on digestibility are discussed in UNIT 1.2: CHEMICAL INHIBITORS OF DIGESTIBILITY. Then CELLULAR AND DIGESTIBILITY DIFFERENCES BETWEEN PLANT GROUPS such as herbaceous and woody plants, and between different kinds of herbaceous and woody plants, are discussed in UNIT 1.3.

Different plant parts serve different functions. Some parts are structural (stems), some are decorative (flower), etc. Their functions are reflected in their structures, which in turn, affect digestibilities. These are discussed in UNIT 1.4.

UNIT 1.1: CELL COMPONENTS AND DIGESTIBILITIES

Cell structure is a basic determinant of digestibility. The division of plant cells into the less-digestible cell wall and the more digestible protoplasm, called cell solubles, provides a suitable basis for estimating digestilibity based on the cell wall: cell solubles ratio, and by the realtive quantities of lignin-cutin and hemicellulose-cellulose in the cell wall.

Cell characteristics are determined with detergent analyses (Van Soest 1963a and 1963b and Fonnesbeck and Harris 1970) that partition plant cells into cell solubles and cell wall. Neutral detergent treatment removes cell solubles, leaving the cell wall and its hemicellulose, lignin, cutin, and cellulose intact. Acid detergent treatment removes the hemicellulose from the cell wall, leaving lignin, cutin, and cellulose which, as a group, are frequently referred to as acid detergent fiber (ADF). Lignin and cutin are determined by further chemcial analysis of the ADF, and cellulose by arithmetical difference.

Cellulose and hemicellulose in pure form are entirely digestible by rumen bacteria; lignin and cutin are not digestible and apparently inhibit cellulose and hemicellulose digestion (Robbins 1973: 110). The protoplasm, composed of sugars, soluble carbohydrates, starch, pectin, protein, non-protein nitrogen, lipids and other components, is 98% digestible in mule deer (Short and Reagor 1970), and sheep and cattle (Van Soest 1967). Since it is the cell wall that varies in digestibility, its characteristics determine the overall digestibility of forage consumed.

CELL WALL CHARACTERISTICS

A predictable relationship exists between dry matter digestibility and cellulose content of many deciduous browses. Dominant winter twigs from the previous summer's growth of eighteen species of deciduous browse plants were evaluated by Robbins and Moen (1975) for their cell wall characteristics and digestibilities. As the percent lignin content of the acid-detergent fiber increased, cell wall digestibility decreased. The equation expressing this relationship, modified slightly from Robbins and Moen (1975:340), is:

$$CWDP = 155.04 - 38.77 \ln LGNC; \quad R = -0.92$$

where CWDP = cell wall digestibility in percent, and
LGNC = lignin content of the acid-detergent fiber.

An equation was also devised for the relationship between cell wall digestibility and the lignin-cutin content. The equation, modified slightly from Robbins and Moen (1975:340), is:

$$CWDP = 139.97 - 33.15 \ln LGCC; \quad R = -0.93$$

where LGCC = lignin-cutin content of the acid-detergent fiber.

The predictibility of CWDP based on the lignin-cutin content of ADF is slightly better (R = -0.93 compared to -0.92) than that based on lignin content alone. Either equation could be used to estimate cell wall digestibility, depending on the information available.

These equations are for deciduous browse species, and should not be used for other plant groups, or for other plant parts. These effects are discussed in UNITs 1.3 and 1.4.

CELL SOLUBLES

Cell solubles are approximately 98% digestible in the ruminant's digestive tract (See Van Soest 1967, Short and Reagor 1970, and Robbins and Moen 1975). This can be written as:

$$CSDP = 0.98$$

where CSDP = cell soluble digestibilities in percent

OVERALL DIGESTIBILITY AS SUM OF CWDP AND CSDP

Overall digestibility can be considered to be the sum of the digestibilities of its parts. Thus the sum of the cel wall digestibility and cell soluble digestibility is an estimate of overall digestibility, providing that the relative contributions of the cell wall and cell soluble components are considered. Thus a weighted mean procedure is used, with the digestibilities of each component multiplied by the fractions of each component. The formula is:

$$TDMD = (CSFF)\,(CSDP) + (CWFF)\,(CWDP)$$

where TDMD = true dry matter digestibility in percent,
CSFF = cell soluble fraction of the forage,
CSDP = cell soluble digestibility in percent,
CWFF = cell wall fraction of the forage, and
CWDP = cell wall digestibility in percent.

The equations given above for CWDP and CSDP may be combined into a single equation for calculating TDMD.

$$TDMD + (CWFF)\,(139.97 - 33.15 \ln LGCC) + (CSFF)\,(0.98)$$

All of the symbols have been defined. Simply substitute the appropriate numbers and an estimate of TDMD will be derived.

The basic relationships between cell structure and digestibility has been discussed thus far. The arithmetic is simple; the biochemistry is not. The next UNIT includes brief discussions of chemical inhibitors of digestion, compounds which may cause departures from the cell wall - cell soluble predictions of digestibility. Then discussions of the difference between cell wall characteristic of plant groups and plant parts in relation to digestibilities are discussed in UNITs 1.3 and 1.4.

The references listed in the SERIALS list were selected on the basis of key words such as cell components, cell wall, lignin, and other indications of cell structure in relation to digestibility. References on other lists in this CHAPTER 11, especially the Genus-species list (UNIT 2.4), should also be consulted for a more thorough literature search.

LITERATURE CITED

Fonnesbeck, P. U., and L. E. Harris. 1970. Determination of plant cell walls in feeds. Proc. Am. Soc. Anim. Sci., Western Sect. 21:153-161.

Robbins, C. T. 1973. The biological basis for the determination of carrying capacity. Ph.D. Thesis. Cornell Univ., Ithaca, N.Y. 239 p.

Robbins, C. T., and A. N. Moen. 1975. Composition and digestibility of several deciduous browses in the Northeast. J. Wildl. Manage. 39(2):337-341.

Robbins, C. T., P. J. Van Soest, W. W. Mautz, and A. N. Moen. 1975. Feed analyses and digestion with reference to white-tailed deer. J. Wildl. Manage. 39(1):67-79.

Short, H. L., and J. C. Reagor. 1970. Cell wall digestibility affects forage value of woody twigs. J. Wildl. Manage. 34(4):964-967.

Van Soest, P. J. 1963a. Use of detergents in the analysis of fibrous feeds. I. Preparation of fiber residues of low nitrogen content. J. Assoc. Off. Agric. Chem. 46(5):825-829.

Van Soest, P. J. 1963b. Use of detergents in the analysis of fibrous feeds. II. A rapid method for the determination of fiber and lignin. J. Assoc. Off. Agric. Chem. 46(5):829-835.

Van Soest, P. J. 1967. Development of a comprehensive system of feed analyses and its application to forages. J. Anim. Sci. 26(1):119-128.

REFERENCES, UNIT 1.1

CELL COMPONENTS AND DIGESTIBILITIES

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS------------------	AUTHORS-----------	YEAR
JRMGA	22--1	40	43	od--	nutri analysis, 2 brows sp	short,hl; harrell	1969
JRMGA	30--2	122	127	od--	eval, habitat, nutri basis	wallmo,oc; carpen	1977
JWMAA	38--2	197	209	od--	fiber comp, forage digesti	short,hl; blair,/	1974
JWMAA	41--4	667	676	od--	seas nutr yld,dig, pine,tx	blair,rm; short,/	1977

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JANSA	36--4	792	796	odvi	estim digest, browse tissu	short,hl; blair,/	1973
JWMAA	35--2	221	231	odvi/	cellulos dig, chem com, mo	torgerson,o; pfan	1971
JWMAA	38--1	20	31	odvi	in vitro dig, food, ozarks	snider,cc; asplun	1974
JWMAA	39--1	67	79	odvi/	feed analyses and digestio	robbins,ct; van /	1975
JWMAA	39--2	337	341	odvi/	comp, dig, decid brws, n e	robbins,ct; moen,	1975
JWMAA	40--2	283	289	odvi	nutr qual, seed, frui, tex	short hl; epps,ea	1976
JWMAA	40--4	630	638	odvi/	digest, nutrit, 7 brows sp	mautz,ww; silver/	1976

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JRMGA	9---3	142	145	odhe	apparent digestibi, lignin	smith,ad; turner/	1956
JWMAA	30--1	163	167	odhe	eff cellulo lev, appar dig	short,hl	1966
JWMAA	34--4	964	967	odhe	cell wall dige, woody twgs	short,hl; reagor,	1970
JWMAA	38--4	823	829	odhe	utiliz fibrous alfal diets	schoonveld,gg; n/	1974

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
BJNUA	40--2	347	358	ceel	dosh, seas digestn forages	milne,ja; macrae/	1978

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
HOECD	4---1	59	65	alal	caca, seas diff, dig brows	cederlund,g; nyst	1981

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				rata			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				anam			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				bibi			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ovca			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ovda			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				obmo			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				oram			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
COVEA	67--3	307	326	hrbv	plnt fibr, herbivore nutri	van soest,pj	1977

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
AGJOA	66--2	195	200	rumi	nutr, crwnvtch, struct con	burns,jc; cope,wa	1974
CPLSA	49--4	499	504	rumi	lign, cell wall dig, pl pa	mowat,dm; kwain,/	1969
JANCA	46--5	825	829	rumi	prep fiber resid, low nitr	van soest,pj	1963
JANCA	46--5	829	835	rumi	rapid meth, det fiber, lig	van soest,pj	1963
JANCA	50--1	50	55	rumi	deterg, plnt cell wall con	van soest,pj; win	1967
JANCA	51--4	780	785	rumi	det lignin, cellulose, adf	van soest,pj; win	1968
JANCA	56--4	781	784	rumi	study, acid-dtr fibr, lign	van soest,pj	1973

rumi continued on the next page

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JANSA	23--3	838	845	rumi	chem procedure, eval forag	van soest,pj	1964
JANSA	26--1	119	128	rumi	syst, feed anal, fora appl	van soest,pj	1967
JANSA	29--1	11	15	rumi	dig forag cellulo, hemicel	keys,je; van soe/	1969
JANSA	41--1	185	197	rumi	cell-wall fractns, digestn	johnson,wl; pezo,	1975
JDSCA	50--7	1130	1135	rumi	cell wall const, adf fract	colburn,mw; evans	1967
JRMGA	22--1	40	43	rumi	nutr analy, two brows spec	short,hl; harrell	1969
JSFAA	26--9	1433	1433	rumi	physi chem aspct, fibr dig	van soest,pj	19__
NAWTA	31---	122	128	rumi	meth, eval forag, wild rum	short,hl	1966
NETMA	17--2	119	127	rumi	predic forag dig, lab prcd	deinum,b; van soe	1969
NEZFA	13--3	591	604	rumi	carbohyd, lign comp, grass	bailey,rw; uylatt	1970
XAAHA	379--	1	20	rumi	forage fiber analys, appli	goering,hk: van s	1970

UNIT 1.2: CHEMICAL INHIBITORS OF DIGESTIBILITY

Chemical analyses of foods have been done for over 100 years. Specific groups of compounds are isolated in the proximate analysis approach, and chemical composition data given for specific foods. Early studies of the digestibilities of forages for wild ruminants yielded results that were not always explained by chemical analyses. Feeding trials of sagebrush (Artemisia tridentata) were conducted by Smith (1950), for example, who concluded that "In spite of the high volues of digestible nutrients all animals lost weight. This may have been due to. . . some quality of the sage brush not expressed by standard chemical analysis."

The quality of the sagebrush which Smith speculated on was discribed by Nagy et al. (1964) as a result of research on the effects of essential oils on the growth and metabolism of rumen microorganisms of mule deer. Sagebrush essential oils inhibited the growth of deer rumen microorganisms. Appetite and rumen movements ceased completely when 7-pound daily portions of sagebrush were introduced through the rumen fistula of a steer. A sagebrush extract had been found to inhibit certain bacteria in 1946 (Carlson et al. 1946). Maruzella and Lichtenstein (1956) demonstrated that the majority of over 100 volatile oils exhibited some kind of antibacterial action. Thus the evidence for chemical inhibitors of digestion in plants has been available for over 30 years. Knowledge of the effects of different inhibitors on diet digestibilities are not yet well understood, however.

Fraenkal (1959) called attention to the role of secondary plant compounds as defense mechanisms of plants against herbivores. Such compounds afford a chemical protection, which is much more subtle and difficult to recognize than thorns and spines which afford a mechanical protection. Secondary substances include such things as glucosides, saponins, tannins, alkaloids, essential oils, and organic acids. Those substances, apparently not involved in the basic metabolism of a plant, do reduce herbivory. It must also be pointed out that wild ruminants make up a very small portion of the worldl's herbivores; insects, though much smaller, have the potential for greater practical import in the entire vegetation than wild ruminants do.

The subject under consideration here is not the roles of chemical inhibitors as defense mechanisms in plants, but the effects of chemical inhibitors on digestion. The presence of inhibitor-containing plants on the range makes it possible for them to be included in the diet. The foraging pressure on the range has a part in determining whether such plants will be consumed. Generally speaking, they are not consumed if there is an ample supply of other forage plants available, or consumed in small enough quantities that the inhibitors have little or no effects on overall diet digestibility.

LITERATURE CITED

Carlson, H. J., H. D. Bissell, and M. G. Mueller. 1946 Antimalarial and antibacterial substances separated from higher plants. J. Bacteriol. 52(2):155-168.

Fraenkal, G. S. 1959. The raison d'etre of secondary plant substances. Science 129:1466-1470.

Maruzella, J. C., and M. B. Lichtenstein. 1956. The in vitro antibacterial activity of oils. Jour. Amer. Phar. Assoc. Sci. Ed. 45(6):378-381.

Nagy, J. G., H. W. Steinhoff, and G. M. Ward. 1964. Effects of essential oils of sagebrush on deer rumen microbial function. J. Wildl. Manage. 28(4):785-790.

Smith, A. D. 1950. Sagebrush as a winter feed for deer. J. Wildl. Manage. 14(3):285-289.

REFERENCES, UNIT 1.2

CHEMICAL INHIBITORS OF DIGESTIBILITY

SERIALS

CODEN	VO-NU	BEPA	ENPA	SCSB*	KEY WORDS-----------------	AUTHORS----------	YEAR
				alkd			

CODEN	VO-NU	BEPA	ENPA	SCSB*	KEY WORDS-----------------	AUTHORS----------	YEAR
APMBA	15--4	777	784	esol	odhe, dosh,fir,rumn microb	oh,hk; sakai,t; /	1967
APMBA	15--4	819	821	esol	rumi antibacter, sagebrush	nagy,jg, tengerdy	1967
APMBA	16--1	39	44	esol	odhe,rumen microb inhibitn	oh,hk; jones,mb;/	1968
APMBA	16--3	441	444	esol	odhe sagebrush, antibacter	nagy,jg; tengerdy	1968
CJFRA	2---3	250	255	esol	odhe,d fir genot,brws pref	radwan,ma	1972
FOSCA	16--1	21	27	esol	odhe,d fir, microb fermnta	oh,jh; jones,mb;/	1970
JPHAA	45--6	378	381	esol	rumi in vitro, antimicrobi	maruzzella,jc; 1/	1956
JWMAA	14--3	285	289	esol	sagebrush as a winter feed	smith,ad	1950
JWMAA	28--4	785	790	esol	odhe sagebru, rumen microb	nagy,jg; steinho/	1964
JWMAA	44--1	107	113	esol	odvi,juniper, terpenoi con	schwartz,cc; nag/	1980
JWMAA	44--1	114	120	esol	odhe, junipr, volatile oil	schwartz,cc; reg/	1980

*SCSB = Secondary Substances

CODEN	VO-NU	BEPA	ENPA	SCSB	KEY WORDS-----------------	AUTHORS----------	YEAR
				flvd			

CODEN	VO-NU	BEPA	ENPA	SCSB*	KEY WORDS-----------------	AUTHORS----------	YEAR
				glcs			

CODEN	VO-NU	BEPA	ENPA	SCSB	KEY WORDS-----------------	AUTHORS----------	YEAR
ADAGA	19---	107	149	mnrl	silica in soils,plnts,anim	jones,lhp; handre	1967
JDSCA	51-10	1644	1648	mnrl	effect of silica, digestib	van soest,pj; jo/	1968
JWMAA	34--3	565	569	mnrl	alal, comp, herbage, alask	kubota,j; rieger/	1970

CODEN	VO-NU	BEPA	ENPA	SCSB	KEY WORDS-----------------	AUTHORS----------	YEAR
AMNTA	105--	157	181	phnl	plant phenolics: eco persp	levin,da	1971
BIJOA	139-1	285	288	phnl	polyphenl-protein interact	haslam,e	1974
BOREA	10---	1	65	phnl	conif, lich-biol, econ sig	perez-llano,ga	1944
JSFAA	10--2	135	144	phnl	constit, prunus domesticus	hillis,we; swain,	1959
PYTCA	5---3	423	438	phnl	plant phenolic comp, enzym	loomis,wd; battai	1966

CODEN	VO-NU	BEPA	ENPA	SCSB	KEY WORDS-----------------	AUTHORS----------	YEAR
AGJOA	45--7	335	336	tann	tan, palatab, sericea lesp	wilkins,hl; bate/	1953
AGJOA	46--2	96	97	tann	palatabi, sericia lespedez	donnelly,ed	1954
AGJOA	66--2	195	200	tann	phnl, nutri val crwn vetch	burns,jc; cope,wa	1976
CRPSA	11--2	231	233	tann	rel tan lev,nutr val,seric	cope,wa; burns,jc	1971
CRPSA	14--5	640	643	tann	eff, in vitr, dry mat,prot	schaffert,re; le/	1974
ECOLA	51--4	565	581	tann	seas chan, oak tanni, nutr	feeny,p	1970
JANSA	34--3	465	468	tann	dosh, nutr val, soybn meal	driedger,a; hatfi	1972
JAGRA	58--2	131	139	tann	seas var, cont,lespedz ser	clarke,id; frey,/	1939
JSFAA	23-10	1157	1162	tann	lucern tan, infl dig enzym	milic,bl; stojan/	1972
NAREA	44-11	803	815	tann	tann, role in forage quali	mcleod,mn	1974

tann continued on the next page

CODEN	VO-NU	BEPA	ENPA	SCSB*	KEY WORDS-----------------	AUTHORS----------	YEAR
PYTCA	2---4	371	383	tann	chnges in ripening fruits	goldstein,jl; swa	1963
PYTCA	4---1	185	192	tann	inhibitn of enzymes by tan	goldstein,jl; swa	1965
PYTCA	7....	871	880	tann	seas change, tan, oak leav	feeny,pp; bostock	1968
PYTCA	8--11	2119	2126	tann	oak leaf inhib prot hydrol	feeny,pp	1969
PYTCA	12...	1809	....	tann	tan, hebaceous leguminosae	bate-smith,ec	1973
PYTCA	15--9	1407	1409	tann	condnsd, pastur legume spp	jones,wt; broadh/	1976
PYTCA	16--9	1421	1426	tann	astringent tanni, acer spp	bate-smith,ec	1977
SCIEA	193--	1137	1138	tann	microb degrad, condens tan	grant,wd	1976

CODEN	VO-NU	BEPA	ENPA	SCSB	KEY WORDS-----------------	AUTHORS----------	YEAR
AMEBA	28---	1	82	otss	rata antibiot eff, lich, s	vartia,ko	1950
AMNTA	108--	268	289	otss	mamm, herb, plnt sec compn	freeland,wj; janz	1974
APMBA	15--4	954	996	otss	rumi bac grwth,tetrzl slts	tengerdy,rp; nag/	1967
BSECB	5---3	177	183	otss	seas var,palata, pteridium	cooper-driver,ga/	1977
BTBCA	72---	157	164	otss	rata antibioti activ, lich	burkholder,pr; ev	1945
CRPSA	16--2	225	229	otss	suppr in vitro, crwn vetch	burns,jc; cope,w/	1976
ENDEA	10--4	95	99	otss	rata antibact substn, lich	bustinza,f	1951
JDSCA	40-10	1945	1946	otss	inhi rumn cellulas,sericea	smart,wwg,jr; be/	1961
JRMGA	29--5	356	363	otss	rumi, maj plant toxi, w us	james,lf; johnson	1976
JWMAA	44--3	613	622	otss	rata diges, rangifer forag	person,sj; pegau/	1980
PNASA	30--9	250	255	otss	rata antibiot activ, lichn	burkholder,pr; m/	1944
PYTCA	14--4	1107	1113	otss	phytochm,proanthocyanidins	bate-smith,ec	1975
ZTTFA	24--4	200	204	otss	ceel,doca, rumn cllys,bark	prins,ra; geelen,	1968

*SCSB = Secondary Substance

alkd = alkaloids**
esol = essential oils
flvd = flavonoids
glcs = glucosides**
mnrl = minerals
otss = other secondary substances
phnl = phenols, phenolic compounds
tann = tannins

**These were not used in the serials lists; additional publications may be available on these substances.

UNIT 1.3: CELLULAR AND DIGESTIBILITY DIFFERENCES BETWEEN PLANT GROUPS

Herbaceous and woody plants are differentiated on taxonomic bases, and they also have distinct differences in their cellular characteristics and digestibilities. The major difference is the larger quantity of crude fiber in the woody plants; the larger quantity of fiber is what makes the plants woody. This difference affects forage availability as woody browse is often the only forage available to deer and moose living in the northern forests in the winter when snow covers herbaceous material from the previous growing season.

There are differences in the cellular characteristics and digestibilities of different kinds of herbaceous plants too. Grasses and legumes have been studied because of their importance to domestic animals, with considerable emphasis on the time of cutting as well as the taxonomic groups of these forages.

Digestibilities may be calculated with regression equations having cell characteristics as the independent variable. A single relationship, however, cannot be used for all forages. Rather, regression equations need to be derived for different plant groups. Equations need to be derived for different groups of plants such as grasses, legumes, etc., because the slopes of the regression lines appear to be related to taxonomic groups. Equations have not yet been derived for sufficiently large numbers of species in all groups; grasses and legumes have been evaluated most thoroughly because of their importance as forages for domestic animals.

LICHENS

Very limited amounts of research have been conducted on the cellular characteristics of lichens in relation to digestibility. Person et al. (1980) give data on two species, which is not enough to derive generalized equations for lichens as a group. Simple regression equations for the relationships between digestibility and fiber composition of different arctic forages in four different groupsg (lichens, shrubs, grass-like plants, and forbs) are given by Person et al. (1980); some of their results may be useful when evaluating material in the rest of this UNIT.

GRASSES

A wide range in the cell wall components of grasses exists for different species (See Van Soest 1965: 837; and Moen 1973: 169). They are generally less digestible than legumes, but a wide range in the phenology of different species results in grasses being available at different stages of growth throughout much of the growing season.

LEGUMES

Legumes may be generally more digestible than grasses because of their lower cell wall component. Alfalfa had about 40-60% cell wall compared to 45-72% for different grasses (Van Soest 1965: 837; and Moen 1973: 169). Legumes are much more important as forages for domestic ruminants than wild ones; they are raised and harvested for their high nutritive values.

FORBS

The forbs analyzed by Whittemore and Moen (1980) were highly digestible. Deer need high quality forage during the summer to meet their increased metabolic requirements at that time and to build up fat reserves to survive the winter period of low quality forages (Moen 1978). It is often difficult to detect evidence of selective grazing on forbs and other summer foods, and their importance to the animal is easily underestimated. There is a need for more detailed observations of foods consumed on the summer range and their relationship to the winter survival of white-tailed deer (Whittemore and Moen 1980).

DECIDUOUS BROWSES

The current annual growth (CAG) of deciduous browse is the part of woody plants preferred by browsing animals. The distal portions of the CAG is more digestible than the proximal portion. In fact, Whittemore and Moen (ms in preparation) suggest that it is necessary to know the length intervals of the twig before a digestibility estimate can be given. Digestibilities decrease from the distal to the proximal portion as less meristematic and more structural tissue is found along that length gradient.

There is a predictable relationship between browse dry matter digestibility and cell soluble content, but this is not enough to estimate dry matter digestibility because of variations in cell wall content (Robbins and Moen 1975). The cell walls of browse species tend to be relatively low in diggestibility due to the high lignin-cutin content. An equation expressing this relationship from Robbins et al. (1975:72) is:

$$CWDG = 146.59 - 34.61 \ln LCUC$$

where CWDG = in vivo cell wall digestibility, and
LCUC = lignin-cutin content expressed as percent of the acid-detergent fiber.

The predictability of this relationship and the estimated cell-soluble digestibility (0.98) form a basis for general prediction of forage true dry matter digestibility (TDMD):

$$TDMD = 0.98 (CSCP) + (CWCP) (139.97 - 33.15 \ln LGCC$$

where 0.98 = digestibility of cell solubles,
CSCP = cell soluble content in percent of forage,
CWCP = cell wall content in percent of forage, and
LGCC = lignin-cutin content as a percent of the acid-detergent fiber.

CONIFEROUS BROWSES

The current annual growth of coniferous browse is the part preferred by browsing animals. Again, the distal portions of the CAG is more digestible. The range in digestibility from the distal end for 2-year-old growth in hemlock was as great as the range in average digestibilities of preferred foods to starvation foods (Moen, unpublished data).

OTHERS

A fungus (Polyporus squamosus) and a moss (Atrichum sp.) were analyzed by Whittemore and Moen (1980), and digestibilites found to be 41 and 39%, respectively. These are quite low. Digestibilities of other fungi and mosses have not been measured.

The references in the SERIALS list were selected on the basis of key words such as cell components, cell wall, lignin, and other indicators of cell structure in relation to digestibility of forages in different plant groups. References in other lists in this CHAPTER 11, especially the Genus-species list (UNIT 2.4), will provide additional information for nutritive analyses.

LITERATURE CITED

Person, S. J., R. G. White, and J. R. Luick. 1980. Determination of nutrituve value of reindeer-caribou range. Pages 224-239 In: Reimers, E., E. Gaare, and S. Skjenneberg (eds.). Proc. 2nd Reindeer/Caribou Symp., Roros, Norway, 1979. Direktoratet for vilt og ferskvannsfisk, Trondheim.

Robbins, C. T. and A. N. Moen. Composition and digestibility of several deciduous browses in the Northeast. J. Wildl. Manage. 39(2):337-341.

Robbins, C. T., P. J. Van Soest, W. W. Mautz and A. N. Moen. 1975. Feed analyses and digestion with reference to white-tailed deer. J. Wildl. Manage. 39(1):67-79.

Whittemore, S. and Moen, A. N. 1980. Composition and in vitro digestibilities of various summer foods of white-tailed deer. Can. J. Anim. Sci. 60:189-192.

Van Soest, P. J. 1965. Symposium on factors influencing the voluntary intake of herbage by ruminants:voluntary intake in relation to chemical composition and digestibility. J. Animal Sci. 23(3):834-843.

REFERENCES, UNIT 1.3

CELLULAR AND DIGESTIBILITY DIFFERENCES BETWEEN PLANT GROUPS

SERIALS

CODEN	VO-NU	BEPA	ENPA	PLGR*	KEY WORDS-----------------	AUTHORS----------	YEAR
JANSA	16--2	476	480	dest	digestib live oak, chamise	bissell,hd; weir,	1957
JRMGA	18--2	139	144	dest	fecal cellulo,esti pl tiss	short,hl; remmeng	1965
JWMAA	35--4	732	743	dest	limit, wint aspn brws,mich	ullrey,de; youat/	1971
JWMAA	36--3	885	891	dest	dig, est metabl aspn brows	ullrey,de youat/	1972
JWMAA	39--1	67	79	dest	feed analysis, digestion	robbins,ct; soes/	1975
JWMAA	39--2	337	341	dest	comp, digest, decidu brows	robbins,ct; moen,	1975

CODEN	VO-NU	BEPA	ENPA	PLGR	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	31--3	448	454	evst	dig cedar, jack pine brows	ullrey,de; youat/	1967
JWMAA	32--1	162	171	evst	dig cedar, balsam fir brow	ullrey,de; youat/	1968
PCGFA	10---	53	58	evst	nutri probl, sou pine type	lay,dw	1956
ZEJAA	9---2	54	62	evst	[on digest fresh fir bark]	ueckermann,e; har	1963

CODEN	VO-NU	BEPA	ENPA	PLGR	KEY WORDS-----------------	AUTHORS----------	YEAR
CNJNA	60---	189	192	frbs	compos digestib herb forag	whittemore,s;moen	1980

CODEN	VO-NU	BEPA	ENPA	PLGR	KEY WORDS-----------------	AUTHORS----------	YEAR
JANSA	38--1	149	153	gras	compar,dig, grasses, niger	olubajo,fo; van /	1974
JANSA	39--2	423	434	gras	intk, digest, napier grass	grant,rj; van soe	1974

CODEN	VO-NU	BEPA	ENPA	PLGR	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	31--3	443	447	hedi	previous diet, dige alfalf	nagy,jg; vidacs,/	1967

*PLGR = Plant group

CODEN	VO-NU	BEPA	ENPA	PLGR	KEY WORDS------------------	AUTHORS----------	YEAR
JWMAA	12--1	109	110	hemo	select most nutrit forages	swift,rw	1948

CODEN	VO-NU	BEPA	ENPA	PLGR	KEY WORDS------------------	AUTHORS----------	YEAR
				lgms			

CODEN	VO-NU	BEPA	ENPA	PLGR	KEY WORDS------------------	AUTHORS----------	YEAR
AZOFA	8--3	385	389	lich	nutr val, lichens, lapland	pulliainen,e	1971

CODEN	VO-NU	BEPA	ENPA	PLGR	KEY WORDS------------------	AUTHORS----------	YEAR
CAFGA	41--1	57	78	many	diges, naturl, artif foods	bissell,hd; harr/	1955
JWMAA	16--3	309	312	many	diges, some native forages	smith, ad	1952
JWMAA	28--4	791	797	many	digest cedar, aspen browse	ullrey,de; youat/	1964
JWMAA	35--4	698	706	many	forage dige, diet s upland	short,hl	1971
JWMAA	36--1	174	177	many	qual, wint fora, ark ozark	segelquist,ca; s/	1972
JWMAA	40--4	630	638	many	dig,rel nutr, 7 n brows sp	mautz,ww; silver/	1976
NEZFA	13--3	591	604	many	crbhyd, lign, grass, legum	bailey,rw; ulyatt	1970
XFPSA	136--	1	11	many	habi, pine-hardwd, louisia	blair,rm; brunett	1977

CODEN	VO-NU	BEPA	ENPA	PLGR	KEY WORDS------------------	AUTHORS----------	YEAR
CNJNA	60---	189	192	othr	compos digestib herb forag	whittemore,s;moen	1980

*PLGR = Plant Group

dest = deciduous shrubs and trees
evst = evergreen shrubs and trees
frbs = forbes
grss = grasses
hedi = herbaceous dicots
hemo = herbaceous monocots
lgms = legumes
lich = lichens
many = two or more plant groups
othr = others

CHAPTER 11, WORKSHEET 1.3a

Cell wall percents and predicted digestibilities

The relationship between percent cell wall and *in vitro* digestibility may be demonstrated with data in Table 1 of Whittemore and Moen (1980). The percents cell wall and measured *in vitro* digestibilities given below may be used to calculate linear regression equations for digestibilities, the dependent variable, of stems and leaves and of the floral parts in relation to percents cell wall (the independent variable).

Calculate linear regression equations for the two sets of data below. PTCW = percent cell wall, and DMDP = dry matter digestibility in percent.

	Floral parts		Stems and leaves	
Scientific name	PTCW	DMDP	PTCW	DMDP
Anaphalis margaritacea	48.1	83.1	46.7	77.4
Aster novae-anglicae	33.1	85.8	51.0	67.9
Chrysanthemum leucanthemum	43.7	79.8	55.8	69.8
Daucus carota	26.7	91.2	59.1	70.8
Eupatorium maculatum	50.1	72.2	45.5	72.5
Impatiens biflora	30.9	87.2	40.3	79.2
Linaria vulgaris	27.1	86.3	49.8	73.7
Plantago major	54.1	67.7	32.2	82.7
Solidago graminifolia	39.2	76.1	43.1	74.6
Solidago juncea	45.6	72.0	57.5	62.9
Taraxicum officinale	32.6	87.1	34.7	91.3
Trifolium pratense	41.8	79.9	51.6	72.0

The calculated equations are, for the floral parts:

DMDP = ______ + ______ PTCW

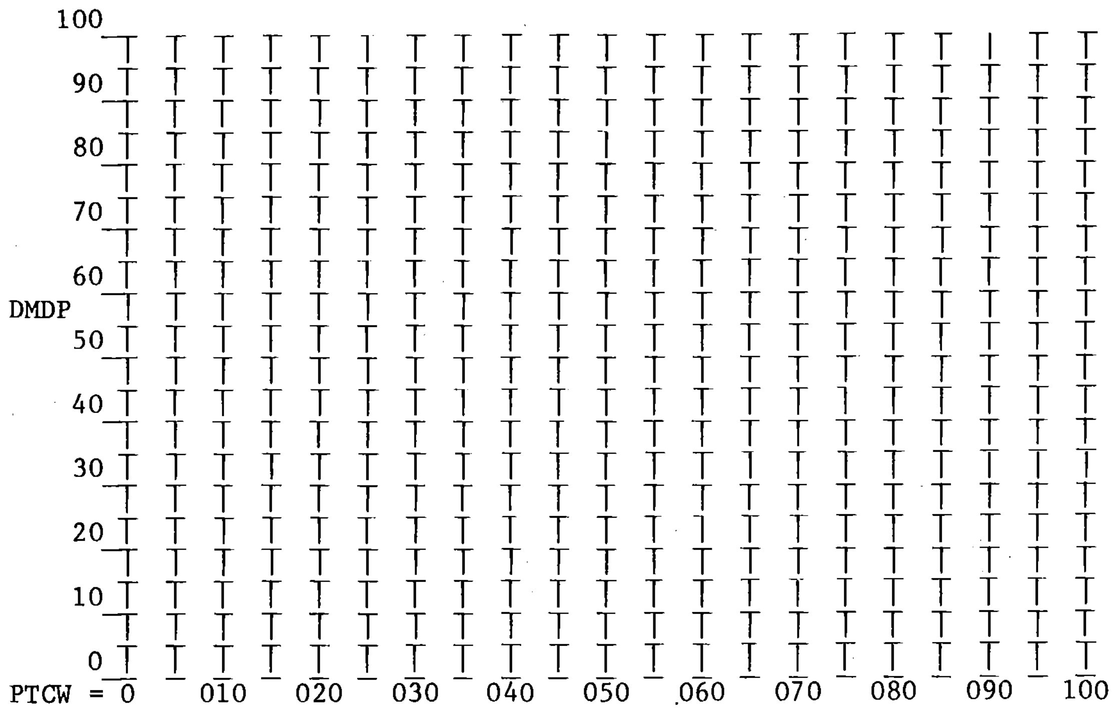
and for the stems and leaves:

DMDP = ______ + ______ PTCW.

Similar analyses may be made for other species reported in the literature. Non-linear regressions may result in best fits for different sets of data.

Plot the data on the grid on the back of this page. Note how similar the slopes (b) are; all the data were combined and a single linear regression used to express the relationship between percent cell wall and digestibility in the published paper. The equation is:

$$DMDP = 113.7 - 0.8\ PTCW;\ R^2 = 0.93$$



LITERATURE CITED

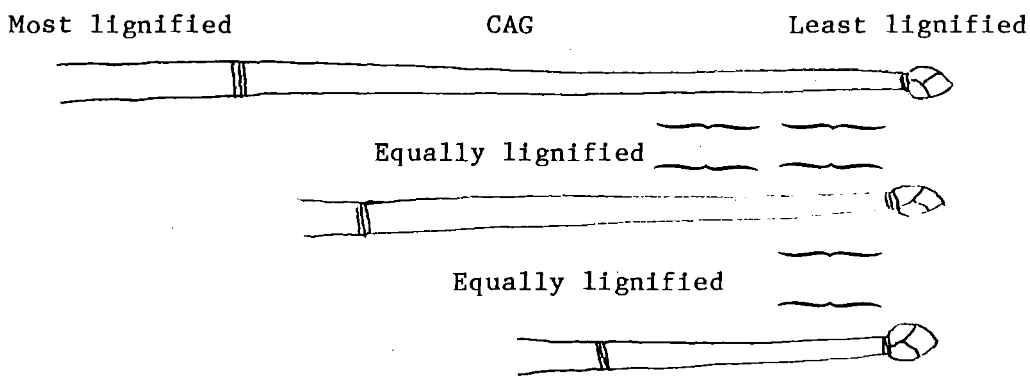
Whittemore, S. and A. N. Moen. 1980. Composition and in vitro digestibilities of various sommer foods of white-tailed deer. Can. J. Anim. Sci. 60:189-192.

UNIT 1.4: CELLULAR AND DIGESTIBILITY DIFFERENCES BETWEEN PLANT PARTS

It is desirable to consider the cellular characteristics of the parts of a single plant before considering several species, since variations between some of the plant parts may be greater than differences between species. Unfortunately, many published data on nutritive characteristics of different species are not accompanied by identification of the plant parts analyzed. Differences in cellular characteristics of different plant parts are related to their functions.

STEMS

Stems provide structural support for most plants, and therefore one would expect their cell walls to be rather rigid and firm. This suggests that the stems are highly lignified, with complex molecules of high molecular weights. The older parts of the stems are expected to be more highly lignified than the younger, growing parts.



Current annual growth (CAG) is the one part of a stem that is often analyzed in wild ruminant nutrition. Differences in cell structures are expected for different lengths of current annual growth and at different times during the growing season, however. Data on cell characteristics of stems or parts of stems are scarce; there is a need for many more laboratory analyses of growth and time effects on these characteristics of importance in nutritive analyses.

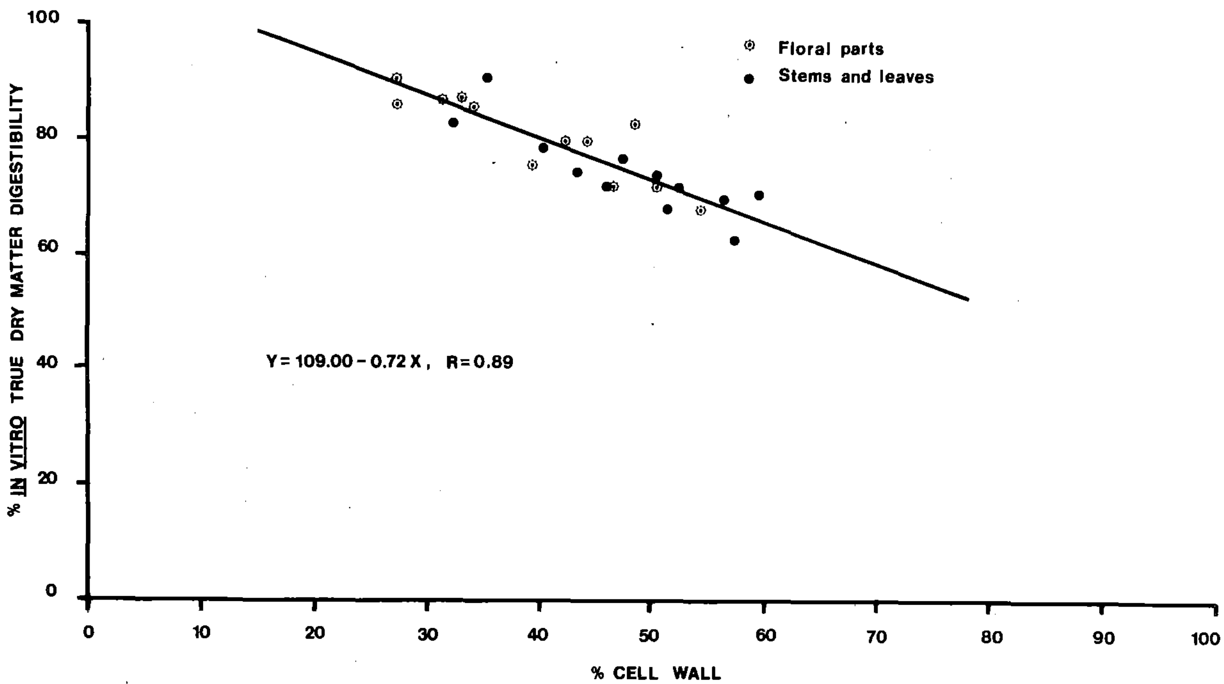
LEAVES

Leaves of annuals and deciduous plants go through an annual cycle of emergence, maturation, and decadence. Cell walls are expected to become thicker and more lignified as the leaves mature, of course. Decadent annual and deciduous leaves also lose nutrients through translocation, so their nutritive contents change as cell structures change through time.

Two-year old and older leaves are present on evergreens. Cell structural changes are expected to be less after the first year of rapid growth and maturation.

FLOWERS

The delicate petals, anthers, stamens, and other floral parts of flowering plants are expected to have thinner cell walls than the supporting structures. The figure below shows that the floral parts of herbaceous species tend to have lower percents cell wall than the stems and leaves tabular data in Whittemore and Moen (1980). The rigidity of the petals is due more to turgid cells as a result of a high free-water content than to rigid cell walls.



FRUITS AND SEEDS

Fruits and seeds show considerable variation in their structural characteristics. Fruits are often fleshy with a high water content. Seeds are often covered by rigid protective structures, and have pericarps that are often quite strong. Materials inside of the protective structures may be structurally quite weak.

LITERATURE CITED

Whittemore, S. and A. N. Moen. 1980. Composition and digestibility of various herbaceous forages of the white-tailed deer. Can J. Anim. Sci. 60(1):189-192.

REFERENCES, UNIT 1.4

CELLULAR AND DIGESTIBILITY DIFFERENCES BETWEEN PLANT PARTS

SERIALS

CODEN	VO-NU	BEPA	ENPA	PLPA*	KEY WORDS------------------	AUTHORS----------	YEAR
CNJNA	60--1	189	192	flwr	compos, diges summer foods	whittemore,s; moe	1980

CODEN	VO-NU	BEPA	ENPA	PLPA	KEY WORDS------------------	AUTHORS----------	YEAR
				frut			

CODEN	VO-NU	BEPA	ENPA	PLPA	KEY WORDS------------------	AUTHORS----------	YEAR
CNJNA	60--1	189	192	leav	compos, diges summer foods	whittemore,s; moe	1980
PYTCA	7....	871	880	leav	seas changes, tannin contn	feeny,pp; bostock	1968
PYTCA	8--11	2119	2126	leav	inhib eff tann prot hydrol	feeny,pp	1969

CODEN	VO-NU	BEPA	ENPA	PLPA	KEY WORDS------------------	AUTHORS----------	YEAR
ECOLA	49--5	956	961	seed	caloric val, 4 sites, kans	johnson,sr; robel	1968

CODEN	VO-NU	BEPA	ENPA	PLPA	KEY WORDS------------------	AUTHORS----------	YEAR
CNJNA	60--1	189	192	stem	compos, diges summer foods	whittemore,s; moe	1980
ZEJAA	9---2	177	184	stem	[on digest fresh fir bark]	ueckermann,e; har	1963

CODEN	VO-NU	BEPA	ENPA	PLPA	KEY WORDS------------------	AUTHORS----------	YEAR
JWMAA	40--4	630	638	twig	dig, rel nutr, 7 n species	mautz,mm; silver/	1976

*PLPA = Plant part

CODEN	VO-NU	BEPA	ENPA	PLPA	KEY WORDS-----------------	AUTHORS----------	YEAR
CPLSA	49--4	499	504	many	ligni, in vitr dig, pl prt	mowat,dm; kwain,/	1969
JWMAA	35--2	221	231	many	cellulo dig, chem, missour	torgerson,o; pfan	1971
XFPSA	136--	1	11	many	habi, pine-hardwd, louisia	blair,rm; brunett	1977

*PLPA = Plant part

flwr = flowers
frut = fruit
leav = leaves
many = two or more plant parts
seed = seeds
stem = stems
twig = twigs

TOPIC 2. CHEMICAL CHARACTERISTICS

Cell characteristics and digestibilities were discussed in TOPIC 1, with the relationships between cell structure, plant parts, and digestibilities considered. Plants have changing chemical profiles as photosynthates are produced and then metabolized or stored in different plant parts. Translocation occurs too; soluble nutrients move from the leaves to the stems just prior to leaf fall, for example. Some plants may, at different stages, contain digestion inhibitors, and these may reduce digestibilites of other forage ingested. All of these changing functions, combined with the changes in animal metabolism over the annual cycle, make nutritive relationships between animal and range very dynamic.

Wild ruminants are selective feeders, choosing certain plant parts rather than simply consuming the entire plant or the most accessible parts of the plant. The overall digestibility of the mass of ingesta is dependent on the combined effects of changes in forage characteristics over time and in the selection of plant parts by the animals.

This TOPIC contains four units of information on chemical characteristics of forages and range plants. Many of the references contain information based on proximate analysis. They are valuable references as long as the limitations of proximate analysis are recognized. The information is organized with UNIT 2.1 listing the references on the basic nutrients (ENERGY, PROTEIN, MINERALS, AND VITAMINS), followed by information on CHANGES IN CHEMICAL CHARACTERISTICS OVER TIME (UNIT 2.2), CHEMICAL COMPOSITION OF DIFFERENT PLANT PARTS (UNIT 2.3), and finally, CHEMICAL COMPOSITION BY GENUS AND SPECIES (UNIT 2.4). The last UNIT contains several thousand references in the SERIALS list, and should be consulted whenever nutritive evaluations are being made in other units in this CHAPTER, and in other chapters too.

UNIT 2.1: ENERGY, PROTEIN, MINERALS, AND VITAMINS

The four categories of nutrients that make up the title of this UNIT 2.1 represent the nutrients used by animals for metabolism. Since nutrients in these categories are required for metabolism, it is reasonable to evaluate forages for these nutrients. Publications resulting from nutritive analyses generally reflect the techniques in vogue at the time. Some nutritionists have suggested standardizing techniques and output formats so more direct comparisons of results from different laboratories may be made. Styles and standardizations are fine, providing they are conceptually correct and biologically useful for years to come.

A major decision was made by the NRC Committee on Animal Nutrition in 1958 when it passed a resolution to start using the caloric system to describe the energy values of feeds. This decision was important conceptually because it allows for the use of internationally defined units when evaluating both forage and animal, permitting research on fundamental biological processes without masking the results in index-type outputs.

Brief discussions of the four categories of nutrients follow. References in the SERIALS list have been identified because of their nutrient information and the time of year the plant material was collected.

ENERGY

The energy value of forages may be described by a sequence of values from gross to digestible to metabolizable to net energy, with the last three values dependent on the animal's efficiencies in extracting and using the potential energy in the forage. The energy levels from gross to net are discussed in the first few pages of this CHAPTER 11.

Published data on the energy use of forages is often limited to digestible energy. Apparent digestible energy is quite easily determined by feeding trials and fecal collections. Gross energy may be measured in a bomb calorimeter or calculated from chemical composition (See UNIT 2.2 and WORKSHEET 2.2a). Metabolizable energy determinations require urine and methane collections, and net energy determinations require measurements of the heat increment.

The references listed in the SERIALS list are sorted into the four nutrient categories, with the energy category being rather short. Be sure to consult the Genus-species list in UNIT 2.4 for additional references that contain energy information.

PROTEIN

The amount of protein in forage is generally represented is a percent of the dry weight of the forage. This results in a value for the crude protein in the forage. It is a gross protein estimate, indicating the amount present in the forage. The amount useful to the animal is dependent on the total concentration of protein in the forage, the animal's ability to digest protein, and the amino acids making up the protein.

The references to protein in the SERIALS list include information on the time of year when the forage was collected. This enables one to compile a protein profile over the annual cycle, illustrating the changing amounts of protein as plants go through their different phases of growth and maturation.

MINERALS

The mineral composition of forage plants has been given some attention in recent years, with calcium and phosphorous being the two most commonly measured minerals. Little detailed analysis may be done on animal-range relationships, simply because so little is known about the mineral requirements of wild ruminants. It is easy to conclude that if the energy and protein needs of a free-ranging ruminant are being met, the mineral needs are also being met. However, large differences in the sizes of antlers of white-tailed deer, for example, indicate that mineral metabolism and subsequent antler growth may be a good indicator of general nutritional status. Further, antler growth of yearling whitetails and female reproductive rates also appear to be correlated (See PART VI). The usefulness of this relationship for management purposes suggests that more attention should be given the mineral composition of the forage, the productivity of the range, and mineral metabolism of the animals.

VITAMINS

The vitamin compositions of forages consumed by wild ruminants have been given practically no attention. The B-complex is unimportant since they are synthesized in the rumen. Other vitamins are apparently supplied in sufficient quantities since reduced productivity due to vitamin defficiencies has never been mentioned for wild ruminants. The evaluation of forages should always be from the animal's perspective, and the domestic animal scientists have been moving in this direction in recent years.

Crampton and Harris (1969) include good discussions of the four categories of nutrients in relation to domestic animals, and many of their concepts may be applied to free-ranging ruminants. As good basic, biologically-sound analyses are completed on the nutritive relationships of domestic ruminants, information will be available for aplication to domestic ruminants as well.

The references in the SERIALS list are not the only ones available with information of value in this UNIT. Check the Genus-species list in UNIT 2.4 for additional references of importance to the nutritive evaluation of forages.

LITERATURE CITED

Crampton, E. W. and L. E. Harris. 1969. Applied animal nutrition. W. H. Freeman and Co., San Francisco. 753 pp.

REFERENCES, UNIT 2.1

ENERGY, PROTEIN, MINERALS, AND VITAMINS

SERIALS

CODEN	VO-NU	BEPA	ENPA	NUTR*	KEY WORDS-----------------	AUTHORS----------	YEAR
ECOLA	42--3	581	584	ener	energy valu, plant materia	golley,fb	1961
ECOLA	49--5	956	961	ener	caloric val, 4 sites, kans	johnson,sr; robel	1968
ECOLA	51--6	1094	1097	ener	caloric value of pine, var	madgwick,hai	1970
ECOLA	52--5	923	926	ener	seas calor val, wdlnd, eng	hughes,mk	1971
JRMGA	20--3	179	180	ener	gross energ val, alpine pl	smith,dr	1967
JWMAA	32--4	162	171	ener	dig cedar, blsm fir browse	ullrey,de; youat/	1968
JWMAA	36--3	885	891	ener	dig, est metabl, aspn brow	ullrey,de; youat/	1972
TWNSD	31---	113	122	ener	odvi, nutr, physiol resear	mautz,ww	1974

CODEN	VO-NU	BEPA	ENPA	NUTR	KEY WORDS-----------------	AUTHORS----------	YEAR
AGNSA	46...	309	310	mnrl	saltbush, mineral composit	benjamin,ms	1935
BOREA	40--3	347	394	mnrl	minerl status, foliar anal	vanden driessche,	1974
CJBOA	36--2	209	220	mnrl	mineral conte, leav, humus	gagnon,d; lafond/	1958
CJBOA	51--2	421	427	mnrl	trace elements, yukon, nwt	doyle,p; fletche/	1973
CJBOA	51-11	2037	2046	mnrl	mnrl comp, stand prod,utah	harner,rf; harper	1973
CPLSA	53--2	263	268	mnrl	forage pl, reindeer presrv	scotter,gw; milti	1973
HLTPA	29--1	43	51	mnrl	fall-out pluton, lich, swe	holm,e; persson,/	1975
HLTPA	30--2	245	247	mnrl	radiocesium, lichn, alaska	hedlund,jd	1976
JECOA	64--3	965	974	mnrl	minerl nutri accum, cyclin	turner,j; cole,d/	1976
JRMGA	11--5	247	248	mnrl	minerals, nutr, louisi for	duncan,da; epps,e	1958
JWMAA	34--3	565	569	mnrl	mnrl comp, herbage, alaska	kubota,j; rieger/	1970
JWMAA	41--2	330	331	mnrl	minrl cont, volc, tree ash	franzmann,aw; fly	1977
JWMAA	41--3	533	542	mnrl	browse quality, kenai popu	oldemeyer,jl; fr/	1977
NEXAA	246--	1	75	mnrl	calci, phospho cont, range	watkins,we	1937
NFGJA	14--1	76	78	mnrl	minrl cont, browse, n york	bailey,ja	1967

mnrl continued on the next page

*NUTR = nutrient

CODEN	VO-NU	BEPA	ENPA	NUTR	KEY WORDS------------------	AUTHORS----------	YEAR
NCANA	101-1	291	305	mnrl	mineral comp, moose forage	kubota,j	1974
PLSOA	45--1	17	26	mnrl	nutrit elem, forest plants	langille,wm; macl	1976
SWNAA	24--2	297	310	mnrl	botan comp, nutr cont diet	everitt,jh; gonza	1979
WUAPA	14---	1	27	mnrl	mnrl cont, nativ plnt, wis	gerlogg,gc; moor/	1964
XAMPA	369--	1	164	mnrl	mineral comp, crops, soils	beeson,kc	1941

CODEN	VO-NU	BEPA	ENPA	NUTR	KEY WORDS------------------	AUTHORS----------	YEAR
AGJOA	46--5	233	237	prot	legume nitrog vs fert nitr	wagner,re	1954
AGJOA	69--3	497	501	prot	time, qual fora, wdlnd clr	kalmbacher,rs; wa	1977
CAFGA	38--3	285	293	prot	pronghorn food habi, calif	ferrel,cm; leach,	1952
CAFGA	41--2	145	155	prot	crude protein varia, calif	bissell,hd; stron	1955
CJZOA	48--5	905	913	prot	seas chan ener, nitrg intk	mcewan,eh; whiteh	1970
JANSA	25--2	593	593	prot	est, nrc feed comp tables	knight,ad; harris	1966
JASIA	94--1	47	56	prot	util, nitrg, five herbages	egan,ar; ulyatt,m	1980
JECOA	51--3	555	566	prot	nitrog, decompos, sess oak	bocock,kl	1963
JFUSA	72--5	282	285	prot	logging, forage val, color	regelin,wl; wall/	1974
JONUA	42--3	525	535	prot	dosh nitrog dig, poor hrbg	macrae,jc; milne/	1979
JWMAA	27--1	81	93	prot	food habits, saskatchewan	dirschl,hj	1963
JWMAA	31--1	188	190	prot	prot, phosph, sprng growth	blair,rm' epps,ea	1967
JWMAA	31--3	437	442	prot	samplng brows, crude prote	bailey,ja	1967
JWMAA	36--1	174	177	prot	qual wint forag, ark ozark	segelquist,ca; s/	1972
NAWTA	11---	309	312	prot	crude prot det, deer food	einarsen,a	1946
NAWTA	21---	141	158	prot	prot, phosphorus cont, brw	swank,wg	1956
NFGJA	15--2	155	164	prot	soil frtl, crude prot, brw	bailey,ja	1968
SWNAA	24--2	297	310	prot	botan comp, nutr cont diet	everitt,jh; gonza	1979
XAGCA	796--	1	27	prot	forg utiliz, sum rang, ore	pickford,gd; reid	1948
XFPNA	44---	1	20	prot	fluc forage qual, blue mts	skovlin,jm	1967

CODEN	VO-NU	BEPA	ENPA	NUTR	KEY WORDS------------------	AUTHORS----------	YEAR
CNRDA	28--5	249	271	vtmn	forst succ, nutr val, brws	cowan,imct; hoar/	1950
JWMAA	13--3	271	274	vtmn	vit a, carotene, wldlf foo	nestler,rb; derb/	1949

CODEN	VO-NU	BEPA	ENPA	NUTR	KEY WORDS------------------	AUTHORS----------	YEAR
AGJOA	51--4	223	226	tech	animal var, meas fora qual	mott,go	1959
AGJOA	54--6	511	515	tech	eval fora crops, chem anal	sullivan,jt	1962

CODEN	VO-NU	BEPA	ENPA	NUTR	KEY WORDS------------------	AUTHORS----------	YEAR
ADCSA	95...	262	278		comp, maturity, nutri valu	van soest,pj	1969
NAWTA	9----	19	28		soil fertility, wildlife	albrecht,wa	1944
NAWTA	31---	122	128		eval forag, meth, ruminant	short,hl	1966
WZMNA	27...	189	198		nutr, rumn cont, wint brws	anke,m; groppel,/	1978
XFIPA	76---	1	8		moisture, timelag, equilib	mutch,rw; gastine	1970

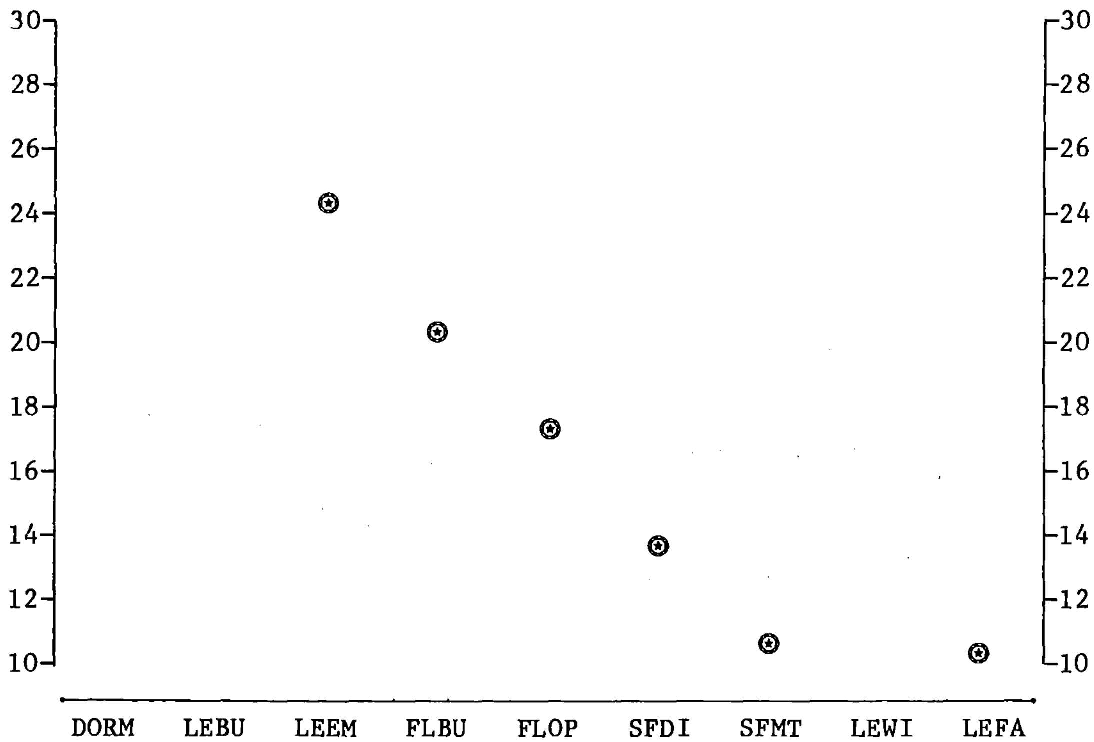
*NUTR = nutrient

ener = energy
mnrl = mineral
prot = protein
vtmn = vitamins
tech = technique

UNIT 2.2: CHANGES IN CHEMICAL COMPOSITION OVER TIME

The importance of time in relation to the growth and development of an animal has been discussed in CHAPTER 1. Plant materials support this growth and development as they are the only important source of nutrients for the functional ruminant. Plant materials are obviously not chemically stable over time, so chemical interactions between animals and plant materials ingested are very labile.

Seasonal differences in the chemical compositions of herbaceous and woody browse species occur in relation to the development of the plant. Alfalfa (Medicago sativa) protein data from Crampton and Harris (1969: 478-479) (aerial part, fresh-cut) are used to illustrate these changes over time as the plant develops in the drawing below.



Note that the time scale is not represented on a calendar basis. This is so because the growing season, or the functional cause of seasonal variations in chemical composition, does not coincide exactly with the calendar. Thus physiological events are used on the x-axis to denote the progression of time. The several stages of growth and development of a plant through its annual cycle, include dormant (DORM), leaf buds (LEBU), leaves emerging (LEEM), floral buds (FLBU), flowers open (FLOP), seeds and fruits maturing (SFMT), seeds and fruits dispersed (SFDI), leaves withering (LEWI), leaves fallen (LEFA), and others. Each of the stages has cell structures that are characteristic of its functions through the the annual cycle.

Marked increases in the protein contents of twigs of browse species occur just prior to leaf fall because of translocation from the leaves to the stem. From a nutritional standpoint, the change is a chemical one, and is related to nutritive physiology in a chemical way. Shifts in food habits occur as leaf fall progresses and fruit and seed production occurs, resulting in very dynamic nutritive relationships before the dormant winter season when nutritive characteristics are quite stable and the quantity of forage available becomes the important factor.

The references in the SERIALS lists are sorted by season. Those listed here include references to the time of year collected. Additional references with general information on chemical composition are also listed at the end of this unit under "chco" (chemical composition). These references, plus those on the Genus-species list in UNIT 2.4, may provide additional information on the nutritive characteristics when evaluating phenology and nutritive charateristics of different forage plants.

LITERATURE CITED

Crampton, E. W. and L. E. Harris. 1969. Applied animal nutrition. W. H. Freeman and Co., San Francisco. 753 pp.

REFERENCES, UNIT 2.2

CHANGES IN CHEMICAL COMPOSITION OVER TIME

SERIAL PUBLICATIONS

CODEN	VO-NU	BEPA	ENPA	TIME	KEY WORDS-----------------	AUTHORS----------	YEAR
AGJOA	67--1	92	93	wntr	elbon rye forag, wint,ozar	short,hl; segelqu	1975
BZSSA	24--4	302	313	wntr	[chem compo, wint pasture]	florovskaya,ef	1939
CJZOA	52-10	1201	1205	wntr	predict digest, wint brows	mautz,ww; silver/	1974
JRMGA	10--4	162	164	wntr	nutritive valu, wint brows	smith,ad	1957
JRMGA	21--6	385	388	wntr	bighorn winter forage, bc	demarchi,ra	1968
JWMAA	4---3	315	325	wntr	month var nutr val, wint f	hellmers,h	1940
JWMAA	25--1	77	81	wntr	nutr,accp, hrdwd sla, wntr	alkon,pu	1961
JWMAA	25--3	342	342	wntr	atlntc wh-ced, wint browse	gould,wp; brown,j	1961
JWMAA	35--4	681	688	wntr	in vitr dig, wint for, wyo	ward,al	1971
JWMAA	35--4	732	743	wntr	limita, winte aspen browse	ullrey,de; youat/	1971
JWMAA	36--1	174	177	wntr	qual, wint forag, ark ozar	segelquist,ca; s/	1972
UAXBA	277--	1	48	wntr	winter range plants, utah	esplin,ac; greav/	1937
XFINA	221--	1	6	wntr	rose hips, energy, utah	welch,bl; andrus,	1977

CODEN	VO-NU	BEPA	ENPA	TIME	KEY WORDS-----------------	AUTHORS----------	YEAR
				spng			

CODEN	VO-NU	BEPA	ENPA	TIME	KEY WORDS-----------------	AUTHORS----------	YEAR
CNJNA	60--1	189	192	smmr	comp, <u>in vitro</u> dig, sum fo	whittemore,s; moe	1980
GRBNA	39--2	122	128	smmr	chem comp,summr plnts,utah	pederson,jc; harp	1979
JWMAA	38--4	792	798	smmr	nutr qual, prnghn diet, ut	smith,ad; maleche	1974
UAXBA	305--	1	22	smmr	summer range plants, utah	stoddart,la; grea	1942

CODEN	VO-NU	BEPA	ENPA	TIME	KEY WORDS-----------------	AUTHORS----------	YEAR
				fall			

CODEN	VO-NU	BEPA	ENPA	TIME	KEY WORDS-----------------	AUTHORS----------	YEAR
CAEBA	543--	1	62	seas	season, chem compos, range	hart,gh; guilber/	1932
ECOLA	51--4	565	581	seas	seas chan, tannins, nutrie	feeny,p	1970
JRMGA	27--2	114	117	seas	soil, seasonal forage qual	krueger,wc; donar	1974
JWMAA	39--2	321	329	seas	utri, south, diff seasons	short,hl	1975
OJSCA	21--3	89	103	seas	seas change, carbohydrates	mitra,sk	1921
PLPHA	10--4	739	751	seas	growth, seas chang, leaves	sampson,aw; samis	1935
PYTCA	7---5	871	880	seas	seas chang, tannin, leaves	feeny,pp; bostock	1968
UAXBA	472--	1	55	seas	nutri value, seasona range	cook,cw; harris,l	1968

CODEN	VO-NU	BEPA	ENPA	TIME	KEY WORDS-----------------	AUTHORS----------	YEAR
ADCSA	95...	262	278	chco	comp, maturity, nutri valu	van soest,pj	1969
AJGOA	56--2	160	161	chco	age, chem comp, digestibil	burton,gw; knox,/	1964
AGNSA	50...	240	276	chco	chem compo of prickly pear	benjamin,ms; old,	1939
AJBOA	61--7	749	753	chco	var nutr, pine, oak leaves	woodwell,gm	1974
ATICA	25--1	21	27	chco	forage plnts, reindee, nwt	scotter,gw	1972
ATRLA	18--1	81	91	chco	natu feed, roe deer, inges	drozdz,a; osiecki	1973
AZOFA	8---3	385	389	chco	nutr val, grz, ungrz lichn	pulliainen,e	1971
CAEBA	150--	1	21	chco	value oak of leaves, forag	mackie,ww	1903
CAEBA	627--	1	95	chco	comp foothill plnts, calif	gordon,a; sapson,	1939
CAFGA	39--2	163	175	chco	nutr val deer forag, calif	hagen,hl	1953
CAFGA	45--1	57	58	chco	interpret chem anal, brows	bissell,hd	1959
CJBOA	38--3	313	333	chco	chlorophyl, nativ, managed	bray,jr	1960
CJFRA	2---3	250	255	chco	doug fir genot, brows pref	radwan,ma	1972
CNAPA	769--	1	60	chco	nativ plants, alberta,sask	clarke,se; tisdal	1945
CNRDA	28--5	249	271	chco	nutrit valu, forest succes	cowan,imct; hoar/	1950
CPLSA	42--1	105	115	chco	festuca scabrella associat	johnston,a; bezea	1962
CPLSA	45--3	246	250	chco	forag lich,saskat, b g car	scotter,gw	1965
ECOLA	34--4	786	793	chco	nutr, leaf litte rocky mts	daubenmire,r	1953
ECOLA	40--4	644	651	chco	chem cont, current growth	cook,cw; stoddar/	1959
ECOLA	43--4	753	757	chco	caloric,lipid cont, alpine	bliss,lc	1962
ECOLA	47--2	222	229	chco	select nutr, browse plants	short,hl; dietz,/	1966
ELPLB	23--4	637	648	chco	nutri withdrawal fr leaves	stachurski,a; zim	1975
JANCA	12---	317	319	chco	chem composit, alaska lich	spencer,gc; krumb	1929
JANSA	41--2	601	609	chco	nutr value, aquatic plants	inn,jg; staba,ej/	1975
JANSA	45--2	365	376	chco	odvi, nutr throughout year	holter,jb; urban/	1977

continued on the next page

CODEN	VO-NU	BEPA	ENPA	TIME	KEY WORDS------------------	AUTHORS----------	YEAR
JAPEA	13--1	295	301	chco	nutr distrib, cyclng,conif	turner,j; singer,	1976
JCECD	4---6	675	683	chco	deer browsing pref, d-fir	radwan,ma; crouch	1978
JFUSA	55--5	342	347	chco	brows, prescrb burn, s pin	lay,dw	1957
JRMGA	5---5	346	353	chco	var, chem comp,range plnts	blaisdell,jp; wi/	1952
JRMGA	26--2	117	120	chco	productiv, nutrient status	smith,al	1973
JRMGA	30--3	206	209	chco	fo hab, semi-des grass-shr	short,hl	1977
JRMGA	30--3	227	230	chco	bermuda grass, saline soil	gonzalez,cl; heil	1977
JWMAA	15--4	352	357	chco	odvi,chem comp plnts s dak	gastler,gf; moxo/	1951
JWMAA	19--1	65	70	chco	chng, bros nutr valu, fire	dewitt,jb; derby,	1955
JWMAA	20--4	359	367	chco	chem comp, browse, n carol	smith,fh; beeson/	1956
JWMAA	23--1	81	90	chco	avail nutr, brws, dif soil	hundley,lr	1959
JWMAA	30--1	163	167	celu	cellulo level, appar diges	short,hl	1966
JWMAA	32--4	773	777	chco	chm comp, alpine tundr pln	johnston,a; beze/	1968
JWMAA	33--3	499	505	chco	nutr anal, mistletoe, ariz	urness,pj	1969
JWMAA	34--3	540	545	chco	eff, prescrib burn, browse	dills,gg	1970
JWMAA	35--2	221	231	chco	chem compo, missouri foods	torgerson,o; pfan	1971
JWMAA	35--4	698	706	chco	forage, dig, s uplnd range	short,hl	1971
JWMAA	36--3	913	923	chco	rata food hab, newfoundlnd	bergerud,at	1972
JWMAA	38--1	32	41	chco	plnt char rel, fd pref, or	radwan,ma; crouch	1974
JWMAA	38--3	517	524	chco	nutr cont, fertilizd brows	abell,dh; gilbert	1974
JWMAA	39--4	670	673	chco	nutr, diet, pnderosa, ariz	urness,pj; neff,/	1975
JWMAA	41--2	161	168	chco	anam diet qual, fora avail	schwartz,cc; nag/	1977
LATBA	488--	1	18	chco	nutr val, nativ plnts, lou	campbell,rs; epp/	1954
NAWTA	30---	274	285	chco	nutr reserve, range manage	dietz,dr	1965
NEXAA	311--	1	43	chco	compositi, grasses, browse	watkins,we	1943
NCANA	101-1	217	226	chco	nutritiv value, moose fora	oldemeyer,jl	1974
PCGFA	20---	34	104	chco	nutr anal, deer, so caroli	thorsland,oa	1966
PCGFA	28---	574	580	chco	qual, deer for, ea we virg	towry,rk,jr; mic/	1974
PMSCA	31--1	73	77	chco	nutr val,red osier,mt mapl	fashingbauer,ba;/	1963
PSAFA	1958-	117	122	chco	5 key brows species, color	dietz,dr; udall,/	1958

continued on the next page

CODEN	VO-NU	BEPA	ENPA	TIME	KEY WORDS-----------------	AUTHORS----------	YEAR
SZSLA	21---	117	128	chco	semi-domest reindeer nutri	steen,e	1968
TAEBA	245--	1	29	chco	feedin values, feed stuffs	fraps,gs	1919
TAEBA	461--	1	63	chco	comp, utiliz tex feed stuf	fraps,gs	1932
TAEBA	461--	1	94	chco	comp, utiliz tex feed stuf	fraps,gs	1947
TAEMA	384--	1	8	chco	factors, range forag plnts	vallentine,jf; yo	1959
TPCWD*	14---	1	89	chco	digestibil, forag sp, colo	dietz,dr; udall,/	1962
WAEBA	65---	1	52	chco	comp forage plants, wyomin	knight,hg; hepne/	1905
WAEBA	70---	1	75	chco	comp forage plants, wyomin	knight,hg; hepne/	1906
WAEBA	76---	1	112	chco	comp forage plants, wyomin	knight,hg; hepne/	1908
WAEBA	87---	1	152	chco	comp forage plants, wyomin	knight,hg; hepne/	1911
WAEBA	137--	1	16	chco	comp forage plants, wyomin	cundy,at	1924
WAEBA	146--	1	89	chco	comp forage plants, wyomin	roberts,en	1926
WAEBA	157--	89	107	chco	comp forage plants, wyomin	mccreary,o	1927
WAEBA	184--	1	21	chco	comp forage plants, wyomin	mccreary,oc	1931
WAEBA	311--	1	40	chco	comp forage plants, wyomin	beath,oa; hamilto	1952
WGFBA	12---	1	61	chco	anam food hab, abund, dist	sundstrom,c; hepl	1973
WLMOA	48---	1	65	chco	alal habita selec, for mng	peek,jm; urich,d/	1976
XFPSA	51---	1	35	chco	seas dist nutr, 7 brows sp	blair,rm; epps,ea	1969

*TPCWD is thought to be the correct CODEN for: State of Colorado - Department of Game and Fish, Technical Publication Number Fourteen.

CHAPTER 11, WORKSHEET 2.2a

Calculation of gross energy from chemical composition

The gross energy of a forage may be calculated from its chemical composition by multiplying the proximate analysis-determined fractions by their respective caloric values. The sum of the caloric yields of each of the fractions is the gross energy.

This procedure is discussed by Crampton and Harris (1969:73) for cattle feeds. A modified table for making these calculations is shown below.

Chemical component	Fraction		KCAL per gram		Contribution of each chemical component
Protein	______	x	5.6	=	________
Ether extract	______	x	9.3	=	________
Fiber	______	x	4.3	=	________
N-free extract	______	x	4.3	=	________
Ash	______				
Water	______				
SUMS =	1.00				________ = Calculated gross energy

Calculated gross energy values will come out close to 4.5 Kcal per gram, or 4500 Kcal per kg. Each of you must decide if 4500 is an adequate approximation for diet components, or if more precise measurements or calculations should be made for the kinds nutrient and ecological analyses being completed.

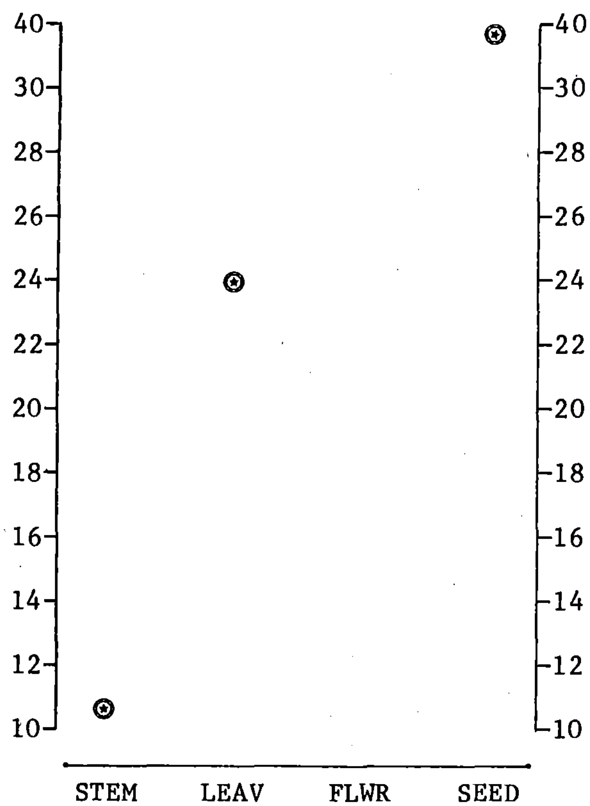
LITERATURE CITED

Crampton, E. W. and L. E. Harris. 1969. Applied animal nutrition. W. H. Freeman and Company, San Francisco. 753 pp.

UNIT 2.3: CHEMICAL COMPOSITIONS OF DIFFERENT PLANT PARTS

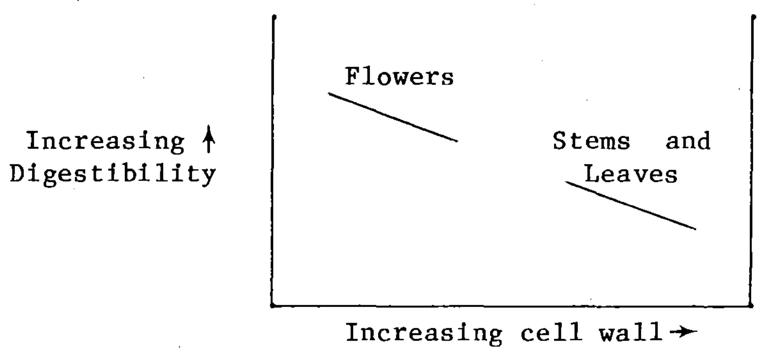
Since different plant parts have different functions, it is not surprising that there are differences in both cell structures and chemical compositions. There are some data on these differences in cultivated plants. The energy and matter morphology of a corn plant, for example, is illustrated in Moen (1973:307). In general, the stalk has the least digestible energy and the grain the most. Conversely, the stalk has the most ash and the grain the least. These differences reflect the different functions of these plant parts.

Changes in forage species and plant parts selected by wild ruminants reflect plant differences in plant tissues through the annual cycle. Changes in protein composition of alfalfa through time were illustrated in UNIT 2.2. Using the alfalfa data for stems and leaves and sweetclover data for seeds (Crampton and Harris 1969), the illustration below shows differences between parts of the plant.



Cell wall contents and *in vitro* digestibilities of the floral parts and stems and leaves of 12 species of forbs evaluated by Whittemore and Moen (1980) show that the floral parts had significantly lower cell wall contents and significantly higher *in vitro* digestibilities than the stems and leaves. This is not surprizing, since the stems are supporting structures and are expected to contain more lignified cells than the petals of flowers.

The significant characteristic of the data on cell wall and digestibility of these forbs is that the slopes of the regression lines for these plant parts were not different. Thus the basic relationship between cell wall and digestibility is the same for different plant parts, but the amount of cell wall is different. This is illustrated conceptually in the drawing below, and for data in Whittemore and Moen (1980) in a WORKSHEET.



The two lines afove have the same slope, but occur over different x-values. This illustration is an exaggeration of the data in Whittemore and Moen (1980); some overlap occurred in the cell wall percents of floral parts and stems and leaves.

The references in the SERIALS list are sorted in relation to the nutritional characteristics of the plant parts. The time of year was usually given, or could be inferred from the plant part analyzed. Additional data may be found in the comprehensive Genus-Species lists in UNIT 2.4.

LITERATURE CITED

Crampton, E. W. and L. E. Harris. 1969. Applied animal nutrition. W. H. Freeman and Co., San Francisco. 753 pp.

Moen, A. N. 1973. Wildlife Ecology: An analytical approach. W. H. Freeman and Co., San Francisco. 458 pp.

Whittemore, S. and A. N. Moen. 1980. Composition and digestibility of various herbaceous forages of the white-tailed deer. Can. J. Anim. Sci. 60:189-192.

REFERENCES, UNIT 2.3

CHEMICAL CHARACTERISTICS OF DIFFERENT PLANT PARTS

SERIALS

CODEN	VO-NU	BEPA	ENPA	PLPA*	KEY WORDS-----------------	AUTHORS----------	YEAR
CNJNA	60--1	189	192	flwr	comp, in vitro dig, sum fo	whittemore,s; moe	1980

CODEN	VO-NU	BEPA	ENPA	PLPA	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	13--3	271	274	frut	vit a, carotene, wildl fds	nestler,rb; derby	1949
JWMAA	37--4	585	587	frut	caloric, moisture cont val	burns,ta; viers,c	1973
JWMAA	40--2	283	289	frut	nutritn quality, digestion	epps,ea,jr	1976
XFINA	221--	1	6	frut	rose hips, energ, wint, ut	welch,bl; andrus,	1977

CODEN	VO-NU	BEPA	ENPA	PLPA	KEY WORDS-----------------	AUTHORS----------	YEAR
BOGAA	94--2	381	393	leav	minrl, nitrog, leave, time	mchargue,js; roy,	1932
CJBOA	36--2	209	220	leav	minerl contnt, leav, humus	gagnon,d; lafond/	5958
FRCRA	41--2	222	236	leav	conifer nutrie content, bc	beaton,jd; moss,/	1965
FRCRA	44--3	28	35	leav	prot, calor cont, lodg pol	boag,da; kiceniuk	1968
FRSTA	37--1	87	94	leav	chem comp,well, poor grown	madgwick,hai	1964
JACSA	39---	1286	1296	leav	plant food, forest leaves	serex,p,jr	1917
JSFAA	27--9	877	882	leav	element compos red raspber	john,mk; daubeny/	1976
JWMAA	34--2	475	478	leav	seas var, nutr cont, aspen	tew,rk	1970
JWMAA	35--4	668	673	leav	nutritive value, sourwood	harshbarger,tj; m	1971
PLPHA	10--4	739	751	leav	growth, seas chang, leaves	sampson,aw; samis	1935
PLSOA	24--1	90	112	leav	trace, maj elem comp, seas	guha,mm; mitchel,	1966

CODEN	VO-NU	BEPA	ENPA	PLPA	KEY WORDS-----------------	AUTHORS----------	YEAR
ECOLA	34--4	786	793	lttr	nutr, leaf litte rocky mts	daubenmire,r	1953
JFUSA	49-12	914	915	lttr	nutrient cont, litter fall	tarrant,rf; isaa/	1951

lttr continued on the next page

*PLPA = plant part

CODEN	VO-NU	BEPA	ENPA	PLPA	KEY WORDS-----------------	AUTHORS----------	YEAR
NOSCA	49--4	183	189	lttr	litterfall, doug-fir, oreg	rickard,wh	1975
OIKSA	25--3	341	352	lttr	chem comp, weight, decompo	howard,pja; howar	1974
SOSCA	43---	349	355	lttr	compos, forest tree litter	coile,ts	1937

CODEN	VO-NU	BEPA	ENPA	PLPA	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	37--4	585	587	mast	caloric, moisture cont val	burns,ta; viers,c	1973
PCGFA	13---	54	61	mast	acorns in diet of wildlife	goodrum,pd	1959

CODEN	VO-NU	BEPA	ENPA	PLPA	KEY WORDS-----------------	AUTHORS----------	YEAR
ECOLA	49--5	956	961	seed	caloric val, 4 sites, kans	johnson,sr; robel	1968
JAGRA	66--9	349	355	seed	proteins, various tree see	lund,ap; sandstro	1943
JANSA	44--3	389	394	seed	chem compos, 15 weed seeds	harrold,rl; nalew	1977
JWMAA	13--3	271	274	seed	vit a, carotene, wildl fds	nestler,rb; derby	1949
JWMAA	40--2	283	289	seed	nutritn quality, digestion	epps,ea,jr	1976

CODEN	VO-NU	BEPA	ENPA	PLPA	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	4--3	315	325	twig	month var nutr val, wint f	hellmer,h	1940
JWMAA	16--4	401	409	twig	brows stud, lake state reg	aldous,se	1952
JWMAA	25--1	77	81	twig	nutr, accp, hrdwd sla, wnt	alkon,pu	1961
JWMAA	31--3	437	442	twig	samplng browse, crude prot	bailey,ja	1967
JWMAA	38--1	32	41	twig	plnt char rel, fd pref, or	radwan,ma; crouch	1974
JWMAA	38--3	517	524	twig	nutr, fertliz brows, maine	abell,dh; gilbert	1974
JWMAA	40--4	630	638	twig	dig,rel nutr, 7 n brows sp	mautz,ww; silver/	1976

CODEN	VO-NU	BEPA	ENPA	PLPA	KEY WORDS-----------------	AUTHORS----------	YEAR
ATICA	25--1	21	27	many	forage plnts, reindee, nwt	scotter,gw	1972
CAEBA	627--	1	95	many	comp foothill plnts, calif	gordon,a; sapson,	1939
ECMOA	34--4	321	357	many	energ rel, alpin pl, n ham	hadley,eb; buss,l	1964

many continued on the next page

CODEN	VO-NU	BEPA	ENPA	PLPA	KEY WORDS-----------------	AUTHORS----------	YEAR
FOSCA	22--2	195	208	many	nutr elem chang,seas dynam	grigal,df; ohman/	1976
JRMGA	24--1	37	40	many	monthly var, desert saltbu	chatterton,nj; g/	1971
JRMGA	29--4	344	345	many	calor cont, rocky mt plnts	andersen,dc; armi	1976
JRMGA	30--3	206	209	many	fo hab, semi-des gras-shru	short,hl	1977
JWMAA	12--1	1	8	many	nutri value, 14 odvi foods	atwood,el	1948
JWMAA	31--1	188	190	many	prot, phosph, sprng growth	blair,rm; epps,ea	1967
JWMAA	33--4	1028	1031	many	browse qual, tree ovrstory	halls,lk; epps,ea	1969
JWMAA	34--3	565	569	many	minerl comp, herbag, alask	kubota,j; rieger/	1970
JWMAA	37--3	279	287	many	imprtn, non-brws food,alas	herescke,re; davi	1973
PCGFA	21---	57	62	many	growth, forag qual, browse	blair,rm; halls,l	1967
PCGFA	25---	47	53	many	quan,qual hnysckl, arkansa	segelquist,ca; r/	1971
PLSOA	45--1	17	26	many	nutrit elem, forest plants	langille,wm; macl	1976
SSSAA	40--1	116	119	many	leaf fall, floor character	van lear,dh; goeb	1976
UAXBA	344--	1	45	many	nutr val, range forag, uta	cook,cw; harris,l	1950
XFPSA	51---	1	35	many	seas distrib nutrien, 7 sp	blair,rm; epps,ea	1969
XFPSA	111--	1	10	many	comp, dig, s forest browse	short,hl; blair,/	1975

*PLPA = Plant Part

flwr = flower
frut = fruit
leav = leaves
lttr = litter
seed = seeds
sprt = sprouts
twig = twigs
many = two or more plant parts
mast = mast

CHAPTER 11, WORKSHEET 2.3a

Chemical compositions of different plant parts

Chemical compositions of different parts of forage plants consumed by domestic ruminants are given in the NAS (1971) Atlas of Nutritional Data on United States and Canadian Feeds. Chemical compositions of parts of naturally-growing forages consumed by wild ruminants are available in much more limited quantities. Using the data in the NAS Atlas and from the references listed in this CHAPTER, tabulate chemical compositions in the format below and identify patterns for use in making estimates for those forage species that have not been measured.

Chemical or nutritive component: ______________________

		PLPA						
Genus	species	sprt	twig	leav	flwr	frut	seed	lttr

UNIT 2.4: CHEMICAL CHARACTERISTICS BY GENUS AND SPECIES

Chemical characteristics of a large number of North American forage plants have been determined by nutritionists. Data on the feeds of interest to domestic animal scientists are published in comprehensive data books such as the Atlas of Nutritional Data on United States and Canadian Feeds (NAS 1971). Analytical data for 6,152 feeds are given in that Atlas. It is well-organized and easy to use. Plants are listed alphabetically by common name. Chemical characteristics, including dry matter, ash, crude fiber, ether etract, N-free extract, minerals, protein, and energy, are given. Further, energy and protein digestibility coefficients for sheep, cattle, goats, horses, and rabbits are given. The publication is an impressive collection of nutritional data. Since there are several entries for many of the species over time and for different plant parts, patterns of nutrient change can be identified.

No such atlas exists for the forges of wild ruminants. Perhaps none should since the tabulation of information on plant species that are selectively grazed or browsed by free-ranging animals over time can hardly be representive of the actual forage consumed through the annual cycle due to the many dynamics involved. On the other hand, the information is needed. Changes in digestibilities through time, changing cell wall characteristics, differences in the nutritive values of plant parts, changes in the preferences of the animals for different species, changes in foods available imposed by range conditions, changes in the nutrient needs of the animals. . . these are examples of some of the dynamics.

Other UNITS in this CHAPTER and other CHAPTERS include information and references on these and other dynamics of the animal-range relationship. Questions about nutritive relationships should be process-oriented, with analyses focused on different nutritive processes. Mineral metabolism, for example, is discussed in CHAPTER 9. References to mineral compositions of plants are listed in UNIT 2.1 of this CHAPTER. If the material on a nutritive process described in other UNITS and CHAPTERS does not contain the necessary information for a selected diet, then the GENUS-SPECIES lists in this UNIT 2.4 should be consulted for additional information.

The Genus-species list that follows is very comprehensive. Note that the KEY WORDS sometimes contain the four-letter genus and species code for the animal for which the nutritive analysis was done. Shorter lists in other UNITS are useful when specific characters are being evaluated; the long Genus-species list is a master list that provides the information necessary to find the published paper when evaluating the plant as forage.

LITERATURE CITED

National Academy of Sciences. 1971. Atlas of nutritional data on United States and Canadian feeds. National Academy of Sciences, Washington, D.C. 772 pp.

REFERENCES, UNIT 2.4

CHEMICAL CHARACTERISTICS BY GENUS AND SPECIES

SERIALS

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
FRCRA	41--2	222	236	abie	amab	forag nutr cont conif	beaton,jd; moss,/	1965
JAPEA	13--1	295	301	abie	amab	nutr distr cyclng alp	turner,j; singer,	1976
*****					****			
BOREA	40--3	347	394	abie	bals	pred miner nutr stats	vanden driessche,	1976
CJFRA	5---4	655	661	abie	bals	litter fall afte fire	grigal,df; mccoll	1975
CJZOA	52-10	1201	1205	abie	bals	odvi, forag nutr valu	mautz,ww; silver/	1974
FRCRA	41--2	222	236	abie	bals	forag nutr cont conif	beaton,jd; moss,/	1965
JWMAA	32--1	162	171	abie	bals	digesti of fir browse	ullrey,de; youat/	1968
JWMAA	32--4	729	746	abie	bals	alal damage to balsam	bergerud,at; manu	1968
JWMAA	38--3	517	524	abie	bals	odvi, nutr cont brows	abell,dh; gilbert	1974
JWMAA	39--1	67	79	abie	bals	odvi, feed analy & di	robbins,ct; van /	1975
JWMAA	40--4	630	638	abie	bals	odvi, diges & nut dat	mautz,ww; silver/	1976
NFGJA	14--1	76	78	abie	bals	od, mineral cont brow	bailey,ja	1967
PLSOA	45--1	17	26	abie	bals	essen nutr eleme firs	langille,wm; macl	1976
WUAPA	14---	1	27	abie	bals	mineral cont of plant	gerloff,gc; moor/	1964
*****					****			
JWMAA	25--2	209	210	abie	conc	qual winte food blu-g	hoffman,rs	1961
JWMAA	36--2	595	605	abie	conc	odhe, forest manip on	lawrence,g; biswe	1972
*****					****			
ECOLA	34--4	786	793	abie	gran	nutr cont leaf litter	daubenmire,r	1953
*****					****			
CJBOA	51--2	421	427	abie	lasi	trace eleme cont soil	doyle,j; fletche/	1973
CNRDA	28--5	249	271	abie	lasi	alal, forest succ & f	cowan,imct; hoar/	1950
ECOLA	34--4	786	793	abie	lasi	nutr cont leaf litter	daubenmire,r	1953
*****					****			
JFUSA	49...	914	915	abie	----	littr fall & foli nut	tarrant,rf; issa/	1951

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
TAEBA	461--	1	63	abut	inca	comp, util of rang ve	fraps,gs; cory,vl	1940
*****					****			
CRPSA	15--6	821	827	abut	theo	forag nutr & palat of	marten,gc; anders	1975
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
TAEBA	461--	1	63	acac	angu	comp, util of rang ve	fraps,gs; cory,vl	1940
					****			
ECOLA	49--5	956	961	acac	farn	cal valu seeds, ne ka	johson,sr; robel,	1968
					****			
JRMGA	30--3	206	209	acac	greg	odhe, food habi grass	short,hl	1977
					****			
TAEBA	461--	1	63	acac	roem	comp, util of rang ve	fraps,gs; cory,vl	1940
*****					****			
JWMAA	35--3	469	475	acac	----	odhe, odvi, nutr inta	urness,pj; neff,/	1971

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
TAEBA	461--	1	63	acal	grac	comp, util of rang ve	fraps,gs; cory,vl	1940

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
AZOFA	8---3	385	389	acer	circ	odhe, plan characte &	radwan,ma; crouch	1974
NAWTA	11---	309	312	acer	circ	crud prot deter & man	einarsen,a	1946
*****					****			
CNRDA	28--5	249	271	acer	glau	alal, forest succ & f	cowan,imct; hoar/	1950
ECOLA	57--2	367	373	acer	glau	seaso & diurnal water	cline,rg; campbel	1976
WAEBA	184-9	1	21	acer	glau	forag plan & chem com	mccreary,oc	1931
*****					****			
JFUSA	49...	914	915	acer	macr	foliag nutr cont, ltt	tarrant,rf; issa/	1951
*****					****			
JWMAA	39--2	337	341	acer	negu	odvi, brow comp & dig	robbins,ct; moen,	1975
JWMAA	40--2	283	289	acer	negu	nutr qual of diges of	short,hl; epps,ea	1976
WUAPA	14---	1	14	acer	negu	mineral cont of plant	gerloff,gc; moor/	1964
*****					****			
CJZOA	52-10	1201	1205	acer	pens	odvi, forag nut value	mautz,ww; silver/	1974
JWMAA	40--4	630	638	acer	pens	odvi, diges & nut dat	mautz,ww; silver/	1976
NFGJA	14--1	76	78	acer	pens	odvi, mineral cont br	bailey,ja	1967
PLSOA	45--1	17	26	acer	pens	essen nutr elem fores	langille,wm; macl	1976
*****					****			
ECOLA	34--4	786	793	acer	pseu	nutr cont leaf litter	vanden driessche,	1974
NCANA	101--	291	305	acer	pseu	alal, brows miner com	kubota,j	1974
*****					****			
CJFRA	5---4	655	661	acer	rubr	litter fall after fir	grigal,df; mccoll	1975

acer rubr cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CJZOA	52-10	1201	1205	acer	rubr	odvi, forag nutr valu	mautz,ww; silver/	1974
JWMAA	4---3	315	325	acer	rubr	od, mon var food nutr	hellmers,h	1940
JWMAA	19--1	65	70	acer	rubr	chan brows nutr value	dewitt,jb; derby,	1955
JWMAA	20--4	359	367	acer	rubr	herb brows chem compo	smith,fk; beeson/	1956
JWMAA	23--1	81	90	acer	rubr	od, avail nutri brows	hundley,lr	1959
JWMAA	25--1	77	81	acer	rubr	od, slash winter brow	alkon,pu	1961
JWMAA	35--2	221	231	acer	rubr	cellulos diges & comp	torgerson,o; pfan	1971
JWMAA	36--1	174	177	acer	rubr	odvi, wint forag qual	segelquist,ca; /	1972
JWMAA	38--1	20	31	acer	rubr	odvi, in vitro digest	snider,cc; asphun	1974
JWMAA	38--3	517	524	acer	rubr	odvi, brows nutr cont	abell,dh; gilbert	1974
JWMAA	39--1	67	79	acer	rubr	odvi, feed anal & dig	robbins,ct; vans/	1975
JWMAA	39--2	337	341	acer	rubr	odvi, brow comp & dig	robbins,ct; moen,	1975
JWMAA	40--4	630	638	acer	rubr	odvi, diges & nut dat	mautz,ww; silver/	1976
JWMAA	41--1	144	147	acer	rubr	leam, wint brows nutr	walski,tw; mautz,	1977
NFGJA	14--1	76	78	acer	rubr	od, mineral cont brow	bailey,ja	1967
PCGFA	28---	574	580	acer	rubr	odvi, qual deer forag	towry,rkjr; mich/	1974
PLSOA	45--1	17	26	acer	rubr	essen nutr elem fores	langille,wm; macl	1976
SOSCA	43---	349	355	acer	rubr	comp forest tree litt	coile,ts	1937
WUAPA	14---	1	14	acer	rubr	mineral cont of plant	gerloff,gc; moor/	1964
*****					****			
JWMAA	12--1	1	8	acer	sacc	a nutr knowled shortc	atwood,el	1948
*****					****			
BOGAA	94---	381	391	acer	sach	mineral & nitrog cont	mchargue,js; roy,	1932
JACSA	39--1	1286	1296	acer	sach	plant food mater, lea	serex,pjr	1917
JWMAA	12--1	1	8	acer	sach	a nutr knowled shortc	atwood,el	1948
JWMAA	14--1	76	78	acer	sach	od, mineral cont brow	bailey,ja	1967
JWMAA	25--1	77	81	acer	sach	od, slash winter brow	alkon,pu	1961
JWMAA	35--2	221	231	acer	sach	cellulos diges & comp	torgerson,o; pfan	1971
JWMAA	38--1	20	31	acer	sach	odvi, in vitro digest	snider,cc; asplun	1974
JWMAA	38--3	517	524	acer	sach	odvi, brows nutr cont	abell,dh; gilbert	1974
JWMAA	39--2	337	341	acer	sach	odvi, brow comp & dig	robbins,ct; moen,	1975
JWMAA	40--2	283	289	acer	sach	nutr qual of diges of	short,hl; epps,ea	1976
PLSOA	45--1	17	26	acer	sach	essen nutr elem fores	langille,wm; macl	1976
WUAPA	14---	1	14	acer	sach	mineral cont of plant	gerloff,gc; moor/	1964
*****					****			
CJZOA	52-10	1201	1205	acer	spic	odvi, forag nut value	mautz,ww; silver/	1974
FOSCA	22--2	195	208	acer	spic	seas dynam tall shrub	grigal,df; ohman/	1976

acer spic cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	39--1	67	79	acer	spic	odvi, feed anal & dig	robbins,ct; vans/	1975
JWMAA	40--4	630	638	acer	spic	odvi, diges & nut dat	mautz,ww; silver/	1976
PMSCA	31--1	73	78	acer	spic	dogwood & mt maple as	fashingbauer,ba;/	1963

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--1	63	65	achi	lanu	effect 2,4-d on diges	thilenius,jf; bro	1976
*****					****			
CJBOA	51-11	2037	2046	achi	mill	miner comp grassla sp	harner,rf; harper	1973
JRMGA	28--5	419	421	achi	mill	odvi, in vitro consta	uresk,dw; diets,/	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CAFGA	41--1	57	78	aden	fasc	natura & art food dig	bissell,hd; harr/	1955
CAFGA	41--2	145	155	aden	fasc	crude prot var browse	bissell,hd; stron	1955
JANSA	16--2	476	480	aden	fasc	diges of interior oak	bissell,hd; weir,	1957
JWMAA	7---1	119	122	aden	fasc	chaparral crown sprou	reynolds,hg; samp	1943

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
BOGAA	94---	381	391	aesc	cali	mineral & nitrog cont	mchargue,js; roy,	1932
JAGRA	62-10	627	636	aesc	cali	chem comp forest frui	wainio,ww	1941
*****					****			
ECOLA	34--4	786	793	aesc	hipp	nutr cont leaf litter	vanden driessche,	1974
NCANA	101--	291	305	aesc	hipp	alal, brow miner comp	kubota,j	1974
*****					****			
JWMAA	40--2	283	289	aesc	pavi	nutr qual of diges of	short,hl; epps,ea	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
MGLHA	65--4	476	478	agar	arve	se, hg cont edib mush	stijve,t; cardina	1974
*****					****			

agar spp. cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
MGLHA	65--4	476	478	agar	bisp	se, hg cont edib mush	stijve,t; cardina	1974
*****					****			
JAFCA	23--3	464	467	agar	camp	aa comp morel mushroo	mckellar,rl; kohr	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	20--3	179	180	agos	glau	gross ener alpin plan	smith,dr	1967
JRMGA	29--1	63	65	agos	glau	effect 2,4-d on diges	thilenius,jf; bro	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JAPEA	11--2	489	497	agro	smit	comp rang plan & soil	hamilton,jw; gilb	1972
JRMGA	30--2	122	127	agro	smit	odhe, odvi, hab evalu	wallmo,oc; carpe/	1977
JWMAA	35--4	681	688	agro	smit	ceel, in vitro digest	ward,al	1971
*****					****			
CJBOA	55-11	2037	2046	agro	spic	miner comp grassla sp	harner,rf; harper	1973
JRMGA	30--2	122	127	agro	spic	odhe, odvi, hab evalu	wallmo,oc; carpe/	1977
JWMAA	35--4	681	688	agro	spic	ceel, in vitro digest	ward,al	1971
*****					****			
ECOLA	43--4	753	757	agro	trac	caloric & lipid conte	bliss,lc	1962
*****					****			
JRMGA	29--1	63	65	agro	trah	effect 2,4-d on diges	thilenius,jf; bro	1976
*****					****			
JWMAA	39--4	670	673	agro	----	odhe, nutr cont diets	urness,pj; neff,/	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ECOLA	43--4	753	757	agrs	bore	caloric & lipid conte	bliss,lc	1962
*****					****			
JRMGA	29--1	63	65	agrs	idah	effect 2,4-d on diges	thilenius,jf; bro	1976
*****					****			
NATUA	263--	763	763	agrs	----	ceel, ov, intak & dig	milne,ja; macrai/	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
PCGFA	21---	34	104	albi	juli	od, food nutr analysi	thorsland,oa	1966
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
AZOFA	8---3	385	389	alec	juba	rata, lichen nut valu	pulliaihen,e	1971
JWMAA	36--3	913	923	alec	juba	rata, food habit of n	bergerud,at	1972
*****					****			
AZOFA	8---3	385	389	alec	sarm	rata, lichen nut valu	pulliainen,e	1971
*****					****			
CJBOA	51--2	421	427	alec	----	trace eleme cont soil	doyle,p; fletche/	1973

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JAPEA	11--2	489	497	alli	text	bibi, tropic ecology	peden,dg; vandyn/	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
FOSCA	22--2	195	208	alnu	cris	seas dynmic tall shru	grigal,df; ohman/	1976
JWMAA	36--3	913	923	alnu	cris	rata, food habit of n	bergerud,at	1972
NCANA	101--	291	305	alnu	cris	alal, brows mind comp	kubota,j	1974
*****					****			
PLSOA	45--1	17	26	alnu	crmo	esstial nut elem fore	langille,wm; macl	1976
*****					****			
ELPLB	23--4	637	648	alnu	glut	method stud for ecolo	stachurski,a; zim	1975
JWMAA	38--4	875	879	alnu	glut	leti, nutr cont & foo	lindlof,b; linds/	1974
*****					****			
ABSZA	29--4	1	196	alnu	inca	trace eleme in plants	lounamaa,j	1956
JWMAA	14--1	76	78	alnu	inca	od, mineral cont brow	bailey,ja	1967
*****					****			
AZOFA	8---3	385	389	alnu	rubr	odhe, plant charact &	radwan,ma; crouch	1974
JAPEA	13--1	295	301	alnu	rubr	nutr dist, cyclin alp	turner,j; singer,	1976
NAWTA	11---	309	312	alnu	rubr	crud prot deter & man	einarsen,a	1946
*****					****			
PLSOA	45--1	17	26	alnu	rugo	essen nutr elem fores	langille,wm; macd	1976
WUAPA	14---	1	14	alnu	rugo	mineral cont of plant	gerloff,gc; moor/	1964
*****					****			
ECOLA	57--2	367	373	alnu	sinu	season & diurnal wate	cline,rg; campbel	1976
*****					****			
CNRDA	28--5	249	271	alnu	sito	alal, for succ & food	cowan,imct; hoar/	1950
*****					****			
JWMAA	10--1	12	17	alnu	----	nutr cont winter food	treichler,rr; st/	1946
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--5	356	363	amar	palm	maj plan toxic in wes	james,lf; johnson	1976
JRMGA	30--3	227	230	amar	palm	yield & chemi comp of	gonzalez,cl; heil	1977
*****					****			
CRPSA	15--6	821	867	amar	retr	forag nutr & palat of	marten,gc; anders	1975
JANSA	44--3	389	394	amar	retr	prox miner & aa compo	harrold,rl; nalew	1977
JRMGA	29--5	356	363	amar	retr	maj plan toxic in wes	james,lf; johnson	1976
NDFRA	32--1	15	17	amar	retr	prox & aa analy ergot	harrold,rl; nalew	1974
*****					****			
XARRA	304--	1	6	amar	----	odhe, nutr val forage	urness,pj; neff,/	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CRPSA	15--6	821	827	ambr	arte	forag nutr & palat of	marten,gc; anders	1975
*****					****			
JWMAA	40--2	283	289	ambr	psil	nutr qual of diges of	short,hl; epps,ea	1976
*****					****			
CRPSA	15--6	821	827	ambr	trif	forag nutr & palat of	marten,gc; anders	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CAFGA	39--2	163	175	amel	alni	nutr valu forage plan	hagen,hl	1953
CAFGA	41--2	145	155	amel	alni	crude prot var browse	bissell,hd; stron	1955
CNAPA	769--	1	60	amel	alni	chem comp nativ plant	clarke,se; tisdal	1945
JRMGA	30--2	122	127	amel	alni	odhe, odvi, hab evalu	wallmo,oc; carpe/	1977
JWMAA	35--4	681	688	amel	alni	ceel, in vitro digest	ward,al	1971
PSAFA	1958-	117	122	amel	alni	seas progr chem conte	dietz,dr; udall,/	1958
UAXBA	305--	1	22	amel	alni	comp summer ran plant	stoddart,la; grea	1942
UAXBA	342--	1	66	amel	alni	dosh, nutri cont diet	cook,cw; harris,	1950
WAEBA	184-9	1	21	amel	alni	forag plan & chem com	mccreary,oc	1931
*****					****			
TNWSD	1975-	67	76	amel	arbo	selec, qual & in vitr	whelan,jb; harlo/	1971
*****					****			
JWMAA	36--3	913	923	amel	bart	rata, food habit of n	bergerud,at	1972
*****					****			
JAGRA	62-10	627	636	amel	cana	chem comp fores fruit	wainio,ww	1941

amel cana cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	10--1	12	17	amel	cana	nutr cont winter food	treichler,rr; st/	1946
JWMAA	36--1	174	177	amel	cana	odvi, wint forag qual	selelquist,ca; /	1972
*****					****			
CNRDA	28--5	249	271	amel	flor	alal, for succ & food	cowan,imct; hoar/	1950
*****					****			
JWMAA	15--4	352	357	amel	spic	od, comp plant eat by	gastler gf: moxo/	1951
*****					****			
JWMAA	39--4	670	673	amel	utah	odhe, nutr cont diets	urness,pj; neff,/	1975
XARRA	304--	1	6	amel	utah	odhe, nut valu forage	urness,pj; neff,/	1975
*****					****			
FOSCA	22--2	195	208	amel	----	seas dynam tall shrub	grigal,df; ohman/	1976
PLSOA	45--1	17	26	amel	----	essen nutr elem fores	langille,wm; macl	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
WUAPA	14---	1	14	amor	cane	mineral cont of plant	gerloff,gc; moor/	1964

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JANSA	36--4	792	796	ampe	arbo	est digest brow tissu	short,hl; blair,/	1973
JWMAA	38--2	197	209	ampe	arbo	fiber com & forag dig	short,hl; blair,/	1974
XFPSA	111--	1	10	ampe	arbo	od, comp & diges brow	short,hl: blair,/	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JANSA	41--2	601	609	anac	cana	nutr valu aquat plant	linn,jg: staba,e/	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
WUAPA	14---	1	14	andm	glau	mineral cont of plant	gerloff,gc; moor/	1964

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	26--6	423	426	andp	dive	pine overs, herb qual	wolters,gl	1973

andp dive cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	40--2	283	289	andp	dive	nutr qual of diges of	short,hl; epps,ea	1976
*****					****			
JRMGA	26--6	423	426	andp	elli	pine overs, herb qual	wolters,gl	1973
*****					****			
JRMGA	26--6	423	426	andp	gera	pine overs, herb qual	wolters,gl	1973
*****					****			
JRMGA	26--6	423	426	andp	subt	pine overs, herb qual	wolters,gl	1973
*****					****			
JRMGA	26--6	423	426	andp	tene	pine overs, herb qual	wolters,gl	1973
*****					****			
JRMGA	26--6	423	426	andp	tern	pine overs, herb qual	wolters,gl	1973
*****					****			
ECOLA	42--3	581	584	andp	virg	ener valu ecol matter	golley,fb	1961
JRMGA	26--6	423	426	andp	virg	pine overs, herb qual	wolters,gl	1973
*****					****			
JANSA	41--1	208	212	andp	----	seas trend nut & dige	lewis,ce; lowrey/	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	38--1	20	31	ante	plan	odvi, in vitro digest	snider,cc; asplun	1974
JWMAA	38--2	197	209	ante	plan	fiber com & forag dig	short,hl; blair,/	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--4	344	345	arab	drum	cal cont subalpin pla	anderson,dc; armi	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	38--3	517	524	aral	nudi	odvi, nut cont browse	abell,dh; gilbert	1974
WUAPA	14---	1	14	aral	nudi	mineral cont of plant	gerloff,gc; moor/	1964
*****					****			
WUAPA	14---	1	14	aral	race	mineral cont of plant	gerloff,gc; moor/	1964

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ATICA	25--1	21	27	arcg	lati	chem comp forag plant	scotter,gw	1972
CPLSA	53--2	263	268	arcg	lati	rata, mineral content	scotter,gw; milt,	1973
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ECOLA	43--4	753	757	arcs	alpi	caloric & lipid conte	bliss,lc	1962
*****					****			
CAFGA	41--2	145	155	arcs	glan	crude prot var browse	bissell,hd; stron	1955
*****					****			
CAFGA	41--2	145	155	arcs	patu	crude prot var browse	bissell,hd; stron	1955
*****					****			
NAWTA	21---	141	158	arcs	pung	prot, phosphorous con	swank,wg	1956
*****					****			
CAFGA	41--2	145	155	arcs	stan	crude prot var browse	bissell,hd; stron	1955
*****					****			
ABSZA	29--4	1	196	arcs	uvur	trace elemen in plant	lounamaa,j	1956
CPLSA	45--3	246	250	arcs	uvur	chem comp forag liche	scotter,gw	1965
JRMGA	28--5	419	421	arcs	uvur	odvi, in vitro consta	uresk,dw; diets,/	1975
JWMAA	15--4	352	357	arcs	uvur	od, comp plants eaten	gastler,gf; moxo/	1951
*****					****			
CAFGA	41--2	145	155	arcs	visc	crude prot var browse	bissell,hd; stron	1955
JWMAA	36--2	595	605	arcs	visc	odhe, forest manip on	lawrence,g; biswe	1972
*****					****			
CAFGA	39--2	163	175	arcs	----	nutr valu forag plant	hagen,hl	1953
CAFGA	41--2	145	155	arcs	----	crude prot var browse	bissell,hd; stron	1955

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
AAAHA	13-63	404	410	arct	cale	nutr valu temp pastur	mcivor,jg; smith,	1973

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ECOLA	43--4	753	757	aren	groe	caloric & lipid conte	bliss,lc	1962

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JAPEA	11--2	489	497	aris	long	bibi, tropic ecolo of	peden,dg; vandyn/	1974
*****					****			
JANSA	41--1	208	212	aris	stri	seas trend nut & dige	lewis,ce; lowrey/	1975
*****					****			
JWMAA	35--3	469	475	aris	----	odhe, odvi, nut intak	urness,pj; green/	1971
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--1	63	65	arni	fulg	effect 2,4-d digestib	thilenius,jf; bro	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JAGRA	62-10	627	636	aron	arbu	chem comp fores fruit	wainio,ww	1941
*****					****			
JAGRA	62-10	627	636	aron	mela	chem comp fores fruit	wainio,ww	1941

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
WAEBA	157-8	1	18	arte	arbu	forag plan & chem com	mccreary,oc	1927
*****					****			
CJBOA	55-11	2037	2046	arte	arno	comp rang plan & soil	harner,rf; harper	1973
*****					****			
ECMOA	35--3	259	284	arte	arct	od, ecol rang in alas	klein,dr	1965
*****					****			
CAFGA	41--2	145	155	arte	cali	crude prot var browse	bissell,hd; stron	1955
*****					****			
ABSZA	29--4	1	196	arte	camp	trace elemen in plant	luonamaa,j	1956
*****					****			
CNAPA	769--	1	60	arte	cana	chem comp nativ plant	clarke,se; tisdal	1945
NEXAA	246--	1	75	arte	cana	ca, p cont ran forage	watkins,we	1937
*****					****			
NEXAA	246--	1	75	arte	fili	ca, p cont ran forage	watkins,we	1937
NEXAA	311--	1	43	arte	fili	comp rang grass brows	watkins,we	1943
*****					****			
CNAPA	769--	1	60	arte	frig	chem comp nativ plant	clarke,se; tisdal	1945
JAPEA	11--2	489	497	arte	frig	bibi, tropic ecolo of	peden,dg; vandyn/	1974
JRMGA	26--1	385	388B	arte	frig	ovca, chem com winter	demarchi,ra	1968
NEXAA	246--	1	75	arte	frig	ca, p cont ran forage	watkins,we	1937
WAEBA	157-8	1	18	arte	frig	forag plan & chem com	mccreary,oc	1927
WAEBA	184-9	1	27	arte	frig	forag plan & chem com	mccreary,oc	1931
*****					****			
CPLSA	42--1	105	115	arte	gnap	chem comp rang forage	johnston,a; bezea	1962
CPLSA	42--4	692	697	arte	gnap	in vitro digest range	bezeau,lm; johnst	1962
CPLSA	46--6	625	631	arte	gnap	silic, prot cont prai	bezeau,lm; johns/	1966
NUABA	197--	1	38	arte	gnap	phenol vs compo plant	robertson,hj; tor	1958
*****					****			

arte spp. cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CJBOA	51-11	2037	2046	arte	ludo	comp rang plan & soil	harner,rj; harper	1973
JRMGA	30--2	119	121	arte	ludo	odhe, digestib forage	urness,pj; smith/	1977
*****					****			
AGJOA	51--4	226	234	arte	nova	symposium forage eval	harris,le; cook,/	1959
ECOLA	40--4	644	651	arte	nova	chem cont salt-desser	cook,cw; stoddar/	1959
NUABA	197--	1	38	arte	nova	phenol vs compo plant	robertson,hj; tor	1958
UAXBA	227--	1	46	arte	nova	utah's winter range	esplin,ac; greav/	1937
UAXBA	372--	1	56	arte	nova	nutr valu winter rang	cook,cw; stoddar/	1954
UAXBA	472--	1	55	arte	nova	nutr valu seas ranges	cook,cw; harris,l	1968
WAEBA	157-8	1	18	arte	nova	forag plan & chem com	mccreary,oc	1927
*****					****			
WAEBA	157-8	1	18	arte	peda	forag plan & chem com	mccreary,oc	1927
*****					****			
NASRA	1684-	1	92	arte	spin	table of feed composi	nrcp,canada	1969
UAXBA	227--	1	46	arte	spin	utah's winter range	esplin,ac; grear/	1937
UAXBA	372--	1	56	arte	spin	nutr val winter range	cook,cw; stoddar/	1954
UAXBA	472--	1	55	arte	spin	nutr valu seas ranges	cook,cw; harris,l	1968
WAEBA	157-8	1	18	arte	spin	forag plan & chem com	mccreary,oc	1927
WAEBA	184-9	1	21	arte	spin	forag plan & chem com	mccreary,oc	1931
*****					****			
AGJOA	51--4	226	234	arte	trid	symposium forag evalu	harris,le; cook,/	1959
CAFGA	41--1	57	78	arte	trid	natur & art food dige	bissell,hd; harr/	1955
CAFGA	41--2	145	155	arte	trid	crude prot var browse	bissell,hd; stron	1955
ECOLA	47--2	222	229	arte	trid	od, selec nutr browse	short,hl; dietz,/	1966
JANSA	11--3	578	590	arte	trid	digest & metab energy	cook,cw; stoddar/	1952
JRMGA	6---1	51	54	arte	trid	graz inten & nutr val	cook,cw; stoddar/	1953
JRMGA	9---3	142	145	arte	trid	apparent digest ligni	smith,ad; turner/	1956
JRMGA	10--4	162	164	arte	trid	nutr winter brows pla	smith,ad	1957
JRMGA	30--2	119	121	arte	trid	odhe, digest deer for	urness,pj; smith/	1977
JRMGA	30--2	122	127	arte	trid	odhe, odvi, hab evalu	wallmo,oc; carpe/	1977
JWMAA	14--3	285	289	arte	trid	sagebrush winter feed	smith,ad	1950
JWMAA	35--4	681	688	arte	trid	ceel, in vitro digest	ward,al	1971
NASRA	1684-	1	92	arte	trid	table of feed composi	nrcp,canada	1969
NEXAA	246--	1	75	arte	trid	ca, p cont rang forag	watkins,we	1937

arte trid cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
NUABA	197--	1	38	arte	trid	phenol vs compo plant	robertson,jh; tor	1958
PSAFA	1958-	117	122	arte	trid	seas progr chem conte	dietz,dr; udall,/	1958
UAXBA	227--	1	46	arte	trid	utah's winter range	epslin,ac; greav/	1937
UAXBA	372--	1	56	arte	trid	nutr val winter range	cook,cw; stoddar/	1954
UAXBA	472--	1	55	arte	trid	nutr valu seas ranges	cook,cw; harris,l	1968
WAEBA	157-8	1	18	arte	trid	forag plan & chem com	mccreary,oc	1927
WAEBA	184-9	1	21	arte	trid	forag plan & chem com	mccreary,oc	1931
XATBA	943--	1	61	arte	trid	nutr qual rang forage	savage,da; heller	1947
XFINA	221--	1	6	arte	trid	odhe, high-energ food	welch,bl; andrus,	1977
*****					****			
JRMGA	5	346	353	arte	trip	var chem comp rang pl	blaisdell,jp; wi/	1952
*****					****			
TAEBA	461--	1	63	arte	vulg	comp,util of rang veg	fraps,gs; cory,vl	1940
*****					****			
JANSA	11	578	590	arte	----	digstb & meta engy by	cook,cw; stoddar/	1952
JANSA	26	1169	1174	arte	----	botan nutr cont diets	cook,cw; stoddar/	1967

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CJBOA	51-11	2037	2046	aste	chil	minrl comp graslnd sp	harner,rf; harper	1973
*****					****			
XARRA	304--	1	6	aste	comm	odhe, nutr valu forag	urness,pj; neff,/	1975
*****					****			
JRMGA	29--1	63	65	aste	foli	effct 2,4-D on digstb	thilenius,jf; bro	1976
*****					****			
JWMAA	38--1	20	31	aste	pilo	odvi, in vitro digstb	snider,cc; asplun	1974
*****					****			
JAPEA	11--2	489	497	aste	tena	bibi,tropic ecolgy of	peden,dg; vandyn/	1974
*****					****			
CJBOA	51-11	2037	2046	aste	----	minrl comp graslnd sp	harner,rf; harper	1973
JWMAA	39--4	670	673	aste	----	odhe, nutr cont diets	urness,pj; neff,/	1975
XARRA	304--	1	6	aste	----	odhe, nutr valu forag	urness,pj; neff,/	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--5	356	362	astr	bisu	maj plnt toxicty w us	james,lf; johnson	1976
*****					****			
				astr	spp.	cont on the next page		

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--6	356	362	astr	emor	maj plnt toxicty w us	james,lf; johnson	1976
*****					****			
JRMGA	29--6	356	362	astr	mise	maj plnt toxicty w us	james,lj; johnson	1976
*****					****			
JRMGA	29--6	356	362	astr	patt	maj plnt toxicty w us	james,lj; johnson	1976
*****					****			
XARRA	304--	1	6	astr	recu	odhe, nutr valu forag	urness,pj; neff,/	1975
XFRMA	158--	1	35	astr	recu	rang mgmt & ecol basi	clary,wp	1975
*****					****			
JRMGA	29--6	356	362	astr	tetr	maj plnt toxicty w us	james,lf; johnson	1976
*****					****			
JAPEA	11--2	489	497	astr	----	bibi,tropic ecolgy of	peden,dg; vandyn/	1974
JRMGA	29--6	356	362	astr	----	maj plnt toxicty w us	james,lf; johnson	1976
XARRA	304--	1	6	astr	----	odhe, nutr valu forag	urness,pj; neff,/	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
AZATA	113--	1	17	atri	cane	comp arizona forages	catlin,cn	1925
ECOLA	40--4	644	651	atri	cane	chem cont salt-desert	cook,cw; stoddar/	1959
NEXAA	133--	1	38	atri	cane	yucca,chamiza as supl	brown,ls	1922
NEXAA	246--	1	75	atri	cane	Ca P cont rang forage	watkins,we	1937
NEXAA	311--	1	43	atri	cane	comp rang gras browse	watkins,we	1943
NEXAA	561--	1	33	atri	cane	chem comp forag spp	nelson,ab; herbe/	1970
TAEBA	329--	1	59	atri	cane	engy-prod coef feedin	fraps,gs	1925
UAXBA	227--	1	46	atri	cane	utah's winter range	esplin,ac; greau/	1937
UAXBX	427--	1	55	atri	cane	nutr valu seas ranges	cook,cw; harris,l	1968
*****					****			
AGJOA	51--4	226	234	atri	conf	symposium forag evalu	harris,le; cook,/	1959
ECOLA	40--4	644	651	atri	conf	chem cont salt-desert	cook,cw; stoddar/	1959
JANSA	11--3	578	590	atri	conf	digstb & meta engy by	cook,cw; stoddar/	1952
JRMGA	6---1	51	54	atri	conf	graz intns & nutr val	cook,cw; stoddar/	1953
NASRA	1684	1	92	atri	conf	table of feed compost	nrcp, canda	1969
NEXAA	246--	1	75	atri	conf	Ca, P cont rang forag	watkins,we	1937
NUABA	197--	1	38	atri	conf	phenol vs comp plnt &	robertson,jh; tor	1958

atri conf cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
UAXBA	227--	1	46	atri	conf	utah's winter range	esplin,ac; greav/	1937
UAXBA	472--	1	55	atri	conf	nutr valu seas ranges	cook,cw; harris,l	1968
WAEBA	76--3	1	109	atri	conf	wyoming forag plnt-#1	knight,hg; hepne/	1908
WAEBA	157-8	1	18	atri	conf	forag plnt & chem com	mccreary,oc	1927
WAEBA	184-9	1	21	atri	conf	forag plnt & chem com	mccreary,oc	1931
*****					****			
AZATA	113--	1	17	atri	coro	compo arizona forages	carlin,cn	1925
*****					****			
AZATA	113--	1	17	atri	eleg	compo arizona forages	catlin,cn	1925
*****					****			
WAEBA	65--1	1	53	atri	hali	wyoming forag plnt-#1	knight,ng; hepne/	1905
*****					****			
WAEBA	65--1	1	53	atri	holo	wyoming forag plnt-#1	knight,ng; hepne/	1905
*****					****			
AZATA	113--	1	17	atri	lent	comp arizona forages	catlin,cn	1925
NEXAA	246--	1	75	atri	lent	Ca, P cont rang forag	watkins,we	1937
*****					****			
AZATA	113--	1	17	atri	line	compo arizona forages	catlin,cn	1925
*****					****			
CNAPA	769--	1	60	atri	nutt	chem comp nativ plnts	clarke,se; tisdal	1945
JRMGA	29--5	356	363	atri	nutt	maj plnt toxicty w us	james,lf; johnson	1976
NASRA	1684-	1	92	atri	nutt	table of feed compost	nrcp, canada	1969
NUABA	197--	1	38	atri	nutt	phenol vs comp plnt &	robertson,jh tor	1958
UAXBA	227--	1	46	atri	nutt	utah's winter range	esplin,ac; greav/	1937
UAXBA	372--	1	56	atri	nutt	nutr valu wintr range	cook,cw; stoddar/	1954
UAXBA	472--	1	55	atri	nutt	nutr valu seas ranges	cook,cw; harris,l	1968
WAEBA	65--1	1	53	atri	nutt	wyoming forag plnt-#1	knight,hg; hepne/	1905
WAEBA	157-8	1	18	atri	nutt	forag plnt & chem com	mccreary,oc	1927
WAEBA	184-9	1	21	atri	nutt	forag plnt & chem com	mccreary,oc	1931
*****					****			
AZATA	113--	1	18	atri	poly	compo arizona forages	catlin,cn	1925
JRMGA	34--1	37	40	atri	poly	compo desert saltbush	chatterton,nj; g/	1970
*****					****			
WAEBA	157-8	1	19	atri	rose	forag plnt & chem com	mccreary,oc	1927
WAEBA	184-9	1	21	atri	rose	forag plnt & chem com	mccreary,oc	1931
*****					****			
AGNSA	46...	309	310	atri	semi	saltbush, minera comp	benjamin,ms	1935
AZATA	113--	1	18	atri	semi	compo arizona forages	catlin,cn	1925

atri semi cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
NEXAA	246--	1	75	atri	semi	ca, p cont rang forag	watkins,we	1937
WAEBA	65--1	1	53	atri	semi	wyoming forag plnt-#1	knight,hg; hepne/	1905
*****					****			
WAEBA	65--1	1	53	atri	volu	wyoming forag plnt-#1	knight,hg; hepne/	1905

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ECOLA	43--4	753	757	aula	turg	caloric & lipid conte	bliss,lc	1962

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JANSA	44--3	389	394	aven	fatu	prox, miner & aa comp	harrold,rl; nalew	1977
NDFRA	32--1	15	17	aven	fatu	prox & aa analy ergot	harrold,rl; nalew	1974
*****					****			
CRPSA	15--6	821	827	aven	sati	forag nutr & palat of	marten,gc; anders	1975
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JAPEA	11--2	489	497	bahi	oppo	bibi, tropic ecology	peden,dg; vandyn/	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CJBOA	51-11	2037	2046	bals	sagg	minrl comp graslnd sp	harner,rf; harper	1973

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JARRA	62-10	627	636	benz	aest	chem comp frst friuts	wainio,ww	1941

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JECOA	64--3	965	974	berb	nerv	red alder stand, nutr	turner,j; cole,d/	1976
*****					****			
JAGRA	69--1	33	46	berb	thun	chem comp wld feedstu	king,tr; mcclure,	1944
*****					****			
TAEBA	461--	1	63	berb	trif	comp, util of ran veg	fraps,gs; cory,vl	1940

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JANSA	36--4	792	796	berc	scan	est digstb brow tissu	short,hl; blair,/	1973
JFUSA	55--5	342	347	berc	scan	burnin & brows qualit	lay,dw	1957
JWMAA	33--4	1028	1031	berc	scan	ovrstry on brows qual	halls,lk; epps,ea	1969
JWMAA	38--2	197	209	berc	scan	fibr comp & forag dig	short,hl; blair,/	1974
PCGFA	10---	53	58	berc	scan	od, nutr in south pin	lay,dw	1956
XFPSA	111--	1	10	berc	scan	od, compos & dig brow	short,hl; blair,/	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	38--4	875	879	betu	alba	leti, nut cont & food	linklof,b; linds/	1974
ECOLA	34--4	786	793	betu	alle	nutr cont leaf litter	vandan driessche,	1974
*****					****			
ATICA	25--1	21	27	betu	glan	chem comp forag plnts	scotter,gw	1972

betu glan cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CJBOA	51--2	421	427	betu	glan	trace elemt cont soil	doyle,p; fletche/	1973
CNRDA	28--5	249	271	betu	glan	alal, frst succ on nu	cowan,imct; hoar/	1950
CPLSA	53--2	263	268	betu	glan	rata, mineral content	scotter,gw; milti	1973
NCANA	101--	291	305	betu	glan	alal, brows minrl com	kubota,j	1974
*****					****			
JWMAA	20--4	359	367	betu	lent	herb brows chem compo	smith,f; beeson,/	1956
*****					****			
BOREA	40--3	347	394	betu	lute	pred minrl nutr stats	vandan driessche,	1974
JWMAA	10--1	12	17	betu	lute	nutr cont winter food	treichler,r; sto/	1946
NFGJA	14--1	76	78	betu	lute	od, mineral cont brow	bailey,ja	1967
PLSOA	45--1	17	26	betu	lute	esstl nutr elemt frst	langille,wm; macl	1976
*****					****			
ECOLA	43--4	753	757	betu	mino	caloric & lipid conte	bliss,lc	1962
*****					****			
JWMAA	38--4	875	879	betu	nana	leti, nut cont & food	lindlof,b; linds/	1974
*****					****			
WUAPA	14---	1	27	betu	nigr	mineral cont of plant	gerloff,gc; moor/	1964
*****					****			
CJFRA	5---4	626	639	betu	papy	litter fall & cycling	van cleve,k; noon	1975
CJFRA	5---4	655	661	betu	papy	littr fall after fire	grigal,df; mccoll	1975
CNRDA	28--5	249	271	betu	papy	alal, for succ on nut	cowan,imct; hoar/	1950
JWMAA	15--4	352	357	betu	papy	odvi, comp plnt eaten	gastler,gf; moxo/	1951
JWMAA	25--1	77	81	betu	papy	odvi, slash, wint foo	alkon,pu	1961
JWMAA	34--3	565	569	betu	papy	herb brows minrl comp	kubota,j; reiger/	1970
JWMAA	37--3	279	287	betu	papy	alal, non-browse food	leresche,re; davi	1972
JWMAA	39--1	67	79	betu	papy	odvi, feed anal & dig	robbins,ct; moen,	1975
JWMAA	41--2	330	331	betu	papy	alal, volc & tree ash	franzmann,aw	1977
NCANA	101--	217	226	betu	papy	alal, nutr valu forag	oldmeyer,jl	1974
NCANA	101--	291	305	betu	papy	alal, brow minrl comp	kubota,j	1974
PLSOA	45--1	17	26	betu	papy	esstl nutr elemt frst	langille,wm; macl	1976
*****					****			
OIKSA	25--3	341	352	betu	pend	micrb decomp of littr	howard,pja; howar	1974
*****					****			
NCANA	101--	291	305	betu	popu	alal, brow minrl comp	kubota,j	1974
PLSOA	45--1	17	26	betu	popu	esstl nutr elemt frst	langille,wm; macl	1976
*****					****			
OIKSA	25--3	341	352	betu	pube	micrb decomp of littr	howard,pja; howar	1974
*****					****			

betu spp. cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	36--3	913	923	betu	pulm	rata, food habt of ne	bergerud,at	1972
*****					****			
JWMAA	36--3	913	923	betu	pumi	rata, food habt of ne	bergerud,at	1972
WUAPA	14---	1	27	betu	pumi	mineral cont of plant	gerloff,gc; moor/	1964
*****					****			
ABSZA	29--4	1	196	betu	verr	trace elemts in plnts	lounamaa,j	1956
BOREA	40--3	347	394	betu	verr	pred minrl nutr stats	vanden driessche,	1974
*****					****			
JWMAA	34--3	565	569	betu	----	herb brows minrl comp	kubota,j; reiger/	1970
NCANA	101--	291	305	betu	----	alal, brws minrl comp	kubota,j	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
TAEBA	461--	1	63	boer	tenu	comp, util of rng veg	fraps,gs; cory,vl	1940

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
MGLHA	65--4	476	478	bole	edul	se, hg cont edib mush	stijve,t; cardina	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JAPEA	11--2	489	497	bout	grac	bibi, tropc ecolog of	peden,dj; vandyn/	1974
JRMGA	30--2	122	127	bout	grac	odhe, odvi; hab evalu	wallmo,oc; carpe/	1977
JWMAA	39--4	670	673	bout	grac	odhe, nutr cont diets	urness,pj; neff,/	1975
XARRA	304--	1	6	bout	grac	odhe, nutr val forage	urness,pj; neff,/	1975
*****					****			
JWMAA	35--3	469	475	bout	----	odhe, odvi; nutr intk	urness,pj; green/	1971

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JANSA	41--1	185	197	brac	decu	in vitr digst peru fd	johnson,wl; pezo,	1975
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CRPSA	15--6	821	827	bras	kabe	forag nutr & palat of	marten,gc; anders	1975
JANSA	44--3	389	394	bras	kabe	prox, minrl & aa comp	harrold,rl; nalew	1977
NDFRA	32--1	15	17	bras	kabe	prox & aa analy ergot	harrold,rl; nalew	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CJBOA	51-11	2037	2046	brom	briz	minrl comp graslnd sp	harner,rj; harper	1973
*****					****			
AAAHA	13-63	404	410	brom	moll	nutr valu tempr pastu	mcivor,jg; smith,	1973
*****					****			
JRMGA	29--1	63	65	brom	pump	effct 2,4-D on digstb	thilenius,jf; bro	1976
*****					****			
AAAHA	13-63	404	410	brom	rigi	nutr valu tempr pastu	mcivor,jg; smith,	1973
*****					****			
CJBOA	51-11	2037	2046	brom	tect	minrl comp graslnd sp	harner,rj; harper	1973
JAPEA	11--2	489	497	brom	tect	bibi, trop ecology of	peden,dj; vandyn/	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	40--2	283	289	brun	cirr	nutr qual of digst of	short,hl; epps,ea	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JAPEA	11--2	489	497	buch	dact	bibi, trop ecology of	peden,dj; vandyn/	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
TAEBA	461--	1	63	bume	texa	comp, util of rng veg	fraps,gs; cory,vl	1940
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
NCANA	101--	291	305	cala	cana	alal, brws minrl comp	kubota,j	1974
*****					****			
ECOLA	43--4	753	757	cala	casc	caloric & lipid conte	bliss,lc	1962

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JANSA	36--4	792	796	calc	amer	digstb south brow tis	short,hl; blair,/	1973
JFUSA	55--5	342	347	calc	amer	burnng & brows qualit	lay,dw	1957
JRMGA	22--1	40	43	calc	amer	2 brow spp nutr analy	short,hl; harrell	1969
JWMAA	33--4	1028	1031	calc	amer	ovrstry on brows qual	halls,lk; epps,ea	1969
JWMAA	37--4	585	587	calc	amer	caloric & moistr cont	burns,ta; viers,e	1973
JWMAA	38--2	197	209	calc	amer	fibr comp & forag dig	short,hl; blair,/	1974
PCGFA	10---	53	58	calc	amer	od nutr in south pine	lay,dw	1956
XFPSA	51---	1	35	calc	amer	seas nutr dist in pln	blair,rm; epps,ea	1969
XFPSA	111--	1	10	calc	amer	od, comp & digs brows	short,hl; blair,/	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ECOLA	43--4	753	757	cale	stra	caloric & lipid conte	bliss,lc	1962

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	36--3	913	923	calg	schi	rata, food habt of ne	bergerud,at	1972

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	30--2	119	121	cali	erio	odhe, digst deer fora	urness,pj; smith/	1977
JRMGA	30--2	206	209	cali	erio	odhe, food hab grassl	short,hl	1977

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JANSA	41--2	601	609	call	palu	nutr valu aquat plnts	linn,jg; staba,e/	1975
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CJBOA	51--2	421	427	calm	cana	trace elemt cont soil	doyle,p; fletche/	1973

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--4	344	345	calt	lept	cal cont subalpn plnt	anderson,dc; armi	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ABSZA	29--4	1	196	calu	vulg	trace elemts in plnts	lounamaa,j	1956
JASIA	34...	151	155	calu	vulg	compos common heather	thomas,b	1974
JWMAA	38--4	875	879	calu	vulg	leti, nutr cont & foo	lindlof,b; linds/	1974
JWMAA	40--2	371	373	calu	vulg	ceel, rumen-cannulati	staines,bw	1976
NATUA	263--	763	763	calu	vulg	ceel, ov; intak & dig	milne,ja; macrae/	1976
PNUSA	28---	21A	22A	calu	vulg	ceel, heather digesta	staines,bw	1969

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CJBOA	51-11	2037	2046	came	micr	minrl comp graslnd sp	harner,rj; harper	1973

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ECOLA	43--4	753	757	camp	rotu	caloric & lipid conte	bliss,lc	1962

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JANSA	36--4	792	796	cams	radi	wildland shrubs	short,hj; blair,/	1973
JWMAA	38--2	197	209	cams	radi	digst south brow tiss	short,hl; blair,/	1974
PCGFA	21---	34	104	cams	radi	od food nutrit analys	thorsland,oa	1966
XFPSA	111--	1	10	cams	radi	od, digestabil browse	short,hl; blair,/	1975
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
MGLHA	65--4	476	478	cant	ciba	se, hg cont edibl mush	stijve,t; cardina	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	37--3	279	287	care	aqua	alal, imptnc non-brow	leresche,re; davi	1972
*****					****			
ECMOA	34--4	321	357	care	bige	engy relatn apln plnt	hadley,eb; buss,l	1964
ECOLA	43--4	753	757	care	bige	caloric & lipid conte	bliss,lc	1962
*****					****			
JRMGA	20	179	180	care	brev	gross engy alpn plnts	smith,dr	1967
*****					****			
ECOLA	43--4	753	757	care	cane	caloric & lipid cont	bliss,l	1962
*****					****			
JRMGA	20--3	179	180	care	eben	gross engy alpn plnts	smith,dr	1967
*****					****			
XFRMA	158--	1	35	care	geop	rang mgmt & ecol basi	clary,wp	1975
*****					****			
JAPEA	11--2	489	497	care	heli	bibi,tropic ecolgy of	peden,dg; vandyn/	1974
*****					****			
JANSA	41--2	601	609	care	lacu	nutr valu aquat plnts	linn,jg; staba,e/	1975
*****					****			
JWMAA	36--2	595	605	care	mult	odhe,forest manipu on	lawrence,g; biswe	1972
*****					****			
ECOLA	45--4	753	757	care	scir	caloric & lipid cont	bliss,lc	1962
*****					****			
JANSA	41--2	601	609	care	stri	nutr valu aquat plnts	linn,jg; staba,e/	1975
*****					****			
JRMGA	29--1	63	65	care	----	effct 2,4-d on digstb	thilenius,jf; bro	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	35--3	39	68	carn	giga	odhe,odvi, nutr intak	urness,pj; green/	1971

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ELPLB	23--4	637	648	carp	betu	methd study frst ecol	stachurski, ; zi	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
NASRA	1684-	1	92	cart	tinc	tabl of feed compostn	nrcp,canada	1969
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	37--4	585	587	cary	aqua	caloric & moistr cont	burns,ta; viers,c	1973
JWMAA	40--2	283	289	cary	aqua	nutr qual of digst of	short,hl; epps,ea	1976
*****					****			
JWMAA	40--2	283	289	cary	cord	nutr qual of digst of	short,hl; epps,ea	1976
*****					****			
JWMAA	37--4	585	587	cary	glab	caloric & moistr cont	burns,ta; viers,c	1973
*****					****			
JWMAA	34--1	176	182	cary	illi	mega, nutr wintr food	billingsley,bb; a	1970
JWMAA	37--4	585	587	cary	illi	caloric & moistr cont	burns,ta; viers,c	1973
*****					****			
JWMAA	37--4	585	587	cary	leid	caloric & moistr cont	burns,ta; viers,c	1973
*****					****			
JWMAA	12--1	1	8	cary	ovat	a nutr knwldg shrtcut	atwood,el	1948
JWMAA	37--4	585	587	cary	ovat	caloric & moistr cont	burns,ta; viers,c	1973
JWMAA	39--2	337	341	cary	ovat	odvi,brow comp & digs	robbins,ct; moen,	1975
WUAPA	14---	1	27	cary	ovat	mineral cont of plnts	geroff,gc; moor/	1964
*****					****			
JWMAA	37--4	585	587	cary	texa	caloric & moistr cont	burns,at; viers,c	1973
*****					****			
JWMAA	37--4	585	587	cary	tome	caloric & moistr cont	burns,at; viers,c	1973
JWMAA	40--2	283	289	cary	tome	nutr qual of digst of	short,ta; epps,ea	1976
*****					****			
TAEBA	461--	1	63	cary	----	comp,util texas fdstf	fraps,gs	1947

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JAGRA	69--1	33	46	casa	cham	chem comp wld feedstf	king,tr; mcclure	1944
*****					****			
JWMAA	40--2	283	289	casa	fasc	nutr qual of digst of	short,hl; epps,ea	1976
*****					****			
JWMAA	40--2	283	289	casa	mari	nutr qual of digst of	short,hl; epps,ea	1976
*****					****			
JAGRA	69--1	33	46	casa	nict	chem comp wld feedstf	king,tr; mcclure	1944
*****					****			
TAEBA	461--	1	63	casa	roem	comp,util of rang veg	fraps,gs; cory,vl	1940
*****					****			
TAEBA	461--	1	63	casa	----	comp,util texas fdstf	fraps,gs;	1947

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ECOLA	43--4	753	757	casi	hypn	caloric & lipid cont	bliss,lc	1962
*****					****			
CJBOA	51--2	421	427	casi	tetr	trace elemt cont soil	doyle,p; fletche/	1973
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JACSA	39--6	1286	1296	casn	dent	plnt food natrl in lf	serex,pjr	1917
*****					****			
JAGRA	62-10	627	636	casn	vulg	chem comp frst fruits	wainio,ww	1941

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
BOGAA	94---	381	393	cata	spec	mineral & nitrgn cont	mchargue,js; roy	1932

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	35--2	221	231	cean	amer	cellulos digst & comp	torgerson,o; pfan	1971
JWMAA	38--1	20	31	cean	amer	odvi, in vitro digstb	snider,cc; aspund	1974
WUAPA	14---	1	27	cean	amer	mineral cont of plnts	gerloff,gc; moor/	1964
*****					****			
CAFGA	39--2	162	175	cean	cord	nutr valu forage plnt	hagen,hl	1953
CAFGA	41--1	57	78	cean	cord	natul & art food digs	bissell,hd; stron	1955
*****					****			
CAEBA	627--	1	95	cean	cune	ca foothill plnt mgmt	gordon,a; sampson	1939
CAFGA	39--2	162	175	cean	cune	nutr valu forage plnt	hagen,hl	1953
CAFGA	41--1	57	78	cean	cune	natul & art food digs	bissell,hd; stron	1955
*****					****			
CAEBA	627--	1	95	cean	diva	ca foothill plnt mgmt	gordon,a; sampson	1939
*****					****			
TWMAA	39--4	670	673	cean	fend	odhe, nutr cont diets	urness,pj; neff,/	1975
XARRA	304--	1	6	cean	fend	odhe, nutr cont forag	urness,pj; neff,/	1975
XFRMA	158--	1	35	cean	fend	rang mgmt & ecol basi	clary,wp	1975
*****					****			
CAFGA	41--1	57	78	cean	foli	natul & art food digs	bissell,hd; stron	1955
*****					****			
JRMGA	30--2	119	121	cean	greg	odhe, digestib forage	urness,pj; smith/	1977
*****					****			
CAFGA	39--2	162	175	cean	inte	nutr valu forage plnt	hagen,hl	1953
CAFGA	41--1	57	78	cean	inte	natul & art food digs	bissell,hd; stron	1955
*****					****			
CAFGA	41--1	57	78	cean	leuc	natul & art food digs	bissell,hd; stron	1955
****					****			
JWMAA	36--2	595	605	cean	parv	odhe, forest manip on	lawrence,g; biswe	1972
****					****			

cean spp. cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CAFGA	39--2	162	175	cean	pros	nutr valu forage plnt	hagen,hl	1953
CAFGA	41--1	57	78	cean	pros	natul & art food digs	bissell,hd; stron	1955
*****					****			
CAFGA	39--2	162	175	cean	velu	nutr valu forage plnt	hagen,hl	1953
CAFGA	41--1	57	78	cean	velu	natul & art food digs	bissell,hd; stron	1955
JWMAA	15--4	352	357	cean	velu	od, comp plant eat by	gastler,gf; moxo/	1951
*****					****			
AZWBA	3----	34	47	cean	----	od, analyse ipt herds	swank,wg	1958
NAWTA	21---	141	158	cean	----	prot, phosphorus cont	swank,wg	1956

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	34--1	176	182	celt	laev	mega, nut winter food	billingsley,bb; a	1970
JWMAA	40--2	283	289	celt	laev	nutr qual of digst of	short,hl; epps,ea	1976
*****					****			
BOGAA	94---	381	393	celt	occi	mineral & nitrog cont	mchargue,js; roy,	1932
JAGRA	62-10	627	636	celt	occi	chem comp frst fruits	wainio,ww	1941
WUAPA	14---	1	27	celt	occi	mineral cont of plant	gerloff,gc; moor/	1964
*****					****			
JAGRA	69--1	33	46	celt	pall	chem comp wld feedstu	king,tr; mcclure,	1944
*****					****			
TAEBA	461--	1	63	celt	reti	comp, util of rang ve	fraps,gs; cory,vl	1940

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--1	63	65	cera	arve	effct 2,4-d on digstb	thilenius,jf; bro	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CAFGA	39--2	163	173	cerc	betu	nutr valu forage plnt	hagen,hl	1953
CAFGA	41--2	145	155	cerc	betu	crude prot var browse	bissell,hd; stron	1955
JFUSA	65-12	905	908	cerc	betu	od, use crown sprouts	reynolds,hg	1967
JWMAA	35--3	469	475	cerc	betu	odhe, odvi, nut intak	urness,pj; green/	1971
*****					****			
JWMAA	39--4	670	673	cerc	brev	odhe, nutr cont diets	urness,pj; neff,/	1975

cerc brev cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
XARRA	304--	1	6	cerc	brev	odhe, nut valu forage	urness,pj; neff,/	1975
*****					****			
CAFGA	41--2	145	155	cerc	ledi	crude prot var browse	bissell,hd; stron	1955
JRMGA	9---3	142	145	cerc	ledi	apparnt digstb lignin	smith,ad; turner/	1956
JRMGA	10--4	162	164	cerc	ledi	nutr wintr brows plnt	smith,ad	1957
JRMGA	30--2	119	121	cerc	ledi	odhe, digst of forage	urness,pj; smith/	1977
*****					****			
ECOLA	47--2	222	229	cerc	mont	od, selec nutr browse	short,hl; dietz,/	1966
JRMGA	9---3	142	145	cerc	mont	apparnt digstb lignin	smith,ad; turner/	1956
JRMGA	10--4	162	164	cerc	mont	nutr wintr brows plnt	smith,ad	1957
JRMGA	30--2	119	121	cerc	mont	odhe, digst deer fora	urness,pj; smith/	1977
JWMAA	16--3	309	312	cerc	mont	digstb nativ forag of	smith,ad	1952
NAWTA	21---	141	158	cerc	mont	prot, phosphorus cont	swank,wg	1956
PSAFA	1958-	117	122	cerc	mont	seas progr chem conte	dietz,dr; udall,/	1958

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	35--3	469	475	cerd	----	odhe, odvi, nutr inta	urness,pj; green/	1971

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JANSA	41--2	601	609	cerp	deme	nutr valu aquat plnts	linn,jg; staba,e/	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	40--2	283	289	cers	cana	nutr qual of digst of	short,hl; epps,ea	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ECOLA	43--4	753	757	cetr	cucu	caloric & lipid conte	bliss,lc	1962
ECOLA	43--4	753	757	cetr	isla	caloric & lipid conte	bliss,lc	1962
*****					****			

cetr spp. cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ATICA	25--1	21	27	cetr	niva	chem comp forag plnts	scotter,gw	1972
CPLSA	53--2	263	268	cetr	niva	rata, mineral content	scotter,gw; milti	1973
ECOLA	43--4	753	757	cetr	niva	caloric & lipid conte	bliss,lc	1962

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
PLSOA	45--1	17	26	chae	caly	esstl nutr elemt frst	langille,wm; macl	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CAFGA	39--2	163	175	cham	foli	nutr valu forage plnt	hagen,hl	1953

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	36--3	913	923	chan	caly	rata, food habit of n	bergerund,at	1972
WUAPA	14---	1	27	chan	caly	mineral cont of plnts	gerloff,gc; moor/	1964

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	25--3	342	342	chap	thyo	atlntic white-cedr as	gould,wp; brown,j	1961

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JANSA	41--2	601	609	char	vulg	nutr valu aquat plnts	linn,jg; staba,e/	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CRPSA	15--6	821	827	chen	albu	forag nutr & palat of	marten,gc; anders	1975
JANSA	44--3	389	394	chen	albu	proxm minrl & aa comp	harrold,rl; nalew	1977
JRMGA	29--5	356	363	chen	albu	maj plnt toxic in wus	james,lf; johnson	1976
NDFRA	32--1	15	17	chen	albu	prox & aa analy ergot	harrold,rl; nalew	1974
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	30--3	227	230	chlo	cucu	yield & chemi comp of	gonzalez,cl; heil	1977
*****					****			
JRMGA	30--3	227	230	chlo	gaya	yield & chemi comp of	gonzalez,cl; heil	1977

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	26--6	423	426	chrs	gram	pine overst, herb qua	wolters,gl	1973

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
WAEBA	184-9	1	21	chry	lanc	forag plnt & chem com	mccreary,oc	1931
*****					****			
ECOLA	47--2	222	229	chry	naus	od, selec nutr browse	short,hl; dietz,/	1966
JAPEA	11--2	489	497	chry	naus	bibi, tropic ecology	peden,dg; vandyn/	1974
JWMAA	35--4	681	688	chry	naus	ceel, in vitro digstb	ward,al	1971
NUABA	197--	1	38	chry	naus	phenol vs comp plnt &	robertson,jh; tor	1958
UAXBA	227--	1	46	chry	naus	utah's winter range	esplin,ac; greav/	1937
UAXBA	305--	1	22	chry	naus	comp summr rang plnts	stoddart,la; grea	1942
*****					****			
WAEBA	184-9	1	21	chry	pulc	forag plnt & chem com	mccreary,oc	1931
*****					****			
CAFGA	41--2	145	155	chry	tere	crude prot var browse	bissell,hd; stron	1955
*****					****			
NASRA	1684-	1	92	chry	sten	tabl of feed composit	nrcp,canada	1969
NUABA	197--	1	38	chry	sten	phenol vs comp plnt &	robertson,jh; tor	1958
UAXBA	372--	1	56	chry	sten	nutr valu wintr range	cook,cw; stoddar/	1954
UAXBA	472--	1	55	chry	sten	nutr valu seas ranges	cook,cw; harris,l	1968
*****					****			
CJBOA	51-11	2037	2046	chry	visc	minrl comp graslnd sp	harner,rf; harper	1973
JRMGA	30--2	122	127	chry	visc	odhe, odvi, hab evalu	wallmo,oc; carpe/	1977
NUABA	197--	1	38	chry	visc	phenol vs comp plnt &	robertson,jh; tor	1958
UAXBA	227--	1	46	chry	visc	utah's winter range	esplin,ac; greav/	1937
UAXBA	305--	1	22	chry	visc	comp summr rang plnts	stoddart,la; grea	1942
*****					****			
NEXAA	246--	1	75	chry	vise	ca, p cont ran forage	watkins,we	1937
*****					****			
ECOLA	40--4	644	651	chry	----	chem cont salt-dessrt	cook,cw; stoddar/	1959
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--5	356	363	cicu	----	maj plnt toxicity wus	james,lf; johnson	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--4	344	345	cirs	hook	cal cont cubalpn plnt	anderson,dc; armi	1976
*****					****			
JAPEA	11--2	489	497	cirs	undu	bibi, tropic ecolo of	peden,dg; vandyn/	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
XAMPA	369--	1	164	citr	limo	minrl comp crop & soi	beeson,kc	1941

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ATICA	25--1	21	27	clad	alpe	chem comp forag plnts	scotter,gw	1972
AZOFA	8---3	385	389	clad	alpe	rata, lichen nutr val	pulliainen,e	1971
BPURD	1----	251	256	clad	alpe	rata, in vitro digest	person,sj; white/	1975
CJBOA	51--2	421	427	clad	alpe	trace elemt cont soil	doyle,p; fletche/	1973
CJZOA	54--5	737	751	clad	alpe	rata, digs engy intak	mcewan,eh; white/	1976
ECOLA	43--4	753	757	clad	alpe	caloric & lipid conte	bliss,lc	1962
JWMAA	36--3	913	923	clad	alpe	rata, food habit of n	bergerud,at	1972
*****					****			
ECOLA	43--4	753	757	clad	grac	caloric & lipid conte	bliss,lc	1962
*****					****			
ATICA	25--1	21	27	clad	miti	chem comp forag plnts	scotter,gw	1972
CPLSA	53--2	263	268	clad	miti	rata, mineral content	scotter,gw; miltm	1973
ECOLA	43--4	753	757	clad	miti	caloric & lipid conte	bliss,lc	1962
JWMAA	36--3	913	923	clad	miti	rata, food habit of n	bergerund,at	1972
*****					****			
AZOFA	8---3	385	389	clad	rang	rata, lichen nut valu	pulliainen,e	1971
*****					****			
ATICA	25--1	21	27	clad	rani	chem comp forag plnts	scotter,gw	1972
CPLSA	53--2	263	268	clad	rani	rata, mineral content	scotter,gw; miltm	1973

clad rani cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ECOLA	43--4	753	757	clad	rani	caloric & lipid conte	bliss,lc	1962
JWMAA	36--3	913	923	clad	rani	rata, food habit of n	bergerund,at	1972
*****					****			
NCANA	101--	291	305	clad	----	alal, brow minr compo	kubota,j	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
BOGAA	94---	381	393	clar	lute	minrl & nitrogen cont	mchargue,js; ray,	1932

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
NDFRA	32--1	15	17	clav	purp	prox & aa analy ergot	harrold,rl; nalew	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
TAEBA	461--	1	63	clem	drum	comp, util of ran veg	fraps,gs; cory,vl	1940

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
PCGFA	21---	34	104	clet	alni	od, food nutr analyse	thorsland,oa	1966

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CAFGA	41--2	145	155	cole	ramo	crude prot var browse	bissell,hd; stron	1955

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--1	63	65	coll	line	effct 2,4-d on digstb	thilenius,jf; bro	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JAGRA	69--1	33	46	colu	texe	chem comp wld feedstu	king,tr; mcclure,	1944
TAEBA	461--	1	63	colu	texe	comp, util of ran veg	fraps,gs; cory,vl	1940
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CJBOA	51-11	2037	2046	coma	pall	minrl comp graslnd sp	harner,rf; harper	1973
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
PLSOA	45--1	17	26	comp	pere	esstl nutrelemt frst	langille,wm; macl	1926

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
TAEBA	461--	1	63	cond	obtu	comp util of rang veg	fraps,gs; cory,vl	1940
TAEBA	461--	1	63	cond	obtu	comp util texas fdstf	fraps,gs	1947

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CJBOA	51-11	2037	2046	conv	arve	minrl comp graslnd sp	harner,rf; harper	1973

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
NFGJA	14--1	76	78	corn	alte	od, minrl cont browse	bailey,ja	1967
*****					****			
JWMAA	36--3	913	923	corn	cana	tata, food habit of n	bergerud,at	1972
WUAPA	14---	1	27	corn	cana	mineral cont of plnts	gerloff,gc; moor/	1964
*****					****			
ECOLA	49--5	956	961	corn	drum	cal valu seeds, ne ka	johnson,sr; robel	1968
JWMAA	35--2	221	231	corn	drum	cellulos digst & comp	torgerson,o; pfan	1971
*****					****			
BOGAA	94---	381	393	corn	flor	minrl & nitrogen cont	mchargue,js; roy,	1932
JAGRA	62-10	627	636	corn	flor	chem comp frst fruits	wainio,ww	1941
JANSA	36--4	792	796	corn	flor	digstb south brow tis	short,hl; blair,/	1973
JFUSA	55--5	342	347	corn	flor	burnin & brows qualit	lay,dw	1957
JRMGA	9---3	142	145	corn	flor	apparnt digstb lignin	smith,ad; turner/	1956
JWMAA	19--1	65	70	corn	flor	chng brows nutr value	dewitt,jb; derby,	1955
JWMAA	23--1	81	90	corn	flor	od, avail nutr browse	hundley,lr	1959
JWMAA	33--4	1028	1031	corn	flor	ovrstry on brows qual	halls,lk; epps,ea	1969

corn flor cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	34--1	176	182	corn	flor	mega, nutr winter foo	bellingsley,bb; a	1970
JWMAA	36--1	174	177	corn	flor	odvi, wint forag qual	segelquist,ca; /	1972
JWMAA	37--4	585	587	corn	flor	caloric & moistr cont	burns,ta; viers,e	1973
JWMAA	38--2	197	209	corn	flor	fibr comp & forag dig	short,hl; blair,/	1974
PCGFA	10---	53	58	corn	flor	od, nutr in south pin	lay,dw	1956
PCGFA	28---	574	580	corn	flor	odvi, qual deer forag	towry,rk,jr; mic/	1974
SOSCA	43---	349	355	corn	flor	comp frst tree litter	coile,ts	1937
*****					****			
JWMAA	36--2	595	605	corn	nutt	odhe, forest manipula	lawrence,g; biswe	1972
*****					****			
JWMAA	4---3	315	325	corn	pani	od, mon var food nutr	hellmers,h	1940
*****					****			
JWMAA	12--1	1	8	corn	race	a nutr knwldg shrtcut	atwood,el	1948
JWMAA	39--2	337	341	corn	race	odvi, brow comp & dig	robbins,ct; moen,	1975
WUAPA	14---	1	27	corn	race	mineral cont of plnts	gerloff,gc; moor/	1964
*****					****			
WUAPA	14---	1	27	corn	rugo	mineral cont of plnts	gerloff,gc; moor/	1964
*****					****			
CNRDA	28--5	249	271	corn	stol	alal, frst succ on nu	cowan,imct; hoar/	1950
JAGRA	62-10	627	636	corn	stol	chem comp frst fruits	wainio,ww	1941
JWMAA	12--1	1	8	corn	stol	a nutr knwldg shrtcut	atwood,el	1948
JWMAA	35--4	681	688	corn	stol	ceel, in vitro digstb	ward,al	1971
JWMAA	39--2	337	341	corn	stol	odvi, brow comp & dig	robbins,ct; moen,	1975
PMSCA	31--1	73	78	corn	stol	seas chng tannin cont	fashingbauer,ba;/	1963
WUAPA	14---	1	27	corn	stol	mineral cont of plnts	gerloff,gc; moor/	1964
*****					****			
JWMAA	5---1	108	114	corn	----	odvi, digest capac of	forbes,eb; marcy/	1941

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	40--2	301	307	coro	vari	odvi,bota,in vitr dig	palmer,wl; cowan/	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JAGRA	62-10	627	636	cory	amer	chem comp frst fruits	wainio,ww	1941
JWMAA	4---3	315	325	cory	amer	mon var deer food nut	hellmers,h	1940
JWMAA	12--1	1	8	cory	amer	a nutr knwldg shrtcut	atwood,el	1948

cory amer cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
WUAPA	14---	1	27	cory	amer	mineral cont of plnts	gerloff,gc; moor/	1964
*****					****			
ATRLA	18--3	81	91	cory	avel	caca,intak,digst feed	drozdz,a; osieck	1973
OIKSA	25--3	341	352	cory	avel	micrb decomp of littr	howard,pja; howar	1974
*****					****			
CNRDA	28--5	249	271	cory	cali	alal,frst succ on nut	cowan,imct; hora/	1950
JWMAA	38--1	32	41	cory	cali	odhe, plant charact &	radwan,ma; crouch	1974
*****					****			
CJZOA	52-10	1201	1205	cory	corn	odvi,forag nutr value	mautz,ww; silver/	1974
FOSCA	22--2	195	208	cory	corn	seas dynmcs tall shru	grigal,df; ohman/	1976
JWMAA	36--2	595	605	cory	corn	odhe,frst manipult on	lawrence,g; biswe	1972
JWMAA	38--3	517	524	cory	corn	odvi,nutr cont browse	abell,dh; gilbert	1974
JWMAA	39--1	67	79	cory	corn	odvi,feed analy & dig	robbins,ct; vans/	1975
JWMAA	40--4	630	638	cory	corn	odvi, digst nutr data	mautz,ww; silver/	1976
NCANA	101-1	291	305	cory	corn	alal,brows minrl comp	kubota,j	1974
PLSOA	45--1	17	26	cory	corn	esstl nutr elemt frst	langille,wm; macl	1976
*****					****			
JWMAA	10--1	12	17	cory	rost	nutr cont winter food	treichler,r; sto/	1946
JWMAA	15--4	352	357	cory	rost	comp plnt eat by deer	gastler,gf; moxo/	1951
NFGJA	14--1	76	78	cory	rost	minrl cont deer brows	bailey,ja	1967
*****					****			
BMAEA	171--	1	39	cory	----	autmnl migr of nitrog	murneek,ac; logan	1932
JAGRA	69--1	33	46	cory	----	chem comp wld feedstu	king,tr; mcclure,	1944
JWMAA	39--2	337	341	cory	----	odvi,brow comp & digs	robbins,ct; moen,	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	37--4	585	587	coto	pyra	caloric & moistr cont	burns,ta; viers,e	1973

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
AZATA	113--	1	17	covi	trid	comp arizona forages	catlins,cn	1925
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	9---3	142	145	cowa	stan	apparnt digstb lignin	smith,ad; turner/	1956
JRMGA	10--4	162	164	cowa	stan	nutr wintr brows plnt	smith,ad	1957

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JAGRA	62-10	627	636	crat	crus	chem comp frst fruits	wainio,ww	1941
*****					****			
OIKSA	25--3	341	352	crat	mono	micrb decomp of littr	howard,pja; howar	1974
*****					****			
BOGAA	94---	381	393	crat	poli	minrl & nitrogen cont	mchargue,js; roy,	1932
*****					****			
JANSA	36--4	792	796	crat	----	digstb south brow tis	short,hl; blair,/	1973
JWMAA	38--2	197		crat	----	fibr comp & forag dig	short,hl; blair,/	1974
JWMAA	39--2	337	341	crat	----	odvi,brow comp & digs	robbins,ct; moen,	1975
XFPSA	111--	1	10	crat	----	od--,comp & digs brow	short,hl; blair,/	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
NEXAA	561--	1	33	crot	cory	chem comp forage spp	nelson,ab; herbe/	1970
TAEBA	461--	1	63	crot	cory	comp,util of rang veg	fraps,gs; cory,vl	1940
*****					****			
TAEBA	461--	1	63	crot	mona	comp,util of rang veg	fraps,gs; cory,vl	1940
*****					****			
TAEBA	461--	1	63	crot	neom	comp,util of rang veg	fraps,gs; cory,vl	1940
*****					****			
JWMAA	40--2	283	289	crot	----	nutr qual of digst of	short,hl; epps,ea	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
BOREA	40--3	347	394	cryp	japo	pred minrl nutr stats	vander driessche,	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
TAEBA	461--	1	63	cucu	foet	comp,util of rang veg	fraps,gs; cory,vl	1940
*****					****			
TAEBA	329--	1	59	cucu	pepo	engy-prod coeff feedg	fraps,gs	1925
XAMPA	369--	1	164	cucu	pepo	minrl comp crop & soi	beeson,kc	1941
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
TAEBA	461--	1	63	cusc	exal	comp,util of rang veg	fraps,gs; cory,vl	1940
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--5	356	363	cymo	wats	maj plnt toxicty w us	james,lf; johnson	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ABSZA	29--4	1	196	cyna	vinc	trace elemts in plnts	lounamaa,j	1956

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	30--3	227	230	cyno	dact	yield & chem comp of,	gonzalez,cl; heil	1977

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--4	344	345	cypc	----	cal cont subalpn plnt	anderson,dc; armi	1976
PCGFA	28---	574	580	cypc	----	odvi,qual deer forage	towry,rkjr; mich/	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	25--2	125	127	cype	rotn	develp var carbhydrat	smithl,ae	1972

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JFUSA	55--5	342	347	cyri	race	burning & brows quali	lay,dw	1957
JRMGA	9---3	142	145	cyri	race	apparnt digstb lignin	smith,ad; turner/	1956
PCGFA	10---	53	58	cyri	race	odvi,nutr in sou pine	lay,dw	1956
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	39--4	670	673	dact	glom	odhe, nutr cont diets	urness,pj; neff,/	1975
XARRA	304--	1	6	dact	glom	odhe,nutr valu forag	urness,pj; neff,/	1975
XFRMA	158--	1	35	dact	glom	rang mgmt & ecol basi	clary,wp	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
XARRA	304--	1	6	dale	albi	odhe,nutr valu forage	urness,pj; neff,/	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ABSZA	29--4	1	196	daph	meze	trace elemts in plnts	lounamaa,j	1956

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--5	356	363	delp	ande	maj plnt toxicty w us	james,lf; johnson	1976
*****					****			
JRMGA	29--5	356	363	delp	barb	maj plnt toxicty w us	james,lf; johnson	1976
JRMGA	30--3	237	238	delp	barb	rano,toxi extrct from	olsen,jd	1977
*****					****			
JRMGA	30--3	237	238	delp	glac	rano,toxi extrct from	olsen,jd	1977
*****					****			
JRMGA	29--5	356	363	delp	glam	maj plnt toxicty w us	james,lj; johnson	1976
*****					****			
JRMGA	29--5	356	363	delp	nels	maj plnt toxicty w us	james,lf; johnson	1976
*****					****			
JRMGA	29--5	356	363	delp	occi	maj plnt toxicty w us	james,lf; johnson	1976
JRMGA	30--3	237	238	delp	occi	rano,toxi extrct from	olsen,jd	1977
*****					****			
JRMGA	29--5	356	363	delp	----	maj plnt toxicty w us	james,lf; johnson	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JANSA	44--3	389	394	desc	soph	prox,minrl & aa comp	harrold,rl; nalew	1977
NDFRA	32--1	15	17	desc	soph	prox & aa analy ergot	harrold,rl; nalew	1974
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	20--3	179	180	desh	caes	gross engy alpn plnts	smith,dr	1967
*****					****			
ECOLA	43--4	753	757	desh	flex	caloric & lipid cont	bliss,lc	1962

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CJBOA	51-11	2037	2046	desi	soph	minrl comp graslnd sp	harner,rf; harper	1973

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
XARRA	304--	1	6	desm	cool	odhe,nutr valu forag	urness,pj; neff,/	1975
XFRMA	158--	1	35	desm	cool	rang mgmt & ecol basi	clary,wp	1975
*****					****			
TAEBA	461--	1	63	desm	fall	comp,util of rang veg	fraps,gs; cory,vl	1940

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	38--1	20	31	deso	glut	odvi,in vitro digstb	snider,cc; asplun	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ECMOA	34--4	321	357	diap	lapp	engy relatn alpn plnt	hadley,eb; buss,l	1964
ECOLA	43--4	753	757	diap	lapp	caloric & lipid cont	bliss,lc	1962

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ECOLA	43--4	753	757	dicr	beig	caloric & lipid cont	bliss,lc	1962

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
WUAPA	14---	1	27	dier	loni	mineral cont of plnts	gerloff,gc; moor/	1964
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	40--2	283	289	dioc	mult	nutr qual of digst of	short,hl; epps,ea	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
TAEBA	461--	1	63	dios	texa	comp,util of rang veg	fraps,gs; cory,vl	1940
*****					****			
BOGAA	94---	381	393	dios	virg	minrl & nitrogen cont	mchargue,js; roy,	1932
JAGRA	69--1	33	46	dios	virg	chem comp wld feedstu	king,tr; mcclure,	1944

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--4	344	345	drab	aure	cal cont subalpn plnt	anderson,dc; armi	1976
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CRPSA	15--6	821	827	echi	crus	forag nutr & palat of	marten,gc; anders	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JANSA	44--3	389	394	ecin	crus	prox,minrl & aa comp	harold,rl; nalew	1977
NDFRA	32--1	15	17	ecin	crus	prox & aa analy ergot	harrold,rl; nalew	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JAGRA	69--1	33	46	elae	angu	chem comp wld feedstu	king,tr; mccure	1944

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JANSA	41--2	601	609	eleo	smal	nutr valu aquat plnts	linn,jg; staba,e/	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	27--2	114	117	elym	glau	odhe,soil & seas frag	krueger,wc; donar	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ECMOA	34--4	321	357	empe	eame	engy relatn alpn plnt	hadley,eb; buss,l	1964
ECOLA	43--4	753	757	empe	eame	caloric & lipid cont	bliss,lc	1962
*****					****			
ABSZA	29--4	1	196	empe	nigr	trace elemts in plnts	lounamaa,j	1956
CJBOA	51--2	421	427	empe	nigr	trace elemt cont soil	doyle,p; fletche/	1973

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
TAEBA	461--	1	63	ephe	anti	comp,util of rang veg	fraps,gs; cory,vl	1940
*****					****			
UAXBA	227--	1	46	ephe	neva	utah's winter range	esplin,ac; greav/	1937
UAXBA	472--	1	55	ephe	neva	nutr valu seas ranges	cook,cw; harris,l	1968
*****					****			

ephe spp. cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
NEXAA *****	561--	1	33	ephe	torr ****	chem comp forage spp	nelson,ab; herbe/	1970
NEXAA *****	561--	1	33	ephe	trif ****	chem comp forage spp	nelson,ab; herbe/	1970
CAFGA *****	52--2	68	84	ephe	viri ****	ovca,wintr observa on	mccullogh,dr; sch	1966
ECOLA	40--4	644	651	ephe	----	chem cont salt-desert	cook,cw; stoddar/	1959

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CJBOA	51--2	421	427	epil	angu	trace elemt cont soil	doyle,p; fletche/	1973
JRMGA	29--1	63	65	epil	angu	effct 2,4-D on digstb	thilenius,jf; bro	1976
NCANA *****	101-1	291	305	epil	angu ****	alal,brows minrl comp	kubota,j	1974
CJBOA	51--2	421	427	epil	lati	trace elemt cont soil	doyle,p; fletche/	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
NCANA	101-1	291	305	equi	----	alal,brows minrl comp	kubota,j	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	30--3	227	230	erag	----	yield & chem comp of,	gonzalez,cl; heil	1977

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
XFRMA	158--	1	35	ergo	race	rang mgmt & ecol basi	clary,wp	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	30--3	206	209	eria	----	odhe,food habt gras-s	short,hl	1977

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CAFGA *****	41--2	145	155	erid	cali ****	crude prot var browse	bissell,hd; stron	1955

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
XARRA	304--	1	6	erie	----	odhe,nutr valu forag	urness,pj; neff,d/	1975
XFRMA	158--	1	35	erie	----	rang mgmt & ecol basi	clary,wp	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CJBOA	51-11	2037	2046	erig	hera	minrl comp graslnt sp	harner,rf; harper	1973
*****					****			
XARRA	304--	1	6	erig	race	odhe,nutr valu forage	urness,pj; neff,d	1975
****					****			
JRMGA	30--2	119	121	erig	wrig	odhe,digst deer forag	urness,pj; smith/	1977
*****					****			
JAPEA	11--2	489	497	erig	----	bibi,tropic ecolgy of	peden,dg; vandyn/	1974
JWMAA	39--4	670	673	erig	----	odhe, nutr cont diets	urness,pj; neff,/	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ATICA	25--1	21	27	erip	vagi	chem comp forag plnts	scotter,gw	1972
CPLSA	53--2	263	268	erip	vagi	rata, mineral content	scotter,gw; milti	1973
*****					****			
NCANA	101-1	291	305	erip	----	alal,brows minrl comp	kubota,j	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	30--2	119	121	erod	cicu	odhe,digst deer forag	urness,pj; smith/	1977
*****					****			
AAAHA	13-63	404	410	erod	mosc	nutr valu tempr pastu	mcivor,jg; smith,	1973

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--4	344	345	erys	aspe	cal cont subalpn plnt	anderson,dc; armi	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
SCIEA	193--	1126	1128	eryt	amer	role of, in engy flow	muller,rn; borman	1976
*****					****			
JRMGA	29--4	753	757	eryt	gran	cal cont subalpn plnt	anderson,dc; armi	1976
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CJFRA	5---4	626	639	euca	obli	littrfall & cyclng al	van cleve,k; noon	1975
ECOLA	49--1	142	145	euca	obli	loss elmt decomp litt	attiwill,pm	1968

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	33--4	1028	1031	euon	amer	ovrstry on brows qual	halls,lk; epps,ea	1969
JWMAA	40--2	283	289	euon	amer	nutr qual of digst of	short,hl epps,ea	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
TAEBA	461--	1	63	euph	cict	comp,util of rang veg	fraps,gs; cory,vl	1940
*****					****			
WUAPA	14---	1	27	euph	coro	mineral cont of plnts	gerloff,gc; moor/	1964
****					****			
XARRA	304--	1	6	euph	fend	odhe,nutr valu forage	urness,pj; neff,/	1975
*****					****			
TAEBA	461--	1	63	euph	pros	comp,util of rang veg	fraps,gs; cory,vl	1940
*****					****			
JRMGA	30--3	206	209	euph	----	odhe,food habt gras-s	short,hl	1977
JRMGA	30--3	227	230	euph	----	yield & chem comp of,	gonzalez,cl; heil	1977

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
AGJOA	51--4	226	234	euro	lana	symposium forag evalu	harris,le; cook,/	1959
CNAPA	769--	1	60	euro	lana	chem comp nativ plnts	clarke,se; tisda/	1945
ECOLA	40--4	644	651	euro	lana	chem cont salt-desert	cook,cw; stoddar/	1959
JANCA	51--4	780	785	euro	lana	detr lignin & cellulo	van soest,pj; win	1968
NASRA	1684-	1	92	euro	lana	tabl of feed composit	nrcp, canada	1969
NEXAA	246--	1	75	euro	lana	Ca, P cont rang forag	watkins,we	1937
NUABA	197--	1	38	euro	lana	phenol vs comp plnt &	robertson,jh; tor	1959
UAXBA	227--	1	46	euro	lana	utah's winter range	esplin,ac; greav/	1937
UAXBA	372--	1	56	euro	lana	nutr valu wintr range	cook,cw; stoddar/	1952
UAXBA	472--	1	55	euro	lana	nutr valu seas ranges	cook,cw; harris,l	1968

euro lana cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
WAEBA	65---	1	53	euro	lana	wyoming forag plnt #1	knight,hg; hepne/	1905
WAEBA	87---	1	152	euro	lana	wyoming forag plnt #4	knight,hg; hepne/	1911
WAEBA	157--	1	18	euro	lana	forag plnt & chem com	mccreary,oc	1927
WAEBA	184--	1	21	euro	lana	forag plnt & chem com	mccreary,oc	1931

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JAPEA	11--2	489	497	evol	nutt	bibi,tropic ecolgy of	peden,dg; vandyn/	1974
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
BMAEA	171--	1	39	fagu	gran	autmnl migr of nitrog	murneek,ae; logan	1932
NFGJA	14--1	76	78	fagu	gran	minrl cont deer brows	bailey,ja	1967
JWMAA	39--2	337	341	fagu	gran	odvi,brow comp & digs	robbins,ct; moen,	1975
PLSOA	45--1	17	26	fagu	gran	esstl nutr elemt frst	langille,wm; macl	1976
*****					****			
ATRLA	18--3	81	91	fagu	sylv	chem comp plant field	bornkamm,r; benne	1971
BOREA	40--3	347	394	fagu	sylv	pred minrl nutr stats	vanden driessche,	1974
*****					****			
CJFRA	5---4	626	639	fagu	----	littrfall & cyclng al	van cleve,k; noon	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	30--3	206	209	fero	wisl	odhe,food habt grslnd	short,hl	1977

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CJBOA	51--2	421	427	fest	alta	trace elemt cont soil	doyle,p; fletche/	1973
*****					****			
JWMAA	39--4	670	673	fest	ariz	odhe, nutr cont diets	urness,pj; neff,/	1975
XFRMA	158--	1	35	fest	ariz	rang mgmt & ecol base	clary,wp	1975
*****					****			
JRMGA	29--1	63	65	fest	idah	eff 2,4-D, digs, prod	thilenius,jf; bro	1976
*****					****			
JAPEA	11--2	489	497	fest	octo	bibi,tropic ecolgy of	peden,dg; vandyn/	1974
*****					****			
NATUA	263--	763	763	fest	----	ceel,ov--,intak & dig	milne,ja; macrae/	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
NEXAA	561--	1	33	flou	cern	chem comp forage spp	nelson,ab; herbe/	1970

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	36--2	595	605	fome	----	odhe, forest manip on	lawrence,g; biswe	1972
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
TAEBA	461--	1	63	fore	neom	comp,util of rang veg	fraps,gs; cory,vl	1940

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--1	63	65	frag	amer	effct 2,4-D on digstb	thilenius,jf; bro	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	35--3	469	475	fras	----	odvi,odhe, nutr intak	urness,pj; green/	1971

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
NFGJA	14--1	76	78	frax	amer	minrl cont deer brows	bailey,ja	1967
JFUSA	55--5	342	347	frax	amer	burning & browse qual	lay,dw	1957
WUAPA	14---	1	27	frax	amer	mineral cont of plnts	gerloff,gc; moor/	1964
*****					****			
OIKSA	25--3	341	352	frax	exce	micrb decomp of littr	howard,pja; howar	1974
*****					****			
NOSCA	49--4	183	189	frax	lati	littrfall douglas-fir	richard,wh	1975
*****					****			
BOGAA	94---	381	393	frax	quad	mineral, nitrogen con	mchargue,js; roy	1932
*****					****			
JWMAA	36--1	174	177	frax	----	odvi, wint forag qual	segelquist,ca; sl	1972
PCGFA	10---	53	58	frax	----	deer nutr in sou pine	lay,dw	1956

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JANSA	44--3	389	394	fuma	offi	prox & aa analy ergot	harrold,rl; nalew	1974
NDFRA	32--1	15	17	fuma	offi	prox, minrl & aa comp	harrold,rl; nalew	1977
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--1	63	65	gali	bore	effct 2,4-D on digstb	thilenius,jf; bro	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
PCGFA	28---	574	580	gaul	proc	odvi,qaul deer forage	towry,rk,jr; mic/	1974
WVAFA	6---1	2	4	gual	proc	odvi,forag prod & dee	towry,r	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	37--4	585	587	gayl	bacc	caloric & moistr cont	burns,ta; viers,e	1973
PLSOA	45--1	17	26	gayl	bacc	esstl nutr elemt frst	langille,wm; macl	1976
WVAFA	6---1	2	4	gayl	bacc	odvi,forag prod & dee	towry,r	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JFUSA	55--5	342	347	gels	semp	burning & browse qual	lay,dw	1957
JWMAA	33--4	1028	1031	gels	semp	ovrstry on brows qual	halls,lk; epps,ea	1969
JWMAA	40--2	283	289	gels	semp	nutr qual of digst of	short,hl; epps,ea	1976
PCGFA	10---	53	58	gels	semp	deer nutr in sou pine	lay,dw	1956
PCGFA	20---	34	104	gels	semp	deer food nutr analys	thorsland,oa	1966
PCGFA	21---	57	62	gels	semp	grwth,forag qual brows	blair,rm; halls/	1967
XFPSA	51---	1	35	gels	semp	seas nutr dist in pln	blair,rm; epps,ea	1969

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--1	63	65	gera	rich	effct 2,4-D on digstb	thilenius,jf; bro	1976
*****					****			
JWMAA	39--4	670	673	gera	----	odhe, nutr cont diets	urness,pj; neff,/	1975
XARRA	304--	1	6	gera	----	odhe, nutr valu forag	urness,pj; neff,/	1975
XFRMA	158--	1	35	gera	----	rang mgmt & ecol basi	clary,wp	1975
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CAFGA	39--2	321	357	geum	peck	engy relatn alpn plnt	hadley,eb; bliss	1964
ECOLA	43--4	753	757	geum	peck	caloric & lipid cont	bliss,lc	1962
*****					****			
JRMGA	29--1	63	65	geum	trif	effct 2,4-D on digstb	thilenius,jf; bro	1976
*****					****			
XARRA	304--	1	6	geum	----	odhe, nutr valu forag	urness,pj; neff,/	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
XARRA	304--	1	6	gili	mult	odhe, nutr valu forag	urness,pj; neff,/	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	40--2	283	289	gled	tria	nutr qual of digst of	short,hl; epps,ea	1976
PCGFA	21---	34	104	gled	tria	deer food nutr analys	thorsland,oa	1966

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--4	344	345	gram	----	cal cont subalpn plnt	anderson,dc; armi	1976
PCGFA	28---	574	580	gram	----	odvi,qual deer forage	towry,rk,jr; mic/	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
NUABA	197--	1	38	gray	spin	phenol vs comp plnt &	robertson,jh; tor	1958
WAEBA	184-9	1	21	gray	spin	forag plnt & chem com	mccreary,oc	1931

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
TAEBA	461--	1	63	guai	coul	comp,util texas fdstf	fraps,gs	1947

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JAPEA	11--2	489	497	guar	cocc	bibi,tropic ecolgy of	peden,dg; vandyn/	1974
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--5	356	363	guti	micr	maj plnt toxicty w us	james,lf; johnson	1976
*****					****			
AGJOA	51--4	226	234	guti	saro	symposium forag evalu	harris,le; cook,/	1959
JAPEA	11--2	489	497	guti	saro	bibi,tropic ecolgy of	peden,dg; vandyn/	1974
NEXAA	246--	1	75	guti	saro	Ca,P cont rang forage	watkins,we	1937
NEXAA	561--	1	33	guti	saro	chem comp forage spp	nelson,ab; herbe/	1970
UAXBA	227--	1	46	guti	saro	utah's winter range	esplin,ac; greav/	1937
*****					****			
NEXAA	561--	1	33	guti	spha	chem comp forage spp	nelson,ab; herbe/	1970
*****					****			
TAEBA	461--	1	63	guti	texa	comp,util of rang veg	fraps,gs; cory,vl	1940

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
MGHLA	65--4	476	478	gyro	escu	Se,Hg cont edibl mush	stijve,t; cardina	1974
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--5	356	363	halo	glom	maj plnt toxicty w us	james,lf; johnson	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	35--2	221	231	hama	vern	cellulos digst & comp	torgerson,o; pfan	1971
JWMAA	38--1	20	31	hama	vern	odvi, in vitro digstb	snider,cc; asplun	1974
*****					****			
JWMAA	39--2	337	.341	hama	virg	odvi,brow comp & digs	robbins,ct; moen,	1975
PCGFA	28---	574	580	hama	virg	odvi,qual deer forage	towry,rk,jr; mic/	1974
PLSOA	45--1	17	26	hama	virg	esstl nutr elemt frst	langille,wm; macl	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CJBOA	51-11	2037	2046	hedy	bore	minrl comp grslnd spp	harner,rf; harper	1973

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--5	356	363	hele	hoop	maj plnt toxicty w us	james,lf; johnson	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--1	63	65	heli	quin	effct 2,4-D on digstb	thilenius,jf; bro	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	26--6	423	426	heln	angu	pine overstr,herb qua	woltes,gl	1973
*****					****			
JRMGA	30--3	227	230	heln	annu	yield & chem comp of,	gonzalez,cl; heil	1977
JWMAA	35--4	681	688	heln	annu	ceel, in vitro digstb	ward,al	1971
*****					****			
JWMAA	38--1	20	31	heln	hirs	odvi, in vitro digstb	snider,cc; asplun	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	38--1	20	31	helo	heli	odvi, in vitro digstb	snider,cc; asplun	1974
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
BOREA	40--3	347	394	heve	----	pred minrl nutr stats	vanden driessche,	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JAFCA	23--3	464	467	hevl	escu	aa comp morel mushrm	mckellar,rl; kohr	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JAGRA	62-10	627	636	hico	ovat	chem comp frst fruits	wainio,ww	1941

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	35--3	469	475	hila	bela	odvi,odhe, nutr intak	urness,pj; green/	1971

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
TAEBA	461	1	63	hoff	brac	comp,util of rang veg	fraps,gs; cory,vl	1940

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
AAAHA	13-63	404	410	hord	lepo	nutr valu tempr pastu	mcivor,jg; smsith	1973

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ECOLA	43--4	753	757	hous	caer	caloric & lipid cont	bliss,lc	1962

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	35--2	221	231	hydr	arbo	cellulos digst & comp	torgerson,o; pfan	1971
JWMAA	38--1	20	31	hydr	arbo	odvi, in vitro digstb	snider,cc; asplun	1974
PCGFA	21---	34	104	hydr	arbo	deer food nutr analys	thorsland,oa	1966
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--5	356	363	hyme	odor	maj plnt toxicty w us	james,lf; johnson	1976
*****					****			
JRMGA	29--5	356	363	hyme	rich	maj plnt toxicty w us	james,lf; johnson	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ABSZA	29--4	1	196	hype	macu	trace elemts in plnts	lounamaa,j	1956

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ABSZA	29--4	1	196	hypr	perf	trace elemts in plnts	lounamaa,j	1956
JRMGA	29--5	356	363	hypr	perf	maj plnt toxicty w us	james,lf; johnson	1976
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JFUSA	55--5	342	347	ilex	cori	burnng & brow quality	lay,dw	1957
PCGFA	10---	53	58	ilex	cori	deer nutr in sou pine	layl,dw	1956
*****					****			
JWMAA	40--2	283	289	ilex	deci	nutr qual of digst of	short,hl; epps,ea	1976
*****					****			
JWMAA	20--4	359	367	ilex	glab	herb brows chem comp	smith,f; beeson,/	1956
PLSOA	45--1	17	26	ilex	glab	esstl nutr elemt frst	langille,wm; macl	1976
*****					****			
BOGAA	94---	381	393	ilex	opac	minrl & nitrogen cont	mchargue,js; roy,	1932
JFUSA	55--5	342	347	ilex	opac	burnng & brow quality	lay,dw	1957
PCGFA	10---	53	58	ilex	opac	deer nutr in sou pine	lay,dw	1956
*****					****			
JAGRA	62-10	627	636	ilex	vert	chem comp frst fruits	wainio,ww	1941
*****					****			
JANSA	36--4	792	796	ilex	vomi	digst south brows tis	short,hl; blair,/	1973
JFUSA	55--5	342	347	ilex	vomi	burnng & brow quality	lay,dw	1957
JWMAA	31--3	432	437	ilex	vomi	deer forag,loblolly p	blair,rm	1967
JWMAA	33--4	1028	1031	ilex	vomi	ovrstry on brows qual	halls,lk; epps,ea	1969
JWMAA	37--4	585	587	ilex	vomi	caloric & moist cot	burns,ta; viers,e	1973
JWMAA	38--2	197	209	ilex	vomi	fibr comp & forag dig	short,hl; blair,/	1974
PCGFA	10---	53	58	ilex	vomi	deer nutr in sou pine	lay,dw	1956
XFPSA	111--	1	10	ilex	vomi	od--,comp & digs brow	short,hl; blair,/	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	38--1	20	31	impa	cape	odvi, in vitro digstb	snider,cc; asplun	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	40--2	283	289	ipom	----	nutr qual of digst of	short,hl; epps,ea	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JAPEA	11--2	489	497	iva	axil	bibi, tropic ecolgy of	peden,dg; vandyn/	1974
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	40--2	283	289	jacq	tamn	nutr qual of digst of	short,hl; epps,ea	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
WUAPA	14---	1	27	jugl	cine	minrl cont of plnt,wi	gerloff,gc; moor/	1964
*****					****			
BOGAA	94---	381	393	jugl	nigr	minrl & nitrogen cont	mchargue,js; roy,	1932
JAGRA	62-10	627	636	jugl	nigr	chem comp frst fruits	wainio,ww	1941
JWMAA	40--2	283	289	jugl	nigr	nutr qual of digst of	short,hl; epps,ea	1976
WUAPA	14---	1	27	jugl	nigr	minrl cont of plnt,wi	gerloff,gc; moor/	1964

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ABSZA	29--4	1	196	junc	comm	trace elemts in plnts	lounamaa,j	1956
JWMAA	15-11	352	357	junc	comm	comp plnt eat by deer	gastler,gf, moxo/	1951
*****					****			
ECMOA	34--4	321	357	junc	trif	engy relatn alpn plnt	hadley,eb; bliss	1964
ECOLA	43--3	753	757	junc	trif	caloric & lipid cont	bliss,lc	1962

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	15--4	352	357	juni	hori	comp plnt eat by deer	gastler,gf; moxo/	1951
*****					****			
WAEBA	184-9	1	21	juni	knig	forag plnt & chem com	mccreary,oc	1931
*****					****			
CAFGA	41--2	145	155	juni	occi	crude prot var browse	bissell,hd; stron	1955
*****					****			
TAEBA	461--	1	63	juni	pinc	comp,util of rang veg	fraps,gs; cory,vl	1940
*****					****			
ECOLA	47--2	222	229	juni	scop	selec nutr deer brows	short,hl; dietz,/	1966
*****					****			
NAWTA	21---	141	158	juni	utah	prot, phosphorus cont	swank,wg	1956
JRMGA	9---3	142	145	juni	utah	apparnt digstb lignin	smith,ad; turner/	1956
JRMGA	10--4	162	164	juni	utah	nutr wintr brows plnt	smith,ad	1957
UAXBA	227--	1	46	juni	utah	utah's winter range	esplin,ac; greav/	1957
*****					****			

juni spp. cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	35--2	221	231	juni	virg	cellulos digst & comp	torgerson,o; pfan	1971
JWMAA	36--1	174	177	juni	virg	odvi,wintr forag qual	segelquist,ca; s/	1972
JWMAA	38--1	20	31	juni	virg	odvi, in vitro digstb	snider,cc; asplun	1974
SOSCA	43---	349	355	juni	virg	comp frst tree litter	coile,ts	1937
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	36--3	913	923	kalm	angu	rata,food habit of ne	bergerud,at	1972
PLSOA	45--1	17	26	kalm	angu	esstl nutr elemt frst	langille,wm; macl	1976
*****					****			
ECOLA	12--2	323	333	kalm	lati	odvi, mt spp as food	forbes,eb; bechde	1931
JRMGA	9---3	142	145	kalm	lati	apparnt digstb lignin	smith,ad; turner/	1956
JWMAA	10--1	12	17	kalm	lati	nutr cont winter food	treichler,r; sto/	1946
PCGFA	28---	574	580	kalm	lati	odvi,qual deer forage	towry,rk,jr; mic/	1974
TNWSD	28---	67	76	kalm	lati	a tent model deer foo	whelan,jb; harlo/	1971
WVAFA	6---1	2	4	kalm	lati	odvi,forag prod & dee	towry,r	1975
*****					****			
JWMAA	36--3	913	923	kalm	poli	rata,food habit of ne	bergerud,at	1972
WUAPA	14---	1	27	kalm	poli	minrl cont of plnt wi	gerloff,gc; moor/	1964

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
WAEBA	184-9	1	21	koch	amer	forag plnt & chem com	mccreary,oc	1931
*****					****			
CPLSA	40--1	123	129	koch	chil	dry mattr dig in vitr	clark,kw; mott,go	1960
*****					****			
CPLSA	40--1	123	129	koch	scop	dry mattr dig in vitr	clark,kw; mott,go	1960
JANSA	44--3	389	394	koch	scop	prox, minrl & aa comp	harrold,rl; nalew	1977
JAPEA	11--2	489	497	koch	scop	bibi,tropic ecolgy of	peden,dg; vandyn/	1974
*****					****			
NASRA	1684-	1	92	koch	vest	table of feed composi	nrcp, canada	1969
NUABA	197--	1	38	koch	vest	phenol vs comp plnt &	robertson,jh; tor	1958
UAXBA	227--	1	46	koch	vest	utah's winter range	esplin,ac; greav/	1937
UAXBA	472--	1	55	koch	vest	nutr valu seas ranges	cook,cw; harris,l	1968
UAXBA	372--	1	56	koch	vest	nutr valu wintr range	cook,cw; stoddar/	1954

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
TAEBA	461--	1	63	kram	secu	comp,util of rang veg	fraps,gs; cory,vl	1940
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
TAEBA	329--	1	59	kunz	trid	engy-prod coeff feedg	fraps,gs	1925
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	38--1	20	31	lact	cana	odvi, <u>in vitro</u> digstb	snider,cc; asplun	1974
*****					****			
XARRA	304--	1	6	lact	----	odhe, nutr valu forag	urness,pj; neff,/	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JANSA	41--2	601	609	lamn	minr	nutr valu aquatc plnt	linn,jg; staba,e/	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CJBOA	38--3	313	333	lari	lari	chlorophyll cont plnt	bray,jr	1960
JWMAA	36--3	913	923	lari	lari	rata,food habit of ne	bergerud,at	1972
WUAPA	14---	1	27	lari	lari	minrl cont of plnt,wi	gerloff,gc; moor/	1964
*****					****			
BOREA	40--3	347	394	lari	lept	pred minrl nutr stats	vanden driessche	1974
*****					****			
ECOLA	34--4	786	793	lari	occi	nutr cont leaf litter	daubenmire,v	1953

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
XARRA	304--	1	6	lath	----	odhe, nutr valu forag	urness,pj; neff,/	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	28--5	419	421	laty	ochr	odvi, <u>in vitro</u> consti	uresk,dw; dietz,/	1975
*****					****			
XARRA	304--	1	6	laty	----	odhe, nutr valu forag	urness,pj; neff,/	1975
XFRMA	158--	1	35	laty	----	rang mgmt & ecol basi	clary,wp	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CPLSA	45--3	246	250	ledu	groe	chem comp forag lichn	scotter,gw	1965
ECMOA	34--4	321	357	ledu	groe	engy relatn apln plnt	hadley,eb; bliss,	1964
ECOLA	43--4	753	757	ledu	groe	caloric & lipid cont	bliss,lc	1962

ledu groe cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
PLSOA	45--1	17	26	ledu	groe	esstl nutr elemt frst	langille,wm; macl	1976
WUAPA	14---	1	27	ledu	groe	minrl cont of plnt wi	gerloff,gc; moor/	1964
*****					****			
ATICA	25--1	21	27	ledu	palu	chem comp forag plnts	scotter,gw	1972
CPLSA	53--2	263	268	ledu	palu	rata, mineral content	scotter,gw; milti	1973

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
NUABA	197--	1	38	lept	mult	phenol vs comp plnt &	robertson,jh; tor	1958
TAEBA	329--	1	59	lept	mult	engy-prod coeff feedg	fraps,gs	1925

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	38--1	20	31	lesp	stip	odvi, in vitro digstb	snider,cc; asplun	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
TAEBA	461--	1	63	leuc	retu	comp,util of rang veg	fraps,gs; cory,vl	1940

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
TAEBA	461--	1	63	leuo	minu	comp,util of rang veg$	fraps,gs; cory,vl	1940

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	9---3	142	145	leut	edit	apparnt digstb lignin	smith,ad; turner/	1956

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--4	344	345	lewi	pygm	cal cont subalpn plnt	anderson,dc; armi	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JAPEA	11--2	489	497	liat	punc	bibi,tropic ceolgy of	peden,dg; vandyn/	1974
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	36--2	595	605	libo	decu	odhe,forst manipu on	lawrence,g; biswe	1972

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--4	344	345	ligs	port	calor cont rcky mt pl	andersen,dc; armi	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JAGRA	69--1	33	46	ligu	obtu	chem comp wld feedstu	king,tr; mcclure,	1944

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	34--1	176	182	lind	benz	mega,nutr wintr food	billingsley,bb; a	1970

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
BOREA	40--3	347	394	linm	usit	pred minrl nutr stats	vanden driessche,	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
BOGAA	94---	381	393	liqu	styr	minrl & nitrogen cont	mchargue,js; roy	1932
JAGRA	69--1	33	46	liqu	sryr	chem comp wld feedstu	king,tr; mcclure,	1944
JANSA	36--4	792	796	liqu	styr	digstb south brow tis	short,hl; blair,/	1973
JFUSA	55--5	342	347	liqu	styr	burnng & brows qualit	lay,dw	1957
JWMAA	38--2	197	???	liqu	styr	fibr comp & forag dig	short,hl; blair,/	1974
JWMAA	40--3	479	483	liqu	styr	squirrel use b/w oaks	short,hl	1976
PCGFA	10---	53	58	liqu	styr	deer nutr in sou pine	lay,dw	1956
PCGFA	21---	34	104	liqu	styr	deer food nutr analys	thorsland,oa	1966
SOSCA	43---	349	355	liqu	styr	comp frst tree litter	coile,ts	1937
XFPSA	51---	1	35	liqu	styr	seas nutr dist in pln	blair,rm; epps,ea	1969
XFPSA	111--	1	10	liqu	styr	od--,comp & digs brow	short,hl; blair,/	1975
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
BOGAA	94---	381	393	liri	tuli	minrl & nitrogen cont	mchargue,js; roy,	1932
JRMGA	9---3	142	145	liri	tuli	apparnt digstb lignin	smith,ad; turner/	1956
JWMAA	40--2	283	289	liri	tuli	nutr qual of digst of	short,hl; epps,ea	1976
PCGFA	21---	34	104	liri	tuli	deer food nutr analys	thorsland,oa	1966
SOSCA	43---	349	355	liri	tuli	comp frst tree litter	coile,ts	1937

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ECOLA	43--4	753	757	lois	proc	caloric & lipid cont	bliss,lc	1962

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
AAAHA	13-63	404	410	loli	rigi	nutr valu tempr pastu	mcivor,jg; smith	1973

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
TAEBA	461--	1	63	loni	albi	comp,util of rang veg	fraps,gs; cory,vl	1940
*****					****			
NFGJA	14--1	76	78	loni	cana	minrl cont deer brows	bailey,ja	1967
*****					****			
UAXBA	305--	1	22	loni	invo	comp summr rang plnts	stoddart,la; grea	1942
*****					****			
JAGRA	69--1	33	46	loni	japo	chem comp wld feedstu	king,tr; mcclure,	1944
JANSA	36--4	792	796	loni	japo	digstb south brow tis	short,hl; blair,/	1973
JWMAA	33--4	1028	1031	loni	japo	ovrstry on brows qual	halls,lk; epps,ea	1969
JWMAA	37--4	585	587	loni	japo	caloric & moist cont	burns,ta; viers,e	1973
JWMAA	38--2	197	???	loni	japo	fibr comp & forag dig	short,hl; blair,/	1974
JWMAA	39--2	321	329	loni	japo	odvi,nutr in diff sea	short,hl	1975
JWMAA	40--2	283	289	loni	japo	nutr qual of digst of	short,hl; epps,ea	1976
PCGFA	21---	34	104	loni	japo	deer food nutr analys	thorsland,oa	1966
TAEBA	461--	1	63	loni	japo	comp,util texas fdstf	fraps,gs	1947
XFPSA	111--	1	10	loni	japo	od--,comp & digs brow	short,hl; blair,/	1975
*****					****			
JAGRA	69--1	33	46	loni	morr	chem comp wld feedstu	king,tr; mcclure	1944
*****					****			

loni spp. cont on the next page

ECOLA	43--4	753	757	loni	vill	caloric & lipid cont	bliss,lc	1962
*****					****			
ABSZA	29--4	1	196	loni	xylo	trace elemts in plnts	lounamaa,j	1956

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
XARRA	304--	1	6	lotu	wrig	odhe,nutr valu forage	urness,pj; neff,/	1975
XFRMA	158--	1	35	lotu	wrig	rang mgmt & ecol basi	clary,wp	1975
*****					****			
JWMAA	39--4	670	673	lotu	----	odhe, nutr cont diets	urness,pj; neff,/	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CJBOA	51--2	421	427	lupi	arct	trace elemt cont soil	doyle,p; fletche/	1973
*****					****			
JRMGA	29--5	356	363	lupi	caud	maj plnt toxicty w us	james,lf; johnson	1976
*****					****			
JRMGA	29--1	63	65	lupi	seri	effct 2,4-D on digest	thilenius,jf; bro	1976
JRMGA	29--5	356	363	lupi	seri	maj plnt toxicty w us	james,lf; johnson	1976
*****					****			
JWMAA	39--4	670	673	lupi	----	odhe, nutr cont diets	urness,pj; neff,/	1975
NCANA	101-1	291	305	lupi	----	alal,brows minrl comp	kubota,j	1974
XARRA	304--	1	6	lupi	----	odhe, nutr valu forag	urness,pj; neff,/	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ECOLA	43--4	753	757	luzu	spic	caloric & lipid cont	bliss,lc	1962

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ECOLA	43--4	753	757	lyco	anno	caloric & lipid cont	bliss,lc	1962
*****					****			
ECOLA	43--4	753	757	lyco	sela	caloric & lipid cont	bliss,lc	1962

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
SSSJD	40--4	582	585	lyon	luci	nutr prob pinus taeda	maccarthy,r; dave	1976
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	40--2	283	289	macl	pomi	nutr qual of digst of	short,hl; epps,ea	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JAGRA	62-10	627	636	magn	acum	chem comp frst fruits	wainio,ww	1941
JWMAA	39--2	337	341	magn	acum	odvi,brow comp & digs	robbins,ct; moen,	1975
*****					****			
BOGAA	94---	381	393	magn	macr	minrl & nitrogen cont	machargue,js; roy	1932
*****					****			
JFUSA	55--5	342	347	magn	virg	burnng & brows qualit	lay,dw	1957
JWMAA	40--2	283	289	magn	virg	nutr qual of digst of	short,hl; epps,ea	1976
PCGFA	10---	53	58	magn	virg	deer nutr in sou pine	lay,dw	1956
PCGFA	21---	34	104	magn	virg	deer food nutr analys	thorsland,oa	1966

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CJBOA	51-11	2037	2046	maho	repe	minrl comp graslnd sp	harner,rf: harper	1973

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	38--3	517	524	maia	cana	odvi, nutr cont brows	abell,dh; gilbert	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
TAEBA	329--	1	59	mani	escu	engy-prod coeff feedg	fraps,gs	1925

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CRPSA	15--6	821	827	medi	sati	forag nutr & palat of	marten,gc; anders	1975
JANSA	41--2	601	609	medi	sati	nutr valu aquat plnts	linn,jg; staba,e/	1975
JWMAA	38--4	823	829	medi	sati	odhe, fibrous alfalfa	schoonveld,gg; o/	1974
XFINA	221--	1	6	medi	sati	odhe,hi-enrgy food of	welch,bl; andrus/	1977
*****					****			

```
CODEN VO-NU BEPA ENPA GENS SPEC KEY WORDS------------ AUTHORS---------- YEAR

XARRA 304-- 1    6    meli offi odhe, nutr valu forag urness,pj; neff,/ 1975

XFRMA 158-- 1    35   meli offi rang mgmt & ecol basi clary,wp          1975
*****                      ****
JWMAA 39--4 670  673  meli ---- odhe, nutr cont diets urness,pj; neff,/ 1975


CODEN VO-NU BEPA ENPA GENS SPEC KEY WORDS------------ AUTHORS---------- YEAR

BOREA 40--3 347  394  ment pipe pred minrl nutr stats vanden driessche, 1974


CODEN VO-NU BEPA ENPA GENS SPEC KEY WORDS------------ AUTHORS---------- YEAR

JWMAA 10--1 12   17   menz pilo nutr cont winter food treichler,r; sto/ 1946


CODEN VO-NU BEPA ENPA GENS SPEC KEY WORDS------------ AUTHORS---------- YEAR

JRMGA 29--4 344  345  mert cili cal cont subalpn plnt anderson,dc; armi 1976


CODEN VO-NU BEPA ENPA GENS SPEC KEY WORDS------------ AUTHORS---------- YEAR

TAEBA 461-- 1    63   mimo frag comp,util of rang veg fraps,gs; cory,vl 1940


CODEN VO-NU BEPA ENPA GENS SPEC KEY WORDS------------ AUTHORS---------- YEAR

JAPEA 11--2 489  497  mira line bibi,tropic ecolgy of peden,dg; vandyn/ 1974


CODEN VO-NU BEPA ENPA GENS SPEC KEY WORDS------------ AUTHORS---------- YEAR

XARRA 304-- 1    6    mona odor odhe, nutr valu forag urness,pj; neff,/ 1975


CODEN VO-NU BEPA ENPA GENS SPEC KEY WORDS------------ AUTHORS---------- YEAR

JAFCA 23--3 464  467  morc angu aa comp morel  mushrm mckellar,rl; kohr 1975
*****                      ****
MGLHA 65--4 476  478  morc coni Se,Hg cont edibl mush stijve,t; cardina 1974
*****                      ****
                      morc spp. cont on the next page
```

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JAFCA	23--3	464	467	morc	cras	aa comp morel mushrm	mckellar,rl; kohr	1975
*****					****			
JAFCA	23--3	464	467	morc	deli	aa comp morel mushrm	mckellar,rl; kohr	1975
*****					****			
JAFCA	23--3	464	467	morc	escu	aa comp morel mushrm	mckellar,rl; kohr	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JAGRA	69--1	33	46	moru	alba	chem comp wld feedstu	king,tr; mcclure	1944
*****					****			
TAEBA	461--	1	63	moru	micr	comp,util of rang veg	fraps,gs; cory,vl	1940
*****					****			
BOGAA	94---	381	393	moru	rubr	minrl & nitrogen cont	mchargue,js; roy,	1932
JWMAA	33--4	1028	1031	moru	rubr	ovrstry on brows qual	halls,lk; epps,ea	1969

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	39--4	670	673	muhl	mont	odhe, nutr cont diets	urness,pj; neff,/	1975
XFRMA	158--	1	35	muhl	mont	rang mgmt & ecol basi	clary,wp	1975
*****					****			
JAPEA	11--2	489	497	muhl	----	bibi,tropic ecolgy of	peden,dg; vandyn/	1974
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
BOREA	40--3	347	394	musa	acum	pred minrl nutr stats	vanden driessche,	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--1	63	65	myos	alpe	effct 2,4-D on digstb	thilenius,jf; bro	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	4---3	315	325	myri	aspl	mon var deer food nut	hellmers,h	1940
WUAPA	14---	1	27	myri	aspl	minrl cont, ntv pl,wi	gerloff,gc; moor/	1964
*****					****			

myri spp. cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JAGRA	69--1	33	46	myri	ceri	chem comp wld feedstu	king,tr; mcclure,	1944
JFUSA	55--5	342	347	myri	ceri	burnng & brow quality	lay,dw	1957
JRMGA	9---3	142	145	myri	ceri	apparnt digstb lignin	smith,ad; turner/	1956
JRMGA	40--2	283	289	myri	ceri	nutr qual of digst of	short,hl; epps,ea	1976
LATBA	488--	1	18	myri	ceri	plnt nutr valu & rang	campbell,rs; epp/	1954
PCGFA	10---	53	58	myri	ceri	deer nutr in sou pine	lay,dw	1956
*****					****			
JWMAA	38--4	875	879	myri	gale	leti,nutr cont & food	lindlof,b; linds/	1976
PLSOA	45--1	17	26	myri	gale	esstl nutr elemt frst	langille,wm; macl	1976
*****					****			
JAGRA	69--1	33	46	myri	pens	chem comp wld feedstu	king,tr; mcclure,	1944
PLSOA	45--1	17	26	myri	pens	esstl nutr elemt frst	langille,wm; macl	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JANSA	41--2	601	609	myro	exal	nutr valu aquat plnts	linn,jg; staba,e/	1975
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JAGRA	60-10	627	636	nemo	mucr	chem comp frst fruits	wainio,ww	1941
WUAPA	14---	1	27	nemo	mucr	minrl cont of plnt wi	gerloff,gc; moor/	1964

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
NCANA	101-1	291	305	neph	arct	alal,brows minrl comp	kubota,j	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
AZATA	113--	1	17	noli	macr	comp arizona forages	catlin,cn	1925
*****					****			
TAEBA	461--	1	63	noli	micr	comp,util texas fdstf	fraps,gs	1947
*****					****			
TAEBA	461--	1	63	noli	texa	comp,util of rang veg	fraps,gs; cory,vl	1940

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JANSA	41--2	601	609	nuph	vari	nutr valu aquat plnts	linn,jg; staba,e/	1975
*****					****			
NCANA	101-1	291	305	nuph	----	alal,brows minrl comp	kubota,j	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JANSA	41--2	601	609	nymp	tube	nutr valu aquat plnts	linn,jg; staba,e/	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JANSA	36--4	792	796	nyss	sylv	digst southn brow tis	short,hl; blair,/	1973
JFUSA	55--5	342	347	nyss	sylv	burnng & brows qualit	lay,dw	1957
JWMAA	38--2	197	209	nyss	sylv	fibr comp & forag dig	short,hl; blair,/	1974
PCGFA	10---	53	58	nyss	sylv	deer nutr in sou pine	lay,dw	1956
PCGFA	28---	574	580	nyss	sylv	odvi,qual deer forage	towry,rk,jr; mic/	1974
XFPSA	51---	1	35	nyss	sylv	seas nutr dist in pln	blair,rm; epps,ea	1969
XFPSA	111--	1	10	nyss	sylv	od--,comp & digs brow	short,hl; blair,/	1975
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JAPEA	11--2	489	497	oeno	----	bibi,tropic ecolgy of	peden,dg; vandyn/	1974
XARRA	304--	1	6	oeno	----	odhe,nutr valu forage	urness,pj; neff,/	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	30--3	206	209	opun	enge	odhe,food habt gras-s	short,hl	1977
*****					****			
JRMGA	30--3	206	209	opun	fulg	odhe,food habt gras-s	short,hl	1977
*****					****			
JAPEA	11--2	489	497	opun	poly	bibi,tropic ecolgy of	peden,dg; vandyn/	1974
*****					****			
JRMGA	30--3	206	209	opun	spin	odhe,food habt gras-s	short,hl	1977
*****					****			
JWMAA	35--3	469	475	opun	----	odvi,odhe, nutr intak	urness,pj; green/	1971

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
UAXBA	342--	1	66	orth	lute	nutri cont sheep diet	cook,cw; harris,l	1950

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	28--5	419	421	oryz	aspe	odhe, in vitro consti	uresk,dw; dietz,/	1975
*****					****			
JAPEA	11--2	489	497	oryz	hyme	bibi,tropic ecolgy of	peden,dg; vandyn/	1974
JWMAA	35--4	681	688	oryz	hyme	ceel, in vitro digstb	ward,al	1971

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
WUAPA	14---	1	27	osmo	clay	minrl cont of plnt wi	gerloff,gc; moor/	1964
*****					****			
NUABA	197--	1	38	osmo	occi	phenol vs comp plnt &	robertson,jh; tor	1958
UAXBA	342--	1	66	osmo	occi	nutri cont sheep diet	cook,cw; harris,l	1950

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
BMAEA	171--	1	39	ostr	virg	autmnl migr of nitrog	murneek,ae; logan	1932

ostr virg cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JAGRA	66--9	1349	355	ostr	virg	prot of var tree seed	lund,ap; sandstro	1943
JWMAA	15--4	352	357	ostr	virg	comp plnt eat by deer	gastler,gf; moxo/	1951
JWMAA	40--2	283	289	ostr	virg	nutr qual of digst of	short,hl; epps,ea	1976
WUAPA	14---	1	27	ostr	virg	minrl cont of plnt wi	gerloff,gc; moor/	1964

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	9---3	142	145	oxyd	arbo	apparnt digstb lignin	smith,ad; turner/	1956
JWMAA	35--4	668	673	oxyd	arbo	nutr valu sourwood lf	harshbarger,tj; m	1971

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--5	356	363	oxyt	----	maj plnt toxicty w us	james,lf; johnson	1976
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	26--6	423	426	pani	----	pine ovrstr,herb qual	wolters,gl	1973
JWMAA	38--2	197	209	pani	----	fibr comp & forag dig	short,hl; blair,/	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
AZATA	113--	1	17	park	----	compo arizona forages	catlin,cn	1925

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	36--3	913	923	parm	----	rata,food habit of ne	bergerud,at	1972

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	35--2	221	231	part	quin	cellulos digst & comp	torgerson,o; pfan	1971
JWMAA	38--1	20	31	part	quin	odvi, <u>in vitro</u> digstb	snider,cc; asplun	1974
*****					****			
WUAPA	14---	1	27	part	vita	minrl cont of plnt wi	gerloff,gc; moor/	1964

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	26--6	423	426	pasp	----	pine ovrstr,herb qual	wolters,gl	1973

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	37--3	279	287	pelg	----	alal,non-brow food to	leresche,re; davi	1972

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CJBOA	51--1	2037	2046	pens	leon	minrl comp graslnd sp	harner,rf; harper,	1973
*****					****			
JRMGA	29--4	344	345	pens	whip	cal cont subalpn plnt	anderson,dc; armi	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
NEXAA	561--	1	33	pere	nana	chem comp forage spp	nelson,ab; herbe/	1970
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--1	63	65	peri	gair	effct 2,4-D on digstb	thilenius,jf; bro	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JFUSA	55--5	342	347	pers	borb	burnng & brows qualit	lay,dw	1957
PCGFA	10---	53	58	pers	borb	od nutr in south pine	lay,dw	1956
*****					****			
JRMGA	9---3	142	145	pers	----	apparnt digstb lignin	smith,ad; turner/	1956

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
NOSCA	49--4	183	189	phal	arun	littrfall douglas-fir	rickard,wh	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
BOREA	40--3	347	394	phas	----	pred minrl nutr stats	vanden driessche,	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	40--2	301	307	phle	prat	doca odvi, in vit dig	palmer,wl; cowan/	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ECOLA	43--4	753	757	phyl	caer	caloric & lipid conte	bliss,lc	1962

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ECOLA	57--2	367	373	phys	malv	seasn & diurnal water	cline,rg; campbel	1976
*****					****			
WAEBA	184-9	1	21	phys	pube	forag plnt & chem com	mccreary,oc	1931

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	38--1	20	31	phyt	amer	odvi, in vitro digstb	snider,cc; asplun	1974
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ABSZA	29--4	1	196	pice	abie	trace elemts in plnts	lounamaa,j	1956
BOREA	40--3	347	394	pice	abie	pred minrl nutr stats	vanden driessche,	1974
*****					****			
CNRDA	28--5	249	271	pice	enge	alal, for succ on nut	cowan,imct; hoar/	1950
ECOLA	34--4	786	793	pice	enge	nutr cont leaf litter	daubenmire,v	1953
FRCRA	41--2	222	236	pice	enge	forag nutr cont conif	beaton,jd; moss,a	1965
*****					****			
BOREA	40--3	347	394	pice	glau	pred minrl nutr stats	vanden driessche,	1974
CJBOA	51--2	421	427	pice	glau	trace elemt cont soil	doyle,p; fletche/	1973
CJFRA	5---4	640	648	pice	glau	fert & nut-grwth rela	phu,td; gagnon,jd	1975
CJFRA	5---4	655	661	pice	glau	littr fall after fire	grigal,df; mccoll	1975
JWMAA	30--4	729	735	pice	glau	seas food & wint diet	ellison,l	1966
JWMAA	41--2	330	331	pice	glau	alal, volc & tree ash	franzmann,aw	1977
PLSOA	45--1	17	26	pice	glau	esstl nutr elemt frst	langille,wm; macl	1976
WUAPA	14---	1	27	pice	glau	minrl cont of plnt wi	gerloff,gc; moor/	1964
*****					****			
BOREA	40--3	347	394	pice	mari	pred minrl nutr stats	vanden driessche,	1974
CJFRA	5---4	655	661	pice	mari	littr fall after fire	grigal,df; mccoll	1975
JWMAA	30--4	729	735	pice	mari	seas food & wint diet	ellison,l	1966
JWMAA	41--2	330	331	pice	mari	alal, volc & tree ash	franzmann,aw	1977
PLSOA	45--1	17	26	pice	mari	esstl nutr elemt frst	langille,wm; macl	1976
WUAPA	14---	1	27	pice	mari	minrl cont of plnt wi	gerloff,gc; moor/	1964
*****					****			
SJECA	6---3	211	215	pice	obov	ash comp in taiga frs	firsova,vp; pavlo	1975
*****					****			
MLTBB	63---	1	21	pice	rube	var foliar nutri conc	schomaker,ce	1973
NFGJA	14--1	76	78	pice	rube	minrl cont deer brows	bailey,ja	1967
PLSOA	45--1	17	26	pice	rube	esstl nutr elemt frst	langille,wm; macl	1976
*****					****			
FRCRA	41--2	222	236	pice	sitc	forag nutr cont conif	beaton,jd; moss,a	1965
JFUSA	49...	914	915	pice	sitc	littrfall & foli nutr	tarrant,rf; issa/	1951
*****					****			
CNDRA	73--4	437	443	pice	----	grouse, nutri aspects	pendergast,ba; bo	1971
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ECOLA	34--4	786	793	pins	albi	nutr cont leaf litter	daubenmire,r	1953
*****					****			
BOREA	40--3	347	394	pins	bank	pred minrl nutr stats	vanden driessche,	1974
CJBOA	38--3	313	333	pins	bank	chlorophyll cont plnt	bray,jr	1960
CJFRA	4---3	381	398	pins	bank	jack pine N fertiliza	weetman,gf; algar	1974
CJFRA	5---4	655	661	pins	bank	littr fall after fire	grigal,df; mccoll	1975
ECOLA	51--6	1094	1097	pins	bank	caloric val of P. vir	madgwick,hai	1970
JWMAA	31--3	448	454	pins	bank	cedar, jack pine brws	ullrey,de; youat/	1967
JWMAA	36--1	80	87	pins	bank	chem jack pine needle	gurchinoff,s; rob	1972
WUAPA	14---	1	27	pins	bank	minrl cont of plnt wi	gerloff,gc; moor/	1964
*****					****			
CAFGA	41--2	145	155	pins	cemb	crude prot var browse	bissell,hd; stron	1955
*****					****			
ECOLA	51--6	1094	1097	pins	clau	caloric val of P. vir	madgwick,hai	1970
*****					****			
CNDRA	73--4	437	443	pins	cont	grouse, nutri aspects	pendergast,ba; bo	1971
CNRDA	28--5	249	271	pins	cont	alal, frst succ, nutr	cowan,imct; hoar/	1950
ECOLA	51--6	1094	1097	pins	cont	caloric val of P. vir	madgwick,hai	1970
FRCRA	41	222	236	pins	cont	forag nutr cont conif	beaton,jd; moss,/	1965
FRCRA	44--4	28	31	pins	cont	prot, cal cont lodg p	boag,da; kiceniuk	1968
JFUSA	49...	914	915	pins	cont	littrfall & foli nutr	tarrant,rf; issa/	1951
*****					****			
BOREA	40--3	347	394	pins	ctla	pred minrl nutr stats	vanden driessche,	1974
ECOLA	34--4	786	793	pins	ctla	nutr cont leaf litter	daubenmire,r	1953
*****					****			
JAGRA	69--1	33	46	pins	echi	chem comp wld feedstu	king,tr; mcclure,	1964
JANSA	36--4	792	796	pins	echi	digst southn brow tis	short,hl; blair,/	1973
JWMAA	35--2	221	231	pins	echi	cellulos digst & comp	torgerson,o; pfan	1971
JWMAA	38--1	20	31	pins	echi	odvi, in vitro digstb	snider,cc; asplun	1974
JWMAA	38--2	197	209	pins	echi	fibr comp & forag dig	short,hl; blair,/	1974
JWMAA	40--2	283	289	pins	echi	nutr qual of digst of	short,hl; epps,ea	1976
LATBA	488--	1	18	pins	echi	plnt nutr valu & rang	campbell,rs; epp/	1954
SOSCA	43---	348	355	pins	echi	comp frst tree litter	coile,ts	1937

pins echi cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
XFPSA	111--	1	10	pins	echi	od, comp & digst brws	short,hl; blair,/	1975
*****					****			
BOREA	40--3	347	394	pins	elli	pred minrl nutr stats	vanden driessche,	1974
ECOLA	51--6	1094	1097	pins	elli	caloric val of P. vir	madgwick,hai	1970
FOSCA	9---4	461	469	pins	elli	slash pine in sand cu	mcgee,c	1963
JRMGA	26--6	423	426	pins	elli	pne ovrstr, herb qual	wolters,gl	1973
*****					****			
JWMAA	36--2	595	605	pins	lamb	odhe, forest manip on	lawrence,g; biswe	1972
*****					****			
ECOLA	34--4	786	793	pins	mont	nutr cont leaf litter	daubenmire,v	1953
ECOLA	57--2	367	373	pins	mont	seasn & diurnal water	cline,rg; campbel	1976
JFUSA	49...	914	915	pins	mont	littrfall & foli nutr	tarrant,rf; issa/	1951
*****					****			
BOREA	40--3	347	394	pins	nigr	pred minrl nutr stats	vanden driessche,	1974
ECOLA	51--6	1094	1097	pins	nigr	caloric val of P. vir	madgwick,hai	1970
*****					****			
BOREA	40--3	347	394	pins	nrca	pred minrl nutr stats	vanden driessche,	1974
*****					****			
JAPEA	13--3	955	966	pins	nrma	N supp & nutrn uptake	miller,hg; mille/	1976
*****					****			
JAGRA	69--1	33	46	pins	palu	chem comp wld feedstu	king,tr; mcclure,	1964
JRMGA	26--6	423	426	pins	palu	pne ovrstr, herb qual	wolters,gl	1973
JWMAA	40--2	283	289	pins	palu	nutr qual of digst of	short,hl; epps,ea	1976
LATBA	488--	1	18	pins	palu	plnt nutr valu & rang	campbell,rs; epp/	1954
*****					****			
ECOLA	34--4	786	793	pins	pond	nutr cont leaf litter	daubenmire,v	1953
JAGRA	69--1	33	46	pins	pond	chem comp wld feedstu	king,tr; mcclure,	1964
JFUSA	49...	914	915	pins	pond	littrfall & foli nutr	tarrant,rf; issa/	1951
JRMGA	29--5	356	363	pins	pond	maj plnt toxicity wUS	james,lf; johnson	1976
JWMAA	15--4	352	357	pins	pond	comp plnt eat by deer	gastler,gf; moxo/	1951
JWMAA	36--2	595	605	pins	pond	odhe, forest manip on	lawrence,g; biswe	1972
XARRA	304--	1	6	pins	pond	odhe, nutr valu forag	urness,pj; neff,/	1975
XFRMA	158--	1	35	pins	pond	rang mgmt & ecol basi	clary,wp	1975
*****					****			

pins spp. cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
BOREA	40--3	347	394	pins	radi	pred minrl nutr stats	vanden driessche,	1974
*****					****			
BOREA	40--3	347	394	pins	resi	pred minrl nutr stats	vanden driessche,	1974
CJFRA	5---4	655	661	pins	resi	littr fall after fire	grigal,df; mccoll	1975
FRSTA	37--1	87	94	pins	resi	var comp red pine lf	madgwick,hai	1964
WUAPA	14---	1	27	pins	resi	minrl cont of plnt wi	gerloff,gc; moor/	1964
*****					****			
AJBOA	61--7	749	753	pins	rigi	lf nutr var Q.alba,Q.	woodwell,gm	1974
PCGFA	28---	574	580	pins	rigi	odvi,qual deer forage	towry,rk,jr; mic/	1974
*****					****			
SJECA	6---3	211	215	pins	sibe	ash comp in taiga frs	firsova,vp; pavlo	1975
*****					****			
ECOLA	42--3	581	5841	pins	silv	engy valu ecol matter	golley,fb	1961
SJECA	6---3	211	215	pins	silv	ash comp in taiga frt	firsova,vp; pavlo	1975
*****					****			
BOREA	40--3	347	394	pins	stro	pred minrl nutr stats	vanden driessche,	1974
CJFRA	5---4	655	661	pins	stro	littr fall after fire	grigal,df; mccoll	1975
ECOLA	51--6	1094	1097	pins	stro	caloric valu of P vir	madgwick,hai	1970
NFGJA	14--1	76	78	pins	stro	minrl cont deer brows	bailey,ja	1967
WUAPA	14---	1	27	pins	stro	minrl cont of plnt wi	gerloff,gc; moor/	1964
*****					****			
ABSZA	29--4	1	196	pins	sylv	trace elemts in plnts	lounamaa,j	1956
BOREA	40--3	347	394	pins	sylv	pred minrl nutr stats	vanden driessche,	1974
ECOLA	51--6	1094	1097	pins	sylv	caloric valu of P vir	madgwick,hai	1970
ELPLB	23--4	637	648	pins	sylv	methd study frst ecol	stachurski,a; zim	1975
*****					****			
BOREA	40--3	347	394	pins	taed	pred minrl nutr stats	vanden driessche,	1974
JAGRA	69--1	33	46	pins	taed	chem comp wld feedstu	king,tr; mcclure,	1944
JANSA	36--4	792	796	pins	taed	digstb south brow tis	short,hd; blair,/	1973
JFUSA	55--5	342	347	pins	taed	burnng & brows qualit	lay,dw	1957
JWMAA	35--4	698	706	pins	taed	deer,forag digst,diet	short,hl	1971
JWMAA	38--2	197	209	pins	taed	fibr comp & forag dig	short,hl; blair,/	1974

pins taed cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
LATBA	488--	1	18	pins	taed	plnt nutr valu & rang	campbell,rs; epp/	1954
NFGJA	14--1	76	78	pins	taed	minrl cont deer brows	imperil ag bureau	1947
PCGFA	10---	53	58	pins	taed	deer nutr in sou pine	lay,dw	1956
PCGFA	21---	57	62	pins	taed	grwth,forag qual brow	blair,rm; epps,ea	1969
SOSCA	43---	349	355	pins	taed	comp frst tree littrs	coile,ts	1937
SSSJD	40--1	116	119	pins	taed	frst floor charac of,	van lear,dh; goeb	1976
SSSJD	40--4	582	585	pins	taed	nutr prob Pinus taeda	maccarthy,r; dave	1976
XFPSA	111--	1	10	pins	taed	od--,comp & digs brow	short,hl; blair,/	1975
*****					****			
BOREA	40--3	347	394	pins	virg	pred minrl nutr stats	vanden driessche,	1974
ECOLA	51--6	1094	1097	pins	virg	caloric valu of P vir	madgwick,hai	1970
*****					****			
JRMGA	9---3	142	145	pins	----	apparnt digstb lignin	smith,ad; turner/	1956

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ATRLA	18--3	81	91	plan	majo	caca,intak,digst feed	drozdz,a; osiecki	1973
*****					****			
JAPEA	11--2	489	497	plan	purs	bibi,tropic ecolgy of	peden,dg; vandyn/	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
BOGAA	94---	381	393	plat	occi	minrl & nitrogen cont	mchargue,js; roy,	1932
JWMAA	49--2	283	289	plat	occi	nutr qual of digst of	short,hl; epps,ea	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
SJECA	6---3	211	215	pleu	schr	ash comp in taiga frs	firsova,vp; pavlo	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	20--3	179	180	poa	cusi	gross engy alpn plnts	smith,dr	1967
*****					****			

poa spp. cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CJBOA	51-11	2037	2046	poa	fend	minrl comp graslnd sp	harner,rf; harper	1973
JRMGA	30--2	122	127	poa	fend	odvi,odhe, habt evalu	wallmo,oc; carpe/	1977
*****					****			
ECOLA	43--4	753	757	poa	fern	caloric & lipid cont	bliss,lc	1962
*****					****			
JRMGA	20--3	179	180	poa	patt	gross engy alpn plnts	smith,dr	1967
*****					****			
JRMGA	20--3	179	180	poa	rupi	gross engy apln plnts	smith,dr	1967
*****					****			
CJBOA	51-11	2037	2046	poa	sand	minrl comp graslnd sp	harner,rf; harper	1973
*****					****			
JRMGA	29--1	63	65	poa	----	effct 2,4-D on digstb	thilenius,rf; bro	1976
XARRA	304--	1	6	poa	----	odhe,nutr valu forage	urness,pj; neff,/	1975
XFRMA	158--	1	35	poa	----	rang mgmt & ecol basi	clary,wp	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CJBOA	51--2	421	427	poly	alas	trace elemt cont soil	doyle,p; fletche/	1973
*****					****			
XARRA	304--	1	6	poly	avic	odhe,nutr valu forage	urness,pj; neff,/	1975
*****					****			
JANSA	44--3	389	394	poly	conv	prox, minrl & aa comp	harrold,rl; nalew	1977
NDFRA	32--1	15	17	poly	conv	prox & aa analy ergot	harrold,rl; nalew	1974
*****					****			
JRMGA	29--5	356	363	poly	fago	maj plnt toxicty w us	james,lf; johnson	1976
*****					****			
ECOLA	15--6	821	827	poly	pens	forag nutr & papat of	marten,gc; anders	1975
*****					****			
ECOLA	43--4	753	757	poly	vivi	caloric & lipid cont	bliss,lc	1962

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JECOA	64--3	965	974	poys	muni	red alder stand, nutr	turner,j; cole,d/	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ECOLA	43--4	753	757	poyt	juni	caloric & lipid cont	bliss,lc	1962
*****					****			
ECOLA	43--4	753	757	poyt	pili	caloric & lipid cont	bliss,lc	1962
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
BOREA	40--3	347	394	popu	delt	pred minrl nutr stats	vanden driessche,	1974
NCANA	101-1	291	305	popu	delt	alal, brow minrl comp	kubota,j	1974
WUAPA	14---	1	27	popu	delt	minrl cont of plnt wi	gerloff,gc; moor/	1964
*****					****			
JWMAA	28--4	791	797	popu	gran	digst cedar,aspn brow	ullrey,de; youat/	1964
JWMAA	35--4	732	743	popu	gran	limit wintr brows wtd	ullrey,de; youat/	1971
JWMAA	36--3	885	891	popu	gran	odvi,est meta aspn br	ullrey,de; youat/	1972
PLSOA	45--1	17	26	popu	gran	esstl nutr elemt frst	langille,wm; macl	1976
WUAPA	14---	1	27	popu	gran	minrl cont of plnt wi	gerloff,gc; moor/	1964
*****					****			
ABSZA	29--4	1	196	popu	trem	trace elemts in plnts	lounamaa,j	1956
*****					****			
CJBOA	38--3	313	333	popu	treu	chlorophyll cont plnt	bray,jr	1960
CJFRA	5---4	626	639	popu	treu	littrfall & cyclng AL	van cleve,k; noon	1975
CJFRA	5---4	655	661	popu	treu	littr fall after fire	grigal,df; mccoll	1975
CNAPA	769--	1	60	popu	treu	chem comp nativ plnts	clarke,se; tisdal	1945
CNRDA	28--5	249	271	popu	treu	alal,frst succ on nut	cowan,imct; hoar/	1950
CPLSA	42--1	105	115	popu	treu	chem comp rang forage	johnston,a; bezea	1962
CPLSA	42--4	692	697	popu	treu	in vitro digst rang p	bezeau,lm; johnst	1962
CPLSA	46--6	625	631	popu	treu	silica,prot cont prai	bezeau,lm; johns/	1966
ECOLA	34--4	786	793	popu	treu	nutr cont leaf litter	daubenmire,v	1953
ECOLA	47--2	222	229	popu	treu	selec nutr deer brows	short,hl; dietz,/	1966
JANSA	26--5	1169	1174	popu	treu	botan nutr cont diets	cook,cw; stoddar/	1967
JWMAA	4---3	315	325	popu	treu	mon var deer food nut	hellmers,h	1940
JWMAA	15--4	352	357	popu	treu	comp plnt eat by deer	gastler,gf; moxo/	1951
JWMAA	34--2	475	478	popu	treu	seas var nutr aspen f	tew,rk	1970
JWMAA	34--3	565	569	popu	treu	herb brows minrl comp	kubota,j; reiger/	1970
JWMAA	37--3	279	287	popu	treu	alal,non-brow food to	leresche,re; davi	1972
JWMAA	38--3	517	524	popu	treu	odvi,nutr cont brows	abell,dh; gilbert	1974
JWMAA	38--4	875	879	popu	treu	hare,nutr cont & food	lindlof,b; linds/	1974
JWMAA	39--4	670	673	popu	treu	odhe, nutr cont diets	urness,pj; neff,/	1975
JWMAA	41--1	144	147	popu	treu	hare,wintr brows nutr	walski,tw; mautz,	1977
NCANA	101-1	291	305	popu	treu	alal,brows minrl comp	kubota,j	1974
PLSOA	45--1	17	26	popu	treu	esstl nutr elemt frst	langille,wm; macl	1976
UAXBA	305--	1	22	popu	treu	comp summr rang plnts	stoddart,la; grea	1942

popu treu cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
UAXBA	472--	1	55	popu	treu	nutr valu seas ranges	cook,cw; harris,l	1968
*****					****			
CNRDA	28--5	249	271	popu	tric	alal,frst succ on nut	cowan,imct; hoar/	1950
NOSCA	49--4	183	189	popu	tric	littrfall douglas-fir	rickard,wh	1975
*****					****			
WAEBA	184-9	1	21	popu	----	forag plnt & chem com	mccreary,oc	1931

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JANSA	41--2	601	609	pota	ampl	nutr valu aquat plnts	linn,jg; staba,e/	1975
NCANA	101-1	291	305	pota	ampl	alal,brows minrl comp	kubota,j	1974
*****					****			
NCANA	101-1	291	305	pota	epih	alal,brows minrl comp	kubota,j	1974
*****					****			
JANSA	41--2	601	609	pota	pect	nutr valu aquat plnts	linn,jg; staba,e/	1975
*****					****			
JANSA	41--2	601	609	pota	rich	nutr valu aquat plnts	linn,jg; staba,e/	1975
NCANA	101-1	291	305	pota	rich	alal,brows minrl comp	kubota,j	1974
*****					****			
NCANA	101-1	291	305	pota	robi	alal,brows minrl comp	kubota,j	1974
*****					****			
NCANA	101-1	291	305	pota	zost	alal,brows minrl comp	kubota,j	1974
*****					****			
NCANA	101-1	291	305	pota	----	alal,brows minrl comp	kubota,j	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--1	63	65	pote	dive	effct 2,4-D on digstb	thilenius,jf; bro	1976
*****					****			
JRMGA	29--1	63	65	pote	grac	effct 2,4-D on digstb	thilenius,jf; bro	1976
*****					****			
ECMOA	34--4	321	357	pote	trid	engy relatn apln plnt	hadley,eb; bliss,	1964
ECOLA	43--4	753	757	pote	trid	caloric & lipid cont	bliss,lc	1962
*****					****			
XARRA	304-1	1	6	pote	----	odhe,nutr valu forage	urness,pj; neff,/	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
TAEBA	461--	1	63	pros	chil	comp,util of rang veg	fraps,gs; cory,vl	1940
*****					****			

pros spp. cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	30--2	119	121	pros	juli	odhe,digst deer forag	arness,pj; smith/	1977
JRMGA	30--3	206	209	pros	juli	odhe,rood habt gras-s	short,hl	1977
NEXAA	561--	1	33	pros	juli	chem comp forage spp	nelson,ab; herbe/	1970
*****					****			
AZATA	113--	1	17	pros	velu	comp of arizona forag	catlin,cn	1925
JWMAA	35--3	469	475	pros	velu	odvi,odhe, nutr intak	urness,pj; green/	1971
*****					****			
TAEBA	461--	1	63	pros	----	comp,util texas fdstf	fraps,gs	1947

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JANSA	36--4	792	796	prun	amer	digstb south brow tis	short,hl; blair,/	1973
JWMAA	38--2	197		prun	amer	fibr comp & forag dig	short,hl; blair,/	1974
XFPSA	111--	1	10	prun	amer	od--,comp & digs brow	short,hl; blair,/	1975
*****					****			
CAFGA	41--2	145	155	prun	ande	crude prot var browse	bissell,hd; stron	1955
*****					****			
UAXBA	342--	1	66	prun	demi	nutr cont sheep diets	cook,cw; harris,l	1950
*****					****			
CAFGA	39--2	163	175	prun	emar	nutr valu forag plnts	hagen,hl	1953
CAFGA	41--2	145	155	prun	emar	crude prot var browse	bissell,hd; stron	1955
*****					****			
JWMAA	38--4	792	798	prun	fasc	anam, nutr summr diet	smith,ad; maleche	1974
*****					****			
CAFGA	41--2	145	155	prun	ilic	crude prot var browse	bissell,hd; stron	1955
*****					****			
JAGRA	69--1	33	46	prun	mari	chem comp wld feedstu	king,tr; mcclure,	1944
*****					****			
CNAPA	769--	1	60	prun	mela	chem comp nativ plnts	clarke,se; tisdal	1945
JWMAA	15--4	352	357	prun	mela	comp plnt eat by deer	gastler,gf; moxo/	1951
UAXBA	305--	1	22	prun	mela	comp summr rang plnts	stoddart,la; grea	1942
*****					****			
TAEBA	461--	1	63	prun	minu	comp,util of rang veg	fraps,gs; cory,vl	1940
*****					****			
NFGJA	14--1	76	78	prun	pens	minrl cont deer brows	bailey,ja	1967
PLSOA	45--1	17	26	prun	pens	esstl nutr elemt frst	langille,wm; macl	1976
*****					****			
BOGAA	94---	381	393	prun	sero	minrl & nitrogen cont	mchargue,js; roy,	1932
NFGJA	14--1	76	78	prun	sero	minrl cont deer brows	bailey,ja	1967

prun sero cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
WUAPA	14---	1	27	prun	sero	minrl cont of plnt wi	gerloff,gc; moor/	1964
*****					****			
CAFGA	41--2	145	155	prun	subc	crude prot var browse	bissell,hd; stron	1955
*****					****			
JANSA	36--4	792	796	prun	umbe	digstb south brow tis	short,hl; blair,/	1973
JWMAA	38--2	197	209	prun	umbe	fibr comp & forag dig	short,hl; blair,/	1974
XFPSA	111--	1	10	prun	umbe	od--,comp & digs brow	short,hl; blair,/	1975
*****					****			
CAFGA	41--2	145	155	prun	virg	crude prot var browse	bissell,hd; stron	1955
JAGRA	62-10	627	636	prun	virg	chem comp frst fruits	wainio,ww	1941
JRMGA	9---3	142	145	prun	virg	apparnt digstb lignin	smith,ad; turner,	1956
JRMGA	10--4	162	164	prun	virg	nutr wintr brows plnt	smith,ad	1957
JRMGA	28--5	419	421	prun	virg	odvi,in vitro constnt	uresk,dw; dietz,/	1975
JRMGA	29--5	356	363	prun	virg	maj plnt toxicty w us	james,lf; johnson	1976
PLSOA	45--1	17	26	prun	virg	esstl nutr elemt frst	langille,wm; macl	1976
*****					****			
NUABA	197--	1	38	prun	vrme	phenol vs comp plnt &	robertson,jh; tor	1958
*****					****			
JWMAA	36--1	174	177	prun	----	odvi,wintr forag qual	segelquist,ca; s/	1972
JWMAA	40--2	301	307	prun	----	odvi,doca,in vitr dig	palmer,wl; cowan/	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--4	344	345	pscy	mont	cal cont subalpn plnt	anderson,dc; armi	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CJFRA	5---4	626	639	pseu	menz	littrfall & cyclng AL	van cleve,k; noon	1975
FRCRA	41--2	222	236	pseu	menz	forag nutr cont conif	beaton,jd; moss,a	1965
JAPEA	13--1	295	301	pseu	menz	nutr distr,cyclng alp	turner,j; singer,	1976
JECOA	64--3	965	974	pseu	menz	red alder stand, nutr	turner,j; cole,d/	1976
JFUSA	49...	914	915	pseu	menz	littrfall & foli nutr	tarrant,rf; issa/	1951
JRMGA	29--6	486	489	pseu	menz	odhe,palat dougls-fir	tucker,re; majak/	1976

pseu menz cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	38--1	32	41	pseu	menz	odhe,plnt charactr &,	radwan,ma; crouch	1974
NOSCA	49--4	183	189	pseu	menz	littrfall douglas-fir	rickard,wh	1975
XFPNA	182--	1	6	pseu	menz	odhe, influ of fert N	radwan,ma; crouc/	1974
*****					****			
CNRDA	28--5	249	271	pseu	taxi	alal,frst succ on nut	cowan,imct; hoar/	1950
*****					****			
ECOLA	34--4	786	793	pseu	tagl	nutr cont leaf litter	daubenmire,v	1953

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JAPEA	11--2	489	497	psor	tenu	bibi,tropic ecolgy of	peden,dg; vandyn/	1974
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JECOA	64--3	965	974	pter	aqui	red alder stand; nutr	turner,j; cole,d/	1976
JWMAA	38--3	517	524	pter	aqui	odvi, nutr cont brows	abell,dh; gilbert	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
TAEBA	461--	1	63	puer	loba	comp,util texas fdstf	fraps,gs	1947

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CAFGA	39--2	163	175	purs	trid	nutr valu forag plnts	hagen,hl	1953
CAFGA	41--1	57	78	purs	trid	natul & art food digs	bissell,hd; harr/	1955
ECOLA	47--2	222	229	purs	trid	selec nutr deer brows	short,hl; dietz,/	1966
JRMGA	5---5	346	353	purs	trid	var chem comp rang pl	blaisdell,jp; wi/	1952
JRMGA	9---3	142	145	purs	trid	apparnt digstb lignin	smith,ad; turner/	1956
JRMGA	30--2	119	121	purs	trid	odhe,digst deer forag	urness,pj; smith/	1977
JRMGA	30--2	122	127	purs	trid	odvi,odhe, habt evalu	wallmo,oc; carpe/	1977
JWMAA	16--3	309	312	purs	trid	digst native forag of	smith,ad	1952
JWMAA	35--4	681	688	purs	trid	ceel,in vitro digestb	ward,al	1971
NUABA	197--	1	38	purs	trid	phenol vs comp plnt &	robertson,jh; tor	1958

purs trid cont on the next page

ODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
PSAFA	1958-	117	122	purs	trid	seas progr chem cont	dietz,dr; udall,/	1958
UAXBA	305--	1	22	purs	trid	comp summr rang plnts	stoddart,la; grea	1942
UAXBA	342--	1	66	purs	trid	nutr cont sheep diets	cook,cw; harris,l	1950
XPNWA	33---	1	6	purs	trid	bitterbrush nutr levl	dealy,je	1966
*****					****			
CAFGA	52--2	68	84	purs	----	wintr obsv on bighorn	mccullogh,dr; sch	1966

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	9---3	142	145	pyrl	pube	apparnt digstb lignin	smith,ad turner/	1956
JWMAA	23--1	81	90	pyrl	pube	avail nutr deer brows	hundley,l	1959

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	37--4	585	587	pyru	angu	caloric & moistr cont	burns,ta viers,e	1973
*****					****			
PLPHA	6---3	519	529	pyru	comm	seas chng in prot & N	mulay,as	1931
*****					****			
BOGAA	94---	381	393	pyru	coro	minrl & nitrogen cont	mchargue,js; roy,	1932
JAGRA	62-10	627	636	pyru	coro	chem comp frst fruits	wainio,ww	1941
*****					****			
MUATA	53---	1	67	pyru	malu	moist,CHO,ash in twig	traub,hp	1927
OJSCA	21--3	89	103	pyru	malu	seas chng & trans CHO	mitra,sk	1921
SZSLA	21---	77	87	pyru	malu	mammal diet in zoo	bilby,lw	1968
*****					****			
PASHA	26---	253	255	pyru	----	N distr in pear trees	lincoln,fb benne	1926
PASHA	27---	207	209	pyru	----	N loss from pear leaf	lincoln,fb	1927
TAEBA	329--	1	59	pyru	----	engy-prod coeff feedg	fraps,gs	1925
XAMPA	369--	1	164	pyru	----	minrl comp crop & soi	beeson,kc	1941
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	40--3	479	483	quer	acut	scni, use of b/w oaks	short,hl	1976
*****					****			
CAFGA	41--2	145	155	quer	agri	crude prot var browse	bissell,hd; stron	1955
*****					****			
AJBOA	61--7	749	753	quer	alba	lf nutr var, Q alba,Q	woodwell,gm	1974
JACSA	39--6	1286	1296	quer	alba	plnt food matrl in lf	serex,pjr	1917
JAGRA	62-10	627	636	quer	alba	chem comp frst fruits	wainio,ww	1941
JAGRA	66--9	349	355	quer	alba	prot of var tree seed	lund,ap; sandstro	1945
JAGRA	69--1	33	46	quer	alba	chem comp wld feedstu	king,tr; mcclure	1944
JFUSA	55--5	342	347	quer	alba	burnng & brows qualit	lay,dw	1957
JWMAA	12--1	1	8	quer	alba	a nutr knwldg shrtcut	atwood,el	1948
JWMAA	19--1	65	70	quer	alba	chng brows nutr value	dewitt,jb: derby	1955
JWMAA	37--4	585	587	quer	alba	caloric & moistr cont	burns,ta; viers,e	1973
JWMAA	40--2	283	289	quer	alba	nutr qual of digst of	short,hl; epps,ea	1976
JWMAA	40--3	479	483	quer	alba	use, blck/whit oak gr	short,hl	1976
PCGFA	10---	53	58	quer	alba	deer nutr in sou pine	lay,dw	1956
SOSCA	43---	349	355	quer	alba	comp frst tree litter	coile,ts	1937
WUAPA	14---	1	27	quer	alba	minrl cont of plnt,wi	gerloff,gc; moor/	1964
*****					****			
WUAPA	14---	1	27	quer	bico	minrl cont of plnt wi	gerloff,gc; moor/	1964
*****					****			
PLSOA	45--1	17	26	quer	bore	esstl nutr elemt frst	langille,wm; macl	1976
*****					****			
TAEBA	245--	1	29	quer	bref	feedg valu of feedstu	fraps,gs	1919
*****					****			
TAEBA	461--	1	63	quer	brev	comp,util of rang veg	fraps,gs; cory,vl	1940
*****					****			
CAEBA	150--	1	21	quer	cali	forag valu of oak lvs	mackie,ww	1903
*****					****			
CAEBA	150--	1	21	quer	chry	forag valu of oak lvs	mackie,ww	1905
CAFGA	41--2	145	155	quer	chry	crude prot var browse	bissell,hd; stron	1955
JWMAA	36--2	595	605	quer	chry	odhe,forest manipu on	lawrence,g; biswe	1972
*****					****			
JAGRA	69--1	33	46	quer	cine	chem comp wld feedstu	king,tr; mcclure	1944
*****					****			
AJBOA	60--7	749	753	quer	cocc	lf nutr var Q alba, Q	woodwell,gm	1974
*****					****			
CAEBA	150--	1	21	quer	doug	forag valu of oak lvs	mackie,ww	1903
CAEBA	627--	1	95	quer	doug	ca foothill plnt mgmt	gorden,a; sampson	1939

quer doug cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CAFGA	41--2	145	155	quer	doug	crude prot var browse	bissell,hd; stron	1945
*****					****			
CAEBA	150--	1	21	quer	dumo	forag valu of oak lvs	mackie,ww	1903
CAFGA	41--2	145	155	quer	dumo	crude prot var browse	bissell,hd; stron	1955
*****					****			
CAFGA	41--2	145	155	quer	dura	crude prot var browse	bissell,hd; stron	1955
CJBOA	38--3	313	333	quer	dura	chlorophyll cont plnt	bray,jr	1960
*****					****			
WUAPA	14---	1	27	quer	elli	minrl cont of plnt wi	gerloff,gc; moor/	1964
*****					****			
AZWBA	3----	34	47	quer	emor	analy impt deer herds	swank,wg	1958
*****					****			
JAGRA	69--1	33	46	quer	falc	chem comp wld feedstu	king,tr; mcclure,	1944
JWMAA	37--4	585	587	quer	falc	caloric & moistr cont	burns,ta; viers,e	1973
JWMAA	40--2	283	289	quer	falc	nutr qual of digst of	short,hl; epps,ea	1976
JWMAA	40--3	479	483	quer	falc	use, blck/whit oak gr	short,hl	1976
*****					****			
JRMGA	9---3	142	145	quer	gamb	apparnt digstb lignin	smith,ad; turner,	1956
JRMGA	10--4	162	164	quer	gamb	nutr wintr brows plnt	smith,ad	1957
JWMAA	39--4	670	673	quer	gamb	odhe, nutr cont diets	urness,pj; neff,/	1975
PLPHA	10--4	739	751	quer	gamb	grwth & seas chng,oak	sampson,aw; samis	1935
PSAFA	1958-	117	122	quer	gamb	seas progr chem cont	dietz,dr; udall,/	1958
XARRA	304--	1	6	quer	gamb	odhe,nutr valu forage	urness,pj; neff,/	1975
XFRMA	158--	1	35	quer	gamb	rang mgmt & ecol basi	clary,wp	1975
*****					****			
CAEBA	150--	1	21	quer	garr	forag valu of oak lvs	mackie,ww	1903
CAFGA	41--2	145	155	quer	garr	crude prot rar browse	bissell,hd; stron	1955
JRMGA	27--2	114	117	quer	garr	odhe,soil & seas frag	krueger,wc; donar	1974
*****					****			
JAGRA	69--1	33	46	quer	harv	chem comp wld feedstu	king,tr; mcclure	1944
*****					****			
JAGRA	62-10	627	636	quer	ilic	chem comp frst fruits	wainio,ww	1941
JAGRA	69--1	33	46	quer	ilic	chem comp wld feedstu	king,tr; mcclure	1944
JWMAA	4---3	315	325	quer	ilic	mon var deer food nut	hellmers,h	1940
PCGFA	28---	574	580	quer	ilic	odvi,qual deer forage	towry,rk,jr; mic/	1974

quer ilic cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
WVAFA	6---1	2	4	quer	ilic	odvi,forag prod & dee	towry,r	1975
*****					****			
JWMAA	40--2	283	289	quer	inca	nutr qual of digst of	short,hl; epps,ea	1976
JWMAA	40--3	479	483	quer	inca	use, blk/white oak gr	short,hl	1976
*****					****			
PLPHA	10--4	739	751	quer	kell	grwth & seas chng,oak	sampson,aw; sami	1935
*****					****			
JWMAA	37--4	585	787	quer	lyra	caloric & moistr cont	burns,ta; vies,e	1973
*****					****			
CJBOA	38--3	313	333	quer	macr	chlorophyll cont plnt	bray,jr	1960
JAGRA	66--9	349	355	quer	macr	prot of var tree seed	lund,ap; sandstro	1943
JWMAA	15--4	352	357	quer	macr	comp plnt eat by deer	gastler,gf; maxol	1951
JWMAA	37--4	585	587	quer	macr	caloric & moistr cont	burns,ta; viers,e	1973
JWMAA	39--2	337	341	quer	macr	odvi,brow comp & digs	robbins,ct; moen,	1975
TAEBA	245--	1	29	quer	macr	feedg valu of feedstu	fraps,gs	1919
WUAPA	14---	1	27	quer	macr	minrl cont of plnt wi	gerloff,gc; moor/	1964
*****					****			
JAGRA	69--1	33	46	quer	mari	chem comp wld feedstu	king,tr; mcclure	1944
JWMAA	37--4	585	587	quer	mari	caloric & moistr cont	burns,ta; viers,e	1973
JWMAA	40--2	283	289	quer	mari	nutr qual of digst of	short,hl; epps,ea	1976
*****					****			
JWMAA	40--2	283	289	quer	mini	nutr qual of digst of	short,hl; epps,ea	1976
*****					****			
TAEBA	245--	1	29	quer	mino	feedg valu of feedstu	fraps,gs	1919
*****					****			
PCGFA	28---	574	580	quer	mont	odvi,qual deer forage	towry,rk,jr; mic/	1974
WVAFA	6---1	2	4	quer	mont	odvi,forag prod & dee	towry,r	1975
*****					****			
JAGRA	69--1	33	46	quer	nigr	chem comp wld feedstu	king,tr; mcclure	1944
JANSA	36--4	792	796	quer	nigr	digstb south brow tis	short,hl; blair,/	1973
JWMAA	34--1	176	182	quer	nigr	mega,nutr wintr food	billingsley,bb; a	1970
JWMAA	36--2	595	605	quer	nigr	deer nutr in sou pine	lay,dw	1956
JWMAA	37--4	585	587	quer	nigr	caloric & moistr cont	burns,ta; viers,e	1973
JWMAA	38--2	197		quer	nigr	fibr comp & forag dig	short,hl; blair,/	1974
JWMAA	40--2	283	289	quer	nigr	nutr qual of digst of	short,hl; epps,ea	1976
JWMAA	40--3	479	483	quer	nigr	use, blk/white oak gr	short,hl	1976
PCGFA	10---	53	58	quer	nigr	burnng & brows qualit	lay,dw	1957
TAEBA	245--	1	29	quer	nigr	feedg valu of feedstu	fraps,gs	1919

quer nigr cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
XFPSA	111--	1	10	quer	nigr	od--,comp & digs brow	short,hl; blair,/	1975
*****					****			
JAGRA	69--1	33	46	quer	nutt	chem comp wld feedstu	king,tr; mcclure,	1944
JWMAA	37--4	585	587	quer	nutt	caloric & moistr cont	burns,ta; viers,e	1973
*****					****			
JWMAA	37--4	585	587	quer	obtu	caloric & moistr cont	burns,ta; viers,e	1973
*****					****			
BOGAA	94---	381	393	quer	palu	minrl & nitrogen cont	mchargue,js; roy,	1932
*****					****			
JECOA	51--3	555	566	quer	petr	N amt in decomps leaf	bocock,kl	1963
OIKSA	25--3	341	352	quer	petr	microb decomp of litt	howard,pja; howar	1974
*****					****			
JANSA	36--4	792	796	quer	phel	digstb south brow tis	short,hl; blair,/	1973
JWMAA	37--4	585	587	quer	phel	caloric & moistr cont	burns,ta; viers,e	1973
JWMAA	38--2	197		quer	phel	fibr comp & forag dig	short,hl; blair,/	1974
JWMAA	40--2	283	289	quer	phel	nutr qual of digst of	short,hl; epps,ea	1976
JWMAA	40--3	479	483	quer	phel	use, blk/white oak gr	short,hl	1976
TAEBA	245--	1	29	quer	phel	feedg valu of feedstu	fraps,gs	1919
XFPSA	111--	1	10	quer	phel	od--,comp & digs brow	short,hl; blair,/	1975
*****					****			
JAGRA	69--1	23	46	quer	phil	chem comp wld feedstu	king,tr; mcclure,	1944
*****					****			
JAGRA	62-10	627	636	quer	prin	chem comp frst fruits	wainio,ww	1941
JWMAA	4---3	315	325	quer	prin	mon var deer food nut	hellmers,h	1940
*****					****			
JAGRA	62-10	627	636	quer	prnu	chem comp frst fruits	wainio,ww	1941
JAGRA	69--1	33	46	quer	prnu	chem comp wld feedstu	king,tr; mcclure,	1944
JWMAA	37--4	585	587	quer	prnu	caloric & moistr cont	burns,ta; viers,e	1973
JWMAA	40--2	283	289	quer	prnu	nutr qual of digst of	short,hl; epps,ea	1976
JWMAA	40--3	479	483	quer	prnu	use, blk/white oak gr	short,hl	1976
*****					****			
ABSZA	29--4	1	196	quer	robu	trace elemts in plnts	lounamaa,j	1956
ECOLA	51--4	565	581	quer	robu	wintr moth feed oaklf	feeny,pp	1970
ELPLB	23--4	637	648	quer	robu	methd study frst ecol	stachurski,a; zim	1975
OIKSA	25--3	341	352	quer	robu	micrb decomp of littr	howard,pja; howar	1974
PYTCA	7....	871	880	quer	robu	seas chng tannin cont	feeny,pp; bostock	1968
PYTCA	8--11	2119	2126	quer	robu	tannin inhib prot hyd	feeny,pp	1969
*****					****			
CJFRA	5---4	655	661	quer	rubr	littr fall after fire	grigal,df; mccoll	1975

quer rubr cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JAGRA	62-10	627	636	quer	rubr	chem comp frst fruits	wainio,ww	1941
JAGRA	66--9	349	355	quer	rubr	prot of var free seed	lund,ap; sandstro	1943
JWMAA	35--2	221	231	quer	rubr	cellulos digst & comp	torgerson,o; pfan	1971
JWMAA	39--2	337	341	quer	rubr	odvi,brow comp & digs	robbins,ct; moen,	1975
JWMAA	38--1	20	31	quer	rubr	odvi, in vitro digstb	snider,cc; asplu	1974
JWMAA	40--3	479	483	quer	rubr	use, blk/white oak gr	short,hl	1976
TAEBA	245--	1	29	quer	rubr	feedg valu of feedstu	fraps,gs	1919
WUAPA	14---	1	27	quer	rubr	minrl cont of plnt wi	gerloff,gc; moor/	1964
WVAFA	6---1	2	4	quer	rubr	odvi,forag prod & dee	towry,r	1975
*****					****			
JWMAA	37--4	585	587	quer	shum	caloric & moistr cont	burns,ta; viers,e	1973
JWMAA	40--2	283	289	quer	shum	nutr qual of digst of	short,hl; epps,ea	1976
*****					****			
JAGRA	69--1	33	46	quer	stel	chem comp wld feedstu	king,tr; mcclure	1944
JWMAA	37--4	585	587	quer	stel	caloric & moistr cont	burns,ta; viers,e	1973
JWMAA	40--2	283	289	quer	stel	nutr qual of digst of	short,hl; epps,ea	1976
JWMAA	40--3	479	483	quer	stel	chem comp wld feedstu	king,tr; mcclure	1944
*****					****			
CAFGA	41--2	145	155	quer	turb	crude prot var browse	bissell,hd; stron	1955
JFUSA	65-12	905	908	quer	turb	deer use crown sprout	reynolds,hg	1967
JWMAA	35--3	469	475	quer	turb	odvi,odhe, nutr intak	urness,pj; green/	1971
NAWTA	21---	141	158	quer	turb	prot, phosphorus cont	swank,wg	1956
*****					****			
BOGAA	94---	381	393	quer	velu	minrl & nitrogen cont	mchargue,js; roy,	1932
JWMAA	37--4	585	587	quer	velu	caloric & moistr cont	burns,ta; viers,e	1973
JWMAA	40--3	479	483	quer	velu	use, blk/white oak gr	short,hl	1976
SOSCA	43---	349	355	quer	velu	comp frst tree litter	coile,ts	1937
WUAPA	14---	1	27	quer	velu	minrl cont of plnt wi	gerloff,gc; moor/	1964
*****					****			
JAGRA	69--1	33	46	quer	virg	chem comp wld feedstu	king,tr; mcclure,	1944
JWMAA	37--4	585	587	quer	virg	caloric & moistr cont	burns,ta; viers,e	1973
JWMAA	40--2	283	289	quer	virg	nutr qual of digst of	short,hl; epps,ea	1976
JWMAA	40--3	479	483	quer	virg	use, blk/white oak gr	short,hl	1976
TAEBA	245--	1	29	quer	virg	feedg valu of feedstu	fraps,gs	1919

quer virg cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
TAEBA	329--	1	59	quer	virg	engy-prod coeff feedg	fraps,gs	1925
TAEBA	461--	1	63	quer	virg	comp,util of rang veg	fraps,gs; cory,vl	1940
TAEMA	384--	1	8	quer	virg	comp rang forag plant	vallentine,jf; yo	1959
*****					****			
CAEBA	150--	1	21	quer	wisl	forag valu of oak lvs	mackie,ww	1903
CAFGA	41--1	57	78	quer	wisl	natul & art food digs	bissell,ha; harr/	1955
CAFGA	41--2	145	155	quer	wisl	crude prot var browse	bissell,hd; stron	1955
JANSA	16--2	476	480	quer	wisl	digst of interior oak	bissell,hd; weir	1957
*****					****			
ATRLA	18--3	81	91	quer	----	caca,intak,digst feed	drozdz,a; osiecki	1973
AZATA	113--	1	17	quer	----	comp of arizona forag	catlin,cn	1925
BMAEA	171--	1	39	quer	----	autmnl migr of nitrog	murneek,ae; logan	1932
CJFRA	5---4	626	639	quer	----	littrfall & cyclng AL	van cleve,k; noon	1975
JAGRA	66--9	349	355	quer	----	prot of var tree seed	lund,ap; sandstro	1943
JWMAA	5---1	108	114	quer	----	odvi,digest capaci of	forbes,eb; marcy/	1941
JWMAA	12--1	1	8	quer	----	a nutr knwldg shrtcut	atwood,el	1948
JWMAA	36--1	174	177	quer	----	odvi,wintr forag qual	segelquist,ca; s/	1972
JWMAA	39--2	321	329	quer	----	odvi,nutr in diff sea	short,hl	1975
PCGFA	21---	34	104	quer	----	deer food nutr analys	thorsland,oa	1966
PCGFA	28---	574	580	quer	----	odvi,qual deer forage	towry,rk,jr; mic/	1974
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--4	344	345	ranu	----	cal cont subalpn plnt	anderson,dc; armi	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CAEBA	627--	1	95	rham	cali	ca foothill plnt mgmt	gorden,a; sampson	1939
CAFGA	41--2	145	155	rham	cali	crude prot var browse	bissell,hd; stron	1955
*****					****			
JWMAA	40--2	283	289	rham	caro	nutr qual of digst of	short,hl; epps,ea	1976
*****					****			
ABSZA	29--4	1	196	rham	fran	trace elemnt in plnts	lounamaa,j	1956
*****					****			
JWMAA	38--1	32	41	rham	purs	odhe, plnt charactr &	radwan,ma; crouch	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ECOLA	43--4	753	757	rhod	lapp	caloric & lipid cont	bliss,lc	1962
*****					****			
ECOLA	12--2	323	333	rhod	maxi	odvi, mt laurel, food	forbes,eb; bechde	1931
JRMGA	9---3	142	145	rhod	maxi	apparnt digstb lignin	smith,ad; turner/	1956
JWMAA	23--1	81	90	rhod	maxi	avail nutr deer brows	hundley,l	1959
PCGFA	21---	34	104	rhod	maxi	deer food nutr analys	thorsland,oa	1966
*****					****			
PCGFA	28---	574	580	rhod	rose	odvi,qual deer forage	towry,rk,jr; mic/	1974
*****					****			
WVAFA	6---1	2	4	rhod	----	odvi,forag prod & dee	towry,r	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
PLSOA	45--1	17	26	rhoo	cana	esstl nutr elemt frst	langille,wm; macl	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ECOLA	49--5	956	961	rhus	arom	cal valu seeds,ne kan	johnson,sr; robel	1968
JWMAA	35--2	221	231	rhus	arom	cellulos digst & comp	torgerson,o; pfan	1971
JWMAA	38--1	20	31	rhus	arom	odvi, in vitro digest	snider,cc; asplun	1974
*****					****			

rhus spp. cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JAGRA	69--1	33	46	rhus	cana	chem comp wld feedstu	king,tr; mcclure,	1944
*****					****			
JAGRA	69--1	33	46	rhus	copa	chem comp wld feedstu	king,tr; mcclure,	1944
JWMAA	35--2	221	231	rhus	copa	cellulos digst & comp	torgerson,o; pfan	1971
JWMAA	38--1	20	31	rhus	copa	odvi, in vitro digstb	snider,cc; asplun	1974
JWMAA	40--2	283	289	rhus	copa	nutr qual of digst of	short,hl; epps,ea	1976
LATBA	488--	1	18	rhus	copa	plnt nutr valu & rang	campbell,rs; epp/	1954
*****					****			
CAEBA	150--	1	21	rhus	dive	forag valu of oak lvs	macki,ww	1903
CAEBA	627--	1	95	rhus	dive	ca foothill plnt mgmt	gorden,a; sampson	1939
CAFGA	41--2	145	155	rhus	dive	crude prot var browse	bissell,hd; stron	1955
*****					****			
ECOLA	49--5	956	961	rhus	glab	cal valu seeds,ne kan	johnson,sr; robel	1968
JAGRA	62-10	627	636	rhus	glab	chem comp frst fruits	wainio,ww	1941
JAGRA	69--1	33	46	rhus	glab	chem comp wld feedstu	king,tr; mcclure,	1944
JWMAA	12--1	1	8	rhus	glab	a nutr knwldg shrtcut	atwood,el	1948
JWMAA	35--2	221	231	rhus	glab	cellulos digst & comp	torgeson,o; pfan	1971
JWMAA	37--4	585	587	rhus	glab	caloric & moistr cont	burns,ta; viers,e	1973
JWMAA	38--1	20	31	rhus	glab	odvi, in vitro digstb	snider,cc; asplun	1974
WUAPA	14---	1	27	rhus	glab	minrl cont of plnt wi	gerloff,gc; moor/	1964
*****					****			
JAGRA	62-10	627	636	rhus	hirt	chem comp frst fruits	wainio,ww	1941
*****					****			
TAEBA	461--	1	63	rhus	micr	comp,util of rang veg	fraps,gs; cory,vl	1940
*****					****			
JWMAA	35--2	221	231	rhus	radi	cellulos digst & comp	torgerson,o; pfan	1971
JWMAA	38--1	20	31	rhus	radi	odvi, in vitro digstb	snider,cc; asplun	1974
*****					****			
CAFGA	41--2	145	155	rhus	tril	crude prot var browse	bissell,hd; stron	1953
TAEBA	461--	1	63	rhus	tril	comp,util of rang veg	fraps,gs; cory,vl	1940
XATBA	943--	1	61	rhus	tril	nutr qual rang forage	savage,da; heller	1947
*****					****			
JWMAA	39--2	337	341	rhus	typh	odvi,brow comp & digs	robbins,ct; moen,	1975
*****					****			
TAEBA	461--	1	63	rhus	vire	comp,util of rang veg	fraps,gs; cory,vl	1940
*****					****			
AZWBA	3----	34	47	rhus	----	analy impt deer herds	swank,wg	1958
PCGFA	21---	34	104	rhus	----	deer food nutr analys	thorsland,oa	1966
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	39--4	670	673	robi	neom	odhe, nutr cont diets	urness,pj; neff,/	1975
XARRA	304--	1	6	robi	neom	odhe, nutr valu forag	urness,pj; neff,/	1975
*****					****			
BMAEA	171--	1	39	robi	pseu	autmnl migr of nitrog	murneek,ae; logan	1932
BOGAA	94---	381	393	robi	pseu	minrl & nitrogen cont	mchargue,js; roy,	1932
JAGRA	69--1	33	46	robi	pseu	chem comp wld feedstu	king,tr; mcclure,	1944
JWMAA	23--1	81	90	robi	pseu	avail nutr deer brows	hundley,l	1959

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ABSZA	29--4	1	196	rosa	acic	trace elemts in plnts	lounamaa,j	1956
*****					****			
XFINA	221--	1	6	rosa	egla	odhe, hi-engy food of	welch,bl; andrus,	1977
*****					****			
WAEBA	184-9	1	21	rosa	fend	forag plnt & chem com	mccreary,oc	1931
*****					****			
JWMAA	10--1	12	17	rosa	humi	nutr cont winter food	treichler,r; sto/	1946
*****					****			
CNAPA	769--	1	60	rosa	maco	chem comp nativ plnts	clarke,se; tisdal	1945
*****					****			
ABSZA	29--4	1	196	rosa	maja	trace elemts in plnts	lounamaa,j	1956
*****					****			
JAGRA	69--1	33	46	rosa	mult	chem comp wld feedstu	king,tr; mcclure,	1944
*****					****			
JAGRA	69--1	33	46	rosa	palu	chem comp wld feedstu	king,tr; mcclure,	1944
*****					****			
JAGRA	69--1	33	46	rosa	rugo	chem comp wld feedstu	king,tr; mcclure,	1944
*****					****			
JWMAA	35--2	221	231	rosa	setg	cellulos digst & comp	torgerson,o; pfan	1971
*****					****			
JWMAA	38--1	20	31	rosa	setr	odvi, in vitro digstb	snider,cc; asplun	1974
*****					****			
UAXBA	305--	1	22	rosa	spal	comp summr rang plnts	stoddart,la; grea	1942
*****					****			
JWMAA	15--4	352	357	rosa	spin	comp plnt eat by deer	gastler,gs; moxo/	1951
*****					****			
CPLSA	42--4	692	697	rosa	wood	in vitr digs rang pln	bezeau,lm; johnst	1962
CPLSA	46--6	625	631	rosa	wood	silica,prot cont prai	bezeau,lm; johns/	1966
*****					****			
XFINA	221--	1	6	rosa	woul	odhe, hi-engy food of	welch,bl; ancrus,	1977
*****					****			
AZWBA	3----	34	47	rosa	----	analy impt deer herds	swank,wg	1958
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
WUAPA	14---	1	27	rubu	alle	minrl cont of plnt wi	gerloff,gc; moor/	1964
*****					****			
ABSZA	29--4	1	196	rubu	arct	brace elemts in plnts	lounamaa,j	1956
*****					****			
JAGRA	62-10	627	636	rubu	bail	chem comp frst fruits	wainio,ww	1941
*****					****			
JWMAA	36--3	913	923	rubu	cham	rata,food habit of ne	bergerud,at	1972
*****					****			
ABSZA	29--4	1	196	rubu	idae	trace elemts in plnts	lounamaa,j	1956
ATRLA	18--3	81	91	rubu	idae	caca,intak,digst feed	drozdz,a; osiecki	1973
JSFAA	27--9	877	882	rubu	idae	comp red raspberry lf	john,mk; daubeny/	1976
*****					****			
JAGRA	62-10	627	636	rubu	occi	chem comp frst fruits	wainio,ww	1941
JWMAA	12--1	1	8	rubu	occi	a nutr knwldg shrtcut	atwood,el	1948
WUAPA	14---	1	27	rubu	occi	minrl cont of plnt wi	gerloff,gc; moor/	1964
*****					****			
NAWTA	11---	309	312	rubu	parv	crud prot detrm & mgt	einarsen,a	1946
*****					****			
ABSZA	29--4	1	196	rubu	saxa	trace elemts in plnts	lounamaa,j	1956
*****					****			
NAWTA	11---	309	312	rubu	spec	crud prot detrm & mgt	einarsen,a	1946
*****					****			
NAWTA	11---	309	312	rubu	viti	crud prot detrm & mgt	einarsen,a	1946
*****					****			
JAGRA	69--1	33	46	rubu	----	chem comp wld feedstu	king,tr; mcclure,	1944
JANSA	36--4	792	796	rubu	----	digstb south brow tis	short,hl; blair,/	1973
JRMGA	9---3	142	145	rubu	----	apparnt digstb lignin	smith,ad; turner/	1956
JWMAA	38--2	197		rubu	----	fibr comp & forag dig	short,hl; blair,/	1974
PCGFA	21---	34	104	rubu	----	deer food nutr analys	thorsland,oa	1966
PCGFA	28---	574	580	rubu	----	odvi,qual deer forage	towry,rk,jr; mic/	1974
XFPSA	111--	1	10	rubu	----	od--, comp & digs brow	short,hl; blair/	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	38--1	20	31	rudb	hirt	odvi, in vitro digstb	snider,cc; asplun	1974
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA *****	27--2	114	117	rume	acet ****	odhe,soil & seas frag	krueger,wc; donar	1974
JANSA	44--3	389	394	rume	cris	prox, minrl & aa comp	harrold,rl; nalew	1975
NDFRA *****	32--1	15	17	rume	cris ****	prox & aa analy ergot	harrold,rl; nalew	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
TAEBA	461--	1	63	saba	----	comp,util texas fdstf	fraps,gs	1947

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JANSA	41--2	601	609	sagi	cune	nutr valu aquat plnts	linn,jg; staba,e/	1975
*****					****			
JANSA	41--2	601	609	sagi	rigi	nutr valu aquat plnts	linn,jg; staba,e/	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CJBOA	51--2	421	427	sali	alax	trace elemt cont soil	doyle,p; fletche/	1973
*****					****			
WUAPA	14---	1	27	sali	amyg	minrl cont of plnt wi	gerloff,gc; moor/	1964
*****					****			
NCANA	101-1	217	226	sali	arbu	alal,nutr valu forage	oldemeyer,jl	1974
*****					****			
JWMAA	32--4	773	777	sali	arct	comp alpn tundra plnt	johnston,a; beza/	1968
*****					****			
CNRDA	28--5	249	271	sali	bebb	alal,frst succ on nut	cowan,imct; hoar/	1950
FOSCA	22--2	195	208	sali	bebb	seas dynmcs tall shru	grigal,df; ohman/	1976
*****					****			
ABSZA	29--4	1	196	sali	capr	trace elemts in plnts	lounamaa,j	1956
*****					****			
ATICA	25--1	21	27	sali	glau	chem comp forag plnts	scotter,gw	1972
CPLSA	53--2	263	268	sali	glau	rata , mineral contnt	scotter,gw; milti	1973
*****					****			
JWMAA	4---3	315	325	sali	humi	mon var deer food nut	hellmers,h	1940
*****					****			
CNAPA	769--	1	60	sali	inte	chem comp nativ plnt	clarke,se; tisdal	1945
*****					****			
JRMGA	27--2	114	117	sali	lasi	odhe,soil & seas frag	krueger,wc; donar	1974
*****					****			
UAXBA	305--	1	22	sali	lute	comp summr rang plnts	stoddart,la; grea	1942
*****					****			
WUAPA	14---	1	27	sali	nigr	minrl cont of plnt wi	gerloff,gc; moor/	1964
*****					****			
CJBOA	51--2	421	427	sali	phyl	trace elemt cont soil	doyle,p; fletche/	1973
*****					****			
ECOLA	43--4	753	757	sali	plan	caloric & lipid cont	bliss,lc	1962
*****					****			
CNRDA	28--5	249	271	sali	scou	alal,frst succ on nut	cowan,imct; hoar/	1950
*****					****			
ECOLA	43--4	753	757	sali	uvur	caloric & lipid cont	bliss,lc	1962
*****					****			

sali spp. cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ATRLA	18--3	81	91	sali	----	caca,intak,digst feed	drozdz,a; osiecki	1973
CAFGA	41--2	145	155	sali	----	crude prot var browse	bissell,hd; stron	1955
CNAPA	769--	1	60	sali	----	chem comp nativ plnts	clarke,se; tisdal	1945
CNRDA	28--5	249	271	sali	----	alal,frst succ on nut	cowan,imct; hoar/	1950
CPLSA	42--1	105	115	sali	----	chem comp rang forage	johnston,a; bezea	1962
CPLSA	46--6	625	697	sali	----	in vitro digst rang p	bezeau,lm; johns/	1966
ECOLA	47--2	222	229	sali	----	selec nutr deer brows	short,hl; dietz,/	1966
JWMAA	5---1	108	114	sali	----	odvi, digst capaci of	forbes,eb; marcy/	1941
JWMAA	34--3	565	569	sali	----	herb brows minrl comp	kubota,j; reiger/	1970
JWMAA	37--3	279	287	sali	----	alal,non-brow food to	leresche,re; davi	1972
JWMAA	38--4	875	879	sali	----	nutrint contnt & food	lindlof,b; linds/	1974
NCANA	101-1	291	305	sali	----	alal,brows minrl comp	kubota,j	1974
NUABA	197--	1	38	sali	----	phenol vs comp plnt &	robertson,jh; tor	1958
PLSOA	45--1	17	26	sali	----	esstl nutr elemt frst	langille,wm; macl	1976
XARRA	304--	1	6	sali	----	odhe,nutr valu forage	urness,pj; neff,/	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JANSA	44--3	389	394	sals	kali	prox, minrl & aa comp	harrold,rl; nalew	1977
JAPEA	11--2	489	497	sals	kali	bibi,tropic ecolgy of	peden,dg; vandyn/	1974
NDFRA	32--1	15	17	sals	kali	prox & aa analy ergot	harrold,rl; nalew	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
NASRA	1684-	1	92	salv	mell	tabl of feed composit	nrcp, canada	1969
*****					****			
TAEBA	461--	1	63	salv	refl	comp,util of rang veg	fraps,gs; cory,vl	1940
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
NAWTA	11---	309	312	samb	call	crud prot detrm & mgt	einarsen,a	1946
JAGRA	62-10	627	636	samb	cana	chem comp frst fruits	wainio,ww	1941
JWMAA	40--2	283	289	samb	cana	nutr qual of digst of	short,hl; epps,ea	1976
WUAPA	14---	1	27	samb	cana	minrl cont of plnt,wi	gerloff,gc; moor/	1964
*****					****			
CAEBA	627--	1	95	samb	glau	ca foothill plnt mgmt	gordon,a; sampson	1939
*****					****			
PLSOA	45--1	17	26	samb	pube	esstl nutr elemt frst	langille,wm; macl	1976
*****					****			
NFGJA	14--1	76	78	samb	----	minrl cont deer brows	bailey,ja	1967

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	36--3	913	923	sang	cana	rata,food habit of ne	bergerud,at	1972

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	40--2	283	289	sapi	sebi	nutr qual of digst of	short,hl; epps,ea	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CNAPA	769--	1	60	sarc	verm	chem comp nativ plnts	clarke,se; tisdal	1945
JRMGA	29--5	356	363	sarc	verm	maj plnt toxicty w us	james,lf; johnson	1976
NEXAA	246--	1	75	sarc	verm	ca, p cont rang forag	watkins,we	1937
WAEBA	184-9	1	21	sarc	verm	forag plnt & chem com	mccreary,oc	1931

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JANSA	36--4	792	796	sass	albi	digstb south brow tis	short,hl; blair,/	1973
JFUSA	55--5	342	347	sass	albi	burnng & brows qualit	lay,dw	1957
JWMAA	33--4	1028	1031	sass	albi	ovrstry on brows qual	halls,lk; epps,ea	1969
JWMAA	35--2	221	231	sass	albi	cellulos digst & comp	torgerson,o; pfan	1971
JWMAA	38--1	20	31	sass	albi	odvi, in vitro digstb	snider,cc; asplun	1974

sass albi cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	38--2	197	209	sass	albi	fibr comp & forag dig	short,hl; blair,/	1974
PCGFA	10---	53	58	sass	albi	deer nutr in sou pine	lay,dw	1956
PCGFA	21---	34	104	sass	albi	deer food nutr analys	thorsland,oa	1966
PCGFA	28---	574	580	sass	albiodvi,	qual deer forage	towry,rk,jr; mic/	1974
XFPSA	111--	1	10	sass	albi	od--,comp & digs brow	short,hl; blair,/	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
NAWTA	21---	141	158	schm	tril	prot, phosphorus cont	swank,wg	1956

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ECOLA	43--4	753	757	scir	cesp	caloric & lipid cont	bliss,lc	1962
JWMAA	36--3	913	923	scir	cesp	rata,food habit of,ne	bergerud,at	1972

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	26--2	117	120	scol	fest	prod,nutr of whitetop	smith,al	1973

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--5	356	363	sene	jaco	maj plnt toxicty w us	james,lf; johnson	1976
*****					****			
JRMGA	29--5	356	363	sene	long	maj plnt toxicty w us	james,lf; johnson	1976
*****					****			
XARRA	304--	1	6	sene	neom	odhe, nutr val forage	urness,pj; neff,/	1975
*****					****			
JRMGA	29--5	356	363	sene	ridd	maj plnt toxicty w us	james,lf; johnson	1976
*****					****			
CJBOA	51--2	421	427	sene	tria	trace elemt cont soil	doyle,p; fletche/	1973
*****					****			
JWMAA	39--4	670	673	sene	----	odhe, nutr cont diets	urness,pj; neff,/	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	36--2	595	605	sequ	giga	odhe, frst manipul on	lawrence,g; biswe	1972
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CRPSA	15--6	821	827	seta	fabr	forag nutr & palat of	marten,gc; anders	1975
*****					****			
CRPSA	15--6	821	827	seta	glau	forag nutr & palat of	marten,gc; anders	1975
*****					****			
JANSA	44--3	389	394	seta	lute	prox, minrl & aa comp	harrold,rl; nalew	1977
NDFRA	32--1	15	17	seta	lute	prox & aa analy ergot	harrold,rl; nalew	1974
*****					****			
CRPSA	15--6	821	827	seta	viri	forag nutr & palat of	marten,gc; anders	1975
JANSA	44--3	389	394	seta	viri	prox, minrl & aa comp	harrold,rl; nalew	1977
NDFRA	32--1	15	17	seta	viri	prox & aa analy ergot	harrold,rl; nalew	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CNRDA	28--5	249	271	shep	cana	alal, frst suc on nut	cowan,imct; hoar/	1950
JWMAA	15--4	352	357	shep	cana	comp plnt eat by deer	gastler,gf; moxo/	1951

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--4	344	346	sibb	proc	cal cont subalp plnts	anderson,dc; armi	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ECOLA	43--4	753	757	sile	acau	caloric & lipid conte	bliss,lc	1962
*****					****			
CJBOA	51-11	2037	2046	sile	doug	minrl comp graslnd sp	harner,rf; harper	1973
*****					****			
JANSA	44--3	389	394	sile	noct	prox, minrl & aa comp	harrold,rl; nalew	1977
NDFRA	32--1	15	17	sile	noct	prox & aa analy ergot	harrold,rl; nalew	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	30--2	119	121	simm	chin	odhe, digst deer fora	urness,pj; smith/	1977
JWMAA	35--3	469	475	simm	chin	odhe, odvi; nutr intk	urness,pj; green/	1971
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	39--4	670	673	sita	hyst	odhe, nutr cont diets	urness,pj; neff,/	1975
XARRA	304--	1	6	sita	hyst	odhe, nutr valu forag	urness,pj; neff,/	1975
XFRMA	158--	1	35	sita	hyst	rang mgmt & ecol basi	clary,wp	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	36--3	913	923	smia	trif	rata,food habit of,ne	bergerud,at	1972

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JANSA	36--4	792	796	smil	bona	digstb south brow tis	short,hl; blair,/	1973
JWMAA	38--2	197	209	smil	bona	fibr comp & forag dig	short,hl; blair,/	1974
XFPSA	111--	1	10	smil	bona	od--,comp & digs brow	short,hl; blair,/	1975
*****					****			
JAGRA	69--1	33	46	smil	glau	chem comp wld feedstu	king,tr; mcclure,	194
JFUSA	55--5	342	347	smil	glau	burnng & brows qualit	lay,dw	1957
JRMGA	9---3	142	145	smil	glau	apparnt digstb lignin	smith,ad; turner/	1956
PCGFA	10---	53	58	smil	glau	deer nutr in sou pine	lay,dw	1956
*****					****			
JANSA	36--4	792	796	smil	rotu	digstb south brow tis	short,hl; blair,/	1973
JRMGA	9---3	142	145	smil	rotu	apparnt digstb lignin	smith,ad; turner/	1956
JWMAA	19--1	65	70	smil	rotu	chng brows nutr value	dewitt,jb; derby,	1955
JWMAA	33--4	1028	1031	smil	rutu	ovrstry on brows qual	halls,lk; epps,ea	1969
JWMAA	34--1	176	182	smil	rotu	wld turkey wintr food	billingsley,bb; a	1970
JWMAA	38--2	197	209	smil	rotu	fibr comp & forag dig	short,hl; blair,/	1974
PCGFA	21---	57	62	smil	rotu	grwth,forag qual brow	blair,rm; halls,l	1967
XFPSA	51---	1	35	smil	rotu	seas nutr dist in pln	blair,rm; epps,ea	1969
XFPSA	111--	1	10	smil	rotu	od--,comp & digs brow	short,hl; blair,/	1975
*****					****			
JFUSA	55--5	342	347	smil	smal	burnng & brows qualit	lay,dw	1957
PCGFA	10---	53	58	smil	smal	deer nutr in sou pine	lay,dw	1956
*****					****			
JWMAA	38--1	20	31	smil	tamm	odvi, <u>in vitro</u> digstb	snider,cc; asplun	1974

smil spp. cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	35--2	221	231	smil	tamn	cellulos digst & comp	torgerson,o; pfan	1971
*****					****			
JWMAA	40--2	283	289	smil	----	nutr qual of digst of	short,hl; epps,ea	1976
PCGFA	21---	34	104	smil	----	deer food nutr analys	thorsland,oa	1966
PCGFA	28---	574	580	smil	----	odvi,qual deer forage	towry,rk,jr; mic/	1974
WVAFA	6---1	2	4	smil	----	odvi,forag prod & dee	towry,r	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	30--3	227	230	sola	----	yield & chem comp of,	gonzaley,cl; heil	1977

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ECOLA	43--4	753	757	soli	cutl	caloric & lipid cont	bliss,lc	1962
*****					****			
ECOLA	43--4	753	757	soli	macr	caloric & lipid cont	bliss,lc	1962
*****					****			
JWMAA	38--1	20	31	soli	nemo	odvi, _in vitro_ digstb	snider,cc; asplun	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JAGRA	62-10	627	636	sorb	amer	chem comp frst fruits	wainio,ww	1941
*****					****			
ABSZA	29--4	1	196	sorb	aucu	trace elemts in plnts	lounamaa,j	1956
JWMAA	38--4	875	879	sorb	aucu	nutrit content & food	lindlof,b; linds/	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	30--3	227	230	sorg	hale	yield & chem comp of,	gonzalez,cl; heil	1977

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JANSA	41--2	601	604	spar	eury	nutr valu aquat plnts	linn,jg; staba,e/	1975
*****					****			
JANSA	41--2	601	604	spar	fluc	nutr valu aquat plnts	linn,jg; staba,e/	1975
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ECOLA	42--3	581	584	spat	----	engy valu ecol matter	golley,fb	1961

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JAPEA	11--2	489	497	spha	cocc	bibi,tropic ecolgy of	peden,dg; vandyn/	1974
*****					****			
JWMAA	38--4	792	798	spha	gros	anam, nutr summr diet	smith,ad; malecke	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ECOLA	43--4	753	757	sphg	fusc	caloric & lipid cont	bliss,lc	1962
*****					****			
ECOLA	43--4	753	757	sphg	girg	caloric & lipid cont	bliss,lc	1962

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
WUAPA	14---	1	27	spir	alba	minrl cont of plnt,wi	gerloff,gc; moor/	1964
*****					****			
PLSOA	45--1	17	26	spir	lati	esstl nutr elemt frst	langille,wm; macl	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JAPEA	11--2	489	497	spor	cryp	bibi,tropic ecolgy of	peden,dg; vandyn/	1974
*****					****			
JANSA	41--1	208	212	spor	curt	seas trend nutr & dig	lewis,ce; lowrey/	1975
*****					****			
JWMAA	39--4	670	673	spor	----	odhe, nutr cont diets	urness,pj; neff,/	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--5	356	363	stan	pinn	maj plnt toxicty w us	james,lf; johnson	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ECOLA	43--4	753	757	ster	pasc	caloric & lipid cont	bliss,lc	1962
*****					****			

ster spp. cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
AZOFA	8---3	385	389	ster	----	rata,lichen nutr valu	pulliainen,e	1971
CJBOA	51--2	421	427	ster	----	trace elemt cont soil	doyle,p; fletche/	1973

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--1	63	65	stip	colu	effct 2,4-D on digstb	thilenius,jf; bro	1976
*****					****			
JAPEA	11--2	489	497	stip	coma	bibi,tropic ecolgy of	peden,dg; vandyn/	1974
JWMAA	35--4	681	688	stip	coma	ceel, in vitro digstb	ward,al	1971
*****					****			
JRMGA	30--2	122	127	stip	pine	odvi, odhe, habt eval	wallmo,oc; carpe/	1977

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CPLSA	42--1	105	115	symp	occi	chem comp range forag	johnston a; bezea	1962
CPLSA	42--4	692	697	symp	occi	in vitr digs rang pln	bezeau,lm; johnst	1962
CPLSA	46--6	625	631	symp	occi	silica,prot cont prai	bezeau,lm; johns/	1966
JWMAA	15--4	352	357	symp	occi	comp plnt eat by deer	gastler,gf; moxo/	1951
*****					****			
ECOLA	49--5	956	961	symp	orbi	cal valu seeds,ne kan	johnson,sr; robel	1968
JAGRA	69--1	33	46	symp	orbi	chem comp wld feedstu	king,tr; mcclure,	1944
JWMAA	35--2	221	231	symp	orbi	cellulos digst & comp	torgerson,o; pfan	1971
JWMAA	38--1	20	31	symp	orbi	odvi, in vitro digstb	snider,cc; asplun	1974
*****					****			
JRMGA	30--2	122	127	symp	oreo	odvi, odhe, habt eval	wallmo,oc; carpe/	1977
*****					****			
JAGRA	63-12	727	739	symp	rotu	comp of, influencd by	stoddart,la	1941
NUABA	197--	1	38	symp	rotu	phenol vs comp plnt &	robertson,jh; tor	1958
UAXBA	305--	1	22	symp	rotu	comp summr rang plnts	stoddart,la; grea	1942
WAEBA	184-9	1	21	symp	rotu	forag plnt & chem com	mccreary,oc	1931
*****					****			
UAXBA	342--	1	66	symp	vacc	nutri cont sheep diet	cook,cw; harris,l	1950
UAXBA	344--	1	45	symp	vacc	nutr valu of rang veg	cook,cw; harris,l	1950
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JFUSA	55--5	342	347	sypl	tinc	burnng & brows qualit	lay,dw	1957
PCGFA	10---	53	58	sypl	tinc	deer nutr in sou pine	lay,ew	1956
PCGFA	21---	57	62	sypl	tinc	grwth,forag qual brow	blair,rm; epps,ea	1969
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--1	63	65	tara	offi	effct 2,4-D on digstb	thilenius,jf; bro	1976
XARRA	304--	1	6	tara	offi	odhe, nutr val forage	urness,pj; neff,/	1975
XFRMA	158--	1	35	tara	offi	rang mgmt & ecol basi	clary,wp	1975
*****					****			
JWMAA	39--4	670	673	tara	----	odhe, nutr cont diets	urness,pj; neff,/	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
BOREA	40--3	347	394	taxu	bacc	pred minrl nutr stats	vanden driessche,	1974
*****					****			
PLSOA	45--1	17	26	taxu	cana	esstl nutr elemt frst	langille,wm; macl	1976
WUAPA	14---	1	27	taxu	cana	minrl con of plnt, wi	gerloff,gc; moor/	1964

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--5	356	363	tetr	cane	maj plnt toxicty w us	james,lj; johnson	1976
NUABA	197--	1	38	tetr	cane	phenol vs comp plnt &	robertson,jh; tor	1958
*****					****			
JRMGA	29--5	356	363	tetr	glab	maj plnt toxicty w us	james,lj; johnson	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JAPEA	11--2	489	497	thel	----	bibi, trpic ecolog of	peden,dg; vandyn/	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--4	344	345	thla	alpe	cal cont subalpn plnt	anderson,dc; armi	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	25--3	342	342	thuj	occi	atlntic white-cedr as	gould,wp; brown,j	1961
JWMAA	28--4	791	797	thuj	occi	digst cedar, aspn brw	ullrey,de; youat/	1964
JWMAA	32--1	162	171	thuj	occi	digestb of fir browse	ullrey,de; youat/	1968
JWMAA	35--4	732	743	thuj	occi	odvi, limit wintr brw	ullrey,de; youat/	1971
JWMAA	36--3	885	891	thuj	occi	odvi, est met aspn br	ullrey,de; youat/	1972

thuj occi cont. on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	40--2	301	307	thuj	occi	doca, odvi in vit dig	palmer,wl; cowan/	1976
JWMAA	41--1	144	147	thuj	occi	hare, wintr brws nutr	walski,tw; mautz,	1977
NFGJA	14--1	76	78	thuj	occi	minrl cont deer brows	bailey,ja	1967
*****					****			
ECOLA	34--4	786	793	thuj	plic	nutr cont leaf litter	daubenmire,v	1953
FRCRA	41--2	222	236	thuj	plic	forag nutr cont conif	beaton,jd; moss,/	1965
JFUSA	49...	914	915	thuj	plic	littr fall & foli nut	tarrant,rf; issa/	1951

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	30--3	227	230	tide	lanu	yield & chem comp of,	gonzalez,cl; heil	1977

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
BOGAA	94	381	393	tili	amer	minrl & nitrogen cont	mchargue,js; roy,	1932
JWMAA	39--2	337	341	tili	amer	odvi, brw comp & digs	robbins,ct; moen,	1975
WUAPA	14---	1	27	tili	amer	minrl con of plnt, wi	gerloff,gc; moor/	1964
*****					****			
ABSZA	29--4	1	196	tili	cord	trace elemts in plnts	lounamaa,j	1956
ATRLA	18--3	81	91	tili	cord	caca intk, digs feed	drozdz,a; osiecki	1973
OIKSA	25--3	341	352	tili	cord	micrb decomp of littr	howard,pja; howar	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JAPEA	11--2	489	497	trad	occi	bibi, trpic ecolog of	peden,dg; vandyn/	1974
*****					****			
JWMAA	39--1	20	31	trad	suba	odvi, in vitro digstb	snider,cc; asplun	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CJBOA	51-11	2037	2046	trag	dubi	minrl comp graslnd sp	harner,rf; harper	1973
*****					****			
JWMAA	39--4	670	673	trag	----	odhe, nutr cont diets	urness,pj; neff,/	1975
XARRA	304--	1	6	trag	----	odhe, nutr valu forag	urness,pj; neff,/	1975
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
NEXAA	246--	1	75	trib	terr	ca, p cont rang forag	watkins,we	1937
TAEBA	461--	1	63	trib	terr	comp, util of rng veg	fraps,gs; cory,vl	1940

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
NCANA	101-1	291	305	trif	hybr	alal, brws minrl comp	kubota,j	1974
*****					****			
JRMGA	20--3	179	180	trif	parr	gross engy alpn plnts	smith,dr	1967
JRMGA	29--4	344	345	trif	parr	cal cont subalpn plnt	anderson,dc; armi	1976
*****					****			
JWMAA	40--2	301	307	trif	prat	doca, odvi in vit dig	palmer,wl; cowan/	1976
*****					****			
AAAHA	13-63	404	410	trif	subt	nutr valu tempr pastu	mcivor,jg; smith,	1973
*****					****			
JWMAA	39--4	670	673	trif	----	odhe, nutr cont diets	urness,pj; neff,/	1975
XARRA	304--	1	6	trif	----	odhe, nutr valu forag	urness,pj; neff,/	1975
XFRMA	158--	1	36	trif	----	rang mgmt & ecol basi	clary,wp	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--5	356	363	trig	mari	maj plnt toxicty w us	james,lf; johnson	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ECOLA	43--4	753	757	tris	spic	caloric & lipid conte	bliss,lc	1962

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CJZOA	52-10	1201	1205	tsug	cana	odvi,forage nutr valu	mautz,ww; silver/	1974
JWMAA	40--4	630	638	tsug	cana	odvi, digst nutr data	mautz,ww; silver/	1976
NFGJA	14--1	76	78	tsug	cana	minrl cont deer brows	bailey,ja	1967
WUAPA	14---	1	27	tsug	cana	minrl cont of plnt,wi	gerloff,gc; moor/	1964
*****					****			
BOREA	40--3	347	394	tsug	hete	pred minrl nutr stats	vanden driessche,	1974

tsug hete cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ECOLA	34--4	786	793	tsug	hete	nutr cont leaf litter	daubenmire,v	1953
FRCRA	41--2	222	236	tsug	hete	forag nutr cont conif	beaton,jd; moss,/	1965
JFUSA	49...	914	915	tsug	hete	littr fall & foli nut	tarrant,rf; issa/	1951

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JANSA	41--2	601	609	typh	augu	nutr valu aquat plnts	linn,jg; stata,e/	1975
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JANSA	36--4	792	796	ulmu	alat	digstb south brow tis	short,hl; blair,/	1973
JWMAA	38--2	197	209	ulmu	alat	fibr comp & forag dig	short,hl; blair,/	1974
XFPSA	111--	1	10	ulmu	alat	od--,comp & digs brow	short,hl; blair,/	1975
*****					****			
BOGAA	94---	381	393	ulmu	amer	minrl & nitrogen cont	mchargue,js; roy,	1952
JAGRA	66--9	349	355	ulmu	amer	prot of var tree seed	lund,ap; sandstro	1943
JWMAA	12--1	1	8	ulmu	amer	a nutr knwldg shrtcut	atwood,el	1948
JWMAA	35--2	221	231	ulmu	amer	cellulos digst & comp	torgerson,o; pfan	1971
JWMAA	38--1	20	31	ulmu	amer	odvi,in vitro digestb	snider,cc; asplun	1974
WUAPA	14---	1	27	ulmu	amer	minrl cont of plnt,wi	gerloff,gc; moor/	1964
*****					****			
OIKSA	25--3	341	352	ulmu	glab	micrb decomp of littr	howard,pja; howar	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CJBOA	51--2	421	427	umbi	----	trace elemt cont soil	doyle,p; fletche/	1973

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CAFGA	41--2	145	155	umbr	cali	crude prot var browse	bissell,hd; stron	1953

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
TAEBA	461--	1	63	ungn	spec	comp,util of rang veg	fraps,gs; cory,vl	1940

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	40--2	283	289	unio	lata	nutr qual of digst of	short,hl; epp,ea	1976
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ECOLA	43--4	753	757	vacc	angu	caloric & lipid cont	bliss,lc	1962
JWMAA	36--3	913	923	vacc	angu	rata,food habit of ne	bergerud,at	1972
WUAPA	14---	1	27	vacc	angu	minrl cont of plnt,wi	gerloff,gc; moor/	1964
*****					****			
JFUSA	55--5	342	347	vacc	arbo	burnng & brows qualit	lay,dw	1957
PCGFA	10---	53	58	vacc	arbo	deer nutr in sou pine	lay,dw	1956
*****					****			
JWMAA	32--4	773	777	vacc	caes	comp alpn tundra plnt	johnston,a; beza/	1968
*****					****			
JRMGA	9---3	142	145	vacc	cras	apparnt digstb lignin	smith,ad;turner/	1956
*****					****			
LATBA	488--	1	18	vacc	elli	plnt nutr valu & rang	campbell,rs; epp/	1954
*****					****			
SJECA	6---3	211	215	vacc	idae	ash comp in taiga frs	firsova,vp; pavlo	1975
*****					****			
CNDRA	73--4	437	443	vacc	memb	grouse, nutri aspects	pendergast,ba; bo	1971
*****					****			
WUAPA	14---	1	27	vacc	myrt	minrl cont of plnt,wi	gerloff,gc; moor/	1964
*****					****			
ABSZA	29--4	1	196	vacc	myti	trace elemts in plnts	lounamaa,j	1956
ATRLA	18--3	81	91	vacc	myti	caca,intak,digst feed	drozdz,a; osiecki	1973
JWMAA	38--4	875	879	vacc	myti	nutritn contnt & food	lindlof,b; linds/	1974
*****					****			
ECMOA	35--3	259	284	vacc	oval	ecol deer rang in ala	klein,dr	1956
*****					****			
WUAPA	14---	1	27	vacc	oxyc	minrl cont of plnt,wi	gerloff,gc; moor/	1964
*****					****			
JWMAA	38--1	32	41	vacc	parv	odhe, plnt charactr &	radwan,ma; crouch	1974
NAWTA	11---	309	312	vacc	parv	crud prot detrm & mgt	einarsen,a	1946
*****					****			
ECOLA	47--2	222	229	vacc	scop	selec nutr deer brows	short,hl; dietz,/	1966
*****					****			
JAGRA	62-10	627	636	vacc	stam	chem comp frst fruits	wainio,ww	1941
JWMAA	35--2	221	231	vacc	stam	cellulos digst & comp	torgerson,o; pfan	1971
JWMAA	36--1	174	177	vacc	stam	odvi,wintr forag qual	segelquist,ca; s/	1972
JWMAA	38--1	20	31	vacc	stam	odvi, in vitro digstb	snider,cc; asplun	1974
*****					****			
ABSZA	29--4	1	196	vacc	ulig	trace elemts in plnts	lounamaa,j	1956
JWMAA	38--4	875	879	vacc	ulig	nutrint contnt & food	lindlof,b; linds/	1974
*****					****			
ECMOA	34--4	321	357	vacc	ulal	engy relatn alpn plnt	hadley,eb; bliss	1964

vacc ulal cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
ECOLA	43--4	753	757	vacc	ulal	caloric & lipid cont	bliss,lc	1962
*****					****			
JWMAA	36--1	174	177	vacc	vaci	odvi,wintr forag qual	segelquist,ca; s/	1972
*****					****			
ABSZA	29--4	1	196	vacc	viti	trace elemts in plnts	lounamaa,j	1956
CJBOA	54--9	966	970	vacc	viti	alal,nutr qual & occu	oldemeyer,jl; see	1976
CPLSA	45--3	246	250	vacc	viti	chem comp forag lichn	scotter,gw	1965
JWMAA	37--3	279	287	vacc	viti	alal,non-brow food to	leresche,re; davi	1972
NCANA	101-1	217	226	vacc	viti	alal,nutr valu forage	oldemeyer,jl	1974
NCANA	101-1	291	305	vacc	viti	alal,brows minrl comp	kubota,j	1974
CNDRA	73--4	437	443	vacc	viti	grouse, nutri aspects	pendergast,ba; bo	1971
*****					****			
ECMOA	34--4	321	357	vacc	vitm	engy relatn alpn plnt	hadley,eb; bliss,	1964
ECOLA	43--4	753	757	vacc	vitm	caloric & lipid cont	bliss,lc	1962
*****					****			
JAGRA	62-10	627	636	vacc	----	chem comp frst fruits	wainio,ww	1941
PCGFA	28---	574	580	vacc	----	odvi,qual deer forage	towry,rk,jr; mic/	1974
PLSOA	45--1	17	26	vacc	----	esstl nutr elemt frst	langille,wm; macl	1976
WVAFA	6---1	2	4	vacc	----	odvi,forag prod & dee	towry,r	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--1	63	65	vale	occi	effct 2,4-D on digstb	thilenius,jf; bro	1976
*****					****			
CJBOA	51--2	421	427	vale	sitc	trace elemt cont soil	doyle,p; fletche/	1973

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JANSA	41--2	601	609	vall	amer	nutr valu aquat plnts	linn,jg; staba,e/	1975
NCANA	101-1	291	305	vall	amer	alal,brows minrl comp	kubota,j	1975
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--5	356	363	vera	cali	maj plnt toxicty w us	james,lf; johnson	1976
*****					****			
CJBOA	51--2	421	427	vera	viri	trace elemt cont soil	doyle,p; fletche/	1973

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	30--3	227	230	vere	ence	yield & chem comp of,	gonzalez,cl; heil	1977

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--4	344	345	vero	worm	cal cont subalpn plnt	anderson,dc; armi	1976

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JAFCA	23--3	464	467	verp	bohe	aa comp morel mushrm	mckellar,rl; kohr	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CJZOA	52-10	1201	1205	vibu	alni	odvi,forag nutr value	mautz,ww; silver/	1974
JWMAA	31--3	437	442	vibu	alni	samplng deer brow for	bailey,ja	1967
JWMAA	40--4	630	638	vibu	alni	odvi, digst nutr data	mautz,ww; silver/	1976
NFGJA	14--1	76	78	vibu	alni	minrl cont deer brows	bailey,ja	1967
*****					****			
NFGJA	14--1	76	78	vibu	cass	minrl cont deer brows	bailey,ja	1967
PLSOA	45--1	17	26	vibu	cass	esstl nutr elemt frst	langille,wm; macl	1976
*****					****			
JWMAA	39--2	337	341	vibu	dent	odvi,brow comp & digs	robbins,ct; moen,	1975
*****					****			
JAGRA	62-10	627	636	vibu	lent	chem comp frst fruits	wainio,ww	1941
JWMAA	39--2	337	341	vibu	lent	odvi,brow comp & digs	robbins,ct; moen,	1975
*****					****			
JFUSA	55--5	342	347	vibu	moll	burnng & brows qualit	lay,dw	1957
PCGFA	10---	53	58	vibu	moll	deer nutr in sou pine	lay,dw	1956
*****					****			
ABSZA	29--4	1	196	vibu	opul	trace elemts in plnts	lounamaa,j	1956
*****					****			

vibu spp. cont on the next page

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JAGRA	62-10	627	636	vibu	prun	chem comp frst fruits	wainio,ww	1941
*****					****			
JANSA	36--4	792	796	vibu	rufi	digstb south brow tis	short,hl; blair,/	1973
JRMGA	22--1	40	43	vibu	rufi	nutr analy 2 brow spp	short,hl; harrell	1969
JWMAA	31--3	432	437	vibu	rufi	deer forag,loblolly p	blair,rm	1967
JWMAA	33--4	1028	1031	vibu	rufi	ovrstry on brows qual	halls,lk; epps,ea	1969
JWMAA	38--2	197		vibu	rufi	fibr comp & forag dig	short,hl; blair,/	1974
PCGFA	21---	57	62	vibu	rufi	grwth,forag qual brow	blair,rm; halls,l	1968
XFPSA	111--	1	10	vibu	rufi	od--,comp & digs brow	short,hl; blair,/	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
XARRA	304--	1	6	vici	pulc	odhe,nutr valu forage	urness,pj; neff,/	1975
XFRMA	158--	1	35	vici	pulc	rang mgmt & ecol basi	clary,wp	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	34--1	176	182	viti	aest	wld turkey wintr food	billingsley,bb; a	1970
JWMAA	35--2	221	231	viti	aest	cellulos digst & comp	torgerson,o; pfan	1971
JWMAA	38--1	20	31	viti	aest	odvi, in vitro digstb	snider,cc; asplun	1974
*****					****			
JWMAA	12--1	1	8	viti	bico	a nutr knwldg shrtcut	atwood,el	1948
*****					****			
JAGRA	62-10	627	636	viti	cord	chem comp frst fruits	wainio,ww	1941
*****					****			
WUAPA	14---	1	27	viti	ripa	minrl cont of plnt,wi	gerloff,gc; moor/	1964
*****					****			
JFUSA	55--5	342	347	viti	rotu	burnng & brows qualit	lay,dw	1957
PCGFA	10---	53	58	viti	rotu	deer nutr in sou pine	lay,dw	1956
*****					****			
JAGRA	69--1	33	46	viti	vulp	chem comp wld feedstu	king,tr; mcclure,	1944
*****					****			
JANSA	36--4	792	796	viti	----	digstb south brow tis	short,hl; blair,/	1973
JWMAA	38--2	197	209	viti	----	fibr comp & forag dig	short,hl; blair,/	1974
XFPSA	111--	1	10	viti	----	od--,comp & digs brow	short,hl; blair,/	1975
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
CRPSA	15--6	821	827	xant	pens	forag nutr & palat of	marten,gc; anders	1975
JANSA	44--3	389	394	xant	pens	prox, minrl & aa comp	harrold,rl; nalew	1977
NDFRA	32--1	15	17	xant	pens	prox & aa analy ergot	harrold,rl; nalew	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
TAEBA *****	461--	1	63	xanx	frut ****	comp,util of rang veg	fraps,gs; cory,vl	1940

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
NEXAA	133--	1	38	yucc	elat	yucca,chamiza as supl	brown,ls	1922
NEXAA	246--	1	75	yucc	elat	ca, p cont rang forag	watkins,wr	1937
NEXAA	561--	1	33	yucc	elat	chemi comp forage spp	nelson,ab; herbe/	1970
TAEBA	329--	1	59	yucc	elat	engy-prod coeff feedg	fraps,gs	1925
*****					****			
JAPEA	11--2	489	497	yucc	glau	bibi,tropic ecolgy of	peden,dg; vandyn/	1974
JWMAA	15--4	352	357	yucc	glau	comp plnt eat by deer	gastler,gf;moxo/	1951
NEXAA	246--	1	75	yucc	glau	ca, p cont rang forag	watkins,we	1937
*****					****			
AZATA	113--	1	17	yucc	moha	comp arizona forages	catlin,cn	1925
*****					****			
TAEBA	461--	1	63	yucc	reve	comp,util of rang veg	fraps,gs; cory,vl	1940
*****					****			
TAEBA	461--	1	63	yucc	thom	comp,util of rang veg	fraps,gs; cory,vl	1940
*****					****			
TAEBA	461--	1	63	yucc	trec	comp,util of rang veg	fraps,gs; cory,vl	1940
*****					****			
AZATA	113--	1	17	yucc	----	comp arizona forages	catlin,cn	1925
TAEBA	461--	1	63	yucc	----	comp,util texas fdstf	fraps,gs	1947
*****					****			

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JWMAA	38--1	20	31	zea	mays	odvi, in vitro digstb	snider,cc; asplun	1974

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JANSA	41--2	601	609	ziza	equa	nutr valu aquat plnts	linn,jg; staba,e/	1975

CODEN	VO-NU	BEPA	ENPA	GENS	SPEC	KEY WORDS------------	AUTHORS----------	YEAR
JRMGA	29--4	344	345	zyga	eleg	cal cont subalpn plnt	andersen,dc; armi	1976
*****					****			

OTHER PUBLICATIONS

Dietz, D. R., R. H. Udall & L. E. Yeager. 1962. Chemical composition and digestibility by mule deer of selected forage species, Cache la Poudre range, Colorado. State of Colorado - Department of Game and Fish Technical Publication Number Fourteen. 89 p.

Hamilton, J. W. & C. S. Gilbert. 1972. Composition of Wyoming range plants and soils. Research J., Agric. Exp. Sta., Univ. of Wyoming #55, 14 p.

Luick, J. M. 1974. Studies on the nutrition and metabolism of reindeer-caribou in Alaska with special interest in nutritional and environmental adaptation. Progress report, July 1973 - December 1974. Alaska Univ. College Inst. of Arctic Biology. 114 p.

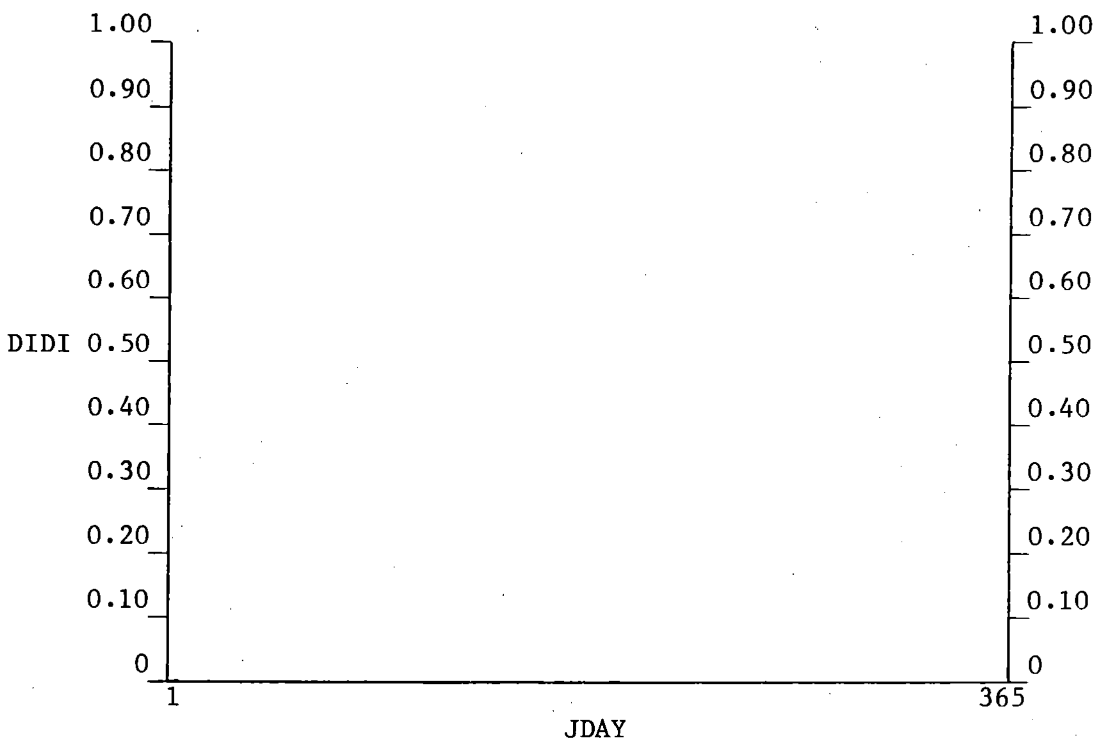
McCulloch, C. Y. & P. J. Urness. 1973. Deer nutrition in Arizona chaparral and desert habitats. Special Report #3, Arizona Game and Fish Dept., U. S. Forest Serv. Rocky Mtn. For. & Range Exp. Sta. p. 39-52, 53-68.

Silver, H. & N. F. Colovos. 1957. Nutritive evaluation of some forage rations of deer. Tech. Cir. 15, Fed. Aid Proj. FW-2-R. N. H. Fish and Game Dept. 56 p.

TOPIC 3. DIET DIGESTIBILITIES

General trends in diet digestibilities follow the general trends in the cell structures of the plants. The stages and parts of plant growth that have thinner and less lignified cell walls are, for the most part, more digestible than those stages and parts with more lignified cell walls. Cell chemistry also affects digestibility, however. Tannins, for example, act as inhibitors of digestion. Changes in cell structure occur as plant phenology changes over the growing season. Emerging, growing tissue cannot have rigid cell walls, for new tissue is being added as cells increase in both number and size. When the numbers and sizes of cells in plant tissue have both reached maximum, cell maturation occurs and cell walls increase in thickness and rigidity. The cells in stems become very rigid and serve as supporting tissue. Cells in leaf tissue mature, become decadent, and the leaf falls to the ground. Flower petals mature, wither, and fall. Functional changes in different plant parts are accompanied by structural changes in the cells, and these changes affect nutritive relationships between animal and range.

The concepts underlying relationships between cell structure and digestibility permit one to generalize on seasonal variations in diet digestibility. Consumption of decadent lignified dormant forage results in stable diet digestibilities. As the growing season progresses, diet digestibilities increase as new growth makes up an increasing proportion of the diet. As the growing season progresses and plants mature, diet digestibilities begin to drop until they reach the annual low when only decadent lignified forage is available again. Patterns of seasonal change are illustrated below.



Free-ranging ruminants are generally quite selective feeders, but there are times and locations where preferred species and parts are limited. In the spring, for example, new growth becomes available at a rate that is dependent on species phenology and growing conditions. As the snow melts, animals can supplement the winter diet of dormant forage with new growth as it becomes available, and overall diet digestibilities increase slowly. As plant growth continues, larger amounts of new growth become available and diet digestibilities increase more rapidly. It is important to realize that this pattern of digestibility coefficients applies to the diet rather than individual plants. Digestibilities change in relation to the phenology of the plant, and new plant tissue makes up increasingly larger proportions of the diet in the first part of the growing season and smaller proportions in the last part.

Digestibilities are measured by _in vivo_ or _in vitro_ methods. The former involves live animals and the latter, laboratory procedures. _In vivo_ measurements were conducted in the early years of nutrition experimentation, and _in vitro_ has become an accepted technique in later years. These two kinds of measurements are discussed and references given in UNITS 3.1 and 3.2. When direct measurements of particular diets are not available, then calculated diet digestibilities may be determined (UNIT 3.3). Reasonable estimates of digestibilities should be possible for all wild ruminants if general knowledge of nutritive processes is used to make the estimate.

UNIT 3.1: *IN VIVO* MEASUREMENTS OF DIGESTIBILITIES

There have been many experimental feeding trials of wild ruminants on different forages, with concomitant collection of feces and urine in order to determine at least apparent digestibilities. Results of these are published in the long lists of references that follow this UNIT.

Some of the empirical measurements are made in live animals consuming prescribed, often single-species diets. These measurements are not only expensive because collecting the current annual growth of browse plants is a very slow process. One very convincing exercise illustrating foraging conditions in the winter is the collection of a daily supply of dry weight current annual growth on a cold day with a clippers and bag, especially on an overbrowsed range. The cost of clipping just the CAG is prohibitive if wages must be paid. Volunteers have helped collect on some research projects. Ruminants must be on the test forages for several days before measurements are actually made to allow previous diet residues to pass through the gastrointestinal tract. Thus a five-day trial must last about two weeks total.

Another way to conduct *in vivo* trials is by collecting the entire plant and letting the test animals browse the parts and amounts desired. It is harder to determine the amounts eaten using this procedure, but less expensive to collect and feed the browse.

In vivo measurements are difficult to complete because wild ruminants do not consume single-species diets very readily, especially of lower quality forage. Single species tests eliminate the beneficial effects of associative digestibilities, resulting in even lower estimates of digestibilities of the lower-quality forages. A mix of forages provides a more suitable substrate for rumen microflora than a single-species substrate.

In vivo measurements of digestibilities have been tried using nylon bag techniques which permit tests of selected forages in a bag suspended in the rumen of a fistulated animal. This technique reduces the expense of large-scale collections, and alleviates the problem of consumption of low-palatibility forages and single-species diets. The bag does impede rumen fluid circulation and sorting, so the results are not exactly as they would be if the forage were free in the rumen.

In vivo digestibilities give the impression of biological reality, but all test results must be considered as estimates that vary in relation to a large number of test conditions. Results should be evaluated as patterns in an ecological context.

REFERENCES, UNIT 3.1

IN VIVO MEASUREMENTS OF DIGESTIBILITIES

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	41--4	667	676	od--	seas nutr yield, dig, pine	blair,rm; short,/	1977

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CJZOA	52-10	1201	1205	odvi	dig, prox comp, wint brows	mautz,ww; silver/	1974
JANSA	21--4	1017	1018	odvi	diges, brwse, cedar, aspen	youatt,wg; ullre/	1961
JANSA	32--5	999	1002	odvi	chrm-51, totl collctn tech	mautz,ww	1971
JRMGA	29--1	82	83	odvi	comparis in vivo, in vitro	ruggiero,lf; whel	1976
JWMAA	5---1	108	114	odvi	digestiv capacit of wt dee	forbes,eb; marcy/	1941
JWMAA	28--4	791	797	odvi	diges, cedar, aspen browse	ullrey,de; youat/	1964
JWMAA	31--3	448	454	odvi	dig, cedar, jack pine brow	ullrey,de; youat/	1967
JWMAA	32--1	162	171	odvi	dig, cedar, basalm fir brw	ullrey,de; youat/	1968
JWMAA	33--3	482	490	odvi	digest ener req, mich does	ullrey,de; youatt	1969
JWMAA	35--2	366	368	odvi	confin eff, dry mattr dige	mautz,ww	1971
JWMAA	35--4	732	743	odvi	limita, winter aspen brows	ullrey,de, youat/	1971
JWMAA	36--3	885	891	odvi	dig, metabol, aspen browse	ullrey,de; youat/	1972
JWMAA	36--4	1052	1060	odvi	var, determ diges capacity	mothershead,cl; /	1972
JWMAA	37--2	195	201	odvi	dry matter, enrg intak,dig	ammann,ap; cowan/	1973
JWMAA	39--1	67	79	odvi	feed analyses, digest, w-t	robbins,ct; van /	1975
JWMAA	40--4	630	638	odvi	dige, 7 northern browse sp	mautz,ww, silver/	1976
JWMAA	43--3	798	801	odvi	dosh, compar digest capaci	palmer,wl; cowan,	1979
UASPA	51--2	89	89	odvi	compar in viv, in vitr dig	ruggiero,l	1974

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
TPCWD*	14---	1	89	odhe	digestibil, forag sp, colo	dietz,dr; udall,/	1962
CAFGA	39--2	163	175	odhe	nutr val, fora plnts,calif	hagen,hl	1953
CAFGA	41--1	57	78	odhe	dig, naturl, artific foods	bissell,hd; harr/	1955
CWSPA	43---	1	44	odhe	vivo/vit rela, forag, colo	milchunas,dg; dy/	1978
JANSA	16--2	476	480	odhe	dosh, live oak, chamis, ca	bissell,hd; weir,	1957

odhe continued on the next page

*TPCWD is thought to be the correct CODEN for: State of Colorado - Dept. of Game and Fish Technical Publication.

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JRMGA	10--4	162	164	odhe	nutr val, wntr brows plnts	smith,ad	1957
JRMGA	12--1	8	13	odhe	browse adequa, overwinteri	smith,ad	1959
JRMGA	30--2	119	121	odhe	comp in viv, in vitr diges	urness,pj; smith/	1977
JRMGA	30--2	122	127	odhe/	evaluat deer habitat, nutr	wallmo,oc; carpe/	1977
JWIDA	10--2	166	169	odhe	invest tansy ragwort poisn	dean,re; winward,	1974
JWMAA	14--3	285	289	odhe	sagebrush as a winter feed	smisth,ad	1950
JWMAA	16--3	309	312	odhe	digestibil, native forages	smith,ad	1952
JWMAA	28--4	785	790	odhe	effect essenti oils, rumen	nagy,jg; steinho/	1964
JWMAA	31--3	443	447	odhe	prev diet, digest alfal ha	nagy,jg; vidacs,/	1967
JWMAA	34--4	964	967	odhe	cell wall dig, forag value	short,hl; reagor,	1970
JWMAA	38--4	823	829	odhe	capabil, utiliz fibr alfal	schoonveld,gg; n/	1974

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
BJNUA	40--2	347	358	ceel	dosh, compar digest foragს	milne,ja; macrae/	1978
HOECD	4---1	59	65	ceel	caca, seas diff, dig brows	cederlund,g; nyst	1981
NATUA	263--	763	764	ceel	intk, diges, vetega, scotl	milne,ja; macrae/	1976

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CJBOA	54--9	966	970	alal	qual, lowbsh crnbry, alask	oldemeyer,jl; sem	1976

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
BPURD	1----	95	107	rata	feeding experimnts, lichns	jacobsen,e; skjen	1975
JWMAA	44--3	613	622	rata	digestib, rangifer forages	person,sj; pegau/	1980

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				anam			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
ATRLA	22-14	225	230	bibi	doca, yak, fora intak, dig	richmond,rj; hud/	1977
IZYBA	16---	54	57	bibi	diges, pelleted diet, rumi	hintz,hf; sedgew/	1976

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ovca			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ovda			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				obmo			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				oram			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JRMGA	24--1	73	75	doca	est dig ener, dry, org mat	rittenhouse,lr; /	1971
JONUA	15--4	383	395	doca	cellul, ligni, nutri value	crampton,ew; mayn	1938
NEXAA	133--	1	38	doca	yucca, chamiza, rang suppl	brown,ls	1922

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
AGJOA	51--3	226	234	dosh	intak, dig tech, suppl fee	harris,le; cook,/	1959
JANSA	23--3	700	710	dosh	nutritnl quali, blue grass	reid,rl; jung,ga/	1964
JBRGA	32--3	141	147	dosh	comparsn meth predic diges	milne,ja	1977

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	40--2	283	289	wldl	nutr qual, dig, seed, frui	epps,ea,jr	1976
XAMPA	1147-	1	220	wldl	range, wildl habit evaluat	paulson,ha,ed; r/	1970

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
ATRLA	18--3	81	91	caca	natu feed, roe de, ingesti	drozdz,a; osiecki	1973
ATRLA	24-13	137	170	caca	seas intak, dig, nat foods	drozdz,a; osiecki	1979

UNIT 3.2: IN VITRO MEASUREMENTS OF DIGESTIBILITIES

In vitro digestibility measurements have become common-place since the early 1960's. Tilley and Terry (1963) used in vitro fermentation followed by pepsin digestion, and Oh et al. (1966) found the two-step technique of Tilley and Terry to be an accurate predictor (r = 0.88) of in vivo ruminant digestion of legumes and grasses. Van Soest (1965) related in vitro results to cell wall components of the feed. These early studies have been followed by a fair number of measurements on white-tailed and mule deer, but few studies have been done on the other wild ruminants.

In vitro measurements of digestibilities involve the use of very small samples of forage (a gram or less) in a temperature-controlled fermentation bath that has been inoculated with rumen fluid. The fermentation bath is maintained at body temperature for about 48 hours while digestion takes place. In vitro equipment used at Cornell's Wildlife Ecology Laboratory is pictured in Moen (1973:150). Up to 12 samples may be fermented at one time with this equipment. Duplicate samples of each forage are used, so six species may be evaluated during each run.

The cost and biological problems associated with in vivo measurements are eliminated with in vitro studies. New problems arise, however, as in vitro systems are more or less closed systems without biological absorption and feedback. Thus, the single sample present as a substrate is different from the real situation in the rumen where periodic feeding during each 24-hour period results in additions of new material tdo the rumen. The more or less continuous rumination and fermentation in the live animal results in a steady flow of both metabolites through the gastrointestinal walls and undigested waste products through the gastrointestinal canal.

Differences in the results from in vivo and properly-completed in vitro studies are not great. The economic advantages to in vitro studies are great, however. Further, the source of inocula need not be a major consideration; results with inocula from a captive deer on an alfalfa diet were within 2% of in vivo determinations, from a wild deer, within 1/2%, and from a cow, within 3% (Robbins et al. 1975). These differences may not satisfy a nutrition specialist, but they are all well within the range of accuracy when estimating diets, populations, and other ecological parameters of free-ranging animals. The use of cow inocula alleviates the need to hold wild ruminants for inocula. A fistulated white-tailed deer was available for rumen fluid for several years (See Moen 1973:149), but the much smaller fistula opening and the lower fluid component of rumen material in the deer compared to the cow made it much more convenient to use the readily-available and easily-collected rumen fluid from a cow at Cornell's Department of Animal Science. If docile wild ruminants are available for fistulation, especially the larger ones such as elk, then they should be used of course.

The results of a large number of *in vitro* tests of different plant parts, of forages collected at different times of the year, of associative digestibilities, and of the effects of inhibitors make it possible to get a much more complete picture of nutritive processes and patterns through the year under a wide variety of range conditions than with *in vivo* measurements. The accuracy of *in vitro* determinations of digestibilities by wild ruminants are fully as great as the accuracies in determining food habits and other characteristics of free-ranging animals. Hence *in vitro* measurements offer particular advantages for work with wild ruminants that far outweigh the disadvantages. Simply stated, many important and revealing nutritive evaluations could not be made without *in vitro* digestion techniques.

I wish to thank Dr. Peter Van Soest, Department of Animal Science, Cornell University, for the assistance given students and staff at the Wildlife Ecology Laboratory over the years as we have measured forage unique to white-tailed deer in New York State.

LITERATURE CITED

Moen, A. N. 1973. Wildlife ecology. W. H. Freeman and Company, San Francisco. 458 pp.

Oh, H. K., B. R. Baumgardt, and J. M. Scholl. 1966. Evaluation of forages in the laboratory. V. Comparison of chemical analyses, solubility tests, and *in vitro* fermentation. J. Dairy Sci. 49:850-855.

Robbins, C. T., P. J. Van Soest, W. W. Mautz, and A. N. Moen. 1975. Feed analyses and digestion with reference to white-tailed deer. J. Wildl. Manage. 39(1):67-79.

Tilley, J. M. A. and R. A. Terry. 1963. A two-stage technique for the in vitro digestion of forage crops. J. Brit. Grassl. Soc. 18:104-111.

Van Soest, P. J. 1965. Non-nutritive residues: A system of analysis for the replacement of crude fiber. J. Assoc. Off. Agric. Chem. 49:546-551.

REFERENCES, UNIT 3.2

IN VITRO MEASUREMENTS OF DIGESTIBILITIES

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JANSA	39--1	248	248	odvi	cow vs deer, inoculm sourc	palmer,wl; cowan,	1974
JRMGA	28--5	419	421	odvi	in vitr solu, dry mttr dig	uresk,dw; dietz,/	1975
JRMGA	29--1	82	83	odvi	comparis in vitro, in vivo	ruggiero,l; whela	1976
JWMAA	27--2	184	195	odvi	rumen fermentation, energ	short,hl	1963
JWMAA	35--2	221	231	odvi	cellulo dig, chem, missour	torgerson,o; pfa/	1971
JWMAA	35--3	469	475	odvi	odhe, nutr, chappral, ariz	urness,pj; green/	1971
JWMAA	35--4	698	706	odvi	forag dig, diet, uplnd rng	short,hl	1971
JWMAA	38--1	20	31	odvi	in vitr dig, foods, missou	snider,cc; asplun	1974
JWMAA	39--1	67	79	odvi/	feed analyses, digest, w-t	robbins,ct; van /	1975
JWMAA	39--2	337	341	odvi	comp, digest, decid br, ne	robbins,ct; moen,	1975
JWMAA	40--2	301	307	odvi	eff innoc source, in vitro	palmer,wl; cowan/	1976
JWMAA	43--3	650	656	odvi	carbohyd, urea influ diges	mccullough,y	1979
JWMAA	43--3	788	790	odvi	pH influen, in vitro diges	burbank,rk; wool/	1979
SWNAA	24--2	297	310	odvi	botan comp, nutr cont diet	everitt,jh; gonza	1979
UASPA	51--2	89	89	odvi	compar in viv/in vitr dige	ruggiero,l	1974

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CJFRA	2---3	250	255	odhe	doug fir genot, brows pref	radwan,ma	1972
CWSPA	43---	1	44	odhe	viv/vitr rela, forag, colo	milchunas,dg; dy/	1978
FOSCA	16--1	21	27	odhe	dougl-fir, microb ferm, ca	oh,jh; jones,mb;/	1970
JRMGA	30--2	119	121	odhe	comparis in vitro, in vivo	urness,pj; smith/	1977
JRMGA	30--2	122	127	odhe	evaluat deer habitat, nutr	wallmo,oc; carpe/	1977
JRMGA	30--3	206	209	odhe	fo hab, semi-des grass-shr	short,hl	1977
JWMAA	28--4	785	790	odhe	eff essen oils,rumn micro	nagy,jg; steinhof/	1964
JWMAA	31--3	443	447	odhe	diet and dig, alfalfa hay	nagy,jg; vidacs,g/	1967
JWMAA	34--4	964	967	odhe	cell wall dig, forag value	short,hl; reagor,	1970
JWMAA	36--4	1341	1343	odhe	maint rumen fluid, in vitr	schwartz,cc; nagy	1972
JWMAA	38--3	531	534	odhe	pestici eff, in vitro dige	schwartz,cc; nagy	1974
JWMAA	39--4	670	673	odhe	nutr, diet, pondr pine ran	urness,pj; neff,/	1975

CODEN	VO-NU	BEPA	ENPA	ANIM KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	35--4	681	688	ceel in vitr dig, wint for, wyo	ward,al	1971
ZTTFA	24--4	200	204	ceel inhib rum cellulolys, bark	prins,ra; geelen,	1968

CODEN	VO-NU	BEPA	ENPA	ANIM KEY WORDS-----------------	AUTHORS----------	YEAR
CJBOA	54--9	966	970	alal nutr qual,lo bush cran, al	oldemeyer,jl; see	1976
JWMAA	41--3	533	542	alal browse qual, popula, kenai	oldemeyer,jl; fr/	1977

CODEN	VO-NU	BEPA	ENPA	ANIM KEY WORDS-----------------	AUTHORS----------	YEAR
BPURD	1----	251	256	rata in vitro digest of forages	person,sj; white/	1975
JWMAA	44--3	613	622	rata in vitr, nylon-bag digesti	person,sj; pegau/	1980

CODEN	VO-NU	BEPA	ENPA	ANIM KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	41--2	161	168	anam/bibi, diet qual, for avail	schwartz,cc; nag/	1977

CODEN	VO-NU	BEPA	ENPA	ANIM KEY WORDS-----------------	AUTHORS----------	YEAR
JAPEA	11--2	489	497	bibi trophi ecol, shrtgras plai	peden,dg; van dy/	1974

CODEN	VO-NU	BEPA	ENPA	ANIM KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	32--4	773	777	ovca dig, alpine tundra plants	johnston,; bezau,/	1968

CODEN	VO-NU	BEPA	ENPA	ANIM KEY WORDS-----------------	AUTHORS----------	YEAR
				ovda		

CODEN	VO-NU	BEPA	ENPA	ANIM KEY WORDS-----------------	AUTHORS----------	YEAR
				obmo		

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				oram			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JBRGA	18--2	104	111	doca	dosh,2-stage tech, in vitr	tilley,jma; terry	1963
JDSCA	44-12	2242	2249	doca	eff partic size, cellu dig	dehority,ba; john	1961
JDSCA	49--7	850	855	doca	chem anal, solubili, fermn	oh,hk; baumgardt,	19
JRMGA	21--1	5	7	doca	in vitr dig, cattle, range	hoehne,oe; clant/	1968

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JANSA	23--3	700	710	dosh	nutrit qual, in viv, vitro	reid,rl; jung ga/	1964

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CPLSA	42--4	692	697		in vitro diges, festu asso	bezeau,lm; johnst	1962
JRMGA	24--2	134	136		in vitr dige, native hay	karn,jf; clanton/	1971
JRMGA	29--1	63	65	many	effect of 2,4-d on digestn	thilenius,jf; br/	1976
XAMPA	1147-	1	220	wldl	range, wildl habit evaluat	paulson,ha,ed; r/	1970

CHAPTER 11, WORKSHEET 3.2a

In vitro browse digestibilities

The SERIALS lists include many references with data on digestibilities. The tabulation below includes results of in vitro measurements on dormant browse plants of New York State that have been evaluated at Cornell's Wildlife Ecology Laboratory. They are included here to provide digestibility data for a relatively large number of white-tailed deer browses in Northeastern United States. Additional species should be added from published papers.

Common name	Scientific name	GENS SPEC	Dry matter Digestibility Coefficient
Alternate leaved dogwood	Cornus alternifolia	corn alte	0.64 *
Apple	Pyrus malus	pyru malu	0.62 **
Arrowwood	Viburnum dentatum	vibu dent	0.45 **
Aspen	Populus tremuloides	popu trem	0.61 **
Balsam fir	Abies balsamea	abie bals	0.62 *
Basswood	Tilia americana	tili amer	0.57 **
Beech	Fagus grandifolia	fagu gran	0.40 **
Blackberry	Rubus alleghaniensis	rubu alle	0.48 *
Black cherry	Prunus serotina	prun sero	0.37 *
Boxelder	Acer negundo	acer negu	0.57 **
Bur oak	Quercus macrocarpa	quer macr	0.43 **
Cucumber tree	Magnolia acuminata	magn acum	0.53 **
Elderberrry	Sambucus canadensis	samb cana	0.37 *
Elm	Ulmus americana	ulmu amer	0.38 *
Fire cherry	Prunus pensylvanica	prun pens	0.40 *
Gray birch	Betula populifolia	betu popu	0.47 *
Gray dogwood	Cornus racemosa	corn race	0.55 ***
Hawthorn	Crategus sp.	crat ----	0.43 **
Hazelnut	Corylus cornuta	cory corn	0.51 **
Hemlock	Tsuga canadensis	tsug cana	0.70 **
Hop hornbeam	Ostrya virginiana	ostr virg	0.37 *
Lilac	Syringa vulgaris	syri vulg	0.46 *
Meadow sweet	Spiraea sp.	spir ----	0.35 *
Mountain maple	Acer spicatum	acer spic	0.49 *
Nannyberry	Viburnum lentago	vibu lent	0.54 **

Continued on the next page

Paper birch	Betula papyrifera	betu papy	0.56 **
Red maple	Acer rubrum	acer rubr	0.57 **
Red oak	Quercus rubra	quer rubr	0.42 **
Red osier dogwood	Cornus stolonifera	corn stol	0.51 **
Red raspberry	Rubus idaeus	rubu idae	0.42 *
Red spruce	Picea rubens	pice rube	0.55 *
Scotch pine	Pinus sylvestris	pins sylv	0.64 *
Shagbark hickory	Carya ovata	cary ovat	0.48 **
Speckled alder	Alnus rugosa	alnu ovat	0.30 *
Staghorn sumac	Rhus typhina	alnu rugo	0.55 **
Striped maple	Acer pensylvanicum	rhus typh	0.54 *
Sugar maple	Acer saccharum	acer pens	0.46 **
White ash	Fraxinus americana	acer sach	0.48 **
White cedar	Thuja occidentalis	frax amer	0.67 **
White pine	Pinus strobus	thuj occi	0.60 *
Wild grape	Vitis sp.	pins stro	0.38 *
Willow	Salix sp.	viti ----	0.53 *
Witch hazel	Hamamelis virginiana	sali ----	0.49 **
Yellow birch	Betula alleghaniensis	betu alle	0.33 *

* - Wildlife Ecology Laboratory, New York measurements for Delmar.
** - Robbins, C. T. 1973. The biological basis for the determination of carrying capacity. PhD Thesis, Cornell University, Ithaca, N.Y. 239 pp.
*** - WEL Job # 74-01.

UNIT 3.3: CALCULATED DIET DIGESTIBILITIES

Wild ruminants have mixtures of species in their rumens at any one time, resulting in overall diet digestibilities that represents the effects of all of the individual forage species combined. How can diet digestibilities be estimated when the digestibilities of each of the forages in the diet at any one time have not been measured?

The dynamic characteristics of wild ruminant diets can never be duplicated under controlled condiitions. It is, therefore, inevitable that diet digestibilities must be calculated since there is no place to "look up" the digestibilities of selected natural diets.

How can diet digestibilities be calculated? First, diet components are tabulated from food habits studies. Second, the fractions of the total diet made up of the different components are determined from preference and rumen content studies. Third, estimates of the digestibilities of each forage and plant part for the time of year being analyzed are made based on published data, patterns useful for estimation and interpolation, and first approximations where necessary. Fourth, a weighted mean procedurre is used to calculate overall diet digestibility.

Weighted means are determined by multiplying the forage digestibility coefficient (FDIC) of each forage and plant part by its fraction in the diet (FRDI). The sum of the forage digestibilities is the weighted mean diet digestibility (DIDI). A tabular format for this is illustrated below.

Forage		
1. ____________	FDIC x FRDI =	____
2. ____________	FDIC x FRDI =	____
.		
.		
n. ____________	FDIC x FRDI =	____

A sample calculation:

1. _ _ _ _ _ _ _ _ _ _	0.62	x	0.15	=	0.09	
2. _ _ _ _ _ _ _ _ _ _	0.60	x	0.20	=	0.12	
3. _ _ _ _ _ _ _ _ _ _	0.54	x	0.25	=	0.14	
4. _ _ _ _ _ _ _ _ _ _	0.50	x	0.40	=	0.20	
	SUMS		1.00		0.55	= DIDI

This weighted mean procedure is useful for estimating the contributions of different forages based on animal preferences, for estimating the contributions of different plant parts in relation to their abundance in the rumen and digestibilies, and other effects of selective grazing or browsing. The procedure does not take interactions between different components of a diet, or associative digestibility effects, however. Highly digestible species may provide a suitable substrate that will increase the digestibilities of lower quality species. Another associative digestibility effect to consider is that of chemical inhibition. One species may contain inhibitors that not only result in a low digestibility of that species, but also reduce digestibilities of otehr species present in the rumen at the same time.

The weighted mean procedure is a good place to start evaluating diets. More research on actual diet mixtures taken by free-ranging wild ruminants would result in better understanding of nutritive processes, however. Even though we do not yet have ultimate knowledge of these processes, ecological processes continue and all components of the total picture should be considered in context. Thus we go on to new considerations in the remaining CHAPTERS of this book.

REFERENCES, UNIT 3.3

CALCULATED DIET DIGESTIBILITIES

SERIALS

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

odvi

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

odhe

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

ceel

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

alal

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

rata

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

anam

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

bibi

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

ovca

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

ovda

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

obmo

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

oram

CHAPTER 11, WORKSHEET 3.3a

Weighted mean diet digestibilities

This WORKSHEET presents a format for calculating weighted mean diet digestibilities. Ten blanks are provided: most diets are composed of as few as three or four most abundant forages. Use blanks 1 - 9 for the forage species that should be considered separately. Combine all the rest in the last blank.

Animal ______________________ Location ______________________ JDAY _____

		FDIC	x	FRDI	=	
1.	____________________	____	x	____	=	____
2.	____________________	____	x	____	=	____
3.	____________________	____	x	____	=	____
4.	____________________	____	x	____	=	____
5.	____________________	____	x	____	=	____
6.	____________________	____	x	____	=	____
7.	____________________	____	x	____	=	____
8.	____________________	____	x	____	=	____
9.	____________________	____	x	____	=	____
10.	____________________	____	x	____	=	____
		SUMS		____		____ = DIDI

CLOSING COMMENTS

CHAPTER ELEVEN: FORAGE CHARACTERISTICS AND THE DIGESTIBILITY OF PLANT TISSUE, contains descriptions of some of the basic cell characteristics that affect the digestibilities of different species and plant parts through time. The relatively recent cellular approach to digestibilities was preceded by a century of chemical analyses of plant material. The relatively recent *in vitro* digestibility measurements have been preceded by thousands of *in vivo* trials on domestic ruminants, and a fair number on wild ruminants. Extensive literature lists covering both the earlier chemical composition and the later cell characteristics work, the earlier *in vivo* measurements and the later *in vitro* ones, have been included in this CHAPTER. The data in these references are needed when calculating forage consumption in CHAPTER 12.

GLOSSARY OF SYMBOLS USED - CHAPTER ELEVEN

ABUP = Absorbed but unused protein
ACTI = Activity
ADF = Acid detergent fiber
APDE = Apparent digestible energy
APDP = Apparent digestible protein
AUUE = Absorbed but unused urinary energy

CRPR = Crude protein
CSCP = Cell soluble content in percent of forage
CSDP = Cell soluble digestibility in percent
CSFF = Cell soluble fraction of the forage
CWCP = Cell wall content in percent of forage
CWDG = In vivo cell wall digestibility
CWDP = Cell wall digestibility in percent
CWFF = Cell wall fraction of the forage

DIDI = Diet digestibility
DMDP = Dry matter digestibility in percent
DORM = Dormant

EURN = Endogenous urinary nitrogen

FDIC = Forage digestibility coefficient
FEEN = Fecal energy
FEPR = Fecal protein
FLBU = Floral buds
FLOP = Flowers open
FRDI = Fraction of the diet digestibility

GREN = Gross energy

HEFE = Heat of fermentation
HNUM = Heat of nutrient metabolism

JDAY = Julian day

KCAL = Kilocalories

LCUC = Lignin-cutin content expressed as percent of the acid-detergent fiber
LEBU = Leaf buds
LEEM = Leaves emerging
LEFA = Leaves fallen
LEWI = Leaves withering
LGCC = Lignin-cutin content of the acid-detergent fiber
LGCC = Lignin-cutin content as a percent of the acid-detergent fiber
LGNC = Lignin content of the acid-detergent fiber

MAIN = Maintenance
MEEN = Metabolizable energy
MFEN = Metabolic fecal energy
MFNT = Metabolic fecal nitrogen
MNIC = Metabolizable nitrogenous compounds
MUEN = Metabolic urinary energy

NEEN = Net energy
NENS = Net nitrogen synthesized

PIUF = Protein in undigested forage
PLPA = Plant Part
PROD = Production
PTCW = Percent cell wall

REGU = Regulation

SFDI = Seeds and fruits dispersed
SFMT = Seeds and fruits maturing

TDIP = True digestible protein
TDMD = True dry matter digestibility in percent
TRDE = True digestible energy

UFOR = Undigested forage residue
UREN = Urinary energy
URNI = Urinary nitrogen

AAAHA Australian Journal of Experimental Agriculture and Animal Husbandry
ABSZA Annales Botanici Societatis Zoologicae Botanicae Fennicae Vanamo
ADAGA Advances in Agronomy
ADCSA Advances in Chemistry Series
AGJOA Agronomy Journal(US)
AGNSA New South Wales Agricultural Gazette
AJBOA American Journal of Botany
AJCNA American Journal of Clinical Nutrition
AMEBA Annales Medicinae Experimentalis et Biologiae Fenniae
AMNAA American Midland Naturalist
AMNTA American Naturalist
AMSCA American Scientist
APMBA Applied Microbiology (US)
ATICA Arctic (Canada)
ATRLA Acta Theriologica (Poland)
AZOFA Annales Zoologici Fennici (Finland)
AZWBA Arizona Game and Fish Department Wildlife Bulletin

BIJOA Biochemical Journal (England)
BJNUA British Journal of Nutrition (England)
BOGAA Botanical Gazette (US)
BOREA Botanical Review (US)
BPURD Biological Papers of the University of Alaska Special Report
BSECB Biochemical Systematics and Ecology
BTBCA Bulletin of the Torrey Botanical Club
BZSSA Botanicheskii Zhurnal SSSR (USSR)

CAEBA California Agricultural Experiment Station Bulletin
CAFGA California Fish and Game
CFGGA California Department of Fish and Game, Game Bulletin
CGFPA Colorado Division of Game, Fish, and Parks Special Report
CJBOA Canadian Journal of Botany
CJFRA Canadian Journal of Forest Research (Canada)
CJZOA Canadian Journal of Zoology
CNAPA Canada Department of Agriculture Publication
CNDRA Condor
CNJNA Canadian Journal of Animal Science
CNRDA Canadian Journal of Research, Section D, Zoological Sciences
COVEA Cornell Veterinarian
CPLSA Canadian Journal of Plant Science
CRPSA Crop Science
CWRSB Canadian Wildlife Service Report and Management Bulletin Series
CWSPA Colorado Division of Wildlife Special Report

ECMOA Ecological Monographs
ECOLA Ecology
ELPLB Ekologia Polska
ENDEA Endeavour

FOSCA Forest Science
FRCRA Forestry Chronicle
FRSTA Forestry

GRBNA Great Basin Naturalist

HLTPA Health Physics
HOECD Holarctic Ecology

IZYBA International Zoo Year Book

JACSA Journal of the American Chemical Society
JAFCA Journal of Agricultural Food and Chemistry
JAGRA Journal of Agricultural Research
JANCA Journal of the Association of Official Analytic Chemists
JANSA Journal of Animal Science
JAPEA Journal of Applied Ecology
JASIA Journal of Agricultural Science
JBRGA Journal of the British Grassland Society
JCECD Journal of Chemical Ecology
JDSCA Journal of Dairy Science
JECOA Journal of Ecology
JFUSA Journal of Forestry
JOMAA Journal of Mammalogy
JONUA Journal of Nutrition
JPHAA Journal of the American Pharmaceutical Association
JRMGA Journal of Range Management
JSFAA Journal of the Science of Food and Agriculture
JWIDA Journal of Wildlife Diseases
JWMAA Journal of Wildlife Management

LATBA Louisiana Agricultural Experiment Station Bulletin

MDCBA Minnesota Department of Conservation Technical Bulletin
MDCRA Michigan Department of Conservation Game Division Report
MGLHA Mitteilungen aus dem Gebiete derr Lebensmitteruntersuchung und hygiene
MLTBB Maine Life Sciences and Agricultural Experiment Station Technical Bulletin
MUATA Minnesota Agricultural Experiment Station Technical Bulletin

NAREA Nutrition Abstracts and Reviews
NASRA National Academy of Sciences--National Research Council, Publication
NATUA Nature (England)
NAWTA North American Wildlife and Natural Resources Conference, Transactions of the, NCANA Naturaliste Canadien, Le
NDFRA North Dakota Farm Research
NETMA Netherlands Journal of Agricultural Science
NEXAA New Mexico Agricultural Experiment Station Bulletin
NEZFA New Zealand Journal of Agricultural Research
NFGJA New York Fish and Game Journal

NOSCA Northwest Science
NUABA Nevada Agricultural Experiment Station Bulletin

OIKSA Oikos (Denmark)
OJSCA Ohio Journal of Science

PASHA Proceedings of the American Society for Horticultural Science
PCGFA Proceedings of the Southeastern Association of Game and Fish Commissioners
PLPHA Plant Physiology
PLSOA Plant and Soil
PMSCA Proceedings of the Minnesota Academy of Science
PNASA Proceedings of the National Academy of Sciences of the United States
PNUSA Proceedings of the Nutrition Society
PSAFA Proceedings of the Society of American Foresters
PYTCA Phytochemistry
PZSLA Proceedings of the Zoological Society of London

RAPHB Recent Advances in Phytochemistry

SCIEA Science
SJECA Soviet Journal of Ecology (English translation of Ekologiya)
SOSCA Soil Science
SSSAA Soil Science Society of America, Proceedings
SSSJD Soil science Society of America Journal
SWNAA Southwestern Naturalist
SZSLA Symposia of the Zoological Society of London

TAEBA Texas Agricultural Experiment Station Bulletin
TAEMA Texas Agricultural Experiment Station Miscellaneous Publication
TNWSD Transactions of the Northeast Section, The Wildlife Society
TPCWD Colorado Division of Wildlife Technical Publication

UABPA Biological Papers of the University of Alaska
UASPA Proceedings of the Utah Academy of Sciences, Arts and Letters
UAXBA Utah Agricultural Experiment Station Bulletin
UCPZA University of California Publications in Zoology

WAEBA Wyoming Agricultural Experiment Station Bulletin
WCDBA Wisconsin Department of Natural Resources Technical Bulletin
WGFBA Wyoming Game and Fish Commission Bulletin
WLMOA Wildlife Monographs
WMBAA Wildlife Management Bulletin (Ottowa) Series 1 (Canada)
WUAPA Wisconsin Agricultural Experiment Station, Research Report
WVAFA West Virginia Agriculture and Forestry
WZMNA Wissenschaftliche Zeitschrift Karl-Marx Universitaet Leipzig Mathematisch-Naturwissenschaftliche Reihe

XAAHA U S D A Agricultural Handbook
XAGCA U S D A Circular
XAMPA U S D A Miscellaneous Publication

XARRA U S Forest Service Research Note RM
XATBA U S D A Technical Bulletin
XFINA U S Forest Service Research Note INT
XFIPA U S Forest Service Research Paper INT
XFNSA U S Forest Service Research Note SO
XFPNA U S Forest Service Research Paper PNW
XFPSA U S Forest Service Research Paper SO
XFRMA U S Forest Service Research Paper RM
XPNWA U S Forest Service Research Note PNW

ZEJAA Zeitschrift fuer Jagdwissenschaft
ZTTFA Zeitschrift fuer Tierphysiologie Tierer naehrung und Futtermittelkunde

LIST OF PUBLISHERS - CHAPTER ELEVEN

acpr	Academic Press	New York	nyny
agrc	Agricultural Research Council	London	loen
butt	Butterworth	Washington, D. C.	wadc
cdch	C. D. Church	Corvallis, OR	coor
dvnc	D. Van Nostrand Co.	New York	nyny
esli	E. and S. Livingstone, Publishers	Edinburgh, Great Britain	edgb
isup	Iowa State University Press	Ames, IO	amia
long	Longman	London	loen
mhbc	McGraw-Hill Book Company, Inc.	New York	nyny
mopc	Morrison Publishing Company	Ithaca, NY	itny
nasc	National Academy of Science	Washington, D. C.	wadc
nhfg	New Hampshire Fish & Game Dept.	Concord, NH	conh
olbo	Oliver and Boyd	Edinburgh, Scotland	edsc
prha	Prentice-Hall, Inc.	Englewood Cliffs, NJ	ecnj
spve	Springer-Verlaug Inc.	New York	nyny
stmp	St. Martin's Press	New York	nyny
whfr	W. H. Freeman Co.	San Francisco, CA	sfca

LIST OF WORKSHEETS - CHAPTER ELEVEN

GLOSSARY OF PLANT CODE NAMES

GENS SPEC	SCIENTIFIC NAME
abie amab	Abies amabilis
abie bals	Abies balsamea
abie conc	Abies concolor
abie gran	Abies grandis
abie lasi	Abies lasiocarpa
abie ----	Abies
abut inca	Abutilon incanum
abut theo	Abutilon theophrasti
acac angu	Acacia angustissima
acac farn	Acacia farnesiana
acac greg	Acacia greggii
acac roem	Acacia roemeriana
acac ----	Acacia
acal grac	Acalypha gracilens
acer circ	Acer circinatum
acer glau	Acer glaubrum
acer macr	Acer macrophyllum
acer negu	Acer negundo
acer pens	Acer pensylvanicum
acer pseu	Acer pseudoplatanus
acer rubr	Acer rubrum
acer sacc	Acer saccharinum
acer sach	Acer saccharum
acer spic	Acer spicatum
acer ----	Acer
achi lanu	Achillea lanulosa
achi mill	Achillea millefolium
aden fasc	Adenostoma fasciculatum
aesc cali	Aesculus californica
aesc hipp	Aesculus hippocastanum
aesc pavi	Aesculus pavia
agar arve	Agaricus arvensis
agar bisp	Agaricus bisporus
agar camp	Agaricus campestris
agos glau	Agoseris glauca

agro smit	Agropyron smithii
agro spic	Agropyron spicatum
agro trac	Agropyron trachycaulon var. majus
agro trah	Agropyron trachycaulon
agro ----	Agropyron
agrs bore	Agrostis borealis
agrs idah	Agrostis idahoensis
agrs ----	Agrostis
albi juli	Albizia julibrissin
alec juba	Alectoria jubata
alec sarm	Alectoria sarmentosa
alec ----	Alectoria
alli text	Allium textile
alnu cris	Alnus crispa
alnu crmo	Alnus crispa var. mollis
alnu glut	Alnus glutinosa
alnu inca	Alnus incana
alnu rubr	Alnus rubra
alnu rugo	Alnus rugosa
alnu sinu	Alnus sinuata
alnu sito	Alnus sitohensis
alnu ----	Alnus
amar palm	Amaranthus palmerii
amar retr	Amaranthus retroflexus
amar ----	Amaranthus
ambr arte	Ambrosia artemisiifolia
ambr psil	Ambrosia psilostachya
ambr trif	Ambrosia trifida
amel alni	Amelanchier alnifolia
amel arbo	Amelanchier arborea
amel bart	Amelanchier bartramiana
amel cana	Amelanchier canadensis
amel flor	Amelanchier florida
amel spic	Amelanchier spicata
amel utah	Amelanchier utahensis
amel ----	Amelanchier
amor cane	Amorpha canescens
ampe arbo	Ampelopsis arborea
anac cana	Anacharis canadensis
andm glau	Andromeda glaucophylla

andp dive	Andropogon divergens
andp elli	Andropogon elliottii
andp gera	Andropogon gerardi
andp subt	Andropogon subtenuis
andp tene	Andropogon tener
andp tern	Andropogon ternarius
andp virg	Andropogon virginicus
andp ----	Andropogon
ante plan	Antennaria plantaginifolia
arab drum	Arabis drummondii
aral nudi	Aralia nudicaulis
aral race	Aralia racemosa
arcg lati	Arctagrostis latifolia
arcs alpi	Arctostaphylos alpina
arcs glan	Arctostaphylos glandulosa
arcs patu	Arctostaphylos patula
arcs pung	Arctostaphylos pungens
arcs stan	Arctostaphylos stanfordiana
arcs uvur	Arctostaphylos uva-ursi
arcs visc	Arctostaphylos viscida
arcs ----	Arctostaphylos
arct cale	Arctotheca calendula
aren groe	Arenaria groenlandica
aris long	Aristida longiseta
aris stri	Aristida stricta
aris ----	Aristida
arni fulg	Arnica fulgens
aron arbu	Aronia arbutifolia
aron mela	Aronia melanocarpa
arte arbu	Artemisia arbuscula
arte arno	Artemisia arbuscula nova
arte arct	Artemisia arctica
arte cali	Artemisia californica
arte camp	Artemisia campestris
arte cana	Artemisia cana
arte fili	Artemisia filifolia
arte frig	Artemisia frigida
arte gnap	Artemisia gnaphalodes (see also arte vulg)
arte ludo	Artemisia ludoviciana
arte nova	Artemisia nova
arte peda	Artemisia pedatifida

arte spin	Artemisia spinescens
arte trid	Artemisia tridentata
arte trip	Artemisia tripartita
arte vulg	Artemisia vulgaris (see also arte gnap)
arte ----	Artemisia
aste chil	Aster chilensis
aste comm	Aster commutatus
aste foli	Aster foliaceus
aste pilo	Aster pilosus
aste tena	Aster tenacetifolius
aste ----	Aster
astr bisu	Astragalus bisulcatus
astr emor	Astragalus emoryanus
astr mise	Astragalus miser
astr patt	Astragalus pattersonii
astr recu	Astragalus recurvus
astr tetr	Astragalus tetrapterus
astr ----	Astragalus
atri cane	Atriplex canescens
atri conf	Atriplex confertifolia
atri coro	Atriplex coronata
atri eleg	Atriplex elegans
atri hali	Atriplex halimoides
atri holo	Atriplex holocarpa
atri lent	Atriplex lentiformis
atri line	Atriplex linearis
atri nutt	Atriplex nuttallii
atri poly	Atriplex polycarpa
atri rose	Atriplex rosea
atri semi	Atriplex semibaccata
atri volu	Atriplex volutans
aula turg	Aulacomnium turgidum
aven fatu	Avena fatua
aven sati	Avena sativa

bahi oppo	Bahia oppositifolia
bals sagg	Balsamorhiza saggittata
benz aest	Benzoin aestivale (see also lind benz)
berb nerv	Berberis nervosa
berb thun	Berberis thunbergii
berb trif	Berberis trifoliata

berc scan	Berchemia scandens
betu alba	Betula alba
betu alle	Betula alleghaniensis
betu glan	Betula glandulosa
betu lent	Betula lenta
betu lute	Betula lutea
betu mino	Betula minor
betu nana	Betula nana
betu nigr	Betula nigra
betu papy	Betula papyrifera
betu pend	Betula pendula
betu popu	Betula populifolia
betu pube	Betula pubescens
betu pulm	Betula pulma
betu pumi	Betula pumila
betu verr	Betula verrucosa
betu ----	Betula
boer tenu	Boerhaavia tenuifolia
bole edul	Boletus edulis
bout grac	Bouteloua gracilis
bout ----	Bouteloua
brac decu	Bracharia decumbens
bras kabe	Brassica kaber
brom briz	Bromus brizaeformis
brom moll	Bromus mollis
brom pump	Bromus pumpellianus
brom rigi	Bromus rigidus
brom tect	Bromus tectorum
brun cirr	Brunnichia cirrhosa
buch dact	Buchloe dactyloides
bume texa	Bumelia texana
cala cana	Calamogrostis canadensis
cala casc	Calamagrostis canadensis var. scabra
calc amer	Callicarpa americana

cale stra	Calliergon stramineum
calg schi	Calliergonella schieberi
cali erio	Calliandra eriophylla
call palu	Calla palustris
calm cana	Calmagrostis canadensis
calt lept	Caltha leptosepala
calu vulg	Calluna vulgaris
came micr	Camelina microcarpa
camp rotu	Campanula rotundifolia
cams radi	Campsis radicans
cant ciba	Cantharellus cibarius
care aqua	Carex aquatilis
care bige	Carex bigelowii
care brev	Carex brevipes
care cane	Carex canescens
care eben	Carex ebenea
care geop	Carex geophila
care heli	Carex heliophora
care lacu	Carex lacustris
care mult	Carex multicaulis
care scir	Carex scirpoidea
care stri	Carex stricta
care ----	Carex
carn giga	Carnegiea gigantea
carp betu	Carpinus betulus
cart tinc	Carthamus tinctorius
cary aqua	Carya aquatica
cary cord	Carya cordiformis
cary glab	Carya glabra
cary illi	Carya illinoensis
cary leid	Carya leidodermus
cary ovat	Carya ovata (see also hico ovat)
cary texa	Carya texana
cary tome	Carya tomentosa
cary ----	Carya

casa cham   Cassia chamaecrista (see also casa fasc)
casa fasc   Cassia fasciculata (see also casa cham)
casa mari   Cassia marilandica
casa nict   Cassia nictitans
casa roem   Cassia roemeriana
casa ----   Cassia

casi hypn   Cassiope hypnoides
casi tetr   Cassiope tetragona

casn dent   Castanea dentata
casn vulg   Castanea vulgaris

cata spec   Catalpa speciosa

cean amer   Ceanothus americanus
cean cord   Ceanothus cordulatus
cean cune   Ceanothus cuneatus
cean diva   Ceanothus divaricatus (see also cean leuc)
cean fend   Ceanothus fenderli
cean foli   Ceanothus foliosus
cean greg   Ceanothus greggii
cean inte   Ceanothus integerrimus
cean leuc   Ceanothus leucodermis (see also cean diva)
cean parv   Ceanothus parvifolius
cean pros   Ceanothus prostratus
cean velu   Ceanothus velutinus
cean ----   Ceanothus

celt laev   Celtis laevigata
celt occi   Celtis occidentalis
celt pall   Celtis pallida
celt reti   Celtis reticulata

cera arve   Cerastium arvense

cerc betu   Cercocarpus betuloides
cerc brev   Cercocarpus breviflorus
cerc ledi   Cercocarpus ledifolius
cerc mont   Cercocarpus montanus

cerd ----   Cercidium

cerp deme   Ceratophyllum demersum

cers cana   Cercis canadensis

cetr cucu   Cetraria cucullata
cetr isla   Cetraria islandica
cetr niva   Cetraria nivalis

chae caly   Chaemaedaphne calyculata

cham foli	Chamaebatia foliolosa
chan caly	Chamaedaphne calyculata
chap thyo	Chamaecyparis thyoides
char vulg	Chara vulgaris
chen albu	Chenopodium album
chlo cucu	Chloris cucullata
chlo gaya	Chloris gayana
chrs gram	Chrysopsis graminifolia
chry lanc	Chrysothamnus lanceolatus
chry naus	Chrysothamnus nauseosus
chry pulc	Chrysothamnus pulcherrimus
chry sten	Chrysothamnus stenophyllus
chry tere	Chrysothamnus teretifolius
chry visc	Chrysothamnus viscidiflorus
chry vise	Chrysothamnus viscidiflorus serrulatus
chry ----	Chrysothamnus
cicu ----	Cicuta
cirs hook	Cirsium hookerianum
cirs undu	Cirsium undulatum
citr limo	Citrus limon
clad alpe	Cladonia alpestris
clad grac	Cladonia gracillis
clad miti	Cladonia mitis
clad rang	Cladonia rangifera
clad rani	Cladonia rangiferina
clad ----	Cladonia
clar lute	Cladrastis lutea
clav purp	Claviceps purpurea
clem drum	Clematis drummondii
clet alni	Clethra alnifolia
cole ramo	Coleogyne ramosissima
coll line	Collomia linearis
colu texe	Colubrina texensis

coma pall	Comandra pallida
comp pere	Comptonia peregrina
cond obtu	Condalia obtusifolia
conv arve	Convolvulus arvensis
corn alte	Cornus alternifolia
corn cana	Cornus canadensis
corn drum	Cornus drummondi
corn flor	Cornus florida
corn nutt	Cornus nuttallii
corn pani	Cornus paniculata (see also corn race)
corn race	Cornus racemosa (see also corn pani)
corn rugo	Cornus rugosa
corn stol	Cornus stolonifera
corn ----	Cornus
coro vari	Coronilla varia
cory amer	Corylus americana
cory avel	Corylus avellana
cory cali	Corylus californica
cory corn	Corylus cornuta (see also cory rost)
cory rost	Corylus rostrata (see also cory corn)
cory ----	Corylus
coto pyra	Cotoneaster pyracantha
covi trid	Covillea tridentata
cowa stan	Cowania stansburiana
crat crus	Crataegus crus-galli
crat mono	Crataegus monogyna
crat poli	Crataegus polita
crat ----	Crataegus
crot cory	Croton corymbulosus
crot mona	Croton monanthogynus
crot neom	Croton neomexicanus
crot ----	Croton
cryp japo	Cryptomeria japonica
cucu foet	Cucurbita foetidissima
cucu pepo	Cucurbita pepo
cusc exal	Cuscuta exaltata
cymo wats	Cymopterus watsonii

cyna vinc	Cynanchum vincetoxicum
cyno dact	Cynodon dactylon
cypc ----	Cyperaceae
cype rotu	Cyperus rotundus
cyri race	Cyrilla racemiflora
dact glom	Dactylis glomerata
dale albi	Dalea albiflora
daph meze	Daphne mezereum
delp ande	Delphinium andersonii
delp barb	Delphinium barbeyi
delp glac	Delphinium glaucescens
delp glam	Delphinium glaucum
delp nels	Delphinium nelsonii
delp occi	Delphinium occidentale
delp ----	Delphinium
desc soph	Descarainia sophia
desh caes	Deschampsia caespitosa
desh flex	Deschampsia flexuosa
desi soph	Descurainia sophia
desm cool	Desmanthus cooleyi
desm fall	Desmanthus fallax
deso glut	Desmodium glutinosum
diap lapp	Diapensia lapponica
dicr beig	Dicranum beigeri
dier loni	Diervilla lonicera
dioc mult	Dioclea multiflora
dios texa	Diospyros texana
dios virg	Diospyros virginiana
drab aure	Draba aurea

echi crus	Echinochloa crusgalli
ecin crus	Ecinochloa crusgalli
elae angu	Elaeagnus angustifolia
eleo smal	Eleocharis smalli
elym glau	Elymus glauca
empe eame	Empetrum eamesii ssp. hermaphroditum
empe nigr	Empetrum nigrum
ephe anti	Ephedra antisyphilitica
ephe neva	Ephedra nevadensis
ephe torr	Ephedra torreyana
ephe trif	Ephedra trifurca
ephe viri	Ephedra viridis
ephe ----	Ephedra
epil angu	Epilobium angustifolium
epil lati	Epilobium latifolium
equi ----	Equisetum
erag ----	Eragrostis
ergo race	Ergonium racemosum
eria ----	Eriastrum
erid cali	Eriodictyon californicum
erie ----	Erigeron
erig hera	Eriogonum heracleoides
erig race	Eriogonum racemosum
erig wrig	Eriogonum wrightii
erig ----	Eriogonum
erip vagi	Eriophorum vaginatum
erip ----	Eriophorum
erod cicu	Erodium cicutarium
erod mosc	Erodium moschatum
erys aspe	Erysimum asperum
eryt amer	Erythronium americanum
eryt gran	Erythronium grandiflorum
euca obli	Eucaluptus obliqua

euon amer	Euonymus americana
euph cict	Euphorbia cictyesperma
euph coro	Euphorbia corollata
euph fend	Euphorbia fendleri
euph pros	Euphorbia prostrata
euph ----	Euphorbia
euro lana	Eurotia lanata
evol nutt	Evolvulus nuttallianus
fagu gran	Fagus grandifolia
fagu sylv	Fagus sylvatica
fagu ----	Fagus
fero wisl	Ferocactus wislizenii
fest alta	Festuca altaica
fest ariz	Festuca arizonia
fest idah	Festuca idahoensis
fest octo	Festuca octoflora
fest ----	Festuca
flou cern	Flourensia cernua
fome ----	Fomes
fore neom	Forestiera neomexicana
frag amer	Fragaria americana
fras ----	Franseria
frax amer	Fraxinus americana
frax exce	Fraxinus excelsior
frax lati	Fraxinus latifolia
frax quad	Fraxinus quadrangulata
frax ----	Fraxinus
fuma offi	Fumaria officinalis
gali bore	Galium boreale
gaul proc	Gaultheria procumbens

gayl bacc	Gaylussacia baccata
gels semp	Gelsemium sempervirens
gera rich	Geranium richardsoni
gera ----	Geranium
geum peck	Geum peckii
geum trif	Geum triflorum
geum ----	Geum
gili mult	Gilia multiflora
gled tria	gleditsia triacanthos
gram ----	gramineae
gray spin	Grayia spinosa
guai coul	Guaiacum coulteri
guar cocc	Guara coccinea
guti micr	Gutierrezia microcephala
guti saro	Gutierrezia sarothrae
guti spha	Gutierrezia sphaerocephala
guti texa	Gutierrezia texana
gyro escu	Gyromitra esculenta
halo glom	Halogeton glomeratus
hama vern	Hamamelis vernalis
hama virg	Hamamelis virginiana
hedy bore	Hedysarum boreale
hele hoop	Helenium hoopesii
heli quin	Helianthella quinquenervis
heln angu	Helianthus angustifolius
heln annu	Helianthus annuus
heln hirs	Helianthus hirsutus
helo heli	Heliopsis helianthoides
heve ----	Hevea

hevl escu	Hevella esculenta
hico ovat	Hicoria ovata
hila bela	Hilaria belangeri
hoff brac	Hoffmanseggia brachycarpa
hord lepo	Hordeum leporinum
hous caer	Houstonia caerulea var. faxonorum
hydr arbo	Hydrangea arborescens
hyme odor	Hymenoxys odorata
hyme rich	Hymenoxys richardsonii var. floribunda
hype macu	Hypericum maculatum
hypr perf	Hypericium perforatum
ilex cori	Ilex coriacea
ilex deci	Ilex decidua
ilex glab	Ilex glabra
ilex opac	ilex opaca
ilex vert	Ilex verticillata
ilex vomi	Ilex vomitoria
impa cape	Impatiens capensis
ipom ----	Ipomoea
iva axil	Iva axillaris
jacq tamn	Jacquemontia tamnifolia
jugl cine	Juglans cinerea
jugl nigr	Juglans nigra
junc comm	Juncus communis
junc trif	Juncus trifidus
juni hori	Juniperus horizontalis
juni knig	Juniperus knightii
juni occi	Juniperus occidentalis

juni pinc	Juniperus pinchoti
juni scop	Juniperus scopulorum
juni utah	Juniperus utahensis
juni virg	Juniperus virginiana

kalm angu	Kalmia angustifolia
kalm lati	Kalmia latifolia
kalm poli	Kalmia polifolia
koch amer	Kochia americana
koch chil	Kochia childsii
koch scop	Kochia scoparia
koch vest	Kochia vestita
kram secu	Krameria secundiflora
kunz trid	Kunzia tridentata (see also purs trid)

lact cana	Lactuca canadensis
lact ----	Lactuca
lamn minr	Lamna minor
lari lari	Larix laricina
lari lept	Larix leptolepis
lari occi	Larix occidentalis
lath ----	Lathyens
laty ochr	Lathyrus ochroleucus
laty ----	Lathyrus
ledu groe	Ledum groenlandicum
ledu palu	Ledum palustris v. decumbens
lept mult	Leptoptaenia multifida
lesp stip	Lespediza stipulacea
leuc retu	Leucaena retusa
leuo minu	Leucophyllum minus
leut edit	Leucothoe editorum
lewi pygm	Lewisia pygmeae

liat punc	Liatrus punctata
libo decu	Libocedrus decurrens
ligs port	Ligusticum porteri
ligu obtu	Ligustrum obtusifolium
lind benz	Lindera benzoin (see also benz aest)
linm usit	Linum usitatissimum
liqu styr	Liquidambar styraciflua
liri tuli	Liriodendron tulipifera
lois proc	Loiseleuria procumbens
loli rigi	Lolium rigidum
loni albi	Lonicera albinura
loni cana	Lonicera canadensis
loni invo	Lonicera involucrata
loni japo	Lonicera japonica
loni morr	Lonicera morrowii
loni vill	Lonicera villosa
loni xylo	Lonicera xylosteum
lotu wrig	Lotus wrightii
lotu ----	Lotus
lupi arct	Lupinus arcticus
lupi caud	Lupinus caudatus
lupi seri	Lupinus sericeus
lupi ----	Lupinus
luzu spic	Luzula spicata
lyco anno	Lycopodium annotinum var. pungens
lyco sela	Lycopodium selago var. appressum
lyon luci	Lyonia lucida
macl pomi	Maclura pomifera
magn acum	Magnolia acuminata
magn macr	Magnolia macrophylla
magn virg	Magnolia virginiana

maho repe	Mahonia repens
maia cana	Maianthemum canadense
mani escu	Manihot esculenta
medi sati	Medicago sativa
meli offi	Melilotus officinalis
meli ----	Melilotus
ment pipe	Mentha piperita
menz pilo	Menziesia pilosa
mert cili	Mertensia ciliata
mimo frag	Mimosa fragrans
mira line	Mirabilis linearis
mona odor	Monardella odoratissima
morc angu	Morchella angusticeps
morc coni	Morchella conica
morc cras	Morchella crassipes
morc deli	Morchella deliciosa
morc escu	Morchella esculenta
moru alba	Morus alba
moru micr	Morus microphylla
moru rubr	Morus rubra
muhl mont	Muhlenbergia montana
muhl ----	Muhlenbergia
musa acum	Musa acuminata
myos alpe	Myosotis alpestris
myri aspl	Myrica asplenifolia
myri ceri	Myrica cerifera
myri gale	Myrica gale
myri pens	Myrica pensylvanica
myro exal	Myriophyllum exalbescens

nemo mucr   Nemopanthus mucronata

neph arct   Nephroma arcticum

noli macr   Nolina macrocarpa
noli micr   Nolina microcarpa
noli texa   Nolina texana

nuph vari   Nuphar variegatum
nuph ----   Nuphar

nymp tube   Nymphaea tuberosa

nyss sylv   Nyssa sylvatica

oeno ----   Oenothera

opun enge   Opuntia engelmannii
opun fulg   Opuntia fulgida
opun poly   Opuntia polycantha
opun spin   Opuntia spinosior
opun ----   Opuntia

orth lute   Orthocarpus luteus

oryz aspe   Oryzopsis asperfolia
oryz hyme   Oryzopsis hymenoides

osmo clay   Osmorhiza claytoni
osmo occi   Osmorhiza occidentalis

ostr virg   Ostrya virginiana

oxyd arbo   Oxydendrum arboreum

oxyt ----   Oxytropis

pani ----   Panicum

park ----   Parkinsonia

parm ----   Parmelia

part quin   Parthenocissus quinquefolia
part vita   Parthenocissus vitacea

pasp ----   Paspalum

pelg ----	Peltigera
pens leon	Penstemon leonardi
pens whip	Penstemon whippleanus
pere nana	Perezia nana
peri gair	Perideridia gairdneri
pers borb	Persea borbonia
pers ----	Persea
phal arun	Phalaris arundinacea
phas ----	Phaseolus
phle prat	Phleum pratense
phyl caer	Phyllodoce caerulea
phys malv	Physocarpus malvaceus
phys pube	Physocarpus pubescens
phyt amer	Phytolacca americana
pice abie	Picea abies
pice enge	Picea engelmanni
pice glau	Picea glauca
pice mari	Picea mariana
pice obov	Picea obovata
pice rube	Picea rubens
pice sitc	Picea sitchensis
pice ----	Picea
pins albi	Pinus albicaulis
pins bank	Pinus banksiana
pins cemb	Pinus cembroides
pins clau	Pinus clausa
pins cont	Pinus contorta
pins ctla	Pinus contorta latifolia
pins echi	Pinus echinata
pins elli	Pinus elliottii
pins lamb	Pinus lambertiana
pins mont	Pinus monticola
pins nigr	Pinus nigra
pins nrca	Pinus nigra var. calabrica
pins nrma	Pinus nigra var. maritima
pins palu	Pinus palustris
pins pond	Pinus ponderosa
pins radi	Pinus radiata
pins resi	Pinus resinosa
pins rigi	Pinus rigida

pins sibe	Pinus siberica
pins silv	Pinus silvestris
pins stro	Pinus strobus
pins sylv	Pinus sylvestris
pins taed	Pinus taeda
pins virg	Pinus virginiana
pins ----	Pinus
plan majo	Plantago major
plan purs	Plantago purshii
plat occi	Platanus occidentalis
pleu schr	Pleurozium schreberi
poa cusi	Poa cusickii
poa fend	Poa fendleriana
poa fern	Poa fernaldiana
poa patt	Poa pattersoni
poa rupi	Poa rupicola
poa sand	Poa sandbergii
poa ----	Poa
poly alas	Polygonum alaskanum
poly avic	Polygonum aviculare
poly conv	Polygonum convolvulus
poly fago	Polygonum fagopyrum
poly pens	Polygonum pensylvanicum
poly vivi	Polygonum viviparum
poys muni	Polystichum munitum
poyt juni	Polytrichum juniperinum var. alpestre
poyt pili	Polytrichum piliferum
popu delt	Populus deltoides
popu gran	Populus grandidentata
popu trem	Populus tremula
popu treu	Populus tremuloides
popu tric	Populus trichocarpa
popu ----	Populus
pota ampl	Potamogeton amplifolius
pota epih	Potamogeton epihydrus
pota pect	Potamogeton pectinatus
pota rich	Potamogeton richardsonii
pota robi	Potamogeton robinsii
pota zost	Potamogeton zosteriformis
pota ----	Potamogeton
pote dive	Potentilla diversifolia
pote grac	Potentilla gracilis

pote trid	Potentilla tridentata
pote ----	Potentilla
pros chil	Prosopis chilensis
pros juli	Prosopis juliflora
pros velu	Prosopis velutina
pros ----	Prosopis
prun amer	Prunus americana
prun ande	Prunus andersonii
prun demi	Prunus demissa (see also prun virg)
prun emar	Prunus emarginata
prun fasc	Prunus fasciculata
prun ilic	Prunus ilicifolia
prun mari	Prunus maritima
prun mela	Prunus melanocarpa (see also prun vrme)
prun minu	Prunus minutiflora
prun pens	Prunus pensylvanica
prun sero	Prunus serotina
prun subc	Prunus subcordata
prun umbe	Prunus umbellata
prun virg	Prunus virginiana (see also prun demi)
prun vrme	Prunus virginiana melanocarpa (see also prun mela)
prun ----	Prunus
pscy mont	Pseudocymopterus montanus
pseu menz	Pseudotsuga menziesii
pseu taxi	Pseudotsuga taxifolia
pseu tagl	Pseudotsuga taxifoflia glauca
psor tenu	Psoralea tenuiflora
pter aqui	Pteridium aquilinum
puer loba	Pueraria lobata
purs trid	Purshia tridentata (see also kunz trid)
purs ----	Purshia
pyrl pube	Pyrularia pubera
pyru angu	Pyrus angustifolia
pyru comm	Pyrus communis
pyru coro	Pyrus coronaria
pyru malu	Pyrus malus
pyru ----	Pyrus

quer acut	Quercus acutissima
quer agri	Quercus agrifolia
quer alba	Quercus alba
quer bico	Quercus bicolor
quer bore	Quercus borealis
quer bref	Quercus brevifolia (see also quer cine)
quer brev	Quercus breviloba
quer cali	Quercus californica
quer chry	Quercus chrysolepis
quer cine	Quercus cinerea (see also quer bref)
quer cocc	Quercus coccinea
quer doug	Quercus douglasii
quer dumo	Quercus dumosa
quer dura	Quercus durata
quer elli	Quercus ellipsoidalis
quer emor	Quercus emoryi
quer falc	Quercus falcata (see also quer rubr)
quer gamb	Quercus gambelli
quer garr	Quercus garryana
quer harv	Quercus harvardii
quer ilic	Quercus ilicifolia
quer inca	Quercus incana
quer kell	Quercus kelloggii
quer lyra	Quercus lyrata
quer macr	Quercus macrocarpa
quer mari	Quercus marilandica
quer mini	Quercus minima
quer mino	Quercus mino (see also quer stel)
quer mont	Quercus montana
quer nigr	Quercus nigra
quer nutt	Quercus nuttallii
quer obtu	Quercus obtusa
quer palu	Quercus palustris
quer petr	Quercus petraea
quer phel	Quercus phellos
quer phil	Quercus philtas
quer prin	Quercus prinoides
quer prnu	Quercus prinus
quer robu	Quercus robur
quer rubr	Quercus rubra (see also quer falc)
quer shum	Quercus shumardii
quer stel	Quercus stellata (see also quer mino)
quer turb	Quercus turbinella
quer velu	Quercus velutina
quer virg	Quercus virginiana
quer wisl	Quercus wislizenii
quer ----	Quercus

ranu ----	Ranunculus
rham cali	Rhamnus californica
rham caro	Rhamnus caroliniana
rham fran	Rhamnus frangula
rham purs	Rhamnus purshiana
rhod lapp	Rhododendron lapponicum
rhod maxi	Rhododendron maximum
rhod rose	Rhododendron roseum
rhod ----	Rhododendron
rhoo cana	Rhodododendron canadense
rhus arom	Rhus aromatica
rhus cana	Rhus canadensis
rhus copa	Rhus copallina
rhus dive	Rhus diversiloba
rhus glab	Rhus glabra
rhus hirt	Rhus hirta (see also rhus typh)
rhus micr	Rhus microphylla
rhus radi	Rhus radicans
rhus tril	Rhus trilobata (see also schm tril)
rhus typh	Rhus typhina (see also rhus hirt)
rhus vire	Rhus virens
rhus ----	Rhus
robi neom	Robinia neomexicana
robi pseu	Robinia pseudoacacia
rosa acic	Rosa acicularis
rosa egla	Rosa eglanteria
rosa fend	Rosa fendleri (see also rosa wood)
rosa humi	Rosa humilis
rosa maco	Rosa macounii
rosa maja	Rosa majalis
rosa mult	Rosa multiflora
rosa palu	Rosa palustris
rosa rugo	Rosa rugosa
rosa setg	Rosa setigera
rosa setr	Rosa setigeria
rosa spal	Rosa spaldingii
rosa spin	Rosa spinosissima
rosa wood	Rosa woodsii (see also rosa fend)
rosa woul	Rosa woodsii ultralmontana
rosa ----	Rosa
rubu alle	Rubus allegheniensis
rubu arct	Rubus arcticus
rubu bail	Rubus baileyanus
rubu cham	Rubus chamaemorus
rubu idae	Rubus idaeus

rubu occi	Rubus occidentalis
rubu parv	Rubus parviflorus
rubu saxa	Rubus saxatilis
rubu spec	Rubus spectabilis
rubu viti	Rubus vitifolius
rubu ----	Rubus
rudb hirt	Rudbeckia hirta
rume acet	Rumex acetosella
rume cris	Rumex crispus
saba ----	Sabal
sagi cune	Sagittaria cuneata
sagi rigi	Sagittaria rigida
sali alax	Salix alaxensis
sali amyg	Salix amygdaloides
sali arbu	Salix arbusculoides
sali arct	Salix arctica
sali bebb	Salix bebbiana
sali capr	Salix caprea
sali glau	Salix glauca
sali humi	Salix humilis
sali inte	Salix interior
sali lasi	Salix lasiolepis
sali lute	Salix lutea
sali nigr	Salix nigra
sali phyl	Salix phylicifolia
sali plan	Salix planifolia
sali scou	Salix scouleriana
sali uvur	Salix uva-ursi
sali ----	Salix
sals kali	Salsola kali
salv mell	Salvia mellifera
salv refl	Salvia reflexa
samb call	Sambucus callicarpa
samb cana	Sambucus canadensis
samb glau	Sambucus glauca
samb pube	Sambucus pubens
samb ----	Sambucus
sang cana	Sanguisorba canadensis
sapi sebi	Sapium sebiferum

sarc verm	Sarcobatus vermiculatus
sass albi	Sassafras albidum
schm tril	Schmaltzia trilobata (see also rhus tril)
scir cesp	Scirpus cespitosus
scol fest	Scolochloa festucacea
sene jaco	Senecio jacobaea
sene long	Senecio longilobus
sene neom	Senecio neomexicanus
sene ridd	Senecio riddellii
sene tria	Senecio triangularis
sene ----	Senecio
sequ giga	Sequoiadendron giganteum
seta fabr	Setaria faberi
seta glau	Setaria glauca
seta lute	Setaria lutescens
seta viri	Setaria viridis
shep cana	Shepherdia canadensis
sibb proc	Sibbaldia procumbens
sile acau	Silene acaulis var. exscapa
sile doug	Silene douglasii
sile noct	Silene noctiflora
simm chin	Simmondsia chinensis
sita hyst	Sitanion hystrix
smia trif	Smilacina trifolia
smil bona	Smilax bona-nox
smil glau	Smilax glauca
smil rotu	Smilax rotundifolia
smil smal	Smilax smallii
smil tamm	Smilax tammoides
smil tamn	Smilax tamnoides
smil ----	Smilax
sola ----	Solanum
soli cutl	Solidago cutleri
soli macr	Solidago macrophylla var. thyrsoidea
soli nemo	Solidago nemoralis

sorb amer	Sorbus americana
sorb aucu	Sorbus aucuparia
sorg hale	Sorghum halepense
spar eury	Sparganium eurycarpum
spar fluc	Sparganium fluctuans
spat ----	Spartina
spha cocc	Sphaeralcea coccinea
spha gros	Sphaeralcea grossulariaefolia
sphg fusc	Sphagnum fuscum
sphg girg	Sphagnum girgensohnii
spir alba	Spiraea alba
spir lati	Spiraea latifolia
spir ----	Spiraea
spor cryp	Sporobolis cryptandrus
spor curt	Sporobolis curtissii
spor ----	Sporobolis
stan pinn	Stanleya pinnata
ster pasc	Stereocaulon paschale
ster ----	Stereocaulon
stip colu	Stipa columbiana
stip coma	Stipa comata
stip pine	Stipa pinetorum
symp occi	Symphoricarpos occidentalis
symp orbi	Symphoricarpos orbiculatus
symp oreo	Symphoricarpos oreophilus
symp rotu	Symphoricarpos rotundifolius
symp vacc	Symphoricarpos vaccinioides
sypl tinc	Symplocos tinctoria
syri vulg	Syringa vulgaris
tara offi	Taraxacum officinale
tara ----	Taraxacum
taxu bacc	Taxus baccata
taxu cana	Taxus canadensis

tetr cane	Tetradymia canescens
tetr glab	Tetradymia glabrata
thel ----	Thelesperma
thla alpe	Thlaspi alpestre
thuj occi	Thuja occidentalis
thuj plic	Thuja plicata
tide lanu	Tidestromia lanuginosa
tili amer	Tilia americana
tili cord	Tilia cordata
trad occi	Tradescantia occidentalis
trad suba	Tradescantia subaspera
trag dubi	Tragopogon dubius
trag ----	Tragopogon
trib terr	Tribulus terrestris
trif hybr	Trifolium hybridum
trif parr	Trifolium parryi
trif prat	Trifolium pratense
trif subt	Trifolium subterraneum
trif ----	Trifolium
trig mari	Triglochin maritima
tris spic	Trisetum spicatum var. pilosiglume
tsug cana	Tsuga canadensis
tsug hete	Tsuga heterophylla
typh augu	Typha augustifolia
ulmu alat	Ulmus alata
ulmu amer	Ulmus americana
ulmu glab	Ulmus glabra
umbi ----	Umbilicaria
umbr cali	Umbrellularia californica
ungn spec	Ungnadia speciosa
unio lati	Uniola latifolia

vacc angu	Vaccinium angustifolium
vacc arbo	Vaccinium arboreum
vacc caes	Vaccinium caespitosum
vacc cras	Vaccinium crassifolium
vacc elli	Vaccinium elliottii
vacc idae	Vaccinium idaea
vacc memb	Vaccinium membranaceum
vacc myrt	Vaccinium myrtilloides (see also vacc myti)
vacc myti	Vaccinium myrtillus (see also vacc myrt)
vacc oval	Vaccinium ovalifolium
vacc oxyc	Vaccinium oxycoccus
vacc parv	Vaccinium parvifolium
vacc scop	Vaccinium scoparium
vacc stam	Vaccinium stamineum
vacc ulig	Vaccinium uliginosum
vacc ulal	Vaccinium uliginosum var. alpinum
vacc vaci	Vaccinium vacillans
vacc viti	Vaccinium vitis-idaea
vacc vitm	Vaccinium vitis-idaea var. minus
vacc ----	Vaccinium
vale occi	Valeriana occidentalis
vale sitc	Valeriana sitchensis
vall amer	Vallisneria americana
vera cali	Veratrum californicum
vera viri	Veratrum viride
verb ence	Verbesina encelioides
vero worm	Veronica wormskjoldii
verp bohe	Verpa bohemica
vibu alni	Viburnum alnifolium
vibu cass	Viburnum cassinoides
vibu dent	Viburnum dentatum
vibu lent	Viburnum lentago
vibu moll	Viburnum molle
vibu opul	Viburnum opulus
vibu prun	Viburnum prunifolium
vibu rufi	Viburnum rufidulum
vici pulc	Vicia pulchella
viti aest	Vitis aestivalis
viti bico	Vitis bicolor
viti cord	Vitis cordifolia (see also viti vulp)
viti ripa	Vitis riparia
viti rotu	Vitis rotundifolia
viti vulp	Vitis vulpina (see also viti cord)
viti ----	Vitis

xant pens	Xanthium pensylvanicum
xanx frut	Xanthoxylum fruticosum
yucc elat	Yucca elata
yucc glau	Yucca glauca
yucc moha	Yucca mohavensis
yucc reve	Yucca reverchonii
yucc thom	Yucca thompsoniana
yucc trec	Yucca treculeana
yucc ----	Yucca
zea mays	Zea mays
ziza equa	Zizania equatica
zyga eleg	Zygadenus elegans

JULIAN DAY: MONTH AND DAY EQUIVALENTS*

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Day
1	001	032	060	091	121	152	182	213	244	274	305	335	1
2	002	033	061	092	122	153	183	214	245	275	306	336	2
3	003	034	062	093	123	154	184	215	246	276	307	337	3
4	004	035	063	094	124	155	185	216	247	277	308	338	4
5	005	036	064	095	125	156	186	217	248	278	309	339	5
6	006	037	065	096	126	157	187	218	249	279	310	340	6
7	007	038	066	097	127	158	188	219	250	280	311	341	7
8	008	039	067	098	128	159	189	220	251	281	312	342	8
9	009	040	068	099	129	160	190	221	252	282	313	343	9
10	010	041	069	100	130	161	191	222	253	283	314	344	10
11	011	042	070	101	131	162	192	223	254	284	315	345	11
12	012	043	071	102	132	163	193	224	255	285	316	346	12
13	013	044	072	103	133	164	194	225	256	286	317	347	13
14	014	045	073	104	134	165	195	226	257	287	318	348	14
15	015	046	074	105	135	166	196	227	258	288	319	349	15
16	016	047	075	106	136	167	197	228	259	289	320	350	16
17	017	048	076	107	137	168	198	229	260	290	321	351	17
18	018	049	077	108	138	169	199	230	261	291	322	352	18
19	019	050	078	109	139	170	200	231	262	292	323	353	19
20	020	051	079	110	140	171	201	232	263	293	324	354	20
21	021	052	080	111	141	172	202	233	264	294	325	355	21
22	022	053	081	112	142	173	203	234	265	295	326	356	22
23	023	054	082	113	143	174	204	235	266	296	327	357	23
24	024	055	083	114	144	175	205	236	267	297	328	358	24
25	025	056	084	115	145	176	206	237	268	298	329	359	25
26	026	057	085	116	146	177	207	238	269	299	330	360	26
27	027	058	086	117	147	178	208	239	270	300	331	361	27
28	028	059	087	118	148	179	209	240	271	301	332	362	28
29	029	[060]	088	119	149	180	210	241	272	302	333	363	29
30	030		089	120	150	181	211	242	273	303	334	364	30
31	031		090		151		212	243		304		365	31

* For leap year, February 29 = JDAY 60. Add 1 to all subsequent JDAYs.

THE BIOLOGY AND MANAGEMENT OF WILD RUMINANTS

CHAPTER TWELVE

FORAGE CONSUMPTION BY WILD RUMINANTS

by

Aaron N. Moen

Professor of Wildlife Ecology

Department of Natural Resources

College of Agriculture and Life Sciences

Cornell University

Ithaca, N.Y. 14853

and

Certified Wildlife Biologist

(The Wildlife Society)

Published by

CornerBrook Press
Box 106
Lansing, N.Y. 14882

Library of Congress Catalog Number 80-70984

CONTENTS OF CHAPTER TWELVE

FORAGE CONSUMPTION BY WILD RUMINANTS

CONTENTS continued on the next page

CHAPTER 12. FORAGE CONSUMPTION BY WILD RUMINANTS

Forage consumption by free-ranging ruminants must be in balance with their nutrient requirements if the animals are to fulfill their ecological roles as productive members of a population. Nutrient requirements are dependent on the metabolic requirements for maintenance, activity, and production. Since these requirements vary during the annual cycle, the nutrients required vary, and are dependent on several factors of ecological importance. Since forage characteristics--cell wall and cell soluble fractions and digestibilities--also vary through the annual cycle, variations in consumption are due to variability in both nutrients required for metabolism and in the quality of the nutrients themselves.

It is obvious that forage consumption is affected by a number of variables. Seasonal variations in weights--an individual may vary as much as 30 percent or more--were discussed in CHAPTER 1, UNIT 1.4. Topography affects the cost of activity; very hilly land demands larger expenditures of energy for movement (CHAPTER 7, UNIT 4.3). The amounts of body reserves present (CHAPTER 2, UNIT 2.1) affect the amounts of forage that are necessary: metabolized fat reduces the need for ingested energy. Weather factors and subsequent heat losses modify behavior and metabolism, altering the amounts of forage that are necessary to meet metabolic needs. Thermal energy balances are discussed in CHAPTER 16.

Forage consumption necessary to meet nutrient requirements may be calculated with a formula in which the nutrients required is the numerator and the nutrients supplied by the forage, depending on the gross composition and digestibility of the forages, is the denominator. The basic formula for calculating forage consumption (FGCP) is:

FGCP = nutrients required by the herbivore/nutrients in the forage

The intake of pen-fed domestic ruminants is subject to direct control by the farmer. Indeed, least-cost analyses, balanced feeding, and other recently-developed feeding programs for domestic animals are based on nutrients required and supplied by different feeds, with cost factors considered in formulating rations. The intake of free-ranging animals is not subject to direct control by a farmer, rancher, or wildlife manager but is related to seasonal variations in nutrients required by the animals, and to seasonal variations in nutrients supplied by the plants. The free-ranging situation is much more complex than the pen-fed one, and the calculations of forage requirements are more challenging.

At this point some very pertinent questions may be asked. How much do we know about the chemical interaction between wild ruminants and their environments? What does the environment contain chemically, and of what values are the different components to the animals? Do greater chemical differences exist between plant species than between populations of the same species on different soils? How much selectivity do different species of wild ruminants exhibit while foraging, or is foraging a random event that results in different species being ingested just because they are dispersed throughout the habitat?

The answers to the above questions are neither simple nor straight forward. As is true of most, if not all, biological situations, there is no single and absolute conclusion that is true in every situation. Species differences per se between plants may be greater than differences due to soil effects. Such answers may be available as a result of research in soils and agronomy. Wild ruminants do select some species, but a random element is very likely present also. The mechanisms for this are not well known since very little is known about chemical interactions between animals and their environments. This is particularly true for game species since the emphasis has been on applied problems of immediate concern. The descriptive approaches usually used may be adequate for identifying the existence of a given relationship, but they do not necessarily yield an understanding of the functioning organism in its very complex environment.

We can conclude that very little is known about chemical interactions between wild ruminants and their environments. We are beginning to understand the requirements of the animals, and how well the environment supplies them, at least in a general way. We know that there are chemical differences between plant species, and we know that there are differences in the chemical characteristics of the soil. We know that wild ruminants have preferences for certain forage species, but that preference lists are not constant between different geographical areas. More information is needed before the functioning organism in its very complex environment is understood, and our information needs will be more clearly identified as we analyze the animal-environment relationship more comprehensively.

The basic relationships between nutrients required and nutrients supplied may be applied to a particular nutrient by using units of energy, mass, and time. The factors affecting these basic relationships are discussed in the TOPICS that follow, beginning with TOPIC 1: FOOD HABITS AND PREFERENCES, and then considering TOPIC 2: OBSERVED CONSUMPTION, followed by CALCULATIONS OF DAILY CONSUMPTION, ENERGY BASE (TOPIC 3); PROTEIN BASE (TOPIC 4); and MINERAL BASE (TOPIC 5).

REFERENCES CHAPTER 12

FORAGE CONSUMPTION BY WILD RUMINANTS

BOOKS

TYPE	PUBL	CITY	PGES	ANIM	KEY WORDS------------------	AUTHORS/EDITORS--	YEAR
aubo	hocl	loen	556	cerv	deer stalking ground, brit	whitehead,gk	1960
edbo	nhfg	conh	256	odvi	whte-taild deer of nw hamp	siegler,hr,ed	1968
edbo	blsp	oxen	477	anim	anim pops reln food resour	watson,a,ed	1970
aubo	whfr	sfca	458	wldl	wildlife ecology	moen,an	1973
edbo	iucn	mosw	759	ungu	behav reltn to mgt, 2 vols	geist,v,ed; walth	1974
edbo	crcp	cloh			handbk series, nutr & food	rechcigl,m,jr,ed	1977

TOPIC 1. FOOD HABITS AND PREFERENCES

Food habits and preference lists of different forage species have been compiled for most species of wild ruminants in many areas of their ranges. The identification and listing of different species ingested is a useful aid when evaluating the biochemical aspects of nutrition. Such descriptive lists are the beginning, not the end, of nutritive analyses.

There are some interesting relationships between taxonomy and biochemistry to consider. Suppose, for example, that two species of plants were identified in the diet of an animal. The use of these species may have been described in the literature in many different ways, including number of twigs browsed, percent browsed, volume in the rumen, frequency of occurrence in the rumen, animal-minutes spent ingesting the species, and in other ways too. Statistical differences between the numerical quantities could be determined and conclusions made.

The data and their analyses in the above example may, however, be quite unrelated to the functional nutritive characteristics of the organism. If the nutrient compositions of two species were similar, then the animal's use of the species would be similar. Separate analyses of the nutritive data for the two species would not be relevant since the animal would "recognize" the forage from a biochemical standpoint rather than a taxonomic one.

There has been considerable work on both the food habits and preferences of wild ruminants. These two characteristics of a species seem straight-forward enough, but they are, in fact, very complex and interrelated. "Food habits" is a term applied to what an animal eats. "Preferences" is a term applied to the order in which foods are chosen. But to what extent are food habits affected by preference alone? Food habits are reflections not only of preference, but also of availability. Highly preferred foods that are unavailable can hardly show up in the "food habits." Some foods may be very low on a preference list, but still eaten in small quantities. As the quantities of the more preferred foods are depleted, the very low preference food may appear to be higher on the preference list.

The ranking of frequencies of different foods on food habits lists may give some indication of preference. If, however, the abundances of different foods in the stomach matches the abundances of the foods on the range, then one must conclude that no preference has been shown. If a frequently-occurring food in the stomach is infrequently found on the range, then a preference is being shown for that food. Conversely, if a very abundant food on the range is found in small quantities in the stomach, then an avoidance (negative preference) is being shown for that food. Statistical tests, such as the Chi-square test or rank-order non-parametric tests may be used to test for departures from expected frequencies of different foods in the stomach based on the abundances of the foods on the range.

The use of relative frequencies and rank-orders provides a basis for numerical indexes that may be used to quantify food preferences. These indexes, while relative and somewhat arbitrary, may provide ways to quantify ideas for use in simulating foraging relationships. Their use may be very helpful as long as index values continue to be treated as relative rather than absolute numbers.

Two units (UNIT 1.1: FOOD HABITS and UNIT 1.2: PREFERENCES) follow, with the literature separated into those references which contain information simply on what is eaten in UNIT 1.1, and those references containing information on the preferences in UNIT 1.2. Sorting of the literature into these two categories cannot be done perfectly, so students interestd in either UNIT should consult the references listed after both UNITS.

UNIT 1.1: FOOD HABITS

There is a large amount of literature on the food habits of different wild ruminants. Surveys of forages ingested without consideration of the relative abundance of different forage species or the preferences of different ruminants for different forages, fall in the "food habits" category, since they only provide information on what was ingested. Foods on the lists reflect foods present on the range, of course. They also reflect seasonal differences in the presence of different forage species. These natural variations in the range contribute to long food habits lists. White-tailed deer, for example, have been observed to eat several hundred different species; the actual list of species eaten very likely exceeds a thousand.

Food habits lists are usually compiled from stomach or rumen analyses. There are several problems associated with this approach, including differences in the recognizability of different plant fragments, differences in the rates of mechanical and chemical breakdown of different plant materials, and differences in the abilities of different persons to recognize the plant species from the fragments. Stomach analyses are very tedious; the work is not particularly exciting to most people.

Food habits lists are important to the range and wildlife ecologist, however, as reasonable estimates of diet composition are needed to evaluate both nutrients ingested and the impact of herbivores on range composition. They are used in calculating intakes for animals on different diets as discussed in TOPICS 3, 4, and 5.

The references that follow provide information on food habits of wild ruminants. The next UNIT (1.2: PREFERENCES) includes lists of foods eaten when additional information on selection by the animal is given.

REFERENCES, UNIT 1.1

FOOD HABITS

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	4---4	404	428	cerv	utili oaks, birds, mammals	van dersal,wr	1940
TNKKA	11...	41	50	cerv	grazing area require, deer	makhaeva,lv	1963

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
AZATA	75---	1	39	od--	experimentl feeding of dee	nichol,aa	1938
CAFGA	37--1	43	52	od--	deer range survey methods	dasmann,up	1951

od-- continued on the next page

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JFUSA	33-11	940	942	od--	use, truck trails, firebre	robinson,cs	1935
JFUSA	48--6	410	415	od--	doca, rnge relations, utah	julander,o; robin	1950
JOMAA	25--2	130	130	od--	a deer brwse survey method	aldous,se	1944
JRMGA	11--1	18	21	od--	livest, tech study competn	julander,o	1958
JWMAA	13--3	314	315	od--	deer forage observat, utah	smith,jg	1949
JWMAA	19--3	358	364	od--	range appraisal, missouri	dunkeson,rl	1955
JWMAA	25--3	342	342	od--	atlan white-ced, wint brow	gould,wp; brown j	1961
JWMAA	30--1	204	206	od--	brws utiliz, percent twigs	stickney,pf	1966
NAWTA	17---	448	458	od--	rumen content, doca compet	davis,rb	1952

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
AMFOA	68--8	24	48	odvi	dinnerbell for the whiteta	hurd,es	1962
AMNAA	89--2	281	286	odvi	foods, martin county, indi	sotala,dj; kirkpa	1973
BIBAA	49--2	184	184	odvi	eating birds in mist nets	allan,ta	1978
CJFRA	4---4	491	498	odvi	use brows in encl, n bruns	drolet,ca	1974
ECOLA	12--2	323	333	odvi	mount laurel, rhododendron	forbes,eb; bechde	1931
ECOLA	16--4	535	553	odvi	wint reln to forests, mass	hosley,nw; ziebar	1935
JAASA	38...			odvi	food habits, telemetry obs	marchinton,rl; ba	1967
JFUSA	37--3	265	267	odvi	pine in the diet, minnesot	aldous,se	1939
JFUSA	41--6	471	475	odvi	seas brows woody pl, oak f	bramble,wc; godda	1943
JFUSA	48-10	684	684	odvi	samp yiel, brow util, wint	morton,ad	1950
JFUSA	51-11	815	819	odvi	seas brows woody plt, penn	bramble,wc; godda	1953
JOMAA	18--1	77	80	odvi	notes on winte foods, mich	howard,wj	1937
JOMAA	44--2	284	284	odvi	insectivorous white-t deer	shaw,h	1963
JRMGA	21--3	158	164	odvi	food habits, south texas	chamrad,ad; box,t	1968
JRMGA	21--3	164	166	odvi	mid-sum diet, welder refug	drawe,dl	1968
JRMGA	26--5	372	375	odvi	intake, obser mastic, tame	crawford,hs; whel	1973
JRMGA	32--2	93	97	odvi	infl brush control on diet	quinton,da; hore/	1979
JWMAA	5---3	314	332	odvi	foods of the united states	atwood,el	1941
JWMAA	6---4	287	291	odvi	winter habits, central ny	cook,db; hamilton	1942
JWMAA	7---2	203	216	odvi	on aransas refuge, texas	halloran,af	1943
JWMAA	9---4	319	322	odvi	odhe, symptoms of malnutri	harris,d	1945
JWMAA	10--1	60	63	odvi	summer brow, cutov hardwoo	cook,db	1946
JWMAA	11--3	263	266	odvi	huron mountain deer herd	manville,rh	1947
JWMAA	13--1	135	141	odvi	avail wint forage, browsin	hough,af	1949

odvi continued on the next page

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	17--2	166	176	odvi	irruption, necedah refuge	martin,fr; krefti	1953
JWMAA	18--4	482	495	odvi	deer management study: mud	hunt,rw; mangus,l	1954
JWMAA	19--3	358	364	odvi	deer range appraisl, misso	dunkeson,rl	1955
JWMAA	21--1	75	80	odvi	effect brows, hardw-hemloc	stoeckeler,jh; s/	1957
JWMAA	21--1	101	103	odvi	interp overbrows ne forest	webb,wl	1957
JWMAA	24--1	68	80	odvi	influence on vegetation, w	beals,ew; cottam/	1960
JWMAA	24--4	387	395	odvi	deer-forest hab relationsh	halls,lk; crawfor	1960
JWMAA	25--1	77	81	odvi	nutri, accept value, slash	alkon,pu	1961
JWMAA	25--4	404	409	odvi	some foods, souther arizon	white,rw	1961
JWMAA	26--2	164	172	odvi	foods, manage impl, missou	korschgen,lj	1962
JWMAA	26--4	371	379	odvi	value, acorns, diet, michi	duvendeck,jp	1962
JWMAA	28--3	473	477	odvi	point frame, samp rum cont	chamrad,ad; box,t	1964
JWMAA	28--4	798	808	odvi	compar food habits, livest	mcmahan,ca	1964
JWMAA	29--2	370	375	odvi	fruit use, southern forest	lay,dw	1965
JWMAA	30--1	151	162	odvi	graz enclosur, tex, livest	mcmahan,ca	1966
JWMAA	31--2	351	353	odvi	brows, hardw seedli, sprou	moore,wh; johnson	1967
JWMAA	31--2	354	356	odvi	elm as deer browse	pogge,fl	1967
JWMAA	32--1	130	141	odvi	rang use, food, cons, prod	allen,eo	1968
JWMAA	32--3	558	565	odvi	habitat rela, odhe, montan	martinka,cj	1968
JWMAA	32--3	623	626	odvi	browse, ouachita for, okla	segelquist,ca; pe	1968
JWMAA	33--3	506	510	odvi	odhe, qual id forag, feces	zyznar,e; urness,	1969
JWMAA	33--3	511	520	odvi	habitat relat, ozark enclo	segelquist,ca; w/	1969
JWMAA	34--1	210	213	odvi	compar volumet, point-anal	robel,rj; watt,pg	1970
JWMAA	34--3	535	540	odvi	food habit, george reserve	coblentz,be	1970
JWMAA	34--4	870	886	odvi	food hab, range char, ohio	nixon,cm; mcclai/	1970
JWMAA	35--3	476	487	odvi	summer habitat, n cent min	kohn,be; mooty,jj	1971
JWMAA	35--4	698	706	odvi	for diges, diet, s upl ran	short,hl	1971
JWMAA	36--3	906	912	odvi	esophageal cannula for w-t	veteto,g; davis,/	1972
JWMAA	37--2	195	201	odvi	dry mat, energ intak, dige	ammann,ap; cowan/	1973
JWMAA	38--2	210	214	odvi	seas foods, n brunswick, c	skinner,wr; telfe	1974
JWMAA	38--2	215	219	odvi	summer foods, no wisconsin	mccaffery,kr; tr/	1974
JWMAA	38--3	535	540	odvi	odhe rumen, fecal anal, de	anthony,rg; smith	1974
JWMAA	39--2	321	329	odvi	nutrition south deer, seas	short,hl	1975
JWMAA	39--2	330	336	odvi	food, mast abundan, scarci	harlow,rf; whela/	1975
JWMAA	39--4	699	704	odvi	consum artif browse, penne	ullrey,de; youat/	1975
JWMAA	40--1	140	144	odvi	odhe, infl droug diet numb	anthony,rg	1976
JWMAA	40--4	645	657	odvi	alal, habitat use, sympatr	kearney,sr; gilbe	1976
JWMAA	42--2	397	403	odvi	impro meth rumen cont anal	puglisi,mj; lisc/	1978
JWMAA	44--1	89	97	odvi	spr sum food, missou ozark	korschgen,lj; po/	1980
JWMAA	44--1	98	106	odvi	tame, sum forg use, n mich	stormer fa; bauer	1980
MOCOA	8---9	4	5	odvi	deer foods, missouri ozark	dalke,pd	1947
MRLTA	54--2	23	23	odvi	white-t deer eating salmon	shea,ds	1973
NAWTA	2----	438	445	odvi	food study, north carolina	stegeman,lc	1937
NAWTA	3----	756	767	odvi	food habi, minn, stom anal	aldous,se; smith,	1938
NAWTA	6----	155	160	odvi	use, avail win brow, misso	dalke,pd	1941

odvi continued on the next page

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
NAWTA	24---	201	215	odvi	food habits, everglades de	loveless,cm; liga	1959
NAWTA	31---	205	212	odvi	use woody brows, nort east	stiteler,wm,jr; s	1966
NAWTA	34---	229	238	odvi	seas chng rmen chem compos	kirkpatrick,rl; /	1969
NFGJA	11--2	115	118	odvi	use, commercial clear-cut	krull,jn	1964
NFGJA	17--1	63	63	odvi	bird ingested by whit-tail	stone,wb; palmat/	1970
PCGFA	8----	83	85	odvi	deer vs livest, gulf coast	goodrum,pd; reid,	1954
PCGFA	13---	54	61	odvi	acorns in diet of wildlife	goodrum,pd	1959
PCGFA	18---	57	62	odvi	imprtn variety, souther d	lay,dw	1964
PCGFA	25---	18	46	odvi	forages eaten southea deer	harlow,rf; hooper	1971
PMASA	7,8--	65	68	odvi	brwsing, ponder pine, mont	adams,l	1948
POASA	46---	220	221	odvi	stomach contents, w-t fawn	clark,tw	1966
PSAFA	58---	139	143	odvi	browsin, longleaf pin belt	goodrum,pd; reid,	1958
SWNAA	24--2	297	310	odvi	botan comp, nutr cont diet	everitt,jh; gonza	1979
TISAA	70--1	47	56	odvi	milo in diet of, illinois	ward,wc; hardin,j	1977
TSASA	70--2	223	240	odvi	food habits, nrtheast kans	watt,pg; miller,/	1967
XANEA	33---	1	37	odvi	browsing hardwds, northeas	shafer,el,jr	1965
XASEA	67---	1	12	odvi	import woody twig ends, se	cushwa,ct; downi/	1970
XFWLA	310--	1	10	odvi	fall, wint food habs, minn	aldous,se; smith,	1948

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CAFGA	36--3	235	240	odhe	food habits, californ herd	ferrel,cm; leach,	1950
CAFGA	38--2	211	224	odhe	food hab, prod, cond, cali	lassen,rw; ferre/	1952
CAFGA	39--2	163	175	odhe	nutrtnl value forag plants	hagen,hl	1953
CAFGA	40--3	215	234	odhe	de fora relat lassen-washo	dasmann,w; blaisd	1954
CAFGA	42--4	243	308	odhe	foo hab great basin, calif	leach,hr	1956
CAFGA	43--3	161	178	odhe	foo habi, tehama deer herd	leach,hr; hiehle,	1957
CAFGA	65--2	68	79	odhe	die comp, ener resrv, preg	holl,sa salwass/	1979
CJFRA	2---3	250	255	odhe	doug fir genot, brows pref	radwan,ma	1972
CNJNA	56--3	531	542	odhe	foo hab fll, win, spri, bc	willms,w; mclean/	1976
ECMOA	15--2	109	139	odhe	eco relat, food, coast, bc	cowan,im	1945

odhe continued on the next page

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JFUSA	35--3	285	292	odhe	plants eaten, california	robinson,cs	1937
JOMAA	25--2	198	199	odhe	some unusual foods, oregon	sooter,ca	1944
JRMGA	2---4	206	212	odhe	de-livesto fora stu, calif	dasmann,wp	1949
JRMGA	4---4	249	253	odhe	ceel, status of brws, oreg	mitchell,ge	1951
JRMGA	6---1	30	37	odhe	captv, cnsmp natv forg sum	smith,ad	1953
JRMGA	30--2	116	118	odhe	wild horse, doca, foods of	hansen,rm; clark/	1977
JRMGA	30--3	206	209	odhe	food hab, sem-des gras-shr	short,hl	1977
JWMAA	6---3	210	220	odhe	survey, winter range, oreg	edwards,ot	1942
JWMAA	7---1	119	122	odhe	chaparral crown spr, brows	reynolds,hg; samp	1943
JWMAA	8---4	317	338	odhe	supplemnt winter fee, utah	doman,er; rasmuss	1944
JWMAA	9---2	145	151	odhe	wint study, mule d, nevada	aldous,cm	1945
JWMAA	10--1	54	59	odhe	managemnt, black-tailed de	einarsen,as	1946
JWMAA	13--3	314	315	odhe	forag observations in utah	smith,jg	1949
JWMAA	14--3	285	289	odhe	sagebrush as a winter feed	smith,ad	1950
JWMAA	15--2	129	157	odhe	in nebraska national fores	mohler,ll; wampo/	1951
JWMAA	15--4	352	357	odhe	odvi, comp some plants eat	gastler,gf; moxo/	1951
JWMAA	16--2	148	155	odhe	food habits of odhe, utah	smith,jg	1952
JWMAA	17--2	101	112	odhe	competitio, sheep, in utah	smith,jg; julande	1953
JWMAA	19--2	215	225	odhe	ceel, winter browse, idaho	hoskins,lw; dalke	1955
JWMAA	21--2	159	169	odhe	fo hab, rang use, agr rela	wilkins,bt	1957
JWMAA	21--2	189	193	odhe	ceel, fo hab, nat bis rang	morris,ms; schwar	1957
JWMAA	22--3	r75	283	odhe	food hab, rang use, montan	lovaas,al	1958
JWMAA	26--3	321	323	odhe	tech, cost brows coll, nut	yeager,le; woloch	1962
JWMAA	29--1	27	33	odhe	mont for wint habi, montan	klebenow,da	1965
JWMAA	29--2	352	366	odhe	stom content anal, new mex	anderson,ae; sny/	1965
JWMAA	32--1	142	148	odhe	obser use, forage, pl comm	miller,fl	1968
JWMAA	32--3	542	553	odhe	forag avail, brows doug-fi	crouch,gl	1968
JWMAA	33--1	191	195	odhe	chang food hab, herd reduc	nellis,ch; ross,r	1969
JWMAA	33--3	506	510	odhe	odvi, identi forage, feces	zyznar,e; urness,	1969
JWMAA	36--4	1025	1033	odhe	forag use, logging, colora	wallmo,oc; regel/	1972
JWMAA	36--4	1336	1340	odhe	ceel, new meth rumen sampl	follis,tb; spille	1972
JWMAA	37--4	556	562	odhe	accur field est, food habs	wallmo,oc;gill,/	1973
JWMAA	38--3	508	516	odhe	forag intak est, cesiu-137	alldredge,aw; li/	1974
JWMAA	43--1	154	161	odhe	summ diet, ldgepl pne hab	deschamp,ja; urn/	1979
NAWTA	4----	560	569	odhe	ceel relationships, oregon	cliff,ep	1939
NAWTA	21---	159	172	odhe	nutri, popu dynam, n calif	taber,rd	1956
NAWTA	35---	35	47	odhe	eval wint use orchar, colo	harder,jd	1970
SWNAA	13--2	159	166	odhe	food plants, habitat, okla	clark,tw	1968
XFPNA	112--	1	12	odhe	ceel, season forg use, ore	edgerton,pj; smit	1971
XPNWA	84---	1	8	odhe	spring browsng of doug-fir	crouch,gl	1968

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
ATRLA	15--6	89	110	ceel	foods, rumen content analy	dzieciolowski,r	1970
CAFNA	93--3	282	287	ceel	summ, aut, wint diet, sask	hunt,hm	1979
ELPLB	15-11	285	305	ceel	winter food deter by track	dzieciolowski,r	1967
ELPLB	18-32	635	645	ceel	variat, food select, envir	dzieciolowski,r	1970
JOMAA	17--3	253	256	ceel	browsing, early wint, wash	skinner,mp	1936
JRMGA	5---2	76	80	ceel	odhe, wint-rang util, wash	buechner,hk	1952
JRMGA	9---1	11	14	ceel	elk, livestock competition	morris,ms	1956
JRMGA	26--2	106	113	ceel	foods eaten, litera review	kufeld,rc	1973
JWMAA	2---3	131	134	ceel	carrying capacity of range	young,va	1938
JWMAA	5---4	427	453	ceel	effect wint brwsng, montan	gaffney,ws	1941
JWMAA	7---3	328	332	ceel	livesto compet. summ range	pickford,gd; reid	1943
JWMAA	9---4	295	319	ceel	roosevlt elk, olym pen, wa	schwartz,je; mitc	1945
JWMAA	26--1	97	100	ceel	day feed hab roosvlt, cal	harper,ja	1962
JWMAA	27--3	412	414	ceel	captiv elk herd in missour	murphy,da	1963
JWMAA	30--2	349	363	ceel	range relat, livestc, mont	stevens,dr	1966
JWMAA	40--2	371	373	ceel	rumen-cannul, evalua rumen	staines,bw	1976
JWMAA	42--4	799	810	ceel	diet, activ, ldgpl pne hab	collins,wb; urne/	1978
JWMAA	43--2	568	570	ceel	rear, train calv, food hab	hobbs,nt; baker,d	1979
NAWTA	3----	421	427	ceel	deer, foods, feedng habits	denio,rm	1938
NAWTA	3----	747	755	ceel	food habits, virginia	baldwin,wp; patto	1938
NAWTA	26---	436	447	ceel	habitat, jackson hole, man	casebeer,rl	1961
NCANA	101--	505	516	ceel	alal rang reltns, rcky mts	stevens,dr	1974
SFORA	26--1	43	50	ceel	bark stripping phenomenon	mcintyre,eb	1972

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
AMNAA	96--1	229	232	alal	clv learn eat by fllw moth	edwards,j	1976
ATRLA	21--5	101	116	alal	food habits, poland	morow,k	1976
CAFNA	83--4	339	343	alal	observ, feed on aquatc, bc	ritcey,rw; verbee	1969
CAFNA	90--1	11	16	alal	food hab, alask, rumen con	cushwa,ct: coady,	1976
CJZOA	54-10	1765	1770	alal	wintr foods, evalu methods	joyal,r	1976
ECOLA	34--1	102	110	alal	feedin habits, yellowst pa	mcmillan,jf	1953
JWMAA	21--1	53	57	alal	wint food hab, jackson hol	harry,gb	1957

alal continued on the next page

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	24--1	52	60	alal	snows hare, foo & rng comp	dodds,dg	1960
JWMAA	24--1	162	170	alal	food habs, mvmt, pops, mon	knowlton,ff	1960
JWMAA	31--3	418	425	alal	odvi, comp wint rng nov sc	telfer,es	1967
JWMAA	34--3	559	564	alal	food habi, sw mont, cattle	dorn,rd	1970
JWMAA	37--3	279	287	alal	impnc nonbrows food, alask	leresche,re; davi	1973
NCANA	95---	1159	1164	alal	use of bark, quebec	desmeules,p	1968
NCANA	101--	195	215	alal	review food habits studies	peek,jm	1974
TLPBA	14--1	105	134	alal	diet optimizatn, genl herb	belovsky,ge	1978
WLMOA	48---	1	65	alal	habitat select, forest mgt	peek,jm; urich,d/	1976

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
ABSZA	30--4	1	44	rata	lichen stands, newfoundlan	ahti,t	1959
ATICA	31--2	125	132	rata	diet, peary carib nw terri	shank,cc; wilkin/	1978
ATYBA	55---	22	25	rata	birch consump, fin lapland	haukioja,e; heino	1974
CAFNA	74--1	3	7	rata	foods, wells gray park, bc	edwards,ry; ritce	1960
CAFNA	80--4	238	241	rata	sieve mesh size, rume anal	scotter,gw	1966
CAFNA	81--1	33	39	rata	winter diet, northn canada	scotter,gw	1967
IUCSB	16...	155	159	rata	grazing in northern sweden	eriksson,o	1970
JWMAA	28--4	809	814	rata	eval rumen food anal, newf	bergerud,at; russ	1964
JWMAA	36--3	913	923	rata	food habits, newfoundland	bergerud,at	1972
LCHNB	6....	165	167	rata	reindeer grazing in britai	gilbert,ol	1975
NAWTA	22---	485	501	rata	hist, food hab, rang requi	cringan,at	1957
NCANA	96--3	333	336	rata	daily consmptio of lichens	desmeules,p; heyl	1969
NPOAA	1973-	113	123	rata	studies of reindee, norway	hjeljord,o	1975
OIKSA	21--2	348	350	rata	food hab, hand-reared, new	bergerud,at; nola	1970
SZSLA	21---	109	115	rata	winter nutr, reind, norway	gaare,e	1968

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
BMAEA	516--	1	63	anam	rang use, food habs, alfal	cole,gf	1956

anam continued on the next page

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CAFGA	36--1	21	26	anam	food habits, of california	ferrel,cm; leach,	1950
CAFGA	38--3	285	293	anam	spec refer, food hab, cali	ferrel,cm; leach,	1952
CAFNA	91--3	282	285	anam	prairie fires, cactus use	stelfox,jg; vrien	1977
JOMAA	22--1	57	60	anam	winter forag habits, oklah	rouse,ch	1941
JRMGA	20--1	21	25	anam	dosh, food pref, wyo deser	severson,ke; may,	1967
JRMGA	32--5	365	368	anam	livest, foods, dese steppe	johnson,mk	1979
JWMAA	10--4	367	367	anam	foods, southeastern montan	couey,fm	1946
JWMAA	16--3	387	389	anam	food habits, measurements	mason,e	1952
JWMAA	26--3	327	328	anam	rumen contents, sieve mesh	dirschl,hj	1962
JWMAA	27--1	81	93	anam	food habits, saskatchewan	dirschl,hj	1963
JWMAA	32--2	399	401	anam	foods, kansas, stock sites	hlavachick,bd	1968
JWMAA	33--3	538	551	anam	winter food hab, rang, mon	bayless,sr	1969
JWMAA	34--3	570	582	anam	forag use, prod, water con	beale,dm; smith,a	1970
JWMAA	35--2	238	250	anam	food hab, range char, albe	mitchell,gj; smol	1971
JWMAA	40--3	469	478	anam	diets, forag avail, coloro	schwartz,cc; nagy	1976
NAWTA	12---	185	192	anam	range use in western texas	buechner,hk	1947
NAWTA	15---	627	644	anam	rang ecol, wichita mt, kan	buechner,hk	1950
UTSCB	29--1	3	6	anam	season forage use, wes uta	beale,dm; scotter	1968
WGFBA	12---	1	61	anam	food hab, abund, distribut	sundstrom,c; hep/	1973

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
AMNAA	96--1	225	229	bibi	botan comp, diets, shortgr	peden,dg	1976
JAPEA	11--2	489	497	bibi	trphic ecol, shrtgras plai	peden,dg; van dy/	1974
JRMGA	27--4	323	325	bibi	doubl samp tech, diet comp	peden ag; hansen/	1974
JWMAA	42--3	581	590	bibi	diet, slv rvr herd, nw ter	reynolds,hw; han/	1978
OFBIA	27---	29	32	bibi	plains bison, north ontari	young,cm	1973

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CAFNA	81--1	23	29	ovca	food habs, ashnola hrd, bc	blood,da	1967
CGFPA	27...	1	21	ovca	food hab, literatur review	todd,jw	1972

ovca continued on the next page

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	13--4	417	419	ovca	od food relation, so n mex	halloran,af; kenn	1949
JWMAA	17--3	318	320	ovca	notes on food, sonoran zon	halloran,af; cran	1953
JWMAA	37--3	363	366	ovca	food hab, plant frag, fece	todd,jw; hansen,r	1973
JWMAA	39--1	108	111	ovca	food of, southern colorado	todd,jw	1975

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CWOPA	35---	1	19	obmo	rata, diets, canadi arctic	parker,gr	1978
JWMAA	40--1	151	162	obmo	rata, sum rang relns, nw t	wilkinson,pf; sh/	1976

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JOMAA	48--2	242	248	oram	food habits, mt goat, colo	hibbs,ld	1967
JWMAA	19--4	429	437	oram	food hab, rang use, montan	saunders,jk,jr	1955
JWMAA	37--3	353	362	oram	forage, habitat pref, alas	hjeljord,o	1973

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JOMAA	25--1	49	54	many	food req alaskan game mamm	palmer,lj	1944
JOMAA	57--1	167	172	herb	prob estim herb diets stom	westoby,m; rost,/	1976
JRMGA	22--1	51	52	herb	tech iden fecal plnt frags	williams,ob	1969
JRMGA	24--5	346	351	ungu	use of maj plant comms, bc	mclean,a; lord,t/	1971
JTBIA	60---	93	108		concep modl of diet select	ellis,je; wiens,/	1976
JWMAA	19--2	206	215	many	util wint brow, bi gam ran	mcculloch,cy,jr	1955
JWMAA	36--4	1068	1076	many	wint food, range use, mont	constan,kj	1972
JWMAA	41--1	76	80	many	foods of ungulates, colora	hansen,rm; clark,	1977
NAWTA	2----	276	287	many	utilizat of browse, kaibab	julander,o	1937
NAWTA	3----	421	427	many	elk & deer food, feed habs	denio,rm	1938
NAWTA	12---	223	227	many	range competition, alberta	cowan,im	1947
NAWTA	22---	152	159	herb	way to anal food hab, feca	adams,l	1957
PECTD	1---2	33	50	many	diets of larg herb mammals	dzieciolowski,r;/	1975
QRBIA	52--2	137	154		optimal foraging theory	pyke,gh; pulliam/	1977

OTHER PUBLICATIONS

Halls, L. K., and T. H. Ripley. 1961. Deer browse plants of southern states. U. S. Forest Service, Southern and Southeastern Forest Expt. Sta. 78 p.

Heintzleman, B. F. 1936. Reindeer grazing. The western range. 74th Cong., 2nd Session, Senate Doc. 199:581-598.

McCulloch, C. Y. 1973. Seasonal diets of mule and white-tailed deer. pp. 1-37 In: Deer nutrition in Arizona chaparral and desert habitats. Arizona Game and Fish Dept. Special Rep. #3. 68 pp.

UNIT 1.2: PREFERENCES

Wild ruminants select some forages more often than others. This can be determined by noting a higher frequency of occurrence in the rumen than is found on the range. A lower frequency of occurrence in the rumen than on the range indicates that the species is avoided. Preferences may also be noted by direct observation. Selective grazing on dandelion flowers by white-tailed deer is easily observed when they appear on a pasture or lawn in the Northeast.

How do the preferences exhibited by wild ruminants relate to the digestibility of the forage chosen? The illustration below provides some indication of a positive relationships between the preferences of white-tailed deer and the digestibilities of dormant woody browse. The following preference list of winter deer foods includes tree and shrub species chosen by deer with the preferred or best liked foods at the beginning, second choice foods next, those readily eaten third, and starvation or poor food fourth. This arrangement is based on thousands of observations in hundreds of wintering areas over many years in all parts of New York (Severinghaus 1974).

Preferred or best liked (1)

Cedar, white or arbor-vitae
Yew
Apple
Sassafras
Maple, mountain
Wintergreen
Maple, striped
Dogwood, alternate leaved
Dogwood, flowering
Sumac, staghorn
Maple, red
Witch hobble
Basswood

Second choice (2)

Elderberry
Elder, red berried
Ash, mountain
Cucumber tree
Cranberry, highbush
Nannyberry
Arbutus
Honeysuckle, fly
Honeysuckle
Hemlock
Wild raisin
Blueberry, highbush
Dogwood, silky
Dogwood, red osier
Dogwood, round-leaved
Willow*

Readily eaten (3)

Greenbrier
Ash, white
Maple, sugar
Arrow wood, maple leaved
Oaks*
Grape, wild
Birch, yellow
Birch, black
Chestnut
Hickory
Cherry, choke
Cherry, wild black
Witch hazel
Spice bush
Elm
Choke berry, black
Arrow wood
Honeysuckle, bush
Walnut, black
Butternut
Hazelnut
Juneberry or shadbush
Holly, mountain
Holly or winterberry*
Ash, black
Blueberry, low sweet
Blueberry, sour top
Blueberry, low bush
Leatherwood

Starvation or poor food (4)

Pine, scots**	Birch, gray
Pine, pitch**	Ironwood, or hop hornbeam
Beech	Blue beech, or muscle wood
Sweet fern	Meadowsweet
Aspen or poplar	Cedar, red**
Gooseberry and currant*	Juniper, pasture**
Buckthorn	Cherry, fire or pin
Raspberry and blackberry	Hawthorn
Steeplebush	Laurel, sheep
Laurel, mountain**	Dogwood, grey-steemed
Rhododendron**	Locust, black
Pine, white**	Huckleberry, black
Pine, red or Norway**	Tamarack
Balsam**	Alder
Birch, paper	Spruces

Footnotes

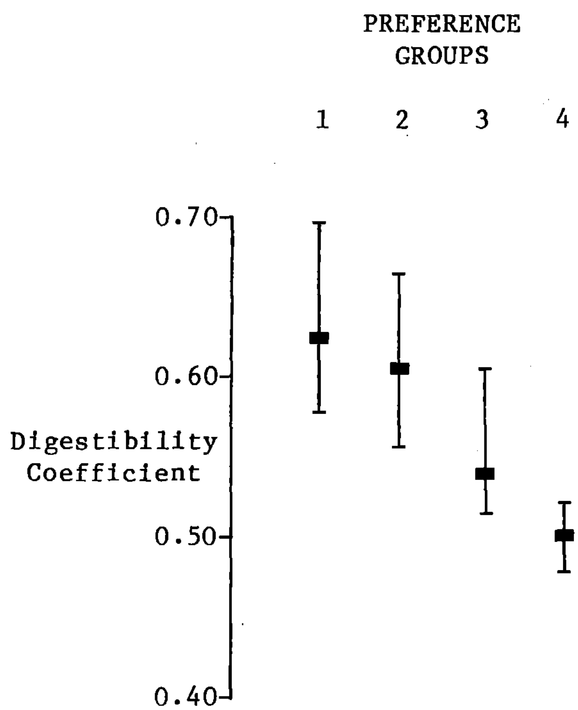
* There are considerable differences in the preferences for different species in this genus. They vary from rapidly eaten to very low.
**These species are often browsed heavily enough to appear to be second choice food in areas where food is inadequate.

Digestibility coefficients for 16 species in these four preference groups have been determined at Cornell's Wildlife Ecology Laboratory. The results are given in the table below.

Species	Average Digestible Energy Coefficient November - March	Range
PREFERRED: Apple, Basswood, Red maple, Sumac, White cedar	0.62	0.578 - 0.694
SECOND CHOICE: Hemlock, Willow, Red osier dogwood	0.60	0.556 - 0.662
READILY EATEN: Black birch, Hickory, Red oak, Sugar maple, White ash, Yellow birch	0.54	0.513 - 0.602
POOR FOOD:* Beech, Hawthorn	0.50	0.474 - 0.518

*Aspen and white pine are sometimes listed as poor food but are readily eaten in some areas. Calculated digestible energy coefficients are 0.60 and 0.62 respectively.

The relationship between preference groups and digestibility coefficients is illustrated below.



The average digestibility coefficient (heavy bar) decreases as the preference category goes down. The maximum and minimum digestibility coefficient within each category also goes down. Thus, the data indicate that digestibility coefficients are generally related to the preference group of the forage. Many of the plant species have not been included in these averages, so the numerical values are subject to change as more data are included.

The lists of serials with references containing information on forage preferences is over five pages long. These references, plus further information that may be gleaned from the eight pages of references to food habits in UNIT 1.1, may be used to compile a list of preference groups and digestibiliites. The derivation of an equation for this relationship is discussed in WORKSHEET 1.2a.

LITERATURE CITED

Severinghaus, C. W. 1974. Deer population - a wildlife roller coaster (Winter deer food preference). N.Y. Conservationist 28(5):36-38.

REFERENCES, UNIT 1.2

PREFERENCES

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
AZATA	75---	1	39	od--	experimentl feedng of deer	nichol,aa	1938
FOSCA	24--1	57	64	od--	hare, model feed preferenc	silen,rr; dimock,	1978
JRMGA	11--1	18	21	od--	livest, tech study competn	julander,o	1958
JWMAA	7---2	233	235	od--	food pref, black hills dee	hill,r harris,d	1943
NAWTA	3----	256	260	od--	meth stud browse pref, dee	deen,jl	1938
NAWTA	34---	146	154	od--	effect qualit food, intake	nagy,jg; hakonso/	1969
NMWIA	13--6	4	5	od--	food preferenc; dept study	lamb,sh	1968
PAABA	553--	suppl	3	od--	dee notions, where to feed	tarr,ja	1953
TNWSD	1964.	1	16	od--	forag pref, capt deer, oak	watts,cr	1964
TNWSD	35---	16	26	od--	util, cutting, prescr burn	philleo,b; cavan/	1978

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
BLRPA	1---5	24	27	odvi	diff brows, fertiliz plots	mitchell,hl; hosl	1936
CJFRA	4---4	491	498	odvi	use brows in encl, n bruns	drolet,ca	1974
ECOLA	12--2	323	333	odvi	mount laurel, rhododendron	forbes,eb; bechde	1931
ECOLA	16--4	535	553	odvi	wint reln to forests, mass	hosley,nw; ziebar	1935
JANSA	36--6	1201	1202	odvi	forage preferences, texas	mccollum,j,; kot/	1973
JFUSA	51-11	815	819	odvi	seas brows woody plt, penn	bramble,wc; godda	1953
JFUSA	62--7	497	499	odvi	deer prefer jack pine	horton,kw	1964
JOMAA	18--1	77	80	odvi	notes on winte foods, mich	howard,wj	1937
JRMGA	21--3	164	166	odvi	mid-sum diet, welder refug	drawe,dl	1968
JRMGA	21--4	225	228	odvi	doca, forage ratings texa	drawe,dl; box,tw	1968
JRMGA	23--2	146	147	odvi	relative browsing, 16 spec	halls,lk; mccart/	1970
JRMGA	32--2	93	97	odvi	infl brush control on diet	quinton,da; hore/	1979

odvi continued on the next page

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	5---1	90	94	odvi	mgt sugges for wh-cedr typ	aldous,se	1941
JWMAA	5---3	314	342	odvi	w-t d foods, united states	atwood,el	1941
JWMAA	5---4	416	422	odvi	rela import wint brow, n y	petrides,ga	1941
JWMAA	10--1	47	54	odvi	palat ratings, black hills	hill,r	1946
JWMAA	12--1	109	110	odvi	select nutritious forages	swift,rw	1948
JWMAA	23--4	455	457	odvi	summer browse pref, adiron	webb,wl	1959
JWMAA	25--1	77	81	odvi	nutr, accep val, hardw sla	alkon,pu	1961
JWMAA	35--4	717	723	odvi	fora pref, tame deer, penn	healy,wm	1971
JWMAA	36--4	1344	1349	odvi	brws selec, nov sc, n brun	telfer,es	1972
JWMAA	39--2	330	336	odvi	food dur oak mast abun, sc	harlow,rf; whela/	1975
JWMAA	39--4	699	704	odvi	consum artif browse, penne	ullrey,de; youat/	1975
JWMAA	44--1	79	88	odvi	seas brws sel, s pine habi	blair,rm; brunett	1980
JWMAA	44--1	264	265	odvi	use of cottonwood monocult	wigley,tb; wesle/	1980
NAWTA	2----	438	445	odvi	food study, north carolina	stegeman,lc	1937
NAWTA	31---	205	212	odvi	use woody brows, nort east	stiteler,wm,jr; s	1966
NFGJA	16--2	145	157	odvi	herbaceous food preference	sauer,pr; tanck,/	1969
PCGFA	8----	83	85	odvi	deer vs livest, gulf coast	goodrum; reid,vh	1954
PCGFA	10---	53	58	odvi	nutri probl, sou pine type	lay,dw	1956
PCGFA	13---	54	61	odvi	acorns in diet of wildlife	goodrum,pd	1959
PPASA	51--2	105	108	odvi	select brow spe, strip min	brenner,fj; musau	1977
SWNAA	22--4	505	509	odvi	diets, rolling plains, tex	quinton,da; horej	1977
SWNAA	24--2	297	310	odvi	botan comp, nutr cont diet	everitt,jh; gonza	1979
TAXNA	26--2	203	207	odvi	evo impl sesqui terpene la	burnett,wc; jone/	1977
TNWSD	25---	35	39	odvi	tame dee, fora pref determ	healy,wm	1968
VIWIA	3---3	3	3	odvi	on refuge pref peach twigs	lewis,mg	1939
VIWIA	3--10	5	5	odvi	feeding habits	ward,hb	1940
WLSBA	7---1	21	24	odvi	dangers of ranking forage	harlow,rf	1979
XFNNA	111--	1	4	odvi	pref pne seedl near locust	davidson,wh	1970

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
AMFOA	50--8	383	385	odhe	food - species, seas, pref	carhart,ah	1944
CAFGA	36--3	235	240	odhe	food habits, californ herd	ferrel,cm; leach,	1950
CAFGA	38--2	211	224	odhe	food hab, prod, cond, cali	lassen,rw ferre/	1952

odhe continued on the next page

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CNJNA	56--3	531	542	odhe	foo hab fll, win, spri, bc	willms,w; mclean/	1976
CNJNA	57--2	375	378	odhe	rel pref, 6 shrubs, bri co	tucker,r; mclean/	1977
ECMOA	15--2	109	139	odhe	eco relat, food, coast, bc	cowan,im	1945
JRMGA	3----	130	132	odhe	feedin deer brows sp, wint	smith,ad	1950
JRMGA	4---4	249	253	odhe	ceel, status of brws, oreg	mitchell,ge	1951
JRMGA	6---1	30	37	odhe	captv, cnsmp natv forg sum	smith,ad	1953
JRMGA	7---6	262	265	odhe	pref, wint forag, nor utah	smith,ad; hubbard	1954
JRMGA	29--6	486	489	odhe	palat, dg-fir, chem, spaci	tucker,re; majak/	1976
JRMGA	30--2	116	118	odhe	food, wld hors, doca, colo	hansen,rm; clark/	1977
JRMGA	30--3	206	209	odhe	fo hab, semi-des grass-shr	short.hl	1977
JRMGA	31--3	192	199	odhe	sprng for selec, sageb, bc	williams,w; mclea	1978
JRMGA	32--1	40	45	odhe	fora selec, wint ran, dosh	smith,ma malech/	1979
JRMGA	32--3	226	229	odhe	fora diver, diet sel, wint	carpenter,lh; wa/	1979
JWMAA	29--2	352	366	odhe	stom content anal, new mex	anderson,ae; sny/	1965
JWMAA	30--3	471	475	odhe	prefer, nativ for, doug-fi	crouch,gl	1966
JWMAA	38--1	32	41	odhe	plant char rel to feed pre	radwan,ma; crouch	1974
JWMAA	38--4	830	836	odhe	taste respons, brws extrc,	rice,pr; church,d	1974
NAWTA	4----	560	569	odhe	ceel relationships, oregon	cliff,ep	1939
NAWTA	15---	512	517	odhe	movable paddocks, for pref	smith,ad; gaufin,	1950
NAWTA	33---	181	192	odhe	basis for palatabil, calif	longhurst,wm; oh/	1968
SWNAA	13--2	159	166	odhe	food plants, habitat, okla	clark,tw	1968

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
ATRLA	15--6	89	110	ceel	foods, rumen content analy	dzieciolowski,r	1970
ATRLA	15-23	361	365	ceel	food selectivi towrd twigs	dzieciolowski,r	1970
CAFNA	93--3	282	287	ceel	summ, aut, wint diet, sask	hunt,hm	1979
DRGBA	5---3	1	44	ceel	food selection, rumen cont	jensen,pv	1968
ELPLB	15-11	285	305	ceel	winter food deter by track	dzieciolowski,r	1967
ELPLB	18-32	635	645	ceel	variat, food select, envir	dzieciolowski,r	1970
JOMAA	17--3	253	256	ceel	browsing, early wint, wash	skinner,mp	1936
JRMGA	26--2	106	113	ceel	foods eaten, litera review	kufeld,rc	1973
JWMAA	2---3	131	134	ceel	carrying capacity of range	young,va	1938
JWMAA	5---4	427	453	ceel	effect wint brwsng, montan	gaffney,ws	1941
JWMAA	24--1	15	21	ceel	on afognak island, alaska	troyer,wa	1960
JWMAA	42--4	799	810	ceel	diet, activ, ldgpl pne hab	collins,wb; urne/	1978

ceel continued on the next page

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
NAWTA	3----	747	755	ceel	food habits, virginia	baldwin,wp; patto	1938
XFPNA	112--	1	12	ceel	odhe, seasonal forage use	edgerton,pj; smit	1971

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
ATRLA	21--5	101	116	alal	food habits, poland	morow,k	1976
CAFNA	90--1	11	16	alal	food hab, alask, rumen con	cushwa,ct; coady,	1976
CJZOA	54-10	1765	1770	alal	wintr foods, evalu methods	joyal,r	1976
ECOLA	34--1	102	110	alal	feedin habits, yellowst pa	mcmillan,jf	1953
JWMAA	24--1	52	60	alal	snows hare, foo & rng comp	dodds,dg	1960
JWMAA	24--1	162	170	alal	food habs, mvmt, pops, mon	knowlton,ff	1960
JWMAA	37--3	279	287	alal	impnc nonbrows food, alask	leresche,re; davi	1973
NCANA	101--	195	215	alal	review food habits studies	peek,jm	1974
WLMOA	48---	1	65	alal	habitat select, forest mgt	peek,jm; urich,d/	1976

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CAFNA	81--1	33	39	rata	winter diet, northn canada	scotter,gw	1967
JWMAA	36--3	913	923	rata	food habits, newfoundland	bergerud,at	1972
NCANA	96---	317	331	rata	food hab, lichen preferenc	desmeules,p; heyl	1969

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JRMGA	20--1	21	25	anam	dosh, food pref, wyo deser	severson,ke; may,	1967
JRMGA	32--4	275	279	anam	comp fecal, rum, util meth	smith,ad; shandru	1979
JRMGA	32--5	365	368	anam	livest, foods, dese steppe	johnson,mk	1979
JWMAA	10--4	367	367	anam	foods, southeastern montan	couey,fm	1946
JWMAA	16--3	387	389	anam	food habits, measurements	mason,e	1952
JWMAA	27--1	81	93	anam	food habits, saskatchewan	dirschl,hj	1963
JWMAA	32--2	399	401	anam	foods, kansas, stock sites	hlavachick bd	1968
JWMAA	33--3	538	551	anam	winter food hab, rang, mon	bayless,sr	1969

anam continued on the next page

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	35--2	238	250	anam	food hab, range char, albe	mitchell,gj; smol	1971
JWMAA	40--3	469	478	anam	diets, forag avail, coloro	schwartz,cc; nagy	1976
NAWTA	15---	627	644	anam	rang ecol, wichita mt, kan	buechner,hk	1950
NAWTA	30---	136	141	anam	browse pref, sou west utah	smith,ad; beale,/	1965
UTSCB	29--1	3	6	anam	season forage use, wes uta	beale,dm; scotter	1968
WGFBA	12---	1	61	anam	food hab, abund, distribut	sundstrom,c; hep/	1973

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
AMNAA	96--1	225	229	bibi	botan comp, diets, shortgr	peden,dg	1976
JAPEA	11--2	489	497	bibi	trphic ecol, shrtgras plai	peden,dg: van dy/	1974
JWMAA	42--3	581	590	bibi	diet, slv rvr herd, nw ter	reynolds,hw; han/	1978

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	39--1	108	111	ovca	food of, southern colorado	todd,jw	1975

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ovda			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CWOPA	35---	1	19	obmo	rata, diets, canadi arctic	parker,gr	1978
JWMAA	40--1	151	162	obmo	rata, sum rang relns, nw t	wilkinson,pf· sh/	1976

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JOMAA	48--2	242	248	oram	food habits, colorado	hibbs,ld	1967

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JOMAA	25--1	49	54	many	food req alaskan game mamm	palmer,lj	1944
JWMAA	36--4	1068	1076	many	wint food, range use, mont	constan,kj	1972
JWMAA	41--1	76	80	many	foods of ungulates, colora	hansen,rm· clark,	1977
NAWTA	2----	276	287	many	utilizat of browse, kaibab	julander,o	1937
NAWTA	12---	223	227	many	range competition, alberta	cowan,im	1947
NAWTA	27---	150	164	rumi	rum cont anal, ran qual in	klein,dr	1962
XFIPA	101--	1	9		pap chrom, palat diff, sag	hanks,dl; brunne/	1971

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
ATRLA	14-18	247	262	caca	the food of the roe deer	siuda,a; zurowsk/	1969
JZOOA	185--	270	273	caca	dosh, comparison wint diet	henry,bam	1978
OIKSA	32--3	373	379	caca	dada, brws pressure, decid	bobek,b; perzano/	1979

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
ATRLA	12-25	367	376	bibo	food, for ecosyst, lit rev	borowski,s; kras/	1967
ATRLA	17-10	105	117	bibo	food pref, requir, eur bis	gebczyinska,z; kr	1972
ATRLA	17-13	151	169	bibo	food pref, snowfree seasns	borowski,s; koss/	1972

CHAPTER 12, WORKSHEET 1.2a

Estimations of digestibilities from preferences for the forage consumed

The general relationship between preference group and digestibilities illustrated in UNIT 1.2 may be expressed as a numerical relationship for use in simulating and computing animal-range relationships.

Suppose a simple linear regression was used to represent the relationship illustrated earlier. The x-y values are:

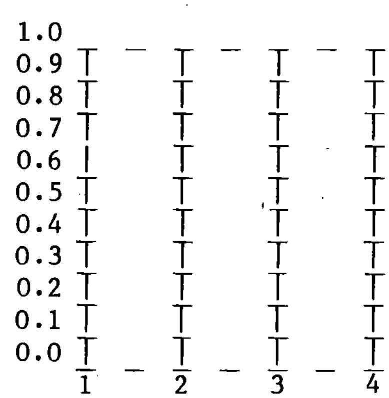
PRCT	AVDC
1	0.62
2	0.60
3	0.54
4	0.50

where PRCT = preference category and
AVDC = average digestibility coefficient.

The linear regression equation for these data is:

$$AVDC = 0.67 - 0.04\ (PRCT); \qquad R^2 = 0.97$$

Plot the points on the grid below and draw the regression line for comparison.



Please remember that these are sample data, and they should be considered subject to change. My suggestion is that the extensive list of references in this UNIT be used to compile a preference list and digestibilities determined from the extensive lists of references on nutritive characteristics given in CHAPTER 11. The best general relationship can then be determined for the species of interest in your area.

TOPIC 2. OBSERVED FORAGE CONSUMPTION AND PASSAGE RATES

There have been relatively few measurements of forage consumption by wild ruminants, and even fewer measurements of passage rates through the gastrointestinal tract. There are good reasons for this; consumption is very difficult to measure or estimate for free-ranging animals, and passage rates are even more difficult since quantities of both forage and marker must be known over time in order to determine passage rate.

Measurements of forage, water, and mineral consumption by free-ranging wild ruminants are very difficult to make because the animals make their own choices of forage species selected, and choose their own time and place for consumption. Estimates of forage consumption are often made indirectly by counting bites and attempting to calibrate the size of bites. The calibration has to be done indirectly too, often by relating twig diameter to twig weights when woody browse is being consumed.

The use of tame animals that can be accompanied by human observers in the field is a recent technique that provides additional insight into selection and consumption. Such animals may be used with the "bite count" method described above.

Grazing animals present a different kind of problem; larger masses of ingesta are taken with each bite. Esophageal fistulas have been used on domestic cattle and sheep, and amounts taken determined.

Water and mineral consumption may be estimated in only very crude ways. Relative consumption may be determined for different times of the year by frequencies and durations of time at water and mineral sources.

Lack of knowledge of forage consumption and passage rates must not minimize their importance. Suppose two forages were consumed in equal amounts and were equally digestible, but one had a passage rate two times faster than the other. The nutrients available <u>per unit time</u> would be two times greater for the rapid-passage forage. Since such events occur in a diet context, there are implications for the overall dietary composition from such differences in forages.

Units on forage consumption (UNIT 2.1) and passage and turnover rates (UNIT 2.2) follow with indications of the use and importance of consumption and passage rate data when working with nutrients available to the animal.

UNIT 2.1: FORAGE CONSUMPTION

There is relatively little information on the amounts of forage consumed by free-ranging wild ruminants. Most of the references on observed forage consumption describe amounts eaten under controlled experimental conditions. These experiments were valuable initially for providing estimates of the masses of different forages ingested, and are also valuable now for comparing with results of the calculations that are described in TOPICS 3, 4, and 5.

References with information on forage consumption can be used for comparing with predicted consumption if data on time of year, weights of animals, and digestibility of the forage consumed is given. Surprisingly few papers contain all of this information (Moen and Scholtz 1981). Those papers in the lists of references that do should be marked for later use when making calculations of daily consumption in TOPICS 3, 4, and 5.

LITERATURE CITED

Moen, A. N. and S. Scholtz. 1981. Nomographic estimation of forage intake by white-tailed deer. J. Range Manage 34(1):74-76.

REFERENCES, UNIT 2.1

FORAGE CONSUMPTION

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	33--4	917	921	cerv	twig wt-diam related browse	telfer,es	1969
JWMAA	34--2	456	460	cerv	lgth-,wt-dia relat, serv-be	lyon,lj	1970
JWMAA	38--4	944	946	cerv	vertical distr of browsing	telfer,es	1974

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
AGJOA	69--3	497	501	od--	est forg cons, wdlnd clrng	kalmbacher,rs; wa	1977
CAFGA	37--1	43	52	od--	deer range survey methods	dasmann,up	1951
JWMAA	9---4	319	322	od--	symptoms, malnutrition, de	harris,d	1945
NEJAA	39--2	3	4	od--	test rye for deer forage	toth,sj; mclain,/	1957
PCGFA	10---	53	58	od--	nutr prob, south pine type	lay,dw	1956
WSCBA	14--2	18	19	od--	starve, feeding stati, wis	stollberg,bp	1949

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
AZATA	75---	1	39	odvi	odhe, experimtl feed, deer	nichol,aa	1938
CJFRA	4---4	491	498	odvi	use brows in encl, n bruns	drolet,ca	1974
JANSA	45--2	365	376	odvi	nutrn wh-t throughout year	holter,jb; urban/	1977
JRMGA	26--5	372	375	odvi	est food intak, obs mastic	crawford,hs; whel	1973
JWMAA	20--3	221	232	odvi	nutr req, growth, antl dev	french,ce; mcewe/	1955
JWMAA	34--2	431	439	odvi	wint feed patterns, penned	ozoga,jj; verme,l	1970
JWMAA	34--4	863	869	odvi	dige, metab ener req, wint	ullrey,de; youat/	1970
JWMAA	35--4	723	731	odvi	food passage rate, w-t dee	mautz,ww; petride	1971
JWMAA	36--4	1052	1060	odvi	variat in determ dig capac	mothershead,cl; /	1972
JWMAA	39--1	67	79	odvi	feed analyses and digestio	robbins,ct; van /	1975
JWMAA	39--2	321	329	odvi	nutr in diff season, south	short,hr	1975
JWMAA	39--2	355	360	odvi	milk consumption & wt gain	robbins,ct; moen,	1975
JWMAA	39--3	596	600	odvi	rumen overload, rumenitis	wobeser,g; runge,	1975
JWMAA	39--4	692	698	odvi	energ, prot, blood urea ni	kirkpatrick,rl; /	1975
JWMAA	39--4	699	704	odvi	artif brws supplmn, penned	ullrey,de; youat/	1975
NAWTA	4----	268	274	odvi	results, feeding exp, mich	davenport,la	1939
NAWTA	22---	119	132	odvi	nutrient requirements, w-t	mcewen,lc; frenc/	1957
NAWTA	22---	179	188	odvi	feed req for growth, maint	cowan,imct; wood/	1957
NAWTA	34---	146	154	odvi	effects qual on food intak	nagy,jg; know.kl/	1969
PAABA	600--	1	50	odvi	nutr req, growth, antl dev	french,ce; mcewe/	1955
PAABA	628--	1	21	odvi	nutr, gro, antl, exp resul	magruder,nd; fre/	1957
PAARA	262--	1	5	odvi	seas fluc in feed consumpt	long,ta; cowan,r/	1965
PCGFA	21---	24	32	odvi	seas var food cons, wt gai	fowler,jf; newso/	1967
XANEA	33---	1	37	odvi	brwsing hardwds, northeast	shafer,el,jr	1965

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
NOSCA	45--2	80	86	odhe	doug fir seedl heigh, brow	dimock,ej,II	1971
JRMGA	6---1	30	37	odhe	captv, cnsmp natv forg sum	smith,ad	1953
JWMAA	35--3	469	475	odhe	nutr intak, ariz chap, des	urness,pj; green/	1971
JWMAA	36--4	1025	1033	odhe	forag use, logging, colora	wallmo,oc; regel/	1972
JWMAA	38--3	508	516	odhe	est forag intak, cesiu-137	alldredge,aw; li/	1974
JWMAA	41--4	782	784	odhe	ceel, ponder pine for open	ffolliott,pf; th/	1977
NAWTA	22---	179	186	odhe	food requir growth & maint	cowan,imct; wood/	1957

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
ATRLA	17-15	187	202	ceel	caca, foo supply cons, pol	bobek,b; weiner,/	1972
BJNUA	40--2	347	357	ceel	dosh, comp intk, dig, fora	milne,ja; macrae/	1978
JAPEA	16--1	227	242	ceel	height, sp, determ browsng	rounds,rc	1979
JWMAA	42--4	799	810	ceel	diet, activ, ldgpl pne hab	collins,wb; urne/	1978
NATUA	263--	763	764	ceel	dosh, intk, dig, hill vege	milne,ja; macrae/	1976

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
ATRLA	21--5	101	116	alal	food habits, poland	morow,k	1976
JOMAA	51--2	403	405	alal	character captiv mich moos	verme,lj	1970
JWMAA	37--3	279	287	alal	impnc nonbrows food, alask	leresche,re; davi	1973
JWMAA	39--2	368	373	alal	daily brows consum, quebec	crete,m; bedard,j	1975
WLMOA	48---	1	65	alal	habitat select, forest mgt	peek,jm; urich,d/	1976

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
ATYBA	55---	22	25	rata	birch consump, fin lapland	haukioja,e; heino	1974
BPURD	1----	71	79	rata	lichn ing rt, fllout cesiu	hanson,wc; whick/	1975
CJZOA	48--5	905	913	rata	seas cha, ener, nitr intak	mcewan,eh; whiteh	1970
NCANA	96---	333	336	rata	food hab, daily lichn cons	desmeules,p; heyl	1969

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JRMGA	20--1	21	25	anam	dosh, food pref, wyo deser	severson,ke; may,	1967
JWMAA	34--3	570	582	anam	forg, watr consump, produc	beale,dm; smith,a	1970
WGFBA	12---	1	61	anam	food hab, abund, distribut	sundstrom,c; hep/	1973
XIBPA	1....	233		anam	field food consump studies	nagy,jg; hoover,j	1971

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
ATRLA	22-14	225	230	bibi	fora intak, dig; doca, yak	richmond,rj; hud/	1977

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ovca			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ovda			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				obmo			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				oram			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
FEPRA	27--6	1361	1366	rumi	regulation of feed intake	baile,ca	1968
JANSA	24--3	834	843	rumi	volun intk, herb, chem com	van soest,pj	1965
JOMAA	25--1	49	54	many	food req alaskan game mamm	palmer,lj	1944
JWMAA	38--4	944	946	many	vert distrib brwsng, canad	telfer,es	1974
QRBIA	52--2	137	154		optim fora: rev theor, tes	pyke,gh; pulliam/	1977
SZSLA	21---	77	87	ungu	investigate ung diets, zoo	bilby,lw	1968
XARRA	22---	1	6		meth estim rnge grass util	springfield,hw; p	1964
ZEJAA	20--1	63	67	wiru	det nutr intake, tame spec	nagy,jg	1974

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
OIKSA	32--3	373	379	caca	dada, brws pressure, decid	bobek,b; perzano/	1979

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
ATRLA	12-25	367	376	bibo	food, for ecosyst, lit rev	borowski,s; kras/	1967

UNIT 2.2: PASSAGE AND TURNOVER RATES

Passage and turnover rates of ingesta of wild ruminants have given little attention. The potential importance of the rate of passage was illustrated with an example of differences in the turnover rate in relation to actual abundance in Moen (1973:158). Four different colored sets of marbles were used to illustrate different entry and turnover rates, with their abundance measured each day. The slow-moving, abundant black marbles had a 50% observed abundance but only 29% actual abundance because their passage rate was slow. The illustration shows how those materials with a slow turnover rate may appear to be more abundant than those with a fast turnover rate, simply because they stay in the rumen longer.

A WORKSHEET illustrates this concept, using hypothetical forage values. It is an important concept to be considered when evaluating diet digestibilities.

LITERATURE CITED

Moen. A. N. 1973. Wildlife ecology. W. H. Freeman Co., San Francisco. 458 pp.

REFERENCES, UNIT 2.2

PASSAGE AND TURNOVER RATES

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	35--4	723	731	odvi	food passage rate	mautz,ww; petride	1971

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				odhe			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	44--1	272	273	ceel	passage rate of alfalfa	dean,re; thorne,/	1980

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				alal			

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

rata

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

anam

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

bibi

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

ovca

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

ovda

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

obmo

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

oram

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

JANSA 25--2 283 289 dosh reln ad lib intk, gut fill ingalls,jr; thom/ 1966

CHAPTER 12, WORKSHEET 2.2a

Food passage rate and turnover time

The amount of different forage species in the rumen would be a true indication of their nutritive importances if they all had the same passage rate and turnover time. Such is not the case, however. Lower quality forages with a slower passage rate than higher quality forages are retained in the rumen longer, and hence may appear to be more important in the diet. The higher quality forages, digested in a short time, yield more nutrients per unit time, however. This is illustrated below with these forages consumed in equal amounts (10 units per day) each day through 5 days.

					Day				
			1	2	3	4	5		
Woody browse, 3-day passage rate:	10	10	10						
		10	10	10					
			10	10	10				
				10	10	10			
					10	10	10		
						10	10	10	
							10	10	10
Herbaceous leaves, 2-day passage rate:	10	10							
		10	10						
			10	10					
				10	10				
					10	10			
						10	10		
							10	10	
Flowers, 1-day passage rate:	10	10	10	10	10	10	10		
	Sums:		60	60	60	60	60		

Note that the relative quantities in the rumen after equilibrium is reached are different from the entry rate. The woody browse, herbaceous leaves, and flowers all enter at the same rate, 10 per day; the diet is composed of 33% of each. The rumen, however, contains 30/60 = 50% woody browse, 20/60 = 33% herbaceous leaves, and 10/60 = 17% flowers. The differences in passage rates result in different amounts in the rumen at one time, which are quite unlike the nutrient entry rate.

Should not more attention be given to passage rates and turnover times when analyzing rumen contents for food habits studies?

TOPIC 3. CALCULATIONS OF FORAGE REQUIRED, ENERGY BASE

The partitioning of nutrients from gross to the metabolizable level illustrated in the first part of CHAPTER 11 makes the final expression of nutrients available compatible with the expression of metabolic requirements. It is necessary, of course, to use the same units of measurement for expressing nutrients in both the numerator and the denominator of this relationship.

Daily forage consumption in relation to energy requirements may be estimated, with both the numerator and the denominator in kcal/day, with the word formula:

forage intake in kg per day = [(ecological metabolism in kcal per day)/ (metabolically useful energy in the forage in kcal per kg)]

This word formula for predicting intake is for an animal in a neutral energy balance, with all of the energy required being met by ingested forage. This is not always the case as body reserves, especially fat, can be mobilized to supplement the ingested forage as a source of energy. The amount of forage required is then reduced.

Seasonal variations in the two components of the basic relationship--ecological metabolism and metabolic energy in the forage--occur. Absolute levels of ecological metabolism vary in relation to ages, weights and reproductive rates of deer. Seasonal variations in weights were described in CHAPTER 1, UNIT 1.4. Seasonal patterns of ecological metabolism are sinusoidal as deer go from winter minimums to summer and early fall maximums (Moen 1978) these are discussed further in CHAPTER 7, UNIT 6.1.

The breakdown of forage materials into chemical energy that can be used by an organism is not a perfectly efficient process, so the ratios of digestible energy to gross energy and metabolizable energy to digestible energy are less than 1.0. These fractions represent the portion of the food ingested that is useful to the animal at each level of breakdown; the coefficient is appropriately called the digestible energy coefficient (DECO) and metabolizable energy coefficient (MECO).

Digestibilities were discussed in CHAPTER 11, with results of *in vivo*, *in vitro*, and calculated weighted mean digestibilites given in TOPIC 3. Metabolizable energy is a fraction of the digestible energy. The metabolizable energy coefficient used for cattle and sheep is 0.82, which is multipled by digestible energy to determine the metabolizable energy in grain and roughage (NRC 1975). Wider variations in the metabolizable energy coefficient for white-tailed deer on browse diets were discussed by Robbins (1973); with metabolizable energy coefficients varying from 0.78 to 0.94 of the digestible energy. A value of 0.86 may be used as an overall estimate for deer on browse if 0.82 is not considered suitable or more specific values are not available.

Expanded formulas for calculating forage consumption, using four-letter symbols, are:

DWFK = ELMD/(GEFO)(DECO)(MECO)

DWFK = (MBLM)(70 IFMW)/(GEFO)(DECO)(MECO)

where DWFK = Dry-weight forage consumed in kg,
ELMD = Ecological metabolism per day,
GEFO = Gross energy in the forage,
DECO = Digestible energy coefficient,
MECO = Metabolizable energy coefficient,
MBLM = Multiple of base-line metabolism, and
IFMW = Ingesta-free metabolic weight.

Calculations of daily consumption based on energy balances are illustrated in the four UNITS. Seasonal variations in the dietary energy and in ecological metabolism are discussed in UNITS 3.1 and 3.2. Then, the role of seasonal variations in energy reserves are discussed in UNIT 3.3, and finally, the use of a nomogram to rapidly estimate intake is illustrated in UNIT 3.4.

LITERATURE CITED

National Research Council. 1975. Nutrient requirements of sheep. National Acad. of Sciences. Washington, D. C. 72 pp.

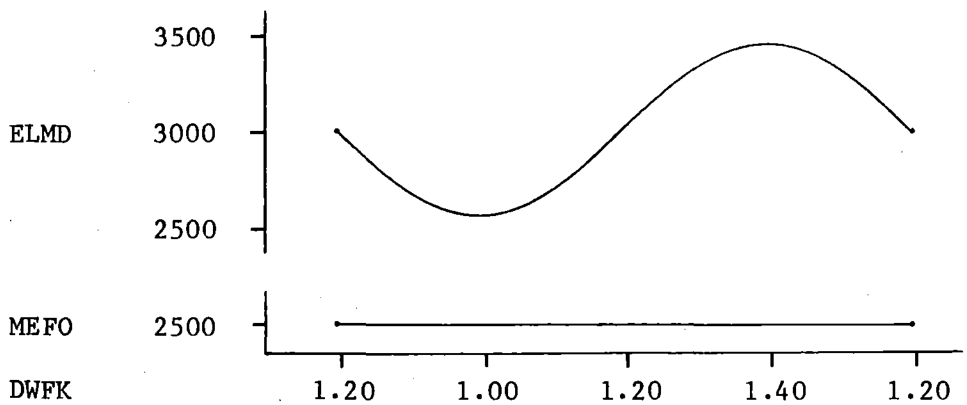
Robbins, C. T. 1973. The biological basis for the calculation of carrying capacity. Ph.D. Thesis. Cornell Univ., Ithaca, NY. 239 pp.

UNIT 3.1: EFFECTS OF VARIATIONS IN DIETARY ENERGY

Diet digestibilities and metabolic energy available in forage are dependent on current growing conditions and weather factors. Diet digestibilities usually change slowly, with a general pattern of winter minimums as animals ingest dormant forage and summer maximums as succulent new growth is ingested. Diet digestibilities may change rapidly if foraging conditions change due to an early winter snowfall, for example, which covers more-digestible herbaceous forage and fruits, leaving only woody browse exposed. Snow also makes movement to fields and other concentrated food sources more difficult for wild ruminants living in agricultural areas. Free-ranging animals consuming dormant woody browse in late winter may quickly shift to new spring growth if snow conditions permit rapid dispersal from winter concentration areas to areas with emerging spring growth.

If digestibility is related to the structure of the plant cell, then it should vary seasonally in relation to plant growth and development. The use of single average values to represent the digestibility of a forage species masks animal-range relationships that are dependent on changes in forage characteristics over time.

The effects of variations in dietary energy are illustrated with the simplified relationship below. MEFO = metabolizable energy in the forage, ELMD = ecological metabolism per day, and DWFK = dry weight forage in kg.



Calculated diet digestibilities illustrating the effects of changes in both diet compositions and in forage digestibilities over time were given in CHAPTER 11, UNIT 3.3. The effects of these changes in forage intake, given a single value for ecological metabolism, are illustrated on the WORKSHEETS.

REFERENCES, UNIT 3.1

EFFECTS OF VARIATIONS IN DIETARY ENERGY

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------------	AUTHORS----------	YEAR
JWMAA	39--2	321	329	odvi	nutr in diff season, south	short,hr	1975
JWMAA	42--4	776	790	odvi	diet prot, energ effc fawn	seal,us; verme,l/	1978

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

odhe

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

ceel

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

TLPBA 14--1 105 134 alal diet optimizatn, genl herb belovsky,ge 1978

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

CJZOA 54--5 737 751 rata dig energy intk, gluc synt mcewan,eh; white/ 1976

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

anam

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

bibi

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

ovca

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

ovda

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

obmo

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

oram

CHAPTER 12, WORKSHEET 3.1a

Variations in forage consumption due to differences in diet digestibilities

The formula for calculating intake is:

DWFK = ELMD/MEFO

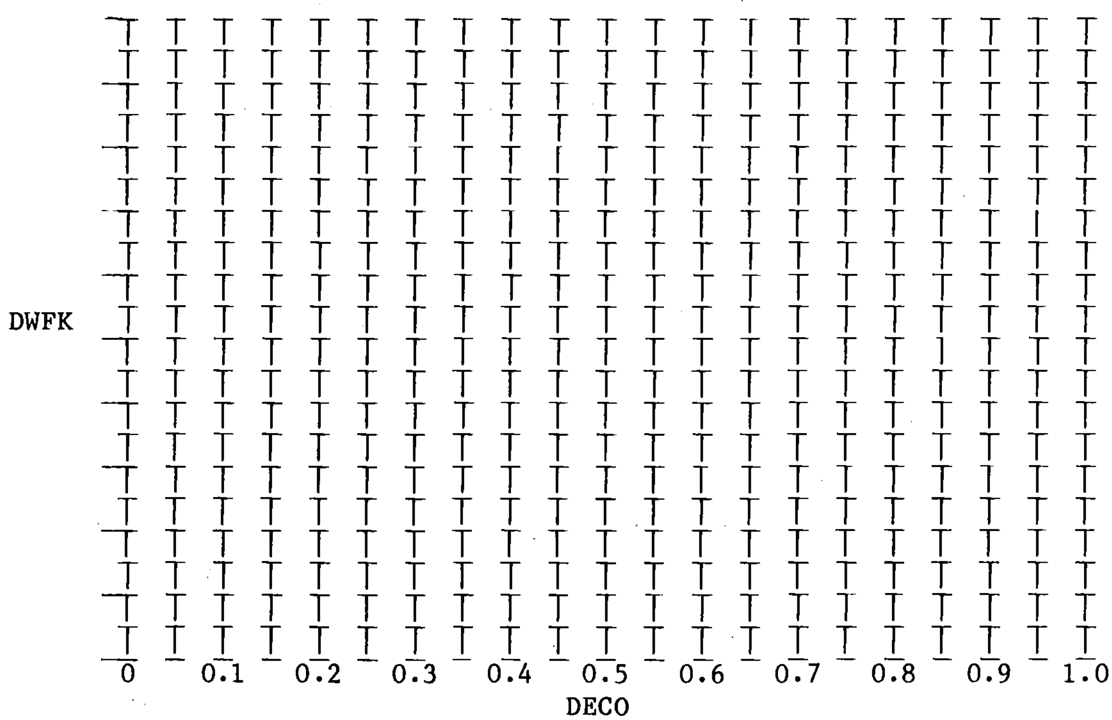
where DWFK = dry weight forage consumed in kg,
ELMD = ecological metabolism per day, and
MEFO = metabolizable energy in the forage.

Metabolizable energy in the forage is determined with the formula:

MEFO = (GEFO)(DECO)(MECO)

where GEFO = gross energy in the forage (= 4500 kcal per kg),
DECO = digestible energy coefficent, and
MECO = metabolizable energy coefficient (0.82).

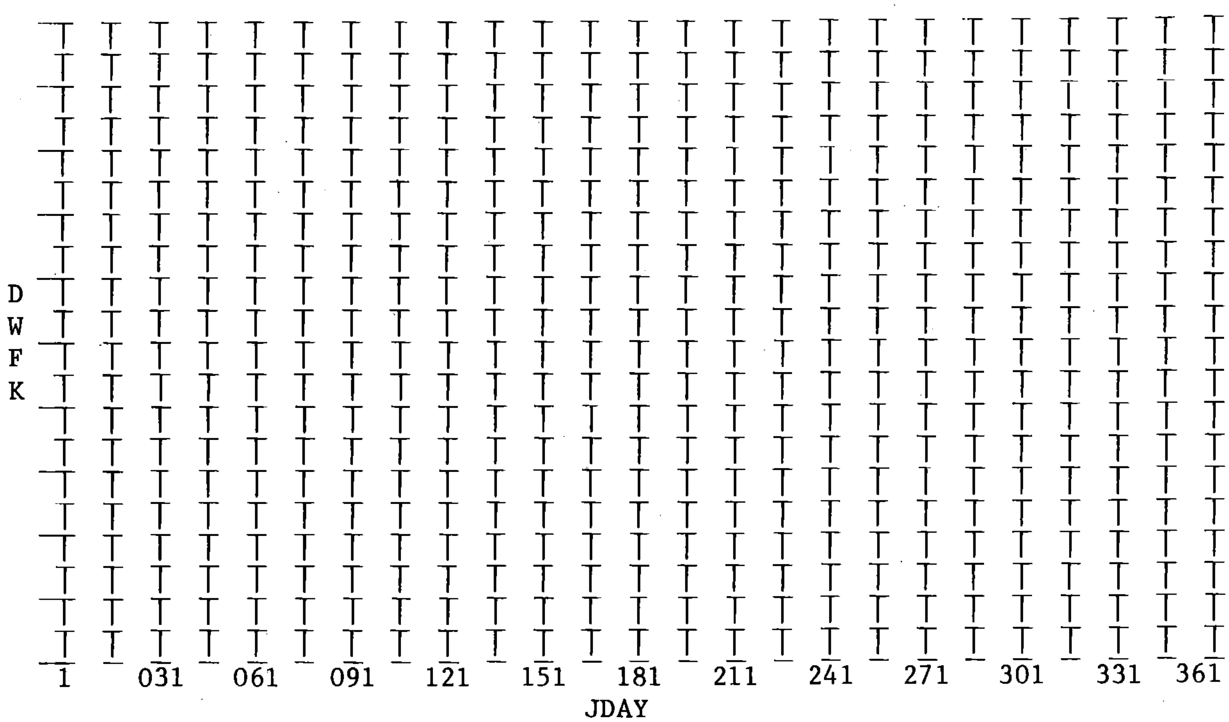
Select a value for ELMD (5000 for a 100 kg animal, for example), complete the calculation of DWFK using DECO = 0.10 to 0.90 at 0.10 intervals, and plot the results on the grid below.



CHAPTER 12, WORKSHEET 3.1b

Variations in forage consumption due to differences in diet digestibilities over time

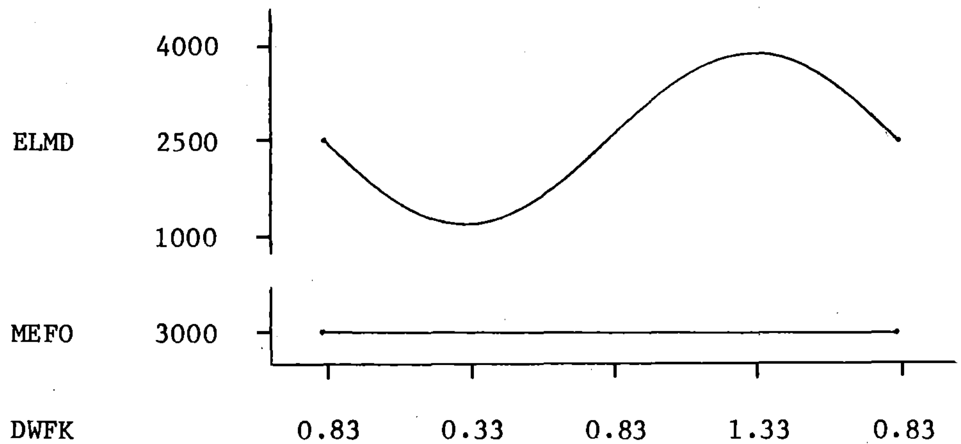
Using the same format as in WORKSHEET 3.1a, complete a new set of calculations using a variable ELMD. Start with the mean value of 5000 and incorporate a sine wave fluctuation of ± 1000 using procedures described in CHAPTER ONE, UNIT 1.4 and CHAPTER SIX, UNIT 6.1. Plot DWFK as separate lines for different DECO in relation to JDAY and ELMD.



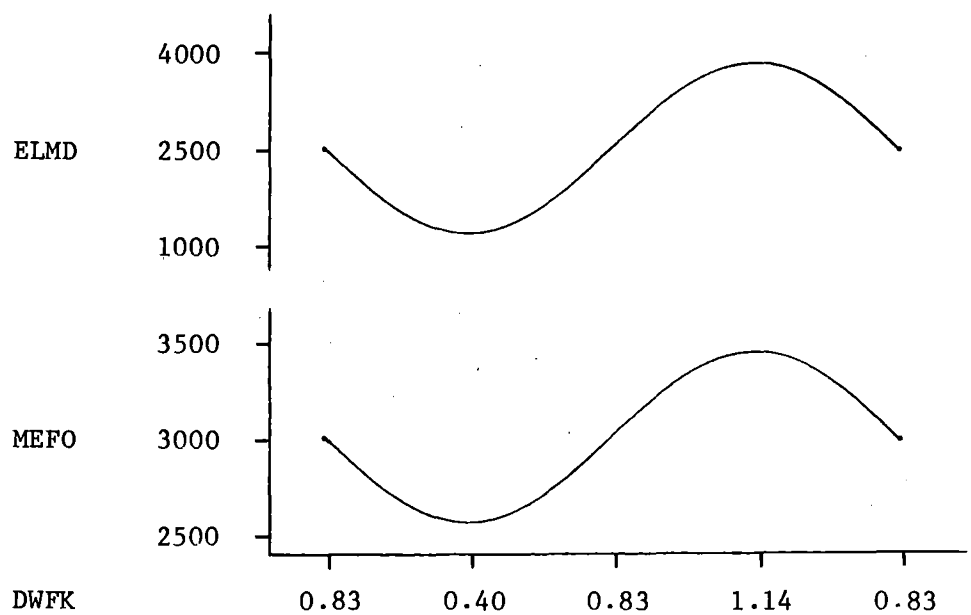
ELMD

UNIT 3.2: EFFECTS OF VARIATIONS IN ECOLOGICAL METABOLISM

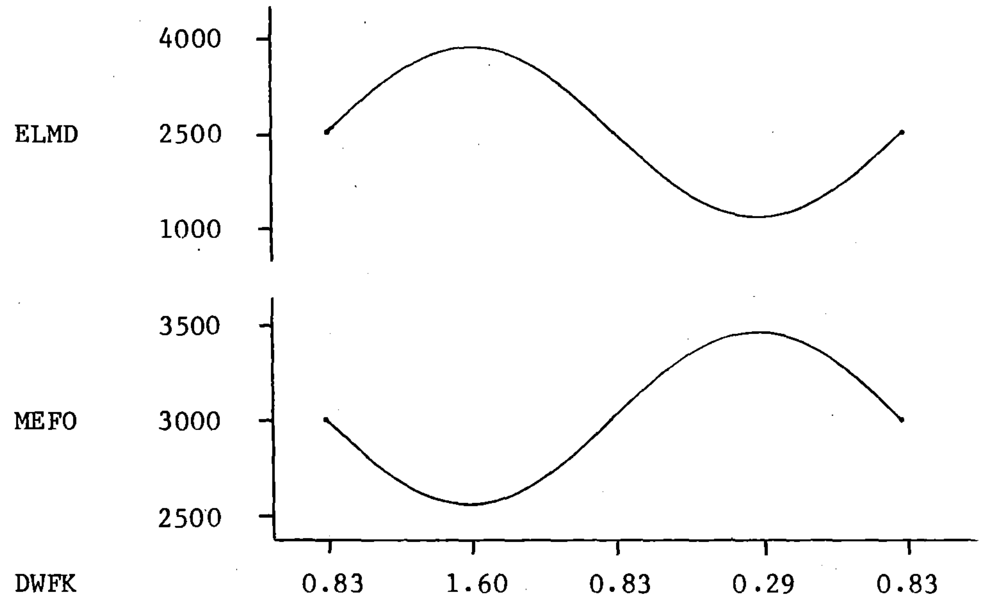
Seasonal variations in ecological metabolism, which were discussed in CHAPTER 7, UNIT 6.1, may now be used to demonstrate their effects on forage consumption. The effects are illustrated with the simplified relationship below.



Seasonal variations in ELMD and in dietary energy combine to cause seasonal variations in forage consumption. Suppose the simplified relationship above is combined with that illustrated in UNIT 3.1. Variations in DWFK as ELMD and MEFO increase and decrease in synchrony are illustrated below.



If MEFO and ELMD are not synchronized, then a marked increase in DWFK is observed when MEFO is low and ELMD is high. This would not be good adaptive strategy. In fact, high ELMD occurs when MEFO is high, early in the growing season when reproductive costs are high. Low ELMD occurs when MEFO is low; the metabolic depression at that time is good adaptive strategy.



These simplified illustrations help one understand the importance of timing and synchrony in seasonal variations of both animal and range. The ratios of change given are illustrative only as MEFO and ELMD were arbitrarily chosen. Absolute levels of ecological metabolism vary in relation to ages, weights, and reproductive rates of the animals, and variations in their activity levels through the year. Range conditions change as plants go from the dormant condition through their growth and reproductive cycles and back to dormancy again. The effects of changes in these two variables--ecological metabolism and range conditions--were discussed and illustrated for white-tailed deer in Moen (1978). Opportunities for additional calculations are provided in the WORKSHEETS that follow.

LITERATURE CITED

Moen, A. N. 1978. Seasonal changes in heart rates, activity, metabolism, and forage intake of white-tailed deer. J. Wildl. Manage. 42(4):715-738.

REFERENCES, UNIT 3.2

EFFECTS OF VARIATIONS IN ECOLOGICAL METABOLISM

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	20--3	221	232	odvi	nutr req, growth, antl dev	french,ce; mcewe/	1955
JWMAA	33--3	482	490	odvi	dig energy req does, wintr	ullrey,de; youat/	1969
JWMAA	34--3	863	869	odvi	dige, metab ener req, wint	ullrey,de; youat/	1970
JWMAA	35--1	57	62	odvi	basal diet for nutr resear	ullrey,de; johns/	1971
JWMAA	42--4	715	738	odvi	seasonal heart rates, meta	moen,an	1978
NAWTA	22---	119	132	odvi	nutrient requirements	mcewen,lc; frenc/	1957
NAWTA	34---	137	146	odvi	eff nutr, clim on sou deer	short,hl; newsom/	1969
PAABA	600--	1	50	odvi	nutr req for grwth, antler	french,ce; mcewe/	1955
TNWSD	1965.	1	13	odvi	n hamp nutr studies, aims,	silver,h; colovo/	1965

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
NAWTA	22---	179	186	odhe	food requir growth & maint	cowan,imct; wood/	1957

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ceel			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
TLPBA	14--1	105	134	alal	diet optimizatn, genl herb	belovsky,ge	1978

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CBPAB	60A-2	123	126	rata	seas chng grwth horm, norw	ringberg,t; jaco/	1978
SZSLA	21---	117	128	rata	aspcts of nutr, semi-domes	steen,e	1968

CODEN VO-NU BEPA ENPA ANIM KEY WORDS------------------ AUTHORS---------- YEAR

anam

CODEN VO-NU BEPA ENPA ANIM KEY WORDS------------------ AUTHORS---------- YEAR

bibi

CODEN VO-NU BEPA ENPA ANIM KEY WORDS------------------ AUTHORS---------- YEAR

ovca

CODEN VO-NU BEPA ENPA ANIM KEY WORDS------------------ AUTHORS---------- YEAR

ovda

CODEN VO-NU BEPA ENPA ANIM KEY WORDS------------------ AUTHORS---------- YEAR

obmo

CODEN VO-NU BEPA ENPA ANIM KEY WORDS------------------ AUTHORS---------- YEAR

oram

UNIT 3.3: EFFECTS OF SEASONAL VARIATIONS IN ENERGY RESERVES

Seasonal weight patterns of wild ruminants are more than interesting anatomical features--they are reflections of storage and mobilization of metabolic reserves, primarily fat, in relation to seasonal variations in range productivity. Increases in the cost of living--ecological metabolism--are observed in late summer and early fall as fat reserves accumulate. As ecological metabolism decreases in the winter, the fat reserve is a source of energy that ameliorates the need for ingesting all of the energy needed. The formula for determining forage consumption when energy reserves are mobilized to supplement the ingested forage as a source of energy is:

forage intake in kg per day = [(ecological metabolism in kcal per day) - (energy metabolized from energy reserves)]/(metabolically useful energy in the forage in kcal per kg)

The contribution of mobilized body tissue to the metabolic energy and the forage equivalent it replaces can be determined by first calculating the weight loss per day using procedures described in CHAPTER 1, UNIT 1.4. Then, determine the composition of the body at the weights calculated (See CHAPTER 2, UNIT 2.1) and the change in fat mass concomitant with the weight loss. Multiply the mass of the fat mobilized by the caloric content of fat (See CHAPTER 7, UNIT 3.1) to get the calories of energy available due to the weight loss and fat depletion. Subtract that quantity in kcal from ELMD. If protein is contributing kcal to the metabolic requirement, multiply the mass of protein mobilized by the caloric content of protein and subtract that quantity in kcal from ELMD also.

After the quantity of kcal that is made available by mobilizing energy reserves has been calculated, it can be expressed as a forage equivalent by dividing the kcal mobilized from energy reserves by the metabolizable energy in the forage. The formula is:

$$FOEQ = KMER/MEFO$$

where FOEQ = forage equivalent,
KMER = kcal mobilized from energy reserves, and
MEFO = metabolizable energy in the forage.

This calculation helps one realize the contribution of the fat reserves to the reduction in forage required through the weight-loss period.

Calculations of the contributions of the fat reserves to the energy metabolized and forage required are made in WORKSHEETS.

REFERENCES, UNIT 3.3

EFFECTS OF SEASONAL VARIATIONS IN ENERGY RESERVES

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	9---4	319	322	odvi	symptoms malnutrition, dee	harris,d	1945

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CAFGA	65--2	68	79	odhe	die comp, ener resrv, preg	holl,sa; salwass/	1979
PMASA	19---	72	79	odhe	annua cycl of condtn, mont	taber,rd; white,/	1959

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ceel			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
TLPBA	14--1	105	134	alal	diet optimizatn, genl herb	belovsky,ge	1978

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				rata			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				anam			

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

bibi

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

ovca

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

ovda

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

obmo

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

oram

CHAPTER 12, WORKSHEET 3.3a

Calculations of the effect of a constant weight loss on fat reserves and energy mobilized on forage required

The contribution of mobilized fat to energy metabolism may be calculated with the following formula, which is a symbol form of the word formula on page 41:

$$DWFK = (ELMD - KMER)/MEFO$$

The contribution of the fat reserve is subtracted from the daily ecological metabolism, resulting in the amount of metabolism left to be supported by forage.

The following steps will illustrate how calculations are made.

1. Calculate ELMD as a function of weight. Begin with an ingesta-free weight of 100 kg and a constant MBLM of 2.5 in this sample calculation. Thus:

$$ELMD = (2.5)(70)(IFWK^{0.75})$$

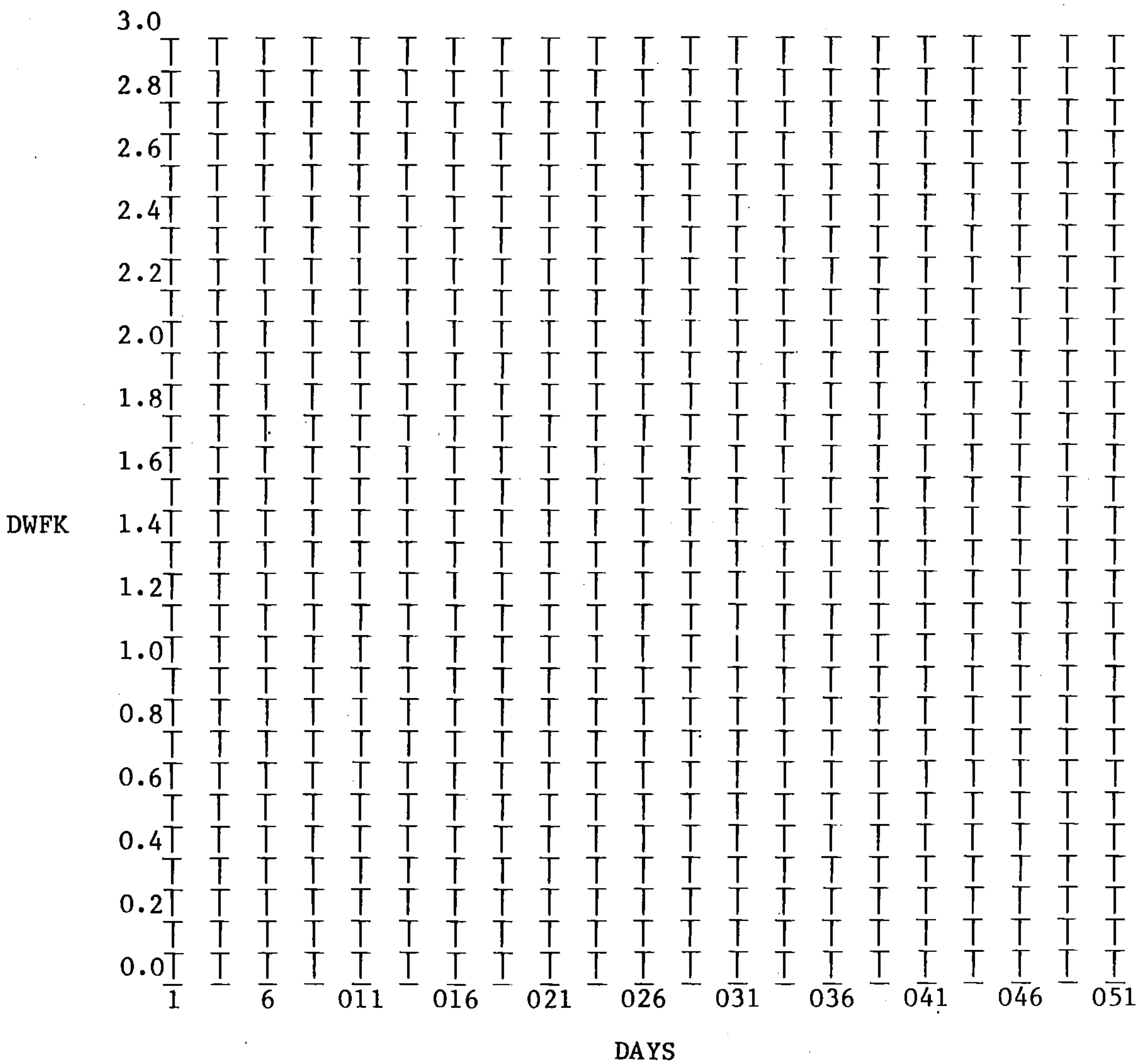
2. Suppose 0.25 kg of fat is mobilized each day. At 9500 kcal per kg:

$$KMER = (0.25)(9500) = 2375$$

3. Suppose the metabolizable energy in the forage is 0.82 of the digestible energy and DECO = 0.50. Then:

$$MEFO = (4500)(0.50)(0.82) = 1845$$

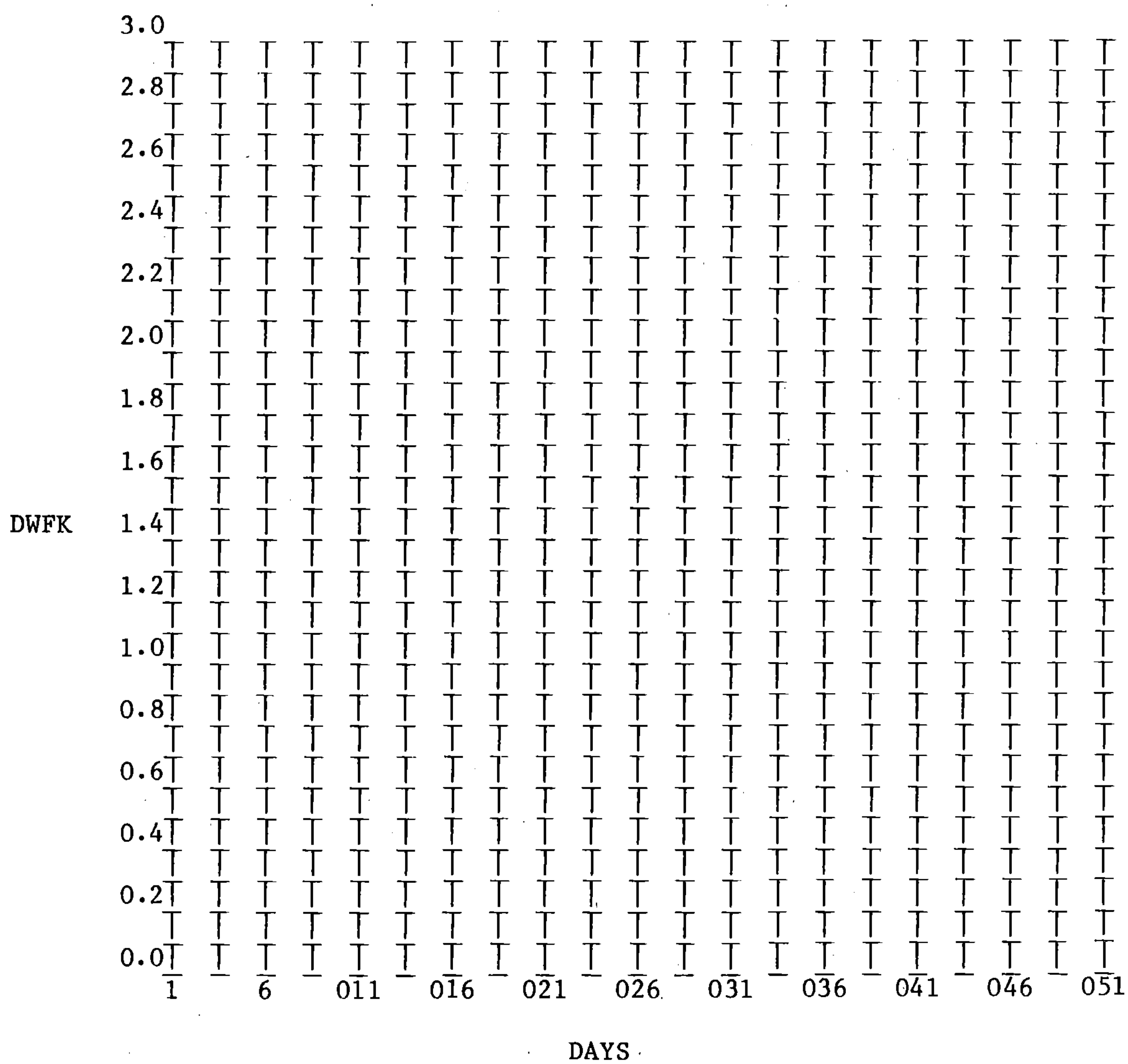
Substitute the values derived in Steps 1-3 in the formula above and determine DWFK. Then, repeat the calculations, but remember to use a new IFWK because 100 - 0.25 = 99.75. This results in a new ELMD. Repeat this adjustment each time. Plot the results in the grid on the next page. I suggest you use 5-day intervals, resulting in a weight loss of 5 x 0.25 = 1.25 between calculations.


DWFK
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1
6
011
016
021
026
031
036
041
046
051
DAYS

CHAPTER 12 - WORKSHEET 3.3b

Calculations of the effect of a percent weight loss on fat reserves and energy mobilized on forage required

This WORKSHEET is like the previous one except that weight loss is calculated as a percent of IFWK rather than a constant 0.25 kg per day. Consider weight loss to be 0.25% of IFWK, or (0.0025)(IFWK). Cycle through the calculations as in WORKSHEET 3.3a, and plot the results below.



CHAPTER 12 - WORKSHEET 3.3c

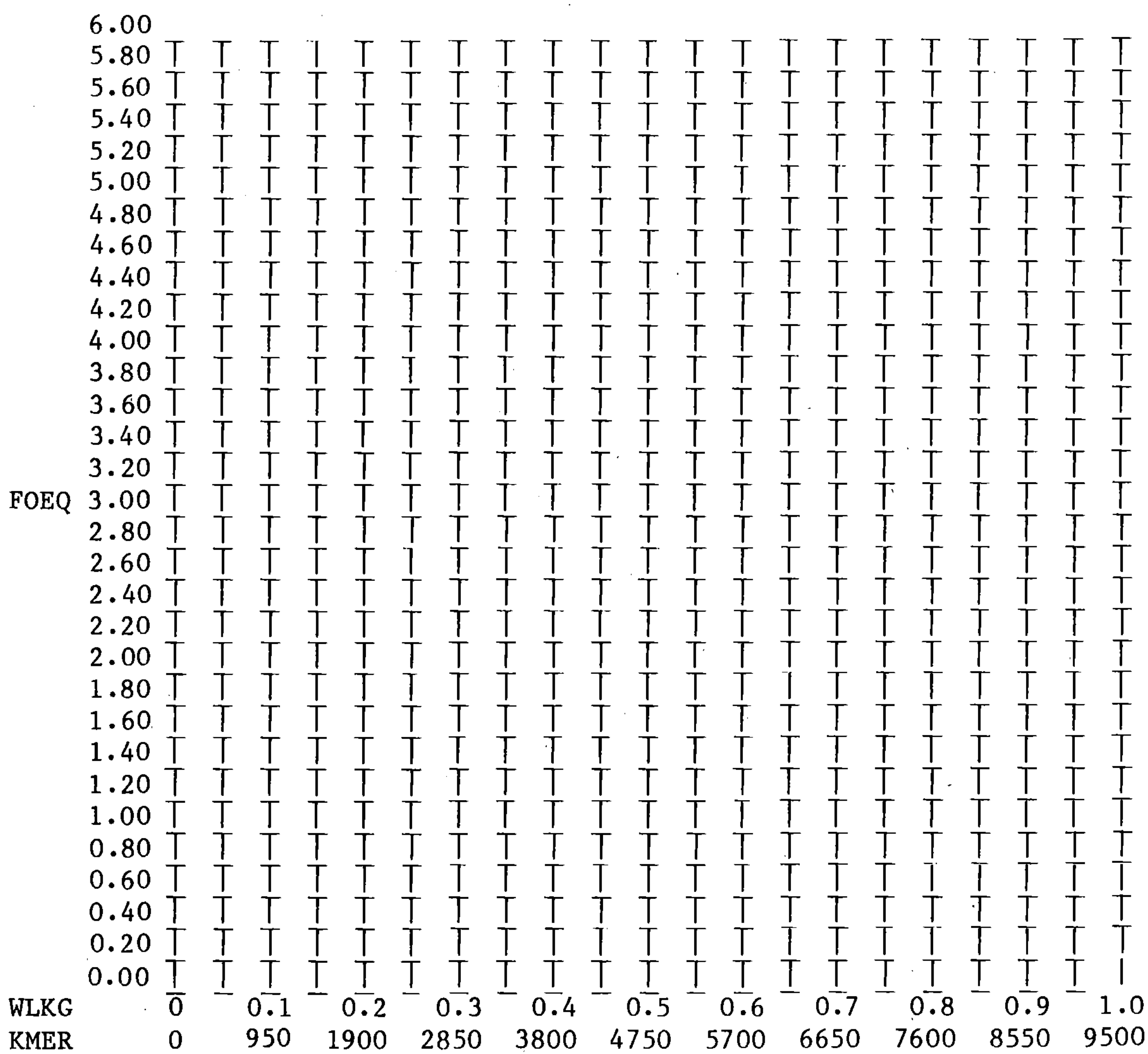
Forage equivalents of mobilized fat reserves

The amount of forage replaced by fat mobilized as a source of energy for metabolism may be calculated with the formula:

$$FOEQ = KMER/MEFO$$

where FOEQ = forage equivalent (in kg),
KMER = kcal mobilized from energy reserves, and
MEFO = metabolizable energy in the forage.

A nomogram may be plotted by considering weight loss in kg (WLKG) and KMER on the x-axis, FOEQ on the y-axis, and MEFO as a family of curves identified by DECO. Substitute the numerical values into the formula, calculate FOEQ, and plot the results to make the nomogram. The line for DECO = 0.50 is already plotted.

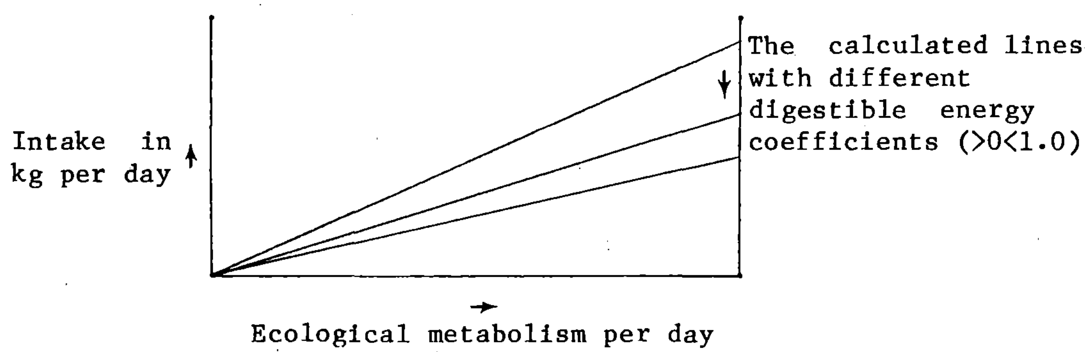


UNIT 3.4: NOMOGRAPHIC PREDICTIONS OF FORAGE REQUIRED, ENERGY BASE

Forage requirements can be predicted from two biological functions--ecological metabolism of the animal and metabolic energy in the forage. The variations in each of these through the year make the calculations tedious when done manually. Programmed computing is very useful when available. A quick way to estimate forage required is by the use of a nomogram.

Estimates of forage requirements made with a nomogram are less accurate than those calculated with programmed computing, but they may be quickly made and are likely to be as accurate as estimates of the number of animals in a population. Further, nomogram estimates are easy to make as seasonal variations in metabolism and diet digestibilities occur.

Nomograms for estimating forage requirements have been published in Moen and Scholtz (1981) and Moen (In Press). The nomograms include ecological metabolism per day on the x-axis, a family of curves for different digestible energy coefficients, and predicted forage requirements on the y-axis. These are illustrated below.



The formulas for calculating the values to be plotted as the DECO lines were given in TOPIC 3 of this CHAPTER (Pages 33-34). In symbol form, the formula is:

$$DWFK = ELMD/(GEFO)(DECO)(MECO)$$

where DWFK = dry-weight forage consumed in kg,
ELMD = ecological metabolism per day,
GEFO = gross energy in the forage,
DECO = digestible energy coefficient, and
MECO = metabolizable energy coefficient.

Be sure to consider the metabolizable energy coefficient when calculating the metabolizable energy in the forage. Values of 0.82 to 0.86 may be used as good approximations. GEFO may be estimated to be 4500 kcal per kg. DECO varies, and is the label for each of the lines on the nomogram.

Since all the lines are straight and they intercept at zero, one needs only to calculate intake for the different digestibilities considered at the highest value of ecological metabolism and draw the lines from those points to zero. A WORKSHEET is set up to facilitate the completion of a nomogram for whatever range of values of ELMD desired.

LITERATURE CITED

Moen, A. N. [In press]. Ecological efficiencies and forage intakes of free-ranging animals. National Academy of Science Publication of a Forage Allocation Workshop, Albuquerque, N.M., November, 1980.

Moen, A. N. and S. Scholtz. 1981. Nomographic estimation of forage intake by white-tailed deer. J. Range Manage. 34(1):74-76.

REFERENCES, UNIT 3.4

NOMOGRAPHIC PREDICTIONS OF FORAGE REQUIRED, ENERGY BASE

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JRMGA	34--1	74	76	odvi	nomographic est forag intk	moen,an; scholtz,	1981

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				odhe			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ceel			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				alal			

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

rata

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

anam

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

bibi

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

ovca

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

ovda

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

obmo

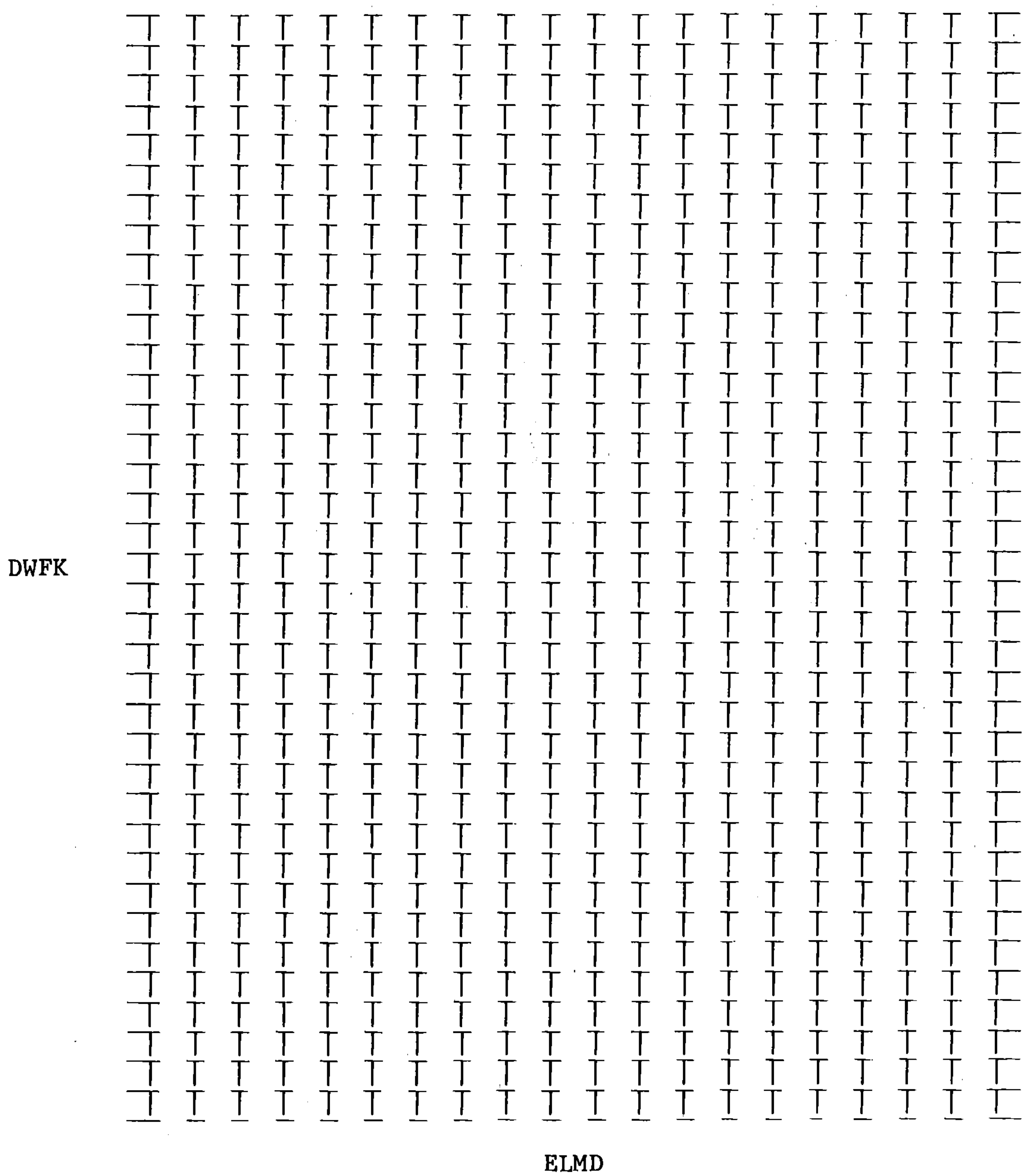
CODEN)VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

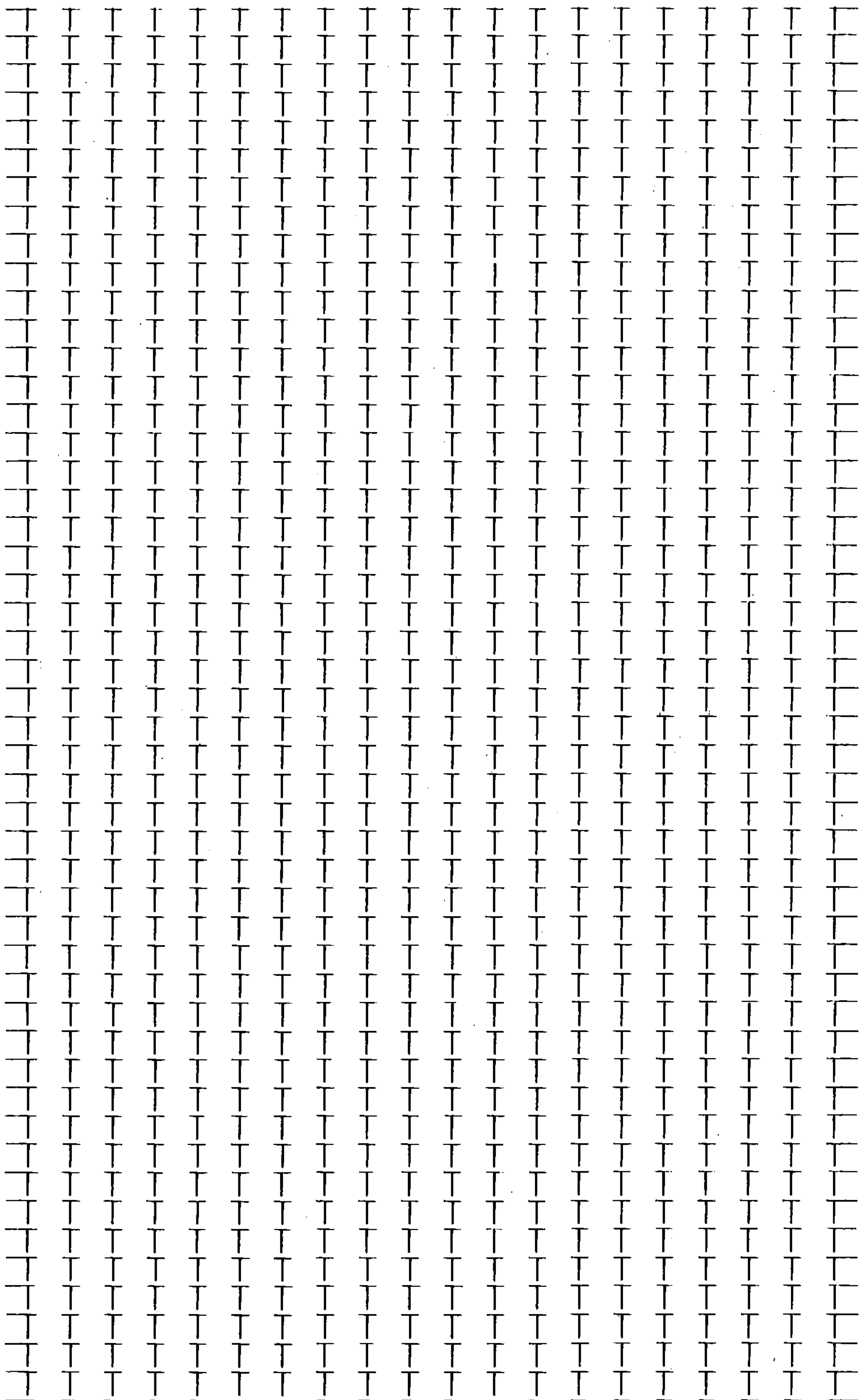
oram

CHAPTER 12, WORKSHEET 3.4a

Nomograms for making predictions of forage required, energy base

The calculations necessary for making a nomogram have been described in this UNIT (page 45) and in the publications cited. Complete a nomogram in the grid below for smaller ruminants, and in the grid on the next page for the larger ruminants. Be sure to use the metabolizable energy in the forage when making the calculations, even though the lines are labeled DECO.




DWFK
ELMD

TOPIC 4. CALCULATIONS OF FORAGE REQUIRED, PROTEIN BASE

The partitioning of nutrients from gross to the metabolizable level illustrated in the first part of CHAPTER 11 makes the final expression of nutrients available compatible with the expression of metabolic requirements. It is necessary, of course, to use the same units of measurement for expressing nutrients in both the numerator and the denominator of this relationship.

Protein-base calculations of daily forage consumption may be made in the same way as the energy-base calculations, except that protein is substituted for energy. The word formula is:

forage intake in kg per day = [(protein metabolism in g per day)/ (metabolically useful protein in the forage in g per day)]

This word formula for predicting intake is for an animal in a neutral nitrogen balance, with all of the protein required being met by ingested forage. This is not always the case as some of the protein required is met by urea recycled. This makes the denominator more complicated as the amount of urea recycled is a function of the protein content of the forage.

Seasonal variations in the two components of this basic relationship--protein metabolism and protein in the forage--occur. Absolute levels of protein metabolism vary in relation to ages, weights and reproductive rates.

The breakdown of forage materials into nitrogenous compounds that can be used by an organism is not a perfectly efficient process, so the ratios of digestible protein to crude protein and metabolizable protein to digestible protein are less than 1.0. These fractions represent the portion of the food ingested that is useful to the animal at each level of breakdown; the coefficients may be designated as the digestible protein coefficient (DPCO) and metabolizable protein coefficient (MPCO).

Expanded formulas for calculating forage consumption on a protein base, using four-letter symbols, are

$$DWFK = NTMD/[(CPFO)(0.16)](DPCO)(MPCO)$$

where DWFK = Dry-weight forage consumed in kg,
NTMD = Nitrogen metabolism per day,
CPFO = Crude protein energy in the forage,
0.16 = The nitrogen fraction of the protein,
DPCO = Digestible protein coefficient, and
MPCO = Metabolizable protein coefficient.

Calculations of daily consumption based on protein balances are illustrated in the next four UNITS. Seasonal variations in dietary protein and in protein metabolism are discussed in UNITS 4.1 and 4.2. Then, the role of seasonal variations in protein reserves are discussed in UNIT 3.3, and finally, the use of a nomogram to rapidly estimate intake is illustrated in UNIT 3.4.

There is less information available on protein metabolism and forage characteristics than on energy. The factors discussed in these units need to be evaluated further and equations derived for analyses in the total total animal-range relationship. Comparisons of predicted intakes based on energy and protein are of particular interest.

LITERATURE CITED

National Research Council. 1975. Nutrient requirements of sheep. National Acad. of Sciences. Washington, D. C. 72 pp.

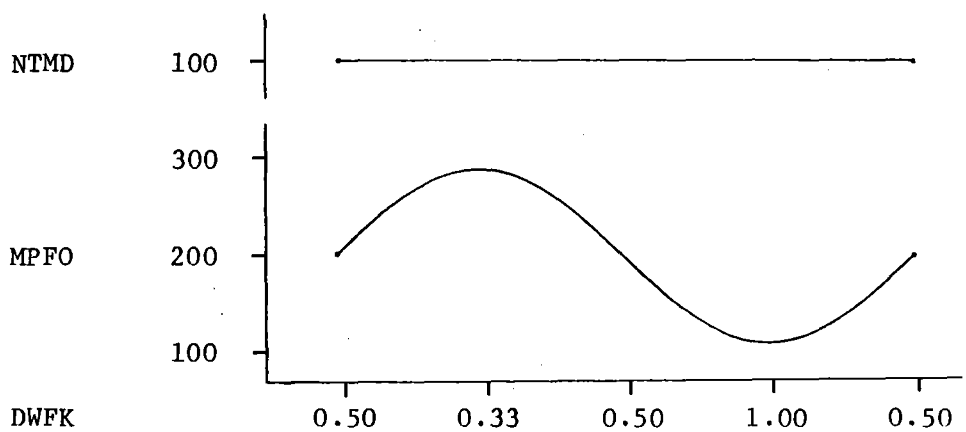
Robbins, C. T. 1973. The biological basis for the calculation of carrying capacity. Ph.D. Thesis. Cornell Univ., Ithaca, NY. 239 pp.

UNIT 4.1: EFFECTS OF VARIATIONS IN DIETARY PROTEIN

The amount of dietary protein is dependent on the phenology of the forage, current growing conditions, and the plant parts selected of the consumers. Dietary protein usually changes slowly, with a general pattern of winter minimums as animals ingest dormant forage and summer maximums as new growth is ingested. Dietary protein may change rapidly if foraging conditions change due to an early winter snowfall that covers higher-protein herbaceous forage and fruits, leaving only lower-protein woody browse exposed. Snow also makes movement to fields and other higher-protein agricultural food sources more difficult for those wild ruminants living in farm areas. Free-ranging animals consuming low-protein woody browse in late winter may shift to high-protein spring growth rather quickly if snow conditions permit rapid dispersal from winter concentration areas to areas with emerging spring growth.

The effects of variations in dietary protein are illustrated with the simplified relationship below. MPFO = metabolizable protein in the forage, NTMD = nitrogen metabolism per day, and DWFK = dry weight forage in kg. The formula is:

DWFK = NTMD/MPFO



The format for calculating the effects of changes in dietary protein on forage intake is illustrated on WORKSHEETS that follow.

REFERENCES, UNIT 4.1

EFFECTS OF VARIATIONS IN DIETARY PROTEIN

SERIALS

CODEN VO-NU BEPA ENPA ANIM KEY WORDS------------------ AUTHORS---------- YEAR

JWMAA 42--4 776 790 odvi diet prot, energ effc fawn seal,us; verme,l/ 1978

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

odhe

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

ceel

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

JWMAA 37--3 279 287 alal importnc of nonbrowse food leresche,re; davi 1973

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

CJZOA 48--5 905 913 rata seas chang, ener, nit intk mcewan,eh; whiteh 1970

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

anam

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

bibi

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

ovca

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

ovda

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

obmo

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

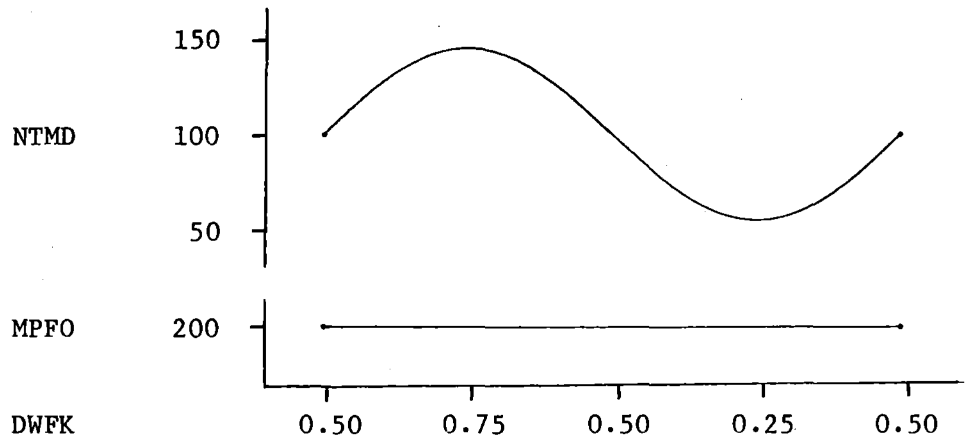
oram

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

CJZOA 48--6 1437 1442 many rumen nitrog level, variat klein,kr; schonhe 1970

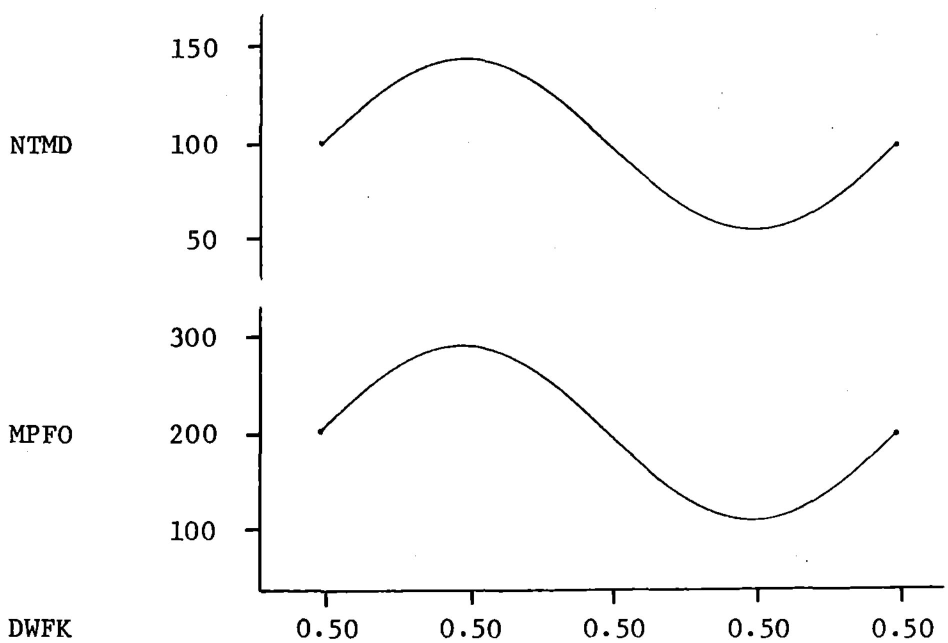
UNIT 4.2: EFFECTS OF VARIATIONS IN PROTEIN REQUIREMENTS

Seasonal variations in protein metabolism, discussed in CHAPTER 7, UNIT 6.1, may now be used to demonstrate their effects on forage consumption. The effects are illustrated with the simplified relationship below.

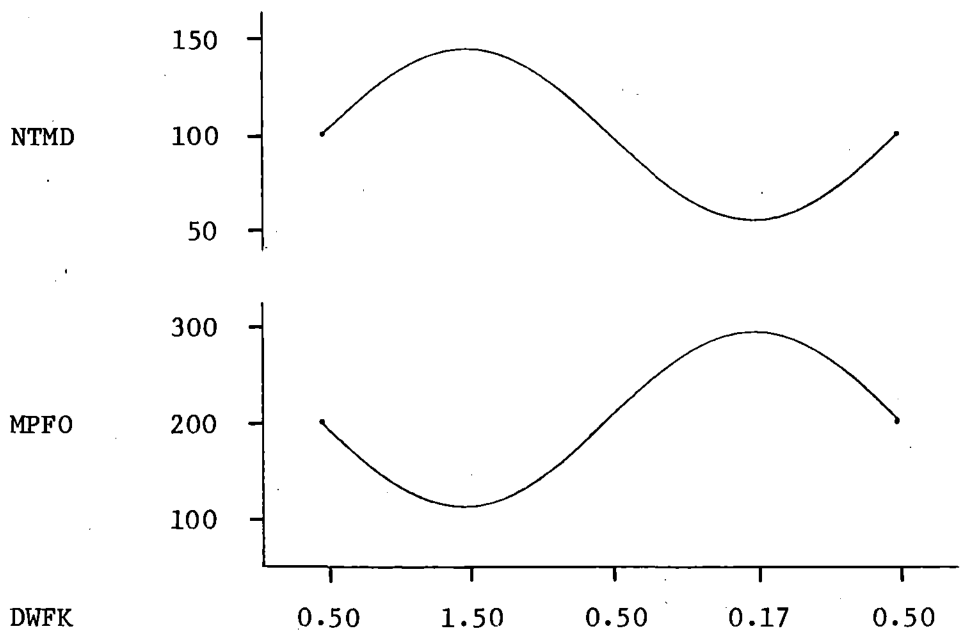


SEASONAL VARIATIONS

Seasonal variations in NTMD and in MPFO combine to cause variations in forage consumption. Suppose the simplified relationship above is combined with that illustrated in UNIT 4.1. Note how DWFK does not vary in this example if nitrogen metabolism and the metabolic protein in the forage are synchronized.



If NTMD and MPFO are not synchronized, then marked changes in DWFK occur when NTMD is high/low and MPFO is low/high.



These simplified illustrations help one understand the importance of timing and synchrony in seasonal variations of both protein regiment and protein quality of the forage on the range. The effects of changes in these two variables may be quantified with species-specific values in WORKSHEETS that follow.

REFERENCES, UNIT 4.2

EFFECTS OF VARIATIONS IN PROTEIN REQUIREMENTS

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	20--3	221	232	odvi	nutr req, growth, antl dev	french,ce; mcewe/	1955
JWMAA	31--4	679	685	odvi	protein requirement, fawns	ullrey,de; youat/	1967
JWMAA	33--3	482	490	odvi	dig energy req does, wintr	ullrey,de; youat/	1969
JWMAA	35--1	57	62	odvi	basal diet for nutr resear	ullrey,de; johns/	1971
NAWTA	22---	119	132	odvi	nutrient requirements	mcewen,lc; frenc/	1957
NAWTA	34---	137	146	odvi	eff nutr, clim on sou deer	short,hl; newsom/	1969
PAABA	600--	1	50	odvi	nutr req for grwth, antler	french,ce; mcewe/	1955
TNWSD	1965.	1	13	odvi	n hamp nutr studies, aims,	silver,h; colovo/	1965

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				odhe			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ceel			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				alal			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
SZSLA	21---	117	128	rata	aspcts of nutr, semi-domes	steen,e	1968

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				anam			

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

bibi

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

ovca

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

ovda

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

obmo

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

oram

UNIT 4.3: EFFECTS OF SEASONAL VARIATIONS IN UREA RECYCLING

Seasonal changes in the amount of urea recycled by wild ruminants are reflections of changes in the crude protein content of the forage, which is in turn a reflection of range phenology. Increases in the cost of living--ecological metabolism--are observed in late summer and early fall as fat reserves accumulate. As ecological metabolism decreases in the winter, the fat reserve is a source of energy that ameliorates the need for ingestion of all of the energy needed. The formula for determining forage consumption when energy reserves are mobilized to supplement the ingested forage as a source of energy is:

forage intake in kg per day = [(nitrogen metabolism in grams per day - urea recycled in grams per day/(metabolically useful protein in the forage in grams]

The contribution of recycled urea to the nitrogen metabolized and the forage equivalent it replaces can be determined by calculating the urea entry rate with the following formula from Robbins et al. (1974):

urea entry rate(g/hour) = urea pool size/turnover time

Urea pool size in grams per kg body weight may be estimated with the following equation, determined from data in Robbins et al. (1974):

$$UGKW = 0.039 + 0.016\ CPFO$$

where UGKW = urea in grams per kg body weight, and
CPFO = crude protein in the forage

The turnover time in the deer measured by Robbins et al. (1974) averaged 4 hours, so the urea entry rate in grams per hour (UEGH) is determined by:

$$UEGH = UGKW/4$$

The urea entry rate per day is:

$$UEGD = (UGKW)(6)$$

where 6 = 24/4.

The urea recycled, expressed as a percent of entry rate, may be calculated with the following equation, modified from Robbins et al. (1974):

$$UPER = e^{5.3197 - 0.5007 \ln CPFO}$$

where UPER = urea recycled as a percent of entry rate, and
CPFO = crude protein in the forage.

These equations may be used to calculate the urea pool size, daily entry rate, and the percent of the daily entry rate recycled as urea (the remainder comes from dietary sources). The quantities involved may then be used to calculate the forage required to meet these nitrogen needs.

Recycled nitrogen represented from 31 to 18% of the total dietary nitrogen intake when 12-26% protein diets were fed (Robbins et al. 1974:190) to white-tailed deer. If a single estimate were to be made for deer on natural diets of about 10% protein, I would estimate that recycled nitrogen represents about a third (0.33) of the total dietary nitrogen intake. This may be interpreted to mean that about 3/4 and 1/4 of the daily nitrogen requirements are met by diet and urea recycling, respectively.

Please be cautious about using the above equations and estimates at this time. I am writing the equations and making the estimates on the basis of one paper and some logic. They are not meant to be definitive at this time, and need further verification on both deer and other species.

LITERATURE CTIED

Robbins, C. T., R. L. Prior, A. N. Moen and W. J. Visek. 1974. Nitrogen metabolism of white-tailed deer. J. Wildl. Manage. 39(4):684-691.

REFERENCES, UNIT 4.3

EFFECTS OF SEASONAL VARIATIONS IN UREA RECYCLING

SERIALS

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

odvi

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

PMASA 19--- 72 79 odhe annua cycl of condtn, mont tabert,rd; white/ 1959

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

ceel

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				alal			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
BJNUA	33--1	63	72	rata	seas, nut eff ser prot, ur	hyvarinen,h; hel/	1975

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				anam			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				bibi			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ovca			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ovda			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				obmo			

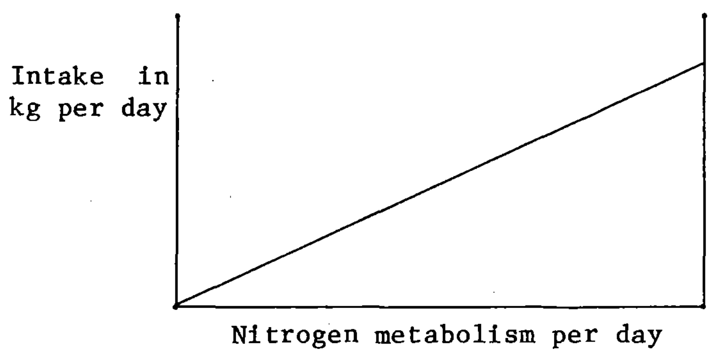
CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				oram			

UNIT 4.4: NOMOGRAPHIC PREDICTIONS OF FORAGE REQUIRED, PROTEIN BASE

Forage requirements can be predicted from two biological functions--nitrogen metabolism of the animal and protein in the forage. The variations in each of these through the year make the calculations tedious when done manually. Programmed computing is very useful when available. A quick way to estimate forage required is by the use of a nomogram.

Estimates of forage requirements made with a nomogram are less accurate than those calculated with programmed computing, but they may be quickly made with the nomogram and they are likely to be as accurate as estimates of the number of animals in a population. Further, nomogram estimates are easy to make as seasonal variations in nitrogen metabolism and dietary protein occur.

The nomogram for predicting forage intake on a protein base includes nitrogen metabolism per day on the x-axis and predicted forage requirements on the y-axis. This is illustrated below.



The formulas for calculating the values to be plotted as the DECO lines were given in TOPIC 3 of this CHAPTER (Pages 33-34). In symbol form, the formula for a protein base calculation is:

$$DWFK = NTMD/(MPFO)(0.16)$$

where DWFK = dry-weight forage consumed in kg,
NTMD = nitrogen metabolism per day, and
MPFO = metabolizable protein in the forage.

This simplified nomogram illustrates the concept. A WORKSHEET is set up to facilitate the completion of a nomogram for species-specific values if desired.

REFERENCES, UNIT 4.4

NOMOGRAPHIC PREDICTIONS OF FORAGE REQUIRED, PROTEIN BASE

SERIALS

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

odvi

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

odhe

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

ceel

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

alal

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

rata

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

anam

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				bibi			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ovca			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ovda			

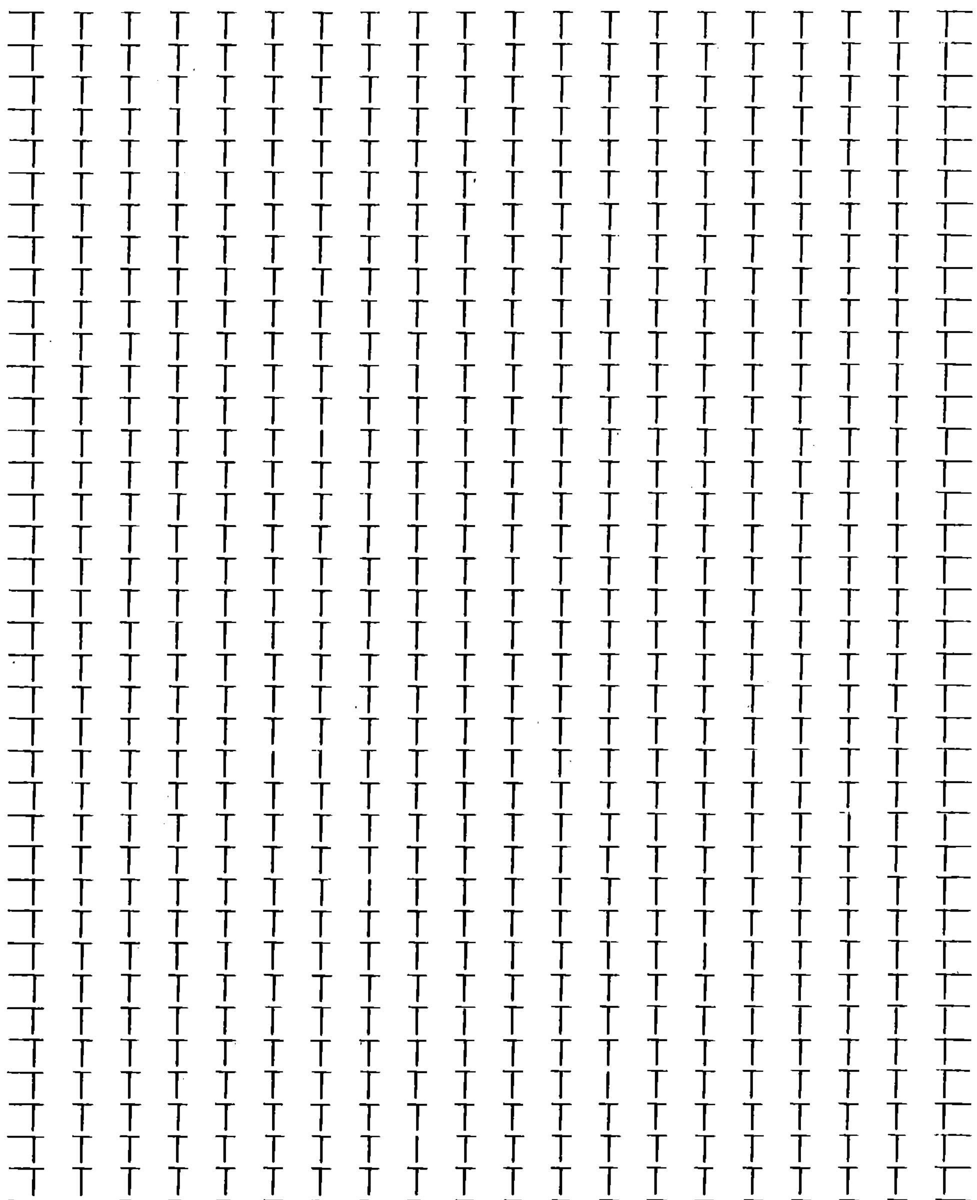
CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				obmo			

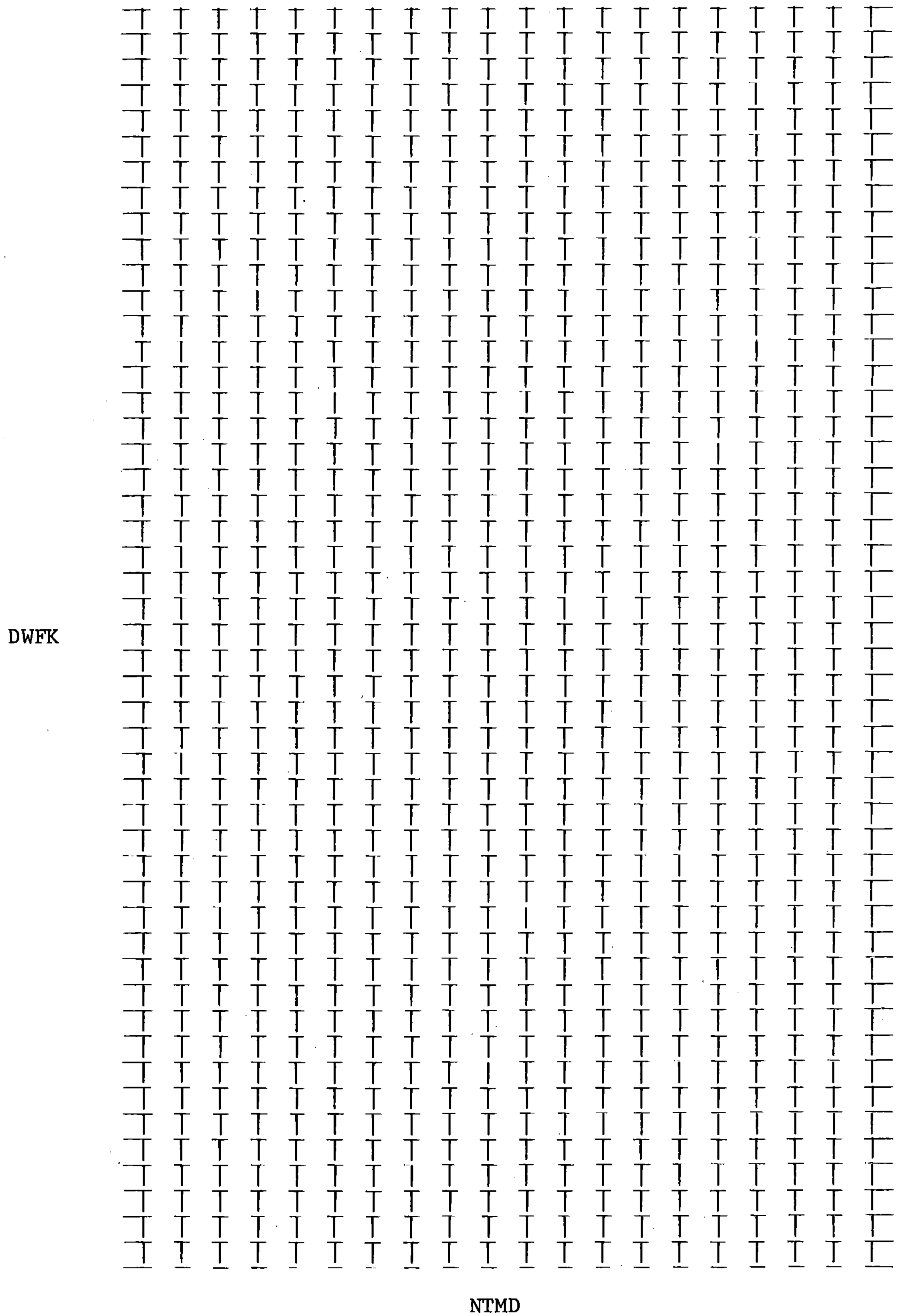
CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				oram			

CHAPTER 12, WORKSHEET 4.4a

Nomograms for making predictions of forage required, protein base

The calculations necessary for making a nomogram have been described in this UNIT (page 61) and in the publications cited. Complete a nomogram in the grid below for smaller ruminants, and in the grid on the next page for the larger ruminants. Be sure to use the metabolizable protein in the forage when making the calculations.




DWFK
NTMD

TOPIC 5. CALCULATIONS OF FORAGE REQUIRED, MINERAL BASE

Calculations of forage required in relation to mineral requirements may be made in the same way that they were made for energy and protein requirements. There are no examples in the literature, however, and limited data on which to base calculations. Rather than ignore the possibility of mineral-base calculations, UNITS 5.1-5.4 are included here, with the serials list so additions may be made as references become available.

UNIT 5.1: EFFECTS OF VARIATIONS IN DIETARY MINERALS

The availability of dietary minerals fluctuates through the annual cycle. Using what little information is available on the mineral composition of forages, evaluate the effects of dietary minerals on forage intake in the same way as for energy and protein.

REFERENCES, UNIT 5.1

EFFECTS OF VARIATIONS IN DIETARY MINERALS

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS------------------	AUTHORS----------	YEAR
JWMAA	35--3	469	475	od--	nutrnt intk, chapar, desrt	urness,pj; green/	1971

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS------------------	AUTHORS----------	YEAR
JWMAA	40--4	610	625	odvi	adap to natur occ sodi def	weeks,hp,jr; kirk	1976

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS------------------	AUTHORS----------	YEAR
JRMGA	30--3	206	209	odhe	food hab, sem-des gras-shr	short,hl	1977

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS------------------	AUTHORS----------	YEAR
				ceel			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	37--3	279	287	alal	importnce of nonbrows food	leresche,re; davi	1973

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				rata			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				anam			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				bibi			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ovca			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ovda			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				obmo			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				oram			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JOMAA	22--1	47	53	biga	criter, propr win forag us	swift,lw	1941
JZAMD	9---3	96	98		nutrit value of hard water	fowler,me	1978

UNIT 5.2: EFFECTS OF VARIATIONS IN MINERAL REQUIREMENTS

Mineral requirements vary through the annual cycle, especially because of the metabolically demanding processes of antlerogenesis and lactation. These variations may be analyzed in the same way the energy and protein variations were in the two previous TOPICS. The space below may be used for ideas and notes when making these evaluations.

REFERENCES, UNIT 5.2

EFFECTS OF VARIATIONS IN MINERAL REQUIREMENTS

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	20--3	221	232	odvi	nutr req, growth, antl dev	french,ce; mcewe/	1955
JWMAA	35--1	57	62	odvi	basal diet for nutr resear	ullrey,de; johns/	1971
NAWTA	22---	119	132	odvi	nutrient requirements	mcewen,lc frenc/	1957
NAWTA	34---	137	146	odvi	eff nutr, clim on sou deer	short,hl; newsom/	1969
PAABA	600--	1	50	odvi	nutr req for grwth, antler	french,ce; mcewe/	1955
PAARA	262--	1	5	odvi	seas fluct in feed consump	long,ta; cowan,r/	1965
TNWSD	1965.	1	13	odvi	n hamp nutr studies, aims,	silver,h; colovo/	1965

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				odhe			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ceel			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				alal			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
SZSLA	21---	117	128	rata	aspcts of nutr, semi-domes	steen,e	1968

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				anam			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				bibi			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ovca			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ovda			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				obmo			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				oram			

UNIT 5.3: EFFECTS OF SEASONAL VARIATIONS IN MINERAL RESERVES

Translocation of minerals occurs when dietary intake is not sufficient to meet the demands for growth. The amounts mobilized may be subtracted from the daily requirements to determine the forage required. The calculations of fat reserve mobilization (UNIT 3.3) is a good example to follow.

REFERENCES, UNIT 5.3

EFFECTS OF SEASONAL VARIATIONS IN MINERAL RESERVES

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	40--4	610	625	odvi	adap to natur occ sodi def	weeks,hp,jr; kirk	1976

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				odhe			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ceel			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				alal			

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

rata

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

anam

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

bibi

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

ovca

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

ovda

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

obmo

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

oram

UNIT 5.4: NOMOGRAPHIC PREDICTIONS OF FORAGE REQUIRED, MINERAL BASE

Nomograms may be developed for predicting the forage required based on mineral metabolism. The concepts are the same as in UNITS 3.4 and 4.4.

One final comment on the prediction of forage required to meet metabolic needs. If the diet were perfectly balanced in proportion to the nutrient needs of the animal, then the answers would be the same when calculating intake on energy, protein, and mineral bases. Such a perfect balance does not exist, of course. Independent calculations on different nutrient bases make interesting comparisons as differences stimulate one's thinking about the accuracies of the calculations, processes used by the animal to overcome negative balances for short periods of time, and other sources of errors and variations in the calculations. Such analyses are not simple. They are mentally stimulating, and the better ecological accountants will undoubtedly arrive at better answers as more calculations are completed.

REFERENCES, UNIT 5.4

NOMOGRAPHIC PREDICTIONS OF FORAGE REQUIRED, MINERAL BASE

SERIALS

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

odvi

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

odhe

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

ceel

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

alal

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

rata

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

anam

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

bibi

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

ovca

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

ovda

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

obmo

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

oram

CLOSING COMMENTS

CHAPTER 12 has included information on food habits, preferences, forage consumption, and passage rates, with demonstrations of calculations of forage required on energy, protein, and mineral bases. Food habits and preferences permit one to calcualte diets. The extensive lists of serials with references on nutritive characteristics in TOPICS 1 and 2 of CHAPTER 11, and the ways to determine diet digestibilities (TOPIC 3, CHAPTER 11) all make it possible to predict forage required. The concepts and methods discussed in CHAPTERS 11 and 12, plus the discussions of forage production in CHAPTER 13, make it possible to evaluate carrying capacities in CHAPTER 20.

Aaron N. Moen
April 10, 1981

GLOSSARY OF SYMBOLS USED - CHAPTER TWELVE

AVDC = Average digestibility coefficient

CPFO = Crude protein in the forage

DECO = Digestible energy coefficient
DPCO = Digestible protein coefficient
DWFK = Dry-weight forage consumed in kilograms

ELMD = Ecological metabolism per day

FGCP = Forage consumption
FOEQ = Forage equivalent

GEFO = Gross energy in the forage

IFMW = Ingesta-free metabolic weight
IFWK = Ingesta-free weight in kilograms

JDAY = Julian day

KMER = Kilocalories mobilized from energy reserves

MBLM = Multiple of base-line metabolism
MECO = Metabolizable energy coefficient
MEFO = Metabolizable energy in the forage
MPCO = Metabolizable protein coefficient
MPFO = Metabolizable protein in the forage

NTMD = Nitrogen metabolism per day

PRCT = Preference category

UEGD = Urea entry rate in grams per day
UEGH = Urea entry rate in grams per hour
UGKW = Urea in grams per kilograms of body weight
UPER = Urea recycled as a percent of entry rate

WLKG = Weight loss in kilograms

CODEN

ABSZA Annales Botanici Societatis Zoologicae Botanicae Fennicae Vanamo
AGJOA Agronomy Journal
AMFOA American Forests
AMNAA American Midland Naturalist
ATICA Arctic
ATRLA Acta Theriologica
ATYBA Annales Univesitatis Turkuensis Series A II. AS262 A11 Ser. A,2 (1)
AZATA Arizona Agricultural Experiment Station Technical Bulletin
BIBAA Bird-Banding
BJNUA British Journal of Nutrition
BLRPA Black Rock Forest Papers
BMAEA Montana Agricultural Experiment Station Bulletin
BPURD Biological Papers of the University of Alaska Special Report
CAFGA California Fish and Game
CAFNA Canadian Field Naturalist
CBPAB Comparative Biochemistry and Physiology A Comparative Physiology
CGFPA Colorado Division of Game, Fish, and Parks Special Report
CJFRA Canadian Journal of Forest Research
CJZOA Canadian Journal of Zoology
CNJNA Canadian Journal of Animal Science
CWOPA Canadian Wildlife Service Occasional Paper
DRGBA Danish Review of Game Biology
ECMOA Ecological Monographs
ECOLA Ecology
ELPLB Ekologia Polska
FEPRA Federation Proceedings
FOSCA Forest Science
IUCSB International Union for Conservation of Nature and Natural Resources Publications New Series
JAASA Journal of the Alabama Academy of Science
JANSA Journal of Animal Science
JAPEA Journal of Applied Ecology
JFUSA Journal of Forestry
JOMAA Journal of Mammalogy
JRMGA Journal of Range Management
JTBIA Journal of Theoretical Biology
JWMAA Journal of Wildlife Management
JZAMD Journal of Zoo Animal Medicine
JZOOA Journal of Zoology
LCHNB Lichenologist
MOCOA Missouri Conservationist
MRLTA Murrelet, The
NATUA Nature
NAWTA North American Wildlife and Natural Resources Conference, Transactions of the,
NCANA Naturaliste Canadien, Le
NEJAA New Jersey Agriculture
NFGJA New York Fish and Game Journal

NMWIA New Mexico Wildlife
NPOAA Norsk Polarinstituut Arbok
OFBIA Ontario Field Biologist
OIKSA Oikos
PAABA Pennsylvania Agricultural Experiment Station Bulletin
PAARA Pennsylvania State University College of Agriculture Agricultural Experiment Station Progress Report
PCGFA Proceedings of the Southeastern Association of Game and Fish Commissioners
PECTD Polish Ecological Studies
PMASA Proceedings of the Montana Academy of Sciences
POASA Proceedings of the Oklahoma Academy of Science
PPASA Proceedings of the Pennsylvania Academy of Science
PSAFA Proceedings of the Society of American Foresters
QRBIA Quarterly Review of Biology
SFORA Scottish Forestry
SWNAA Southwestern Naturalist
SZSLA Symposia of the Zoological Society of London
TAXNA Taxon
TISAA Transactions of the ILlinois State Academy of Science
TLPBA Theoretical Population Biology
TNKKA Trudy Nauchno-Issledovatel'skogo Instituta Sel'skogo Khozyaistva Krainego Severa
TNWSD Transactions of the Northeast Section, The Wildlife Society
TSASA Transactions of the Kansas Academy of Science
UTSCB Utah Science
XANEA U S Forest Service Research Paper NE
XARRA U S Forest Service Resaerch Note SE
XASEA U S Forest Service Research Paper SE
XFIPA U S Forest Service Research Paper INT
XFNNA U S Forest Service Research Note NE
XFPNA U S Forest Service Resaerch Paper PNW
XFWLA U S D I Fish and Wildlife Service, Wildlife Leaflet
XIBPA US-IBP (International Bilogical Program) Analysis of Ecosystems Program Interbiome Abstracts
XPMWA U S Forest Service Research Note PNW
ZEJAA Zeitschrift fuer Jagdwissenschaft

LIST OF PUBLISHERS - CHAPTER TWELVE

blsp	Blackwell Scientific Publications	Oxford, England	oxen
crcp	CRC (Chem. Rubber Co.) Press	Cleveland, OH	cloh
hocl	Hollis & Carter Ltd.	London, England	loen
iucn	IUCN	Morges, Switzerland	mosw
nhfg	New Hampshire Fish & Game Department	Concord, NH	conh
whfr	W. H. Freeman Company	San Francisco,CA	sfca

LIST OF WORKSHEETS - CHAPTER TWELVE

JULIAN DAY: MONTH AND DAY EQUIVALENTS*

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Day
1	001	032	060	091	121	152	182	213	244	274	305	335	1
2	002	033	061	092	122	153	183	214	245	275	306	336	2
3	003	034	062	093	123	154	184	215	246	276	307	337	3
4	004	035	063	094	124	155	185	216	247	277	308	338	4
5	005	036	064	095	125	156	186	217	248	278	309	339	5
6	006	037	065	096	126	157	187	218	249	279	310	340	6
7	007	038	066	097	127	158	188	219	250	280	311	341	7
8	008	039	067	098	128	159	189	220	251	281	312	342	8
9	009	040	068	099	129	160	190	221	252	282	313	343	9
10	010	041	069	100	130	161	191	222	253	283	314	344	10
11	011	042	070	101	131	162	192	223	254	284	315	345	11
12	012	043	071	102	132	163	193	224	255	285	316	346	12
13	013	044	072	103	133	164	194	225	256	286	317	347	13
14	014	045	073	104	134	165	195	226	257	287	318	348	14
15	015	046	074	105	135	166	196	227	258	288	319	349	15
16	016	047	075	106	136	167	197	228	259	289	320	350	16
17	017	048	076	107	137	168	198	229	260	290	321	351	17
18	018	049	077	108	138	169	199	230	261	291	322	352	18
19	019	050	078	109	139	170	200	231	262	292	323	353	19
20	020	051	079	110	140	171	201	232	263	293	324	354	20
21	021	052	080	111	141	172	202	233	264	294	325	355	21
22	022	053	081	112	142	173	203	234	265	295	326	356	22
23	023	054	082	113	143	174	204	235	266	296	327	357	23
24	024	055	083	114	144	175	205	236	267	297	328	358	24
25	025	056	084	115	145	176	206	237	268	298	329	359	25
26	026	057	085	116	146	177	207	238	269	299	330	360	26
27	027	058	086	117	147	178	208	239	270	300	331	361	27
28	028	059	087	118	148	179	209	240	271	301	332	362	28
29	029	[060]	088	119	149	180	210	241	272	302	333	363	29
30	030		089	120	150	181	211	242	273	303	334	364	30
31	031		090		151		212	243		304		365	31

* For leap year, February 29 = JDAY 60. Add 1 to all subsequent JDAYs.

THE BIOLOGY AND MANAGEMENT OF WILD RUMINANTS

CHAPTER THIRTEEN

PRIMARY PRODUCTION AND FORAGE FOR WILD RUMINANTS

by

Aaron N. Moen

Professor of Wildlife Ecology

Department of Natural Resources

College of Agriculture and Life Sciences

Cornell University

Ithaca, N.Y. 14853

and

Certified Wildlife Biologist

(The Wildlife Society)

Published by

CornerBrook Press
Box 106
Lansing, N.Y. 14882

Library of Congress Catalog Card Number 80-70984

CONTENTS OF CHAPTER THIRTEEN

PRIMARY PRODUCTION AND FORAGE FOR WILD RUMINANTS

CHAPTER 13. PRIMARY PRODUCTION AND FORAGE FOR WILD RUMINANTS

Plant material synthesized as a result of photosynthesis is called primary production. The primary production available to wild ruminants is their food base, referred to as forage.

Primary production varies through the year, with the time period between killing frosts referred to as the growing season. Some primary production occurs in natural habitats before and after the killing frosts, but the major portion of plant growth occurs during the warmer weather between them.

Primary production has been given considerable attention by plant physiologists and ecologists. It has an upper limit due to water and solar energy limitations. Water may be in short supply. Solar energy is plentiful enough, but its distribution becomes limited by the plant material; canopies develop and shade the ground surface, limiting primary production there.

Primary production at the ground surface and up to heights of two to three meters becomes the forage base for wild ruminants. Forage production is very much dependent on canopy characteristics. Well-developed canopies do not allow much light to penetrate to the ground and primary production is low.

Forage is also subject to seasonal variations in quantity produced, quality of the nutrients contained, and availability to wild ruminants. Seasonal variations in forage characteristics and digestibilities were discussed in CHAPTER 11. Seasonal variations in forage consumption were discussed in CHAPTER 12. Horizontal and vertical distributions of primary production and forage are discussed in this CHAPTER 13. Uses of information on the spatial distribution of forage are made in CHAPTER 17 as part of range appraisals and again in CHAPTER 20 in calculations of carrying capacity.

Sunshine, water and carbon dioxide are the ingredients necessary for plants to produce new forms of organic matter. The total amount of organic matter synthesized as a result of phototsynthesis is called the <u>gross primary productivity</u>. Plants respire, breaking their own organic products of photosynthesis down and distributing and assimilating the components into plant tissues having specialized functions, such as anchorage, support, absorption, reproduction, photosynthesis, and other functions. The gross primary productivity less the amount used by plants for their own respiration is the <u>net primary productivity</u>.

Primary production is the basis for all life. There is an upper limit to primary production because there is an upper limit to the amount of solar energy that reaches the biosphere, and to the amount that can be absorbed by plants. Primary production is also limited by the availability of nutrients and water. Interactions between these inputs--solar energy, nutrients, and water--determine the characteristics of the growing seasons. In temperate regions, annually occurring growing seasons show marked increases in primary production early in the growing season, a leveling off later in the season, and no production during the dormant season.

The quantity or biomass of plant material present at a point in time is called the standing crop. The standing crop or biomass of annual plants at the end of a growing season can be no greater than the cumulative net primary productivity throughout the growing season, and it is usually less as early leaves wither and die and seeds are dispersed.

The standing crop of perennial plants is greater than the net annual primary productivity as biomass accumulates over the years. This biomass is generally of little or no value to wild ruminants as it becomes lignified and is quite indigestible.

Nutrients stored during the growing season--in bulbs, corms, roots, buds, and other storage organs--are used for growth and the production of photosynthetic tissue at the beginning of the next growing season when primary production begins again. After dormancy, leaf development progesses and primary production increases. Some of this primary production results in additional photosynthetic leaf tissue; a positive feedback loop resulting in accelerated production. Leaf area is an important part of this feedback mechanism, and it is sometimes used as an important parameter in the prediction of photosynthesis. The ratio of leaf area to ground surface area is called "leaf area index" and, in general, the higher the leaf area index, the higher the photosynthesis expected. Differences in leaf area indexes (LAIX) in different plant communities and changes in LAIX over time are important factors in the analyses of primary production in different habitats occupied.

Primary production may be expressed as mass per unit area and quantities for different kinds of plant communities compared. The standing crop on an area of land is the total biomass present at a point in time. The standing crop or biomass of perennial plants exceeds that of annual plants because some of the plant tissue, such as tree trunks, persists from one year to the next. Neither the standing crop nor the entire primary production are available to wild ruminants of course; only the net annual primary production within reach of the animals is part of the food resource base, and not all of that can be consumed without reducing the vigor.

REFERENCES, CHAPTER 13

PRIMARY PRODUCTION AND FORAGE FOR WILD RUMINANTS

BOOKS

TYPE	PUBL	CITY	PGES	PLCO	KEY WORDS-----------------	AUTHORS/EDITORS--	YEAR
aubo	mhbc	nyny	601	many	plant ecology, 2nd edition	weaver,je; clemen	1938
aubo	blak	phpa	596	defo	deciduous forests of n ame	braun,el	1950
edbo	wcbr	duio	828	many	flora of idaho	davis,rj,ed	1952
aubo	whfr	sfca	440	many	stud plant communs, 2nd ed	oosting,hg	1956
edbo	usfs	tige	174	frst	tech meas unders veg, symp	se & sw exp sta	1958
edbo	butt	loen	217	gras	measrmnt grassl prod; symp	ivins,jd,ed	1959
aubo	umpr	aami	272	defo	aspen trees, great lakes	graham,sa; harri/	1963
aubo	butt	wadc	256		quantit plant ecol, 2nd ed	greig-smith,p	1964
aubo	agso	nyny	116	many	potentl nat vegetat of u s	kuchler,aw	1964
aubo	wile	nyny	792		soil-plnt relnshps, 2nd ed	black,ca	1968
aubo	macm	nyny	653		natu, propert soil, 7th ed	buckman,ho· brady	1969
edbo	ibpt	edal	256	tund	prim prod & processe; symp	intnatl biol prog	1973
aubo	mhbc	nyny	532	gras	range management, 3rd edit	stoddart,la; smi/	1975
aubo	spve	nyny	295	gras	grassland simulation model	innis,gs	1978
edbo	spve	nyny	686	tund	vegetat, prod ecol, alaska	tieszen,ll,ed	1978
edbo	spve	nyny	204	gras	perspec in grasslnd ecolog	french,nr,ed	1979

PLCO = plant community

tund = tundra
frst = forest
defo = deciduous forest
gras = grassland
many = more than one type

TOPIC 1. PRIMARY PRODUCTION AND FORAGE IN DIFFERENT PLANT COMMUNITIES

Measurements of primary production on a global scale are pertinent to the calculation of the carrying capacity of all species present of this globe. Wild ruminants are limited to certain areas of the globe and to the lower one to three meters of the biosphere. Further, wild ruminants are selective in their food habits, taking selected plant species, in different orders of preference, and then only certain parts of the plants. Therefore, measurements of primary production available to wild ruminants are limited to ruminant forage, generally considered to be just part of the available current annual growth.

Measurements of forage produced can be made directly or indirectly. Direct measurements include the cutting, drying and weighing of the plant material to determine the mass present. Indirect measurements include the measurement of certain characteristics of the plant material, such as lengths and diameters of twigs, to estimate the mass present, or the visual estimation of densities of the vegetation to come up with yield figures. Direct measurements are very time-consuming but more precise than indirect measurements. The latter can be very quick and, with the proper experience, fairly accurate.

My personal evaluation of the use of direct and indirect measurements includes the use of direct measurements to gain experience with vegetation densities and mass, followed by derivation of decision-making procedures for indirect measurements. Such procedures should include successive stages in the decision-making process that are, by themselves, relatively easy to make, and which, in the entire sequence, lead the evaluater to the right response. I compare such a procedure for estimating forage to a dichotomous key for identifying plants; each decision is made on the basis of evidence for one or the other answer, and the order of questions and answers leads to the right conclusion.

It is necessary to develop some fairly rapid means of estimating forage produced in order to get reasonable estimates distributed over space and time. Plant communities inhabited by wild ruminants are too extensive to be visited on hands and knees with clippers and collecting bag. Visual reconnaissance, photo interpretation, and satellite imagery evaluations provide potential means for estimating forage produced over large areas of space. Once such means are available over space, then estimates can be made over time, simply repeating the estimates at selected intervals to see changes due to natural succession and the effects of man's activities.

The next five UNITS contain information and references for the measurements and distributing of forage production over space and time.

Forage is generally considered to be the current years' growth of herbaceous plants and the current annual growth of woody species. That definition cannot be adhered to strictly because species which retain their leaves for more than one year and lichens which do not differentiate growth between years may be forage for some species.

UNIT 1.1: PRIMARY PRODUCTION IN DIFFERENT PLANT COMMUNITIES

Primary production varies between plant communities, with differences dependent primarily on moisture and temperature conditions during the growing season. These differences result in characteristic physical structures of the communities, with the tundra having no overhead canopy at one extreme and the coniferous forest a very dense canopy.

The discussions of each of the plant communities that follow should be accompanied by mental impressions of the life-forms of the plants and physical structures of the canopies. These characteristics affect the forage available to ruminants, and the amounts are related to the spatial distribution of forage (UNIT 1.3) and stage in succession (UNIT 1.4).

The brief discussions of different plant communities are based on Whittaker (1975) and Lieth (1975). They should be supplemented by further study in plant ecology books and references.

TUNDRA

Tundras are treeless plains in the alpine zones and in the arctic. Tundra vegetation is dominated by dwarf-shrubs, sedges, grasses, mosses, and lichens. The deep layers of the soil are permanently frozen in many areas of arctic tundra and in some alpine communities (Whittaker 1975:156). Productivity of tundra is low because only the upper layer of soil becomes biologically active each summer over permafrost. The vegetation is slow-growing and low in height.

Arctic tundra, which covers most areas of land in the northern part of the North American continent, is inhabited by caribou and muskoxen. Alpine tundra is restricted to small areas at the highest elevations in the mountains of North America. It is inhabited by sheep and goats, but these species move to lower elevations and use other habitats as well.

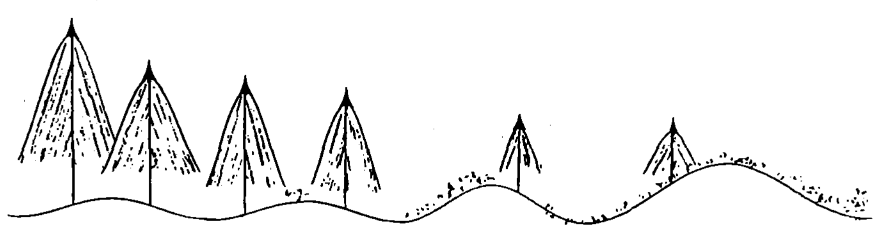
Tundra net primary productivity is very low, with less productivity observed only in desert vegetation. The approximate mean net primary productivity is 140 grams per square meter per year (Lieth 1975:205), with a range from 10 to 400 gms/square meter/year (Whittaker 1975:224). The biomass for tundra and alpine vegetation given by Whittaker (1975:224) is 0.6 kg per square meter as a mean, with a range of 0.1 to 3 kg/square meter. These values are listed in the table on the next page.

All of the tundra vegetation is within reach of foraging wild ruminants; net annual primary productivity equals forage available. Not all of the annual productivity should be consumed, of course, since the plants need reserves in order to remain productive from year to year.

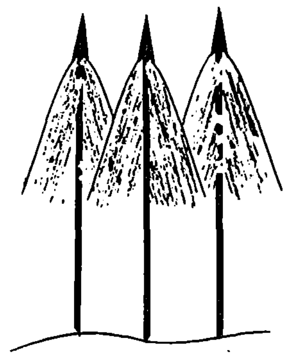
	Net primary productivity ($g/m^2/yr$)		Biomass		Reference
	mean	range	mean	range	
tundra	140				Lieth 1975:205
"		10 - 40	0.6	0.1 - 3.0	Whittaker 1975:224
boreal forest	800	400 - 2000	20	6 - 40	Whittaker 1975:224
temperate evergreen forest	1300	600 - 2500	35	6 - 200	Whittaker 1975:224
temperate deciduous forest	1200	600 - 2500	30	6 - 60	Whittaker 1975:224
woodland	600	200 - 1000	---	2 - 20	Lieth 1975
temperate grassland	600	200 - 1500	1.6	0.2 - 5.0	Whittaker 1975:224
dry desert	0.3	0 - 10			Lieth 1975:205
			0	0	Lieth 1975:207

EVERGREEN FORESTS

Evergreen forests include the taiga, subarctic-subalpine needle-leaved forests and the temperate evergreen forests. Dominant species in the taiga are spruce and fir, and in the temperate evergreen forest, pine. These forests often contain few tree species, with the understory varied depending on land soil and moisture conditions, and the density of the canopy. The taiga merges with the tundra as the trees of the taiga thin out and the tundra vegetation develops between them.

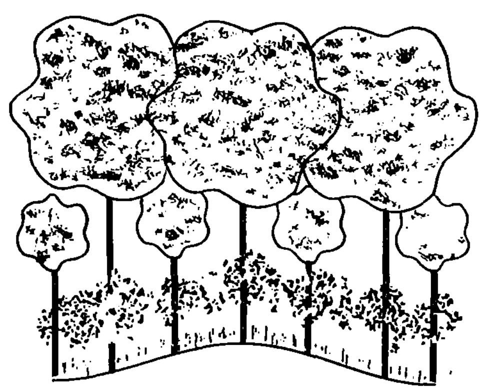


Note in the table on the previous page that both net primary productivity and biomass are larger in the temperate evergreen forest than in the boreal forest. The trees are also taller, spreading the primary productivity and the biomass over a larger vertical dimension. Some of this primary productivity is out reach of the animals (moose, for example) which inhabit these forests, and the canopy also reduces productivity in the forage production zone.



DECIDUOUS FORESTS

The temperate deciduous forest is a vegetation unit characterized by a wide variety of tree species, often organized into 4 distinct layers: a canopy with the crowns of the oldest trees, subcanopy with saplings and trees which mature in the subcanopy, shrub layer, and herb layer. The net primary productivity of such forests is high. Very little of the light that reaches the tree canopy penetrates to the herb layer, especially in the well-established stands containing the species considered characteristic of a mature or climax forest. The herb layer is most active in the spring before the canopy leafs out; an abundance of early-blooming flowers makes the temperate deciduous forest a very beautiful place in the spring.

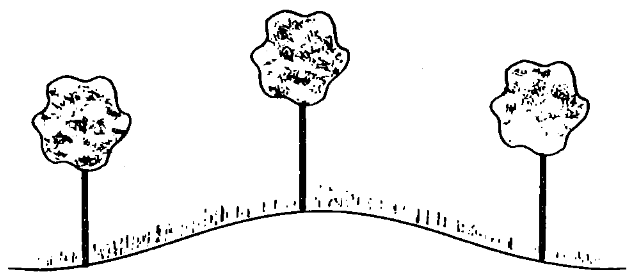


The temperate deciduous forest includes trees that produce seeds and fruits that are often readily consumed by wild ruminants. The abundance of acorns in the fall, for example, may be an important determinant of the condition of deer going into the winter. Much of the primary production in some temperate deciduous forest types is out of reach of wild ruminants, and the shrub and herb layers may be very sparse.

Deciduous forests merge into grassland on both sides of the Great Plains in the midwestern states and prairie provinces, and in other areas of North America. The transition plant community of smaller trees and variable canopy densities is called a woodland.

WOODLANDS

Woodlands are a special type of forest. The canopy may be nearly complete or quite open, with only scattered trees. Woodlands are found in climates too dry for true forests, but not dry enough to give way to grassland, shrublands, and semidesert (Whittaker 1975:139). They may have a very sparse shrub layer. The canopy may be open enough to allow grasses and shrubs to develop on the ground surface. Woodlands are sometimes park-like in their appearance. They may be pastured, and some woodlands may be maintained by prescribed burning. Woodlands mean different things to different people since they are partly a function of man's activities.



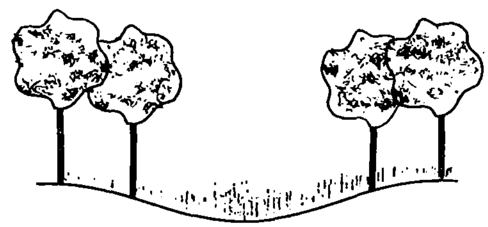
GRASSLANDS, MEADOWS, AND PASTURES

Grasslands are characteristic of dryer areas, without trees and with a sparse shrub layer. The grass and herb layers form the canopy, with a litter layer that builds up if not disturbed by grazing or fire. Overgrazing results in an increase in the shrub components, and fire is often used as a management tool to stimulate the growth of grasses and arrest invasion by shrubs.

The primary productivity of temperate grassland is very high (see the table on page 8), considering the relatively low height of the vegetation. All of the primary productivity is concentrated in a meter or two of vertical height.

Variations in net annual primary productivity of grasslands are marked along a precipitation: evaporation ratio gradient. The most favorable moisture conditions result in tall-grass prairie vegetation, and the least favorable, a short-grass prairie vegetation.

Meadows are openings in forest vegetation which may be due to natural causes, such as mountain meadows, or to clearing by man with little or no secondary successsion occurring due to revegetation by grasses and other herbaceous plants. Meadows may mean different things to different people, depending on experience and associations.



Pastures are grazed and fenced areas that are more or less intensively managed. Pastures may contain only natural vegetation, or they may be planted to selected species. Pastures in some areas include trees, with reduced primary prductivity of the pasture vegetation when it is shaded by an overhead canopy.

DESERTS

Deserts have net annual primary productivity that is very low, limited by a definite lack of moisture. They are productive only after periods of rainfall, with the native desert plants well-adapted to survival during long periods of drought. The morphology of much of the desert vegetation reflects this; plants such as cacti have very low surface areas and thick cuticles, minimizing water loss. These characteristics make the plants rather unattractive to wild ruminants.

Primary production is discussed here in UNIT 1.1 as a prelude to discussions of forage production in UNITS 1.2, 1.3, and 1.4. The next three UNITS call attention to forage production measurements, forage distributions, and forage production at different stages of succession.

LITERATURE CITED

Lieth, H. 1975. Primary production of the major vegetation units of the world. Pages 203-215 In: H. Lieth and R. H. Whittaker, Ed., Primary productivity of the biosphere. Springer-Verlag, NY. 339 pp.

Whittaker, R. H. 1975. Communities and ecosystems. Macmillan Publishing Co., N.Y. 387 pp.

REFERENCES, UNIT 1.1

PRIMARY PRODUCTION IN DIFFERENT PLANT COMMUNITIES

SERIALS

CODEN	VO-NU	BEPA	ENPA	PLCO*	KEY WORDS-----------------	AUTHORS----------	YEAR
ABSZA	30--4	1	44	tund	lichen stands, newfo, rata	ahti,t	1959
ATLPA	4---4	291	305	tund	veget types & plnt biomass	wielgolaski,fe	1972
ATLPA	4---1	307	324	tund	seas cours of abvgrnd prod	tieszen,ll	1972
BPURD	1----	90	94	tund	effect air pollut on liche	schofield,e	1975
BOREA	10---	1	65	tund	conif, lich-biol, econ sig	perez-llano,ga	1944
CAFNA	80--3	119	143	tund	botan inves, subarct, sask	argus,cw	1966
CAFNA	85--1	39	52	tund	lich, forage abund, newfou	bergerud,at	1971
CJBOA	41--8	1199	1202	tund	growth rate, cladonia spec	scotter,gw	1963
ECBOA	10--4	367	392	tund	util lichn, arct, sub-arct	llano,ga	1956
ECMOA	34--3	243	270	tund	env, stand crp, prod, alpn	scott,d; billings	1964
ECOLA	52--6	1058	1064	tund	eff alp plnt communs, wash	douglas,gw; balla	1971
JRMGA	23--1	8	14	tund	ranges nrth of boreal fore	klein,dr	1970
JSABA	42--2	231	263	tund	stan crp, nutr stat, s afr	smith,vr	1976
JSABA	43--2	105	114	tund	veg stand crop, lava flows	smith,vr	1977
NOSCA	48--1	38	51	tund	alpn soil, plnt comm, ovda	lord,tm; luckhurs	1974
PABCA	18---	26	61	tund	vegetation of arctc tundra	britton,me	1957
TBOIA	9....	11	74	tund	growth forag lich, regulat	andreev,vn	1954

CODEN	VO-NU	BEPA	ENPA	PLCO	KEY WORDS-----------------	AUTHORS----------	YEAR
ECMOA	30--1	1	35	frst	phytosoc borea for, gr lak	maycock,pf; curti	1960
ECOLA	42--1	177	180	frst	net prim prod, fore & shrb	whittaker,rh	1961
NZFSA	1....	80	115	frst	cerv, for, scrubl, n fiord	wardle,j; haywar/	1971

frst continued on the next page

*PLCO = plant community

CODEN	VO-NU	BEPA	ENPA	PLCO	KEY WORDS-----------------	AUTHORS----------	YEAR
OIKSA	7---2	202	205	frst	estim avrg produc by trees	ovington,jd; pear	1956
XFNCA	63---	1	55	frst	virgn plant communs, minne	ohmann,lr; ream,r	1971

CODEN	VO-NU	BEPA	ENPA	PLCO	KEY WORDS-----------------	AUTHORS----------	YEAR
ECMOA	22--4	301	330	cofo	forest veg classif, idaho,	daubenmire,r	1952
JWMAA	5---1	90	94	cofo	odvi, mgt sugges, wh-cedar	aldous,se	1941

CODEN	VO-NU	BEPA	ENPA	PLCO	KEY WORDS-----------------	AUTHORS----------	YEAR
ATRLA	17-15	187	202	defo	food supply, decid, poland	bobek,b; weiner,/	1972
OIKSA	32--3	373	379	defo	brows pressure, decid, eur	bobek,b; perzano/	1979

CODEN	VO-NU	BEPA	ENPA	PLCO	KEY WORDS-----------------	AUTHORS----------	YEAR
BOREA	16--6	283	360	gras	ecology of the grassland	hanson,hc	1950
CNAPA	876..	1	11	gras	shortgr prair, albert, sas	smoliak,s; peters	1952
ECMOA	8---1	57	114	gras	char maj grassl types, n d	hanson,hc; whitma	1938
ECMOA	20--4	271	315	gras	ecol, mixed prairie, canad	coupland,rt	1950
ECOLA	29--4	449	460	gras	grassl types, s cent monta	wright,jc; wright	1948
JECOA	49--1	135	167	gras	grassl classif, n gt plain	coupland,rt	1961
JRMGA	5---2	84	89	gras	forage prod, n platte isls	ruby,es	1952
JRMGA	7---6	250	255	gras	doca, rnge fora util, oreg	harris,rw	1954
JWMAA	35--2	238	250	gras	anam, food, rng chars, alb	mitchell,gj; smol	1971
JWMAA	42--3	581	590	gras	bibi, diet, slv rivr, nw t	reynolds,hw; han/	1978
OIKSA	10--1	38	49	gras	prim prod in terres commun	bray,jr; lawrenc/	1959

CODEN	VO-NU	BEPA	ENPA	PLCO	KEY WORDS-----------------	AUTHORS----------	YEAR
AMNAA	97--2	300	320	dsrt	factrs affec seed reserves	nelson,jf; chew,r	1977

dsrt continued on the next page

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JRMGA	20--1	21	25	dsrt	gras, anam, dosh, wyo dese	severson,ke; may,	1967
SWNAA	21--3	311	320	dsrt	standng crop, carb pathwys	syvertsen,jp; ni/	1976

CODEN	VO-NU	BEPA	ENPA	PLCO	KEY WORDS-----------------	AUTHORS----------	YEAR
AMNAA	31--3	697	743	many	range vegetat, texas, odvi	buechner,hk	1944
ECMOA	21--4	317	378	many	gras, marsh communs, alask	hanson,hc	1951
ECMOA	45--4	389	407	many	odvi, desc dynam plnt comm	grigal,df; ohmann	1975
JECOA	45--2	593	599	many	stand crop nat veg, subarc	pearsall,wh; newb	1957
JRMGA	24--5	346	351	many	herb use of plnt comms, bc	mclean,a; lord,l/	1971
OIKSA	7---2	193	201	many	standng crop natural veget	pearsall,wh; gorh	1956
XAGCA	796--	1	27	many	doca, forag util summ rang	pickford,gd; reid	1948

PLCO = plant community

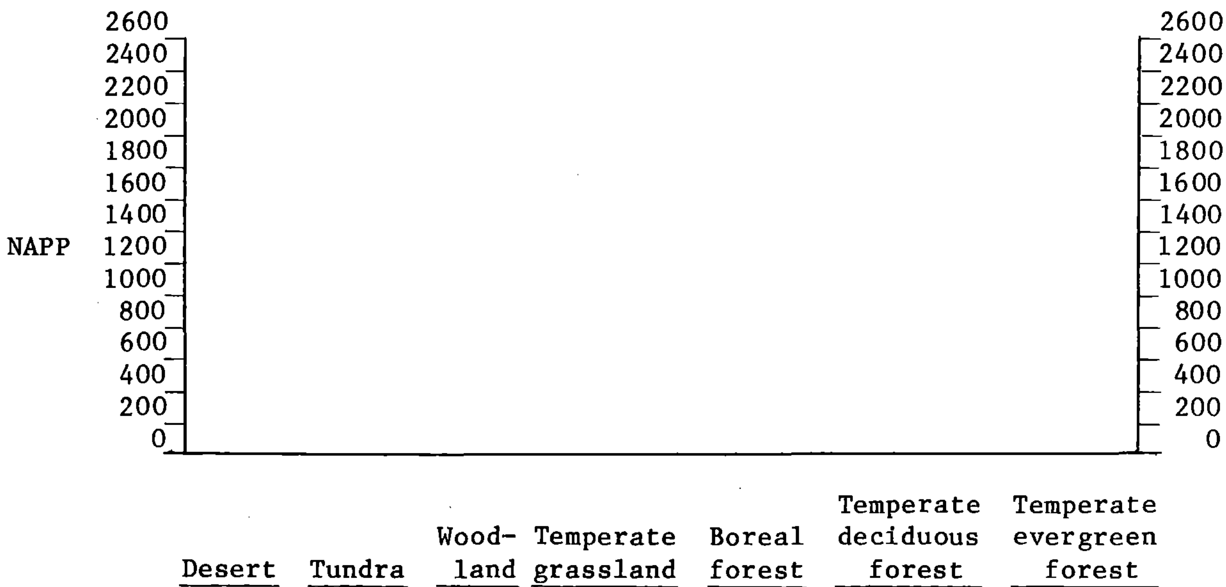
tund = tundra
frst = forest, mixed or unspecified
cofo = coniferous forest
defo = deciduous forest
wdld = woodland
gras = grassland
dsrt = desert
many = more than one community

CHAPTER 13, WORKSHEET 1.1a

Net primary productivities in different vegetation units

Net primary productivity values have been given for several different vegetation types previously in this UNIT. These values will be remembered best by relating them in a way that provides both visual and mental impacts.

Make a bar chart below for the mean and range of net primary productivities in each of the vegetation types, beginning with the lowest and ending with the highest. The values to be plotted are in the table on page 8 of this UNIT. NAPP = net annual productivity in grams/square meter.



The completed bar chart above will provide a visual impression of the quantity of net annual primary productivity. The next WORKSHEET provides an opportunity to visualize the structure of the plant community.

CHAPTER 13, WORKSHEET 1.1b

Visual representations of the vertical structure of plant communities

Each of you have likely had some experience with two or more of the plant communities discussed in this unit. Convert your mental impressions of community structure to drawings in the spaces below, emphasizing the vertical dimension, including overall height and the relative heights of canopies, sub-canopies, shrub layers, and herb layers in each community. HGTM = height in meters.

HGTM

Desert

HGTM

Tundra

HGTM

Woodland

HGTM

Boreal forest

HGTM

Temperate grassland

HGTM

Temperate deciduous forest

HGTM

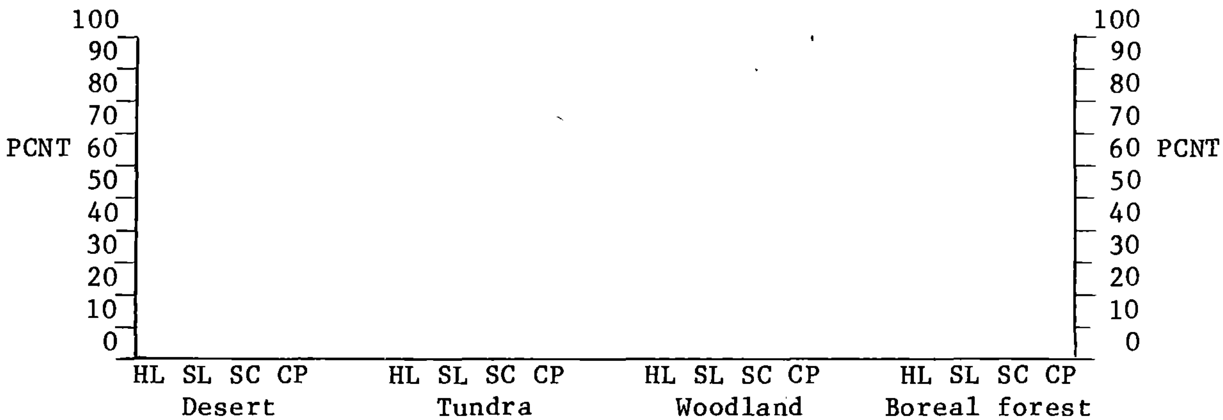
Temperate evergreen forest

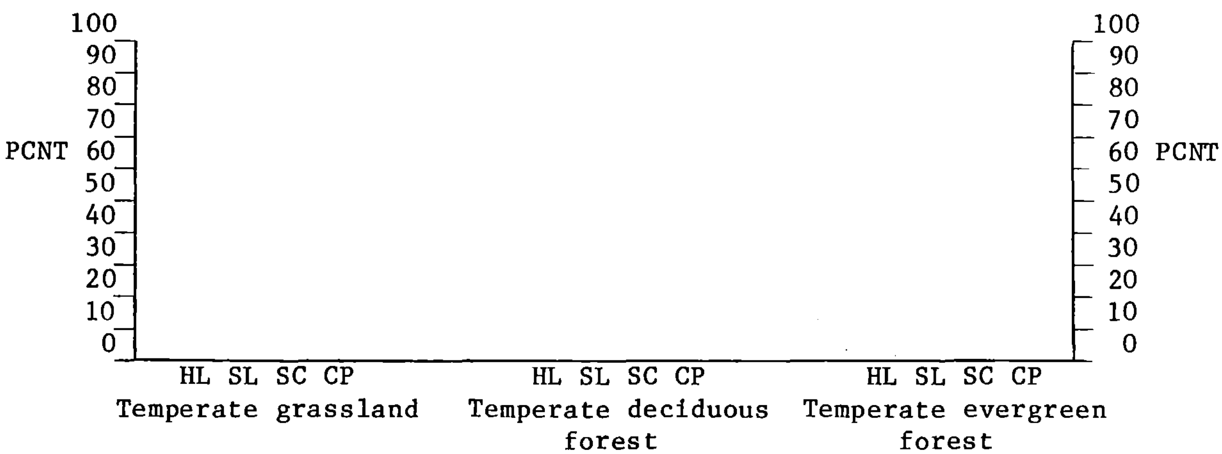
HGTM

CHAPTER 13, WORKSHEET 1.1c

Quantities of primary production in different plant communities

Quantities of primary production in different plant communities were discussed in WORKSHEET 1.1a and the physical structures, i.e. layers, in WORKSHEET 1.1b. Now combine these two into a single drawing, using a bar chart to indicate the relative proportions (PCNT = percent) of the primary productivity found in each of the layers. HL = herb layer, SL = shrub layer, SC = sub-canopy, and CP = canopy.

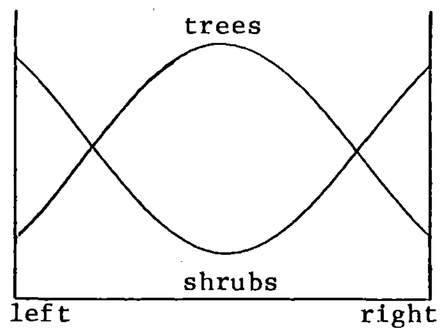




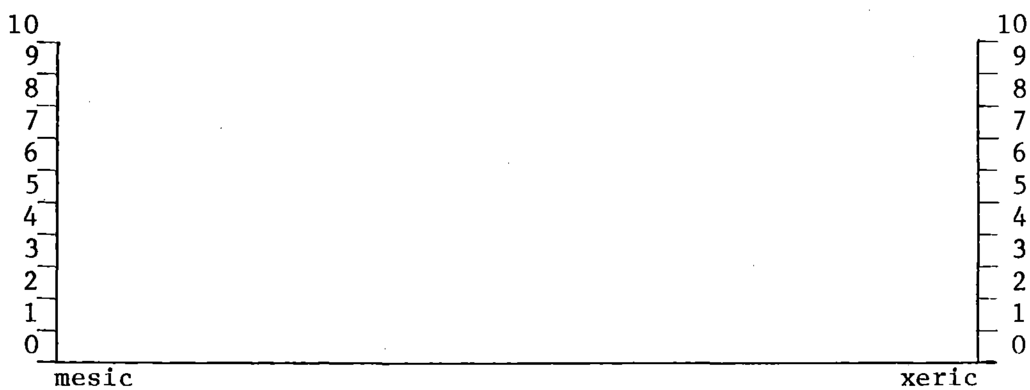
CHAPTER 13, WORKSHEET 1.1d

Primary production in relation to a moisture gradient

Primary production is dependent in part on moisture conditions. Think of the moisture conditions characteristic of each of the plant communities discussed in this UNIT. Now draw the trends in the productivity of each of the strata in relation to a moisture gradient, with the most moist conditions (mesic) on the left and the least (xeric) on the right. After attempting to convert your mental impressions to visual ones, check the drawings in Whittaker and Niering (1975) to see how yours compare. A sample drawing is given to get you started in the kinds of picture being suggested.



Trees increase and then decrease, and shrubs decrease and then increase in relation to left to right.



LITERATURE CITED

Whittaker, R. H. and W. A. Niering. 1975. Vegetation of the Santa Catalina Mountains, Arizona. Biomass, production, and diversity along the elevation gradient. Ecology 56(4):771-790.

UNIT 1.2: FORAGE PRODUCTION MEASUREMENTS

The amount of forage produced is a fundamental calculation in the animal requirement: range supply relationship that underlies the concept of carrying capacity. Measurements of forage production are difficult and time-consuming. They are difficult because of problems in sampling and because of very complex (from a statistical point of view) plant population structures. They are time-consuming because the removal of new growth from each plant simply cannot be done quickly. Since wild ruminants forage selectively, clipping of the forage must also be done selectively, if it is to represent the forage of interest to wild ruminants.

Clipping forage is ususlly done on sample plots with areas equal to some convenient proportion to an acre (43560 square feet) or hectare (10000 square meters). Radii and sides of circular and square plots with different areas are tabulated below. A circular plot with a radius of 11.8 feet has an area of 1/100th acre, and if r = 3.6 feet, A = 1/1000th acre. In hectares, a circular plot with a radius of 5.64 meters has an area of 1/100th hectare, if r = 1.78 meters, A = 1/1000th hectare, and if r = 0.56 meters, A = 1/10000th hectare.

one acre = 43560 square feet:

r = 11.8 feet, A = 1/100th acre
s = 20.9 feet, A = 1/100th acre

r = 3.6 feet, A = 1/1000th acre
s = 6.6 feet, A = 1/1000th acre

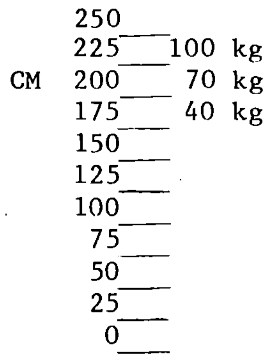
one hectare = 10000 square meters:

r = 5.64 meters, A = 1/100th hectare
s = 10.00 meters, A = 1/100th hectare

r = 1.78 meters, A = 1/1000th hectare
s = 3.16 meters, A = 1/1000th hectare

r = 0.56 meters, A = 1/10000th hectare
s = 1.00 meters, A = 1/10000th hectare

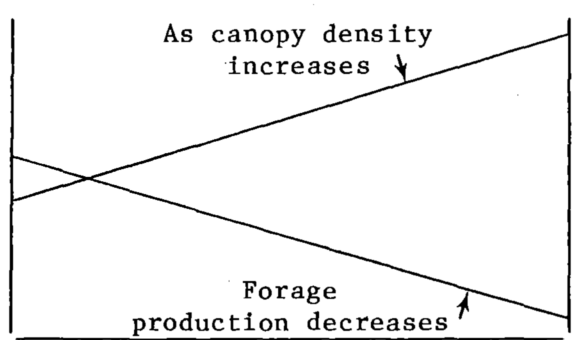
Forage production should also be measured vertically so the distribution of the forage in the foraging space may be evaluated in relation to the heights reached by different species, ages, and sexes of wild ruminants and to the effects of snow accumulation on the forage supply. The vertical distribution of forage production is determined by measuring production at 12-inch or 25-centimeter intervals up to the heights reached by different species of animals.



Heights reached by white-tailed deer of different weights are indicated on the scale on the left. If snow crusts support the deer, then the height of the crust is added to the height reached.

The amount of forage produced is very much dependent on the canopy characteristics of each plant community. Grasslands and tundra have no canopy above the foraging space of wild ruminants; forage production is equal to primary production. In forest communities, overhead canopy characteristics become very important determinants of the amount of forage produced in the foraging space of wild ruminants as dense canopies filter out sunlight necessary for photosynthesis in the shrub and herb layer. Under some canopies, such as a dense evergreen forest canopy, shrub and herb layers are practically non-existent. A dense deciduous canopy also limits forage production in the understory. Sugar maple stands, for example, have very dense canopies and forage production in the understory is very low, consisting primarily of sugar maple seedlings.

The patterns of forage production in relation to canopy characteristics that may be observed suggest that forage production is predictable from canopy characteristics. The relationship may be illustrated with the two lines below.



The relationship is not this simple in natural habitats, of course, but it is generally true in wild ruminant habitat on the North American continent. The lines representing this relationship should probably not be straight; data in the literature may be plotted in WORKSHEET 1.2a and the shapes of the lines determined.

Canopy characteristics are very much related to the stage in succession, with species composition, canopy density, and canopy depth all important determinants of forage production. Succession effects are discussed in UNIT 1.4, where the basic relationships between plant community characteristics and forage production are discussed further, especially in relation to forest type data.

REFERENCES, UNIT 1.2

FORAGE PRODUCTION MEASUREMENTS

SERIALS

CODEN	VO-NU	BEPA	ENPA	FRGE*	KEY WORDS-----------------	AUTHORS----------	YEAR
CAFGA	34--4	189	207	frge	od range surv methods, mgt	dasmann,wp	1948
CAFGA	37--1	43	52	frge	deer range survey methods	dasmann,wp	1951
CAFGA	40--3	215	234	frge	odhe-fora reln lassen-wash	dasmann,w; blaisd	1954
JWMAA	3---4	295	306	frge	yellowst wint rnge studies	grimm,rl	1939
NAWTA	6----	118	126	frge	fora inventory meths, biga	schwan,he; swift,	1941

CODEN	VO-NU	BEPA	ENPA	FRGE	KEY WORDS-----------------	AUTHORS----------	YEAR
ATRLA	17-14	171	186	brws	meth brows est, dif forest	bobek,b; dzieciol	1972
ECOLA	51--6	1098	1101	brws	canop area & vol reln prod	peek,jm	1970
JOMAA	25--2	130	136	brws	a deer brwse survey method	aldous,se	1944
JRMGA	14--5	274	278	brws	whitesage productn, growth	kinsinger,fe; str	1961
JRMGA	18--4	220	222	brws	est brows, twig, stem meas	schuster,jl	1965
JRMGA	19--1	34	38	brws	twig diam-length-weight re	basile,jv; hutchi	1966
JWMAA	2---2	131	134	brws	carry capac big game range	young,va	1938
JWMAA	19--2	215	225	brws	ungu winter browse, idaho	hoskins,lw; dalke	1955
JWMAA	27--3	428	437	brws	twig-count meth meas brows	shafer,el,jr	1963
JWMAA	33--2	399	403	brws	optim plot samp, est brows	barrett,jp; guthr	1969
JWMAA	33--4	917	921	brws	twig wt-diam relat brws sp	telfer,es	1969
JWMAA	34--2	456	460	brws	lgth-, wt-dia rel, serv-be	lyon,lj	1970
JWMAA	35--3	501	507	brws	var twig diam-wt rel, minn	peek,jm; kreftin/	1971
PCGFA	21---	57	62	brws	grwth & forag quali, 4 spp	blair,rm; halls,l	1967
VILTA	9---3	45	192	brws	wiru, win habita, land use	ahlen,i	1975
XAFNB	66---	1	4	brws	prod, rapid sampl, computr	stearns,rw; schw/	1968
XANEA	33---	1	37	brws	odvi browsng hrdwd, northe	shafer,el,jr	1965
XANEA	100--	1	25	brws	design, anal studies brows	shafer,el,jr; lis	1968

CODEN	VO-NU	BEPA	ENPA	FRGE	KEY WORDS-----------------	AUTHORS----------	YEAR
XFNSA	23---	1	5	twig	seas twg grwth so brws spp	hall,lk; alcaniz,	1965

*FRGE = forage type

CODEN	VO-NU	BEPA	ENPA	FRGE	KEY WORDS-----------------	AUTHORS----------	YEAR
AGJOA	41--2	63	65	hrbg	tech est prod, rnge, pastu	frischknecht,nc;/	1949
AGJOA	50--9	504	506	hrbg	plnt ht x cover estim prod	evans,ra; jones,m	1958
JDSCA	28--3	171	185	hrbg	samplng proced, pastur yld	nevens,wb	1945
JRMGA	2---1	30	32	hrbg	determ forag weight, south	cambell,rs; cassa	1949
JRMGA	4---4	270	278	hrbg	aer phot, sub-sam, rng inv	harris,rw	1951

CODEN	VO-NU	BEPA	ENPA	FRGE	KEY WORDS-----------------	AUTHORS----------	YEAR
UTSCB	29--1	3	6	forb	anam, seas forage use, uta	beale,dm; scotter	1968

CODEN	VO-NU	BEPA	ENPA	FRGE	KEY WORDS-----------------	AUTHORS----------	YEAR
ATICA	21--4	255	259	lich	growth rate lichen, alaska	pegau,re	1968

CODEN	VO-NU	BEPA	ENPA	FRGE	KEY WORDS-----------------	AUTHORS----------	YEAR
FOSCA	2....	314	320		spherical densiometer, est	lemon,pe	1956
FPWTA	25...	5	16		study woodl cari rang, ont	ahti,t; hepburn,r	1961
NOSCA	33--1	43	64		canopy-cov meth, veg analy	daubenmire,r	1959

FRGE = forage type

frge = mixed or unspecified forage types
brws = browse
twig = twigs
hrbg = herbage or herbaceous vegetation
forb = forbs
lich = lichens

UNIT 1.3: SPATIAL DISTRIBUTION OF FORAGE PRODUCED

Spatial distributions of forage produced involves three dimensions, including x and y for the horizontal plane and z for the vertical dimension. Distribution over land areas (the horizontal plane) have been studied in many places with both direct and indirect measurements. Forage production values, expressed as pounds per acre or kg per hectare, are available for given areas, usually with reference to the kind of vegetation. Vertical distributions of forage production are almost entirely unknown; measurements of this important characteristic of the range simply have not been made. Measurements on vertical strata make collections more time-consuming, but the effort should be made for different plant communities so the different possible shapes of vertical profiles could be identified. Vertical profiles are important because animals of different species, ages, and sexes can reach to different heights, and snow covers up forage, making less available to animals in the winter. In fact, large amounts of forage may be concentrated in seedlings near the ground surface, and a covering of snow could make a considerable part of that forage supply unavailable. This is an important consideration in the winter when nutritional stress may be great, especially for the younger and smaller animals who not only cannot reach as high for forage as larger animals, but also have greater difficulty in moving through snow.

A major factor affecting the amount of forage produced that is within reach of the wild ruminant is the density of the canopy. Dense forest canopies intercept a high fraction of the sunlight, allowing little to reach the shrub layer. Deer browse production under a dense forest canopy is less than 25 pounds per acre per year (Severinghaus 1973), which is less than 3 gms per square meter, a very small quantity indeed! This amount of forage produced is especially small when compared to primary production, which may be several hundred gms/square meter, nearly all of it in the canopy. Forage production may reach a thousand pounds or more, with the largest production in those areas with the best growing conditions, i.e. good soil, adequate water, and temperature and light conditions that promote high levels of photosynthesis.

A significant conclusion was reached by Telfer (1972) who compared measured forage yield in New Brunswick and Nova Scotia with values reported in other studies. From the highlight (page 446):

> "Forage yields per acre were comparable to values reported from many studies in western North America, but plant composition differed."

This conclusion is significant because it suggests that the same kind of plant community structure results in similar values of forage production. The species in the plant communities are not as important as the forest type, which means that forest type data, which is readily available for many forested areas, may be used to estimate expected forage production. If this is possible and the vertical distribution patterns of forage in different forest types are known, then the amount of forage in all three dimensions of the foraging space can be estimated and used in relation to changing range conditions and population characteristics.

It is important to point out here that the general patterns are most important as the effects of differences and changes are evaluated in relation to the ruminant populations. Once these patterns have been recognized and the mechanisms for evaluating differences and changes determined, then local conditions can be measured and evaluated since the procedures for evaluating the relationships will not change, only the numbers will.

VERTICAL DISTRIBUTIONS

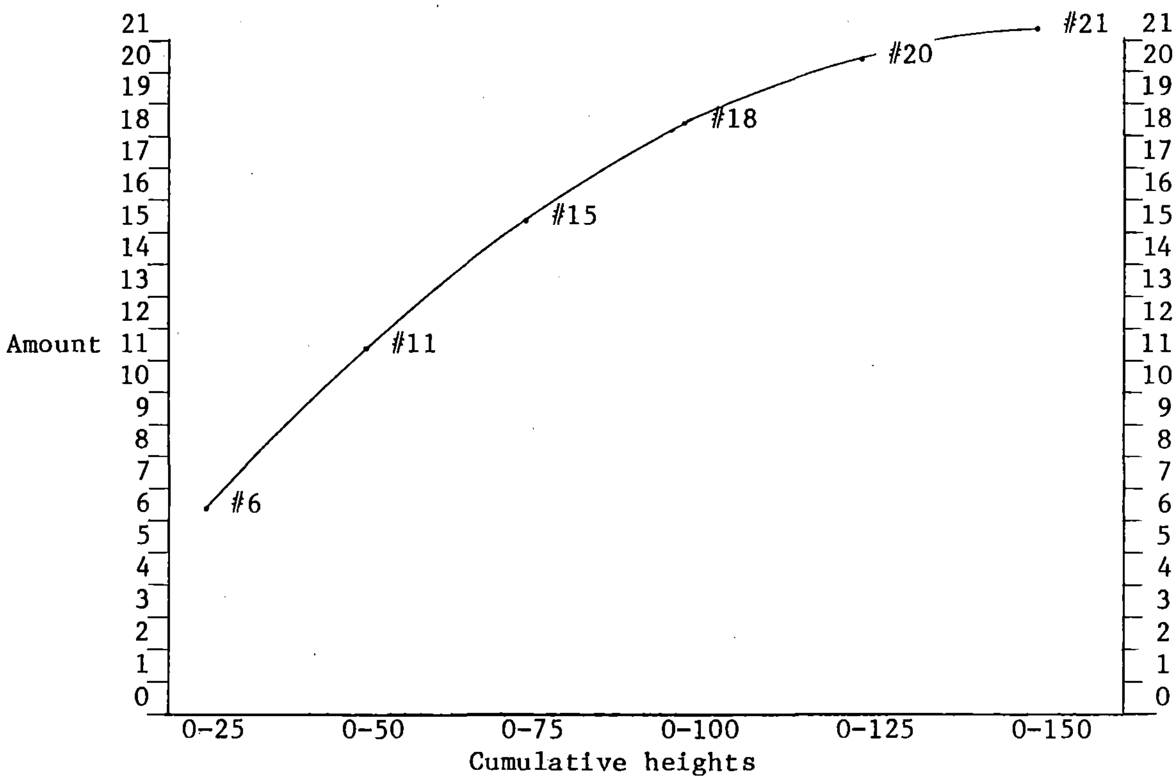
The vertical distribution of forage production, a characteristic of the habitat that has been given practically no attention, may be described quantitatively in two different ways. The illustration below shows the amounts present (X = one unit) at each height interval, representing the results measured in each stratum. This vertical distribution shows the largest quantity in the lowest height interval and the smallest in the highest height interval.

Amount	0-25	25-50	50-75	75-100	100-125	125-150
6	X					
5	X	X				
4	X	X	X			
3	X	X	X	X		
2	X	X	X	X	X	
1	X	X	X	X	X	X
0	X	X	X	X	X	X

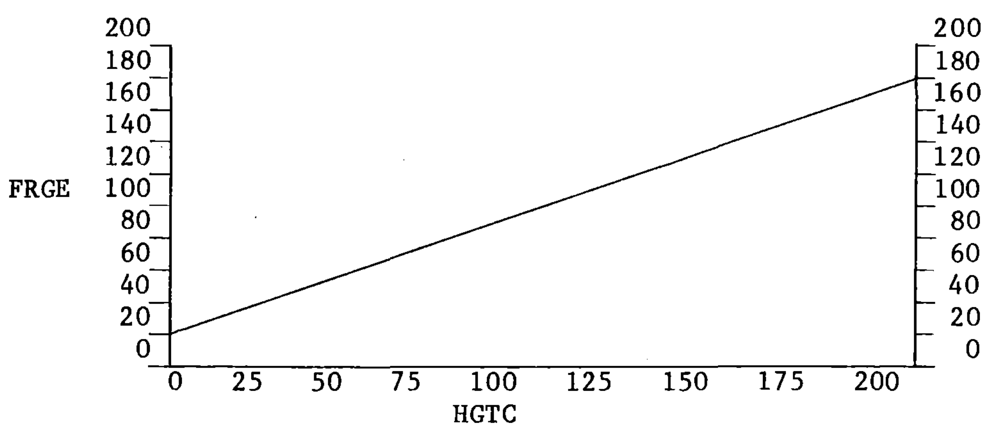
Height intervals

The above chart illustrates the amount present (X = one unit) in each interval, but it does not illustrate how much is present in the total foraging space.

The drawing on the next page represents the cumulative amount from the first height interval of 0-25 through the cumulative height of 0-150 cm. The amount up to any height is clearly indicated in the line drawing.



Cumulative amounts of forage in relation to cumulative heights may be expressed with equations and used to estimate not only the amount of forage up to any height, but also the amount between height intervals. The drawing below illustrates these calculations.



The equation for the line drawn above is:

$$FRGE = 20 + 0.8\ HGTC,$$

where FRGE = kg/hectare and
HGTC = height in cm.

The amount of forage available to an animal that can reach 180 cm is 20 + 0.8 (180) = 164 kg/hectare. Suppose that snow covered the lower 50 cm of vegetation. The amount of forage available to this animal may be calculated by determining the forage available up to the height reached and subtracting the amount covered by snow. Thus:

$$[20 + 0.8\ (180)] - [20 + 0.8\ (50)] = 104 \text{ kg/hectare.}$$

These illustrations show how vertical distributions can be used and why they can be important. Actual distributions of forage may make considerable difference to animals of different sizes, especially in winter when nutritional stress may be severe. Some actual measurements are included in WORKSHEETS, and additional evaluations of the effects of vertical distributions are made in CHAPTERS 17 and 20.

LITERATURE CITED

Severinghaus, C. W. 1973. A modest proposal to improve deer habitat. The Conservationist 27(6):37.

Telfer, E. S. 1972. Forage yield in two forest zones of New Brunswick and Nova Scotia. J. Range Manage. 25(6):446-449.

REFERENCES, UNIT 1.3

SPATIAL DISTRIBUTION OF FORAGE PRODUCED

SERIALS

CODEN	VO-NU	BEPA	ENPA	FRGE*KEY WORDS-----------------	AUTHORS----------	YEAR
JFUSA	65-11	807	813	frge forest cover and logging	young,ja; hedric/	1967
JRMGA	25--6	446	449	frge yld, 2 for zon, n b, nov s	telfer,es	1972
PSAFA	1962-	165	167	frge timb ovrstry detrm od fora	schuster,jl; hall	1962
RWLBA	9---1	1	146	frge edge eff, lesser veg, adir	barick,fb	1950
XFPNA	112--	1	12	frge seas forag use, elk & deer	edgerton,pj; smit	1971
XFWWA	43...	1	48	frge rata st matthw islan range	klein,dr	1959
ZHIVA	11...	62	68	frge rata fodder supply, zhivot	ustinov,vi; pokro	1954

*FRGE = forage type

CODEN	VO-NU	BEPA	ENPA	FRGE	KEY WORDS-----------------	AUTHORS----------	YEAR
CNSVA	27--6	37	37	brws	propos to imprv od habitat	severinghaus,cw	1973
JWMAA	5---1	90	94	brws	mgt sugges for wh-cedr typ	aldous,se	1941
JWMAA	23--3	273	278	brws	odvi win rng veg stud, wis	habeck,jr	1959
JWMAA	35--3	533	537	brws	wldlf food, hrdwd, reg cut	crawford,hs,jr; /	1971
JWMAA	40--2	326	329	brws	odvi brwse inventor, louis	pearson,ha; stern	1976
MXSBA	294--	1	43	brws	isl roy forst, wldlf, fire	hansen,hl· kreft/	1973
NAWTA	18---	581	596	brws	od yard carry cap, browsng	davenport,la; sw/	1953
NFGJA	14--2	193	198	brws	witchhob, site exp, brwsng	bailey,ja	1967
PCGFA	9----	134	156	brws	brow cens, 100 % clip meth	harlow,rf	1955
VILTA	9---3	45	192	brws	wiru, win habita, land use	ahlen,i	1975
WLSBA	6---4	259	260	brws	age, densi, fert, oak prod	wolgast,lj	1978
XFNSA	140--	1	4	brws	odvi browse resourc, arkan	segelquist,ca; p/	1972
XFSEA	2----	1	20	brws	od browse resourc, n georg	ripley,th; mcclur	1963

CODEN	VO-NU	BEPA	ENPA	FRGE	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	32--1	185	186	twig	brows yield, forst opening	halls,lk; alcaniz	1968

CODEN	VO-NU	BEPA	ENPA	FRGE	KEY WORDS-----------------	AUTHORS----------	YEAR
ECOLA	27--3	195	204	hrbg	graz val natv veg, so pine	campbell,rs	1946
ECOLA	35--1	59	62	hrbg	for prod, longlf pne, alab	gaines,em; campb/	1954
JECOA	45--2	593	599	hrbg	stand crop nat veg, subarc	pearsall,wh; newb	1957
JFUSA	63--4	282	283	hrbg	tree - herbage relations	hall,lk; schuster	1965
JRMGA	5---2	76	80	hrbg	herb, ungu, wint-rang util	buechner,hk	1952
JRMGA	26--6	423	426	hrbg	s pine overstory infl herb	wolters,gl	1973
PSAFA	1957-	156	158	hrbg	undrstory veg, stand chars	pase,cp; hurd,rm	1957

CODEN	VO-NU	BEPA	ENPA	FRGE	KEY WORDS-----------------	AUTHORS----------	YEAR
ECOLA	50--5	802	804	leav	foliage profile, vert meas	macarthur,rh; hor	1969

CODEN	VO-NU	BEPA	ENPA	FRGE	KEY WORDS-----------------	AUTHORS----------	YEAR
JFUSA	48--2	118	126	gras	chng pond pne bnchgras rng	arnold,jf	1950

CODEN	VO-NU	BEPA	ENPA	FRGE	KEY WORDS-----------------	AUTHORS----------	YEAR
ASZBA	16--2	155	161	lich	prod arboreal lichns, rata	scotter,gw	1961

CODEN	VO-NU	BEPA	ENPA	FRGE	KEY WORDS-----------------	AUTHORS----------	YEAR
ECMOA	35...	259	284		ecolog, deer range, alaska	klein,dr	1965
JFUSA	46--6	416	425		util summ range plnts, uta	cook,cj; cook,cw/	1948
JWMAA	32--2	330	337		odvi food ylds, 4 for typs	segelquist,ca; gr	1968
JWMAA	42--4	799	810		ceel diet, actv, ldgpl pne	collins,wb; urne/	1978
WMBAA	18---	1	111		effs wldfre rata wint rnge	scotter,gw	1964

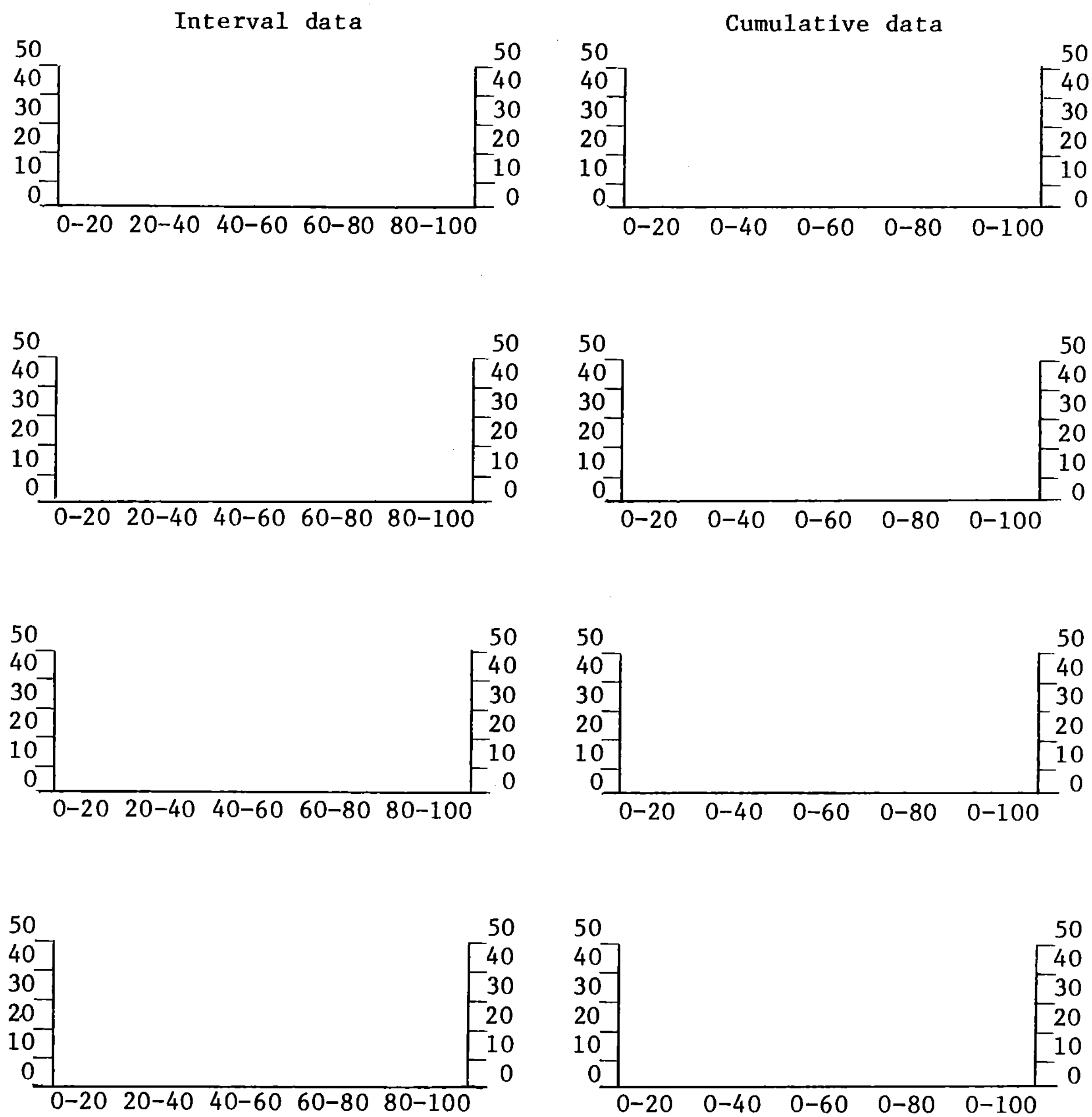
FRGE = forage type

frge = mixed or unspecified forage types
brws = browse
twig = twigs
hrbg = herbage or herbaceous vegetation
leav = leaves
gras = grasses
lich = lichens

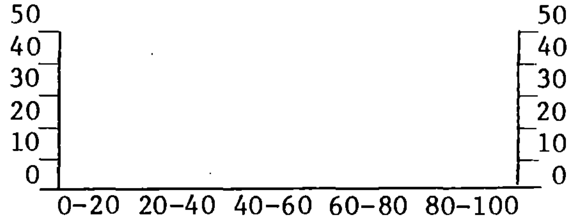
CHAPTER 13, WORKSHEET 1.3a

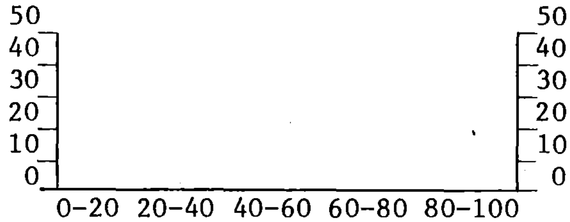
Vertical distributions of forage

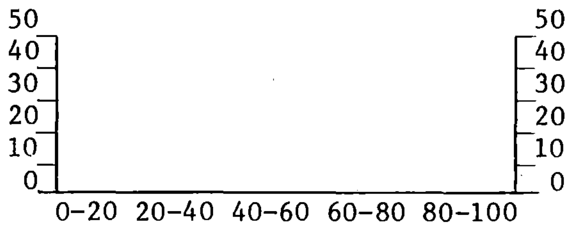
Draw possible vertical distributions of forage in different plant communities in the spaces below and on the next page, putting the interval data on the left and cumulative data on the right. Make up different patterns of interval data based on different plant community structures discussed in UNIT 1.1. See how different interval distributions affect the cumulative distributions.

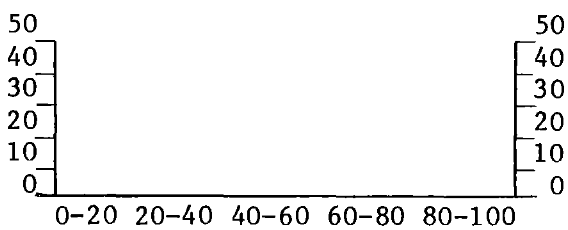


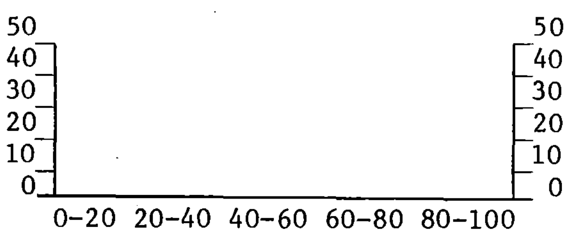
Interval data



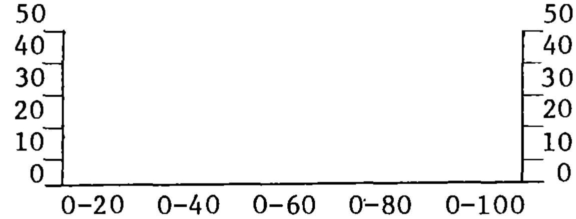


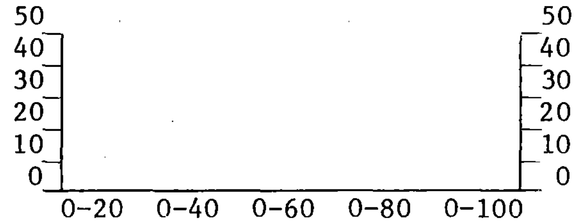


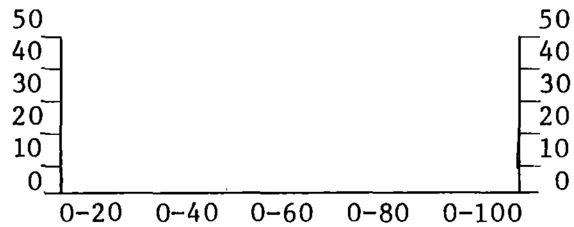


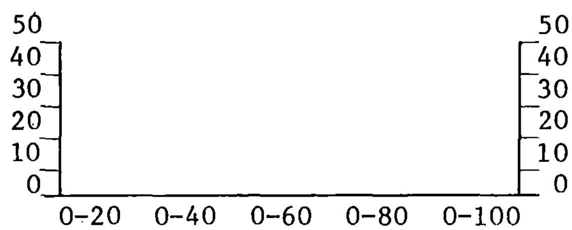


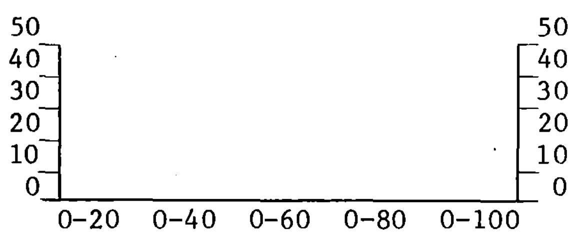
Cumulative data











CHAPTER 13, WORKSHEET 1.3b

Measured vertical distributions of forage

Measurements of forage production at 25 cm vertical intervals in three deciduous stands near Ithaca, New York show differences in forage production between stands but similar patterns of distribution of the forage in these stands. The cumulative sums of forage quantities are close to straight lines, so linear regression equations may be used to calculate the weights of forage up to any height.

Stand descriptions and equations are, where WFKH = weight of forage in kg/hectare and HGTC = height in centimeters:

McGowan's Woods; 70 year-old mixed hardwood stand:

$$WFKH = 2.2926 + 0.03942\ HGTC; \quad R^2 = 0.995$$

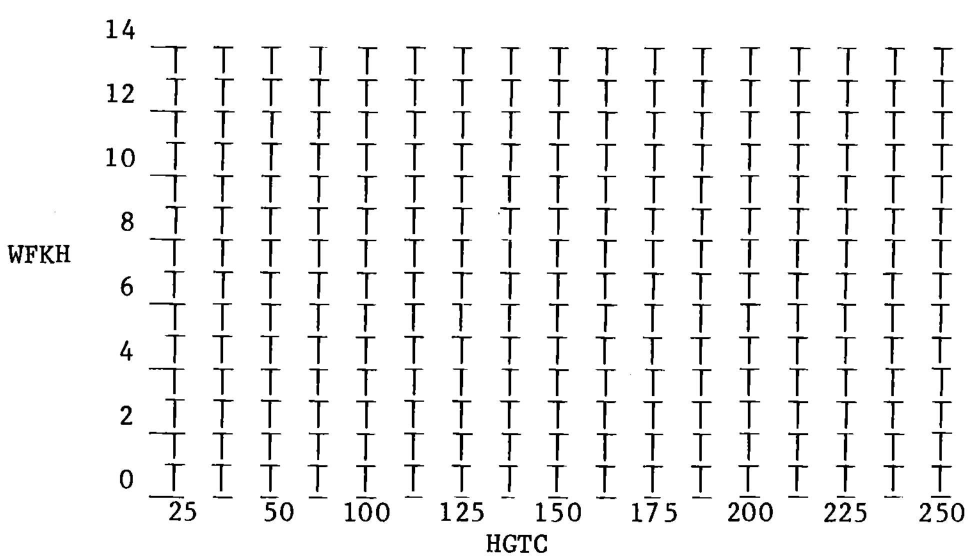
Turkey Hill; 55 year-old mixed hardwood stand, primarily oak and maple:

$$WFKH = 5.0174 + 0.03499\ HGTC; \quad R^2 = 0.942$$

Arnot Forest; 35 year-old sugar maple stand:

$$WFKH = 0.69147 + 0.00679\ HGTC; \quad R^2 = 0.0946$$

Plot and label the lines on the grid below. Note that the sugar maple stand, which had a dense canopy, had much less forage than did the two mixed hardwood stands.

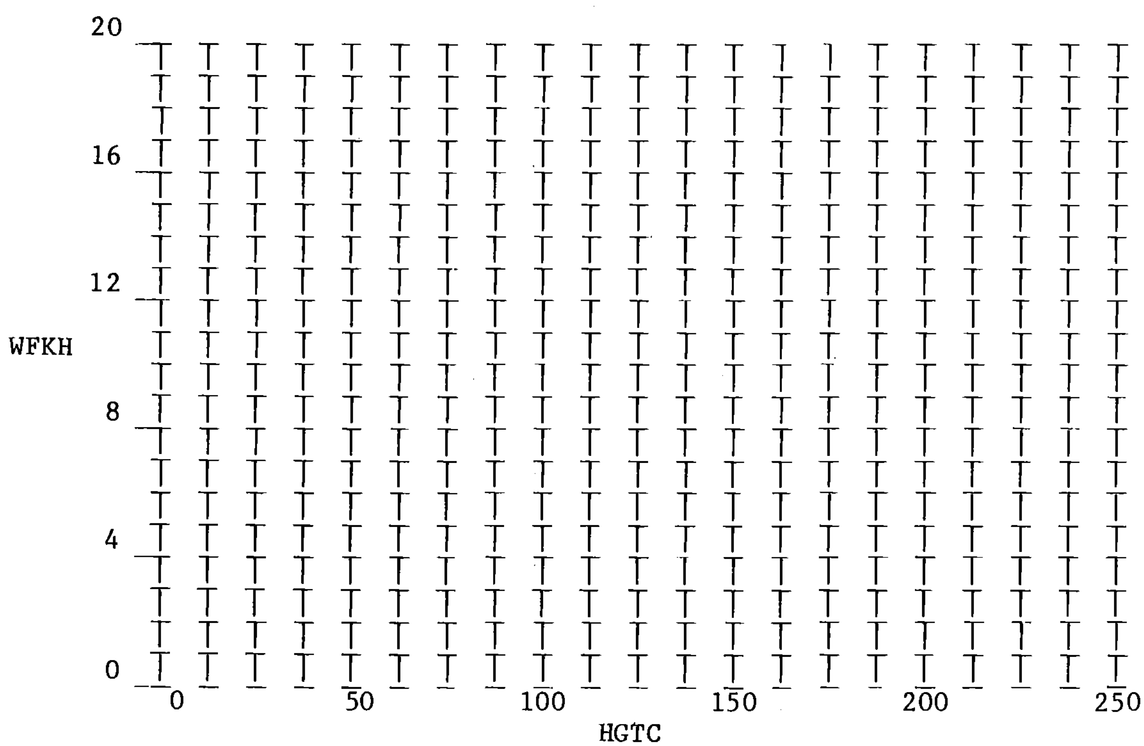


Equations for predicting vertical distributions of forage production

The array of equations below illustrates the effects of different values of a and b on the distribution of forage. Higher values of a indicate greater quantities of forage in the first 25 cm, and higher b values indicate greater quantities per unit height.

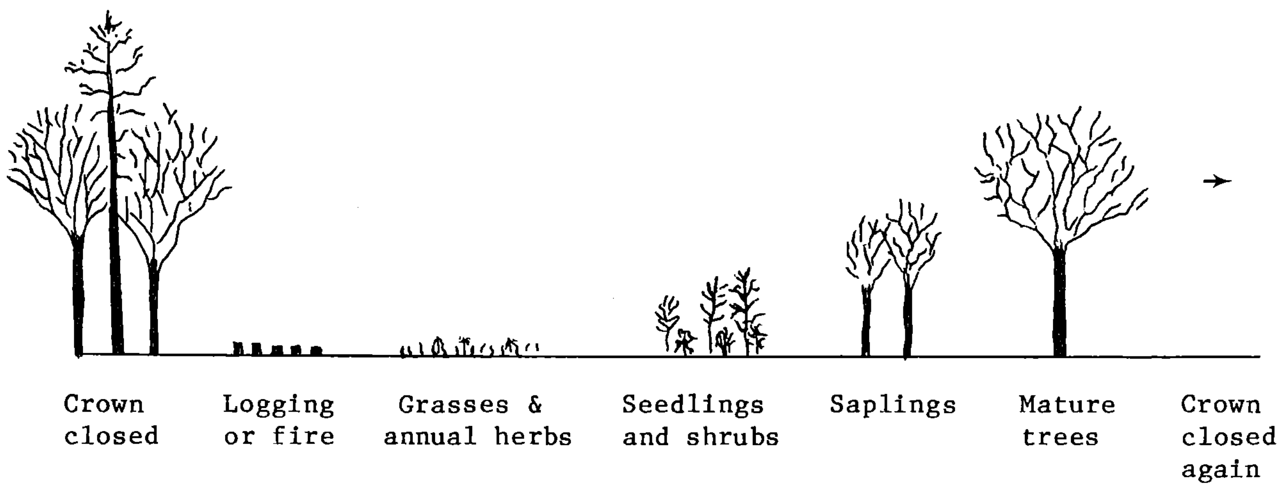
The different distributions may be used to illustrate the effects of snow depths on forage resources available.

Equation number	
1.	WFKH = 7.78 + (0.048) HGTC
2.	WFKH = 6.00 + (0.040) HGTC
3.	WFKH = 4.22 + (0.031) HGTC
4.	WFKH = 2.22 + (0.031) HGTC
5.	WFKH = 0.22 + (0.031) HGTC
6.	WFKH = 4.89 + (0.004) HGTC
7.	WFKH = 2.89 + (0.004) HGTC
8.	WFKH = 0.89 + (0.004) HGTC

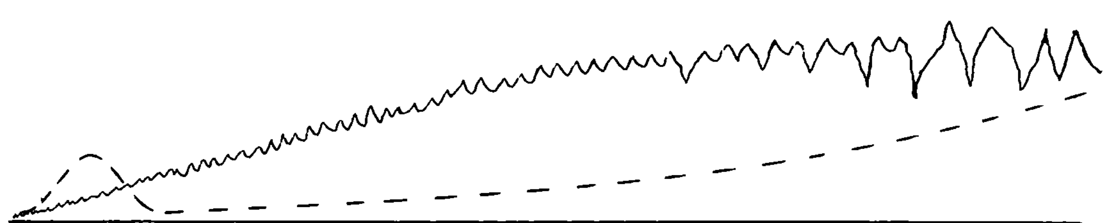


UNIT 1.4: FORAGE PRODUCTION AT DIFFERENT STAGES OF SUCCESSION

The stage in succession is a very important determinant of the amount of forage produced. Early stages in succession may result in 400 pounds of browse per acre (Severinghaus 1974), and over 1000 pounds of browse and other forage have been measured in recent field work at Cornell's Wildlife Ecology Laboratory. More mature stages are characterized by dense canopies and little forage production in the understory; less than 25 lbs of deer browse per acre will be produced under a closed canopy. Logging and fire open the canopy, allowing light to reach the forest floor and stimulate new growth, resulting in increased amounts of forage production in the early stages of secondary succession. As succession continues, the canopy closes and forage production is reduced again. This predictable sequence is illustrated in the sketch below.



If secondary succession proceeds without logging or fire to a point where the climax forest contains overmature trees that are subject to blowdown, decline in vigor, and eventual death, then the later stages in succession will show a rise in forage production. Wallmo and Schoen (1980) illustrate this for the temperate coniferous rain forest in Southeast Alaska. There, fire is uncommon and logging has resulted in an array of even-aged stands of various ages. Overmature stands are also present. These conditions result in openings in the canopy and a rise in the forage production curve to the right of the one sketched above from Severinghaus. Over a longer time scale, the forage production pattern looks like this:



Overmature stands are not abundant in many areas of North America. Short cutting rotations for pulpwood and firewood, for example, remove trees early in secondary succession. In wilderness areas and other lands where logging is prohibited, the potential for overmature and more open canopies late in succession exists. Such areas should be left subject to fires at natural time intervals.

The forage production patterns illustrated by both Severinghaus (1974) and Wallmo and Schoen (1980) are predictable enough to use when making estimates of forage production in relation to forest type. Using the basic pattern in relation to the stage in succession and making some adjustments in absolute quantities in relation to growing conditions and perhaps species composition, forage production estimates may be made and related to forage consumption discussed in CHAPTER 12. Forage consumption by individuals is dependent on their size, reproductive rate, and ecological metabolism (CHAPTERS 1, 18, and 7, respectively) and forage consumption by the population is dependent on the metabolic structure of the population (CHAPTER 19). Thus the basic parameters in the energetic framework of animal-range relationships have been identified and represented by equations so quantitative evaluation may be completed.

LITERATURE CITED

Severinghaus, C. W. 1974. Return of the deer. The Conservationist 29(1):39-480.

Wallmo, O. C. and J. W. Schoen. 1980. Response of deer to secondary forest succession in Southeast Alaska. Forest Sci. 26(3):448-462.

REFERENCES, UNIT 1.4

FORAGE PRODUCTION AT DIFFERENT STAGES OF SUCCESSION

SERIALS

CODEN	VO-NU	BEPA	ENPA	FRGE*	KEY WORDS------------------	AUTHORS----------	YEAR
CNSVA	29--1	39	48	frge	return of the deer	severinghaus,cw	1974
FOSCA	26--3	448	462	frge	resp deer sec succ, alaska	wallmo,oc; schoen	1980

CODEN	VO-NU	BEPA	ENPA	FRGE	KEY WORDS------------------	AUTHORS----------	YEAR
CNRDA	28--5	249	271	brws	alal, successn, quan, nutr	cowan,im; hoar,w/	1950

brws continued on the next page

*FRGE = forage type

CODEN	VO-NU	BEPA	ENPA	FRGE	KEY WORDS-----------------	AUTHORS----------	YEAR
JFUSA	48-10	675	678	brws	deer in reln plnt successn	leopold,as	1950
JFUSA	56--6	416	421	brws	od brws prod fr felled tre	stoeckeler,jh; k/	1958
NAWTA	15---	571	578	brws	deer in reln plnt successn	leopold,as	1950

CODEN	VO-NU	BEPA	ENPA	FRGE	KEY WORDS-----------------	AUTHORS----------	YEAR
ECOLA	41--1	34	49	gras	orgnc produc, old fld succ	odum,ep	1960

CODEN	VO-NU	BEPA	ENPA	FRGE	KEY WORDS-----------------	AUTHORS----------	YEAR
ECMOA	24--4	349	376		ecol successi abandon farm	beckwith,sl	1954
FRCRA	29--3	218	232		survey, conif fores, rocki	cormack,rgh	1953
WMBAA	18---	1	111		effs wldfre rata wint rnge	scotter,gw	1964

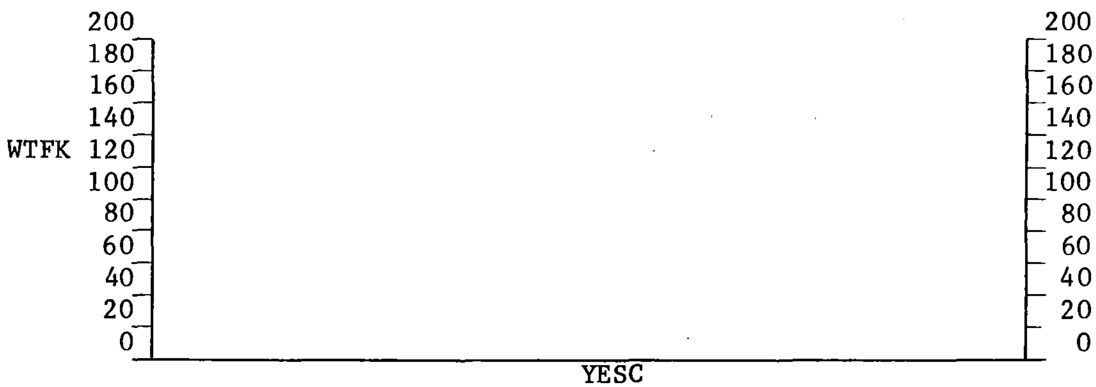
FRGE = forage type

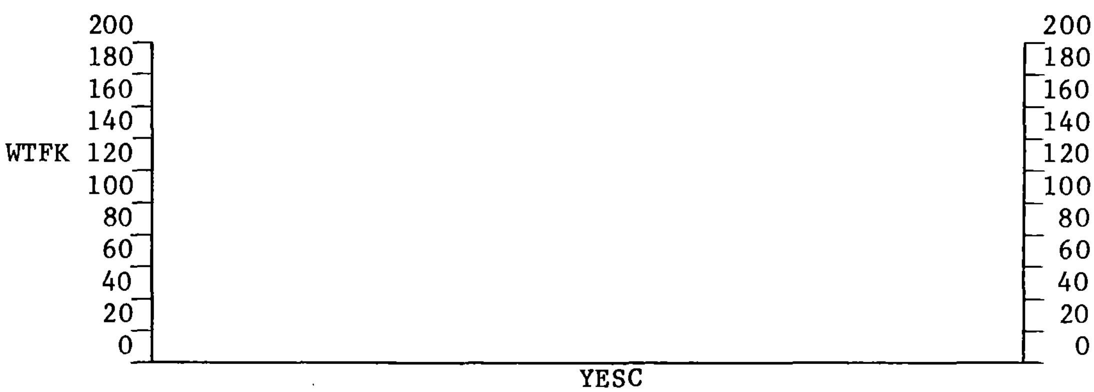
frge = mixed or unspecified forage type
brws = browse
gras = grass

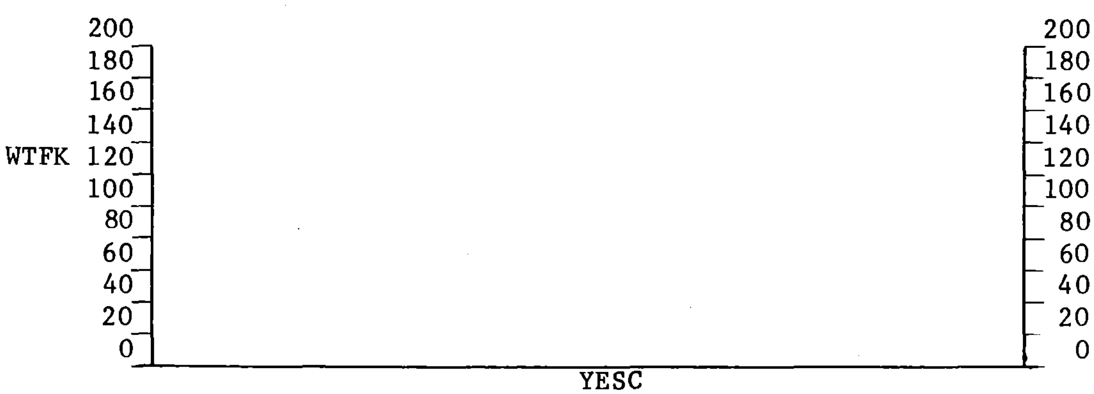
CHAPTER 13, WORKSHEET 1.4a

Weights of forage in relation to years of succession

Patterns of forage production in relation to time and stages in succession have been presented and discussed in this UNIT. Pictures are interesting to look at, but they do not communicate directly with electronic computing equipment. Sketch variations in the weights of forage (in kg) produced in relation to year of succession (YESC) and seek ways to express these variations with equations. Polynomial regressions may be appropriate.







If curve-fitting programs are not readily available, the information shown on the previous page may be tabulated in the column below. Select intervals of YESC (3 years, 5 years, 9 years, or whatever is appropriate for your purposes) and list the expected average forage production for that interval in the blanks below.

Interval of YESC	WTFK
__________	__________
__________	__________
__________	__________
__________	__________
__________	__________
__________	__________
__________	__________
__________	__________
__________	__________
__________	__________
__________	__________
__________	__________
__________	__________
__________	__________
__________	__________
__________	__________
__________	__________
__________	__________
__________	__________
__________	__________
__________	__________
__________	__________
__________	__________
__________	__________
__________	__________
__________	__________
__________	__________
__________	__________
__________	__________

UNIT 1.5: SEED AND MAST PRODUCTION

Mast production may be an important factor in the diet of some of the wild ruminants. The white-tailed deer, abundant in the eastern deciduous forests, is most affected by acorn production, and separate equations for calculating live weight: field dressed weights for "normal" and "acorn" years are given in CHAPTER 1, WORKSHEET 1.5a, Page 26a.

Seed and mast production is quite varible from year to year, depending on weather conditions in the spring during pollination and through the rest of the growing season. Low temperatures in the spring have a detrimental effect on seed production.

The potential production of seeds and mast is dependent on the density of the seed-producing plants and their sizes. Potential acorn production, for example, is partly dependent on the age and size of the tree. Younger and older trees may have less production than those in the middle range of size and age (Gysel 1956). Gysel cited earlier authors who concluded that variations in seed production, probably due to hereditary differences, almost completely obscured variation due to tree size and growth rate.

Crown expanse is apparently an important factor in the production of acorns. If weather conditions are right for high production, then the open-grown trees with the genetic potential for high production can be expected to be the heaviest producers.

Most measurements of seed and mast production are direct counts each year for sample plots. It would be convenient if production coud be predicted on the basis of tree size and crown characteristics, but variations between individuals within years and in the level of production between years make predictions difficult in some areas.

Expected yields of acorns in relation to bole diameters and crown radius have been calculated with regression equations by Goodrum et al. (1971). The correlation coefficients were quite high (0.69 to 0.97 total range), and the authors suggest that expected yield tables could be used to determine the number of trees required to fulfill the needs of game species. They noted that some trees were inherently poor producers; genetics appear to be very important in determining acorn productivity.

LITERATURE CITED

Goodrum, P. D., V. H. Reid, and C. E. Boyd. 1971. Acorn yields, characteristics, and management criterion of oaks of wildlife. J. Wildl. Manage. 35(3):520-532.

Gysel, L. W. 1956. Measurement of acorn crops. Forest Science 2(4):305-313.

REFERENCES, UNIT 1.5

SEED AND MAST PRODUCTION

SERIALS

CODEN	VO-NU	BEPA	ENPA	TYPE*KEY WORDS-----------------	AUTHORS----------	YEAR
JFUSA	61--9	679	680	mast compare 8 types mast traps	thompson,rl; mcgi	1963
JWMAA	6---2	118	121	mast yld, persis wildl foo plnt	park,bc	1942
JWMAA	16--3	338	343	mast meth eval annual mast indx	uhlig,hg; wilson,	1952
JWMAA	17--3	378	380	mast yield seed, mast, hardwood	dalke,pd	1953
JWMAA	42--3	606	613	mast fruit prod pne plan, georg	johnson,as; lande	1978
PCGFA	9----	55	60	mast eff burn forag & mast prod	lay,dw	1955

CODEN	VO-NU	BEPA	ENPA	TYPE KEY WORDS-----------------	AUTHORS----------	YEAR
AJBOA	65--4	487	489	acrn acorn prod, eff site qual,	wolgast,lj	1978
BJASA	23...	21	25	acrn var in prod of immat acorn	wolgast,lj	1978
FOSCA	2---4	305	313	acrn measurement of acorn crops	gysel,lw	1956
JFUSA	32--9	1014	1016	acrn productn, chestnut oak, nj	wood,om	1934
JFUSA	41-12	915	916	acrn better acrns fr fertlz oak	detwiler,sb	1943
JFUSA	42-12	913	920	acrn seed prod s appalachi oaks	downs,aa; mcquilk	1944
JFUSA	53--6	439	441	acrn yld of seed by oak, ozarks	christisen,dm	1955
JWMAA	4---4	404	428	acrn utili oaks, birds, mammals	van dersal,wr	1940
JWMAA	12--3	227	231	acrn yld, us, wat & willow oaks	cypert,e; webster	1948
JWMAA	15--3	332	333	acrn yld fr a post oak, missour	christisen,dm	1951
JWMAA	17--3	380	382	acrn production in east texas	petrides,ga; par/	1953
JWMAA	35--3	520	532	acrn acorn yield, charac, manag	goodrum,pd, reid/	1971
JWMAA	41--2	218	225	acrn pin oak acorn prod, missou	mcquilkin,ra; mus	1977
JWMAA	41--4	685	691	acrn oak repr, eff age, densty,	wolgast,lj stout	1977
LUFPA	6----	1	43	acrn factr infl yiel, use acorn	reid,vh; goodrum,	1957
MOARA	750--	1	24	acrn pin oak acrn prod & regene	minckler,ls; mcde	1960
MOARA	898--	1	15	acrn pin oak prod, norm & flood	minckler,ls; jane	1965
NAWTA	20---	337	357	acrn acorn yield, useage, misso	christisen,dm; ko	1955
NIRKA	57...	209	214	acrn prod, disper, germin acorn	kanazawa,y	1975

*TYPE = type of mast

CODEN	VO-NU	BEPA	ENPA	TYPE	KEY WORDS------------------	AUTHORS----------	YEAR
PAABA	635--	1	22	acrn	evaluat mast yield in oaks	sharp,wm	1958
PCGFA	13---	54	61	acrn	acorns in diet of wildlife	goodrum,pd	1959
PCGFA	30---	656	659	acrn	fertil oak stimu mast prod	colvin,tr	1976
PSAFA	1957-	141	147	acrn	eff hardwd remov on wildlf	reid,vh; goodrum,	1957
XFPSA	136--	1	11	acrn	odvi habi, pine-hardwd, la	blair,rm; brunett	1977
YAXAA	1949-	571	573	acrn	trees and food from acorns	downs,aa	1949

CODEN	VO-NU	BEPA	ENPA	TYPE	KEY WORDS------------------	AUTHORS----------	YEAR
JWMAA	11--2	184	185	nuts	method of measuring yields	allen,dl; mcginle	1947
JWMAA	35--3	516	519	nuts	analys beechnut prod & use	gysel,lw	1971

CODEN	VO-NU	BEPA	ENPA	TYPE	KEY WORDS------------------	AUTHORS----------	YEAR
JWMAA	29--3	497	503	frui	frui-prod tree, shrb, ozar	murphy,da; ehrenr	1965
JWMAA	32--1	185	186	frui	brws plts yld best in open	halls,lk	1968
JWMAA	35--3	533	537	frui	wldlf food, hrdwd, reg cut	crawford,hs,jr; /	1971
PCGFA	15---	30	37	frui	fruit prod, undrstry hardw	lay,dw	1961
PCGFA	18---	57	62	frui	importn variet, south odvi	lay,dw	1964

TYPE = type of mast

mast = more than one or unspecified type of mast
acrn = acorns
nuts = nuts
frui = fruit

TOPIC 2. FORAGE PRODUCTION RESPONSES TO DIFFERENT ECOLOGICAL PERTURBATIONS

The progression of secondary succession to the overmature stage where forage production increases is often interrupted by some kind of ecological perturbation, either natural or caused by man. Fires, depicted in post-settlement years as something bad, are a part of the natural history of many plant communites. Forestry practices change the nature and effects of fire now however. Commercial forestry and other commercial industries often use chemicals to affect succession and plant community composition. Some of these chemicals affect non-target organisms. Some chemicals are used to control biological organisms such as insects that are detrimental to commercial forest interests. Wild ruminants themselves may have a profound effect on the plant community. High populations of primary consumers have the potential for eliminating reproduction of shrubs and trees preferred as forage.

These are examples of ecological perturbations that have both subtle and direct as well as short-term and long-term impacts on forage production. They are discussed in the five UNITS that follow. Management practices designed specifically for increasing forage production are discussed in CHAPTER 21.

UNIT 2.1: FIRE

Fire is a part of the natural history of many plant communities. There are fire species in these plant communities, such as jack pine (*Pinus banksiana*). This species disperses seeds as a response to fire, with the heat opening the cones and causing large quantities of seeds to disperse in a short time. Quaking aspen (*Populus tremuloides*) also responds to fire, with the seeds germinating best on exposed mineral soil.

Red pine (*Pinus resinosa*) is another species that depends on fire for the perpetuation of red pine stands. In the absence of fire, a brushy understory develops which prevents germination and growth of red pine seedlings. A ground fire kills or retards growth of the shrubby understory while not damaging the fire-resistant bark of the boles or the crowns of the trees.

The effects of fire are very dependent on the kind of fire. Ground fires have little effect on canopy trees if the amount of slash is not great. Forestry practices that leave a large amount of slash are fueling potentially hot fires. Hot ground fires may become crown fires, resulting in much greater effects on the plant community than from a ground fire. A crown fire, by definition, burns the crowns, damaging the sites of photosynthesis and thereby affecting the productivity of the stand.

Fires do not always increase the amounts of forage available in the understory. Controlled fires or prescribed burns may be used to affect plant community composition, promoting the growth of some species and reducing the amount of shrubs and, as a result, woody browse in the understory.

Wildfires, which may start from natural causes or as a result of man's activities, do not generally occur according to an overall management plan for an area. Thus fire, which is not universally bad, may cause detrimental effects in relation to certain management objectives, while prescribed burns are conducted for the purpose of reaching these objectives.

The prevention of fires has been so effectively stressed that it is often difficult to convince the public that fires in forests and other natural plant communities are ecologically beneficial under certain conditions. The invasion of the tall-grass prairie by shrubs may be effectively controlled by periodic fires. In fact, fires cannot occur on the prairie every year because there is not enough litter built up to supply the necessary fuel. Fires every three to four years seem to stimulate development of a typical prairie association of grasses and reduce the frequency of forbs and shrubs in the commmunity.

The use of fire in prescribed burning is a relatively recent experimental activity, and there is a need for greater understanding of the effects of fire on different plant communities under different conditions.

The list of serials includes references to both wildfires and prescribed burns. Several early publications contain descriptions of detrimental effects of fire. Some of them contain observations of beneficial effects. Later publications describing prescribed burns contain results of experimental and management work on the effects of fire. Its potential as an ecological perturbation is great, and understanding of its effects under different conditions is increasing.

REFERENCES, UNIT 2.1

FIRE

BOOKS

TYPE	PUBL	CITY	PGES	TYPF*	KEY WORDS-----------------	AUTHORS/EDITORS--	YEAR
edbo	pnfr	poor	275		fire in northern env; symp	slaughter,cw,ed;/	1971

*TYPF = type of fire

SERIALS

CODEN	VO-NU	BEPA	ENPA	TYPF	KEY WORDS-----------------	AUTHORS----------	YEAR
AMNAA	84--1	270	273	wldf	odvi resp to wisc wildfire	vogl,rj; beck,am	1970
AMNAA	94--1	1	14	wldf	subarct rata wintrng groun	johnson,ea; rowe,	1975
BOREA	9---9	617	654	wldf	effects on vegetat, se u s	garren,kh	1943
BRYOA	81--2	294	306	wldf	lichens, tundr transit are	kershaw,ka	1978
CJFRA	5---4	655	661	wldf	litter fall after, minneso	grigal,df; mccoll	1975
ECOLA	52--6	1058	1064	wldf	eff alp plnt communs, wash	douglas,gw; balla	1971
FRCRA	34--1	25	30	wldf	forst fre & protect, wildl	cringan,at	1958
JWMAA	18--4	521	526	wldf	fire, declne mt carib herd	edwards,ry	1954
JWMAA	33--4	778	784	wldf	fire, pinyon-juniper habit	mcculloch,cy	1969
MXSBA	294--	1	43	wldf	isle roy, forest, wildlife	hansen,hl; kreft/	1973
NCANA	101-1	81	100	wldf	alal dist, hab selec, n am	krefting,lw	1974
TTFPB	10---	85	105	wldf	rata habita, taig, n canad	scotter,gw	1970
WMBAA	18---	1	111	wldf	effects, rata winter range	scotter,gw	1964
XATBA	1133-	1	121	wldf	ecol effects, inter alaska	lutz,hj	1956

CODEN	VO-NU	BEPA	ENPA	TYPF	KEY WORDS-----------------	AUTHORS----------	YEAR
ECOLA	30--2	135	145	prsb	successnl resp herbs, pine	lemon,pc	1949
ECOLA	30--2	223	233	prsb	ecol role, pne-oak for, nj	little,s; moore,e	1949
ECOLA	34--3	520	528	prsb	eff on groun covr, pne reg	buell,mf; cantlon	1953
ECOLA	39--1	36	46	prsb	undergrwth veg, south pine	hodgkins,ej	1958
JFUSA	30--4	419	420	prsb	burni stimul aspen suckers	shirley,hl	1932
JFUSA	54--9	582	584	prsb	eff on forage & mast produ	lay,dw	1956
JRMGA	18--4	202	205	prsb	eff yld, prair brush-savan	vogl,rj	1965
JRMGA	29--1	13	18	prsb	shrub, herb, 20 yr prescri	lewis,ce; harshba	1976
JWMAA	34--3	540	545	prsb	effct pr burn, deer browse	dills,gg	1970
JWMAA	35--3	508	515	prsb	sprouting of shrubs, idaho	leege,ta; hickey,	1971
JWMAA	40--3	507	516	prsb	scrub oak habitat, pennsyl	hallisey,dm; wood	1976
JWMAA	41--4	785	789	prsb	odhe ceel resp, cl cut, wy	davis,pr	1977

prsb continued on the next page

CODEN	VO-NU	BEPA	ENPA	TYPF	KEY WORDS-----------------	AUTHORS----------	YEAR
PCGFA	9----	55	60	prsb	eff burn forag & mast prod	lay,dw	1955
TTFPB	13---	39	64	prsb	effs, vert herbivrs, scotl	miller,gr; watson	1973
VILTA	9---3	45	192	prsb	wiru, win habita, land use	ahlen,i	1975
XATBA	683--	1	52	prsb	fire, doca graz, lnglf pne	wahlenberg,wg; g/	1939

CODEN	VO-NU	BEPA	ENPA	TYPF	KEY WORDS-----------------	AUTHORS----------	YEAR
ABSZA	30--4	1	44		lichen stands, newfo, rata	ahti,t	1959
CAFNA	91--3	282	285	both	prair fire, prongh, cactus	stelfox,jg; vrien	1977
ECOLA	41--3	431	445	both	effs on repr & grow, minne	ahlgren,ce	1960
JWMAA	19--1	65	70	both	change, nutrit valu browse	dewitt,jb; derby,	1955
NAWTA	32...	246	259		effect on, bg car, habitat		1967
TTFPB	3----	10	33	both	moose & fire, kenai penins	spencer,dl; hakal	1964
XASRA	118..	1	2		herb yield, burn flatwo ra	rummell,rs	1958

TYPF = type of fire

wldf = wildfire
prsb = prescribed burn
both = both types

UNIT 2.2: FORESTRY PRACTICES

Generally speaking, the direct efforts of wildlife managers to change ecological conditions on land inhabited by wild ruminants are miniscule compared to the efforts of commercially-oriented foresters who manipulate large areas of forest lands. Commercial forestry is an ecological perturbation that affects forest communities as often as cutting is done. Some cutting is very selective, which results in the stand becoming either more or less valuable to the forester, depending on what components are selectively removed. Clear cutting is not selective; all trees are removed, setting succession back to a beginning.

The main forestry practices affecting forest stand composition and other characteristics are reseeding and reforestation, thinning, and harvesting. Reseeding is done on areas where good rates of germination are expected. Good conditions for germination usually result in a dense even-aged stand. Young seedlings are vulnerable to browsing. Some species are very sensitive to browsing, with high mortality or malformed shapes to the seedlings.

Increases in forage production during the regeneration stage compared to the mature forest may be up to 20-fold. Thus a mature forest stand with 20 pounds of forage per acre may produce 40 pounds per acre during regeneration after cutting.

Reforestation is practiced on areas where reseeding is likely not to be succsssful. Direct planting of small trees from nurserys provides a better start for the new forest stand, but it also may attract browsing as the nursery-grown trees attract browsing animals more than natural-grown ones because of the effects of fertilizer on the forage quality.

Established seedling and reforested areas provide large amounts of forage for a few years. They are comparable to early stages in natural succession in amounts produced, but there may be much less diversity than in natural areas. Success in establishing these young stands is often very dependent on the number of browsers, such as deer, in the area.

Thinning is done in forest stands to maintain rapid growth rates so the trees reach harvestable sizes in the shortest possible time. This results in shorter cutting rotations. Thinning reduces size diversity. Culling of unwanted species as well as sizes results in a more even-aged stand that will be as uniform as possible at harvest. The amount of forage production will be dependent on the extent of thinning, and the diversity in forage produced will be dependent on the kind of reforestation practiced and subsequent treatments.

Harvesting of timber may be done selectively or by clear-cutting. Selective cutting results in small openings in the canopy. Little change in forage production is expected if the opening results from the removal of a single crown. As the size of the canopy opening increases, the potential for increased forage production is greater. Clear-cutting results in large increases in forage production the first few years after cutting as secondary succession proceeds from the starting point. The diversity of the invading plant community depends on the species present, treatments, and growing conditions.

The increased use of wood as a heating fuel, especially in the Northeast and the Lake States, adds a new dimension to the patterns of succession in forested land. Many small woodlots, too small to be of much commercial interest, become prime targets for fuelwood cutting. This new demand, coupled with commercial forestry on larger tracts, may result in generally increased amounts of forage production. This may be of particular importance to white-tailed deer because they are abundant in Northeast U.S. and the Lake States where higher human populations result in considerable demand for fuelwood.

The basic ecological effects of different forestry practices should be understood in order to predict potential effects of different forestry practices. Such practices need not always be expected to increase forage production; increases must be accompanied by concomittant increases in the harvest of primary consumers in order to prevent increases in number in excess of the carrying capacity when forage production decreases further along into secondary succession. This latter consideration is dealt with further in PART VII.

The references that follow have been identified because their primary purpose is forestry. References to specific management practices for the primary purpose of increasing forage production are included in CHAPTER 21.

REFERENCES, UNIT 2.2

FORESTRY PRACTICES

SERIALS

CODEN	VO-NU	BEPA	ENPA	FSTP*KEY WORDS-------------------	AUTHORS----------	YEAR
CJFRA	2---3	346	350	harv forg yld & brws util, n br	telfer,es	1972
ECOLA	57--1	18	32	harv phytosociol chan, timb har	blair,rm; brunett	1976
JFUSA	48--2	118	126	harv chng pond pne bnchgras rng	arnold,jf	1950
JFUSA	53--7	513	516	harv harv offset forage decline	martin,sc; dunke/	1955
JFUSA	55-11	803	809	harv silvc prac, wldlf foo, cov	gysel,lw	1957
JFUSA	65-11	807	813	harv forest cover and logging	young,ja; hedric/	1967
JWMAA	18--2	266	271	harv availa browse, aspen, mich	westell,ce,jr	1954

harv continued on the next page

*FSTP = forestry practice

CODEN	VO-NU	BEPA	ENPA	FSTP	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	28--3	458	463	harv	brws rel age & intens harv	patton,dr; mcginn	1964
NAWTA	25---	407	415	harv	brwsng, stan reg, cl & sel	ripley,th; campbe	1960
NCANA	101-1	81	100	harv	alal dist, hab selec, n am	krefting,lw	1974
PSAFA	1957-	137	140	harv	eff pulpwd cutting on deer	gill,j	1957
TNWSD	25---	25	33	harv	cuttng pracs, produc brwse	cromer,ji; smith,	1968
TNWSD	26---	45	55	harv	effecs, prod, util od food	harlow,rf; downin	1969
WLMOA	48---	1	61	harv	alal hab selec, forest mgt	peek,jm; urich,d/	1976
XARRA	139--	1	7	harv	wiru use pine forest, ariz	patton,dr	1969
XANEA	100--	1	25	harv	desgn, anal, mult-use stud	shafer,el,jr; lis	1968

CODEN	VO-NU	BEPA	ENPA	FSTP	KEY WORDS-----------------	AUTHORS----------	YEAR
JFUSA	54--1	13	16	clct	regen in aspen cutovr area	stoeckeler,jh; ma	1956
JFUSA	71--4	210	214	clct	wildlife brief for clearcu	hooven,ef	1973
JFUSA	72--5	282	285	clct	logging forag values, colo	regelin,wl; wall/	1974
JWMAA	35--3	533	537	clct	wldlf food, hrdwd, reg cut	crawford,hs,jr; /	1971
NFGJA	11--2	115	118	clct	odvi use, clear-cut area	krull,jn	1964
WLSBA	7---4	247	252	clct	deer brwse prod, cut overs	potvin,f; huot,j	1979

CODEN	VO-NU	BEPA	ENPA	FSTP	KEY WORDS-----------------	AUTHORS----------	YEAR
XFPSA	136--	1	11	selc	odvi habi, pine-hardwd, la	blair,rm; brunett	1977

CODEN	VO-NU	BEPA	ENPA	FSTP	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	21--2	121	126	tsim	resps odvi forg, t sta imp	baskett,ts; dunk/	1957

CODEN	VO-NU	BEPA	ENPA	FSTP	KEY WORDS-----------------	AUTHORS----------	YEAR
JRMGA	18--3	129	132	thng	undrstory resp 3 yrs, pine	mcconnell,br; smi	1965
JRMGA	25--6	435	437	thng	herbg resp, dir-seeded pne	grelen,he; whita/	1972
JWMAA	24--4	401	405	thng	odvi forag incr, lobl pine	blair,rm	1960
JWMAA	29--4	729	733	thng	eff cleanin odvi brws prod	della-bianca,l; j	1965
JWMAA	31--3	432	437	thng	od forag, loblo pne planta	blair,rm	1967
JWMAA	35--1	163	168	thng	odvi brws, oak, cove hardw	knierim,pg; carv/	1971
NAWTA	30---	296	305	thng	od brws prod, tim sta impr	jordon,js; hagar/	1965

CODEN	VO-NU	BEPA	ENPA	FSTP	KEY WORDS-----------------	AUTHORS----------	YEAR
JFUSA	56--6	416	421	many	od brws prod fr felled tre	stoeckeler,jh; k/	1958
JWMAA	10--1	60	63	many	odvi summ brwsng, hrdw lnd	cook,db	1946
JWMAA	29--4	734	739	many	eff harv & tsi, forag prod	murphy,da; ehrenr	1965
JWMAA	32--3	623	626	many	odvi brws, ouachita forest	segelquist,ca; pe	1968
JWMAA	33--2	394	398	many	site disturb, shade removl	behrend,df; patri	1969
MFNOA	21...	1	2		eff cutting mt maple, brow	krefting,lw	1953
PSAFA	1957-	141	147	many	effct hardwd remov on wldl	reid,vh; goodrum,	1957
PSAFA	1962-	165	167	many	timb ovrstry detrm od fora	schuster,jl; hall	1962
VILTA	9---3	45	192	many	wiru, win habita, land use	ahlen,i	1975

FSTP = forestry practice

harv = harvesting
clct = clear cutting
selc = selective cutting
tsim = timber stand improvement
thng = thinning
many = more than one practice

UNIT 2.3: CHEMICAL EFFECTS

Chemicals are often used as part of forestry practices as fertilizers to stimulate growth, herbicides to control growth of undesirable plants, and pesticides to control undesirable insects that damage the trees. Fertilizers are used regularly in tree nurserys and on crop land to promote rapid growth of the seedlings and crops. Fertilizers are less commonly used on large areas of forest land and range land. They are extensively used on agricultural land. There is some evidence in the literature for fertilized plants being more attractive to foraging animals than unfertilized ones (See CHAPTER 12, TOPIC 1: FOOD HABITS AND PREFERENCES).

Herbicides have the potential for defoliating large areas of vegetation, exposing the ground surface to light. New growth can then occur if the herbicide effect does not persist and affect emerging seedlings. Some herbicides are more selective than others. Herbicides are used in right-of-way control and other specific applications where selected and sometimes small areas are to be treated.

Pesticides are used to control potentially damaging organisms, especially insects. They are often used over large areas, and the benefits are not often weighed against possible detrimental effects. The use of both herbicides and pesticides has occurred before potential effects on non-target organisms have been anticipated fully. The roles of some of these chemicals in the metabolic pathways of wild ruminants need further investigation, and populations exposed to potential hazards need to be monitored.

REFERENCES, UNIT 2.3

CHEMICAL EFFECTS

SERIALS

CODEN	VO-NU	BEPA	ENPA	CHEF*KEY WORDS-----------------	AUTHORS----------	YEAR
AGJOA	56--2	223	226	frtz eff grwt grass, od use, nd	thomas,jr; cospe/	1964
FOSCA	16--1	113	120	frtz upl oak resp, nit, ph, cal	ward,ww; bowersox	1970
JRMGA	25--6	452	456	frtz resp prair grass to fertil	rehm,gw; moline,/	1972
JWMAA	39--3	557	562	frtz odvi brw & hrbg, intns mgt	wolters,gl; schmi	1975
WLSBA	6---4	259	250	frtz eff on bear oak brwse prod	wolgast,lf	1978

*CHEF = chemical effect

CODEN	VO-NU	BEPA	ENPA	CHEF	KEY WORDS-----------------	AUTHORS----------	YEAR
JFUSA	55-11	803	809	hrbc	silvc prac, wldlf foo, cov	gysel,lw	1957
JRMGA	14--3	126	130	hrbc	eff on native forage plnts	mccaleb,je; hodg/	1961
JRMGA	18--6	338	340	hrbc	veg resp, ozrk woodl spray	halls,lk; crawfor	1965
MFNOA	42...	1	2	hrbc	herbici, regrowth mt maple	krefting,lw; hans	1955
MFNOA	66...	1	2	hrbc	wint, spr appl 2,4-d, regr	krefting,lw; hans	1958
NAWTA	21---	127	141	hrbc	implic hardwd & brsh contr	goodrum,pd; reid,	1956
NAWTA	27---	384	393	hrbc	applicat, south, wldlf mgt	chamberlain,eb,j/	1962

CODEN	VO-NU	BEPA	ENPA	CHEF	KEY WORDS-----------------	AUTHORS----------	YEAR
WLMOA	24...	1	81	pstc	ecol, small wat shed, inse	giles,rh,jr	1970

CODEN	VO-NU	BEPA	ENPA	CHEF	KEY WORDS-----------------	AUTHORS----------	YEAR
VILTA	9---3	45	192	many	wiru, win habita, land use	ahlen,i	1975

CHEF = chemical effect

frtz = fertilizer
hrbc = herbicide
pstc = pesticide

UNIT 2.4: BIOLOGICAL EFFECTS

Biological organisms can have a profound effect on the characteristics of a plant community and the amount of forage available. Wild ruminants affect the species composition of forests and other plant communities by removing forage from preferred species, often to the point where plant productivity is reduced. Young plants of such preferred species are often overgrazed and overbrowsed so they never reach maturity. Species subject to such pressures eventually disappear from the community because old plants are not replaced.

The impacts of browsing on plant community composition are subtle because species changes take a long time to occur. The use of exclosures to protect small areas of vegetation dramatically demonstrate the impacts of browsing by high populations of ungulates.

Some exclosures keep out only the large ruminants, allowing rabbits, hares, and smaller mammals to forage on the protected areas. Such exclosures generally demonstrate the impact of large ruminants, with smaller herbivores having a lesser effect.

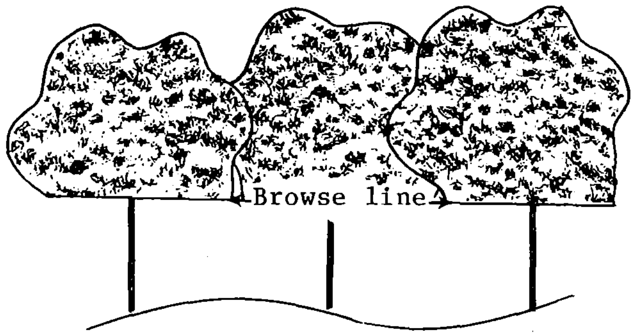
It should be realized that the complete protection of some plant species does not maximize forage production. Periodic removal of some of the production during the growing season prolongs the period of growth and increases total production. This is particularly true of grasses.

Shrubs that are lightly grazed may show increased total production, with several shorter twigs growing in place of the original single one. If browsing is heavier than the plant can tolerate while maintaining productivity, then it assumes a "cropped" appearance, with a large number of very short twigs around its surface and little or no overall growth. There is a delicate balance between the amount of removal that stimulates growth, and the amount that reduces overall growth. As a general rule, no more than 50% of the current annual growth should be removed, although some species will tolerate more than that.

Organisms have other effects on plant communities in addition to grazing and browsing. Trampling may affect soil structure and erosion. Herds of bison had the potential for considerable amounts of trampling. Their movements over large areas prevented extensive damage except in local areas.

Biological organisms such as insects have the potential for defoliating trees, thereby opening up the canopy and increasing forage production in the shrub layer. Extensive insect damage is usually viewed with alarm and control measures instituted quickly.

Wild ruminants themselves probably have the most subtle but potentially serious impacts on the forage production on their own ranges. They are very appealing animals to the public, however, and it is hard to convince people that the impressive and large animals would have such profound effects. Even the presence of a "browse line" is not enough to convince some that there are too many deer present.



One of the most conspicuous cases of population impact on the range is described by Klein (1968) as a herd of 6000 caribou on St. Matthew Island was reduced to just 42 cows and 1 bull in a single winter. This dramatic event occurred in a remote place, however, and its impact is hard to appreciate without opportunities to observe range and animal condition first-hand.

Long-term studies are necessary to demonstrate the effects of different primary consumers on the range. It is surprizing to me that more attention has not been given to the species composition effects of, say, deer on the forest by foresters interested in retaining productive mixed forests. It is an area of study that is difficult to complete because of the long-term studies necessary, but a potentially very revealing one.

LITERATURE CITED

Klein, D. R. 1968. The introduction, increase, and crash of reindeer on St. Matthew Island. J. Wildl. Manage. 32(2):348-367

REFERENCES, UNIT 2.4

BIOLOGICAL EFFECTS

BOOKS

TYPE	PUBL	CITY	PGES	BLEF*KEY WORDS-----------------	AUTHORS/EDITORS--	YEAR
edbo	acpr	nyny	718	graz herbiv: interac w/plnt met	rosenthal,ga,ed;/	1979

*BLEF = biological effect

SERIALS

CODEN	VO-NU	BEPA	ENPA	BLEF	KEY WORDS-----------------	AUTHORS----------	YEAR
AMNAA	95--1	79	92	brws	impct alal brwsg borea for	snyder,jd; janke,	1976
BSETB	41--1	85	94	brws	effs grazng, browsg on veg	nicholson,ia	1970
CAFGA	40--3	215	234	brws	de-fora relat lassen-washo	dasmann,w; blaisd	1954
ECOLA	51--6	1088	1093	brws	lng trm od exclus, pne for	ross,ba; bray,jr/	1970
FOSCA	1....	61	67	brws	eff brws, qual hardw, mich	switzenberg,df	1955
FRCRA	34--1	21	24	brws	infl brwsng anims, regener	de vos,a	1958
JAPEA	16--3	855	861	brws	odvi infl struc & comp for	anderson,rc; louc	1979
JFUSA	48-10	675	678	brws	deer in reln plnt successn	leopold,as	1950
JFUSA	54--6	391	398	brws	odvi eff matur n hrdwd for	webb,wl; king,rt/	1956
JFUSA	56--2	116	121	brws	stand dens, od brws, adiro	curtis,ro; rushmo	1958
JFUSA	64--5	322	326	brws	eff sim od brows, doug-fir	crouch,gl	1966
JFUSA	64-12	801	805	brws	odvi infl logged n hrdw fo	tierson,wc; patr/	1966
JFUSA	67-12	870	874	brws	grwt, dev brwsd mapl seedl	jacobs,rd	1969
JFUSA	68--5	298	300	brws	brwsng, hrdwd regen, appal	harlow,rf: downin	1970
JWMAA	3---4	295	306	brws	yellowst wint rnge studies	grimm,rl	1939
JWMAA	16--4	401	409	brws	odvi brows study, lake sta	aldous,se	1952
JWMAA	17--4	487	494	brws	eff sim od damag, conifers	krefting,lw; stoe	1953
JWMAA	21--1	75	80	brws	odvi eff repro, heml-hrdwd	stoeckeler,jh; s/	1957
JWMAA	24--1	68	80	brws	odvi infl on vege, wiscons	beals,ew; cottam,	1960
JWMAA	30--3	481	488	brws	eff simul & naturl, mt map	krefting,lw; ste/	1966
JWMAA	32--4	729	746	brws	alal dam, fir-wh bir, newf	bergerud,at; manu	1968
JWMAA	32--4	769	772	brws	surv, grwt brwsd bittrbrus	ferguson,rb	1968
NAWTA	15---	571	578	brws	deer in reln plnt successn	leopold,as	1950
NAWTA	19---	526	533	brws	chang n mich frsts, brwsng	graham,sa	1954
NAWTA	23---	478	490	brws	deer exclosure exper, mich	graham,sa	1958
NOSCA	52--3	233	235	brws	odhe & forest reprod, wash	amaral,m	1978
NYCOA	5---3	6	8	brws	what's happen to deer rang	darrow,rw	1950
NZJBA	1---4	405	409	brws	meth stud eff goats, forst	atkinson,iae	1963
OIKSA	32--3	373	379	brws	brows pressure, decid, eur	bobek,b; perzano/	1979
PCGFA	2....	1	6	brws	evaluation of deer browsin	goodrum,p	1948
PCGFA	21---	32	38	brws	odvi damag, citr grv, flor	beckwith,sl; stit	1967

brws continued on the next page

CODEN	VO-NU	BEPA	ENPA	BLEF	KEY WORDS-----------------	AUTHORS----------	YEAR
RWLBA	7---1	1	61	brws	odvi eff, adir forest typs	pearce,j	1937
TISAA	57--3	179	181	brws	odvi eff soybea plnts, ill	klimstra,wd; thom	1964
WSCBA	18--1	3	10	brws	and the browse came back	deboer,sg	1953
XANEA	33---	1	37	brws	od brwsng hardwds, nrth es	shafer,el,jr	1965
XANEA	308--	1	8	brws	odvi impact on hardw regen	marquis,da	1974
XFNNA	33---	1	3	brws	wh-cedar eliminatd by, n j	little,s; somes,h	1965
ZORRA	32...	67	70	brws	browsing shrub vegetation	stalfelt,f	1970

CODEN	VO-NU	BEPA	ENPA	BLEF	KEY WORDS-----------------	AUTHORS----------	YEAR
ABSZA	30--4	1	44	graz	lichen stands, newfo, rata	ahti,t	1959
BRYOA	81--2	294	306	graz	lichens, tundr transit are	kershaw,ka	1978
CPLSA	41--3	615	622	graz	comp light gr, ungr grassl	johnston,a	1961
ECOLA	21--3	381	397	graz	effe overgr & erosn, prair	smith,cc	1940
ECOLA	35--2	200	207	graz	eff compos & prod, prairie	keating,rw	1954
JAPEA	12--1	25	29	graz	nutr remov, doca, sh gr pr	dean,r, ellis,je/	1975
JFUSA	48--2	118	126	graz	chng pond pne bnchgras rng	arnold,jf	1950
JRMGA	18--4	218	220	graz	resp plnt sp elk, doca, wy	jones,wb	1965
JRMGA	25--6	426	429	graz	clippng effects utah range	drawe,dl; grumbl/	1972
JWMAA	10--1	60	63	graz	odvi sum brw, cut-ovr hrdw	cook,db	1946
JWMAA	32--2	348	367	graz	intro, incre & crash, rata	klein,dr	1968
NOSCA	34--1	25	36	graz	resp ceel graz, gras & shr	smith,dr	1960
PASCC	22---	23	24	graz	infl ceel dist, graz, vege	ashby,kr	1971
TAGPA	3....	10	12	graz	od react, popul, graz prac	merrill,lb; teer/	1957
XATBA	683--	1	52	graz	fire, doca graz, lnglf pne	wahlenberg,wg; g/	1939

CODEN	VO-NU	BEPA	ENPA	BLEF	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	8---1	80	81	rbng	inj tree trnk, antl rubbng	lutz,hj; chapman,	1944

CODEN	VO-NU	BEPA	ENPA	BLEF	KEY WORDS-----------------	AUTHORS----------	YEAR
				tmpl			

CODEN	VO-NU	BEPA	ENPA	BLEF	KEY WORDS-----------------	AUTHORS----------	YEAR
CGFPA	12---	1	22	many	lit revw, od orchard damag	harder,jd	1968
JFUSA	47-11	909	913		od eff conifer repro, mont	adams,l	1949
JFUSA	65-11	807	813		forest cover and logging	young,ja; hedric/	1967
JRMGA	7---6	259	261		viabl seeds in feces, odhe	heady,hf	1954
JRMGA	23--2	95	97	many	effec tramplng, graz, lich	pegau,re	1970
JWMAA	5---4	427	453	many	eff ceel wintr brws, monta	gaffney,ws	1941
JWMAA	24--4	387	395	many	odvi-fore habita reln, ark	halls,lk; crawfor	1960
LESOA	3....	67	73		alal effe fore regen, ussr	baleishis,rm; pad	1975
LESOA	3....	74	79		alal eff undrgro, bush woo	yanushko,ad; duni	1975
PBMEA	20--2	169	185		regul plnt comms, foo chai	fretwell,sd	1977
PZESA	8----	52	54		od eff subalpn for & scrub	wardle,p	1961

BLEF = biological effect

brws = browsing
graz = grazing
tmpl = trampling
rbng = antler rubbing
many = more than one effect

UNIT 2.5: OTHER FACTORS

A number of other factors may affect the structures of different plant communities and forage production for wild ruminants. Wind storms cause blowdowns, usually scattered, though hurricanes and tornadoes may affect more extensive areas. Ice storms may, under certain conditions, cause mechanical breakage.

Abandoned clearings, the effects of bulldozing, plowing, discing, and mowing, and reverting farmlands all provide environments for secondary succession, with the amount of forage production dependent on local growing conditions. A mix of factors that results in a variety of plant communities provides a diversity of habitats for a variety of wild species. Adaptable ruminants like the white-tailed deer take advantage of these transition stages and thrive.

REFERENCES, UNIT 2.5

OTHER FACTORS

SERIALS

CODEN	VO-NU	BEPA	ENPA	EFCT*	KEY WORDS-----------------	AUTHORS----------	YEAR
JFUSA	55-11	803	809		bldz silvc prac, wldlf foo, cov	gysel,lw	1957

CODEN	VO-NU	BEPA	ENPA	EFCT	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	39--3	557	562		cult odvi brw & hrbg, intns mgt	wolters,gl; schmi	1975

CODEN	VO-NU	BEPA	ENPA	EFCT	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	9---3	257	258		strm od food produ by ice storm	curtis,jd	1945

*EFCT = type of effect

CODEN	VO-NU	BEPA	ENPA	EFCT	KEY WORDS----------------	AUTHORS----------	YEAR
NAWTA	29---	432	438	many	chang wldlf habitat compos	box,tw	1964
WSCBA	32--5	21	23	many	bargain openings	mccaffery,k	1967

EFCT = type of effect

bldz = bulldozing
cult = cultivation
strm = storms
many = more than one type of effect

CHAPTER 13 - CLOSING COMMENTS

This CHAPTER has provided brief introductions to primary production, forage production, and factors that affect them. There is a large amount of ecological literature available on primary production, beyond the scope of this CHAPTER. The references to forage production provide starting points for further analyses of the effects of different ecological perturbations on carrying capacity. This concept is discussed further in CHAPTER 20, with material from all of the previous PARTS used in the calculations of carrying capacity. A systematic evaluation of the basic characteristics and relationships of local populations to their range and its productivity will provide reviews of the concepts and opportunities for ecological accouting that will strengthen the understanding of the basic biological concepts.

Aaron N. Moen
April 27, 1981

GLOSSARY OF SYMBOLS USED - CHAPTER 13

FRGE = amount of forage in kilograms per hectare

HGTC = height in centimeters

HGTM = height in meters

LAIX = leaf area index

NAPP = net annual productivity in grams per square meter

PCNT = percent

WFKH = weight of forage in kilograms per hectare

YESC = year of succession

GLOSSARY OF CODE NAMES - CHAPTER THIRTEEN

ABSZA Annales Botanici Societatis Zoologicae Botanicae Fennicae Vanamo
AGJOA Agronomy Journal (US)
AJBOA American Journal of Botany
AJBSA Australian Journal of Biological Sciences
AMNAA American Midland Naturalist
ASZBA Archivum Societatis Zoologicae - Botanicae Fennicae Vanamo'
ATICA Arctic (Canada)
ATLPA Arctic and Alpine Research
ATRLA Acta Theriologica (Poland)

BJASA Bulletin of the New Jersey Academy of Science
BOREA Botanical Review (US)
BPURD Biological Papers of the University of Alaska Special Report
BRYOA Bryologist
BSECB Biochemical Systematics and Ecology
BSETB Botanical Society of Edinburgh Transactions

CAFGA California Fish and Game
CAFNA Canadian Field Naturalist
CGFPA Colorado Division of Game, Fish, and Parks Special Report
CJBOA Canadian Journal of Botany
CJFRA Canadian Journal of Forest Research (Canada)
CNAPA Canada Department of Agriculture Publication
CNRDA Canadian Journal of Research, Section D, Zoological Sciences
CNSVA Conservationist
CPLSA Canadian Journal of Plant Science

ECBOA Economic Botany
ECMOA Ecological Monographs
ECOLA Ecology

FOSCA Forest Science
FPWTA Transactions of the Federal-Provincial Wildlife Conference
FRCRA Forestry Chronicle

JAPEA Journal of Applied Ecology
JDSCA Journal of Dairy Science
JECOA Journal of Ecology
JFUSA Journal of Forestry
JRMGA Journal of Range Management
JSABA Journal of South African Botany
JWMAA Journal of Wildlife Management

LESOA Lesovedenie
LUFPA Louisiana State University Proceedings of the Annual Forestry Symposium

MFNOA Minnesota Forestry Notes
MOARA Missouri Agricultural Experiment Station Research Bulletin
MXSBA Minnesota Agricultural Experiment Station, Station Bulletin

NAWTA North American Wildlife and Natural Resources Conference, Transactions of the,
NCANA Naturaliste Canadien, Le

NFGJA New York Fish and Game Journal
NIRKA Journal of the Japanese Forestry Society
NOSCA Northwest Science
NYCOA New York State Conservationist
NZJBA New Zealand Journal of Botany
NZJSA New Zealand Journal of Science

OIKSA Oikos (Denmark)

PAABA Pennsylvania Agricultural Experiment Station Bulletin
PABCA Annual Biology Colloquium
PASCC Proceedings of the Alaskan Scientific Conference
PBMEA Perspectives in Biology and Medicine
PCGFA Proceedings of the Southeastern Association of Game and Fish Commissioners
PSAFA Proceedings of the Society of American Foresters
PZESA Proceedings of the New Zealand Ecological Society

RWLBA Roosevelt Wild Life Bulletin

SWNAA Southwestern Naturalist

TAGPA Texas Agricultural Progress
TBOIA Trudy Botanicheskogo Instituta Akademii Nauk SSSR
TISAA Transactions of the Illinois State Academy of Science
TNWSD Transactions of the Northeast Section, The Wildlife Society
TTFPB Tall Timbers Fire Ecology Conference, Proceedings

UTSCB Utah Science

VILTA Viltrevy

WLMOA Wildlife Monographs
WLSBA Wildlife Society Bulletin
WMBAA Wildlife Management Bulletin (Ottowa) Series 1 (Canada)
WSCBA Wisconsin Conservation Bulletin

XAFNB U S Forest Service Research Note NC
XAGCA U S D A Circular
XANEA U S Forest Service Research Paper NE
XARRA U S Forest Service Research Note RM
XASRA U S Forest Service Research Note SE
XATBA U S D A Technical Bulletin
XFNCA U S Forest Service Research Paper NC
XFNNA U S Forest Service Research Note NE
XFNSA U S Forest Service Research Note SO
XFPNA U S Forest Service Research Paper PNW
XFPSA U S Forest Service Research Paper SO
XFSEA U S Forest Service Resource Bulletin SE
XFWWA U S Fish and Wildlife Service Special Scientific Report - Wildlife
YAXAA U S D A Yearbook of Agriculture

ZHIVA Zhivotnovodstvo
ZORRA Zoologisk Revy

LIST OF PUBLISHERS - CHAPTER 13

acpr	Academic Press	New York	nyny
agso	American Geographical Society	New York	nyny
blak	Blakiston	Philadelphia, PA	phpa
butt	Butterworth	London	loen
butt	Butterworth	Washington, D.C.	wadc
ibpt	International Biological Programme, Tundra Biome	Edmonton, Alberta	edal
macm	MacMillan Co.	New York	nyny
mhbc	McGraw-Hill Book Company, Inc.	New York	nyny
pnfr	U S Pacific Northwest Forest and Range Experiment Station	Portland, OR	poor
spve	Springer-Verlaug Inc.	New York	nyny
umpr	University of Michigan Press	Ann Arbor, MI	aami
usfs	U S Forest Service	Tifton, Georgia	tige
wcbr	W. C. Brown Company	Dubuque, IO	duio
whfr	W. H. Freeman Co.	San Francisco, CA	sfca
wile	Wiley	New York	nyny

LIST OF WORKSHEETS - CHAPTER 13