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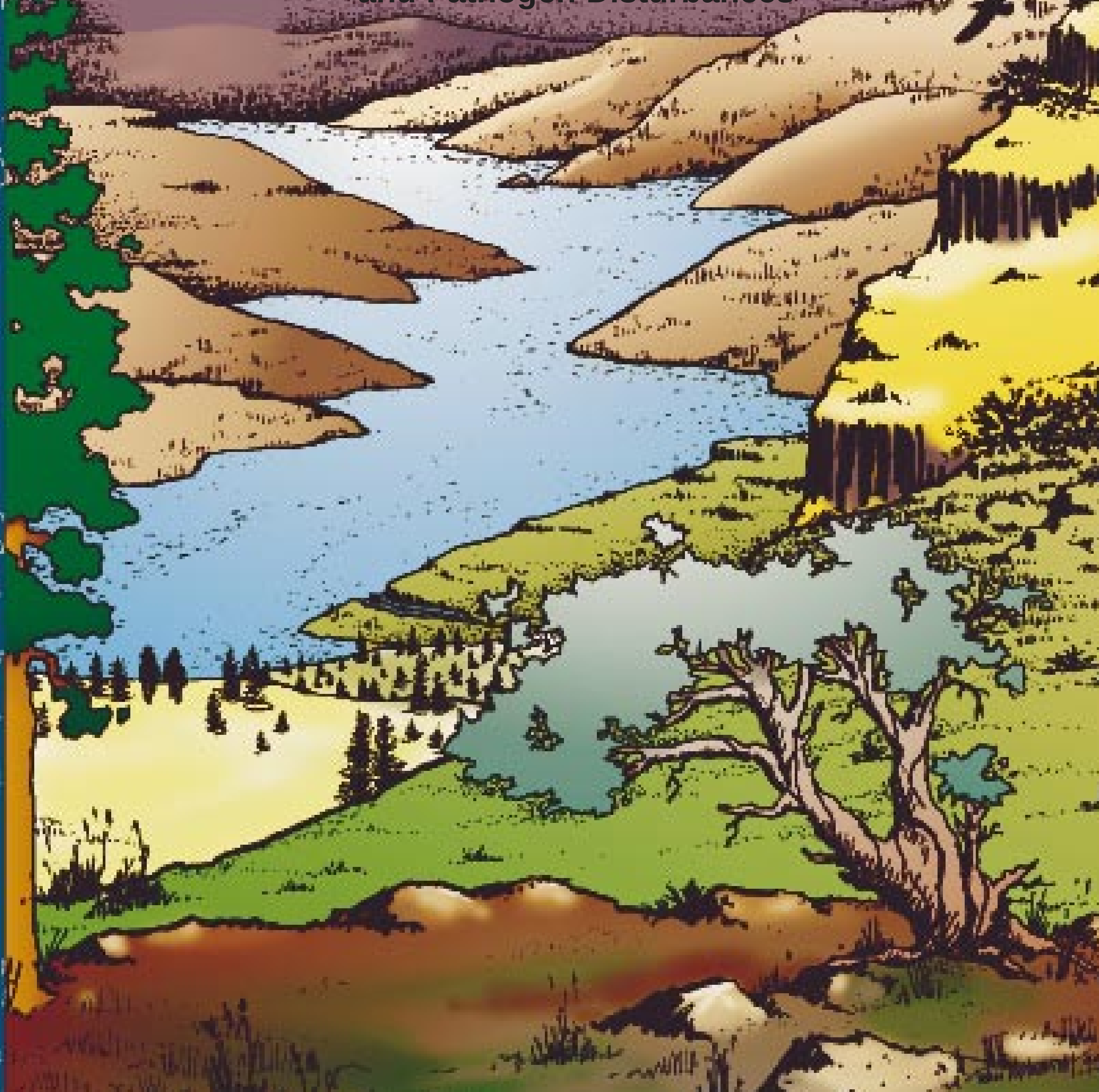
Historical and Current Forest and Range Landscapes in the Interior Columbia River Basin and Portions of the Klamath and Great Basins

Part 1: Linking Vegetation Patterns and Landscape Vulnerability to Potential Insect and Pathogen Disturbances



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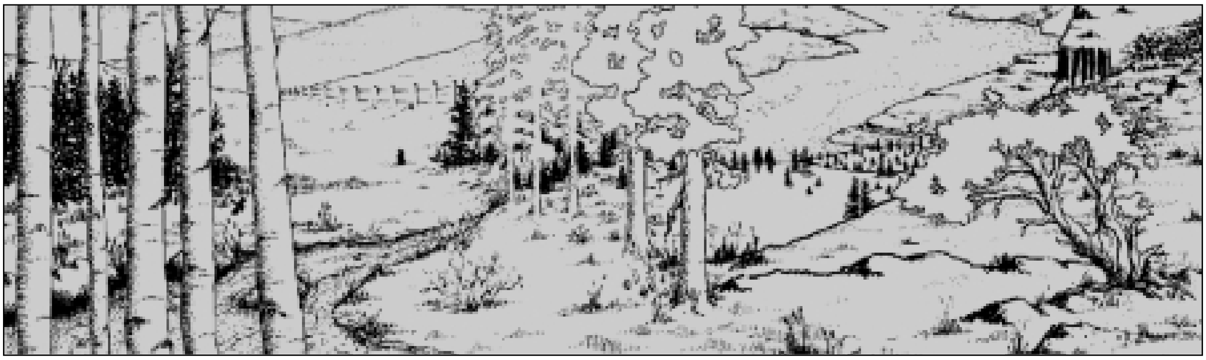

Historical and Current Forest and Range Landscapes in the Interior Columbia River Basin and Portions of the Klamath and Great Basins

Part 1: Linking Vegetation Patterns and Landscape Vulnerability to Potential Insect and Pathogen Disturbances

Paul F. Hessburg, Bradley G. Smith, Scott D. Kreiter, Craig A. Miller, R. Brion Salter, Cecilia H. McNicoll, and Wendel J. Hann

Interior Columbia Basin Ecosystem Management Project: Scientific Assessment

Thomas M. Quigley, Editor

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Abstract

Hessburg, Paul F.; Smith, Bradley G.; Kreiter, Scott D.; Miller, Craig A.; Salter, R. Brion; McNicoll, Cecilia H.; Hann, Wendel J. 1999. Historical and current forest and range landscapes in the interior Columbia River basin and portions of the Klamath and Great Basins. Part I: Linking vegetation patterns and landscape vulnerability to potential insect and pathogen disturbances. Gen. Tech. Rep. PNW-GTR-458. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 357 p. (Quigley, Thomas, M., ed., Interior Columbia Basin Ecosystem Management Project: scientific assessment).

Management activities of the 20th century, especially fire exclusion, timber harvest, and domestic livestock grazing, have significantly modified vegetation spatial patterns of forests and ranges in the interior Columbia basin. Compositional patterns as well as patterns of living and dead structure have changed. Dramatic change in vital ecosystem processes such as fire, insect, and pathogen disturbances, succession, and plant and animal migration is linked to recent change in vegetation patterns. Recent change in vegetation patterns is also a primary reason for current low viability and threatened, endangered, or sensitive status of numerous native plant and animal species. Although well intentioned, 20th-century management practices have not accounted for the larger patterns of living and dead vegetation that enable forest ecosystems to function in perpetuity and maintain their structure and organization through time, or for the disturbances that create and maintain them. Knowledge of change in vegetation patterns enhances resource manager and public awareness of patterns that better correspond with current climate, site conditions, and native disturbance regimes, and improves understanding of conditions to which native terrestrial species have already adapted.

In this study, we characterized recent historical and current vegetation composition and structure of 337 randomly sampled subwatersheds (9500 ha average size), in 43 of 164 total subbasins (404 000 ha average size), selected by stratified random draw on all ownerships within the interior Columbia River basin and portions of the Klamath and Great Basins (collectively referred to as the basin). We compared landscape patterns, vegetation structure and composition, and landscape vulnerability to 21 major insect and pathogen disturbances of historical and current vegetation coverages. For each selected subwatershed, we constructed historical and current vegetation maps from interpretations of 1932-66 and 1981-93 aerial photos, respectively. Areas with homogeneous vegetation composition and structure were delineated as patches to a minimum size of 4 ha. We then attributed cover types (composition), structural classes (structure), and series-level potential vegetation types (site potential) to individual patches within subwatersheds by modeling procedures. We characterized change in vegetation spatial patterns by using an array of class and landscape pattern metrics and a spatial pattern analysis program. Finally, we translated change in vegetation patterns to change in landscape vulnerability to major forest pathogen and insect disturbances. Change analyses results were reported for province-scale ecological reporting units.

Forest and range ecosystems are significantly altered after their first century of active management, but there is reason for guarded optimism. Large areas remain relatively unchanged and intact, such as can be found on the east side of the Cascade Range in Washington and in the central Idaho mountains, and these areas may provide an essential “nucleus” for conservation strategies and ecosystem restoration. Strategies for improving the health of basin ecosystems can build on existing strengths. Improved understanding of change in vegetation patterns, causative factors, and links with disturbance processes will assist managers and policymakers in making informed decisions about how to address important ecosystem health issues.

Keywords: Landscape characterization, ecological assessment, vegetation patterns, interior Columbia River basin, Klamath Basin, Great Basin, ecosystem health, vegetation pattern-disturbance process interactions, insect and disease disturbance, landscape ecology, ecosystem processes, potential natural vegetation modeling, vegetation change, fire effects.

Preface

The Interior Columbia Basin Ecosystem Management Project (ICBEMP) was initiated by the Forest Service and the Bureau of Land Management to respond to several critical issues including, but not limited to, forest and rangeland health, anadromous fish concerns, terrestrial species viability concerns, and the recent decline in traditional commodity flows. The charter given to the project was to develop a scientifically sound, ecosystem-based strategy for managing the lands of the interior Columbia River basin administered by the Forest Service and the Bureau of Land Management.

The Science Integration Team was organized to develop a framework for ecosystem management, a broad-scale assessment of the socioeconomic and biophysical systems in the basin, and an evaluation of alternative management strategies. The broad-scale assessment of the biophysical systems consisted of two parts: (1) a multiscale characterization of biophysical environments of the basin (Jensen and others 1997), and (2) a broad-scale landscape assessment of change in vegetation patterns and disturbance regimes of the basin (Hann and others 1997). In addition to the broad-scale landscape assessment, a midscale assessment was conducted to validate the results of the broad-scale assessment at a scale appropriate to observing the vegetation pattern-disturbance process interactions. This paper is one of a series of four papers developed to document the results of that mid-scale assessment.

The Science Integration Team, although organized functionally, worked hard at integrating the research approaches, analyses, and conclusions. It was the collective effort of the team that provided depth and understanding to the work of the project. The Science Integration Team leadership included deputy team leaders Russel Graham and Sylvia Arbelbide; landscape ecology—Wendel Hann, Paul Hessburg, and Mark Jensen; aquatic—Jim Sedell, Kris Lee, Danny Lee, Jack Williams, Lynn Decker; economic—Richard Haynes, Amy Horne, and Nick Reyna; social science—Jim Burchfield, Steve McCool, and Jon Bumstead; terrestrial—Bruce Marcot, Kurt Nelson, John Lehmkuhl, Richard Holthausen, and Randy Hickenbottom; and broad-scale spatial analysis—Becky Gravenmier, John Steffenson, and Andy Wilson.

Thomas M. Quigley
Editor

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Interior Columbia Basin Ecosystem Management Project

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Summary

In this midscale assessment, we have quantified change in vegetation patterns and landscape vulnerability to fire, insect, and pathogen disturbances over the most recent 50 to 60 years based on a stratified random sample of 337 subwatersheds (9500 ha average size) distributed in 43 subbasins (404 000 ha average size), on all public and private ownerships within the interior Columbia River basin (the basin). Change analyses results were reported by province-scale ecological reporting units (ERUs). In the assessment, we have compared landscape patterns, structure, composition, and vulnerability to insect and pathogen disturbances of historical and current vegetation coverages. Forest and rangeland vegetation composition and structure were remotely sensed from resource aerial photographs taken from 1932 to 1966 (historical), and from 1981 to 1993 (current). Areas with homogeneous vegetation composition and structure were delineated as patches, with a minimum patch size of 4 ha. Cover types, structural classes, and potential vegetation types (PVTs) were modeled for each forest or range patch by using raw photointerpreted attributes and topographic or biophysical data from other digital sources of comparable scale and image resolution.

Each patch was assigned a vulnerability rating for three to seven vulnerability factors associated with each of 21 different potential forest insect and pathogen disturbances: one defoliator disturbance, seven bark beetle disturbances, four dwarf mistletoe disturbances, six root disease disturbances, two rust disturbances, and one stem decay disturbance. Patch vulnerability factors were taken from the published literature or were based on the expert opinions and experiences of field pathologists and entomologists with regional or localized experience in specific geographic areas. Vulnerability factors were unique for each host-pathogen or host-insect interaction modeled and included such items as site quality (differences in site potential), host abundance, canopy layers, host age or host size, stand vigor, stand density, connectivity of host patches, topographic setting, and type of visible logging disturbance.

Vegetation maps, patch attributes, and derived cover type, structural class, and PVT attributes formed the basic data set from which all subsequent pattern analyses were accomplished. Individual patches were described by their composition, structure, and PVT from selected photointerpreted attributes. We used percentage of area, mean patch size, and patch density metrics to describe changes in area and connectivity of patch types in subwatersheds of an ERU. Change from historical to current conditions was estimated as the mean difference between historical and current conditions, not as the percentage of change from historical conditions, to avoid the bias of establishing the historical condition as an essential reference. For each ERU, means, mean standard errors, and confidence intervals were estimated by using methods for simple random samples with subwatersheds as sample units. Statistically significant ($P \leq 0.2$) change was determined by examining the 80-percent confidence interval around the mean difference for the ERU.

We supplemented this statistical test with two additional analyses that enabled us to evaluate the potential ecological significance of patch type change in area or connectivity of area. First, we approximated the historical range of variation by calculating the historical sample median 75-percent range for each metric, and we compared the current sample median value with this estimate of the historical range. Second, we characterized the most significant changes in absolute area of a patch type within a sample by using transition analysis. Ecologically significant change was ultimately determined after examining each of the three pieces of information.

Physiognomic Types

Forest cover increased in the Blue Mountains, Columbia Plateau, Southern Cascades, and Upper Snake ERUs, where our results suggested that effective fire prevention, suppression, and exclusion resulted in expansion of forests into areas that previously were bare ground or shrubland or into former herbland areas previously maintained by fire or created by early logging.

Forest cover declined in the Upper Klamath ERU, and our analysis indicated that timber harvest activities during the sample period caused the observed depletion of forest area. Connectivity of forests increased in the Central Idaho Mountains and Upper Snake ERUs. The Central Idaho Mountains ERU contains large areas of congressionally or administratively designated wilderness or roadless areas, and it is likely that increased connectivity occurred as a result of fire exclusion. Connectivity of forests declined significantly in the Upper Klamath ERU where evidence of timber harvest was widespread. Forests of the Upper Klamath are naturally quite fragmented. Forested slopes often are separated by broad grassy valley bottoms and dry southerly aspects. Timber harvest apparently accentuated this characteristic.

Woodland area increased in the Blue Mountains, Columbia Plateau, Northern Cascades, Northern Great Basin, Owyhee Uplands, Snake Headwaters, and Upper Klamath ERUs and declined in no ERUs, thereby suggesting that fire suppression, fire exclusion, and grazing enabled expansion at the expense of declining herblands and shrublands. Perhaps most dramatic of all changes in physiognomic conditions was the across-the-board regional decline in area of shrublands. Shrubland area declined in all ERUs but the Southern Cascades, which had little to begin with. Ecologically significant reduction was observed in the Blue Mountains, Central Idaho Mountains, Columbia Plateau, Northern Great Basin, Owyhee Uplands, and Snake Headwaters ERUs, and no ERU exhibited increased shrubland area. Transition analyses indicated that losses to native shrublands resulted from various factors, including forest or woodland expansion as observed in the Blue Mountains and Northern Great Basin ERUs, cropland expansion as observed in the Northern Great Basin ERU, and conversion to seminative or nonnative herbland as observed in the Owyhee Uplands or Snake Headwaters ERU.

Herbland area increased significantly in the Central Idaho Mountains, Northern Great Basin, Owyhee Uplands, Snake Headwaters, and Southern Cascades ERUs and did not decline in any ERU. In the Central Idaho Mountains, herbland area increased by about 1 percent, and increases were primarily to colline and montane bunchgrass cover types. But in the Northern Great Basin, herbland area rose at the expense of shrublands; historical shrubland area fell by more than 15 percent of the land area of the ERU. Half of the lost shrubland area is currently occupied by juniper woodland, and the balance of the area currently supports montane bunchgrasses or exotic grass and forb cover. Herbland and shrubland area followed a similar pattern in the Owyhee Uplands. Across the basin, most increase in herbland area was the result of expanding colline exotic grass and forb cover with the conversion of shrublands.

Forest and Range Cover Types

Predicted shifts from early seral forest species, such as ponderosa pine, western larch, lodgepole pine, western white pine, and sugar pine, to late seral species, such as grand fir, white fir, subalpine fir, Engelmann spruce, and western hemlock, were evident in several ERUs. In some, the shift from seral to late seral climax species was at least partially masked by steep climatic gradients. For example, in the Northern Cascades ERU, Douglas-fir is seral in subalpine fir, western hemlock, and Pacific silver fir PVTs but to the east is climax or late seral in the Douglas-fir PVT.

Of all forested ERUs, the most pronounced shifts from early to late seral cover types occurred in the Northern Glaciated Mountains. Western larch cover declined significantly in the Central Idaho Mountains, Columbia Plateau, and Northern Glaciated Mountains ERUs, and ponderosa pine cover decreased in the Northern Cascades, Northern Glaciated Mountains, Upper Clark Fork, and Upper Klamath ERUs. Ponderosa pine cover increased in the Southern Cascades as a result of regrowth of forests clearcut just before the period of our historical photo coverage. Lodgepole pine cover declined in the Snake Headwaters ERU, and in six other ERUs. Western white pine cover decreased in the Northern Glaciated Mountains ERU as a consequence of white pine blister rust, mountain pine beetle mortality, and selective harvesting and increased slightly in the Northern Cascades as a result of recent reforestation efforts. Whitebark pine-subalpine larch cover declined in the Central Idaho Mountains, Northern

Glaciated Mountains, Snake Headwaters, and Upper Clark Fork ERUs and increased in the Blue Mountains and Northern Cascades ERUs. Decline in whitebark pine cover likely was the result of ongoing blister rust and mountain pine beetle mortality.

In contrast, Douglas-fir cover increased significantly in the Blue Mountains, Columbia Plateau, and Northern Cascades ERUs; grand fir-white fir cover increased in the Northern Cascades and Northern Glaciated Mountains; Pacific silver fir cover increased in the Northern Cascades ERU; Engelmann spruce-subalpine fir cover increased in the Northern Glaciated Mountains, Snake Headwaters, Southern Cascades, and Upper Clark Fork ERUs; and western hemlock-western redcedar cover increased in the Columbia Plateau, and Northern Glaciated Mountains ERUs. Engelmann spruce-subalpine fir cover declined significantly in the Blue Mountains, and Engelmann spruce-subalpine fir and western hemlock-western redcedar cover both decreased in the Northern Cascades. We believe the noted increases in shade-tolerant cover types are the direct result of effective fire suppression and exclusion and selective timber harvest.

Among woodland cover types, juniper cover significantly increased in the Blue Mountains, Columbia Plateau, Northern Great Basin, Owyhee Uplands, Snake Headwaters, and Upper Klamath ERUs and decreased in no ERU where it was a major cover type. Oregon white oak cover increased in the Northern Cascades ERU. Fire exclusion and grazing may be primary causes of the observed increases, but we were unable to test this hypothesis directly.

Significant reductions in shrubland cover types were noted in virtually every ERU, but effects were most dramatic where shrublands accounted for more than one-quarter of the land area of an ERU. The largest reductions in shrub cover types occurred in the Columbia Plateau, Northern Great Basin, Owyhee Uplands, and Upper Snake ERUs. Significant declines in shrub cover types also were observed in the Blue Mountains, Snake Headwaters, and Upper Klamath ERUs. In general, the greatest losses to shrublands were associated with forest or woodland expansion as observed in the Blue Mountains and Northern Great Basin ERUs, cropland expansion as observed in the Northern Great Basin ERU, and conversion to seminative or nonnative herbland as observed in the Owyhee Uplands or Snake Headwaters ERUs. Most shrubland cover in the Blue Mountains, Columbia Plateau, Owyhee Uplands, and Upper Snake ERUs resides below lower treeline, and in each case, the most significant losses of shrub cover occurred in these colline settings. Shrublands of the Northern Great Basin, Snake Headwaters, and Upper Klamath primarily occupy montane settings. Cover types of these elevation settings suffered the greatest losses.

In general, herbland cover increased throughout the basin as a result of declining shrubland area, but several important cover type losses also were noteworthy. Bunchgrass cover declined significantly in several ERUs, notably the Columbia Plateau, Northern Cascades, Northern Glaciated Mountains, Upper Clark Fork, and Upper Klamath. Bunchgrass cover increased in the Central Idaho Mountains, Northern Great Basin, Snake Headwaters, and Upper Snake ERUs. Exotic grass and forb cover increased in 9 of 13 ERUs. Significant increases in exotics in either colline or montane settings occurred in the Blue Mountains, Columbia Plateau, Northern Cascades, Northern Great Basin, Owyhee Uplands, Snake Headwaters, and Upper Clark Fork ERUs. Ecological reporting units most affected by expansion of exotics were, in ascending order, the Columbia Plateau, Northern Great Basin, and Owyhee Uplands. Finally, postlogging grass-forb cover increased in all forested ERUs.

Cropland area increased dramatically in two ERUs, the Upper Klamath and the Upper Snake. Cropland area declined in the Blue Mountains. Area in irrigated pastures increased in several ERUs, but only the increase observed in the Northern Glaciated Mountains was significant. Urban and rural developed area increased in half of the ERUs during the sample period; the increase was significant in the Central Idaho Mountains, Northern Cascades, Southern Cascades, and Upper Snake ERUs.

Forest and Range Structural Classes

In general, the structure of current forests of sampled ERUs was simpler when compared with historical forests, but causal links with management are difficult to establish because the amount of fire suppression or total timber harvest, for instance, was not directly measurable or quantifiable. Still, structural changes observed were consistent with management activities implicated as primary factors in the overall simplification of structural complexity of basin forests: namely, timber harvest, fire suppression, fire exclusion, and domestic livestock grazing. In future work, we will compute landscape metrics by using structural classes as patch types to further quantify patterns of structural change.

Area in forest stand-initiation structures declined significantly in four of nine forest-dominated ERUs and increased significantly in one, the Blue Mountains. Area in stand-initiation structures declined in the Central Idaho Mountains, Lower Clark Fork, Northern Glaciated Mountains, and Upper Clark Fork ERUs. Area in old-forest structures declined in most forested ERUs, but the most significant declines occurred in the Blue Mountains, Northern Cascades, Snake Headwaters, and Upper Klamath ERUs. In general, area in intermediate (not new and not old forest) structural classes (stem exclusion, understory reinitiation, and young multistory) increased in most forested ERUs; the most notable increases occurred in the Blue Mountains, Central Idaho Mountains, Columbia Plateau, Lower Clark Fork, Northern Glaciated Mountains, Snake Headwaters, Southern Cascades, and Upper Clark Fork ERUs. Area in intermediate structural classes actually declined in the Upper Klamath ERU, where most evidence suggested extensive past harvesting.

Area of open or closed shrub structure declined in every ERU where the shrubland physiognomic type comprised more than 0.5 percent of the area. The most significant loss of shrub structure in the basin was the loss of open low-medium structures (primarily sagebrushes, rabbitbrush, and bitterbrush). Significant reductions in open low-medium shrub structures were noted in the Blue Mountains, Columbia Plateau, Northern Great Basin, Owyhee Uplands, and Snake Headwaters ERUs. Significant reduction in closed low-medium shrub structure was noted in the Columbia Plateau ERU. Open herbland area increased in most ERUs where significant reduction in open low-medium shrub structure occurred. We speculate that range management activities to improve forage production for domestic livestock were responsible for much of the noted change.

Forest Vulnerability to Insect and Pathogen Disturbances

Forest landscapes have changed significantly in their vulnerability to major insect and pathogen disturbances. Changes have occurred in response to management practices common in the 20th century. Management practices have significantly increased vulnerabilities in some subbasins and ERUs, and decreased them in others. Vulnerability changes at the ERU scale often were insignificant or masked owing to high variation among sampled subwatersheds. High variability among subwatersheds within ERUs was a function of large geographic extent, high variability in vegetative communities and biophysical conditions, and variable climatic and disturbance regimes. We learned that analysis of change in vulnerability to various pathogen and insect disturbances is best accomplished at a subwatershed scale, given change among similar subwatersheds at a subregional scale.

Change analyses indicated that forests of the Blue Mountains ERU were influenced quite predictably by timber harvesting, fire suppression and exclusion, and livestock grazing. Timber harvest minimized old-forest area and area with remnant large trees to a fraction of the historical area and reduced the availability of medium and large trees in all structures. Medium and large trees were harvested from all major cover types including ponderosa pine, grand fir-white fir, Engelmann spruce-subalpine fir, and Douglas-fir. In the absence of frequent fires and under the influence of selective harvesting and grazing, Douglas-fir cover expanded, forest structures became more layered, grass and shrub understories were replaced by conifer understories, and forests and woodlands expanded in areas that were formerly grasslands and shrublands.

In the Blue Mountains, area vulnerable to western spruce budworm did not change significantly; a relatively large proportion of the ERU was vulnerable in the historical coverage, and a similar proportion is vulnerable in the existing condition. But were defoliation to occur under existing conditions, growth and mortality effects likely would be more pronounced. Area vulnerable to Douglas-fir beetle has increased because Blue Mountains landscapes in the existing condition have increased cover, connectivity, size of Douglas-fir, and stand densities. Area vulnerable to western pine beetle (type 1) disturbance of mature and old ponderosa pine fell because medium and large ponderosa pine were selectively harvested from old and other forest structures. Area vulnerable to mountain pine beetle (type 1) disturbance of lodgepole pine declined as a result of declining area where lodgepole pine occurs as a major seral species in mixed types. Area vulnerable to fir engraver and spruce beetle disturbance also declined as a result of timber harvest, extended drought, and bark beetle outbreaks.

Area vulnerable to Douglas-fir dwarf mistletoe increased with expanded area of Douglas-fir and increased canopy layering and contiguity of host patches. In contrast, area vulnerable to ponderosa pine and western larch dwarf mistletoes declined as a result of reduced area of ponderosa pine and western larch overstory cover. Even with declining area of grand fir, white fir, and subalpine fir overstory cover, area vulnerable to S-group annosum root disease likely increased. We believe this is true because the total area occupied by host species increased (but hosts now more often occur in intermediate and lower crown classes), a large percentage of the total forest area has been entered for timber harvest, and freshly cut stumps provide avenues for spread of this disease to new patches. Area and connectivity of area vulnerable to laminated root rot disturbance increased primarily as a result of increased cover and connectivity of Douglas-fir patches, but also as a result of increased area occupied by true firs.

Few significant changes in vulnerability were in evidence in the Central Idaho Mountains. For the most part, vulnerability characterizations indicated that the primary management influence during the sample period was exclusion of fire. Shade-tolerant true firs increased slightly in area and dominance, and insects and pathogens that specialize in attacking true firs were modestly favored by that increase. Area vulnerable to western spruce budworm increased but the change was not significant; a large proportion of the ERU area (49.4 percent) was highly vulnerable in the historical coverage, and a similar proportion (51.1 percent) is vulnerable in the existing condition. Area vulnerable to fir engraver and S-group annosum root disease disturbance also increased.

Our analyses suggested that dry and mesic forests of the Columbia Plateau have been influenced in a predictable manner by selective harvesting, fire suppression, and fire exclusion. Area highly vulnerable to western spruce budworm disturbance increased during the sample period; increased vulnerability was associated with increased area of Douglas-fir cover and increased area of Douglas-fir and grand fir in multilayered understories, both predicted consequences of fire exclusion and selective harvesting. Selective harvesting reduced area in old-forest structures and reduced the abundance of medium and large trees in all structures. Consequently, we observed a modest decline in vulnerability to western pine beetle (type 1) disturbance of mature and old ponderosa pine. Area vulnerable to western pine beetle (type 2) and mountain pine beetle (type 2) disturbance of immature, high-density ponderosa pine increased during the sample period as a result of expanded area of ponderosa pine cover in young multistory structures. Area highly vulnerable to fir engraver increased as a result of increased area with grand fir understories. Area highly vulnerable to S-group annosum also increased because grand fir and western hemlock in mixed species cover types, and occurring as understory species, increased during the sample period, as did area in these types with visible logging entry. Area vulnerable to white pine blister rust (type 1) disturbance of western white pine declined; decline was likely the result of white pine blister rust and mountain pine beetle mortality and selective harvesting.

Analysis of cover type and structural class changes and vulnerability characterizations indicate that significant harvesting has occurred in highly productive forests of the Lower Clark Fork ERU, but fire exclusion perhaps has had the greatest effect on conditions we observe today. In our small sample, area with medium and large trees increased during the sample period, and area in the 90- to 100- percent crown cover class and in multilayered canopies increased. Each change is a predictable consequence of fire suppression and exclusion, especially in an area where stand-replacing fire historically played such a significant role.

Area vulnerable to western spruce budworm increased but the change was not significant; a large proportion of the ERU (56.8 percent) was highly vulnerable in the historical condition, and a similar proportion (65 percent) is vulnerable in the existing condition. The 8.2-percent increase was not statistically significant because of the small sample size; further sampling is needed to establish the trend. In the absence of fire, lodgepole pine-dominated landscapes of the Lower Clark Fork aged and became more synchronous in their vulnerability to bark beetle and fire disturbances. With increased overstory and understory grand fir cover developing during the sample period, vulnerability to fir engraver disturbance also increased, but the 8.7-percent increase again was not statistically significant because of our small sample size. Similarly, area vulnerable to *Armillaria* root disease increased, but the change was not significant.

Results of vulnerability characterizations for the Northern Cascades ERU indicated that the primary effect of management during the sample period was probably timber harvest followed by fire suppression and exclusion. Area occupied by old-forest structures and medium and large trees declined significantly during the sample period, as did area of ponderosa pine cover. Area of Douglas-fir cover increased, but area of medium and large Douglas-fir declined. These results explain much of the change we observed in vulnerability to pathogen and insect disturbances. Vulnerabilities to western pine beetle (type 1) disturbance of mature and old ponderosa pine and Douglas-fir beetle disturbance both declined with the loss of medium and large hosts. Connectivity of vulnerable areas also declined, indicating that remaining distributions of medium and large ponderosa pine and Douglas-fir are relatively fragmented.

Area and connectivity of area vulnerable to western pine beetle (type 2) and mountain pine beetle (type 2) disturbance of immature, high-density ponderosa pine also declined owing to reduced area of ponderosa pine cover in young and middle-aged structures. Area vulnerable to western (ponderosa pine) dwarf mistletoe disturbance declined with the loss of ponderosa pine overstories through harvesting. In contrast, area vulnerable to S-group annosum root disease disturbance increased during the sample period. The observed increase in high-vulnerability area was associated with increased area and stature of grand fir and Pacific silver fir cover and increased area with visible logging entry.

Fire exclusion and timber harvest acted together to produce the changes in vulnerability we observed in the Northern Glaciated Mountains ERU. In our historical vegetation coverage, no visible logging entry was apparent for 91 percent of the forested area. In the current condition, signs of visible logging activity were apparent for 26 percent of that area. But old-forest area and area with remnant large trees did not decline during the sample period. Furthermore, area occupied by medium and large trees actually increased. We speculate that because stand-replacing fires once were common in the ERU, regrowth of forest in the absence of fire apparently offset some of the effects of harvesting at the ERU scale. Predicted effects of fire exclusion also were observed: increased crown cover, increased canopy layering, and increased cover by shade-tolerant understory conifers.

Area vulnerable to western spruce budworm increased with increasing cover of grand fir and subalpine fir and increased canopy layering. In the absence of fire, lodgepole pine-dominated landscapes of the Northern Glaciated Mountains became more synchronous in their vulnerability to mountain pine beetle and fire disturbances. Area and connectivity of area vulnerable to spruce beetle disturbance increased with increased area and stature of spruce in the Engelmann spruce-subalpine fir cover type. As expected, area vulnerable to ponderosa pine and western larch dwarf mistletoes declined with the reduction of ponderosa pine and western larch cover. Area vulnerable to *Armillaria* root disease and S-group annosum root disease increased with the increasing dominance of shade-tolerant overstories and understories; area and connectivity of area vulnerable to white pine blister rust (type 1) disturbance of western white pine declined as a result of white pine blister rust and mountain pine beetle mortality and selective harvesting.

Fire exclusion and, to a lesser extent, timber harvest interacted to produce the changes in vulnerability that we observed in the Snake Headwaters ERU. In the historical vegetation condition, no visible logging entry was apparent in any of the forested area. In the current condition, signs of visible current or past logging were apparent for 2 percent of the area. Old-forest area and area with remnant large trees declined during the sample period, but changes were not statistically significant. Area occupied by medium and large trees also declined. Overall, increased area with visible logging could not account for some of the changes in vulnerability we observed. Area and connectivity of area vulnerable to western spruce budworm disturbance increased dramatically during the sample period; increase was associated with increased area of Engelmann spruce-subalpine fir cover in multilayered structural arrangements. Area and connectivity of area vulnerable to Douglas-fir beetle disturbance also increased. Because total area in old-forest structures declined, most of the increased area likely was associated with increased abundance of Douglas-fir larger than 22.7 cm d.b.h. in structural classes other than old forest.

Area vulnerable to mountain pine beetle (type 1) disturbance of high-density lodgepole pine fell by 5.4 percent, and area of lodgepole pine cover declined by 4.3 percent. These results suggest that the area of small to medium lodgepole pine in both pure and mixed compositions declined during the sample period. We know that before and during the period of our sample, large areas of Snake Headwaters lodgepole pine forest were attacked and killed by the mountain pine beetle. But these results suggest that salvage and regeneration efforts influenced less than half of that area at best. Beetle disturbance and fire exclusion resulted in cover type conversion of some areas to Engelmann spruce and subalpine fir. These changes were corroborated by transition analyses. Area vulnerable to *Armillaria* root disease and S-group annosum root disease increased significantly with increasing dominance of shade-tolerant overstories and understories.

Analyses of vegetation change and characterizations of disturbance vulnerability indicated that the Southern Cascades have been influenced quite significantly and predictably by timber harvesting and fire exclusion. Area of old single-story and old multistory forest structures more than doubled during the sampling period, but area with remnant large trees associated with structures other than old forest declined, albeit nonsignificantly, by 42 percent. Area occupied by medium and large trees associated with all forest structures increased by 10 percent during the sample period. But average area in the forest physiognomic type also rose by 10 percent, mainly as a result of regrowth of large areas being clearcut harvested before our historical vegetation condition. We speculate that the large harvested area likely was dominated by patches with large ponderosa pine trees and old single-story structures.

In the Southern Cascades, area vulnerable to western spruce budworm disturbance increased; the increase was associated with increased area of multilayered, shade-tolerant understories. But area vulnerable to budworm disturbance amounts to little more than 10 percent of the area of the ERU, even in the existing condition. Area vulnerable to Douglas-fir beetle and Douglas-fir dwarf mistletoe disturbances declined because area and connectivity of patches with medium and large Douglas-fir in old forest and other structures declined. Area vulnerable to mountain pine beetle (type 1) disturbance of high-density lodgepole pine declined and area of the lodgepole pine cover remained unchanged. As was the case in the Blue Mountains, these results suggest that area of lodgepole pine in historically mixed compositions declined during the sample period as a result of mountain pine beetle outbreaks and the exclusion of regenerative fires. Area vulnerable to *Armillaria* root disease and laminated root rot disturbance increased with expanded area of subalpine fir, grand fir, and Douglas-fir in pure and mixed species compositions; expanded area of shade-tolerant understories; and increased crown cover of host species.

Forest vegetation of the Upper Clark Fork ERU has been radically altered by timber harvest and, to a lesser extent, fire suppression and exclusion. Most especially, the grain of Upper Clark Fork landscapes has been refined. In our historical vegetation coverage, 12 percent of the forest area exhibited remotely sensed visible signs of logging; in the existing condition, 37 percent of the forest area exhibited visible signs of logging. During the sample period, forest and woodland area affected by regeneration and selective harvesting jumped from 10 to 20 percent of the forest area. Overall, the level of timber harvest had little effect on old-forest area or area with remnant large trees. It was apparent from the area of stand-initiation structures in our historical vegetation coverage, that fire played a major role in regenerating forests, and it is likely that large areas of young and intermediate structure were historically typical for these landscapes. Area with medium and large trees remained relatively unchanged despite the level of timber harvest. In the absence of fires and under the influence of selective harvesting, forest crown cover declined, forest structures became less layered, and large areas developed grass and shrub understories where conifer understories once were more typical. Even area with visible dead trees and snags declined during the sample period.

Among forested ERUs, the Upper Clark Fork was one those most heavily influenced by past timber harvest. It was not surprising that most vulnerability changes were declines. Area and connectivity of area vulnerable to Douglas-fir beetle disturbance declined owing to reduced crown cover of large and medium Douglas-fir across all forest structural classes. Area vulnerable to western pine beetle (type 1) disturbance of mature and old ponderosa pine declined as a consequence of reduced area in the ponderosa pine cover type and reduced crown cover of medium and large ponderosa pine across all forest structural classes.

Area vulnerable to western pine beetle (type 2) and mountain pine beetle (type 2) disturbance of immature, high-density ponderosa pine also declined as a result of reduced area in the ponderosa pine cover type and reduced area of stem-exclusion, understory reinitiation, and young multistory structures with ponderosa pine in pure or mixed compositions. In contrast, area and connectivity of area vulnerable to fir engraver disturbance increased during the sample period. High-vulnerability area increased primarily as a result of increased area in the subalpine fir-Engelmann spruce cover type in all forest structural classes except stand initiation. Vulnerability to dwarf mistletoe disturbances of Douglas-fir, ponderosa pine, and western larch declined during the sample period. The observed decline was the result of significantly reduced patch area and contiguity with medium and large hosts in multilayered structures.

In the historical vegetation condition, more than one-half (53 percent) of all forest cover in the Upper Klamath ERU was ponderosa pine and 23 percent of all forest structure was old forest; 38 percent of all forest structures had at least 10 percent or more crown cover of large trees. In the existing condition, 49 percent of all forest cover is ponderosa pine and 21 percent is old forest; 36 percent of all forest structures have at least 10 percent or more crown cover of large trees, but crown cover of medium and large trees has been substantially reduced. Selection cutting reduced the crown cover of medium and large trees for 31 percent of the forest area. Much like the Upper Clark Fork, in the absence of fires and under the influence of heavy selective harvesting, forest crown cover declined, forest structures became less layered, and large areas developed grass and shrub understories where conifer understories once were more typical. Forest area declined by an average of 3 percent; likewise, area with visible dead trees and snags declined during the sample period. Among forested ERUs, the Upper Klamath was probably the second most heavily influenced by past timber harvest, and as with the Upper Clark Fork, most vulnerability changes were declines.

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Introduction

> A biological system, whether individual or ecological, can be considered healthy when its inherent potential is realized, its condition is stable, its capacity for self repair when perturbed is preserved, and minimal external support [from] management is needed....Stability is not the stability implied in the Clementsian view of the community; rather it is compatible with the widespread recognition that biological systems are metastable (*sensu* Botkin 1990).
>
> Our ability to change the world [now] outpaces the ability of biological systems to respond to those changes. Even our minds and our language evolve too slowly to deal with the rate of environmental degradation....Our success as a world society depends on an environmental revolution—on our ability, that is, to change our vocabulary and our perceptions so that we can indeed protect ecological integrity.
>
> No clear standard has been developed to measure biological condition, however, or to define the nature and extent of degradation. The lack of a standard has, by default, resulted in society's ignoring the status of [human] life support systems. No single innovation can reverse that trend. Recognizing the problem as a serious social issue fosters dialogue to define our goals—to define the level of ecological health we can accept as a society. Hence we must develop a rational approach to the definition of ecological health, methods to measure that health, and mechanisms to incorporate protection of ecological health into society's decision-making processes.
>
> James R. Karr (1992)

Forest and range ecosystems of the interior West are exceedingly rich and diverse owing to great variety in climate, geology, landforms, hydrology, flora, fauna, and ecological processes (Bailey 1995, Franklin and Dyrness 1973, Hann and others 1997, Jensen and others 1997, Lee and others 1997, Marcot and others 1997). Recurring disturbances, such as those caused by fires, insects, pathogens, and wind, are essential to maintaining this diversity (Agee 1990, 1993, 1994; Arno 1976, 1980; Edmonds and Sollins 1974; Gara and others 1985; Hagle and others 1994, 1995; Hall 1976; Harvey and others 1992, 1995; Hessburg and others 1994; Martin 1988; Turner 1987, 1989; Wickman 1992). Terrestrial plant communities range from dry, short grass prairies and sagebrush shrublands, to cool and moist western hemlock and western redcedar forests, and high-elevation whitebark pine and subalpine larch forests, krummholz, and heath.[1] Alpine tundras, rock barrens, and glaciers comprise many of the highest elevations.

Landscape patterns and ecological characteristics of these various communities are closely related to their fire, insect, and pathogen ecology. Even though broad landscape patterns of life forms and physiognomic types arise from broad differences in topography and physiography, lithology, geomorphic processes, climate regime, and large-scale

[1] Scientific names of all species are given in table 8.

disturbances, fine and medium grain[2] patterns within the general framework of coarse patterning are the result of environmental gradients, patch-scale and gap disturbance, stand development, and succession processes.

Native fire regimes range from frequent, nonlethal surface fires typical in dry forests of the ponderosa pine and Douglas-fir series,[3] to moderately infrequent, mixed-severity fires characteristic of mesic and moist forests of the grand fir, western hemlock, and western redcedar series, and infrequent, lethal, stand-replacing fires typical in cold subalpine forests.

Native insect and pathogen disturbance regimes also are variable in their frequency, severity, duration, and spatial extent. Pandemic bark beetle and defoliator outbreaks, for example, occur relatively infrequently in any given geographic area (once or twice a century at most), and such outbreaks often are synchronous with climatic extremes and cycles of geographically dominant vegetation structure or composition resulting from other major pattern-forming agents or events. But bark beetle, defoliator, or pathogen disturbance associated with local and endemic populations is ongoing, blending seamlessly with succession and stand-development processes; for example, dwarf mistletoes and root pathogens bring about the mortality of individual large trees over a span of several decades to several centuries, but their effects on composition and structure of landscapes can be quite spectacular because of their wide distribution, longevity, and degree of host specialization. For the most part, it is appropriate to think of native forest pathogens and insects as agents of succession (*sensu* Byler and others 1996, Hagle and Williams 1995, Hagle and others 1995), selectively killing or reducing the growth and vigor of a particular tree species or size class, and thereby bringing about discernible transitions in composition and structure at patch and landscape scales.

Oliver and Larson (1990) present an ordered progression of stand-development phases resulting from stand dynamics and disturbance processes, but in the interior West, insect, pathogen, and fire disturbances bring about a nonsequential progression of transitions (O'Hara and others 1996). Insect, pathogen, and fire disturbances are, in fact, so common and varied in their effects on vegetation structure and composition that both seral status and structural development may be advanced or retarded by individual disturbances or complex interactions among disturbances (see also Keane and others 1996).

Declining health of forest ecosystems in the interior West has been the subject of much study, concern, and controversy in recent years (for example, see Agee 1994, Byler and others 1994, Byler and Zimmer-Grove 1990, Everett and others 1994, Gast and others 1991, Harvey and others 1995, Hessburg and others 1994, Huff and others 1995, Lehmkuhl and others 1994, Monnig and Byler 1992, O'Laughlin and others 1993, Wickman 1992). Land-use practices of the last 100 years have altered disturbance regimes, spatial and temporal patterns of vegetation, and reduced ecosystem resilience in the face of ongoing disturbance. Concern over "declining forest health" centers around the human perception that past forest management activities have had a deleterious effect on forest ecosystem structure and functioning. The perception is founded on the widely held social value that forest (and rangeland) ecosystems ought to appear natural and be allowed to function naturally. In that context, significant departure from native conditions in the appearance of forests, in attributes of disturbance regimes (such as disturbance frequency, duration,

[2] The grain of a given landscape is a function of the average size and size range of patches comprising that landscape; for example, a landscape with a coarse grain is comprised of relatively large patches ranging in size from hundreds to perhaps thousands of hectares. A landscape of fine grain is comprised of many small patches ranging from a fraction of a hectare to several hectares. The grain of any given landscape depends on the scale at which agents of pattern formation operate locally and the scale of observation.

[3] A *series* is a conceptual grouping of related plant associations having the same predicted dominant climax species; the series takes the name of the dominant species. A *plant association* is a potential vegetation type in a hierarchical classification scheme directly beneath the series level; the plant association takes the name of a predicted climax community type. A *community type* is a conceptual synthesis of all plant communities having similar structure and floristic composition with no successional status implied; it is simply an assemblage of plants that live together, interact, and compete among themselves (Daubenmire and Daubenmire 1968, Driscoll and others 1984).

distribution, intensity, and extent), and in other vital ecosystem processes (such as succession, species migration, speciation, extinction) is indicative of unnatural or deviant functioning and uncertain outcomes. Hence, by virtue of the perceived deviant functioning and unease with expanding uncertainty, a negative connotation is applied to changing ecosystems in the notion of "declining ecosystem health."

Fire suppression, timber harvest, and livestock grazing have contributed most to increased forest ecosystem vulnerability to insect, pathogen, and wildfire disturbance (Agee 1994, Everett and others 1994, Gast and others 1991, Hann and others 1997, Hessburg and others 1994, Johnson and others 1994, Lehmkuhl and others 1994, Martin and others 1976). These conditions are not pervasive, however, and some forests remain in relatively healthy[4] and productive condition.

Many studies focusing at the stand level have characterized fuel loading (Fischer 1981; Maxwell and Ward 1976, 1980) and fire behavior characteristics (Anderson 1982, Brown and See 1981, Fahnestock 1976, Ward and Sandberg 1981) for a broad range of forest structural conditions occurring across an equally broad range of potential vegetation types. Likewise, numerous hazard rating systems have been devised to assess the susceptibility of stands of varying structure, composition, age, vigor, and density to bark beetle disturbance (for example, see Amman and others 1977; Amman and Anhold 1989; Berryman 1978, 1982; Cole 1978; Cole and Cahill 1976; Crookston and others 1977; Mahoney 1978; McGregor 1978; Miller and Keen 1960; Mitchell 1987; Mitchell and others 1983a, 1983b; Roe and Amman 1970; Safranyik and others 1974, 1975; Schenk and others 1980; Shore and others 1989; Stuart 1984; Waring and Pitman 1980) or defoliator infestation (Carlson and others 1985; Heller and Kessler 1985; Stoszek and Mika 1984, 1985; Wulf and Carlson 1985). Stand structural and compositional conditions most conducive to damage by dwarf mistletoes and root pathogens have been characterized, modeled, and articulated as well (Dixon and Hawksworth 1979; Edminster 1978; Edminster and others 1991; Geils and Mathiasen 1990; Hadfield and others 1986; Hawksworth and Johnson 1989; Hawksworth and others 1995; Knutson and Tinnin 1980; Myers and others 1971, 1976; Parmeter 1978; Robinson and Sutherland 1995; Stage and others 1990; Strand and Roth 1976). But little is known of the effects of cumulative stand-level shifts in forest composition and structure over long time spans on landscape composition, structure, and patterns. Even less is known about the effects of shifting landscape patterns on fire, insect, and pathogen disturbance processes or their interactions.

This paper is the first part of a two-part study conducted under the aegis of the Interior Columbia Basin Ecosystem Management Project (ICBEMP). Here, we report on a midscale scientific assessment of vegetation change in terrestrial landscapes of the interior West and associated change in landscape vulnerability to potential insect and pathogen disturbances. Part II (Ottmar and others, in prep.) will evaluate change in ground fuel conditions, potential fire behavior, and related smoke production associated with reported vegetation change. Our assessment area included the interior Columbia River basin east of the crest of the Cascade Range in the Western United States and portions of the Klamath and Great Basins in Oregon (collectively, the basin).

Our study had five objectives:

1. To characterize current structure and composition of a representative sample of forest and range landscapes distributed throughout the basin.
2. To compare existing vegetation conditions (1981-93) to the oldest historical vegetation conditions (1932-66) we could reconstruct at a comparable scale. This was done with the hope of better understanding directions, rates, and magnitudes of vegetation change occurring

[4] In this paper, we say that a forest is healthy when its inherent potential is realized, its condition is metastable, and its capacity for self-repair when perturbed is preserved. Inherent potential is the product of biophysical environment, climate, associated disturbance and other ecological processes. A metastable condition involves continuous yet bounded change; change is bounded in its nature and magnitude due to dominant features of environment, climate, and disturbance regimes.

during the first century of active resource management and exploitation. Our sampling period, although less than 100 years, corresponded well with the period of most intensive timber harvest, road construction, and fire suppression; a period of intermediate or declining intensity in range management; and a period of comparable climate regime.

3. To link historical and current vegetation patterns with landscape vulnerability to potential insect and pathogen disturbances to better understand patterns and disturbance vulnerability relations and more directly characterize some effects of historical management practices.

4. To link historical and current landscape vegetation characteristics throughout the basin with fuel conditions, potential fire behavior, and related smoke production. Our rationale was twofold: these links would enable us to better understand causal connections among historical management activities, such as selective harvesting, fire exclusion, and domestic livestock grazing, and current conditions for potential fire behavior and smoke production; and they would assist us in evaluating current air quality and human health tradeoffs associated with wild and prescribed fires.

5. To synthesize and summarize our findings so that our information might provide regional and subregional contexts for Federal and other management agencies to formulate ecologically sound management strategies for terrestrial ecosystems.

We speculate on possible relations between historical land use and our results, considerations for future management, and research and validation questions that can be answered with further analysis of these and supporting data.

Methods

Study Area

In this study, we sampled environments and vegetation conditions representative of each of the major forest and range provinces of the basin. We characterized recent historical and current vegetation composition and structure of each of these sampled environments and compared landscape patterns, vegetation structure and composition, and landscape vulnerability to major insect and pathogen disturbances of historical and current vegetation coverages. The study area included all of Washington and Oregon east of the crest of the Cascade Range, nearly all of Idaho, and portions of northwestern Montana, western Wyoming, northern California, northern Utah, and northern Nevada (fig. 1). The following Bailey provinces (from Bailey 1989, 1994a, 1994b, 1995) were included in the study area: Northern Rocky Mountain Forest—M333, Cascade—M242, Great Plains-Palouse Dry Steppe—331, Middle Rocky Mountain—M332, Intermountain Semidesert—342, Intermountain Semidesert and Desert—341, Sierran—M261, and Southern Rocky Mountain—M331.

Overview of Biophysical Environments

In this section (adapted from Bailey 1995), we briefly describe broad, province-scale differences in environments of the basin to provide a general overview of biological and physical environment and climatic conditions of the study area. At the end of this "Methods" section, we introduce ecological reporting units (ERUs), province-scale land units used as statistical pooling strata for reporting results of change analysis. Ecological reporting units were developed as land units useful for generalizing results of all broad-scale and midscale basinwide ecological, social, and economic assessments. Because ERUs do not represent purely biophysical environments, we briefly review differences in province-scale ecological land units of the basin. Refer to Jensen and others (1997) for an indepth, multiscale discussion of basin biophysical and hydrologic environments.

Northern Rocky Mountain Forest Province—Landforms of the Northern Rocky Mountain Forest Province (fig. 1) consist primarily of high, glaciated mountains separated by broad, flat valleys. Winters can be severe with a heavy snow pack. Dry growing seasons result from strongly influential westerly air masses; climatic regimes are maritime where Pacific Coast influence dominates and continental elsewhere. Precipitation averages 51 to 102 cm annually and is concentrated in fall, winter, and spring. Forests are mixed coniferous and deciduous, with Douglas-fir and cedar-hemlock often dominating.

Elevation belts are clearly indicated by lifeform changes. Alpine[5] environments are barren and tundralike;[6] subalpine[7] belts are dominated by Engelmann spruce, subalpine fir, or mountain hemlock forests as in the Bitterroot Mountain

[5] Alpine environments occur above upper treeline and below the snow line in mountainous regions. With the exception of subalpine (often called alpine) larch, conifers are unable to persist in these environments in an upright growth form.

[6] Barren treeless environments are found north of the Arctic Circle and above the upper tree line of high mountains (alpine tundra). Tundra environments are characterized by very low winter temperatures and short cool summers; soils display a permafrost layer beneath the uppermost layers affected by summer melt. Tundra vegetation is dominated by lichens, mosses, sedges, low shrubs, and subshrubs.

[7] Subalpine environments occur near the upper treeline. For much of the year, these environments are snow covered, cold, and often harsh. For most coniferous species, the subalpine zone defines the upper elevation range of conifers.

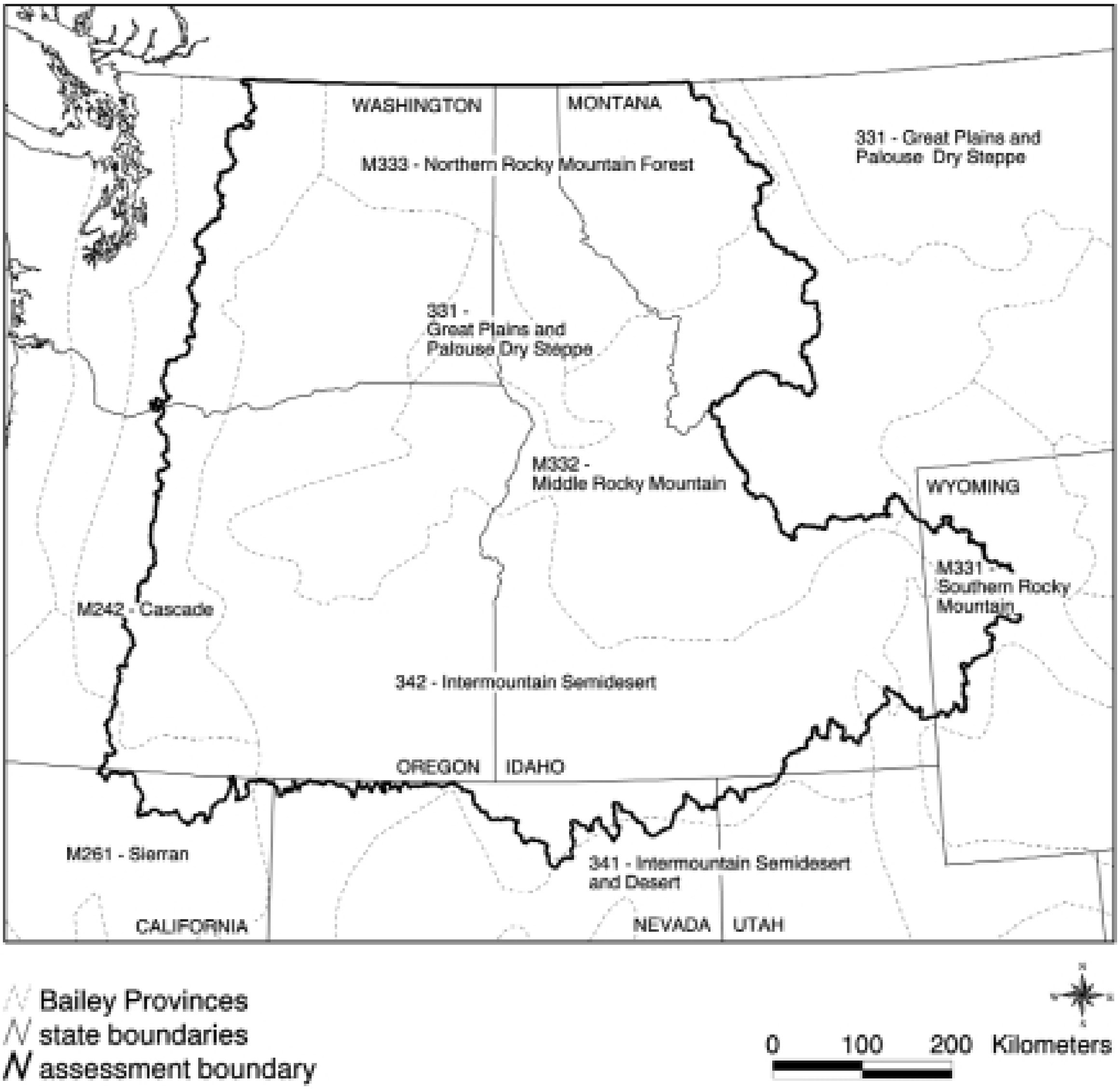

Figure 1—Interior Columbia River basin assessment area with Bailey province boundaries.

Range. Western hemlock and western redcedar forests characterize montane settings in association with Douglas-fir, western white pine, western larch, grand fir, and to a lesser extent ponderosa pine. Lower montane[8] and colline[9] environments are dominated by grasses and sagebrush.

Soils are cool and moist Inceptisols and are often shallow and stony, but unlike elsewhere in the Rocky Mountains, these factors play a minor role in the distributions of forests. Foothill soils tend to be quite productive as a result of rich loess[10] and ash deposits.

Cascade Province—This province is bisected by the study area boundary (fig. 1). We adapted the description so that it pertains to the portion of the province within the basin study area. Dominant landforms of the Cascade Province are the result of widespread volcanic activity. Rugged mountains of the northern Cascades of Washington also have been repeatedly glaciated. Terrain in the north is steep and highly dissected with relatively narrow valley bottoms except where glaciated. Maritime climatic regimes dominate throughout because of the close proximity and influence of Pacific Coast air masses. Precipitation is heavy at the crest and declines rapidly to the east due to rain shadow effects. Annual precipitation at the crest is 380 cm; eastern foothills receive as little as 51 cm precipitation annually. Fog partially compensates for droughty summer seasons. Most precipitation occurs as snow.

Vegetation patterns in the northern and southern extremes of the province are distinctly different. At the northern end, alpine environments are glaciated or barren close to the Cascade crest and are tundralike to the east. Subalpine belts are dominated by mountain hemlock forests and tree-islands intermixed with heath shrublands at the crest. Subalpine fir and Engelmann spruce intermixed with subalpine herblands dominate to the east. Whitebark pine and subalpine larch occur sporadically throughout. Pacific silver fir, western hemlock, Douglas-fir, and noble fir characterize montane forests at the crest; to the east, grand fir, Douglas-fir, western larch, and ponderosa pine dominate. Ponderosa pine and sagebrush steppe[11] characterize the lower montane and colline elevation belts found mainly to the east.

At the southern end of the province, alpine belts are tundralike and barren. Mountain hemlock and lodgepole pine dominate subalpine forests intermixed with barren herblands. Shasta red fir provides the transition to montane forest types dominated by grand fir or white fir, Douglas-fir, and ponderosa pine. Lodgepole pine forms extensive forests in this belt on flat ground. Ponderosa pine, western juniper, and sagebrush dominate lower montane and colline settings.

Andisols are extensive and often overlay volcanic ash. Moist Inceptisols are widely distributed west of the Cascade crest, but soils east of the crest are dry and erosive as a result of deposition of unconsolidated volcanic ash.

Great Plains-Palouse Dry Steppe Province—Landforms of the Palouse dry steppe region (fig. 1) consist of rolling plains and loess-covered basalt tablelands ranging in elevation from 370 to 1800 m. Plains are flat or rolling and frequently dissected by valleys and canyons. The Palouse short grass prairies lie in the rainshadow of the Cascade Range in Washington, where summers are hot and dry. Throughout the Great Plains, winters are cold and dry; but on the Palouse steppe, precipitation reaches its maximum in the winter. Precipitation ranges from 26 cm in

[8] Montane environments are relatively cool, moist upland habitats occurring above the lower treeline, where coniferous vegetation often dominates. Lower montane environments are among the driest forested settings. They occur immediately above the lower tree line. Upper montane environments support coniferous vegetation favoring cool to cold and moist to wet growing conditions.

[9] Colline environments occur immediately below the lower treeline.

[10] Loess, in this usage, refers to soil accumulations derived of fine, unconsolidated, wind-blown volcanic ash and glacial till. In other areas, loess accumulations are the result of aeolian (wind blown) deposits and may be alluvial (silty deposits initially transported by water), colluvial (deposits initially transported by gravity), or lacustrine (lake bottom) in origin.

[11] Steppe refers to semiarid, treeless environments where shrub or herbaceous species comprise the dominant vegetative cover.

the northern portion of the province to more than 64 cm in the south, with maximum rainfall occurring during summer. Evaporation usually exceeds precipitation; when precipitation occurs, it often comes as hail storms and blizzards.

At the time of this assessment, much of the native herbland vegetation of the Palouse region had already been converted to dryland agriculture. What remains, except for remnant shrublands and relict[12] juniper woodlands, are small isolated islands comprised of native short grasses, such as bluebunch wheatgrass, Idaho fescue, and bluegrasses, and often other nonnative grasses and forbs. Soils are derived of rich loess accumulations deposited during periods of glacial recession. Mollisols are common, but humus depth is typically minimal because vegetation is sparse.

Middle Rocky Mountain Province—The Middle Rocky Mountains Province is comprised of the Blue Mountains, Salmon River Mountains, and the basins and ranges of southwestern Montana (fig. 1). Central Idaho and the Salmon River Mountains developed from granitic intrusions that collectively make up what is known as the Idaho Batholith. Terrain is deeply dissected in the batholith with much evidence of weathered granitic substrates. In southwestern Montana, basin and range landforms are mountains with broad alluvial plains at their bases. Most of the highest peaks throughout the province have been influenced by repeated glaciation. The Blue Mountains in the western portion of the province are comprised of uplifted basalts originating from repeated overland flows associated with the Columbia River Basalt Group.

Climate within the province is strongly influenced by maritime air flows up the Columbia mainstem from the Pacific Ocean, but continental influences also are apparent in the southwestern portion of the province, especially in the John Day and Malheur basins. Precipitation in montane forests occurs mostly as snow, and interior valleys tend to be dry and semiarid. Valleys receive less than 51 cm of precipitation annually, but mountainous regions may get up to 77 cm.

[12] Relict, in this usage, refers to a persistent remnant of a formerly widespread western juniper woodland existing in isolated areas.

Clear zones of vegetation by elevation belt are evident. Alpine settings are tundra. Whitebark pine, subalpine fir, and Engelmann spruce dominate subalpine belts. Lower montane forests are dominated by ponderosa pine, and midmontane environments are comprised chiefly of Douglas-fir and grand fir in the more moderate aspects and elevation settings. Lodgepole pine and grasses dominate the basins and ranges in the eastern and southeastern portions of the province. Colline semidesert environments are dominated by sagebrush and short grasses.

Soils of the alluvial fans and interior valleys are Mollisols, which support sagebrushes and grasses. Above 610 m, forest soils are Alfisols except where glaciated or with steep slopes; Inceptisols predominate in the latter locations.

Intermountain Semidesert Province—The Intermountain Semidesert Province (fig. 1), which includes the Columbia River and Snake River plains in eastern Oregon and Washington, southern Idaho, and the Wyoming basin, is the largest province of the basin study area and spans more than 412 000 km^2. Landforms consist of flat to rolling plains and tablelands. Above 762 m, plateaus are surrounded by folded and faulted lava ridges, which make up most of the lava fields of the region. In the southern portion of the province, intermountain basins and isolated mountain ranges meet strongly dissected plateaus.

Climate of the high plateaus is cool and semiarid. Average annual precipitation ranges from a low of 25 cm in the rangelands just east of the Cascade Range, to 51 cm farther east; accumulations are somewhat evenly distributed throughout fall, winter, and spring. Winters are long and cold, and summers are hot and dry. Because of the higher elevation of the Wyoming basin, its climate is cooler than that of the rest of the province, and average precipitation is typically lower, ranging from 13 to 36 cm annually. Summers there are short, hot, and dry, and winters can be quite severe.

Steppe vegetation is dominated by sagebrushes, shadscale, and short grasses. In central Oregon, a large area of western juniper-dominated woodland is apparent where annual precipitation exceeds 25 to 30 cm. Colline valley bottoms are lined with willows and sedges, and those of the intermountain valleys support greasewood and other alkali-tolerant shrubs and herbs. Moist alkali flats also commonly support greasewood cover types. In eastern Washington, areas that once were dominated by bunchgrass herblands now support extensive dryland wheat farms.

Rich alluvial deposits are widespread throughout this province in broad flood plains and at the bases of the Cascade and central Idaho mountains. Dry lake beds are numerous as are dune and loess deposits. Aridisols dominate throughout the province in basin and lowland areas. Mollisols are typical in the higher elevations. Soils of the Wyoming basin, also Aridisols, are alkaline enriched with lime and gypsum, and hardpans[13] often form naturally or with cultivation. Entisols make up much of the Bighorn basin soils.

Intermountain Semidesert and Desert Province—This province enters the basin assessment area at its southern edge in Nevada (fig. 1). Great Basin and northern Colorado Plateau physiographies comprise most of the area. Really a misnomer, the Great Basin consists of many smaller basins with no outlet to the sea. Landforms are varied with mountains rising sharply from semiarid shrub-covered plains. Mountains are well vegetated, but conifer forests are few and limited to the uppermost elevations of high mountains. Summers are hot, and winters are moderate. Annual precipitation averages 13 to 49 cm, much of which accumulates as snow. Almost no rain falls during summer, except occasionally in the mountains. Spring seasons are typically long because mild temperatures come early to the Great Basin, especially in the lower elevations.

Alkaline soil conditions are widespread, and most vegetation is semitolerant of alkali. Lower elevations are dominated with sagebrush often associated with bitterbrush, shadscale, saltbush, rabbitbrush, hopsage, and horsebrush. In the most alkali areas, greasewood and saltgrass cover types dominate. In areas currently sagebrush dominated, steppe grasses such as those of the Palouse Prairie once were more abundant. Current widespread distribution of sagebrushes may be the result of repeated historical overgrazing combined with fire suppression. At higher elevations above a conspicuous shrubland belt, pinyon pine and juniper woodlands dominate. Above the woodlands, ponderosa pine dominates exposed slopes and Douglas-fir the higher, more sheltered settings. Subalpine environments, when occurring, are comprised of subalpine fir and Engelmann spruce. Exact composition of forested settings differs considerably from mountain range to mountain range, presumably the result of differing migration rates. As in the preceding province, soils of basin and lowland areas are Aridisols, and Entisols line some flood plains in narrow bands. Salt flats[14] and playas[15] are typical in the lower elevations of basins with interior drainage.

Sierran Province—The Sierran Province is comprised of the southern extremity of the Cascade Range in Oregon, the northern Coast Range in southwest Oregon, the Klamath Mountains of southern Oregon and northern California, and the Sierra Nevada of east-central California. Of this large area, only the Klamath Mountains and southern Cascades are included in the basin assessment area (fig. 1). Landforms of the province consist of steep to precipitous mountains separated by valleys with long and relatively steep elevation gradients. The Sierra Nevada drop off abruptly to the Great Basin region to the east, and more gradually to the west. Within the basin assessment area, only alpine environments of the Klamath Mountains are glaciated, and subalpine and alpine environments are rugged.

Air masses from the Pacific Coast influence the climate of most of the region. Within the study area, average annual precipitation ranges from 25 to 178 cm with rain and snow occurring in roughly equal proportion. Dense, mixed coniferous forests occupy the montane zone (900 to 2100 m) where the greatest total precipitation

[13] A hardpan is a compacted layer in the B-horizon of a soil typically rich in deposited salts, and restricting drainage and root penetration. The B-horizon is an upper subsoil layer with an accumulation of clay, humus, iron, and various oxides as a result of leaching and translocation from upper layers.

[14] Salt flats are salt-covered, flat-floored, ancient lake beds remaining after an inland lake has evaporated.

[15] Playa is the flat bottom of an undrained desert basin that at times becomes a shallow lake.

occurs. Subalpine settings receive as much as 100 to 125 cm of precipitation, with most occurring as snow.

Elevation zones are distinctly marked by lifeform and vegetation changes. Montane forests within the assessment area are dominated by ponderosa at lower elevations, and Douglas-fir, sugar pine, incense-cedar, Shasta red fir, and white fir in middle and upper elevations. Subalpine forests are composed of Shasta red fir, mountain hemlock, lodgepole pine, western white pine, and an occasional whitebark pine. Below lower treeline, ponderosa pine gives way to juniper woodlands. On mountain slopes where the coastal influence is greatest, soils are Ultisols, whereas dry Alfisols are more typical in lower montane and colline environments. Alluvial and fluvial soils are typically Entisols.

Southern Rocky Mountain Province—In the Southern Rocky Mountain province, only the Snake River headlands in southeastern Idaho and western Wyoming reside within the basin assessment area (fig. 1). Landforms include glaciated high mountains with peaks of 4300 m or more, intermontane parks (herblands and shrublands) or depressions at intermediate elevations (< 1800 m), and semiarid valleys at lower elevations. Climate is dry, resulting primarily from continental air masses. Primary factors of influence to climate are prevailing westerly winds and the north-south orientation of major ranges. The west slope of the Rocky Mountains within this province area receives considerably more moisture than the eastern slope. Average annual precipitation ranges from 25 cm at the lowest elevations to as much as 100 cm in the high mountains where most precipitation occurs as snow.

Distinct vegetation zones are the direct result of elevation and latitude gradients, prevailing winds, and the degree of slope exposure. North aspects and narrow valleys support vegetation associated with the coldest environments for growth and survival. Alpine settings are tundra or barren; subalpine environments are dominated by subalpine fir and Engelmann spruce. Lodgepole pine and aspen are important early seral components of montane and subalpine environments. Montane environments are dominated by Douglas-fir and ponderosa pine; ponderosa pine is especially prominent in the lowest and driest montane settings, and Douglas-fir is restricted to more mesic[16] and sheltered environments. Foothill colline environments within the assessment area are comprised of mixed conifer woodlands, sagebrush, scrub oak, maple, mountain-mahogany, or bitterbrush shrublands, and herblands. Aridisols are characteristic of foothills environments, Mollisols and Alfisols are characteristic of lower and mid-montane settings, and steep glaciated slopes typically have Inceptisols.

Sampling Design

Software tools—In this section, we describe the computing hardware and software we used and its application in this project to provide an analytical context for the subsequent descriptions of methods. We used various commercially available computer hardware and software products to complete this assessment, including geographical information systems (GIS); packages for statistical, spatial, and ecological data analysis; relational databases and spreadsheets; and programming language compilers for custom, inhouse software. These programs were used on several hardware-operating system platforms, including Sun® workstations and X-terminals with Solaris® (Sun's Unix operating system) and personal computers with OS/2® and DOS/Windows® operating systems.[17]

This assessment was a map-based characterization of landscape patterns and ecological processes across space and time. We used two GISs to manipulate and analyze digital maps: ARC/INFO (ESRI 1995) was the principal GIS used for most analyses, and GRASS (USACERL 1992) was used in analyses leading to sample stratification. ARC/INFO was used with a wide variety of maps to manipulate, combine, and query coverages to derive data sets for further analysis with other

[16] Mesic pertains to environmental conditions of moderate moisture or water supply; applies to organisms that occupy habitats displaying intermediate levels of soil moisture or water availability.

[17] The use of trade or firm names in this publication is for reader information and does not imply an endorsement by the U.S. Department of Agriculture of any product or service.

software. We used ARC/INFO's macroprogramming language (AML) to develop and run inhouse spatially explicit models, such as our insect and pathogen vulnerability characterizations (Hessburg and others, in press), and potential fire behavior models (Ottmar and others, in prep.).

Spatial and statistical analyses were done to characterize change in patterns and to quantify statistical and ecological significance of those changes. FRAGSTATS (McGarigal and Marks 1995) was used to compute a variety of class and landscape pattern metrics directly from ARC/INFO data tables; FRAGSTATS is distributed with a source code for Unix operating environments. We modified the FRAGSTATS source code by incorporating additional metrics and correcting computational errors of several algorithms. S-PLUS (MathSoft Inc. 1993) is a statistical package that reads ARC/INFO data files directly. We used it to summarize ARC/INFO and FRAGSTATS outputs. Summaries were displayed in tabular and graphic formats.

A spatially explicit context was not required for some analyses. Data were generated by ARC/INFO and exported into a Paradox® relational database or Excel® spreadsheet. Ad hoc queries were used to generate summaries and reports. Paradox also was used to derive or model other attributes, such as potential vegetation type described later in this section (see also Smith and others, in prep). An ecological data analysis package, EcoAid,[18] which reads Paradox data files directly, was used to conduct some ordination and cluster analyses. Other inhouse programs that read from or wrote to Paradox files also were written for computations not available in conventional software packages. These programs are available through the first and second authors.

Land and hydrologic unit sampling framework—To provide insight into management-induced cause-and-effect relations between terrestrial and aquatic ecosystems, it is preferable that ecological characterizations classify environments as terrestrial (both biological and physical dimensions) and hydrologic, at scales appropriate to observing the patterns, processes, and interactions of interest. If, for example, an analysis is conducted to evaluate effects of roads on the distribution of native trout life histories in an area, land areas ought to be hydrologic domains sufficiently large to represent a nearly full complement of trout life histories. If that were not the case, it would be difficult to separate effects of stream network size from the effects of roads on bull trout life histories. For reasons such as these, we chose large sample units, unique in their hydrology, climate, geology, vegetation, and landform. The ECOMAP land unit hierarchy (ECOMAP 1993) provided a framework for ecological land units used in this assessment; the U.S. Geological Survey (USGS) hydrologic unit hierarchy (Seaber and others 1987) provided an initial framework for hydrologic units. Both were used to stratify watersheds of the basin for sampling and characterization.

The USGS hydrologic unit hierarchy supplied a nested, four-level classification of watersheds of similar size and scale for the entire United States. The fourth level in that hierarchy (subbasin or 4th Hydrological Unit Code [HUC]) was used to initially stratify watersheds of the interior Columbia River basin assessment area for sampling. In addition, results from the Eastside Forest Ecosystem Health Assessment (Everett and others 1994, Lehmkuhl and others 1994) indicate that smaller hydrologic units of 4000 to 8000 or more ha were suitable for characterizing, on a sampling basis, patterns and changes in structural attributes (both composition and configuration) of vegetation within 4th code HUCs. Complete hydrologic unit coverages of this scale for the entire interior Columbia River basin were lacking in the existing USGS hierarchy. Consequently, two additional nested levels (5th code HUCs or watersheds, and 6th code HUCs or subwatersheds) were developed within the established fourth level of the hierarchy for this assessment (fig. 2). Refer to Jensen and others (1997), for a description of watershed and subwatershed delineation methods.

Subbasin stratification and subwatershed selection—Subbasins were selected from a formal stratification of all subbasins in the basin by

[18] EcoAid is an inhouse software package for analyzing ecological data sets. Copies are available on request from the second author.

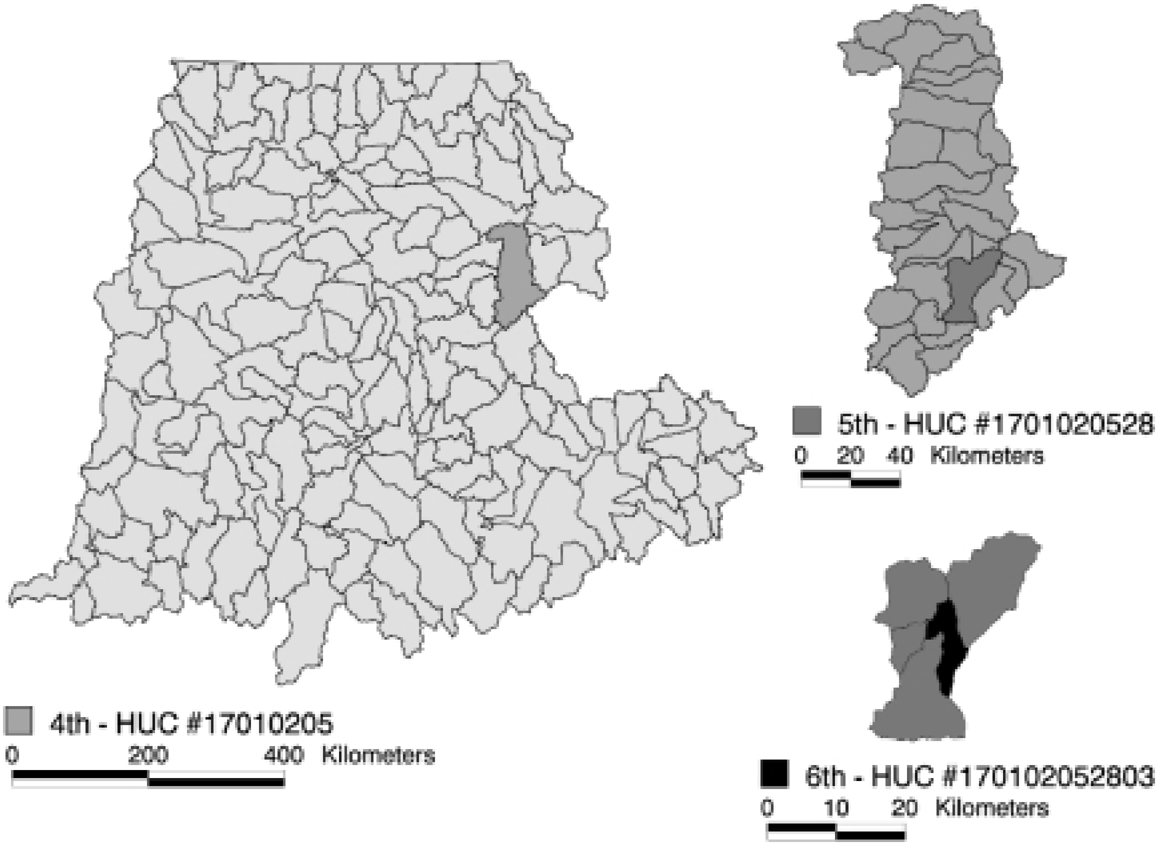

Figure 2—Hierarchical organization of subwatersheds (6th code HUCs), watersheds (5th code HUCs), and subbasins (4th code HUCs) in the interior Columbia River basin and portions of the Klamath and Great Basins.

their Bailey province membership and similarity of area in 304.8-m elevation zones. Subbasin areas in each elevation zone were derived in a GIS by using a 90-m digital elevation model (DEM) resampled to 1-km cell size. Similarity analyses employed the percent similarity (PS) algorithm (Pielou 1984) shown below:

$$PS = 200 \ \frac{\Sigma \min(x_i, y_i)}{\Sigma x_i + \Sigma y_i},$$

where
x_i= the measure of attribute i in subbasin x, and
y_i= the measure of attribute i in subbasin y.

The generated pixel data were treated like any ecological data set consisting of sample units (subbasins) with species abundances (pixel counts within each province-elevation class). The intent was to classify groups of similar subbasins. A smaller set of subbasins was then randomly drawn from within each group, from which subwatersheds were randomly selected. Each group contained similar subbasins where the attributes of similarity were the province-elevation classes. Because provinces were, by definition, relatively homogeneous ecological land units at that scale (ECOMAP 1993), this was a reasonable method of stratification. A recursive analysis was used; each analysis cycle consisted of several steps:

1. The clustering procedure TWINSPAN (two-way indicator species analysis) was used to divide the data in four to eight groups (Hill 1979).
2. Two similarity index tables were developed from the PS algorithm (Pielou 1984). The first table was a subbasin-by-subbasin comparison. The PS uses abundance data to weight the importance of each attribute; for example, two subbasins with similar attributes that have similar abundance values will have higher similarity values than two subbasins also having similar attributes but divergent abundance values. The second table was a cluster-by-cluster comparison using TWINSPAN output. These values represented averages of all the within- or among-group similarity values from the first table. Assessment of cluster homogeneity for presence or absence of attributes was possible with this table.
3. We used the similarity analysis described above to further refine membership of each cluster. We repeated the process for each cluster defined above, applying steps 1 and 2 for each cluster, and stopped when further division produced clusters too small to be useful, or when further subdivision was not ecologically meaningful.

Sixteen subbasin strata were the result of stratification (table 1). Strata contained 4 to 18 subbasins, of which 2 to 4 were randomly selected without replacement from each stratum for sampling. We duplicated the sampling intensity used in the Eastside Forest Ecosystem Health Assessment (Everett and others 1994, Lehmkuhl and others 1994) and allocated that intensity across each stratum in proportion to stratum size. Subbasins previously selected for the Eastside Forest Ecosystem Health Assessment were included in the sample as these data were readily available; subwatersheds within these subbasins also were selected randomly. In all, 43 subbasins were sampled. Table 2 lists sampled subbasins by Bailey province, Omernik ecoregion, and state. Figure 3 displays the locations of all sampled subbasins in the basin study area. Figure 4 shows selected subbasins as they were grouped for mapping, and figures 5 to 22 display subwatersheds within subbasin groupings.

Subwatersheds were randomly selected for vegetation mapping until at least 15 percent of the area of each selected subbasin was represented. We researched availability of recent historical aerial photography for each selected subwatershed at the Cartographic Branch of National Archives offices in Washington, DC, and Salt Lake City. For a few subbasins, historical aerial photographic coverages of randomly selected subwatersheds were either unavailable or incomplete. In most cases, subwatersheds lacking adequate coverage were those comprised primarily of private lands or rangelands. As a general rule, if a subwatershed contained in excess of 55 to 60 percent private land, historical photography would be absent or of insufficient coverage to characterize vegetation conditions. Subwatersheds with insufficient photo coverage were randomly replaced as they were encountered in the draw with others having sufficient coverage. If historical photography was available for a random selection of subwatersheds comprising less than 15 percent of the subbasin area, a new subbasin was randomly selected from within the same stratum.

Availability of the most current resource aerial photography was researched at appropriate local offices of the Forest Service, Bureau of Land Management, or state departments of forestry or natural resources. Ultimately, 337 subwatersheds were sampled in 43 subbasins, and historical and current vegetation maps were constructed for each sampled subwatershed from remotely sensed attributes.

One concern with using subwatersheds of differing area in vegetation pattern analyses is the well-known correlation of some landscape pattern attributes with landscape area (O'Neill and others 1988, Turner 1989). Lehmkuhl and Raphael (1993) show that sample estimates of landscape attributes change asymptotically rather than linearly with landscape area. We used sample subwatersheds averaging at least 4000 ha to avoid bias associated with small sampling units. When subwatersheds smaller than 4000 ha were encountered in the sample, they were joined with an adjacent subwatershed to form a larger logical hydrologic unit.

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Table 1—Stratum membership of subbasins sampled in the midscale ecological assessment of the interior Columbia River basin

Stratum	Subbasin name	4th code HUC	Stratum	Subbasin name	4th code HUC
1	Goose Lake	18020001	6	Middle Columbia-Hood	17070105
1	Lost	18010204	6	Naches	17030002
1	Upper Klamath	18010206	6	Similkameen	17020007
1	Upper Klamath Lake	18010203	6	Sprague	18010202
2	Chief Joseph	17020005	6	Upper Columbia-Entiat	17020010
2	Clearwater	17060306	6	Upper Deschutes	17070301
2	Coeur d’Alene Lake	17010303	6	Upper Yakima	17030001
2	Colville	17020003	6	Wenatchee	17020011
2	Franklin D. Roosevelt Lake	17020001	6	Williamson	18010201
2	Hangman	17010306	7	Gros Ventre	17040102
2	Kettle	17020002	7	New Fork	14040102
2	Little Spokane	17010308	7	Snake Headwaters	17040101
2	Lower Kootenai	17010104	7	Upper Green	14040101
2	Lower Spokan	17010307	8	American Falls	17040206
2	Okanogan	17020006	8	Blackfoot	17040207
2	Pend Oreille	17010216	8	Greys-Hobock	17040103
2	Pend Oreille Lake	17010214	8	Idaho Falls	17040201
2	Priest	17010215	8	Lake Walcott	17040209
2	Sanpoil	17020004	8	Lower Henry’s	17040203
2	Upper Spokane	17010305	8	Palisades	17040104
3	Banks Lake	17020014	8	Portneuf	17040208
3	Lower Crab	17020015	8	Salt	17040105
3	Lower Snake	17060110	8	Teton	17040204
3	Middle Columbia Lake-Wallula	17070101	8	Willow	17040205
3	Moses Coulee	17020012	9	Alvord Lake	17120009
3	Upper Columbia-Priest Rapids	17020016	9	Beaver-South Fork	17070303
3	Upper Crab	17020013	9	Donner und Blitzen	17120003
4	Palouse	17060108	9	Goose	17040211
4	Lower Snake-Tucannon	17060107	9	Guano	17120008
4	Rock	17060109	9	Harney-Malheur Lakes	17120001
4	Walla Walla	17070102	9	Lake Abert	17120006
5	Lower Crooked	17070305	9	Raft	17040210
5	Lower John Day	17070204	9	Salmon Falls	17040213
5	Trout	17070307	9	Silver	17120004
5	Umatilla	17070103	9	Silvies	17120002
5	Willow	17070104	9	South Fork Owyhee	17050105
6	Klickitat	17070106	9	Summer Lake	17120005
6	Lake Chelan	17020009	9	Thousand-Virgin	16040205
6	Little Deschutes	17070302	9	Warner Lakes	17120007
6	Lower Deschutes	17070306	9	Upper Quinn	16040201
6	Lower Yakima	17030003	10	Bruneau	17050102

Table 1—Stratum membership of subbasins sampled in the midscale ecological assessment of the interior Columbia River basin (continued)

Stratum	Subbasin name	4th code HUC	Stratum	Subbasin name	4th code HUC
6	Methow	17020008	10	Bully	17050118
10	Burnt	17050202	12	South Fork Payette	17050120
10	C.J. Strike Reservoir	17050101	12	South Fork Salmon	17060208
10	Crooked-Rattlesnake	17050109	12	Upper Selway	17060301
10	East Little Owyhee	17050106	13	Big Wood	17040219
10	Jordan	17050108	13	Camas	17040220
10	Lower Boise	17050114	13	Little Wood	17040221
10	Lower Malheur	17050117	13	Lower Middle Fork Salmon	17060206
10	Lower Owyhee	17050110	13	Upper Middle Fork Salmon	17060205
10	Middle Owyhee	17050107	13	Upper Salmon	17060201
10	Middle Snake-Payette	17050115	14	Bitterroot	17010205
10	Middle Snake-Succor	17050103	14	Fisher	17010102
10	Upper Malheur	17050116	14	Flathead Lake	17010208
10	Upper Owyhee	17050104	14	Lower Clark Fork	17010213
10	Upper Snake-Rock	17040212	14	Lower Flathead	17010212
10	Weiser	17050124	14	Lower North Fork Clearwater	17060308
10	Willow	17050119	14	Middle Clark Fork	17010204
11	Brownlee Reservoir	17050201	14	Moyie	17010105
11	Hell's Canyon	17060101	14	South Fork Coeur d'Alene	17010302
11	Imnaha	17060102	14	St. Joe	17010304
11	Lower Grande Ronde	17060106	14	Stillwater	17010210
11	Lower Snake-Asotin	17060103	14	Upper Coeur d'Alene	17010301
11	Middle Fork John Day	17070203	14	Upper Kootenai	17010101
11	North Fork John Day	17070202	14	Upper North Fork Clearwater	17060307
11	Powder	17050203	14	Yaak	17010103
11	Upper Crooked	17070304	15	Blackfoot	17010203
11	Upper Grande Ronde	17060104	15	Flint-Rock	17010202
11	Upper John Day	17070201	15	Middle Fork Flathead	17010207
11	Wallowa	17060105	15	North Fork Flathead	17010206
12	Little Salmon	17060210	15	South Fork Flathead	17010209
12	Lochsa	17060303	15	Swan	17010211
12	Lower Salmon	17060209	16	Beaver-Camas	17040214
12	Lower Selway	17060302	16	Big Lost	17040218
12	Middle Fork Clearwater	17060304	16	Birch	17040216
12	Middle Fork Payette	17050121	16	Lemhi	17060204
12	Middle Salmon-Chamberlain	17060207	16	Little Lost	17040217
12	Boise-Mores	17050112	16	Medicine Lodge	17040215
12	North and Middle Forks Boise	17050111	16	Middle Salmon Panther	17060203
12	North Fork Payette	17050123	16	Pahsimeroi	17060202
12	Payette	17050122	16	Upper Clark Fork	17010201
12	South Fork Boise	17050113	16	Upper Henry's	17040202
12	South Fork Clearwater	17060305			

Table 2—Bailey province and Omernik ecoregion membership of sampled subbasins[a] of the midscale ecological assessment of the interior Columbia River basin[b]

Subbasin[c]	4th code HUC	Samples	State	Bailey province	Omernik ecoregion
(1) Pend Oreille	17010216	8	WA	M333—Northern Rocky Mountain	Northern Rockies
(2) Kettle	17020002	5	WA	M333—Northern Rocky Mountain	Northern Rockies
(3) San Poil	17020004	6	WA	M333—Northern Rocky Mountain	Northern Rockies
(4) Methow	17020008	17	WA	M242—Cascade	Cascades
(5) Wenatchee	17020011	11	WA	M242—Cascade	Cascades
(6) Upper Yakima	17030001	10	WA	M242—Cascade	Cascades
(7) Naches	17030002	9	WA	M242—Cascade	East-side Cascades slopes and foothills
(8) Lower Yakima	17030003	8	WA	M242—Cascade	Columbia basin
(9) Palouse	17060108	7	WA	331—Great Plains-Palouse Dry Steppe	Columbia basin
(9) Palouse	17060108	2	ID	331—Great Plains-Palouse Dry Steppe	Columbia basin
(10) Lower Grande Ronde	17060106	9	OR	M332—Middle Rocky Mountain	Blue Mountains
(11) Upper Grande Ronde	17060104	9	OR	M332—Middle Rocky Mountain	Blue Mountains
(12) Wallowa	17060105	7	OR	M332—Middle Rocky Mountain	Blue Mountains
(13) Burnt	17050202	6	OR	M332—Middle Rocky Mountian	Blue Mountains and Snake River basin and high desert
(14) Upper John Day	17070201	11	OR	M332—Middle Rocky Mountain and 342—Intermountain Semidesert	Blue Mountains
(15) Lower John Day	17070204	16	OR	M332—Middle Rocky Mountain and 342—Intermountain Semidesert	Columbia basin and Blue Mountains
(16) Lower Crooked	17070305	6	OR	M332—Middle Rocky Mountain and M242—Cascade	Blue Mountains and Snake River basin and high desert and east-side Cascades slopes and foothills
(17) Upper Deschutes	17070301	10	OR	M242—Cascade	East-side Cascades slopes and foothills
(18) Little Deschutes	17070302	6	OR	M242—Cascade	East-side Cascades slopes and foothills
(19) Silvies	17120002	4	OR	M332—Middle Rocky Mountain	Blue Mountains and Snake River basin and high desert

Table 2—Bailey province and Omernik ecoregion membership of sampled subbasins[a] of the midscale ecological assessment of the interior Columbia River basin[b] (continued)

Subbasin[c]	4th code HUC	Samples	State	Bailey province	Omernik ecoregion
(20) Donner und Blitzen	17120003	4	OR	342—Intermountain Semidesert	Snake River basin and high desert
(21) Crooked Rattlesnake	17050109	7	OR	342—Intermountain Semidesert	Snake River basin and high desert
(22) Lost	18010204	5	OR	M261-Sierran	East-side Cascades slopes and foothills and Snake River basin and high desert
(22) Lost	18010204	4	CA	M261-Sierran	East-side Cascades slopes and foothills and Snake River basin and high desert
(23) Upper Klamath Lake	18010203	4	OR	M261—Sierran and M242—Cascade	East-side Cascades slopes and foothills
(24) Big Wood	17040219	6	ID	342—Intermountain Semidesert and M332—Middle Rocky Mountain	Northern Rockies and Snake River basin and high desert
(25) Blackfoot (Montana)	17010203	16	MT	M332—Middle Rocky Mountain	Northern Rockies and Montana valley and Foothill prairies
(26) Bitterroot	17010205	8	MT	M332—Middle Rocky Mountain and M333—Northern Rocky Mountain	Northern Rockies and Montana valley and Foothill prairies
(27) Boise-Mores	17050112	3	ID	M332—Middle Rocky Mountain	Northern Rockies and Snake River basin and high desert
(28) Flint Rock	17010202	7	MT	M332—Middle Rocky Mountain	Northern Rockies and Montana valley and Foothill prairies
(29) Lake Walcott	17040209	9	ID	342—Intermountain Semidesert	Snake River basin and high desert and Northern Great Basin and range
(30) Lemhi	17060204	6	ID	M332—Middle Rocky Mountain	Northern Rockies and Snake River basin and high desert
(31) Lochsa	17060303	7	ID	M333—Northern Rocky Mountain and M332—Middle Rocky Mountain	Northern Rockies
(32) Lower Flathead	17010212	14	MT	M333—Northern Rocky Mountain	Northern Rockies and Montana valley and Foothill prairies
(33) Lower Henry's	17040203	3	ID	M331—Southern Rocky Mountain and 342—Intermountain Semidesert	Middle Rockies and Snake River basin and high desert
(33) Lower Henry's	17040203	1	WY	M331—Southern Rocky Mountain	Middle Rockies and Snake River basin and high desert

Table 2—Bailey province and Omernik ecoregion membership of sampled subbasins[a] of the midscale ecological assessment of the interior Columbia River basin[b] (continued)

Subbasin[c]	4th code HUC	Samples	State	Bailey province	Omernik ecoregion
(34) Medicine Lodge	17040215	5	ID	342—Intermountain Semidesert and M332—Middle Rocky Mountain	Northern Rockies and Snake River basin and high desert
(35) Palisades	17040104	5	ID	M331—Southern Rocky Mountain	Middle Rockies
(35) Palisades	17040104	1	WY	M331—Southern Rocky Mountain	Middle Rockies
(36) Snake Headwater	17040101	8	WY	M331—Southern Rocky Mountain	Middle Rockies
(37) South Fork Clearwater	17060305	6	ID	M332—Middle Rocky Mountain	Northern Rockies and Columbia basin
(38) South Fork Salmon	17060208	7	ID	M332—Middle Rocky Mountain	Northern Rockies
(39) Swan	17010211	4	MT	M333—Northern Rocky Mountain	Northern Rockies
(40) Upper Owyhee	17050104	12	ID	342—Intermountain Semidesert	Snake River basin and high desert and Northern Great Basin and range
(41) Upper Coeur d'Alene	17010301	5	ID	M333—Northern Rocky Mountain	Northern Rockies
(42) Upper Middle Fork	17060205	9	ID	M332—Middle Rocky Mountain	Northern Rockies
(43) Yaak	17010103	4	MT	M333—Northern Rocky Mountain	Northern Rockies

[a] 337 subwatersheds were sampled in 43 subbasins.

[b] See also figure 3.

[c] Numbers in parentheses identify subbasins shown in figure 3.

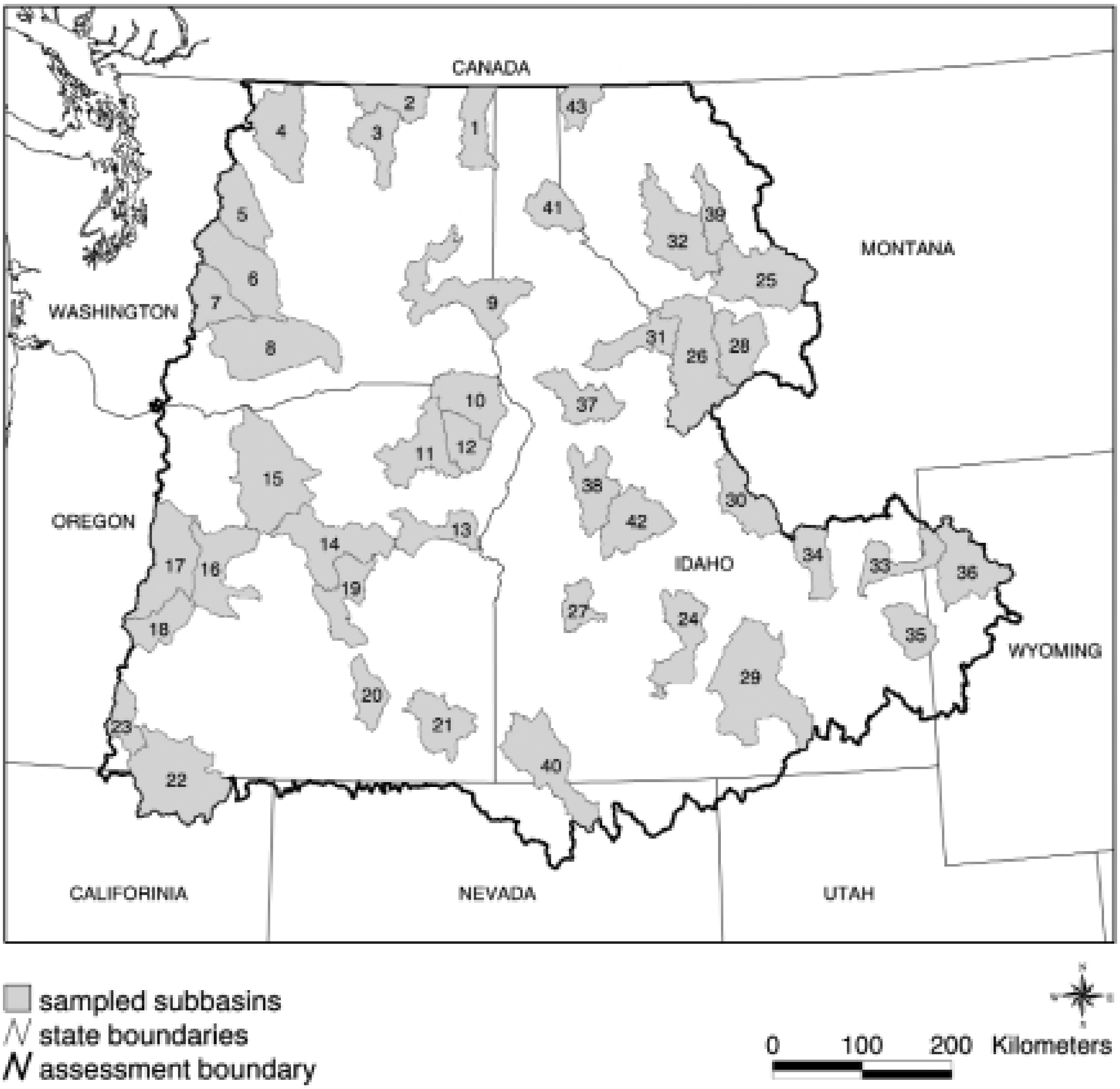

Figure 3—Sampled subbasins of the midscale assessment of the interior Columbia River basin (see also table 2). The assessment area included the portion of the Columbia River basin occurring in the United States east of the crest of the Cascade Range. Subbasins in the upper reaches of the Klamath River basin and the Northern Great Basin also were included to fully represent conditions in eastern Oregon and Washington, Idaho, and western Montana.

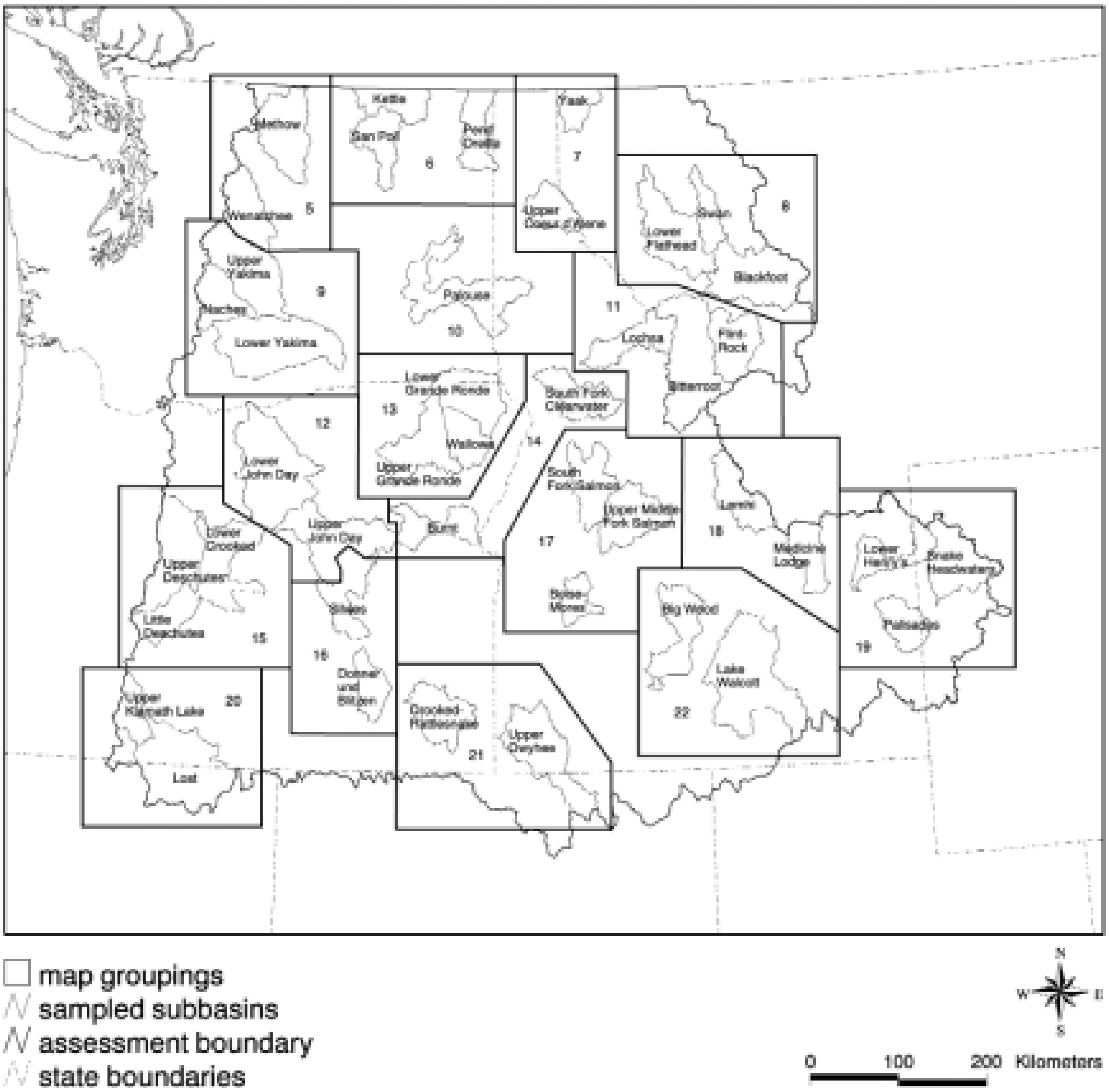

Figure 4—Map groupings of subbasins sampled in the midscale ecological assessment of the interior Columbia River basin. Subbasins were separated for ease of mapping into 18 groups. Sampled watersheds are shown by subbasin group in figures 5 to 22.

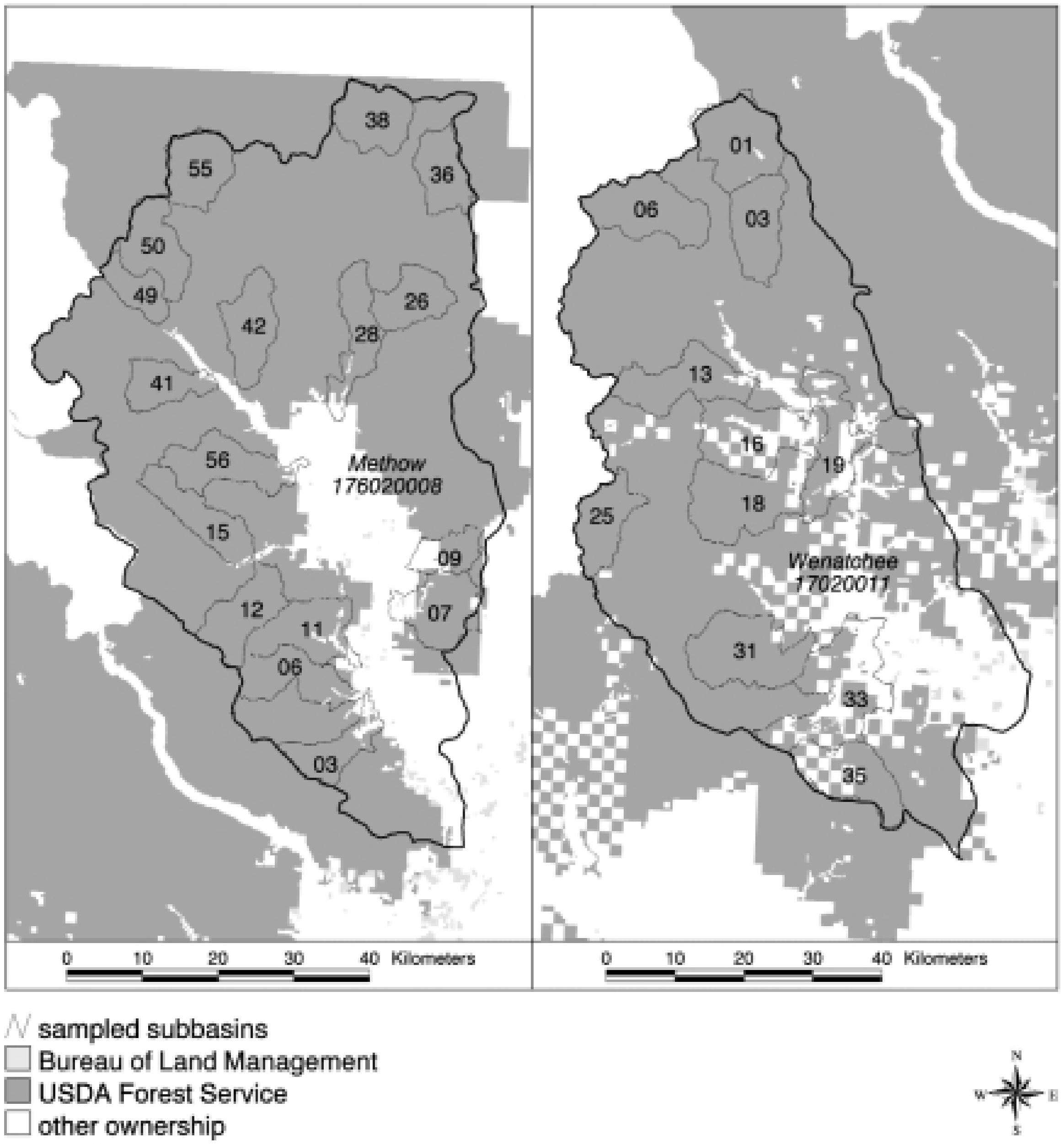

Figure 5—Subwatersheds on USDA Forest Service, Bureau of Land Management, and other ownerships sampled in the Methow and Wenatchee subbasins of Washington for the midscale ecological assessment of the interior Columbia River basin.

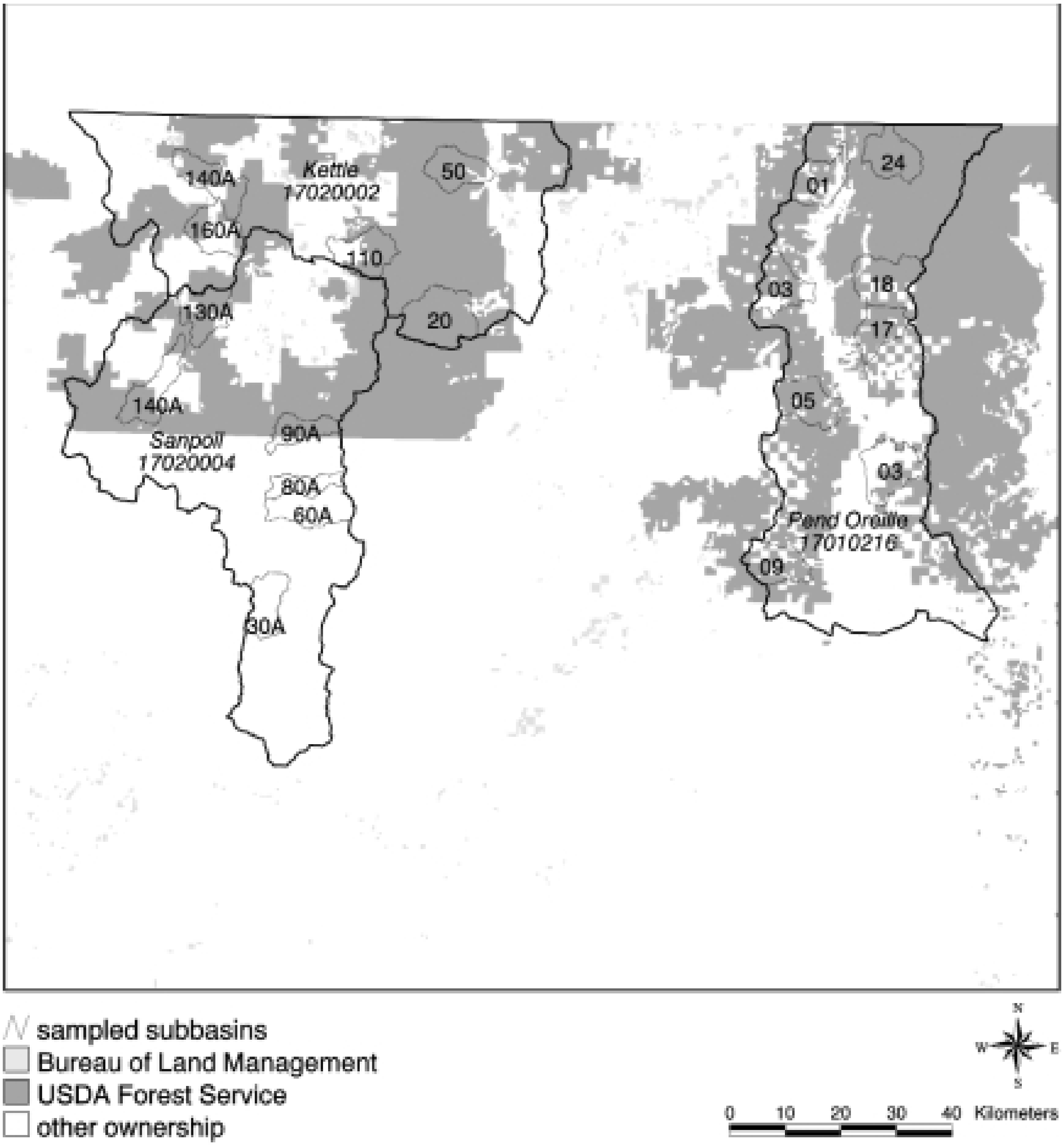

Figure 6—Subwatersheds on USDA Forest Service, Bureau of Land Management, and other ownerships sampled in the Kettle, Sanpoil, and Pend Oreille subbasins of Washington for the midscale ecological assessment of the interior Columbia River basin.

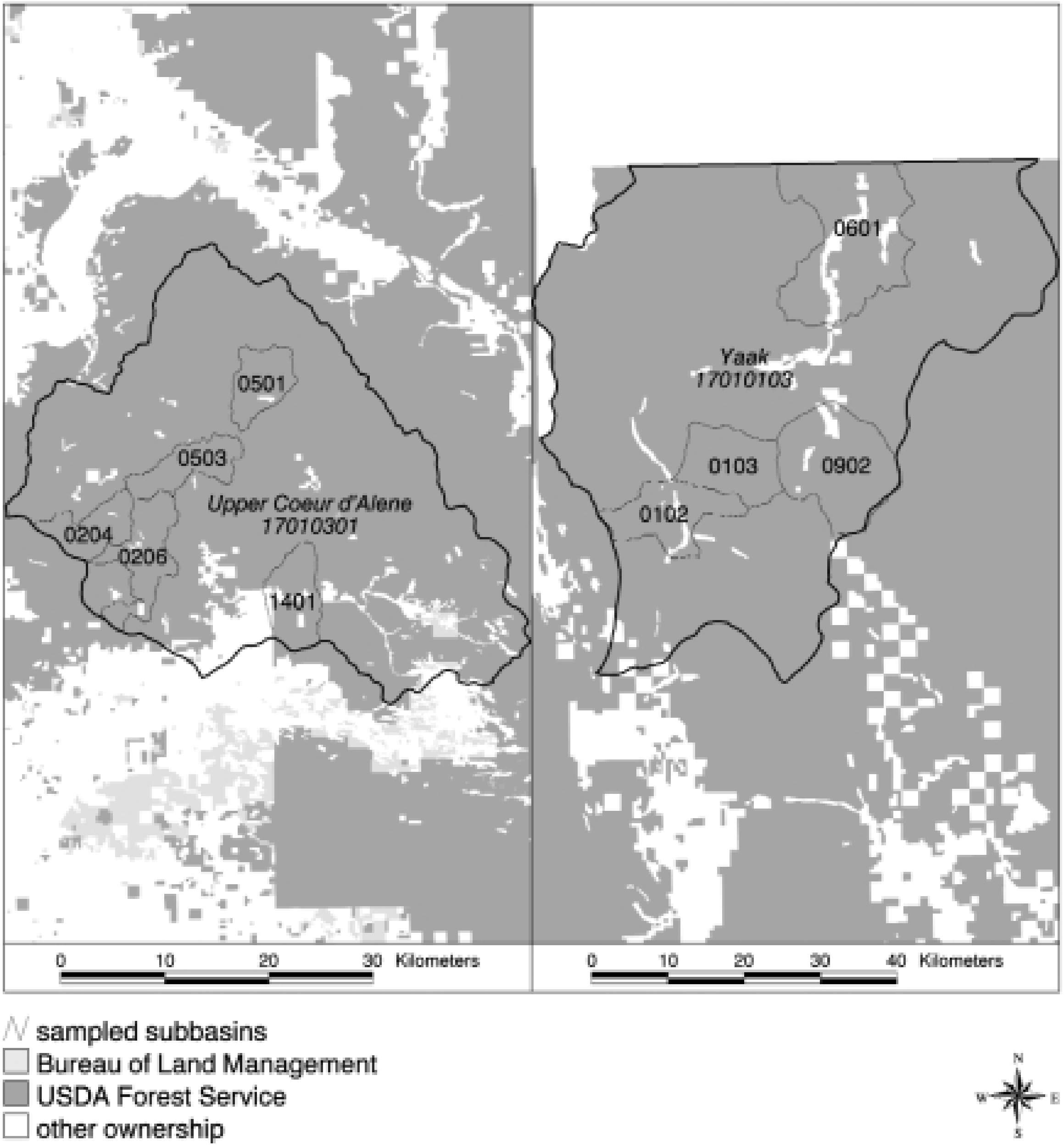

Figure 7—Subwatersheds on USDA Forest Service, Bureau of Land Management, and other ownerships sampled in the Upper Coeur d'Alene and Yaak subbasins of Idaho and Montana for the midscale ecological assessment of the interior Columbia River basin.

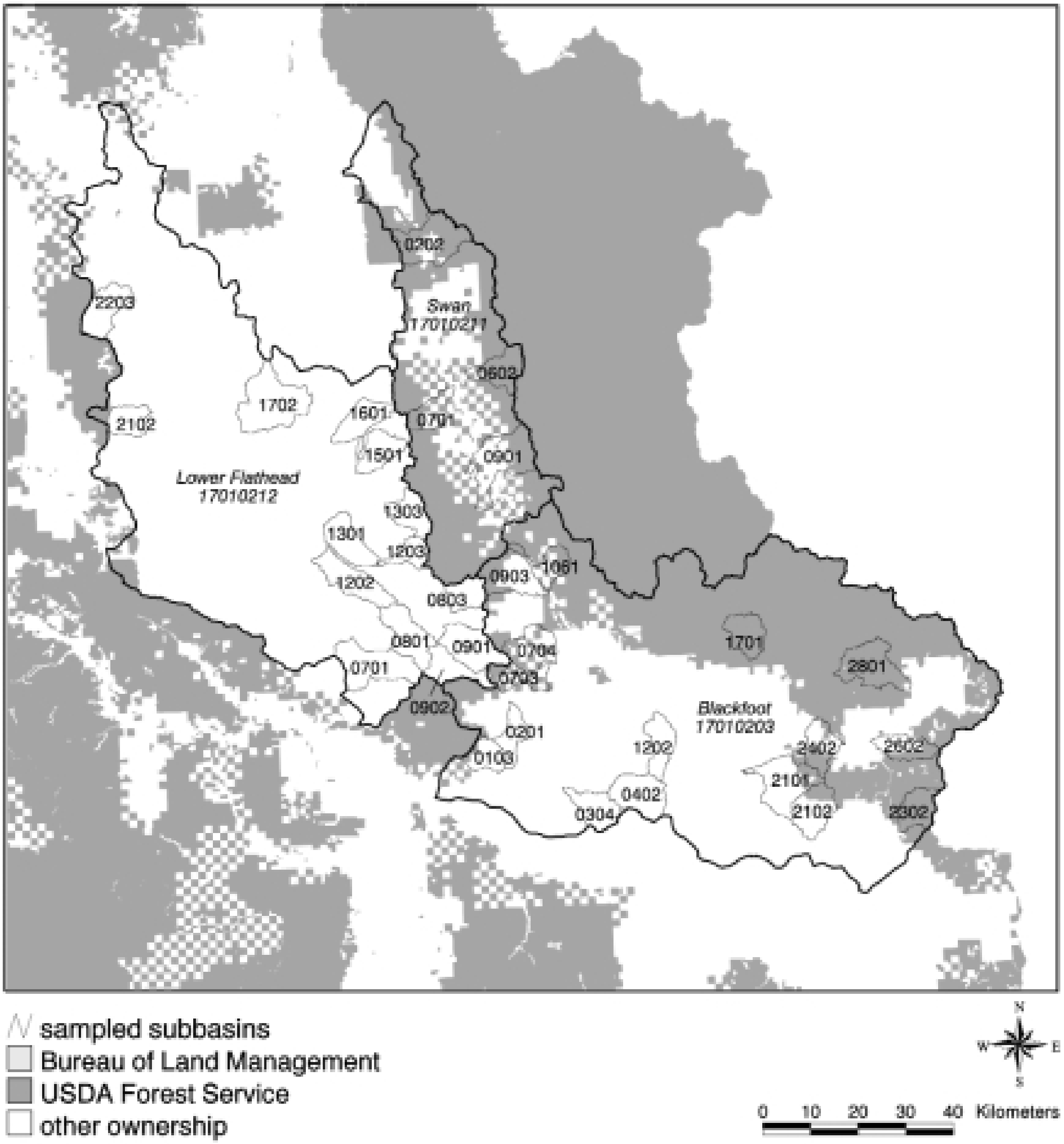

Figure 8—Subwatersheds on USDA Forest Service, Bureau of Land Management, and other ownerships sampled in the Lower Flathead, Swan, and Blackfoot subbasins of Montana for the midscale ecological assessment of the interior Columbia River basin.

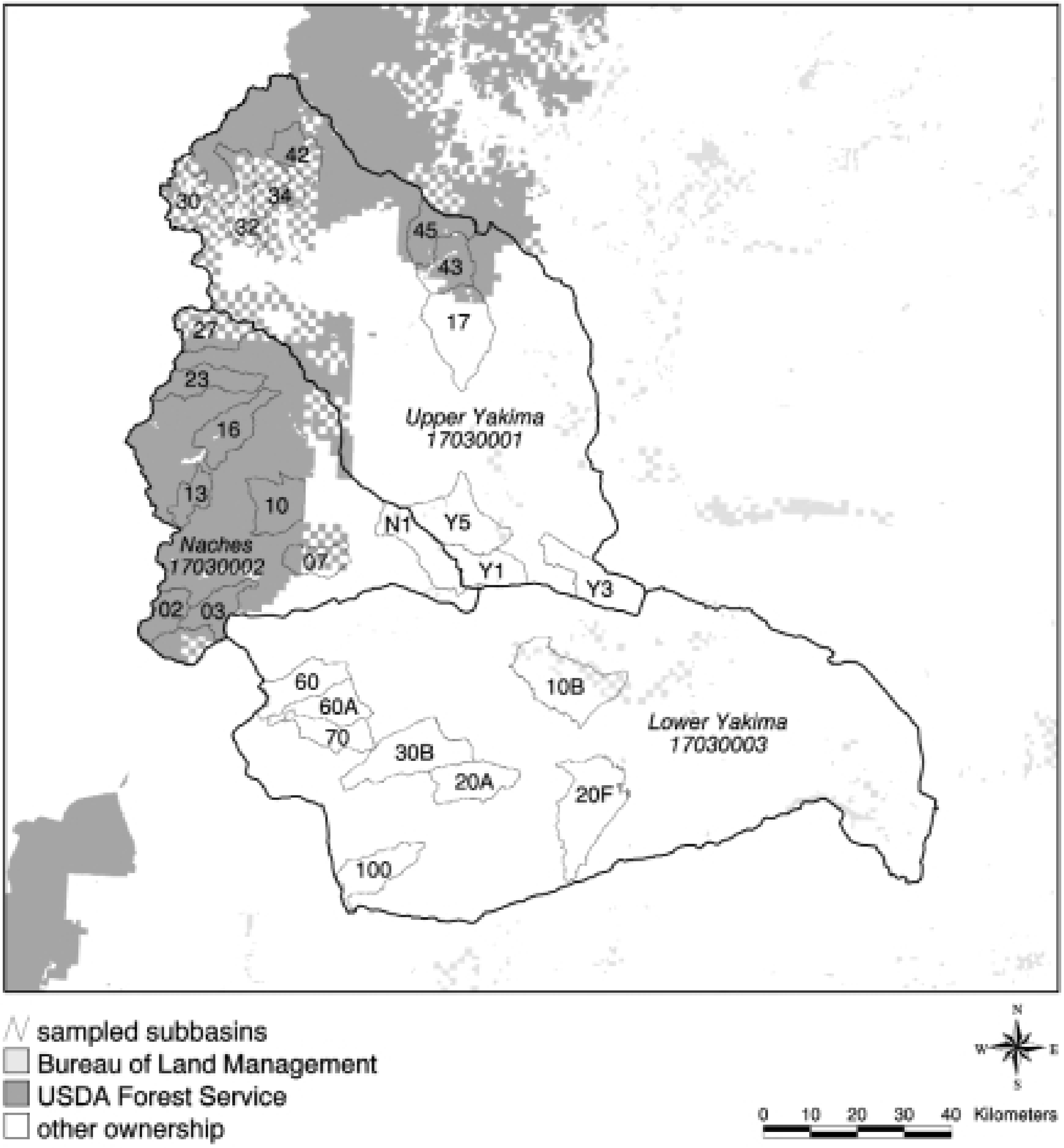

Figure 9—Subwatersheds on USDA Forest Service, Bureau of Land Management, and other ownerships sampled in the Upper Yakima, Naches, and Lower Yakima subbasins of Washington for the midscale ecological assessment of the interior Columbia River basin.

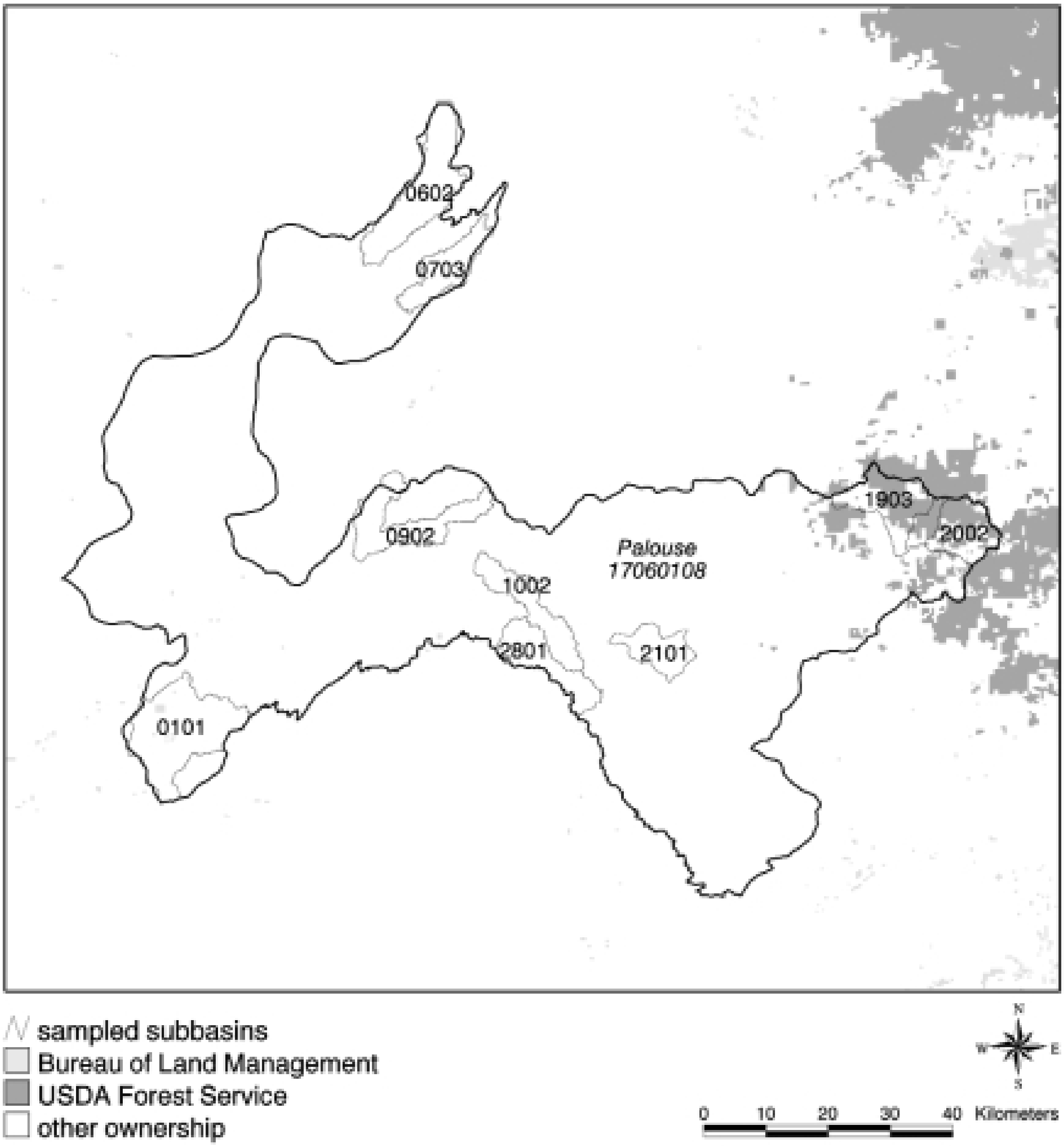

Figure 10—Subwatersheds on USDA Forest Service, Bureau of Land Management, and other ownerships sampled in the Palouse subbasin of Idaho and Washington for the midscale ecological assessment of the interior Columbia River basin.

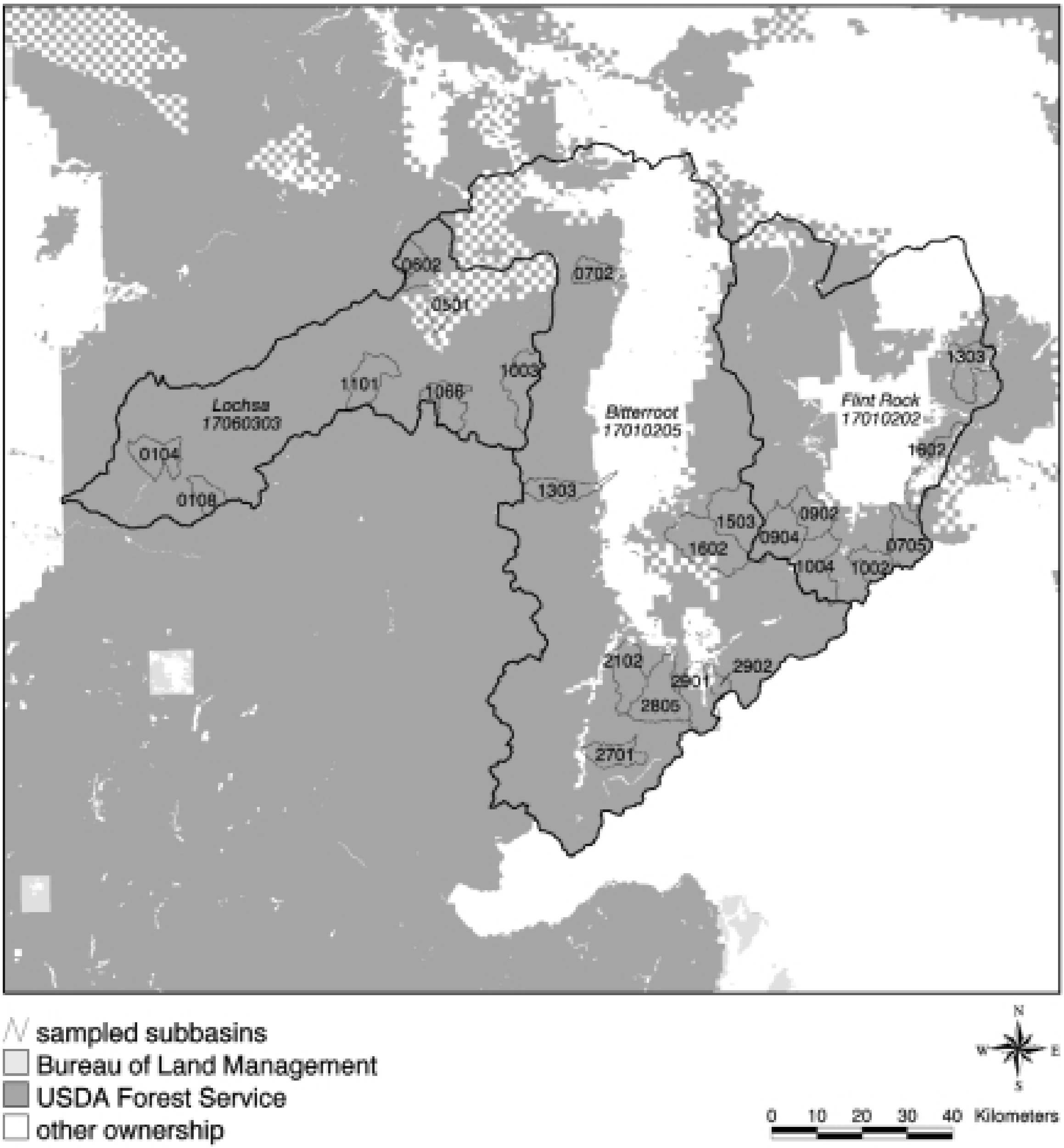

Figure 11—Subwatersheds on USDA Forest Service, Bureau of Land Management, and other ownerships sampled in the Lochsa, Flint Rock, and Bitterroot subbasins of Idaho and Montana for the midscale ecological assessment of the interior Columbia River basin.

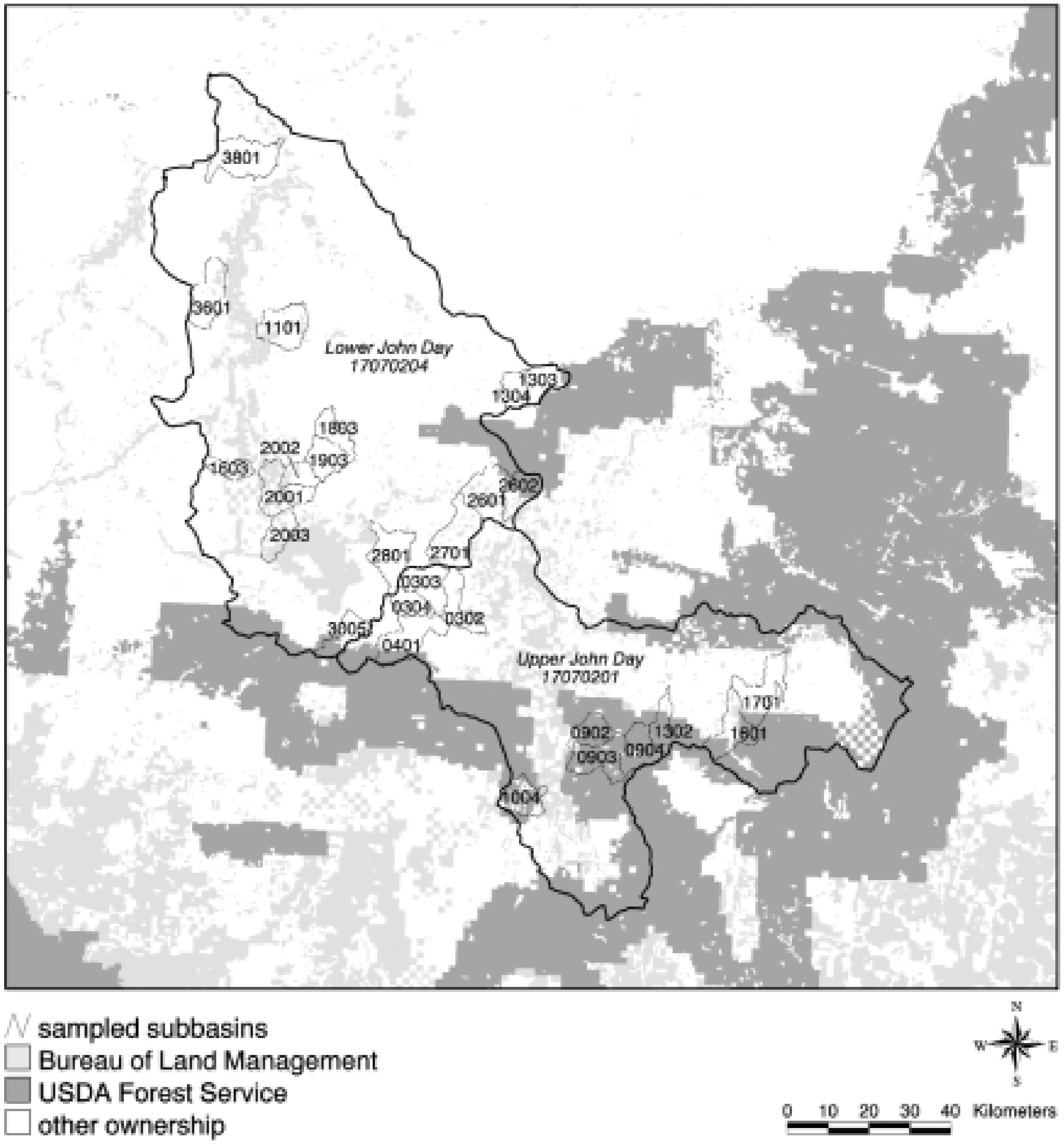

Figure 12—Subwatersheds on USDA Forest Service, Bureau of Land Management, and other ownerships sampled in the Upper and Lower John Day subbasins of Oregon for the midscale ecological assessment of the interior Columbia River basin.

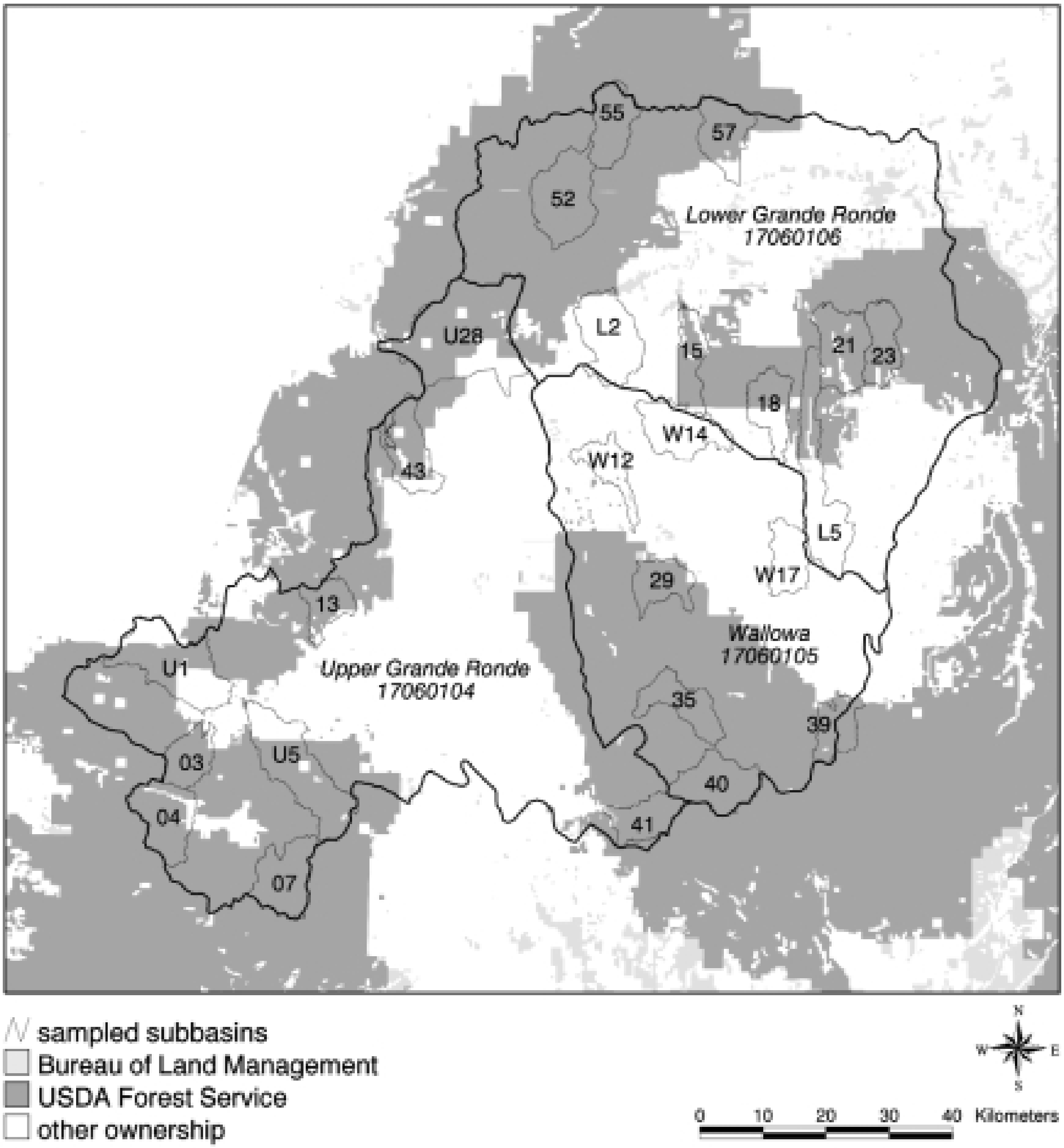

Figure 13—Subwatersheds on USDA Forest Service, Bureau of Land Management, and other ownerships sampled in the Upper Grande Ronde, Wallowa, and Lower Grande Ronde subbasins of Oregon and Washington for the midscale ecological assessment of the interior Columbia River basin.

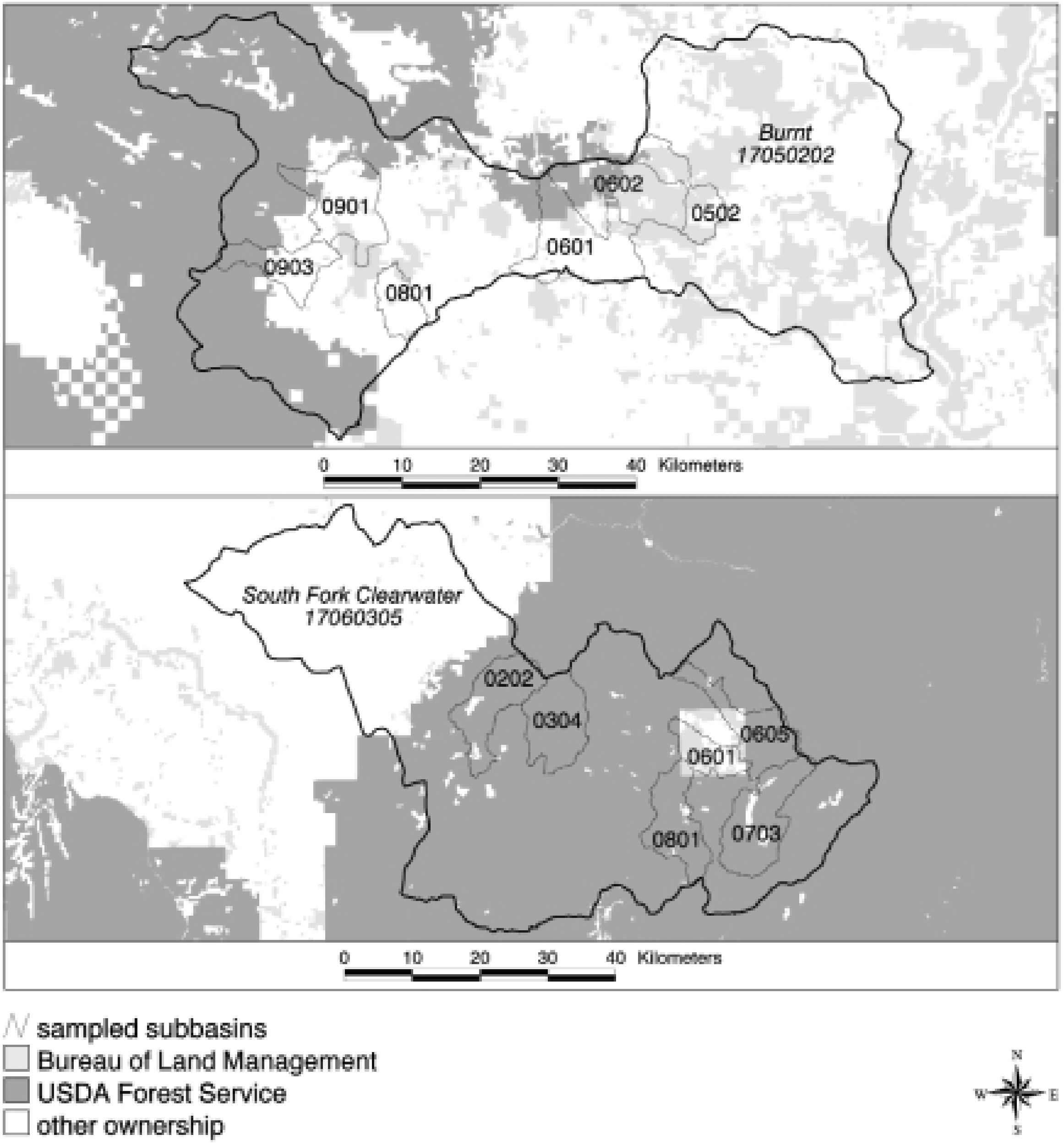

Figure 14—Subwatersheds on USDA Forest Service, Bureau of Land Management, and other ownerships sampled in the Burnt and South Fork Clearwater subbasins of Oregon and Idaho for the midscale ecological assessment of the interior Columbia River basin.

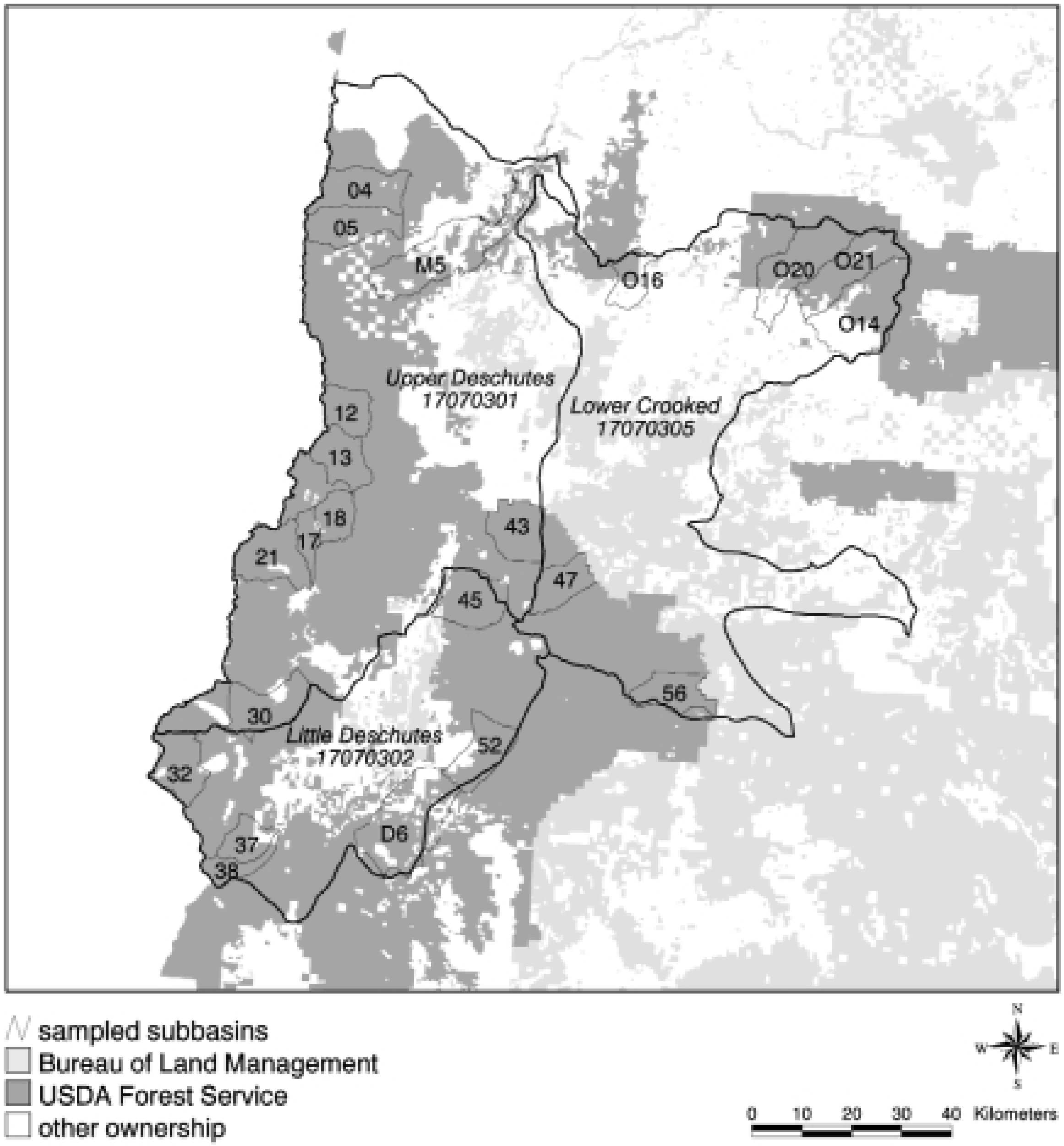

Figure 15—Subwatersheds on USDA Forest Service, Bureau of Land Management, and other ownerships sampled in the Lower Crooked, Upper Deschutes, and Little Deschutes subbasins of Oregon for the midscale ecological assessment of the interior Columbia River basin.

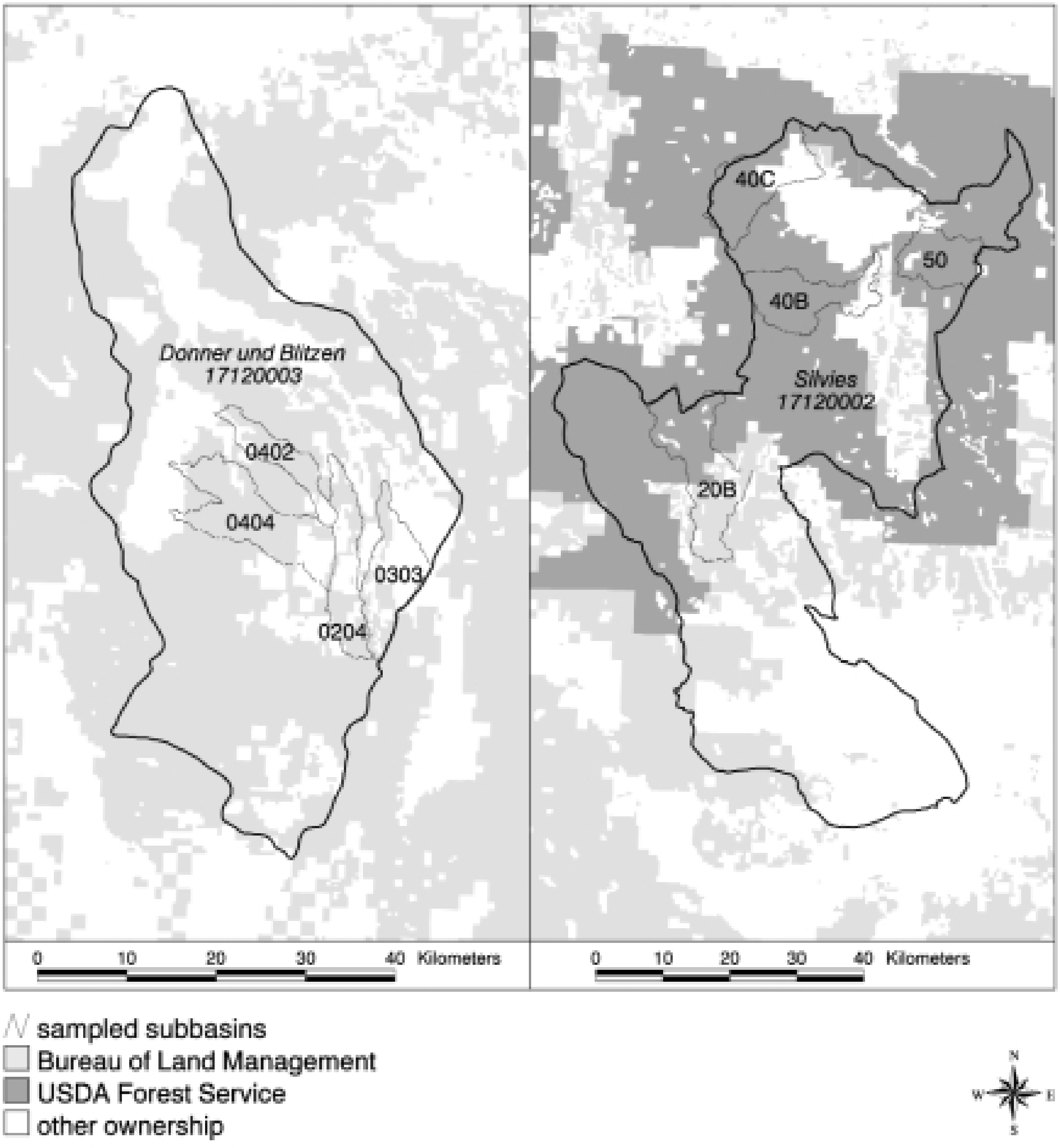

Figure 16—Subwatersheds on USDA Forest Service, Bureau of Land Management, and other ownerships sampled in the Silvies and Donner und Blitzen subbasins of Oregon for the midscale ecological assessment of the interior Columbia River basin.

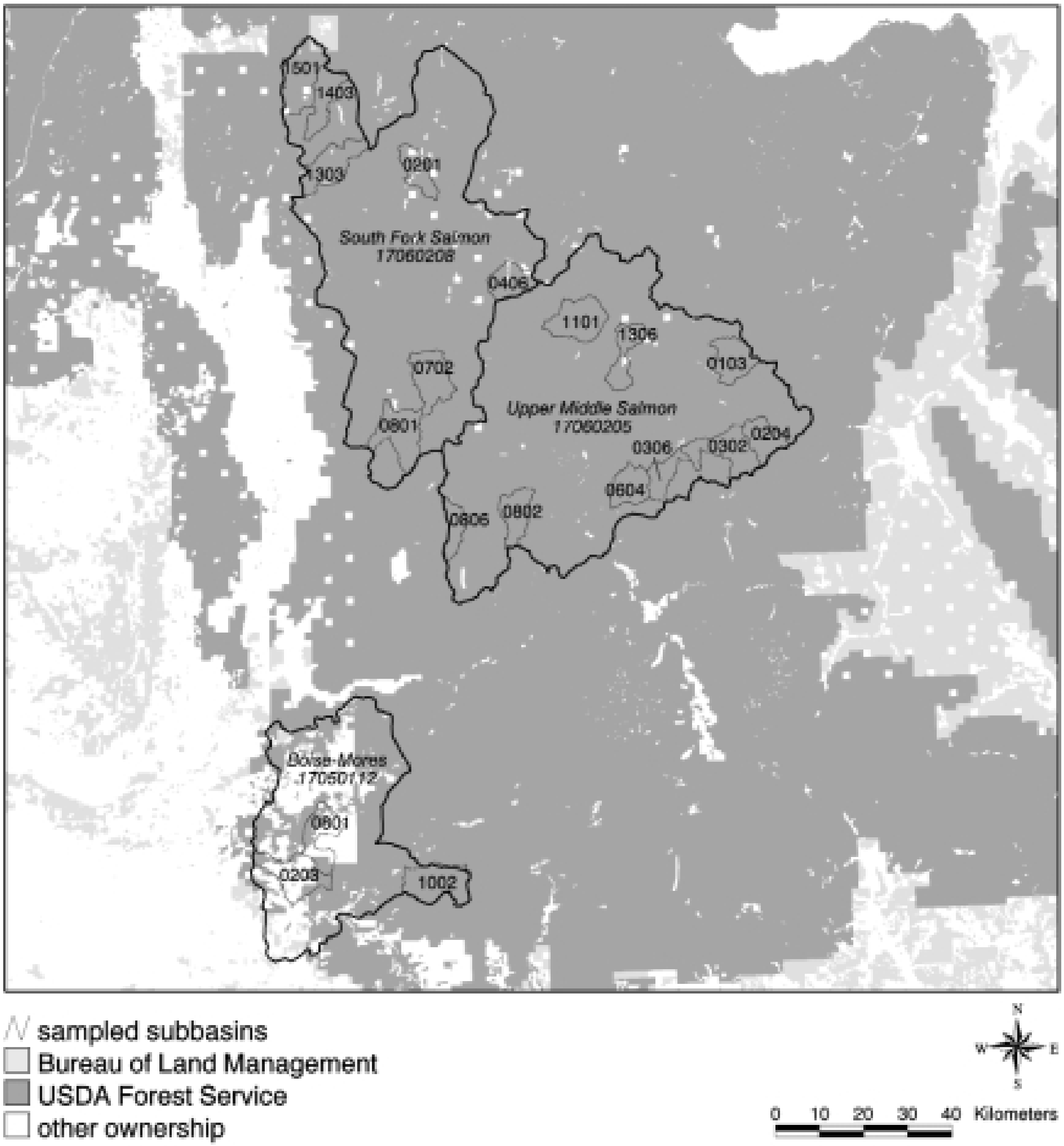

Figure 17—Subwatersheds on USDA Forest Service, Bureau of Land Management, and other ownerships sampled in the South Fork Salmon, Boise-Mores, and Upper Middle Fork Salmon subbasins of Idaho for the midscale ecological assessment of the interior Columbia River basin.

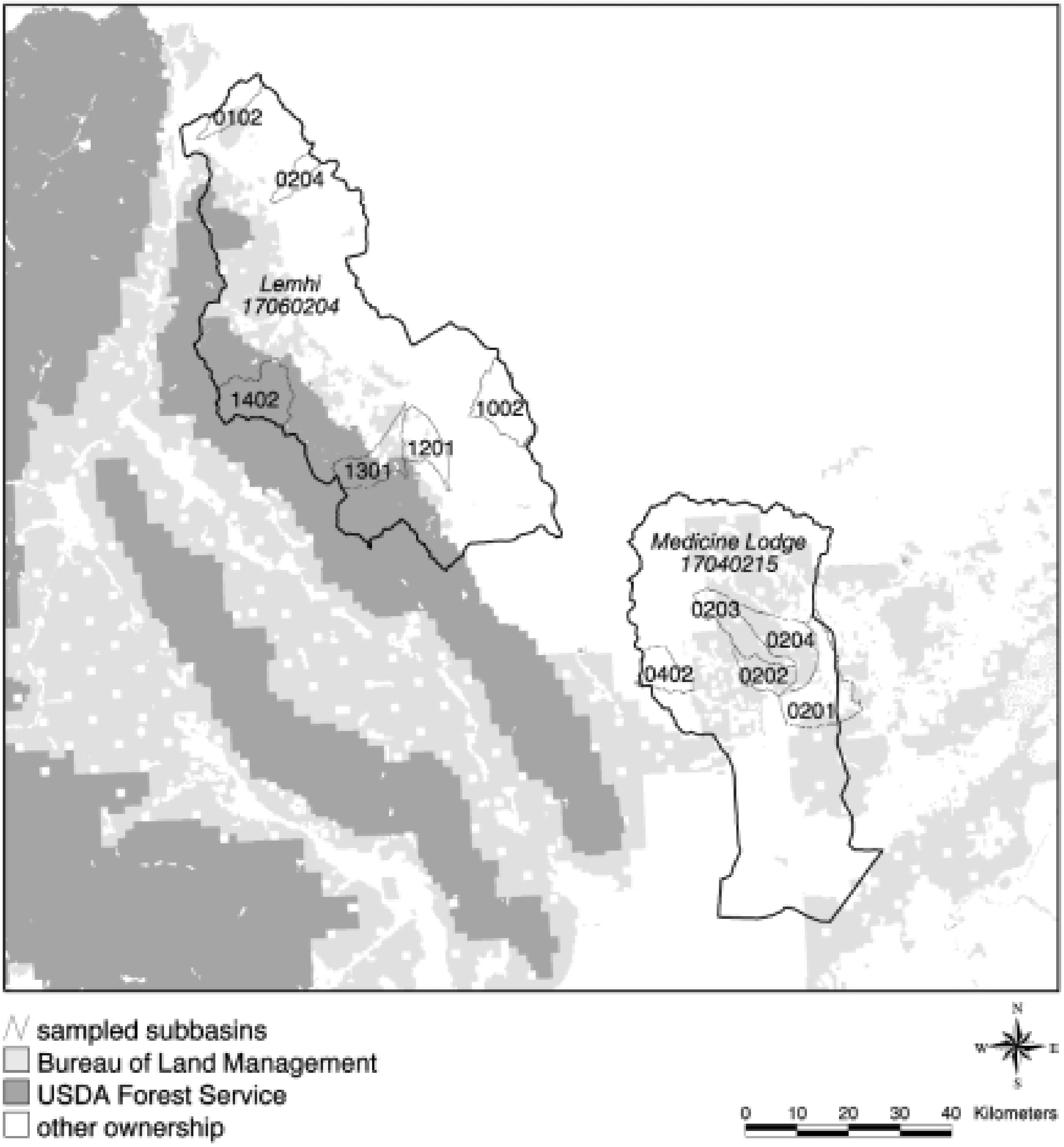

Figure 18—Subwatersheds on USDA Forest Service, Bureau of Land Management, and other ownerships sampled in the Lemhi and Medicine Lodge subbasins of Idaho for the midscale ecological assessment of the interior Columbia River basin.

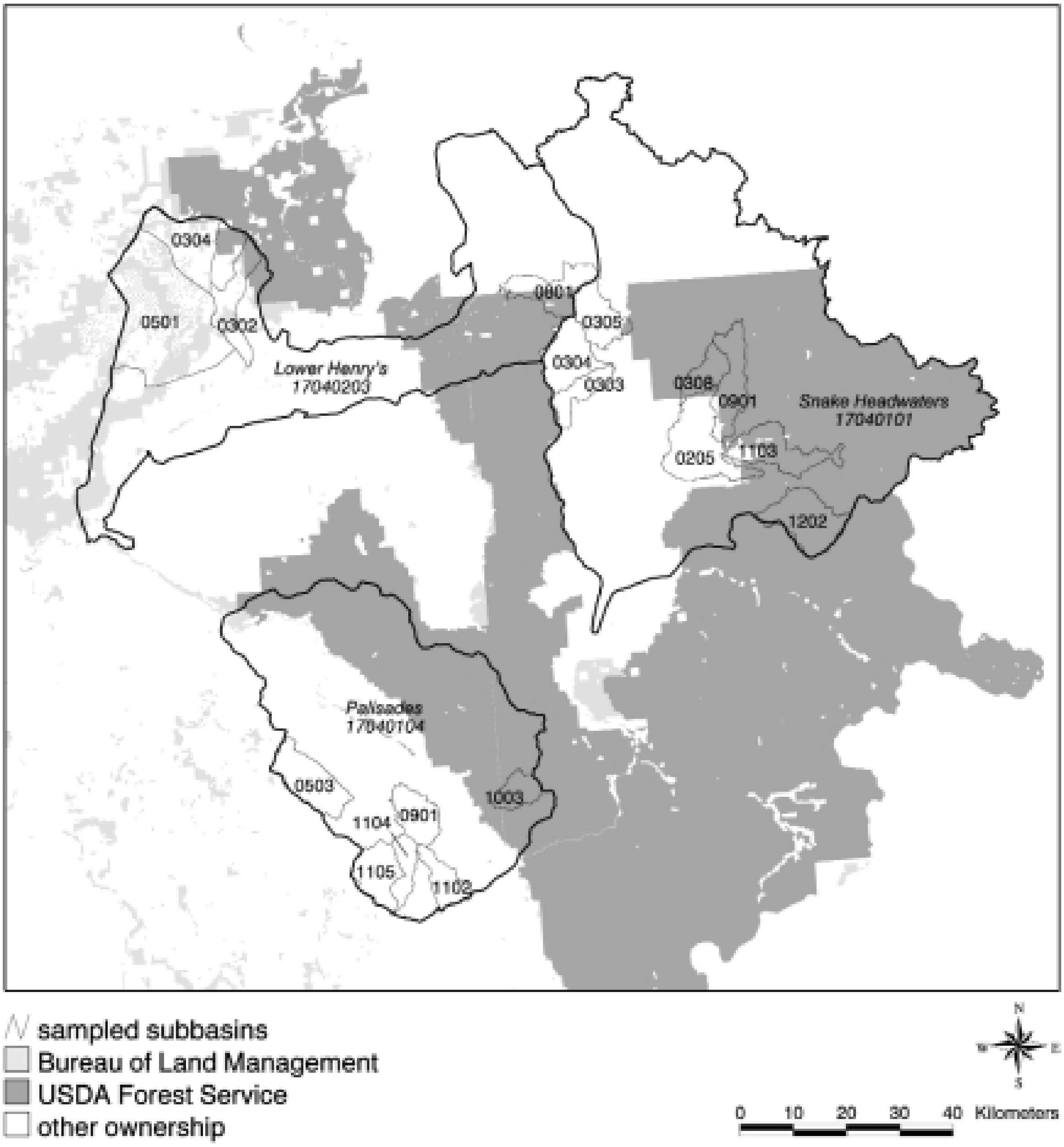

Figure 19—Subwatersheds on USDA Forest Service, Bureau of Land Management, and other ownerships sampled in the Lower Henry's, Palisades, and Snake Headwaters subbasins of Idaho and Wyoming for the midscale ecological assessment of the interior Columbia River basin.

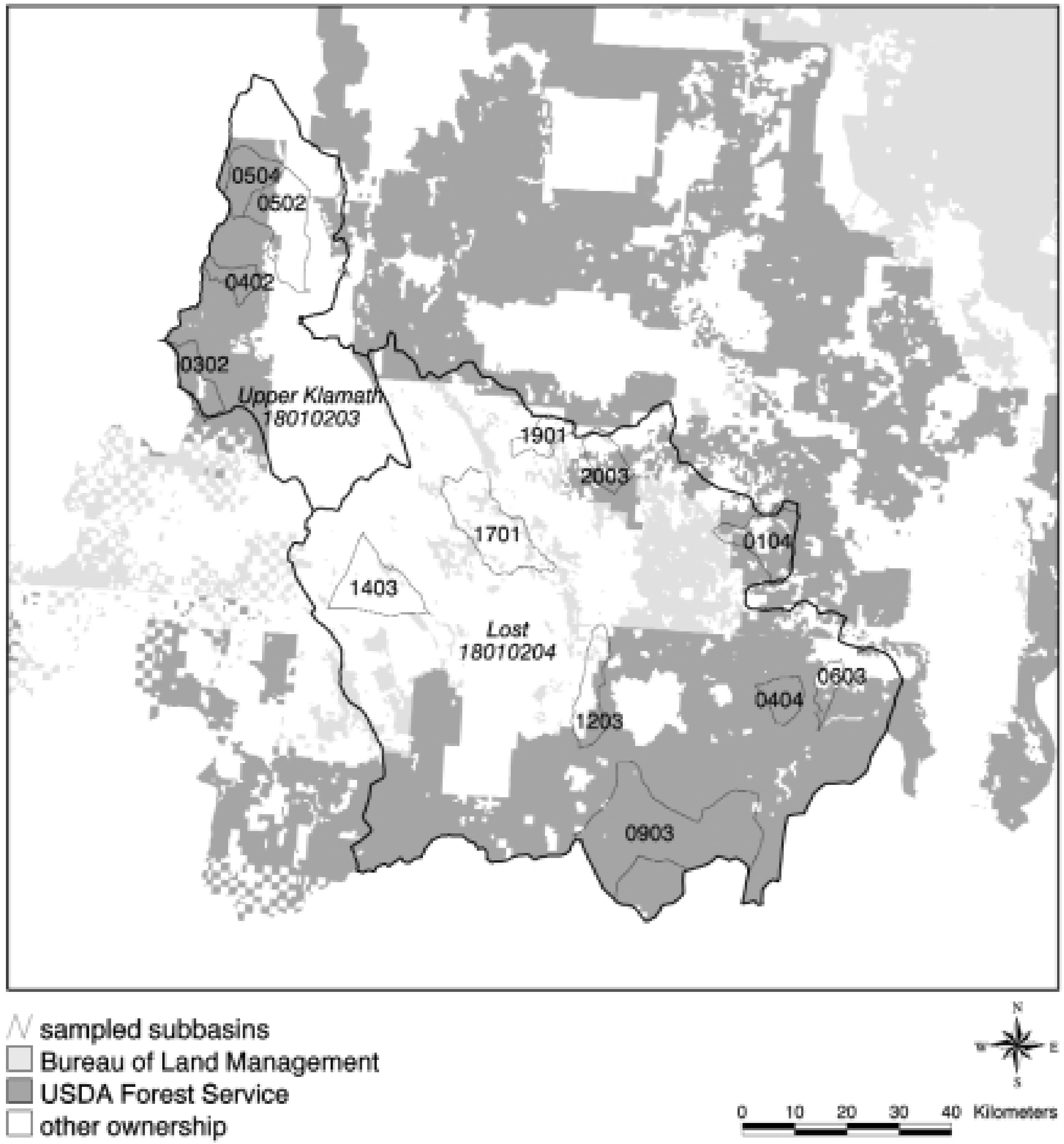

Figure 20—Subwatersheds on USDA Forest Service, Bureau of Land Management, and other ownerships sampled in the Upper Klamath Lake and Lost subbasins of Oregon and California for the midscale ecological assessment of the interior Columbia River basin.

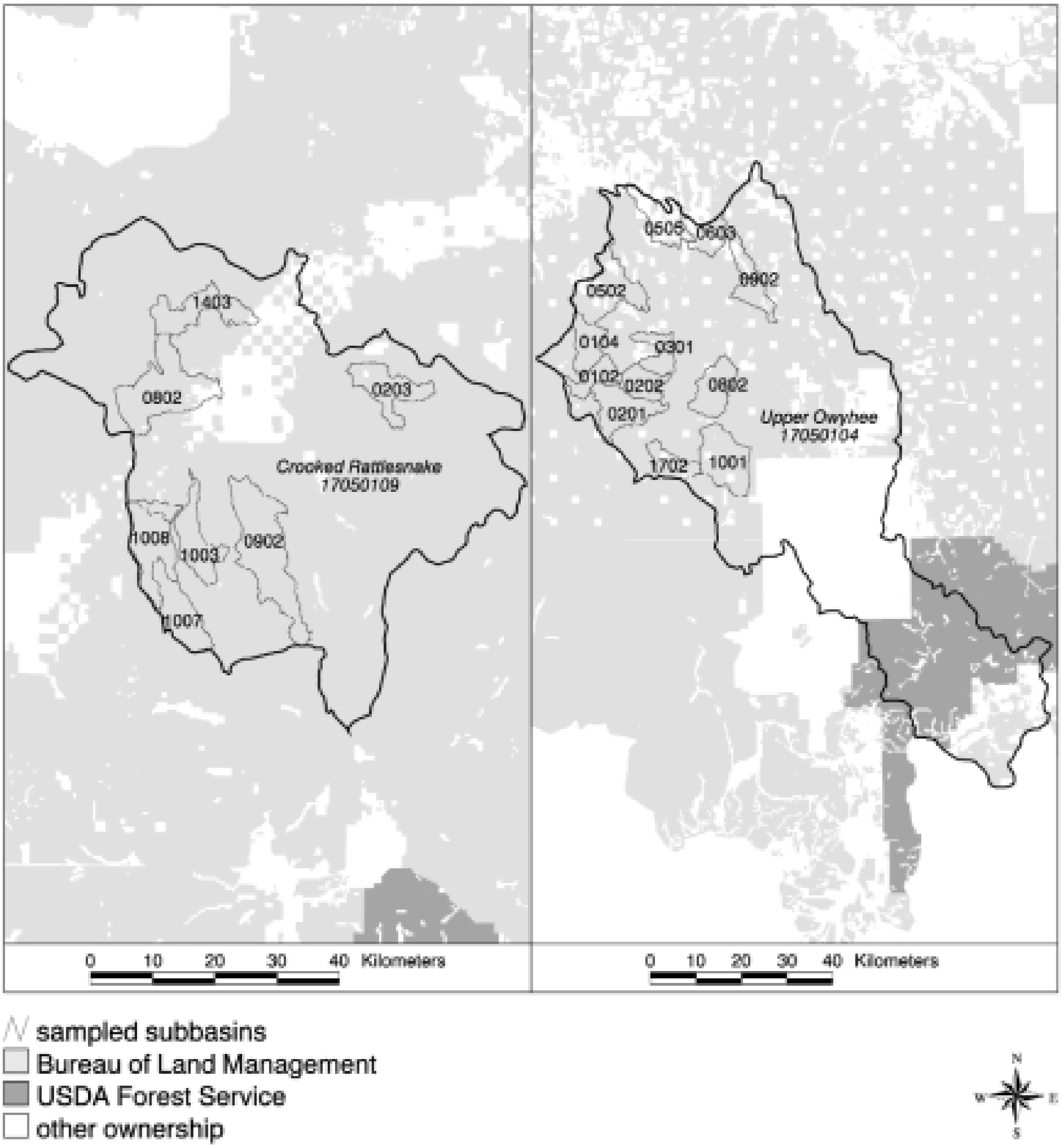

Figure 21—Subwatersheds on USDA Forest Service, Bureau of Land Management, and other ownerships sampled in the Crooked Rattlesnake and Upper Owyhee subbasins of Oregon, Idaho, and Nevada for the midscale ecological assessment of the interior Columbia River basin.

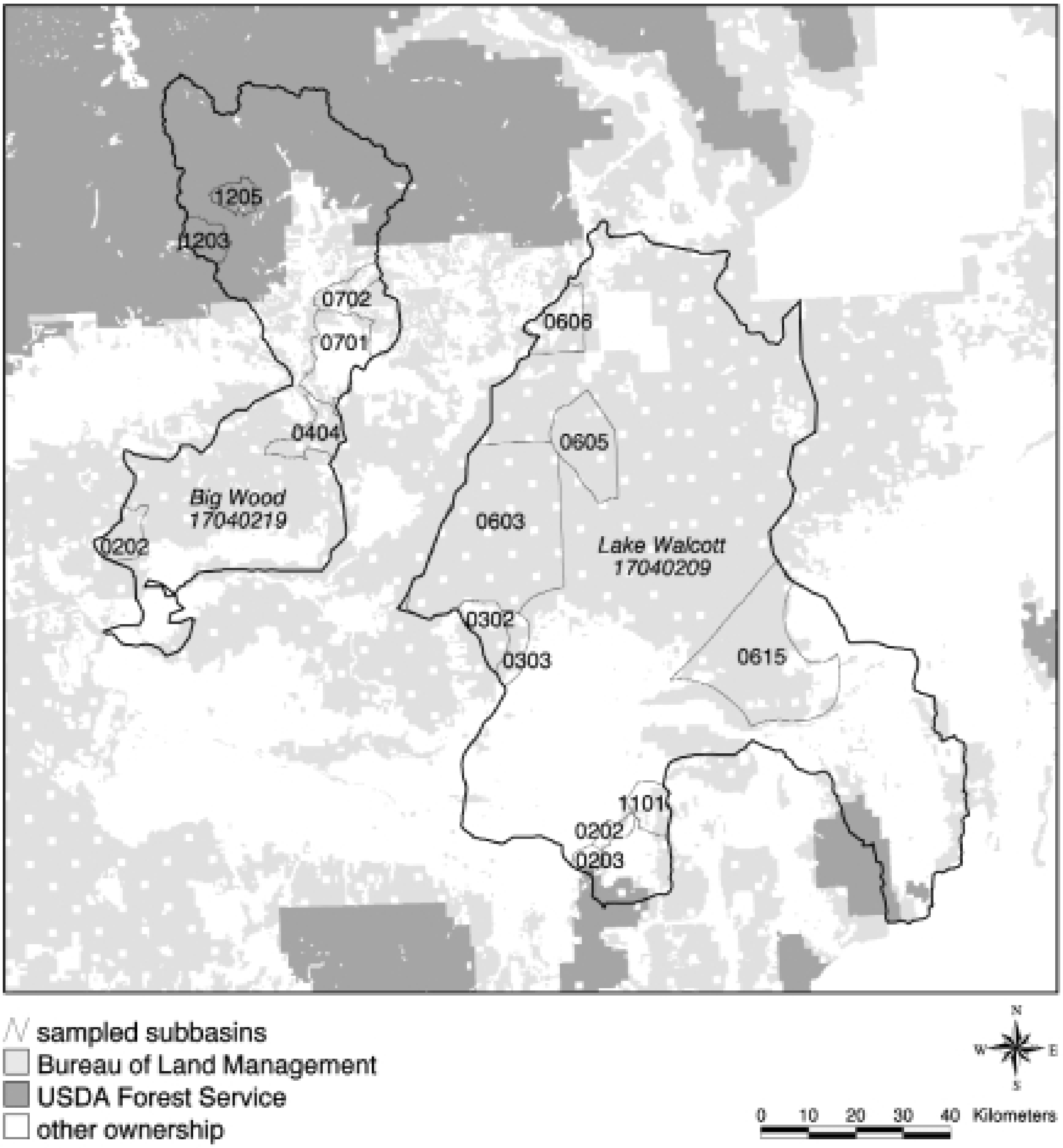

Figure 22—Subwatersheds on USDA Forest Service, Bureau of Land Management, and other ownerships sampled in the Big Wood and Lake Walcott subbasins of Idaho for the midscale ecological assessment of the interior Columbia River basin.

Vegetation Mapping

Landscape ecology is founded primarily on the notion that landscape structure and composition strongly influence ecological processes (Forman and Godron 1986; Li 1990; O'Neill and others 1988; Turner 1989, 1990; Turner and Gardiner 1991; Urban and others 1987). Populations of terrestrial vertebrate species, for example, differ by the area and connectivity of their habitats. Thus, characterizing trends in landscape structural attributes (both composition and configuration) is prerequisite to the study of change in landscape function. In this study, vegetation was mapped for recent historical (1930s to 1960s) and existing conditions (1985 to 1993) to evaluate trends in spatial patterns of structural attributes. Vegetation mapping and subsequent spatial analysis relied on high-quality, comparable (in photo scale and resolution) aerial photography of historical and current vegetation conditions (table 3).

Vegetation patches were delineated to a minimum size of 4 ha by using stereo aerial photography, both color and black and white. Photo scale ranged from 1:12,000, for recent color resource photography, to 1:63,360 high-resolution "real color" or black and white photography. Some 1:30,000 color infrared (Wratten 12 filter) photography also was used where color or black and white photography was unavailable. Higher stereoscopic magnification was used with decreasing photo scale to provide comparable resolution of attributes. Vegetation patches were defined by using an array of patch attributes (appendix 1) useful in characterizing (1) vertical and horizontal structure and composition of vegetation, (2) fuel conditions, (3) potential fire behavior attributes, (4) potential smoke production attributes, and (5) patch and landscape vulnerability to potential pathogen and insect disturbances.

Following is an abbreviated list of remotely sensed attributes: (1) total tree crown cover; (2) overstory tree crown cover; (3) understory tree crown cover, computed by subtraction; (4) clumpiness of tree cover; (5) clump density of tree cover; (6) average clump size of tree cover; (7) degree of crown differentiation among overstory tree crowns; (8) number of canopy layers; (9) riparian or wetland status; (10) nonforest type; (11) type of visible logging entry; (12) overstory size class; (13) understory size class; (14) overstory species or species mix; (15) understory species or species mix; (16) dead tree and snag abundance; (17) elevation belt; and (18) overstory canopy cover of nonforest types. Items 1-9 and 11-16 were interpreted for forest patches; items 9, 10, and 11, and 17-18 applied to nonforest patches. Items 1-3 were estimated to the nearest 10 percent.

Independent attributes were defined instead of being directly interpreted structural descriptions, such as "old-growth" or "ponderosa pine-mature sawtimber," so that attributes could be used independently or in combinations for a wider variety of analyses. Vegetation patches were mapped for historical and existing conditions by using the same attributes, standards, equipment, working conditions, and photointerpreters. Existing conditions were interpreted and mapped first. We obtained experienced photointerpreters who had local knowledge of vegetation conditions, landforms, and management history to interpret the aerial photography and to map and attribute vegetation patches. Photointerpreters were encouraged to field-verify vegetation signatures they were unsure of, and existing inventory and stand exam data were consulted, where available, to confirm visual interpretations.

Vegetation patches were delineated by within-patch uniformity of structure and composition. A single class change of any attribute (appendix 1) prompted delineation of a new patch, provided that the 4-ha minimum patch size limitation was satisfied. Patches were delineated on stereo aerial photo pairs with the aid of high-quality mirrored scanning stereoscopes with variable ocular magnification, then transferred to Mylar® overlays on georeferenced 1:24,000 (7.5-minute quadrangle) orthophotographs. Apparent riparian vegetation areas were delineated first within the effective area[19] of each photo pair. Mylar overlay maps were digitally scanned, edited and edge-matched by using LTplus raster-to-vector conversion

[19] For any aerial photograph that is one of an overlapping series in a flight strip among adjacent and overlapping flight strips, the central part of the photograph, where overlaps with adjacent photographs occur, enables stereo interpretation.

Table 3—Photo years of resource aerial photography used to sample recent historical and current vegetation conditions of subbasins in the midscale ecological assessment of the interior Columbia River basin

Code	Subbasin name	Span, historical	Subbasin percentage 1930s	1940s	1950s	1960s	Span, current	Subbasin percentage 1980s	1990s
BFM	Blackfoot (Montana)	1934-53	63		37		1988-90	63	37
BOM	Boise-Mores	1962-66				100	1988	100	
BTR	Bitterroot	1936-58	83		17		1986-87	100	
BUR	Burnt	1954-60			83	17	1989	100	
BWD	Big Wood	1943-59		33	67		1988	100	
CRT	Crooked-Rattlesnake	1954-63			14	86	1989	100	
DUB	Donner und Blitzen	1958			100		1989	100	
FLR	Flint Rock	1947		100			1990-91		100
KET	Kettle	1944		100			1985-92	40	60
LCR	Lower Crooked	1943-51		33	67		1987-91	33	67
LDS	Little Deschutes	1943-59		50	50		1988-91	92	8
LFH	Lower Flathead	1934-55	86	14			1990		100
LGR	Lower Grande Ronde	1939-64	33	44	17	6	1987-91	78	22
LHE	Lower Henry's	1941-60		75		25	1991-93		100
LJD	Lower John Day	1937-51	50		50		1985-91	88	12
LMH	Lemhi	1960				100	1991-93		100
LOC	Lochsa	1937-62	29		42	29	1990		100
LST	Lost	1942		100			1984	100	
LWC	Lake Walcott	1950-58			100		1988	100	
LYK	Lower Yakima	1949		100			1988-91	87	13
MDL	Medicine Lodge	1941-60		80		20	1987-93	20	80
MET	Methow	1954-56			100		1981-92	18	82
NAC	Naches	1938-49	11	89			1991-92		100
PEN	Pend Oreille	1932-35	100				1985-86	100	
PLS	Palouse	1932-51	22		78		1990-92		100
PSD	Palisades	1956-60				100	1988-90	33	67
SFC	South Fork Clearwater	1959-60			17	83	1991		100
SFS	South Fork Salmon	1962				100	1987-88	100	
SHW	Snake Headwaters	1955-56			100		1987-93	63	37
SIL	Silvies	1956			100		1989	100	
SPO	San Poil	1936-44	50	50			1991-92		100
SWN	Swan	1934-54	75		25		1992		100
UCD	Upper Coeur d' Alene	1933-55	80		20		1990-91		100
UDS	Upper Deschutes	1943-59		30	70		1987-91	20	80
UGR	Upper Grande Ronde	1939-55	88		13		1987	100	
UJD	Upper John Day	1951-56			100		1990-91		100
UKL	Upper Klamath Lake	1952-57			100		1985-92	63	37
UMS	Upper Middle Fork Salmon	1959-62			11	89	1988-91	44	56
UOW	Upper Owyhee	1930-63	8			92	1984-91	67	33
UYK	Upper Yakima	1942-59		67	33		1985-92	89	11
WAL	Wallowa	1939-56	14	36	50		1980-91	57	43
WEN	Wenatchee	1949		100			1992		100
YAA	Yaak	1950-63			50	50	1990-92		100

software, and imported into the ARC/INFO GIS where they were merged with tabular data files. The final product was a vector ARC/INFO map coverage with each polygon (patch) coded with the raw photointerpreted and derived attributes discussed below (see table 4 for a complete list and description of interpreted and derived patch attributes).

Forest vegetation classification—Patch attributes were interpreted for all forest and range vegetation in the sampled subwatersheds. Photointerpreted attributes and structural derivations using those raw attributes provided the basis for analysis. Patches comprised of agricultural cropland and urban or rural developments were interpreted as nonforest and nonrange but could be evaluated independently as anthropogenic[20] types when coupled with the raw photointerpreted nonforest type attribute. Three primary vegetation attributes were derived from remotely sensed data and mapped for all polygons: structural class (SC), cover type (CT), and potential vegetation type (PVT), a midscale measure of site potential and climatic climax vegetation. Structural classes and cover types of nonforest and nonrange and anthropogenic types were classified as other.

***Forest structure*—**Oliver and Larson (1990) describe four stand-development phases: stand initiation (si), stem exclusion, understory reinitiation (ur), and old growth. We added three additional structural classes to account for stand-development characteristics of interior forest conditions with their frequent disturbances (see also O'Hara and others 1996). We subdivided Oliver and Larson's stem-exclusion phase into open canopy and closed canopy conditions. Forest patches classified as stem exclusion-open canopy (seoc) were primarily those where the occurrence of new tree stems was limited by moisture or was the result of stocking control, prescribed underburning, or surface fires. Forest patches classified as stem exclusion-closed canopy (secc) were those where the occurrence of new tree stems was predominantly limited by light.

[20] Anthropogenic, as used in this paper, is defined in Webster's New Collegiate Dictionary, 1981, G & C Merriam Co., Springfield, MA as, of, relating to, or influenced by the impact of man on nature.

We subdivided Oliver and Larson's old-growth stage into single-story and multistory conditions. Old-forest patches classified as single story (ofss) were those resulting from frequent low-intensity surface fires, or other management, with large trees dominating the overstory. Old-forest patches classified as multistory (ofms) were those lacking frequent lethal disturbance to overstory or understory vegetation and also had large trees dominating the overstory.

One additional structural class, young-forest multistory (yfms) was modeled to represent stand development resulting from frequent harvest or lethal disturbance to the overstory. With the addition of these structural classes, we also converted Oliver and Larson's (1990) ordered classes to a set of unordered classes, whose temporal sequence at a given scale was a function of biophysical environment conditions and disturbance history (O'Hara and others 1996). Development of forest structure in the interior West is not the result of an ordered sequence of developmental events but the consequence of often unpredictable disturbances occurring at a variety of scales, broad to fine, that can either advance or retard succession by altering composition or structure. We provide structural class definitions for forest patches in table 5 and rules for classifying forest structures from continuous data in table 6.

Agee (1990, 1993) defines stand-replacing fires in the Pacific Northwest as those causing more than 70 percent mortality of overstory trees. We defined old-forest structures as those dominated by large tree structure; that is, ≥ 30 percent crown cover is displayed by trees larger than 63.5 cm in diameter at breast height (d.b.h.). Other structural classes that were not old forest could display up to 30 percent crown cover by large trees. We did so to allow remnant large trees surviving stand-replacement fires to be factored into definitions of structural classes that were not old forest. Indeed, many non-old-forest structures that have experienced mixed-severity or stand-replacement fires exhibit some characteristics of late successional patches, including large snags, down coarse woody debris accumulation, and complex understories, even though large trees may not dominate forest cover.

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Table 4—Photointerpreted and derived patch attributes of sampled subwatersheds in the midscale ecological assessment of the interior Columbia River basin[a]

No.	Attribute name	Code	Description	Derived or interpreted
1	Area	AREA	Patch area in square meters	D
2	Perimeter	PERIMETER	Length of patch boundary in meters	D
3	Polygon number	PGON#	Unique polygon (patch) number within each subwatershed	I
4	Acres	ACRES	Patch area expressed in acres	D
5	Subbasin	SUB_BASIN	Subbasin name (see also table 1)	I
6	Subwatershed	SUBWATERSHED	Subwatershed number (6th code HUC number), see figures 3 to 20	I
7	Total crown cover	TOTL_CC	Total crown cover estimated to the nearest 10 percent, forest patches	I
8	Overstory crown cover	OS_CC	Overstory tree crown cover estimated to the nearest 10 percent, forest patches	I
9	Understory crown cover	US_CC	TOTL_CC minus OS_CC	I
10	Clumpiness	CLMP	Indicates presence of clumpy tree cover, forest patches	I
11	Clump density	CLMP_DENS	Relative density of clumpy tree cover, forest patches	I
12	Clump size	CLMP_SIZE	Average size of tree clumps where tree cover is clumpy, forest patches	I
13	Crown differentiation	CRWN_DIFF	Degree of differentiation among overstory tree crowns, forest patches	I
14	Canopy layers	CNPY_LYRS	Estimated number of tree canopy layers of forest patches, forest patches	I
15	Riparian or wetland	RIPR_WET	Riparian or wetland status, forest or nonforest patches	I
16	Nonforest type	NON_FRST	Nonforest-nonrange or other anthropogenic type	I
17	Logging type	LOG_TYPE	Indicates apparent logging entry and type of harvest, forest patches	I
18	Percent in small clearcuts	LOG_P_CC	Percentage of patch area in small clearcuts estimated to nearest 10 percent	I
19	Overstory density	DENS_OS	Overstory trees/acre taken from inventory data where available, forest patches	I
20	Understory density	DENS_US	Understory trees/acre taken from inventory data where available, forest patches	I
21	Overstory size class	SIZE_OS	Overstory size class, forest patches	I
22	Understory size class	SIZE_US	Understory size class, forest patches	I
23	Forest overstory species	SPP_OS	Overstory species or species mix, forest patches	I
24	Forest understory species	SPP_US	Understory species or species mix, forest patches	I
25	Dead trees and snags	DEAD_SNAG	Dead tree and snag abundance, forest patches	I
26	Elevation belt	ELEV_BELT	Elevation belt of nonforest types	I
27	Elevation	ELEVATION	Elevation class (1,000 ft) that comprises most of the patch area	D
28	Aspect	ASPECT	Aspect class that comprises most of the patch area	D
29	Slope	SLOPE	Slope class that comprises most of the patch area	D
30	Elevation percent	ELEV_PCT	Percentage of patch area in the dominant elevation class	D
31	Aspect percent	ASPECT_PCT	Percentage of patch area in the dominant aspect class	D
32	Slope percent	SLOPE_PCT	Percentage of patch area in the dominant slope class	D
33	Nonforest overstory species	NON_FRST_SPP_OS	Nonforest (range or other) overstory species	I
34	Nonforest total canopy cover	NON_FRST_TCC	Total canopy cover of nonforest types	I
35	Nonforest, trees present	NON_FRST_TCOV	Indicates presence of sparse tree cover in a nonforest patch	I
36	Cover type	COVER	Modeled cover type	D
37	Potential vegetation type	SERIES	Modeled forest or range potential vegetation type (PVT)	D
38	Broadscale PVT-code	SERIES_CODE	Potential vegetation type numeric codes used in broadscale analyses	D
39	PVT percent	SERIES_PCT	Percentage of patch area comprised of modeled D potential vegetation type	D
40	Structural class	STRUCTURE_2	Modeled structural class	D
41	AROS-site quality	AROS_SQ	*Armillaria* root disease (AROS)-patch vulnerability factor = site quality	D
42	AROS-host abundance	AROS_HA	*Armillaria* root disease-patch vulnerability factor = host abundance	D
43	AROS-canopy structure	AROS_CS	*Armillaria* root disease-patch vulnerability factor = canopy structure	D
44	AROS-host age	AROS_AGE	*Armillaria* root disease-patch vulnerability factor = host age	D
45	AROS-host continuity	AROS_C	*Armillaria* root disease-patch vulnerability factor = continuity of host patches	D
46	AROS-sum of factor ratings	AROS_SUM	*Armillaria* root disease-patch vulnerability factor = sum of factor ratings	D
47	AROS-patch rating	AROS_HAZ	*Armillaria* root disease-patch vulnerability rating	D
48	DFB-site quality	DFB_SQ	Douglas-fir beetle (DFB)-patch vulnerability factor = site quality	D
49	DFB-host abundance	DFB_HA	Douglas-fir beetle-patch vulnerability factor = host abundance	D
50	DFB-canopy structure	DFB_CS	Douglas-fir beetle-patch vulnerability factor = canopy structure	D
51	DFB-host age	DFB_AGE	Douglas-fir beetle-patch vulnerability factor = host age	D
52	DFB-stand density	DFB_D	Douglas-fir beetle-patch vulnerability factor = stand density	D
53	DFB-host continuity	DFB_C	Douglas-fir beetle-patch vulnerability factor = continuity of host patches	D
54	DFB-sum of factor ratings	DFB_SUM	Douglas-fir beetle-patch vulnerability factor = sum of factor ratings	D
55	DFB-patch rating	DFB_HAZ	Douglas-fir beetle-patch vulnerability rating	D
56	AROS-site quality	AROS_SQ	*Armillaria* root disease (AROS)-patch vulnerability factor = site quality	D
57	AROS-host abundance	AROS_HA	*Armillaria* root disease-patch vulnerability factor = host abundance	D

Table 4—Photointerpreted and derived patch attributes of sampled subwatersheds in the midscale ecological assessment of the interior Columbia River basin[a] (continued)

No.	Attribute name	Code	Description	Derived or interpreted
58	AROS-canopy structure	AROS_CS	*Armillaria* root disease-patch vulnerability factor = canopy structure	D
59	AROS-host age	AROS_AGE	*Armillaria* root disease-patch vulnerability factor = host age	D
60	AROS-host continuity	AROS_C	*Armillaria* root disease-patch vulnerability factor = connectivity of host patches	D
61	AROS-sum of factor ratigs	AROS_SUM	*Armillaria* root disease-sum of factor ratings	D
62	AROS-patch rating	AROS_HAZ	*Armillaria* root disease-patch vulnerability rating	D
63	DFB-site quality	DFB_SQ	Douglas-fir beetle (DFB)-patch vulnerability factor = site quality	D
64	DFB-host abundance	DFB_HA	Douglas-fir beetle-patch vulnerability factor = host abundance	D
65	DFB-canopy structure	DFB_CS	Douglas-fir beetle-patch vulnerability factor = canopy structure	D
66	DFB-host age	DFB_AGE	Douglas-fir beetle-patch vulnerability factor = host age	D
67	DFB-stand density	DFB_D	Douglas-fir beetle-patch vulnerability factor = stand density	D
68	DFB-host continuity	DFB_C	Douglas-fir beetle-patch vulnerability factor = connectivity of host patches	D
69	DFB-sum of factor ratings	DFB_SUM	Douglas-fir beetle-sum of factor ratings	D
70	DFB-patch rating	DFB_HAZ	Douglas-fir beetle-patch vulnerability rating	D
71	DFDM-site quality	DFDM_SQ	Douglas-fir dwarf mistletoe (DFDM)-patch vulnerability factor = site quality	D
72	DFDM-host abundance	DFDM_HA	Douglas-fir dwarf mistletoe-patch vulnerability factor = host abundance	D
73	DFDM-canopy structure	DFDM_CS	Douglas-fir dwarf mistletoe-patch vulnerability factor = canopy structure	D
74	DFDM-host age	DFDM_AGE	Douglas-fir dwarf mistletoe-patch vulnerability factor = host age	D
75	DFDM-host continuity	DFDM_C	Douglas-fir dwarf mistletoe-patch vulnerability factor = connectivity of host patches	D
76	DFDM-sum of factor ratings	DFDM_SUM	Douglas-fir dwarf mistletoe-sum of factor ratings	D
77	DFDM-patch rating	DFDM_HAZ	Douglas-fir dwarf mistletoe-patch rating	D
78	FE-site quality	FE_SQ	Fir engraver (FE)-patch vulnerability factor = site quality	D
79	FE-host abundance	FE_HA	Fir engraver-patch vulnerability factor = host abundance	D
80	FE-canopy structure	FE_CS	Fir engraver-patch vulnerability factor = canopy structure	D
81	FE-host size	FE_HS	Fir engraver-patch vulnerability factor = host size	D
82	FE-stand density	FE_D	Fir engraver-patch vulnerability factor = stand density	D
83	FE-host continuity	FE_C	Fir engraver-patch vulnerability factor = connectivity of host patches	D
84	FE-sum of factor ratings	FE_SUM	Fir engraver-sum of factor ratings	D
85	FE-patch rating	FE_HAZ	Fir engraver-patch rating	D
86	LPDM-site quality	LPDM_SQ	Lodgepole pine dwarf mistletoe (LPDM)-patch vulnerability factor = site quality	D
87	LPDM-host abundance	LPDM_HA	Lodgepole pine dwarf mistletoe-patch vulnerability factor = host abundance	D
88	LPDM-canopy structure	LPDM_CS	Lodgepole pine dwarf mistletoe-patch vulnerability factor = canopy structure	D
89	LPDM-host age	LPDM_AGE	Lodgepole pine dwarf mistletoe-patch vulnerability factor = host age	D
90	LPDM-host continuity	LPDM_C	Lodgepole pine dwarf mistletoe-patch vulnerability factor = connectivity of host patches	D
91	LPDM-sum of factor ratings	LPDM_SUM	Lodgepole pine dwarf mistletoe-sum of factor ratings	D
92	LPDM-patch rating	LPDM_HAZ	Lodgepole pine dwarf mistletoe-patch rating	D
93	MPB1-site quality	MPB1_SQ	Mountain pine beetle type1 (MPB1)-patch	D
94	MPB1-host abundance	MPB1_HA	Mountain pine beetle type1-patch vulnerability factor = host abundance	D
95	MPB1-host size	MPB1_HS	Mountain pine beetle type1-patch vulnerability factor = host size	D
96	MPB1-stand density	MPB1_D	Mountain pine beetle type1 -patch vulnerability factor = stand density	D
97	MPB1-stand vigor	MPB1_V	Mountain pine beetle type1-patch vulnerability factor = stand vigor	D
98	MPB1-host continuity	MPB1_C	Mountain pine beetle type1-patch vulnerability factor = connectivity of host patches	D
99	MPB1-sum of factor ratings	MPB1_SUM	Mountain pine beetle type1-sum of factor ratings	D
100	MPB1-patch rating	MPB1_HAZ	Mountain pine beetle type1-patch rating	D
101	MPB2-site quality	MPB2_SQ	Mountain pine beetle type2 (MPB2)-patch vulnerability factor = site quality	D
102	MPB2-host abundance	MPB2_HA	Mountain pine beetle type2-patch vulnerability factor = host abundance	D
103	MPB2-host age	MPB2_AGE	Mountain pine beetle type2-patch vulnerability factor = host age	D
104	MPB2-stand density	MPB2_D	Mountain pine beetle type2 -patch vulnerability factor = stand density	D
105	MPB2-stand vigor	MPB2_V	Mountain pine beetle type2-patch vulnerability factor = stand vigor	D
106	MPB2-host continuity	MPB2_C	Mountain pine beetle type2-patch vulnerability factor = connectivity of host patches	D
107	MPB2-sum of factor ratings	MPB2_SUM	Mountain pine beetle type2-sum of factor ratings	D
108	MPB2-patch rating	MPB2_HAZ	Mountain pine beetle type2-patch rating	D
109	PHEAN-site quality	PHEAN _SQ	P-group annosum root disease (PHEAN)-patch vulnerability factor = site quality	D
110	PHEAN-host abundance	PHEAN _HA	P-group annosum root disease-patch vulnerability factor = host abundance	D
111	PHEAN-canopy structure	PHEAN _CS	P-group annosum root disease-patch vulnerability factor = canopy structure	D
112	PHEAN-host age	PHEAN _AGE	P-group annosum root disease-patch vulnerability factor = host age	D
113	PHEAN-disturbance history	PHEAN_DH	P-group annosum root disease-patch vulnerability factor = logging disturbance history	D

Table 4—Photointerpreted and derived patch attributes of sampled subwatersheds in the midscale ecological assessment of the interior Columbia River basin[a] (continued)

No.	Attribute name	Code	Description	Derived or interpreted
114	PHEAN-host continuity	PHEAN_C	P-group annosum root disease-patch vulnerability factor = connectivity of host patches	D
115	PHEAN-sum of factor ratings	PHEAN_SUM	P-group annosum root disease-sum of factor ratings	D
116	PHEAN-patch rating	PHEAN_HAZ	P-group annosum root disease-patch rating	D
117	PHWE-site quality	PHWE_SQ	Laminated root rot (PHWE)-patch vulnerability factor = site quality	D
118	PHWE-host abundance	PHWE_HA	Laminated root rot-patch vulnerability factor = host abundance	D
119	PHWE-canopy structure	PHWE_CS	Laminated root rot-patch vulnerability factor = canopy structure	D
120	PHWE-host age	PHWE_AGE	Laminated root rot-patch vulnerability factor = host age	D
121	PHWE-host continuity	PHWE_C	Laminated root rot-patch vulnerability factor = connectivity of host patches	D
122	PHWE-sum of factor ratings	PHWE_SUM	Laminated root rot-sum of factor ratings	D
123	PHWE-patch rating	PHWE_HAZ	Laminated root rot-patch vulnerability rating	D
124	PPDM-site quality	PPDM_SQ	Western dwarf mistletoe (PPDM)-patch vulnerability factor = site quality	D
125	PPDM-host abundance	PPDM_HA	Western dwarf mistletoe-patch vulnerability factor = host abundance	D
126	PPDM-canopy structure	PPDM_CS	Western dwarf mistletoe-patch vulnerability factor = canopy structure	D
127	PPDM-host age	PPDM_AGE	Western dwarf mistletoe-patch vulnerability factor = host age	D
128	PPDM-host continuity	PPDM_C	Western dwarf mistletoe-patch vulnerability factor = connectivity of host patches	D
129	PPDM-sum of factor ratings	PPDM_SUM	Western dwarf mistletoe-sum of factor ratings	D
130	PPDM-patch rating	PPDM_HAZ	Western dwarf mistletoe-patch vulnerability rating	D
131	RRSR-site quality	RRSR_SQ	Rust-red stringy rot (RRSR)-patch vulnerability factor = site quality	D
132	RRSR-host abundance	RRSR_HA	Rust-red stringy rot-patch vulnerability factor = host abundance	D
133	RRSR-canopy structure	RRSR_CS	Rust-red stringy rot-patch vulnerability factor = canopy structure	D
134	RRSR-host age	RRSR_AGE	Rust-red stringy rot-patch vulnerability factor = host age	D
135	RRSR-disturbance history	RRSR_DH	Rust-red stringy rot-patch vulnerability factor = logging disturbance history	D
136	RRSR-sum of factor ratings	RRSR_SUM	Rust-red stringy rot-sum of factor ratings	D
137	RRSR-patch rating	RRSR_HAZ	Rust-red stringy rot-patch rating	D
138	SB-site quality	SB_SQ	Spruce beetle (SB)-patch vulnerability factor = site quality	D
139	SB-host abundance	SB_HA	Spruce beetle-patch vulnerability factor = host abundance	D
140	SB-topographic setting	SB_TS	Spruce beetle-patch vulnerability factor = topographic setting	D
141	SB-host size	SB_HS	Spruce beetle-patch vulnerability factor = host size	D
142	SB-stand density	SB_D	Spruce beetle-patch vulnerability factor = stand density	D
143	SB-host continuity	SB_C	Spruce beetle-patch vulnerability factor = connectivity of host patches	D
144	SB-sum of factor ratings	SB_SUM	Spruce beetle-sum of factor ratings	D
145	SB-patch rating	SB_HAZ	Spruce beetle-patch rating	D
146	SHEAN-site quality	SHEAN_SQ	S-group annosum root disease (SHEAN)-patch vulnerability factor = site quality	D
147	SHEAN-host abundance	SHEAN_HA	S-group annosum root disease-patch vulnerability factor = host abundance	D
148	SHEAN-canopy structure	SHEAN_CS	S-group annosum root disease-patch vulnerability factor = canopy structure	D
149	SHEAN-host age	SHEAN_AGE	S-group annosum root disease-patch vulnerability factor = host age	D
150	SHEAN-disturbance history	SHEAN_DH	S-group annosum root disease-patch vulnerability factor = logging disturbance history	D
151	SHEAN-host continuity	SHEAN_C	S-group annosum root disease-patch vulnerability factor = connectivity of host patches	D
152	SHEAN-sum of ratings	SHEAN_SUM	S-group annosum root disease-sum of factor ratings	D
153	SHEAN-patch rating	SHEAN_HAZ	S-group annosum root disease-patch rating	D
154	SRBR-site quality	SRBR_SQ	Schweinitzii root and butt rot (SRBR)-patch vulnerability factor = site quality	D
155	SRBR-host abundance	SRBR_HA	Schweinitzii root and butt rot-patch vulnerability factor = host abundance	D
156	SRBR-host age	SRBR_AGE	Schweinitzii root and butt rot-patch vulnerability factor = host age	D
157	SRBR-host continuity	SRBR_C	Schweinitzii root and butt rot-patch vulnerability factor = connectivity of host patches	D
158	SRBR-sum of factor ratings	SRBR_SUM	Schweinitzii root and butt rot-sum of factor ratings	D
159	SRBR-patch rating	SRBR_HAZ	Schweinitzii root and butt rot-patch rating	D
160	TRBR-host abundance	TRBR_HA	Tomentosus root and butt rot (TRBR)-patch vulnerability factor = host abundance	D
161	TRBR-host age	TRBR_AGE	Tomentosus root and butt rot-patch vulnerability factor = host age	D
162	TRBR-topographic setting	TRBR_TS	Tomentosus root and butt rot-patch vulnerability factor = topographic setting	D
163	TRBR-host continuity	TRBR_C	Tomentosus root and butt rot-patch vulnerability factor = connectivity of host patches	D
164	TRBR-sum of factor ratings	TRBR_SUM	Tomentosus root and butt rot-sum of factor ratings	D
165	TRBR-patch rating	TRBR_HAZ	Tomentosus root and butt rot-patch rating	D
166	WLDM-site quality	WLDM_SQ	Western larch dwarf mistletoe (WLDM)-patch vulnerability factor = site quality	D
167	WLDM-host abundance	WLDM_HA	Western larch dwarf mistletoe-patch vulnerability factor = host abundance	D
168	WLDM-canopy structure	WLDM_CS	Western larch dwarf mistletoe-patch vulnerability factor = canopy structure	D
169	WLDM-host age	WLDM_AGE	Western larch dwarf mistletoe-patch vulnerability factor = host age	D
170	WLDM-host continuity	WLDM_C	Western larch dwarf mistletoe-patch vulnerability factor = connectivity of host patches	D
171	WLDM-sum of factor ratings	WLDM_SUM	Western larch dwarf mistletoe-sum of factor ratings	D

Table 4—Photointerpreted and derived patch attributes of sampled subwatersheds in the midscale ecological assessment of the interior Columbia River basin[a] (continued)

No.	Attribute name	Code	Description	Derived or interpreted
172	WLDM-patch rating	WLDM_HAZ	Western larch dwarf mistletoe-patch rating	D
173	WPB1-site quality	WPB1_SQ	Western pine beetle type1 (WPB1)-patch vulnerability factor = site quality	D
174	WPB1-host abundance	WPB1_HA	Western pine beetle type1-patch vulnerability factor = host abundance	D
175	WPB1-host age	WPB1_AGE	Western pine beetle type1-patch vulnerability factor = host age	D
176	WPB1-stand density	WPB1_D	Western pine beetle type1-patch vulnerability factor = stand density	D
177	WPB1-host continuity	WPB1_C	Western pine beetle type1-patch vulnerability factor = connectivity of host patches	D
178	WPB1-sum of factor ratings	WPB1_SUM	Western pine beetle type1-sum of factor ratings	D
179	WPB1-patch rating	WPB1_HAZ	Western pine beetle type1-patch vulnerability rating	D
180	WPB2-site quality	WPB2_SQ	Western pine beetle type1 (WPB2)-patch vulnerability factor = site quality	D
181	WPB2-host abundance	WPB2_HA	Western pine beetle type1-patch vulnerability factor = host abundance	D
182	WPB2-host age	WPB2_AGE	Western pine beetle type1-patch vulnerability factor = host age	D
183	WPB2-stand vigor	WPB2_V	Western pine beetle type1-patch vulnerability factor = stand vigor	D
184	WPB2-stand density	WPB2_D	Western pine beetle type1-patch vulnerability factor = stand density	D
185	WPB2-host continuity	WPB2_C	Western pine beetle type1-patch vulnerability factor = connectivity of host patches	D
186	WPB2-sum of factor ratings	WPB2_SUM	Western pine beetle type1-sum of factor ratings	D
187	WPB2-patch rating	WPB2_HAZ	Western pine beetle type1-patch vulnerability rating	D
188	WPBR1-site quality	WPBR1_SQ	White pine blister rust (WPBR1)-patch vulnerability factor = site quality	D
189	WPBR1-host abundance	WPBR1_HA	White pine blister rust-patch vulnerability factor = host abundance	D
190	WPBR1-host size	WPBR1_HS	White pine blister rust-patch vulnerability factor = host age	D
191	WPBR1-sum of ratings	WPBR1_SUM	White pine blister rust-sum of factor ratings	D
192	WPBR1-patch rating	WPBR1_HAZ	White pine blister rust-patch vulnerability rating	D
193	WPBR2-site quality	WPBR2_SQ	White pine blister rust (WPBR2)-patch vulnerability factor = site quality	D
194	WPBR2-host abundance	WPBR2_HA	White pine blister rust-patch vulnerability factor = host abundance	D
195	WPBR2-host size	WPBR2_HS	White pine blister rust-patch vulnerability factor = host age	D
196	WPBR2-sum of ratings	WPBR2_SUM	White pine blister rust-sum of factor ratings	D
197	WPBR2-patch rating	WPBR2_HAZ	White pine blister rust-patch vulnerability rating	D
198	WSB-site quality	WSB_SQ	Western spruce budworm (WSB)-patch vulnerability factor = site quality	D
199	WSB-host abundance	WSB_HA	Western spruce budworm-patch vulnerability factor = host abundance	D
200	WSB-canopy structure	WSB_CS	Western spruce budworm-patch vulnerability factor = canopy structure	D
201	WSB-host age	WSB_AGE	Western spruce budworm-patch vulnerability factor = host age	D
202	WSB-stand density	WSB_D	Western spruce budworm-patch vulnerability factor = stand density	D
203	WSB-stand vigor	WSB_V	Western spruce budworm-patch vulnerability factor = stand vigor	D
204	WSB-host continuity	WSB_C	Western spruce budworm-patch vulnerability factor = connectivity of host patches	D
205	WSB-sum of factor ratings	WSB_SUM	Western spruce budworm-sum of factor ratings	D
206	WSB-patch rating	WSB_HAZ	Western spruce budworm-patch rating	D
207	Consumption-wet cond.	CONS_W	Modeled fuel consumption under wet burn conditions	D
208	Consumption-dry cond.	CONS_D	Modeled fuel consumption under dry burn conditions	D
209	Consumption-normal cond.	CONS_N	Modeled fuel consumption under normal or average burn conditions	D
210	Intensity-wet cond.	INT_W	Modeled fireline intensity under wet burn conditions	D
211	Intensity-dry cond.	INT_D	Modeled fireline intensity under dry burn conditions	D
212	Intensity-normal cond.	INT_N	Modeled fireline intensity under normal or average burn conditions	D
213	Flame length-wet cond.	FLAME_W	Modeled flame length under wet burn conditions	D
214	Flame length-dry cond.	FLAME_D	Modeled flame length under dry burn conditions	D
215	Flame length-normal cond.	FLAME_N	Modeled flame length under normal or average burn conditions	D
216	Fire rate of spread-wet	RATE_W	Modeled fire rate of spread under wet burn conditions	D
217	Fire rate of spread-dry	RATE_D	Modeled fire rate of spread under dry burn conditions	D
218	Fire rate of spread-normal	RATE_N	Modeled fire rate of spread under normal or average burn conditions	D
219	Risk of crown fire-wet	RCF_W	Modeled risk of crown fire under wet burn conditions	D
220	Risk of crown fire-dry	RCF_D	Modeled risk of crown fire under dry burn conditions	D
221	Risk of crown fire-normal	RCF_N	Modeled risk of crown fire under normal or average burn conditions	D
222	Smoke emissions-wet	SMOKE_W	Modeled smoke emissions under wet burn conditions	D
223	Smoke emissions-dry	SMOKE_D	Modeled smoke emissions under dry burn conditions	D
224	Smoke emissions-normal	SMOKE_N	Modeled smoke emissions under normal or average burn conditions	D
225	Fuel loading	FUEL	Ground fuel loading	D
226	Aerial photo year	PHOTO_YEAR	Time period of source aerial photography (1930 to 1993)	I

[a] See appendix 1 for descriptions of photointerpreted attributes, and Hessburg and others (in press) for characterization rules for modeling patch and landscape vulnerability to pathogen and insect disturbances.

Table 5—Descriptions of forest structural classes modeled in the midscale ecological assessment of the interior Columbia River basin

Structural class	Definition	Description
Stand initiation	Growing space is reoccupied following a stand-replacing disturbance (e.g., fire, harvest), typically by early seral species	1 canopy stratum (may be broken or continuous); 1 cohort[a] seedlings or saplings; grasses, forbs, shrubs may be present with early seral trees
Stem exclusion open canopy	Occurrence of new tree stems is moisture limited; crowns are open growing; canopy is broken; may be maintained by frequent underburning or density management	1 broken canopy stratum; 1 cohort; trees excluding new stems through competition; poles, small, or medium trees; understory shrubs, grasses, forbs may be present
Stem exclusion closed canopy	Occurrence of new tree stems is mostly light limited; crowns abrading, canopy is closed	Continuous closed canopy; 1 or more canopy strata; 1 cohort; lower strata, if present, are same age as upper strata; poles, small, or medium trees; understory shrubs, grasses, forbs may be present
Understory reinitiation	Second cohort established under older, typically early seral overstory; mortality in the overstory creates growing space for new trees in the understory	Broken overstory canopy; ≥ 2 canopy strata; 2 cohorts; overstory is poles, small, or medium trees; understory is seedlings, saplings, or poles
Young-forest multistory	Several cohorts have established under the influence of management or fires with mixed lethal and nonlethal effects, or by insect and disease group killing; early seral overstory large trees are generally absent as a result of harvesting or other disturbance	Broken overstory canopy; > 2 canopy strata; > 2 cohorts; large trees are absent in the overstory; stands are characterized by diverse horizontal and vertical distributions of trees and tree sizes; seedlings, saplings, poles, small, and medium trees are present
Old-forest multistory	Multicohort, multistrata stands with large, old trees	Broken overstory canopy; > 2 canopy strata; > 2 cohorts; large trees dominate in the overstory; stands are characterized by diverse horizontal and vertical distributions of trees and tree sizes; all tree sizes may be present
Old-forest single story	Single-stratum stands of large, old trees. No or few young trees are present in the understory; parklike conditions resulting from nonlethal natural or prescribed underburning or other management are the dominant feature	Broken or continuous canopy of large, old trees; 1 stratum, may be single but usually multicohort; large trees dominate the overstory; understory absent or seedlings or saplings; grasses, forbs, or shrubs may be present in the understory

[a] Trees within a cohort share a common disturbance history; they are those initiated or released after a disturbance (natural or artificial). Tree ages within a cohort may span several decades.

Table 6—Classification rules for forest structural classes modeled for sampled subwatersheds in the midscale ecological assessment of the interior Columbia River basin

No.	Structural class (code)	Classification rule
1	Stand initiation (si)	LgT_cc[a] < 30 percent (i.e., = 0, 10, or 20 percent) and SS[b]_cc ≥ 10 percent and {[PT_cc + SmT_cc + MedT_cc < 20 percent] or [PT_cc + SmT_cc + MedT_cc ≤ 60 percent and PT_cc + SmT_cc + MedT_cc ≥ 20 percent and SmT_cc + MedT_cc < 10 percent]}
2	Stem exclusion open canopy (seoc)	LgT_cc < 30 percent (i.e., = 0, 10, or 20 percent) and SS_cc < 10 percent and PT_cc + SmT_cc + MedT_cc ≤ 70 percent
3	Stem exclusion closed canopy (secc)	LgT_cc < 30 percent (i.e., = 0, 10, or 20 percent) and SS_cc < 10 percent and PT_cc + SmT_cc + MedT_cc > 70 percent
4	Understory reinitiation (ur)	LgT_cc < 30 percent (i.e., = 0, 10, or 20 percent) and SS_cc ≥ 10 percent and PT_cc + SmT_cc + MedT_cc > 60 percent
5	Young-forest multistory (yfms)	LgT_cc < 30 percent (i.e., = 0, 10, or 20 percent) and SS_cc ≥ 10 percent and PT_cc + SmT_cc + MedT_cc ≤ 60 percent and SmT_cc ≥ 10 percent or MedT_cc ≥ 10 percent
6	Old-forest multistory (ofms)	LgT_cc ≥ 30 percent and SS_cc + PT_cc + SmT_cc + MedT_cc > 20 percent
7	Old-forest single story (ofss)	LgT_cc ≥ 30 percent and SS_cc + PT_cc + SmT_cc + MedT_cc ≤ 20 percent

[a] cc = crown cover; crown cover was interpreted in 10-percent increments and class percentages were expressed as midpoints; e.g., 10 percent = 5 to 14 percent, 20 percent = 15 to 24 percent.

[b] Tree sizes were estimated as SS–seedlings and saplings (< 12.7 cm d.b.h.), PT–poles (12.7 to 22.6 cm d.b.h.), SmT–small trees (22.7 to 40.4 cm d.b.h.), MedT–medium trees (40.5 to 63.5 cm d.b.h.), and LgT–large trees (> 63.5 cm d.b.h.).

Forest composition—Existing vegetation cover attributes were classified into cover types. Cover types were estimated from overstory and understory species composition and total overstory and understory crown cover attributes. Both pure and mixed species cover conditions (appendix 1) were interpreted for forest patches. Cover types were based on the overstory species attribute when overstory crown cover was ≥ 30 percent. Understory species composition determined the cover type when overstory crown cover was ≤ 20 percent and understory crown cover exceeded overstory crown cover.

Forest cover type classes were modeled according to Society of American Foresters (SAF) forest cover type definitions (Eyre 1980). To facilitate comparison of results, forest cover type classes of the midscale assessment were closely matched with cover type classes used in the broad-scale assessment of the basin (see Hann and others 1997). Examples of forest cover types of midscale subwatersheds are ponderosa pine (SAF 237), western larch (SAF 212), lodgepole pine (SAF 218), interior Douglas-fir (SAF 210), and Engelmann spruce-subalpine fir (SAF 206). We classified 17 forest cover types. We provide rules for modeling all midscale forest cover types from remotely sensed cover attributes in table 7. Common and scientific names and abbreviations of species discussed in the text and tables are listed in table 8.

Cover type and structural class items were attributed to each patch; the type assigned to each patch was the doublet of its cover type and structural class. Examples of patch types are Douglas-fir-stand initiation, western larch-stem exclusion-closed canopy, and ponderosa pine-old forest-single story. In subsequent analysis, these patch types become the unique elements of the landscape mosaic and are the focus of change analyses.

Forest potential vegetation types—Environments highly similar in climate attributes, geology, landforms, and geomorphic and hydrologic

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Table 7—Classification rules for forest cover types modeled for sampled subwatersheds in the midscale ecological assessment of the interior Columbia River basin

Forest cover type	SAF cover type(s)	Overstory species composition[a]	Understory species composition[b]
Ponderosa pine	SAF 237	Ponderosa pine,[c] ponderosa pine-Douglas-fir	Grass-forb, shrub, bare ground, ponderosa pine, ponderosa pine-Douglas-fir
Western larch	SAF 212	Western larch, western larch-lodgepole pine, western larch-lodgepole pine-western white pine, western larch-ponderosa pine, western larch-Engelmann spruce, western larch-western white pine	Grass-forb, shrub, or bare ground, western larch-lodgepole pine
Lodgepole pine	SAF 218	Lodgepole pine, lodgepole pine-Engelmann spruce, lodgepole pine-white fir	Grass-forb, shrub, bare ground, lodgepole pine, lodgepole pine-Engelmann spruce, lodgepole pine-white fir, lodgepole pine-ponderosa pine
Douglas-fir	SAF 210	Douglas-fir, Douglas-fir-western larch, Douglas-fir-aspen, Douglas-fir-western white pine, Douglas-fir-lodgepole pine, Douglas-fir-grand fir	Grass-forb, shrub, bare ground, Douglas-fir-western larch, Douglas-fir-lodge-pole pine
Grand fir or white fir, or both	SAF 211 SAF 213	Grand fir or white fir, grand fir-Engelmann spruce, grand fir-ponderosa pine, grand fir-subalpine fir, incense-cedar,[d] grand fir-western white pine, grand fir-western larch	Grass-forb, shrub, bare ground, grand fir or white fir, grand fir-Douglas-fir white fir-Douglas-fir incense-cedar
Pacific silver fir	SAF 226	Pacific silver fir, noble fir	Grass-forb, shrub, bare ground, Pacific silver fir-grand fir, Pacific silver fir-Douglas-fir, Pacific silver fir
Engelmann spruce or subalpine fir, or both	SAF 206	Engelmann spruce-subalpine fir, Engelmann spruce-Douglas-fir, subalpine fir-Douglas-fir subalpine fir-western white pine, subalpine fir-lodgepole pine	Grass-forb, shrub, bare ground, Engelmann spruce- subalpine fir, Engelmann spruce-Douglas-fir
Western hemlock or western redcedar, or both	SAF 224 SAF 227 SAF 228	Western hemlock or western redcedar	Grass-forb, shrub, bare ground, western hemlock or western redcedar
Mountain hemlock	SAF 205	Mountain hemlock, mountain hemlock-Douglas-fir, mountain hemlock-white fir, incense-cedar[e]	Grass-forb, shrub, bare ground, mountain hemlock, mountain hemlock-Douglas-fir, mountain hemlock-white fir, mountain hemlock-lodge pole pine
Whitebark pine or subalpine larch, or both	SAF 208	Whitebark pine or subalpine larch, subalpine fir-subalpine larch	Grass-forb, shrub, bare ground, whitebark pine or subalpine larch
Western white pine or sugar pine, or both	SAF 215[f]	Western white pine or sugar pine, sugar pine-subalpine fir-ponderosa pine	Grass-forb, shrub, bare ground, western white pine and/or sugar pine
Aspen-cottonwood-willow	SAF 217 SAF 222 SAF 235 SAF 233	Hardwoods, maple, birch, aspen, cottonwood, aspen-lodgepole pine	Grass-forb, shrub, bare ground, hardwoods, maple, birch, aspen, cottonwood

Table 7—Classification rules for forest cover types modeled for sampled subwatersheds in the midscale ecological assessment of the interior Columbia River basin (continued)

Forest cover type	SAF cover type(s)	Overstory species composition[a]	Understory species composition[b]
Western or Rocky Mountain juniper	SAF 238 SAF 220	Juniper	Grass-forb, shrub, bare ground, juniper
Shasta red fir	SAF 207	Shasta red fir	Grass-forb, shrub, bare ground, Shasta red fir
Pinyon-juniper	SAF 239	Pinyon pine-juniper, pinyon pine	Grass-forb, shrub, bare ground, pinyon pine-juniper, pinyon pine
Russian olive	n/a	Russian olive	Grass-forb, shrub, bare ground
Limber pine	SAF 219	Limber pine, limber pine-Douglas-fir, limber pine-subalpine fir	Grass-forb, shrub, bare ground, limber pine, limber pine-Douglas-fir

[a] Compositions occurred in pure and mixed types. To be named in a photointerpreted overstory or understory species mix, a species represented at least 20 percent of the total crown cover.

[b] Cover type classification of any forest patch was based on the photointerpreted overstory species attribute when overstory crown cover was ≥ 30 percent. Understory species composition determined the cover type when overstory crown cover was ≥ 20 percent and understory crown cover was greater than overstory crown cover.

[c] Common and scientific names, and abbreviations of species discussed in the text and tables are listed in table 8.

[d] Forest patches with incense-cedar occurring as the dominant overstory species in combination with an understory species mix of Douglas-fir-grand fir or Douglas-fir-white fir were classified to a grand fir-white fir cover type.

[e] Forest patches with incense-cedar occurring as the dominant overstory species in combination with an understory species of mountain hemlock, mountain hemlock-white fir, or mountain hemlock-lodgepole pine were classified to a mountain hemlock cover type.

[f] SAF 215 occurs only in Idaho, Montana, and Washington. The SAF (Eyre 1980) does not provide an explicit cover type for sugar pine. Sugar pine is included in the mixed conifer types of the Sierra, Siskiyou, and Cascades ranges of southern Oregon and California.

Table 8—Common and scientific names, and abbreviations of species

Common name	Abbreviation	Scientific name
Pathogens:		
Annosum root disease	HEAN	*Heterobasidion annosum* (Fr.) Bref.
Armillaria root disease	AROS	*Armillaria ostoyae* (Romag.) Herink
Douglas-fir dwarf mistletoe	DFDM	*Arceuthobium douglasii* Engelm.
Laminated root rot	PHWE	*Phellinus weirii* (Murr.) Gilb.
Lodgepole pine dwarf mistletoe	LPDM	*Arceuthobium americanum* Nutt. ex Engelm.
P-group annosum root disease	HEANp	*Heterobasidion annosum* (Fr.) Bref.
Rust-red stringy rot (Indian paint fungus)	RRSR	*Echinodontium tinctorium* E. & E.
Schweinitzii root and butt rot	SRBR	*Phaeolus schweinitzii* (Fr.) Pat.
S-group annosum root disease	HEANs	*Heterobasidion annosum* (Fr.) Bref.
Tomentosus root and butt rot	TRBR	*Inonotus tomentosus* (Fr.) Teng.
Western dwarf mistletoe	PPDM	*Arceuthobium campylopodum* Engelm.
Western larch dwarf mistletoe	WLDM	*Arceuthobium laricis* (Piper) St. John
White pine blister rust	WPBR	*Cronartium ribicola* Fisch.
Insects:		
Douglas-fir beetle	DFB	*Dendroctonus pseudotsugae* Hopkins
Douglas-fir tussock moth	DFTM	*Orgyia pseudotsugata* (McDonnough)
Fir engraver	FE	*Scolytus ventralis* LeConte
Mountain pine beetle	MPB	*Dendroctonus ponderosae* Hopkins
Spruce beetle	SB	*Dendroctonus rufipennis* (Kirby)
Western pine beetle	WPB	*Dendroctonus brevicomis* LeConte
Western spruce budworm	WSB	*Choristoneura occidentalis* Freeman

Table 8—Common and scientific names, and abbreviations of species (continued)

Common name	Abbreviation	Scientific name
Trees:		
Birch—	Birch	*Betula* spp.
Bog birch	BEGL	*B. glandulosa* Michx.
Paper birch	BEPA	*B. papyrifera* Marsh.
Water birch	BEOC	*B. occidentalis* Hook.
Blue spruce	PIPU	*Picea pungens* Engelm.
Cottonwood—	Cottonwood	*Populus* spp.
Black cottonwood	POTRI	*P. trichocarpa* Torr. & Gray.
Narrow-leaved cottonwood	POAN	*P. angustifolia* James
Douglas-fir	PSME	*Pseudotsuga menziesii* (Mirb.) Franco
Engelmann spruce	PIEN	*Picea engelmannii* Parry ex Engelm.
Grand fir	ABGR	*Abies grandis* (Dougl. ex D. Don) Lindl.
Hemlocks		*Tsuga* spp.
Incense-cedar	CADE	*Libocedrus decurrens* Torr.
Juniper—	Juniper	*Juniperus* spp.
Rocky Mountain juniper	JUSC	*J. scopulorum* Sarg.
Utah juniper	JUOS	*J. osteosperma* (Torr.) Little
Western juniper	JUOC	*J. occidentalis* Hook.
Limber pine	PIFL	*Pinus flexilis* James
Lodgepole pine	PICO	*Pinus contorta* var. *latifolia* Engelm.
Maple—	Maple	*Acer* spp.
Bigleaf maple	ACMA	*A. macrophyllum* Pursh
Bigtooth maple	ACGR	*A. grandidentatum* Nutt.
Douglas maple	ACGLDO	*A. glabrum* var. *douglasii* (Hook.) Dippel
Rocky Mountain maple	ACGLGL	*A. glabrum* var. *glabrum* Torr.
Vine maple	ACCI	*A. circinatum* Pursh
Mountain hemlock	TSME	*Tsuga mertensiana* (Bong.) Carr.
Noble fir	ABPR	*Abies procera* Rehd.
Pacific silver fir	ABAM	*A. amabilis* Dougl. ex Forbes
Pinyon pine	PIMO2	*Pinus monophylla* Torr. & Frem.
Ponderosa pine	PIPO	*P. ponderosa* Dougl. ex Laws.
Quaking aspen	Aspen	*Populus tremuloides* Michx.
Russian olive	ELAN	*Elaeagnus angustifolia* L.
Shasta red fir	ABMA	*Abies magnifica* A. Murr.
Subalpine fir	ABLA2	*A. lasiocarpa* (Hook.) Nutt.
Sugar pine	PILA	*Pinus lambertiana* Dougl.
True firs		*Abies* spp.
Western hemlock	TSHE	*Tsuga heterophylla* (Raf.) Sarg.
Western larch	LAOC	*Larix occidentalis* Nutt.
Western redcedar	THPL	*Thuja plicata* Donn ex D. Don
Western white pine	PIMO	*Pinus monticola* Dougl. ex D. Don
Whitebark pine	PIAL	*P. albicaulis* Engelm.
White fir	ABCO	*Abies concolor* (Gord. & Glend.) Lindl.
White spruce	PIGL	*Picea glauca* (Moench) Voss
Shrubs:		
Alder—	Alder	*Alnus* spp.
Basin big sagebrush	ARTRTR	*Artemisia tridentata* var. *tridentata* Nutt.
Bitterbrush	PUTR	*Purshia tridentata* (Pursh)
Bittercherry	PREM	*Prunus emarginata* (Dougl.) Walp.
Bog birch	BEGL	*Betula glandulosa* Michx.
Common chokecherry	PRVI	*Prunus virginiana* L.
Common snowberry	SYAL	*Symphoricarpos albus* (L.) Blake
Currant		*Ribes* spp.
Curlleaf mahogany	CELE	*Cercocarpus ledifolius* Nutt.

Table 8—Common and scientific names, and abbreviations of species (continued)

Common name	Abbreviation	Scientific name
Dogwood—		*Cornus* spp.
Red-osier dogwood	COST	*C. stolonifera* Michx.
Dwarf sagebrush	ARNO	*Artemisia nova* Nutt.
Greasewood	SAVE	*Sarcobatus vermiculatus* (Hook.) Torr.
Long-leaved sagebrush	ARLO	*Artemisia longifolia* Nutt.
Low sagebrush	ARAR	*Artemisia arbuscula* Nutt.
Mallow ninebark	PHMA	*Physocarpus malvaceus* (Greene) Kuntze
Mountain big sagebrush	ARTRVA	*Artemisia tridentata* var. *vaseyana* Nutt.
Mountain heather	Heather	*Phyllodoce* spp.
Mountain-mahogany	CEMO	*Cercocarpus montanus* Raf.
Mountain snowberry	SYOR	*Symphoricarpos oreophilus* Gray
Rabbitbrush		*Chrysothamnus* spp.
Rose		*Rosa* spp.
Russet buffaloberry	Buffaloberry	*Sheperdia canadensis* (L.) Nutt.
Salt desert shrub—	Salt desert shrub	
Greasewood	SAVE	*Sarcobatus vermiculatus* (Hook.) Torr.
Spiny hopsage	GRSP	*Grayia spinosa*
Spiny saltbush, shadscale	ATCO	*Atriplex confertifolia* (Torr. & Frem.) Wats.
Winterfat	EULA	*Eurotia lanata* (Pursh)
Scouler's willow	SASC	*Salix scouleriana* Barratt
Serviceberry—		*Amelanchier* spp.
Western serviceberry	AMAL	*A. alnifolia* Nutt.
Silver sagebrush	ARCA	*Artemisia cana* Pursh
Snowberry	Snowberry	*Symphoricarpus* spp.
Stiff sagebrush	ARRI	*Artemisia rigida* (Nutt.) Gray
Threetip sagebrush	ARTRI	*A. tripartita* Rydb.
Willow—	Willow	*Salix* spp.
Booth willow	SABO	*S. boothii* Bebb
Geyer willow	SAGE	*S. geyeriana* Anderss.
Hoary willow	SACA	*S. candida* Fluegge
Wolf's willow	SAWO	*S. wolfii* Bebb
Wyoming big sagebrush	ARTRWY	*Artemisia tridentata* var. *wyomingensis* Nutt
Grasses and forbs:		
Alkaligrass		*Pucinellia* spp.
Alkali saltgrass	DIST	*Distichlis stricta* (Torr.) Rydb.
Arrowleaf balsamroot	BASA	*Balsamorhiza sagitata* (Pursh) Nutt.
Bluebunch wheatgrass	AGSP	*Agropyron spicatum* (Pursh) Scribn. & Smith
Bluejoint reedgrass	CACA	*Calamagrostis canadensis* (Michx.) Beauv.
Bluestem wheatgrass	AGSM	*Agropyron smithii* Rybd.
Bottlebrush squirreltail	SIHY	*Sitanion hystrix* (Nutt.) Smith
California brome-grass	BRCA	*Bromus carinatus* H. & A.
Cheat grass	BRTE	*B. tectorum* L.
Crested wheatgrass	AGCR	*Agropyron cristatum* (L.) Gaertn.
Cusick's milkvetch	ASCU	*Astragalus cusickii* Gray
Douglas' water-hemlock	CIDO	*Cicuta douglasii* (D.C.) Coult. & Rose
Fowl bluegrass	POPA	*Poa palustris* L.
Geyer's sedge	CAGE	*Carex geyeri* Boott
Giant wildrye	ELCI	*Elymus cinereus* Scribn. & Merr.
Green fescue	FEVI	*Festuca viridula* Vasey
Hood's sedge	CAHO	*Carex hoodii* Boott
Hounds-tongue hawkweed	HICY	*Hieracium cynoglossoides* Arv.-Touv.

Table 8—Common and scientific names, and abbreviations of species (continued)

Common name	Abbreviation	Scientific name
Idaho fescue	FEID	*Festuca idahoensis* Elmer
Kentucky bluegrass	POPR	*Poa pratensis* L.
Leafy spurge	EUES	*Euphorbia esula* L.
Medusahead	TACA	*Taeniatherum caput-medusae* L.
Narrow-leaved skullcap	SCAN	*Scutellaria angustifolia* Pursh
Needlegrass	STCO	*Stipa comata* Trin. & Rupr.
Prairie junegrass	KOCR	*Koeleria cristata* Pers.
Red threeawn	ARLO	*Aristida longiseta* Steud.
Richardson's needlegrass	STRI	*Stipa richardsonii* Link
Rough fescue	FESC	*Festuca scabrella* Torr.
Rushes—	Rushes	*Juncus* spp.
Baltic rush	JUBA	*J. balticus* Willd.
Salmon River phlox	PHCO	*Phlox colubrina* Wherry & Const.
Sand dropseed	SPCR	*Sporobolus cryptandrus* (Torr.) Gray
Sandberg's bluegrass	POSA	*Poa sandbergii* Vasey
Sedges—	Sedges	*Carex* spp.
Beaked sedge	CARO	*C. rostrata* Stokes
Short-beaked sedge	CASI	*C. simulata* Mack.
Small-winged sedge	CAMI	*C. microptera* Mack.
Nebraska sedge	CANE	*C. nebrascensis* Dewey
Water sedge	CAAQ	*C. aquatilis* Wahl.
Shaggy fleabane	ERPU	*Erigeron pumilis* Nutt.
Silky lupine	LUSE	*Lupinus sericeus* Pursh
Spotted knapweed	CEMA	*Centaurea maculosa* Lam.
Spurred lupine	LULA	*Lupinus laxiflorus* Dougl.
Starvation cactus	OPPO	*Opuntia polyacantha* Haw.
Thread-leaved sedge	CAFI	*Carex filifolia* Nutt.
Thurber's needlegrass	STTH	*Stipa thurberiana* Piper
Timber oatgrass	DAIN	*Danthonia intermedia* Vasey
Tufted hairgrass	DECA	*Deschampsia caespitosa* (L.) Beauv.
Wildrye	Wildrye	*Elymus* spp.
Wyeth buckwheat	ERHI	*Erigonum heracleoides* Nutt.
Yellowstar thistle	CESO	*Centaurea solstitialis* L.

processes display similar area and distribution of PVTs. In this study, we modeled and mapped forest potential vegetation types to better frame our presentation and discussion of vegetation change and to provide a basis to compare changes occurring in similar PVTs in differing geographic locations. Forest PVTs were modeled at approximately the *series* level, as that level has been described in habitat type and plant association classifications throughout the Western United States. The dominant climatic "climax" coniferous species of each forest patch was estimated by using remotely sensed historical and current overstory and understory species composition and elevation, slope, and aspect coverages generated from 90-m digital elevation models of the sampled subbasins.

We created a complex vector map coverage for each sampled subwatershed based on the intersection of a topographic theme, the current remotely sensed vegetation coverage, and the historical vegetation coverage. The topographic theme included elevation and aspect coverages constructed from 90-m DEMs. Elevation and aspect classification rules are shown in tables 9 and 10, respectively. Each polygon was assigned a uniform elevation class (table 9) and a uniform aspect class (table 10). Each polygon in the complex coverage was attributed by elevation class, aspect class, modal slope, and each of the current and historical remotely sensed attributes. Data were exported from ARC/INFO to Paradox for analysis.

Table 9—Elevation classes used to model forest potential vegetation types in the midscale ecological assessment of the interior Columbia River basin

Class	Elevation range	
	Minimum	Maximum
	Meters above sea level	
1	0	304.8
2	304.9	609.6
3	609.7	914.4
4	914.5	1219.2
5	1219.3	1524.0
6	1524.1	1828.8
7	1828.9	2133.6
8	2133.7	2438.4
9	2438.5	2743.2
10	2743.3	3048.0
11	3048.1	3352.8
12	3352.9	3657.6
13	3657.7	3962.4

Table 10—Aspect classes used to model forest potential vegetation types in the midscale ecological assessment of the interior Columbia River basin

Aspect class[a]	Aspect	Range
-1	None	Flat, slope less than 1 percent
1	N	351° to 80°[a]
2	E	81° to 170°
3	S	171° to 260°
4	W	261° to 350°

[a] All aspect values relative to true north.

Potential vegetation analysis was done separately for each subbasin; it involved three modeling steps and a final map-review step. First, attribute combinations were used to provisionally assign a likely PVT. Assignments generally were based on overstory and understory species identities (historical and current), but other attributes such as elevation, slope, aspect, presence of visible logging, and riparian or wetland status, also were used. These rules were effective for determining the forest PVT for polygons in dry, moist, or cold forest environmental settings. They were not immediately useful in classifying PVTs for forest polygons with vegetation dominated by early seral species. For example, the presence of mountain hemlock in either the overstory or understory (current or historical) was sufficient to assign a polygon to the mountain hemlock PVT. But in subwatersheds of the northern Cascade Range of Washington, polygons with Douglas-fir as the principal cover species were not assigned a PVT at this step because Douglas-fir can be early seral, midseral, or climax depending on ecological site conditions. These types of polygons were processed in subsequent steps.

In the second step, probability rules were developed from PVT assignments made in step 1 for all possible elevation and aspect class combinations. We tallied the area of all assigned polygons by PVT within combined elevation and aspect classes and calculated the proportion of the total assigned area within a subbasin comprised of each PVT-elevation-aspect class combination. Unassigned polygons were then assigned a probable PVT based on elevation, aspect, and occasionally, early seral species identity and the result of a uniform random number generator. The PVT labels for this step differed from those assigned in step 1 so that assignments in either step could be revisited. For example, in a particular subbasin with the combination of elevation class = 3 and aspect class = 1, the western hemlock-western redcedar PVT occupied 50 percent of the assignable subbasin area in step 1, the subalpine fir-Engelmann spruce PVT occupied 25 percent of the assignable area, and the Douglas-fir–white fir–grand fir PVT occupied 25 percent of the assignable area. These PVTs were assigned ranges of 1-50, 51-75, and 76-100, respectively. A random draw of 33 assigned an unassigned polygon of the same elevation-aspect class identity to the western hemlock-western redcedar PVT in step 2.

Several PVTs were defined at a series-group level (for example, the Douglas-fir–grand fir–white fir PVT, the western hemlock-western redcedar PVT, and the subalpine fir-Engelmann spruce PVT) because of the limited resolution of remotely sensed data. In step 3, these series-groups were split into cool-moist and warm-dry subgroups by using elevation and aspect rules derived from published species distributions and plant association and habitat type manuals. A third cold-harsh

Table 11—Descriptions of herbland and shrubland structure classes modeled for sampled subwatersheds in the midscale ecological assessment of the interior Columbia River basin

Structural class	Definition	Description
Open herbland[a]	Open canopy herbaceous vegetation	A canopy of herbaceous vegetation with < 66 percent projected canopy cover; < 10 percent cover each of shrubs or trees; ≥ 1 stratum
Closed herbland[b]	Closed canopy herbaceous vegetation	A canopy of herbaceous vegetation with ≥ 66 percent projected canopy cover; < 10 percent cover each of shrubs or trees; ≥ 1 stratum
Open low-medium shrubland[c d]	Dominated by an open canopy of low or medium-sized shrubs	A canopy of low (<50 cm) or medium-sized (50 cm to 2 m) shrubs with < 66 percent projected canopy cover; shrubs dominate; tree cover < 10 percent; ≥ 2 strata, ≥ 2 cohorts possible
Closed low-medium shrubland[c d]	Dominated by a closed canopy of low or medium-sized shrubs	A canopy of low (< 50 cm) or medium-sized (50 cm to 2 m) shrubs with ≥ 66 percent projected canopy cover; shrubs dominate; tree cover < 10 percent; ≥ 2 strata, ≥ 2 cohorts possible
Open tall shrubland[e]	Dominated by an open canopy of tall shrubs	A canopy of tall (2 m to 5 m) shrubs with < 66 percent projected canopy cover; shrubs dominate; tree cover < 10 percent; ≥ 2 strata, ≥ 2 cohorts possible
Closed tall shrubland[e]	Dominated by a closed canopy of tall shrubs	A canopy of tall (2 m to 5 m) shrubs with ≥ 66 percent projected canopy cover; shrubs dominate; tree cover < 10 percent; ≥ 2 strata, ≥ 2 cohorts possible

[a] Open: a canopy with < 66 percent projected canopy cover as remotely sensed by photointerpretation. The 66-percent canopy cover threshold separating open and closed structures does not numerically correspond with canopy cover estimates for open and closed conditions derived by using frame, point sampling, or line intercept survey methods.

[b] Closed: a canopy with 66 percent projected canopy cover.

[c] Low shrubs: shrubs that typically do not exceed 50 centimeters in height.

[d] Medium shrubs: shrubs > 50 centimeters tall and < 2 meters tall.

[e] Tall shrubs: shrubs > 2 meters tall but < 5 meters tall.

subgroup was identified for the subalpine fir-Engelmann spruce PVT where elevation and aspect conditions warranted. Once these three steps were completed, an initial PVT map of the subbasin was made. This was checked for reasonable pattern, location, and setting of PVTs. Step 2 above often would result in odd polygon assignments that became obvious when displayed on a map. These were manually converted to the type of the surrounding matrix. Many polygons were small slivers resulting from initial creation of the complex topographic theme. A smoothing algorithm was applied in ARC/INFO to merge these slivers into larger adjacent units. Polygon boundaries were dissolved to homogeneous PVT areas, and this became the final PVT map for the subbasin.

Forest PVTs of midscale subbasins were ponderosa pine, Douglas-fir–grand fir (or Douglas-fir–white fir), western hemlock-western redcedar, Pacific silver fir, mountain hemlock, subalpine fir-Engelmann spruce, whitebark pine-subalpine larch, Shasta red fir, western juniper-Rocky Mountain juniper, quaking aspen, Oregon white oak, and edaphic lodgepole pine. A complete set of classification rules for midscale forest PVT by subbasin is provided in Smith and others (in prep.). Time and resources did not allow field verification of forest PVTs in each subbasin, but remotely sensed overstory and understory species composition data were checked against inventory and stand exam plot data where available.

Table 12—Classification rules for herbland and shrubland structural classes modeled for sampled subwatersheds in the midscale ecological assessment of the interior Columbia River basin

Structural class	Nonforest (herbland or shrubland) overstory species[a]	Overstory canopy cover (photointerpreted)
		Percent
Open herbland	Native bunchgrasses (fescues, wildrye), annual grasses (cheatgrass, medusahead), seeded wheatgrasses (crested wheatgrass), exotic forbs (knapweeds, leafy spurge, thistles), native moist site herbs (sedges, rushes)	≤ 66
Closed herbland	Same as open herbland	> 66
Open low-medium shrubland	Low sagebrushes (black sage, low sage), salt desert shrub, low alpine shrubs (heathers), big sagebrushes (basin big sage, Wyoming sage), bitterbrush rabbitbrush	≤ 66
Closed low-medium shrubland	Same as open low-medium shrubland	> 66
Open tall shrubland	Mountain-mahogany, curlleaf mahogany	≤ 66
Closed tall shrubland	Same as open tall shrubland	> 66
Open tall mountain shrubland	Serviceberry, rose, snowberry, mountain maple, Scouler's willow, buffaloberry, chokecherry, bittercherry, other mountain shrubs	≤ 66
Closed tall mountain shrubland	Same as open tall mountain shrubland	> 66
Open wet-site tall shrubland	Willow, alder, bog birch, dogwood, other wet-site, shrubs	≤ 66
Closed wet-site tall shrubland	Same as open wet-site tall shrubland	> 66
Open low subshrubs	Beargrass	≤ 66
Closed low subshrubs	Same as open low subshrubs	> 66

[a] Refer also to appendix 1 for examples of nonforest (herbland and shrubland) overstory species representative of each photo-interpreted grouping.

Range vegetation classification—

Herbland and shrubland structure— Structural classes of herbland and shrubland vegetation patches were based on overstory species composition, canopy cover of overstory species, and the stature of overstory species. Herbland and shrubland structure classes were open herbland, closed herbland, open low-medium shrubland, closed low-medium shrubland, open tall shrubland, and closed tall shrubland. We provide descriptions of herbland and shrubland structural classes in table 11; rules for classifying midscale herbland and shrubland structure classes from remotely sensed cover attributes are in table 12.

Herbland and shrubland composition—In addition to classifying herbland and shrubland structural classes, we classified dominant cover types. Dominant cover was estimated from nonforest overstory species, total canopy cover of nonforest types, and elevation belt attributes. Herbland and shrubland cover types were described for colline, montane (lower and upper montane), and subalpine-alpine elevation settings. Both pure and mixed species cover conditions were interpreted for herbland and shrubland patches. Modeled cover types were bunchgrasses, exotic grasses and forbs, moist herbs, low and medium shrubs, tall shrubs, tall mountain shrubs, wet-site shrubs, and subshrubs. Table 13 provides classification rules for herbland and shrubland cover types.

Table 13—Classification rules for herbland and shrubland cover types modeled for sampled subwatersheds in the midscale ecological assessment of the interior Columbia River basin

Elevation belt(s)	Herbland or shrubland overstory species[a]	Cover type
Colline Lower and upper montane Subalpine and alpine	Native bunchgrasses (fescues, wildrye, alkali grass, bottlebrush squirreltail, others)	Colline bunchgrasses Montane bunchgrasses Subalpine and alpine bunchgrasses
Colline Lower and upper montane Subalpine and alpine	Annual grasses (cheatgrass, medusahead, others), seeded wheatgrasses-(crested wheatgrass, other seeded dryland grasses), exotic forbs-(knapweeds, leafy spurge, yellowstar thistle, others)	Colline exotic grasses and forbs Montane exotic grasses and forbs Subalpine and alpine exotic grasses and forbs
Colline Lower and upper montane Subalpine and alpine	Native moist site herbs (sedges, rushes, moist site grasses, forbs, others)	Colline moist herbs Montane moist herbs Subalpine and alpine moist herbs
Colline Lower and upper montane	Low sagebrushes (black sage, low sage), salt desert shrub, big sagebrushes-(basin big sage, Wyoming sage, mountain big sage, silver sagebrush), bitterbrush, rabbitbrush	Colline low-medium shrubs Montane low-medium shrubs
Subalpine and alpine	Low alpine shrubs (heathers), big sagebrushes-(basin big sage, Wyoming sage, mountain big sage, silver sagebrush), bitterbrush, rabbitbrush	Subalpine and alpine low-medium shrubs
Colline Lower and upper montane Subalpine and alpine	Mountain-mahogany, curlleaf mahogany	Colline tall shrubs Montane tall shrubs Subalpine and alpine tall shrubs
Colline Lower and upper montane	Serviceberry, rose, snowberry, mountain maple, Scouler's willow, buffaloberry, chokecherry, bittercherry	Colline tall mountain shrubs Montane tall mountain shrubs
Colline Lower and upper montane Subalpine and alpine	Willow, alder, bog birch, dogwood, other wet-site shrubs	Colline wet-site shrubs Montane wet-site shrubs Subalpine and alpine wet-site shrubs
Lower and upper montane Subalpine and alpine	Beargrass	Montane subshrubs Subalpine and alpine subshrubs

[a] Refer also to appendix 1 for examples of nonforest (herbland and shrubland) overstory species representative of each photo-interpreted grouping.

***Woodlands*—**The woodland physiognomy was classified for juniper, pinyon-juniper, and Oregon white oak cover types only. For data capture purposes, photointerpretation initially treated forest and woodland physiognomies as forest if total tree crown of any patch was at least 10 percent. This enabled us to obtain tree crown cover and overstory tree species information for both woodland and forest structure classifications. Woodland structure classification followed a logic similar to that used for forest structural classes (see table 6). Structure classes for woodland were stand initiation, stem exclusion, understory reinitiation, young multistory, old multistory, and old single story. Rules for classifying woodland structures from continuous data are provided in table 14.

***Herbland, shrubland, and woodland potential vegetation types*—**The PVTs of herbland, shrubland, and woodland physiognomic conditions were modeled as broad habitat-type groups. The dominant “climax” species of each rangeland patch was estimated from remotely sensed attributes, digital elevation data, published range cover type definitions, Bailey’s province and section

Table 14—Classification rules for woodland structural classes modeled for sampled subwatersheds in the midscale ecological assessment of the interior Columbia River basin

No.	Structural class (code)	Classification rule
1	Woodland stand initiation (w_si)	PT_cc[a] + SmT[b]_cc + MedT_cc + LgT_cc < 10 percent and SS_cc ≥ 10 percent
2	Woodland stem exclusion (w_se)	LgT_cc < 10 percent and PT_cc + SmT_cc + MedT_cc ≥ 10 percent and SS_cc < 10 percent
3	Woodland understory reinitiation (w_ur)	LgT_cc < 10 percent and PT_cc + SmT_cc + MedT_cc ≥ 10 percent and SS_cc ≥ 10 percent
4	Young multistory woodland (w_yms)	LgT_cc < 10 percent, and SmT_cc + MedT_cc 10 percent, and PT_cc ≥ 10 percent, and SS_cc ≥ 10 percent
5	Old multistory woodland (w_oms)	LgT_cc ≥ 10 percent, and SS_cc + PT_cc + SmT_cc + MedT_cc ≥ 10 percent
6	Old single story woodland (w_oss)	LgT_cc ≥ 10 percent, and SS_cc + PT_cc + SmT_cc + MedT_cc < 10 percent

[a] cc = crown cover; crown cover was interpreted in 10-percent increments, and class percentages were expressed as midpoints; e.g., 10 percent = 5 to 14 percent, 20 percent = 15 to 24 percent.

[b] Tree sizes were estimated as SS–seedlings and saplings (< 12.7 centimeter d.b.h.), PT–poles (12.7 to 22.6 centimeter d.b.h.), SmT–small trees (22.7 to 40.4 centimeter d.b.h.), MedT–medium trees (40.5 to 63.5 centimeter d.b.h.), and LgT–large trees (> 63.5 centimeter d.b.h.).

boundaries (Bailey 1995, McNab and Avers 1994), and STATSGO (USDA 1993) broad-scale soils, precipitation, and dominant range PVT digital maps. Remotely sensed attributes used were nonforest type, nonforest overstory species, riparian and wetland status, elevation zones of nonforest types, dead tree and snag abundance, and sparse tree cover of herbland and shrubland types. Elevation, slope, and aspect coverages were generated from 90-m digital elevation models of sampled subbasins. We adopted range cover type descriptions of the Society for Range Management (SRM; published in Shiflet 1994). All attributes were used to establish likely SRM cover types (table 15).

Range PVTs were developed by assembling a complex coverage in a GIS through successive map intersections. To begin, the photointerpreted historical vegetation map of sampled subwatersheds and an associated data file including the following attributes—cover type, structural class, overstory and understory species, nonforest type, nonforest overstory species, riparian and wetland status, elevation zones of nonforest types, dead tree and snag abundance, and sparse tree cover of herbland and shrubland types—were intersected with the remotely sensed current vegetation map having the same associated attributes. This first complex coverage then was intersected with derived elevation, slope, and aspect maps. The resultant coverage then was intersected with the STATSGO digital soils map. Each small polygon in the resultant map coverage contained the attributes of the successive intersections.

From published STATSGO precipitation data, dominant vegetation types associated with STATSGO map units, and dominant habitat types associated with SRM cover types and their geographic distribution, polygons were classified by range PVTs through a series of Paradox queries. We derived 29 range PVTs. Examples include bluebunch wheatgrass steppe; antelope bitterbrush steppe; low sagebrush steppe (mesic sites with juniper woodland); Wyoming big sagebrush steppe (hot sites); riverine cottonwood; fescue grassland (with conifers); mountain big

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Table 15—Definitions of range potential vegetation types modeled for sampled subwatersheds in the mid-scale ecological assessment of the interior Columbia River basin

Potential vegetation type	SRM[a] types	Habitat types	Bailey's province or section	Code
Alpine herbland with low shrubs	na	Habitat types not adequately described to date	na	ahls
Antelope bitterbrush steppe	SRM 101 SRM 302	PUTR/FEID,[b] PUTR/FESC, PUTR/AGSP, PUTR/STCO	na	putr
Basin big sagebrush/wildrye steppe	SRM 401	Habitat types not adequately described to date	na	bsbw
Big greasewood/ryegrass	SRM 422	SAVE/DIST, SAVE/AGSM, SAVE/ELCI	na	sarp
Bluebunch wheatgrass steppe	SRM 317 SRM 318 SRM 319 SRM 104 SRM 105	AGSP/POSA,[c] SPCR/POSA, ARLO/POSA, AGSP/OPPO, AGSP/ERHI, AGSP/POSA/SCAN, AGSP/POSA/ASCU, AGSP/POSA/ERPU, AGSP/POSA/PHCO, AGSP/POSA/OPPO, AGSP/SPCR/ARLO	na	agst
Bluebunch wheatgrass steppe (with conifers)	SRM 317 SRM 318 SRM 319 SRM 104 SRM 105	AGSP/POSA with conifers, SPCR/POSA with conifers, ARLO/POSA with conifers, AGSP/OPPO with conifers, AGSP/ERHI with conifers, AGSP/POSA/SCAN with conifers, AGSP/POSA/ASCU with conifers, AGSP/POSA/ERPU with conifers, AGSP/POSA/PHCO with conifers, AGSP/POSA/OPPO with conifers, AGSP/SPCR/ARLO with conifers	na	ags2
Curlleaf mountain-mahogany (without sagebrush)	SRM 415	CELE/AGSP, CELE	Province M332	cew1
Curlleaf mountain-mahogany (with sagebrush)	SRM 322	CELE/AGSP, CELE	Province M331 Province 341 Province 342	cew2
Fescue grassland	SRM 102 SRM 103 SRM 108 SRM 304 SRM 307 SRM 311 SRM 312	AGSP/FEID, FEID/HICY, FEID/SYAL, STCO/POSA, FEID/KOCR, FESC/AGSP, FESC/FEID, FEID/AGSM, FEID/CAFI, FEID/STRI, FEVI/CAHO, FEVI/LULA, FEID/AGSP/LUSE, FEID/AGSP/BASA, FEID/AGSP/PHCO, FEID/DAIN, FEID/CAHO, FEID/CAGE	na	fesc

Table 15—Definitions of range potential vegetation types modeled for sampled subwatersheds in the mid-scale ecological assessment of the interior Columbia River basin (continued)

Potential vegetation type	SRM[a] types	Habitat types	Bailey's province or section	Code
Fescue grassland (with conifers)	SRM 102 SRM 103 SRM 108 SRM 304 SRM 307 SRM 311 SRM 312	AGSP/FEID with conifers, FEID/HICY with conifers, FEID/SYAL with conifers, STCO/POSA with conifers, FEID/KOCR with conifers, FESC/AGSP with conifers, FESC/FEID with conifers, FEID/AGSM with conifers, FEID/CAFI with conifers, FEID/STRI with conifers, FEVI/CAHO with conifers, FEVI/LULA with conifers, FEID/AGSP/LUSE with conifers, FEID/AGSP/BASA with conifers, FEID/AGSP/PHCO with conifers, FEID/DAIN with conifers, FEID/CAHO with conifers, FEID/CAGE with conifers,	na	fes2
Low sagebrush steppe (mesic sites)	SRM 320 SRM 321 SRM 405 SRM 406	ARAR/AGSP, ARAR/FEID, ARNO/AGSP, ARNO/FEID, ARAR/POSA, ARLO/FEID	na	lsme
Low sagebrush steppe (mesic sites with juniper woodland)	SRM 412	ARAR/AGSP with JUOC, ARAR/FEID with JUOC	na	lsmj
Low sagebrush steppe (xeric sites)	SRM 407	ARRI, ARRI/POSA	na	lsxe
Low sagebrush steppe (xeric sites with juniper woodland)	SRM 412	ARAR, ARNO, ARRI with JUOC	na	lsxj
Mountain big sagebrush steppe (mesic sites with Juniper woodland)	SRM 412	ARTRVA/FEID with JUOC, ARTRVA/SYOR/FEID with JUOC, ARTRVA/FEID/AGSP with JUOC	na	bsmj
Mountain big sagebrush steppe (northerly and easterly aspects, mesic sites, > 20 percent slopes)	SRM 314 SRM 315 SRM 316	ARTRVA/FESC, ARTRVA/AGSP, ARTRVA/FEID, ARTRVA/STCO, ARTRVA/SYOR/AGSP, ARTRVA/SYOR/FEID, ARTRVA/SYOR/CAGE	Province M331 Province M332 Province 333	bsme
Mountain big sagebrush steppe (northerly and easterly aspects, mesic sites, with conifers)	SRM 317 SRM 324	ARTRVA/FEID with conifers, ARTRVA/FESC with conifers, ARTRVA/AGSP with conifers, ARTRVA/SYOR/AGSP with conifers, ARTRVA/SYOR/FEID with conifers, ARTRVA/SYOR/CAGE with conifers	na	bsmc
Mountain big sagebrush steppe (northerly and easterly aspects, mesic sites, < 20 percent slopes)	SRM 314 SRM 315 SRM 316	ARTRVA/FESC, ARTRVA/AGSP, ARTRVA/FEID, ARTRVA/STCO, ARTRVA/SYOR/AGSP, ARTRVA/SYOR/FEID, ARTRVA/SYOR/CAGE	Province M331 Province M332 Province 333	bsml

Table 15—Definitions of range potential vegetation types modeled for sampled subwatersheds in the mid-scale ecological assessment of the interior Columbia River basin (continued)

Potential vegetation type	SRM[a] types	Habitat types	Bailey's province or section	Code
Mountain big sagebrush steppe (southerly and westerly aspects, mesic sites)	SRM 402	ARTRVA/AGSP, ARTRVA/FEID, ARTRVA/STCO, ARTRVA/SYOR/AGSP, ARTRVA/SYOR/FEID, ARTRVA/SYOR/CAGE, ARTRVA/CAGE, ARTRVA/PUTR/FEID, ARTRVA/SYOR/BRCA	Province 342 Province 341	bsmw
Mountain riparian low shrub	na	Habitat types not adequately described	na	mrls
Mountain riparian sedge (without willows)	na	Habitat types not adequately described	na	mrsd
Mountain shrub	SRM 419 SRM 420 SRM 421	SYAL/Rosa spp., PHMA/SYAL, Habitat types not adequately described, most are probably early seral stages of PIPO and PSME habitat types.	na	mtsh
Riparian graminoid	SRM 308 SRM 313	FEID/DECA, DECA/Carex spp., Carex spp., CANE/JUBA, DECA, POPA, POPR	na	rigr
Riparian sedge (with willows)	na	SAGE/CARO, SAGE/POPA, SAGE/CACA, SAGE/POPR, SABO/CARO, SABO/CACA, SABO/POPR, SAWO/CAAQ, SAWO/CARO, SAWO/CACA, SAWO/DECA, SAWO/POPA, others	na	salx
Riverine cottonwood	na	POTRI/CIDO, POAN/COST, POAN/POPR, POTRI/COST, POTRI/POPR	na	ctrv
Salt desert shrub	SRM 414	GRSP/POSA, EULA/POSA	na	sdsh
Three-tip sagebrush steppe	SRM 324 SRM 404	ARTRI/AGSP, ARTRI/FEID	na	ttsa
Wyoming big sagebrush steppe (warm to hot sites)	SRM 403	ARTRWY/AGSP, ARTRWY/POSA ARTRWY/SIHY, ARTRWY/STTH, ARTRWY/STCO, ARTRTR/AGSP	Section 342C Section 342I Section 341E	wbsa
Wyoming big sagebrush steppe (cool to cold sites)	SRM 403	ARTRWY/AGSP, ARTRWY/POSA, ARTRWY/SIHY, ARTRWY/STTH, ARTRWY/STCO, ARTRTR/AGSP, ARTRTR/FEID	not in: Section 342C Section 342I Section 341E	wbsc

na = not applicable.

[a] SRM types refers to rangeland cover type descriptions adopted by the Society for Range Management (Shiflet 1994).

[b] Common and scientific names and abbreviations of species discussed in the text and tables are listed in table 8.

[c] POSA (*Poa sandbergia*) is equivalent to POSE (*Poa secunda*).

Table 16—Classification rules for herbland, shrubland, and woodland potential vegetation types modeled for sampled subbasins in the midscale ecological assessment of the interior Columbia River basin

Potential vegetation type	Code	Classification rule
Alpine herbland (with low shrubs)	ahls	(NF_type[a] = alpine meadow) **and** (Elev_belt = subalpine or alpine) **and** (NF_spp_os_C = native moist-ste herbs or low alpine shrubs or beargrass) **or** (STATSGO_MapUnit_ID _Series = XETE[b])
Antelope bitterbrush steppe	putr	(NF_type = shrubland) **and** (NF_spp_os_C = big sagebrush/bitter brush) **and** (NF_spp_os_H = big sagebrush/bitterbrush) **and** (STATSGO_Map Unit_ID_Series = PUTR)
Basin big sagebrush/wildrye steppe	bsbw	(NF_type = shrubland) **and** (NF_spp_os_C = native bunchgrasses or annual grasses or seeded wheatgrasses or exotic forbs or big sagebrush/bitterbrush) **or** (NF_spp_os_H = native bunchgrasses or annual grasses or seeded wheat-grasses or exotic forbs or big sagebrush/bitterbrush) **and** (STATSGO_Map Unit_ID _Series = ELCI)
Big greasewood/ryegrass (streambanks)	sarp	(NF_type = shrubland) **and** (Riparian_Wetland_Status = "yes") **and** (NF_spp_os_C = low sagebrush or other low shrubs) **and** (NF_spp_os_H = low sagebrush or other low shrubs) **and** (STATS GO_MapUnit_ID _Series = ATCO or SAVE)
Bluebunch wheatgrass steppe	agst	(NF_type = grassland) **and** (ELEV_belt = colline or lower montane) **and** (NF_spp_os_C = native bunchgrasses or annual grasses or seeded wheat grasses or exotic forbs) **and** (NF_spp_os_H = native bunchgrasses or annual grasses or seeded wheatgrasses or exotic forbs) **and** (STATSGO_MapUnit_ ID _Series = AGSP)
Bluebunch wheatgrass steppe (with conifers)	ags2	(NF_type = grassland) **and** [(NF_tree_cover = "yes") **or** (DeadTree_Snag _Abundance ≥ 10 percent dead trees)] **and** (NF_spp_os_C = native bunch-grasses or annual grasses or seeded wheatgrasses or exotic forbs) **and** (NF_spp_os_H = native bunchgrasses or annual grasses or seeded wheat-grasses or exotic forbs) or (STATSGO_MapUnit_ID _Series = AGSP)
Curlleaf mountain-mahogany (without sagebrush)	cew1	(NF_type = shrubland) **and** (NF_spp_os_C = mahogany) **and** (NF_spp_os_H = mahogany) **and** (STATSGO_MapUnit_ID _Series = CELE with no ARTRVA)
Curlleaf mountain-mahogany (with sagebrush)	cew2	(NF_type = shrubland) **and** (NF_spp_os_C = mahogany) **and** (NF_spp_os_H =mahogany) **and** (STATSGO_MapUnit_ID _Series = CELE with ARTRVA)
Fescue grassland	fesc	(NF_type = grassland) **and** (NF_spp_os_C = native bunchgrasses or annual grasses or seeded wheatgrasses or exotic forbs) **and** (NF_spp_os_H = native bunchgrasses or annual grasses or seeded wheatgrasses or exotic forbs) **and** (STATSGO_MapUnit_ID_Series = FESC)
Fescue grassland (with conifers)	fes2	(NF_type = grassland) **and** [(NF_tree_cover = "yes") **or** (DeadTree_Snag_ Abundance ≥ 10 percent dead trees)] **and** (NF_spp_os_C = native bunch-grasses or annual grasses or seeded wheatgrasses or exotic forbs) **and** (NF_spp_os_H = native bunchgrasses or annual grasses or seeded wheat-grasses or exotic forbs) **and** (STATSGO_MapUnit_ID _Series = FESC)
Low sagebrush steppe (mesic sites)	lsme	(NF_type = shrubland or grassland) **and** (NF_spp_os_C = native bunch-grasses or annual grasses or seeded wheatgrasses or exotic forbs or low sage-brushes) or (NF_spp_os_H = native bunchgrasses or annual grasses or seeded wheatgrasses or exotic forbs or low sagebrushes) **and** (STATSGO_MapUnit _ID _Series = ARAR or ARNO)

Table 16—Classification rules for herbland, shrubland, and woodland potential vegetation types modeled for sampled subbasins in the midscale ecological assessment of the interior Columbia River basin (continued)

Potential vegetation type	Code	Classification rule
Low sagebrush steppe (mesic sites with juniper woodland)	lsmj	(NF_type = shrubland or grassland) and (NF_spp_os_C = native bunchgrasses or annual grasses or seeded wheatgrasses or exotic forbs or low sagebrushes) **or** (NF_spp_os_H = native bunchgrasses or annual grasses or seeded wheatgrasses or exotic forbs or low sagebrushes) **and** (STATSGO_MapUnit _ID_Series = ARAR or ARNO) **and** (Subbasin_Code[c] = BUR or UDS or LDS or LCR or LFH or LHE or LJD or LST or LWC or MDL or PSD or SIL or SHW or UJD or UOW or DUB) **and** (F_spp_os = juniper)
Low sagebrush steppe (xeric sites)	lsxe	(NF_type = shrubland) **and** (NF_spp_os_C = native bunchgrasses or annual grasses or seeded wheatgrasses or exotic forbs or low sagebrushes) or (NF_ spp_os_H = native bunchgrasses or annual grasses or seeded wheatgrasses or exotic forbs or low sagebrushes) **and** (STATSGO_MapUnit_ID _Series = ARAR or ARNO)
Low sagebrush steppe (xeric sites with juniper woodland)	lsxj	(NF_type = shrubland) **and** (NF_spp_os_C = native bunchgrasses or annual grasses or seeded wheatgrasses or exotic forbs or low sagebrushes) or (NF_ spp_os_H = native bunchgrasses or annual grasses or seeded wheatgrasses or exotic forbs or low sagebrushes) **and** (STATSGO_MapUnit_ID _Series = ARAR or ARNO) **and** (Subbasin_Code =BUR or UDS or LDS or LCR or LFH or LHE or LJD or LST or LWC or MDL or PSD or SIL or SHW or UJD or UOW or DUB) **and** (F_spp_os = juniper)
Mountain big sagebrush steppe (mesic sites with juniper woodland)	bsmj	(NF_type = grassland or shrubland) **and** (NF_spp_os_C = native bunchgrasses or annual grasses or seeded wheatgrasses or exotic forbs or big sagebrush/bitterbrush) or (NF_spp_os_H = native bunchgrasses or annual grasses or seeded wheatgrasses or exotic forbs or big sagebrush/bitterbrush) **and** (STATSGO_MapUnit_ID_Series = ARTRTR or ARTRVA) **and** (Subbasin_Code = BUR or UDS or LDS or LCR or LFH or LHE or LJD or LST or LWC or MDL or PSD or SIL or SHW or UJD or UOW or DUB) **and** (F_spp_os = juniper)
Mountain big sagebrush steppe (northerly and easterly aspects, mesic sites, > 20 percent slopes)	bsme	(NF_type = grassland or shrubland) **and** (NF_spp_os_C = native bunchgrasses or annual grasses or seeded wheatgrasses or exotic forbs or big sagebrush /bitterbrush) **or** (NF_spp_os_H = native bunchgrasses or annual grasses or seeded wheatgrasses or exotic forbs or big sagebrush/bitterbrush) **and** (STATSGO_MapUnit_ID_Series = ARTRTR or ARTRVA) **and** (Subbasin_Code = BFM, BTR, BOM, BWD, FLR, UGR, LGR, WAL, KET, LMH, LOC, LYK, MET, NAC, PEN, PLS, SFC, SFS, SWN, UCD, UKL, UMS, UYK, WEN, YAA) **and** (Slope ≥ 20 percent) **and** (aspects = N or E)
Mountain big sagebrush steppe (northerly and easterly aspects, mesic sites, with conifers)	bsmc	(NF_type = grassland or shrubland) **and** [(NF_tree_cover = “yes”) **or** (Dead Tree_Snag_Abundance ≥ 10 percent dead trees)] and (ELEV_belt = colline or lower montane) **and** (NF_spp_os_C = big sagebrush/bitter brush) **and** (NF_spp_os_H = big sagebrush/bitterbrush) and (STATSGO_MapUnit _ID _Series = ARTRTR or ARTRVA) **and** (aspects = N or E)
Mountain big sagebrush steppe (northerly and easterly aspects, mesic sites, < 20 percent slopes)	bsml	(NF_type = grassland or shrubland) and (NF_spp_os_C = native bunchgrasses or annual grasses or seeded wheatgrasses or exotic forbs or big sagebrush/bitterbrush) **or** (NF_spp_os_H = native bunchgrasses or annual grasses or seeded wheatgrasses or exotic forbs or big sagebrush/bitterbrush) **and** (STATSGO_MapUnit_ID_Series = ARTRTR or ARTRVA) **and** (Slope < 20 percent) **and** (aspects = N or E)

Table 16—Classification rules for herbland, shrubland, and woodland potential vegetation types modeled for sampled subbasins in the midscale ecological assessment of the interior Columbia River basin (continued)

Potential vegetation type	Code	Classification rule
Mountain big sagebrush steppe (southerly and westerly aspects, mesic sites)	bsmw	(NF_type = grassland or shrubland) **and** (NF_spp_os_C = native bunchgrasses or annual grasses or seeded wheatgrasses or exotic forbs or big sagebrush/bitterbrush) **or** (NF_spp_os_H = native bunchgrasses or annual grasses or seeded wheatgrasses or exotic forbs or big sagebrush/bitterbrush) **and** (STATSGO_MapUnit_ID_Series = ARTRTR or ARTRVA) **and** (Subbasin_Code = BUR or UDS or LDS or LCR or LFH or LHE or LJD or LST or LWC or MDL or PSD or SIL or SHW or UJD or UOW or DUB) **and** (aspects = S or W)
Mountain riparian low shrub	mrls	(NF_type = shrubland) **and** (Elev_belt = upper montane or subalpine or alpine) **and** (NF_spp_os_C = wet-site shrubs) **and** (STATSGO_MapUnit_ ID_Series =Salix spp.)
Mountain riparian sedge (without willows)	mrsd	(NF_type = wet meadow) **and** (NF_spp_os_C = native moist-site herbs) **and** (STATSGO_MapUnit_ID _Series = Carex spp.)
Mountain shrub	mtsh	(NF_type = shrubland) **and** (NF_spp_os_C = mountain shrubs) **and** (STATSGO_MapUnit_ID _Series = SYAL, AMAL, Rosa spp.; SASC, PRVI, and ACGL)
Riparian graminoid (without shrubs)	rigr	(NF_type = dry meadow) **and** (NF_spp_os_C = native bunchgrasses) **or** (STATSGO_MapUnit_ID _Series = DECA)
Riparian sedge (with willows)	salx	(NF_type = shrubland or wet meadow or stream channel & nonvegetated flood plain) **and** (NF_spp_os_C = wet-site shrubs) **and** (Riparian_Wetland _Status = “yes”) **and** (Elev_belt = colline or lower montane) **and** (STATSGO_MapUnit_ID_Series = Salix spp.)
Riverine cottonwood	ctrv	(F_spp_os = cottonwood) **and** (Riparian_Wetland_Status = “yes”) **and** (STATSGO_MapUnit_ID _Series = POTRI or POAN)
Salt desert shrub (playas)	sdsh	(NF_type = playa) **and** (NF_spp_os_C = low sagebrush or other low shrubs) **and** (NF_spp_os_H = low sagebrush or other low shrubs) and (STATSGO_MapUnit_ID _Series = ATCO or SAVE)
Three-tip sagebrush steppe	ttsa	(NF_type = shrubland) **and** (NF_spp_os_C = native bunchgrasses or annual grasses or seeded wheatgrasses or exotic forbs or big sagebrush/bitterbrush) **or** (NF_spp_os_H = native bunchgrasses or annual grasses or seeded wheatgrasses or exotic forbs or big sagebrush/bitterbrush) and (STATSGO_ MapUnit_ID _Series = ARTRI)
Wyoming big sagebrush steppe (warm to hot sites)	wbsa	(NF_type = shrubland) and (NF_spp_os_C = native bunchgrasses or annual grasses or seeded wheatgrasses or exotic forbs or big sagebrush/bitterbrush) **or** (NF_spp_os_H = native bunchgrasses or annual grasses or seeded wheatgrasses or exotic forbs or big sagebrush/bitterbrush) **and** (STATSGO_ MapUnit_ID_Series = ARTRWY) and (Subbasin_Code = CRT or BOM)
Wyoming big sagebrush steppe (cold sites)	wbsc	(NF_type = shrubland) **and** (NF_spp_os_C = native bunchgrasses or annual grasses or seeded wheatgrasses or exotic forbs or big sagebrush/bitterbrush) **or** (NF_spp_os_H = native bunchgrasses or annual grasses or seeded wheatgrasses or exotic forbs or big sagebrush/bitterbrush) **and** (STATSGO_ MapUnit_ID _Series = ARTRWY) and (Subbasin_Code ≠ CRT or BOM)

[a] Abbreviations correspond with photointerpreted attributes (appendix 1) and STATSGO (USDA 1993) potential vegetation map units: NF_type = nonforest type; NF_spp_os_C = nonforest overstory species-current condition; NF_spp_os_H = nonforest overstory species-historical condition; NF_tree_cover = tree cover of herbland and shrubland types; STATSGO_MapUnit _ID_Series = dominant climax series; DeadTree_Snag_Abundance = dead trees and snags; Elev_belt = elevation zones of nonforest types.

[b] Common and scientific names, and abbreviations of all species mentioned in the text and tables are listed in table 8.

[c] Sampled subbasin names and corresponding 3 character alpha-codes are provided in table 3.

sagebrush steppe (northerly and easterly aspects, mesic sites, with slopes > 20-percent); riparian sedge (with willows); riparian sedge (without willows); curlleaf mountain-mahogany (without sagebrush); and alpine herbland (with low shrubs). Complete definitions for range PVTs are given in table 15; generalized rules for modeling range PVTs are provided in table 16.[21]

Nonforest-nonrange and anthropogenic cover types—Several cover conditions were interpreted from aerial photographs that did not represent a forest, herbland, shrubland, or woodland physiognomic type. These were typically nonforest or nonrange cover conditions or types of human-caused origin. Cover types such as these were attributed by their actual cover condition but were treated as the class "other" in some analyses, unless otherwise indicated. Naturally occurring nonforest-nonrange cover types were rock, water (pond, lake, river), bare ground (dry lake beds, playa), glacier, sand dune, and stream channel and nonvegetated flood plains. Nonforest-nonrange cover types of anthropogenic origin were bare ground (adjacent to roadcuts), bare ground (burned or logged), bare ground (slumps and erosion), urban and rural developments, cropland, and irrigated pasture. During modeling of forest and range PVTs, bare ground of human origin was assigned to the forest or range PVT of adjacent patches in similar elevation and aspects settings by nearest neighbor analysis.

Vegetation and Landscape Pattern Analysis

Vegetation maps, patch attributes, derived cover type, structural class, and PVT attributes formed the basic data set from which all subsequent pattern analysis was accomplished. Individual patches were defined by both their derived attributes and selected remotely sensed attributes (see appendix 1).

Raster size determination—To quantify change in landscape structural attributes and patterns of various patch types, we used raster versions of current and historical vegetation themes. A raster format was chosen because several useful class metrics (for example, mean nearest neighbor distance [MNN], nearest neighbor coefficient of variation [NNCV], and contagion [CONTAG]) were available in FRAGSTATS only for data in raster format. Map themes stored in vector format in ARC/INFO were converted to raster at a scale appropriate for avoiding biases commonly associated with raster formats (McGarigal and Marks 1995). The appropriate cell size was determined by calculating several class metrics (number of patches [NP], mean patch size [MPS], patch size coefficient of variation [PSCV], edge density [ED], and mean shape index [MSI]) in vector and raster form, with cell sizes ranging from 10 to 100 m (1 ha), in 10-m increments, and at 2.0 and 5.0 ha, and plotting each raster-derived metric value against the vector value. Raster bias was relatively minor for the evaluated metrics at a cell size of 40 m, and insignificant with smaller cell sizes. We used 30-m raster versions for all spatial pattern analysis.

Sample statistics—We used percentage of area (%LAND), mean patch size (MPS), and patch density (PD; see metric descriptions in table 17) in various patch types (for example, patch types are ponderosa pine cover type, or old-forest single-story structural class) to objectively and graphically represent changes in area and connectivity relations of patch types in subwatersheds of a pooling stratum (ecological reporting unit, or ERU; described at the end of "Methods"). We estimated change from historical to current conditions as the mean difference between conditions, not as the percentage of change from historical conditions, to avoid the bias of establishing the historical condition as an essential reference. For the ERU pooling stratum, means, mean standard errors, and confidence intervals were estimated by using methods for simple random samples (Steel and Torrie 1980) with subwatersheds as sample units. Statistically significant ($P \leq 0.2$) change was determined by examining the 80-percent confidence interval around the mean difference for the ERU, which was estimated as the simple random mean from pairwise comparisons of historical and current subwatersheds. If the confidence interval included zero, no significant change was recorded.

[21] Classification rules for each of the 43 subbasins are on file with Don Long, Rocky Mountain Research Station, Fire Sciences Laboratory, P.O. Box 8089, Missoula, MT 59807.

Table 17—FRAGSTATS indices used to quantify connectivity and spatial patterns of patch types in sampled subbasins in the midscale ecological assessment of the interior Columbia River basin

Acronym	Scale	Index name	Description[a]
%LAND	Class	Percentage of landscape (%)	Percentage of a landscape composed of the corresponding patch type
LPI	Class or landscape	Largest patch index (%)	Percentage of a landscape composed of the largest patch of the corresponding patch type
PD	Class or landscape	Patch density (no. per 10 000 hectares)	Number of patches in an area of 10 000 hectares
MPS	Class or landscape	Mean patch size (hectares)	Average patch size
PSCV	Class or landscape	Patch size coefficient of variation (%)	Relative measure of patch size variability
ED	Class or landscape	Edge density (meters per hectare)	Length of edge per hectare of the corresponding patch type
AWMECI	Class or landscape	Area-weighted mean edge contrast index (%)	Average patch edge contrast as a percentage of maximum contrast with patch edge contrasts weighted by patch area; equals 100 when all edge is maximum contrast; approaches 0 when all edge is minimum contrast
AWMSI	Class or landscape	Area-weighted mean shape index	Average patch shape complexity with patch shape index weighted by patch area; equals 1 when all patches are circular, increases as patch shapes become more complex
MNN	Class or landscape	Mean nearest-neighbor distance (meters)	Average distance to the nearest neighbor of the corresponding patch type
NNCV	Class or landscape	Nearest-neighbor coefficient of variation (%)	Relative measure of nearest neighbor distance variability
SHDI	Landscape	Shannon's diversity index	Measures proportional abundance of patch types and the equitable distribution of patch type areas; increases with patch richness (PR) and equitability of area
RPR	Landscape	Relative patch richness (%)	Observed number of patch types within a landscape over a realistic potential maximum number of patch types
PR	Landscape	Patch richness	Observed number of patch types within a landscape boundary
MSIEI	Landscape	Modified Simpson's evenness index	Observed distribution of area of patch types within a landscape over evenly distributed area of patch types
IJI	Class or landscape	Interspersion and juxtaposition index (%)	Observed interspersion of edge types over maximum possible interspersion; IJI approaches 0 when patch types are clumped, IJI approaches 100 when all patch types are equally adjacent to all other patch types
CONTAG	Landscape	Contagion index (%)	Observed contagion over the maximum possible contagion for the given number of patch types; approaches 0 when the distribution of adjacencies among unique patch types becomes increasingly uneven; approaches 100 when all patch types are equally adjacent to all other patch types; measures patch type interspersion and patch dispersion

Table 17—FRAGSTATS indices used to quantify connectivity and spatial patterns of patch types in sampled subbasins in the midscale ecological assessment of the interior Columbia River basin (continued)

Acronym	Scale	Index name	Description[a]
N1	Landscape	Hill's Index N1	A transformation of SHDI, computed as e^{SHDI}; rare patch types are weighted less in the calculation than in PR
N2	Landscape	Hill's index N2	A transformation of SIDI, computed as 1/(1-SIDI); rare patch types are weighted less in the calculation than in N1
R21	Landscape	Alatalo's evenness	Measures evenness of patch types; computed as (N2-1) / (N1-1), index where PR > 1; values approaching 0 indicate uneven distribution of patch type areas; values approaching 1 indicate even distribution of area for the given number of patch types

[a] See McGarigal and Marks (1995) for algorithms and complete descriptions of all indices except N1, N2, and R21.

Evaluating the ecological significance of changes—We supplemented this statistical test with two additional analyses that enabled us to evaluate the potential ecological significance of patch type change in area or connectivity of area. First, we approximated the historical range of variation (Everett and others 1994, Morgan and others 1994, Swanson and others 1994) by calculating the historical sample median 75-percent range for each patch type metric, and we compared the current sample median value with this estimate of the historical range. Second, we characterized the most significant changes in absolute area of a patch type within a sample by using transition analysis. Ecologically significant change ultimately was determined by examining each of the three pieces of information: the 80-percent confidence interval, differences between current median values and historical median 75-percent ranges, and principal transitions between historical and current conditions.

Transition analysis estimated the percentage of area in a pooling stratum that changed from any one cover type or structural condition in the historical vegetation coverage to any other condition in the current coverage, including transitions to the same condition. If change was narrowly focused to a few transition types, and those transitions were credible in light of known management history and successional and disturbance regime changes, the transitions were provisionally judged as ecologically significant. (Note that transition matrices were established from 30-m raster coverages of patch types. The total number of possible transition types within an ERU ranged from 10^2 to 10^3.) Transition analysis enabled us to directly identify transitions responsible for the changes we observed and detect statistically significant "nonsense" changes resulting from rasterization of historical and current vegetation coverages.

The median 75-percent range of the historical condition was used to estimate the significant difference between current median values and the typical range of historical conditions. If the median value of the current condition (for any metric associated with any patch type) was outside the median 75-percent range of the historical condition, and transition analysis determined that no major transitions were nonsense changes, we judged the difference to be ecologically significant. Nearly all changes evaluated as ecologically significant were found to be statistically significant at $P \leq 0.2$ via examination of the 80-percent confidence interval.

We chose the median 75-percent range instead of the full 100-percent range as a meaningful measure of recent historical variation to portray typical variation exclusive of extreme observations. Historical (and current) data distributions most often were highly skewed and only rarely were distributed normally; hence, the sample median value was a more accurate reflection of central tendency than either the mean or mode. Most observations clustered within the median 75- to 80-percent range, and few observations accounted for differences between the range of the clustered observations and the full range. We reasoned that more extreme variation usually results from either unique contexts or environments or from rare events. By imposing the contrast between current median values and a typical range of historical conditions, we retained the ability to detect conditions resulting from management activities, random chance, or perhaps climate change that was unique or abnormal in some aspect. Indeed, a similar rule is applied when we compare our own human physical condition to a standard or set of norms. Although natural variation in human anatomy and morphology includes supernumerary digits, appendages, and teeth, or the noticeable absence of common anatomical features, we compare our condition to a more narrowly defined standard that excludes characteristics associated with the most extreme variation in human populations. We do so because we are aware that these rarer features often are associated with a certain amount of disutility or dysfunction.

We noted earlier in this "Methods" section that historical vegetation maps were developed from the earliest available aerial photography. While researching archived films, we learned that in most cases, the first available continuous coverage of historical photos usually predated the advent of significant timber harvest in a subwatershed. As indicated in our list of remotely sensed attributes (appendix 1), we interpreted the extent and type of visible logging activity and found this to be the case. Historical photographic coverages represented a span of years from 1933 to 1966 (table 3). When we evaluated the ecological significance of vegetation change, we compared current median values with a typical range of historical values: the full range of historical observations minus the most extreme outliers.

The ideal would be to sample vegetation conditions in subwatersheds at many different time depths, over a period of similar climate regime to obtain a representative sample of historical or "natural" variation, but such a sample is expensive and unavailable. In the ideal case, sampling over multiple time depths would enable the observer to characterize variation arising from the stochasticity of environments, disturbance regimes, and climate regimes. We had a span of years rather than a single year to represent historical vegetation conditions and thus could sample more variability in historical vegetation patterns resulting from chance events and contexts, and could more adequately represent natural variation, than had we sampled a single historical year.

Spatial statistics—We used the basic data set to quantify change in area and connectivity of patch types and their spatial patterns in subwatersheds. We assessed change in area and connectivity relations of cover type and structural class patch types by computing nine class metrics for historical and current vegetation coverages and testing for significant change. We evaluated change in spatial patterns of cover type-structural class patch types by computing 10 landscape pattern indices and testing for significant change (table 17). Nine of the 10 landscape metrics were used to evaluate changes in diversity, richness, dominance, evenness, interspersion, and contagion of patch types. One area-weighted mean edge contrast index (AWMECI) was computed; mean edge contrast was defined by using weights ranging from 0 to 1, with increasing weight representing greater edge contrast. Edge contrast weights are provided in table 18. For those patches occurring at the boundary of a subwatershed, the boundary was considered the patch edge for the purpose of calculating area, shape, and other class metrics, even though in reality some patches continued beyond the subwatershed boundary.

All class and landscape metrics were computed for whole subwatersheds from 30-m raster versions of the vector ARC/INFO maps. We used the FRAGSTATS program (McGarigal and Mares 1995) to quantify and contrast all historical and current area and connectivity, and landscape pattern relations. Of the metrics available in FRAGSTATS, a restricted set was used to quantify trends in subwatershed structural attributes and spatial patterns. That set included the following metrics by type: area (%LAND and LPI); patch density, patch size and variability (MPS, PD, and PSCV); edge (ED and AWMECI); shape (AWMSI); nearest neighbor (MNN and NNCV); diversity (SHDI, RPR, PR, and MSIEI); contagion (CONTAG); and interspersion (IJI). In addition, three supplemental diversity metrics were added to the FRAGSTATS source code and computed: Hill's Indices N1 and N2 (Hill 1973), and R21, Alatalo's evenness index (Alatalo 1981); N1 and N2 also were used to derive R21.

Table 18—Edge contrast weights used in calculating the FRAGSTATS metric area weighted mean edge contrast index (AWMECI) in pattern analyses of patch types of sampled subwatersheds in the midscale ecological assessment of the interior Columbia River basin[a]

Physiognomic type	Nonforest and nonrange	Herbland	Shrubland	Woodland	Forest (by structural class[b]) si	seoc and secc	ur and yfms	ofss	ofms
Nonforest and nonrange	0[c]	0.2	0.3	0.4	0.5	0.6	0.8	0.9	1
Herbland		0	0.2	0.3	0.4	0.6	0.7	0.8	0.9
Shrubland			0	0.2	0.3	0.5	0.6	0.7	0.8
Woodland				0	0.3	0.4	0.5	0.6	0.7
Forest si					0	0.3	0.4	0.5	0.6
Forest seoc and secc						0	0.3	0.4	0.5
Forest ur and yfms							0	0.3	0.4
Forest ofss								0	0.3
Forest ofms									0

[a] For FRAGSTATS, see McGarigal and Marks (1995).

[b] Forest structural classes are stand intiation (si); stem exclusion open canopy (seoc); stem exclusion closed canopy (secc); understory reinitiation (ur); young forest multistory (yfms); old forest single story (ofss); and old forest multistory (ofms). See also tables 5 and 6 for forest structural class descriptions, definitions, and classification rules for continuous data.

[c] Range of possible values is 0 to 1, with increasing values representing greater edge contrast.

Landscape pattern analyses—Pattern analyses presented in this paper represent about one-quarter of the total analysis. Time and budget constraints and page limitations prevent a complete presentation of analyses and results. We include those analyses that we thought most essential and that provided the greatest insight into changes occurring in sampled subbasins. In this paper and in Ottmar and others (in prep.), we summarize, by ERUs as the pooling stratum, changes in area and connectivity of the following patch types: (1) physiognomic types; (2) forest cover types; (3) herbland, shrubland, and woodland cover types; (4) nonforest and nonrange cover types; (5) forest structural classes; (6) herbland, shrubland, and woodland structural classes; (7) disturbance vulnerability classes for 21 potential pathogen and insect disturbances; (8) fuel loading classes; (9) potential fuel consumption classes under wet, dry, and normal (average) burning conditions; (10) potential fireline intensity classes under wet, dry, and normal burning conditions; (11) potential flame length classes under wet, dry, and normal burning conditions; (12) potential fire rate of spread classes under wet, dry, and normal burning conditions; (13) potential risk of crown fire classes under wet, dry, and normal burning conditions; (14) potential PM10 smoke emissions under wet, dry, and normal burning conditions (see Ottmar and others, in prep. for analysis of items 8 to 14); (15) forests and woodlands with large trees; (16) forests and woodlands with medium and large trees; (17) forest and woodland tree crown cover; (18) forest and woodland dead tree and snag abundance; (19) forest and woodland visibly affected by logging; and (20) riparian and wetland areas. The ERUs were used as pooling strata to verify the broad-scale assessment findings of Hann and others (1997) and to compare those findings with findings contained herein. Later, we will resummarize change by using more appropriate midscale pooling strata.

In addition to assessing change in area and connectivity relations of cover types and structural classes, we assessed change in physiognomic conditions. Following is the disposition of remotely sensed nonforest types (see appendix 1) to physiognomic types. Patches interpreted as wet meadow, alpine meadow, dry meadow, grasses and forbs after logging, pasture, grassland, and grasses and forbs after burning (wildfire or prescribed) were classified as herbland; patches interpreted as shrubland were classified as shrubland; and patches interpreted as rock, water, bare ground after burning or logging, bare ground associated with slumps and erosion, cropland, urban or rural development, bare ground associated with roads and highways, stream channels and nonvegetated flood plains, dune, glacier, or bare ground associated with dry lake beds or as playa were classified as nonforest-nonrange and other anthropogenic types.

Other change analyses quantified but not summarized in this paper include (1) riparian and wetland area by forest and range cover type; (2) riparian and wetland area by forest and range cover type and PVT; (3) forest cover type by structural class by PVT; (4) range cover type by structural class by PVT; (5) forest cover type by structural class; (6) range cover type by structural class; (7) forest and woodland understory species by cover type; (8) forest and woodland understory species by cover type and PVT; (9) forest and woodland total crown cover classes by cover type; (10) forest and woodland total crown cover classes by cover type and PVT; (11) patch clumpiness by cover type; (12) patch clumpiness by cover type and PVT; (13) patch clump density by cover type; (14) patch clump density by cover type and PVT; (15) patch clump size by cover type; (16) patch clump size by cover type and PVT; (17) patch overstory crown differentiation by cover type; (18) patch overstory crown differentiation by cover type and PVT; (19) patch canopy layers by cover type; (20) patch canopy layers by cover type and PVT; (21) patch visible logging activity class by cover type; (22) patch visible logging activity class by cover type and PVT; (23) patch dead tree and snag abundance by cover type; and (24) patch dead tree and snag abundance by cover type and PVT. Resources allowing, results of these analyses will be summarized for midscale pooling strata and reported at a later time.

Forest Landscape Vulnerability to Insect and Pathogen Disturbances

Here we summarize methods used to assess recent change in vulnerability of forest vegetation to disturbances caused by the major forest insects and pathogens of the basin (see Hessburg and others, in press, for modeling procedures). Change in potential vulnerability was characterized for each of the 337 subwatersheds. Vulnerability characterizations modeled the potential susceptibility or conduciveness of vegetation patterns to alteration by insect or pathogen disturbance. Insect and pathogen disturbances were modeled as succession processes. Vulnerable subwatersheds displayed vegetation patterns conducive to propagating a given pathogen or insect disturbance within and among patches. Structural and compositional succession, as intended here, was the outcome of pathogen infection or insect infestation of susceptible vegetation at patch or landscape scales. Examples of growth and mortality effects leading to succession are tree topkilling, tree mortality, brooming, stem decay, tree collapse, butt rot, windthrow, top breakage, and defoliation.

Disturbance agents—We characterized subwatershed vulnerability to 21 different forest pathogen and insect disturbances. Forest pathogens and insects selected were those that frequently cause patch- and landscape-scale disturbances resulting in measurable structural and compositional change in the interval between stand-replacing fires. Landscape vulnerability was assessed for one defoliator disturbance, seven bark beetle disturbances, four dwarf mistletoe disturbances, four root disease disturbances, two root and butt rot disturbances, two blister rust disturbances, and one stem decay disturbance.

Vulnerability characterizations for two principal defoliators, the western spruce budworm and the Douglas-fir tussock moth, were collapsed into one vulnerability rating, but vulnerability factors used were most appropriate to the western spruce budworm. Vulnerability to bark beetle disturbance was quantified separately for the Douglas-fir beetle, western pine beetle, mountain pine beetle, fir engraver, and spruce beetle. Subwatershed vulnerability to western pine beetle disturbance was addressed in two separate submodels: one (type 1) for landscapes comprised of mature and old ponderosa pine, and another (type 2) for landscapes comprised of immature and high-density ponderosa pine. Similarly, vulnerability to mountain pine beetle disturbance was addressed by two submodels: one (type 1) for landscapes comprised of high-density lodgepole pine, and another (type 2) for landscapes comprised of immature, high-density ponderosa pine.

Subwatershed vulnerability to dwarf mistletoe disturbance was modeled separately for mistletoes of western larch, Douglas-fir, ponderosa pine, and lodgepole pine. Vulnerability to root disease disturbance was modeled separately for laminated root rot, *Armillaria* root disease, S-group annosum root disease, and P-group annosum root disease. Vulnerability to root and butt rot disturbance was modeled separately for tomentosus root and butt rot and Schweinitzii root and butt rot. Vulnerability to white pine blister rust disturbance was addressed in two separate submodels: one (type 1) for western white pine and sugar pine cover types, and another (type 2) for the whitebark pine-subalpine larch cover type. Finally, vulnerability to stem decay disturbance was modeled for rust-red stringy rot caused by the Indian paint fungus.

Vulnerability factors—We used patch composition, structure, logging disturbance, and physical environment attributes to compare the vulnerability of vegetation of historical subwatersheds with that of their current condition. Appendix 1 lists attributes interpreted from historical and current aerial photographs in the midscale assessment and used to derive patch vulnerability. Patch vulnerability factors were unique for each host-pathogen or host-insect interaction modeled and included (1) site quality (differences in ecological site potential), (2) host abundance, (3) canopy structure, (4) host size, (5) patch vigor, (6) patch (stand) density. (7) connectivity of host patches, (8) topographic setting, and (9) logging disturbance.

Site quality was modeled from plant series-level PVTs as described in Hessburg and others (in press) and Smith and others (in prep.). Site quality was used as a vulnerability factor because hosts on poorer sites often are more vulnerable to a particular pathogen or insect disturbance than those occurring on more productive sites; we used site quality to capture some of those differences. Host abundance was used to estimate the proportion of a patch comprised of vegetation capable of hosting a particular pathogen or insect. Where differences in host susceptibility were known, hosts were weighted. Host abundance was estimated from the following photointerpreted attributes: total crown cover, overstory crown cover, understory crown cover, overstory species, and understory species (appendix 1). Canopy structure was used as a vulnerability factor to capture the influence of patch vertical structure on pathogen or insect dispersal and was derived from the following photointerpreted attributes: canopy layers, overstory species, and understory species.

Host size was used to indicate size of hosts and, in some cases, to approximate host age, because host age could not be directly estimated from photointerpretation. Host size was used for a few insects because tree size thresholds or size ranges were germane to estimating host vulnerability within patches. Host size also was used because patch structural attributes are more likely to change as a consequence of disturbance when hosts are large than when hosts are small. Host size was estimated from the following photointerpreted attributes: overstory species, understory species, overstory size class, and understory size class.

Relative differences in patch vigor were represented by the overstory crown differentiation attribute (appendix 1). Relative differences in stand density were represented by using the total crown cover attribute. Connectivity of host patches was estimated by computing the percentage of the area within a specified dispersal radius comprised of host patches at a scale of 30 m with raster coverages. Toe-slope topographic settings were modeled by using the riparian status attribute and a 90-m digital elevation model. Environmental attributes such as site quality and topographic setting aided in defining the influence of selected biophysical conditions on vulnerability of vegetation to a disturbance agent. Logging disturbance was represented by type and apparent extent of harvest (appendix 1).

Modeling change—In brief, the procedure for quantifying subwatershed vulnerability to an insect or pathogen disturbance in the midscale assessment was as follows: (1) we rated patches in each historical and current subwatershed vegetation coverage for all vulnerability factors specified for each disturbance agent; (2) we summed factor ratings for each patch—this sum was the patch vulnerability rating; (3) we assigned a vulnerability class (low, moderate, or high) to each patch according to the patch vulnerability rating; and (4) we computed three FRAGSTATS metrics for each patch type, where patch types were vulnerability classes %LAND—the percentage of area within a patch type, MPS—the mean size in hectares of patches within a patch type, and PD—the estimated patch density, or number of patches per 10 000-ha area (see McGarigal and Marks [1995] for complete descriptions of FRAGSTATS metrics). These metrics were used to describe changes in area and connectivity of area of vulnerability classes in subwatersheds of an ERU. As described in Hessburg and others (in press), change from historical to current conditions was estimated as the difference *between* historical and current conditions, not the percentage of change from historical conditions. For the ERU pooling stratum, means, mean standard errors, and confidence intervals were estimated by using methods for simple random samples (Steel and Torrie 1980) with subwatersheds as sample units. Statistically significant ($P \leq 0.2$) change was determined by examining the 80-percent confidence interval around the mean difference for the ERU, which was estimated as the simple random mean from pairwise comparisons of historical and current subwatersheds. If the confidence interval included zero, no significant change was recorded.

We supplemented this statistical test with two additional analyses described earlier, which enabled us to evaluate the potential ecological significance of patch type change in area or connectivity of area. We approximated the historical range of variation by calculating the historical sample median 75-percent range for each patch type metric, and we compared the current sample median value with this estimate of the historical range. We also characterized the most significant changes in absolute area of a patch type within a sample by using transition analysis. Ecologically significant change was ultimately determined by examining each of the three pieces of information.

Ecological Reporting Units

Rationale—In this project, the Forest Service and Bureau of Land Management were charged (see the ICBEMP charter in Haynes and others 1996) with developing an ecosystem approach to guide assessment, planning, and management of forest, range, and aquatic ecosystems on public lands within the basin. Early in the assessment work, it was apparent that assessment teams needed a common geographic framework useful to all teams for reporting assessment results. Land units were needed that were broadly homogeneous in their biophysical *and* social ecosystem characteristics. A strategy was devised to logically subdivide the basin study area into geographic areas to report assessment results, focus management opportunities, and provide a framework for implementing planning decisions.

The Northwest Forest Plan (USDA and USDI 1994) used the term “province” to designate geographic areas in western Washington and Oregon and northern California for analysis, planning, and management purposes. Province boundaries in this usage were delineated by using large watershed boundaries. McNab and Avers (1994) also used the term “province” when mapping sections of the United States; provinces formed the third level in the national hierarchical framework of ecological land units, and province boundaries were not delineated by hydrography. To avoid further confusion, we adopted the term “ecological reporting units” to refer to land units delineated by both biophysical and socioeconomic criteria.

As Odum (1969) suggests, land use policy should consider ecosystems as the foundation for determining the capacity of any land area to provide goods and services for people. Furthermore, ecosystems should be defined at scales appropriate to ecological and social issues of interest. Ecological land units (*sensu* McNab and Avers 1994) provide some of the needed defining characteristics of ecosystems. But ecosystems have terrestrial and hydrologic dimensions, and ecological land units as such, do not adequately incorporate the hydrologic dimension of ecosystems. To that end, we derived land units at a scale appropriate to assessing the status of ecosystems given their biophysical and social contexts and the need to address corresponding issues in a common environment.

Development—Digital map themes used to develop ERUs included (1) the nested hierarchy of subbasins (4th code HUCs), watersheds (5th code HUCs), and subwatersheds (6th code HUCs) described earlier (Jensen and others 1997, Seaber and others 1987); (2) section (McNab and Avers 1994) and subsection (Jensen and others 1997) biophysical environment maps; and (3) county maps (USDI 1987).

Three maps were generated initially. The first map represented reporting units primarily as biophysical environments; section and subsection boundaries were adjusted to the nearest subwatershed boundary. A second map was created to represent reporting units based on socioeconomic criteria with counties as basic mapping units. Counties were grouped into geographic clusters representative of dominant human uses of natural resources. County clusters were evaluated against several biophysical criteria, including precipitation zones, dominant potential vegetation types, physiognomic types, and major landforms, to further refine boundaries of county clusters and better reflect dominant land uses (see Haynes and Horne 1997).

A third map was developed that emphasized broad geographic differences in hydrology based on multivariate analysis of watershed characteristics and stream gauge data; it incorporated province-scale differences in the zoogeography of aquatic species. Subbasins having similar hydrologic characteristics and aquatic species assemblages were grouped and mapped (Jensen and others 1997). Subbasin group boundaries were adjusted toward the nearest section or subsection boundary following subbasin boundaries.

All three mapping strategies resulted in highly similar delineations with comparable numbers and locations of map units. To create an ERU map, the three maps were merged into a single map by using subwatersheds as the mapping unit. The final map was created as follows: (1) subbasins were aggregated that had > 65 percent of their area within a section (section boundaries were developed by aggregating subsections); (2) subbasins with equal area in two very different sections were split along subwatershed boundaries; and (3) subbasins with equal area in two similar sections were grouped with those subbasins having similar base erosion values (Jensen and others 1997). The resulting ERU map (fig. 23) adequately conserved the integrity of the three original maps.

We used ERUs in midscale analyses as an initial pooling stratum for summarizing results of statistical and spatial analysis of subwatershed trends. This was done as a poststratification procedure primarily to enable validation of broad-scale assessment results (Hann and others 1997) and provide consistency among the assessments in reporting of results. Subsequent to this project, we will report results of midscale analysis at the ecological subregion level (see “Discussion”) derived through hierarchical clustering and ordination techniques. Broad-scale assessment results (Hann and others 1997), biophysical environment descriptions (Jensen and others 1997), results of aquatic and riparian assessment analysis (Lee and others 1997), terrestrial species analysis (Marcot and others 1997), social assessment analysis (McCool and others 1997), and economic analysis (Haynes and Horne 1997) also were reported at this ERU scale. Figure 24 provides a map for comparison of ERUs and our original midscale subbasin sampling strata. Refer to Jensen and others (1997) for a more complete discussion of the rationale and development process for ERUs.

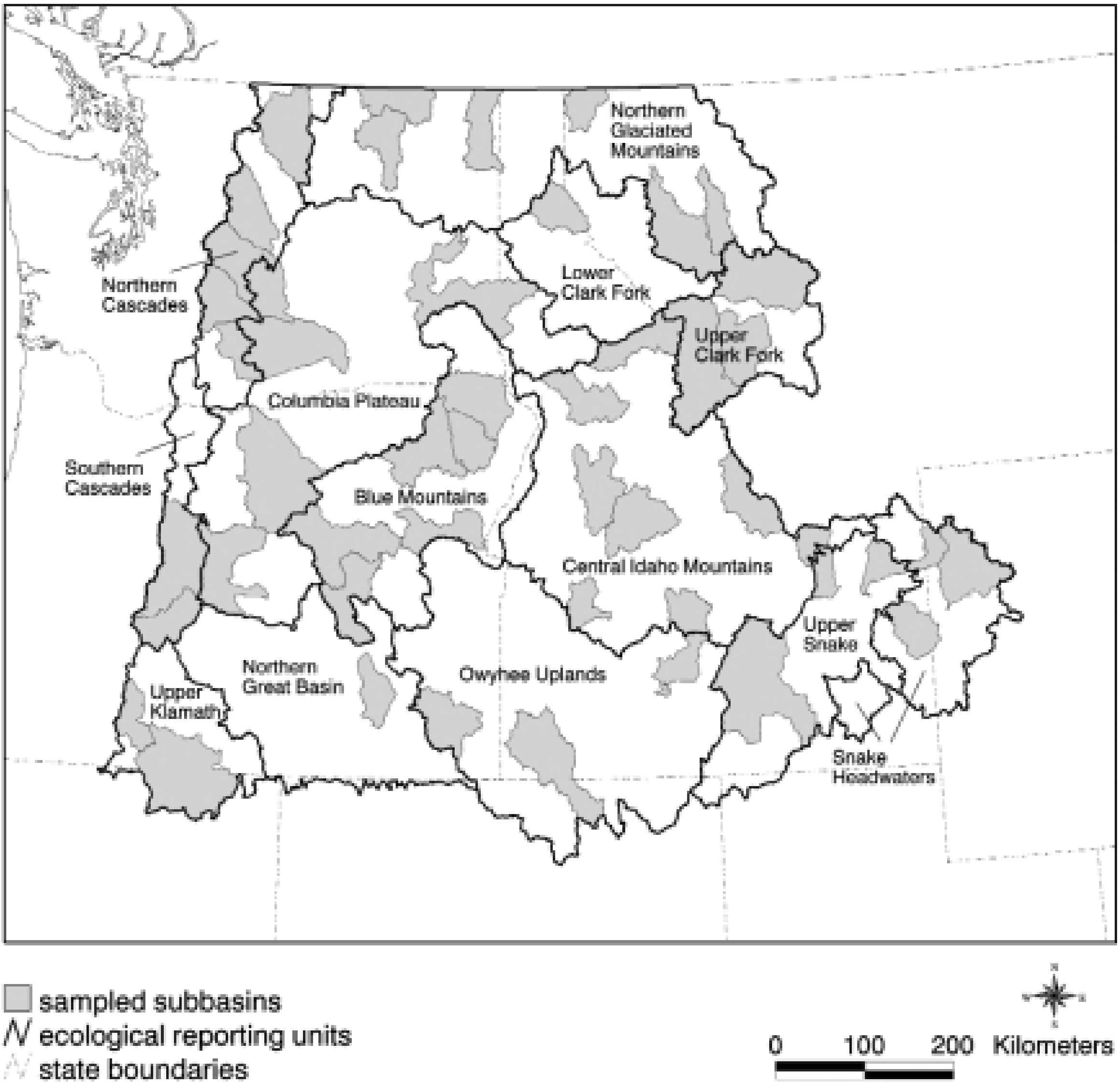


Figure 23—Ecological reporting units (ERUs) of the interior Columbia River basin broad-scale and midscale assessments. Shaded areas denote subbasins sampled within each ERU.

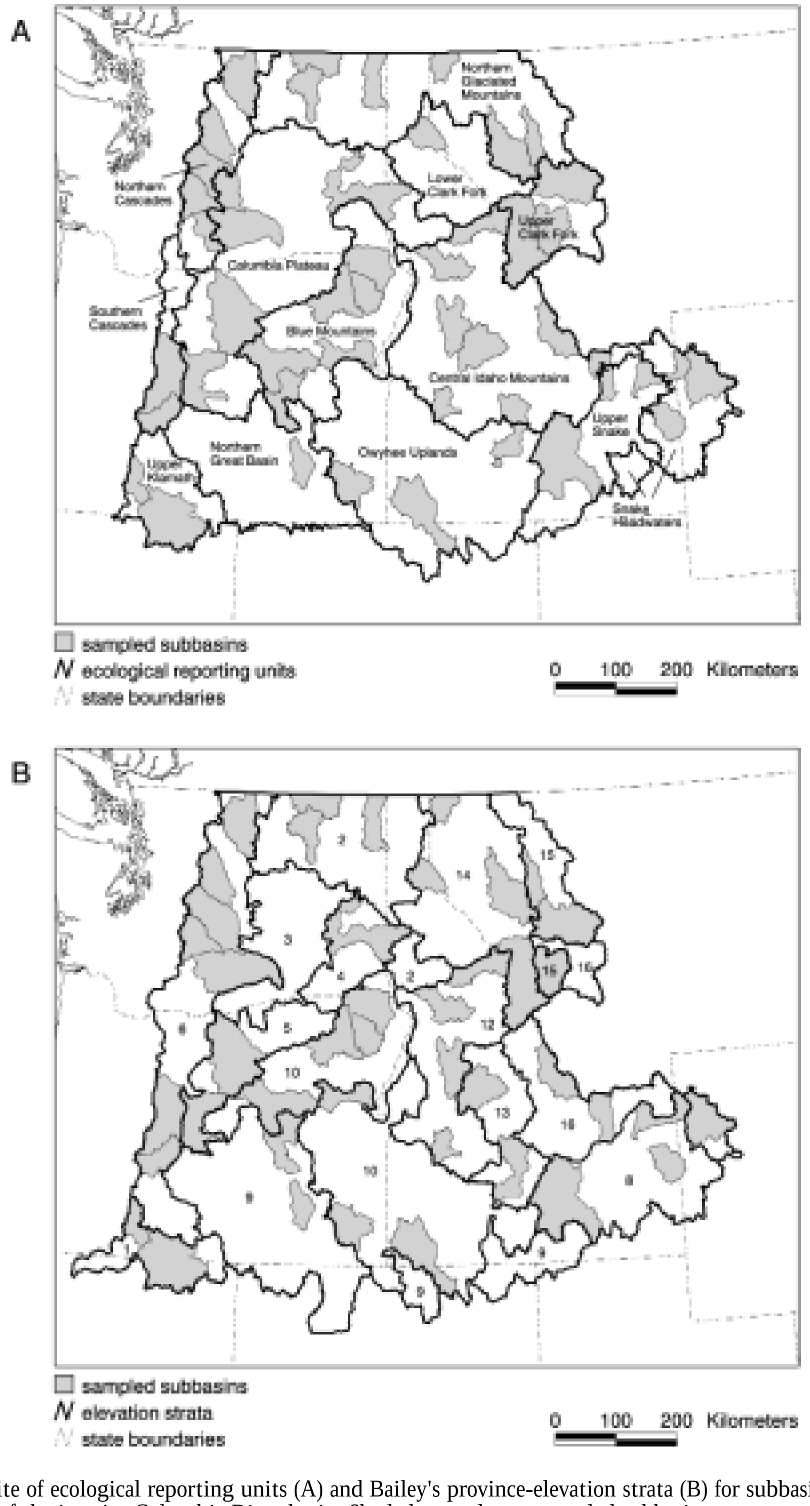


Figure 24—Composite of ecological reporting units (A) and Bailey's province-elevation strata (B) for subbasins sampled in the midscale assessment of the interior Columbia River basin. Shaded areas denote sampled subbasins.

Results

Vegetation

In this first section, we describe ecologically significant[22] change in area and connectivity of patch types, between historical and current vegetation conditions for physiognomic types, cover types, and structural classes of sampled forest and rangeland vegetation; results are summarized by ERU. Ecologically significant change is the primary emphasis; appendix 2 (table 32) provides complete tabular results of all vegetation change analysis summarized in this section. Appendix 3 (table 33) shows change in insect and pathogen disturbance vulnerability classes by ERU. Comparisons among ERUs are provided in the "Discussion" and related tables. We report significant figures for conventional and spatial statistics to one decimal place unless otherwise indicated.

Blue Mountains ERU—Subbasins sampled within the Blue Mountains ERU (figs. 12 to 14 and 16) included the Burnt (BUR), Lower Grande Ronde (LGR), Silvies (SIL), Upper Grande Ronde (UGR), Upper John Day (UJD), and Wallowa (WAL). Among these subbasins, 46 historical and current subwatershed pairs were sampled.

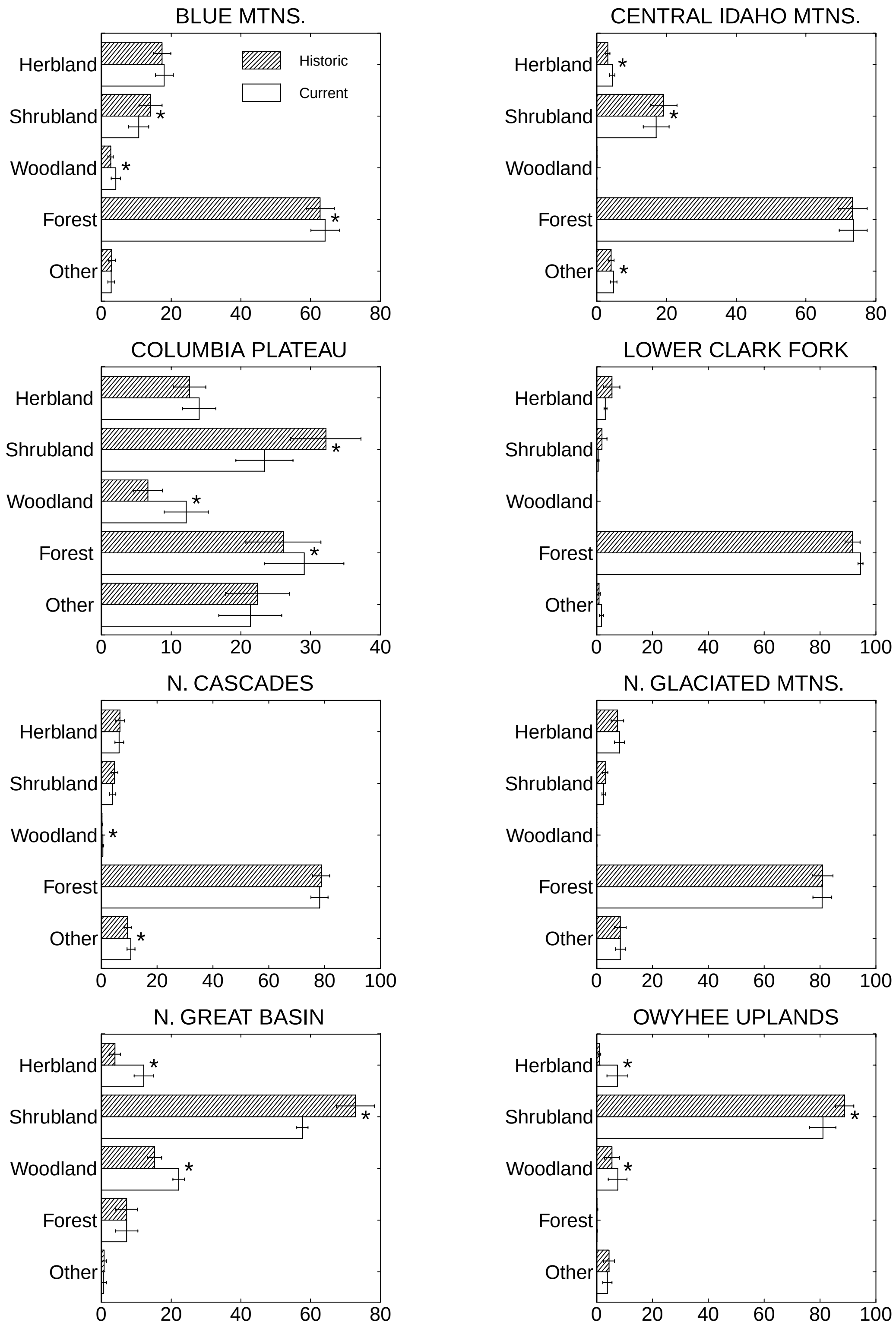
***Physiognomic types*—**Area in the forest physiognomic type increased from an average of 62.8 to 74.2 percent of the area of the ERU, and area in woodland increased from an average of 2.7 to 4.2 percent (fig. 25 and appendix 2) Shrubland area declined from an average of 14.1 to 10.7 percent of the ERU area. Connectivity of woodlands also increased significantly, with patch size increasing from an average of 17.4 to 29.8 ha. Patch density of herblands increased from an average of 24 to 28.8 patches per 10 000 ha. No significant change (hereafter, ns) in area of non-forest-non-range and other anthropogenic types was evident, but patch density declined from an average of 5.5 to 4.6 patches per 10 000 ha.

***Cover types*—**
Forest—Area and connectivity of grand fir-white fir and subalpine fir-Engelmann spruce cover types declined, and that of the Douglas-fir cover type increased (figs. 26 to 28 and appendix 2). Average area of the grand fir-white fir cover type declined from 15.3 percent to 8.4 percent, and area of subalpine fir-Engelmann spruce declined from an average of 6.3 percent to 4.4 percent. Both declines likely were associated with severe bark beetle outbreaks in those types during the last decade (Gast and others 1991). Area of whitebark pine-subalpine larch cover increased by an average of 0.7 percent from 0, and area of Douglas-fir cover increased substantially from an average of 7.7 percent to 17.1 percent. Average patch density of Douglas-fir increased from 11.7 patches to 20.6 patches per 10 000 ha, and mean patch size increased from an average of 54.4 ha to 107.7 ha. Change in Douglas-fir area and connectivity was the most significant occurring among forest cover types of the Blue Mountains.

Changes in connectivity of grand fir-white fir and subalpine fir-Engelmann spruce were nearly as dramatic. Patch density of the grand fir-white fir cover type increased from an average of 8 to 11 patches per 10 000 ha, and patch density of subalpine fir-Engelmann spruce increased from an average of 2.3 to 3.8 patches per 10 000 ha.

Text resumes on page 84

[22] Statistical significance was assessed at P≤0.2. As described in "Methods," we also used transition matrices and an estimate of the historical range of variation for each ERU along with statistical significance to evaluate "ecological significance" referred to in this section.


BLUE MTNS.
Historic
Current
Herbland
Shrubland
Woodland
Forest
Other
0
20
40
60
80
CENTRAL IDAHO MTNS.
COLUMBIA PLATEAU
0
10
20
30
40
LOWER CLARK FORK
0
20
40
60
80
100
N. CASCADES
N. GLACIATED MTNS.
N. GREAT BASIN
OWYHEE UPLANDS
*

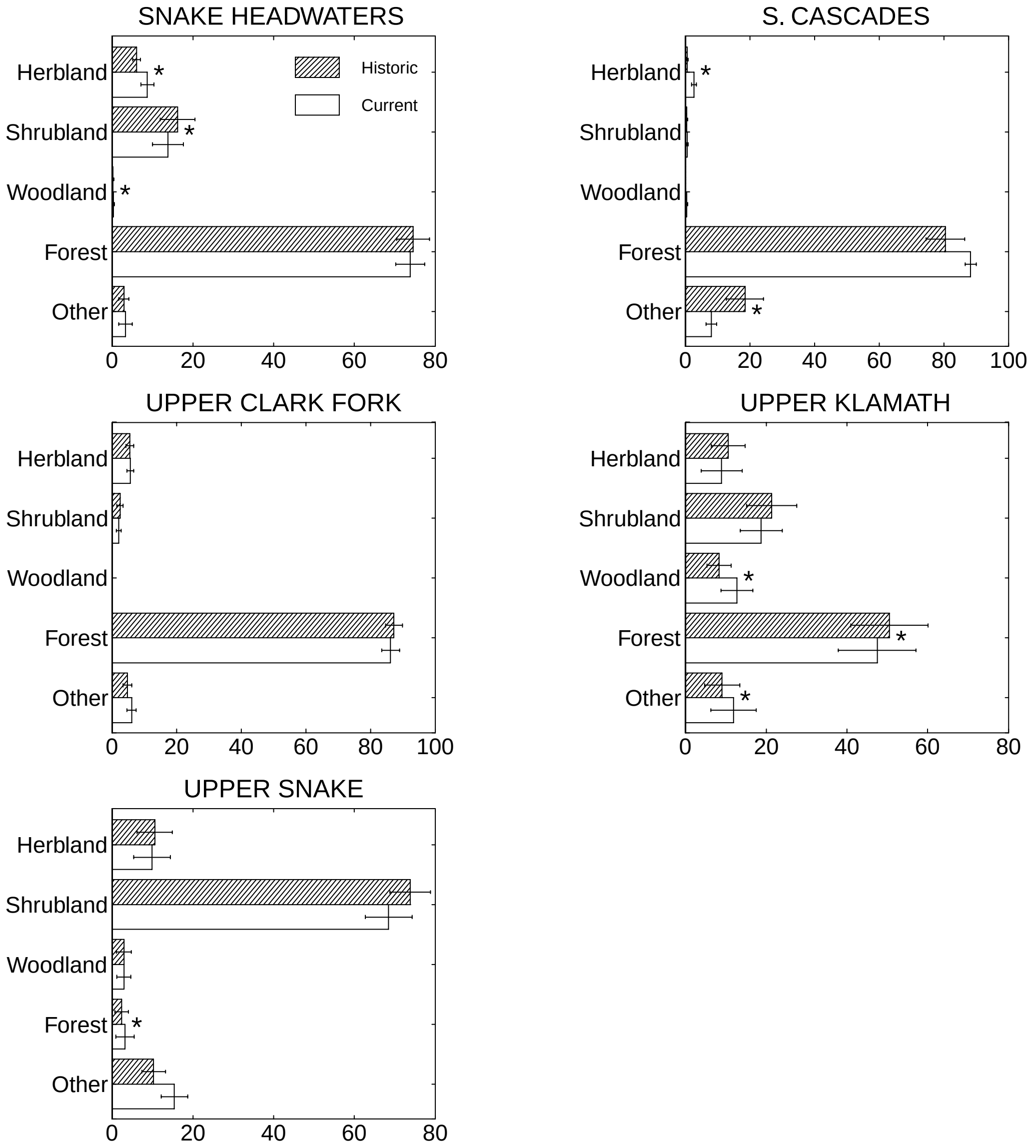
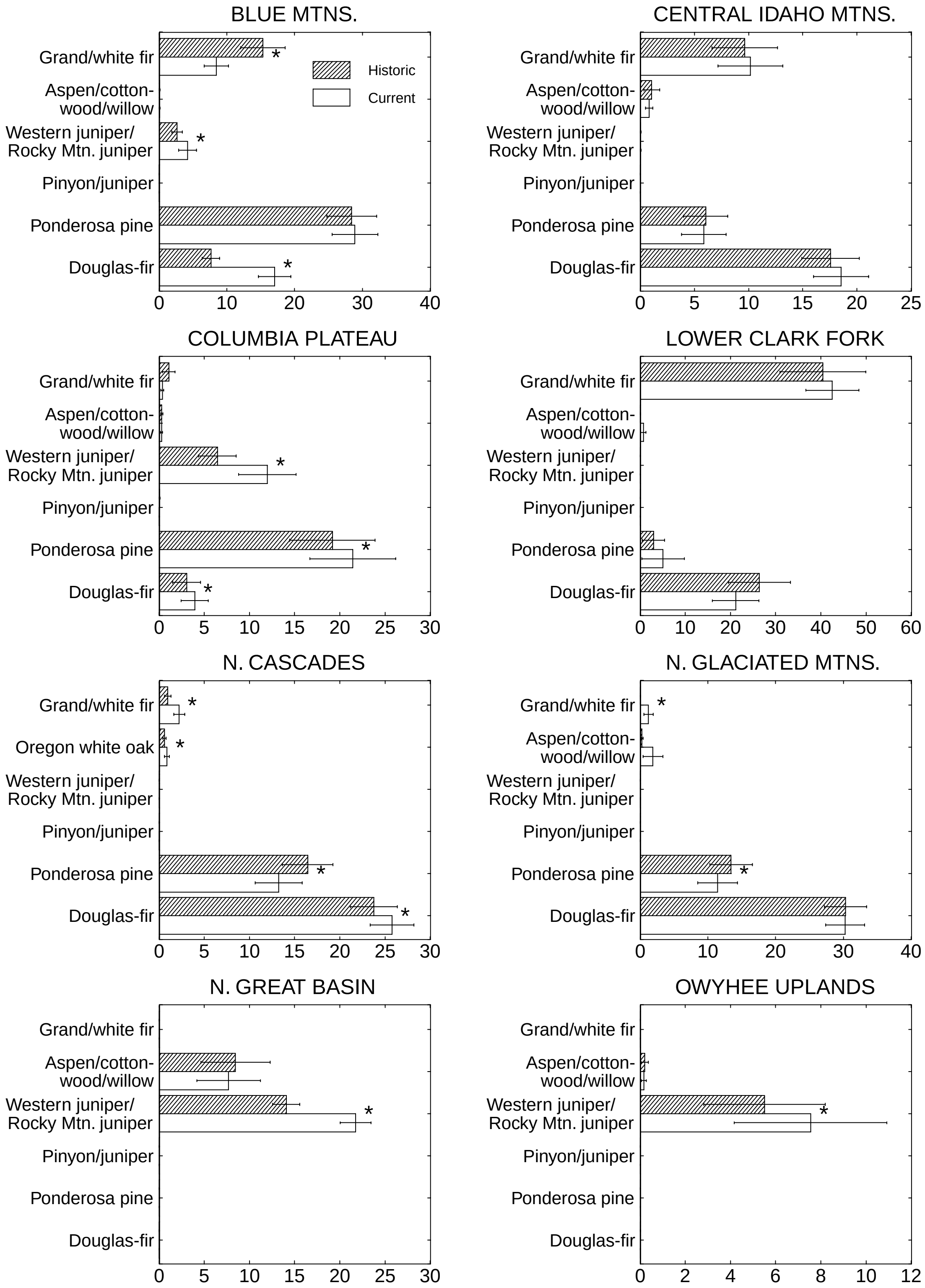


Figure 25—Historical and current distribution of physiognomic types expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) difference between historical and current conditions.


BLUE MTNS.
CENTRAL IDAHO MTNS.
COLUMBIA PLATEAU
LOWER CLARK FORK
N. CASCADES
N. GLACIATED MTNS.
N. GREAT BASIN
OWYHEE UPLANDS
Historic
Current
Grand/white fir
Aspen/cotton-wood/willow
Oregon white oak
Western juniper/ Rocky Mtn. juniper
Pinyon/juniper
Ponderosa pine
Douglas-fir

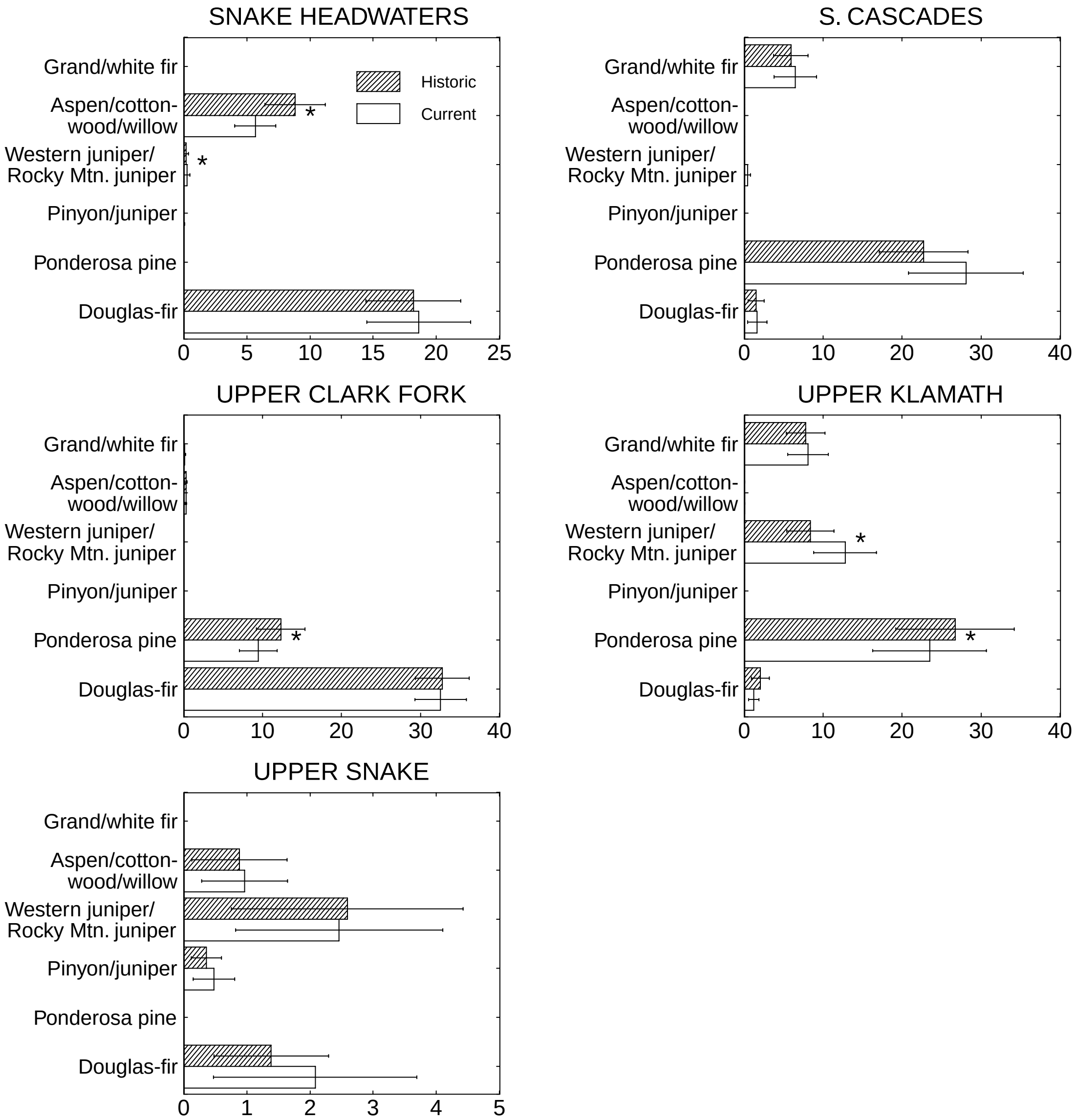
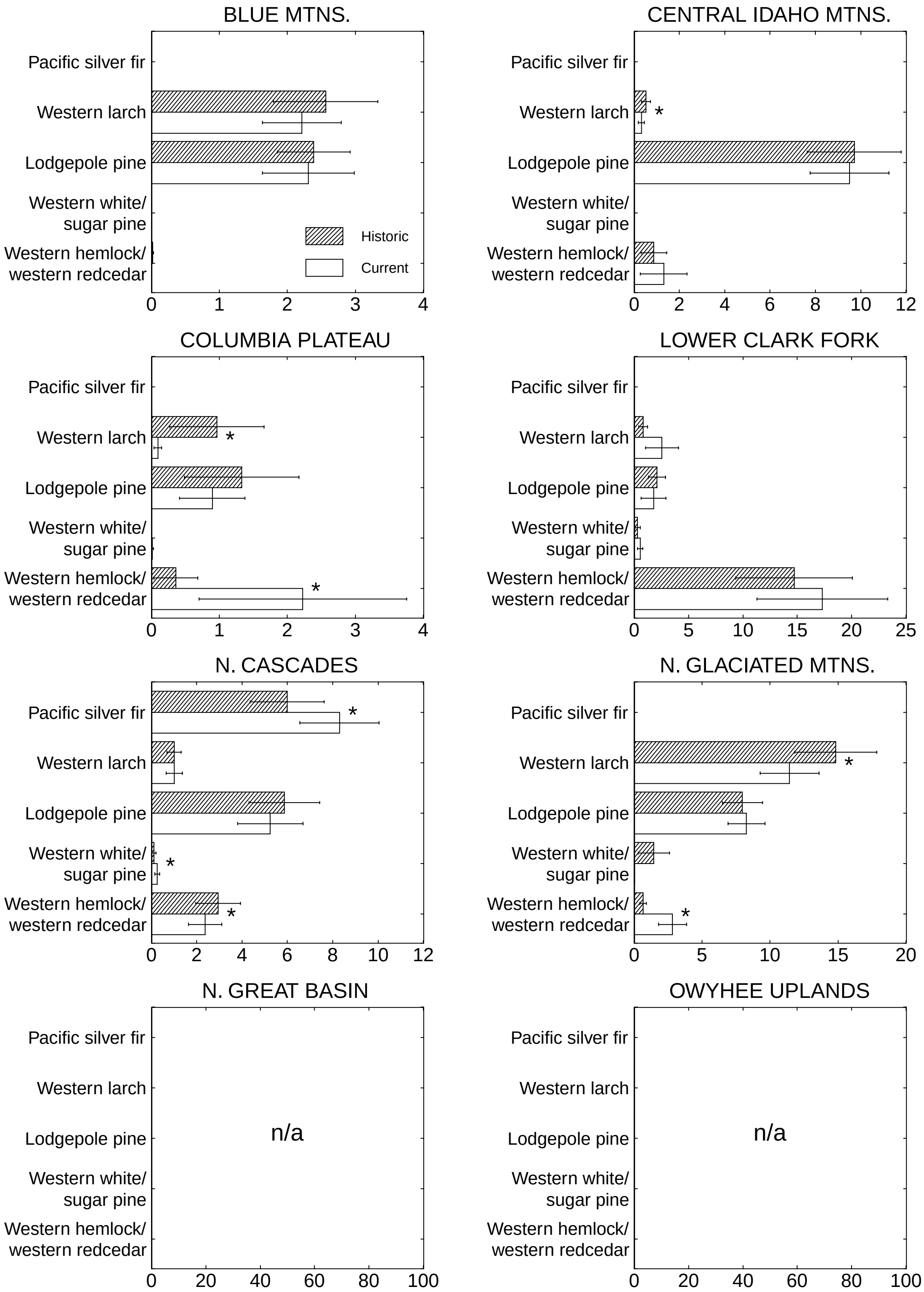


Figure 26—Historical and current distribution of forest and woodland cover types expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) difference between historical and current conditions.



BLUE MTNS.
CENTRAL IDAHO MTNS.
COLUMBIA PLATEAU
LOWER CLARK FORK
N. CASCADES
N. GLACIATED MTNS.
N. GREAT BASIN
OWYHEE UPLANDS
Pacific silver fir
Western larch
Lodgepole pine
Western white/
sugar pine
Western hemlock/
western redcedar
Historic
Current
n/a

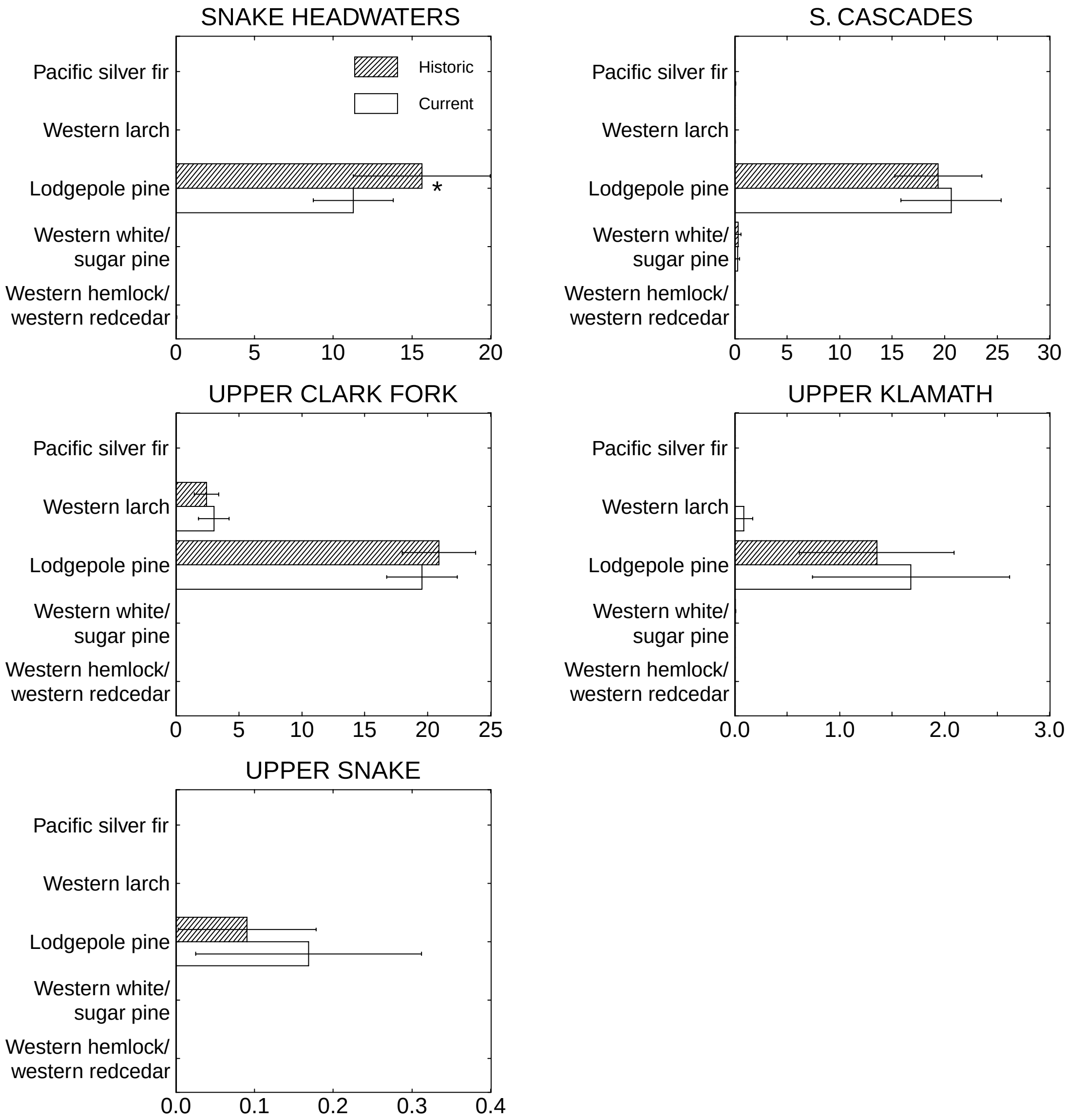
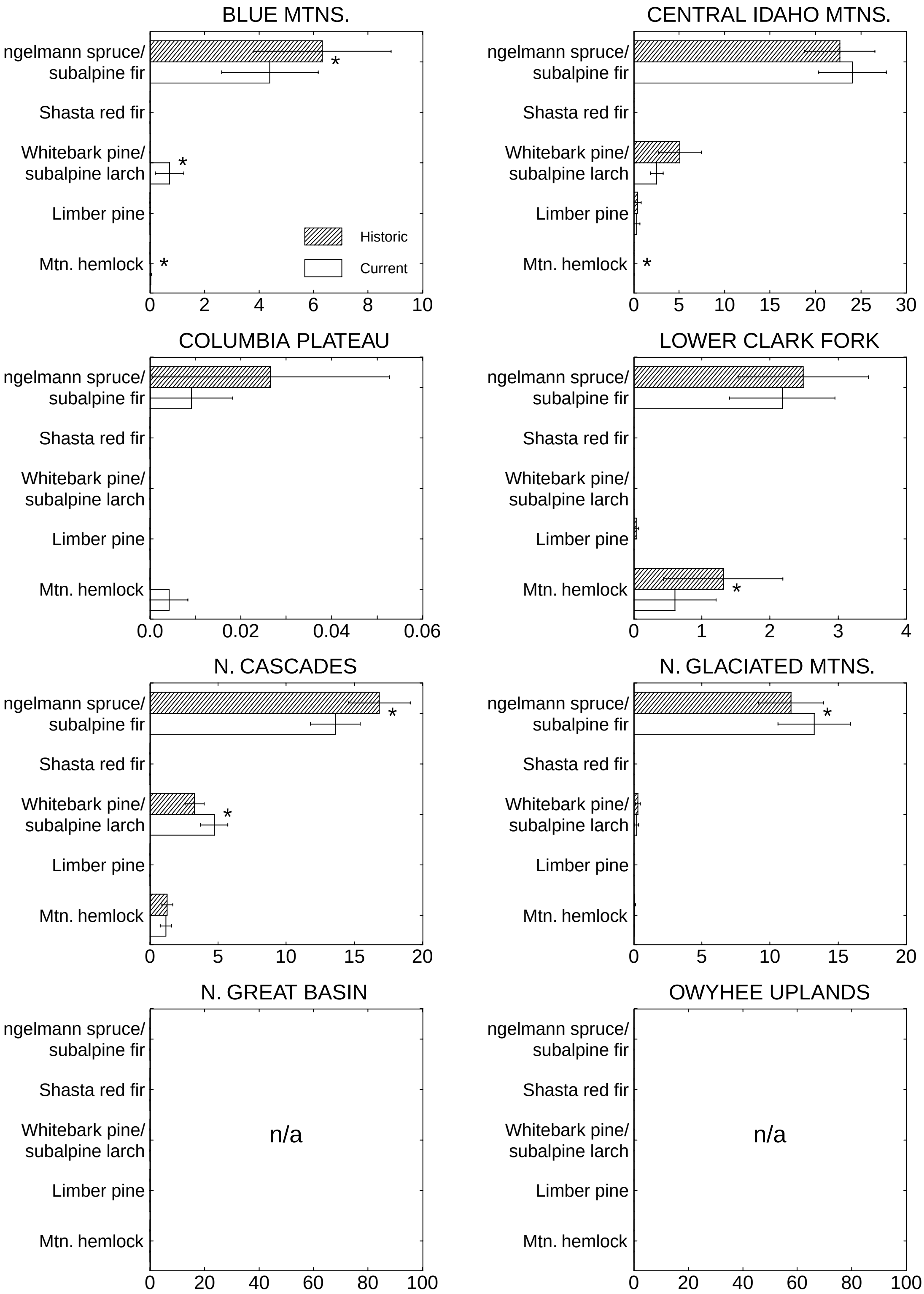


Figure 27—Historical and current distribution of forest cover types expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) difference between historical and current conditions.


BLUE MTNS.
ngelmann spruce/
subalpine fir
Shasta red fir
Whitebark pine/
subalpine larch
Limber pine
Mtn. hemlock
*
*
*
Historic
Current
0 2 4 6 8 10
CENTRAL IDAHO MTNS.
ngelmann spruce/
subalpine fir
Shasta red fir
Whitebark pine/
subalpine larch
Limber pine
Mtn. hemlock
*
0 5 10 15 20 25 30
COLUMBIA PLATEAU
ngelmann spruce/
subalpine fir
Shasta red fir
Whitebark pine/
subalpine larch
Limber pine
Mtn. hemlock
0.0 0.02 0.04 0.06
LOWER CLARK FORK
ngelmann spruce/
subalpine fir
Shasta red fir
Whitebark pine/
subalpine larch
Limber pine
Mtn. hemlock
*
0 1 2 3 4
N. CASCADES
ngelmann spruce/
subalpine fir
Shasta red fir
Whitebark pine/
subalpine larch
Limber pine
Mtn. hemlock
*
*
0 5 10 15 20
N. GLACIATED MTNS.
ngelmann spruce/
subalpine fir
Shasta red fir
Whitebark pine/
subalpine larch
Limber pine
Mtn. hemlock
*
0 5 10 15 20
N. GREAT BASIN
ngelmann spruce/
subalpine fir
Shasta red fir
Whitebark pine/
subalpine larch
Limber pine
Mtn. hemlock
n/a
0 20 40 60 80 100
OWYHEE UPLANDS
ngelmann spruce/
subalpine fir
Shasta red fir
Whitebark pine/
subalpine larch
Limber pine
Mtn. hemlock
n/a
0 20 40 60 80 100

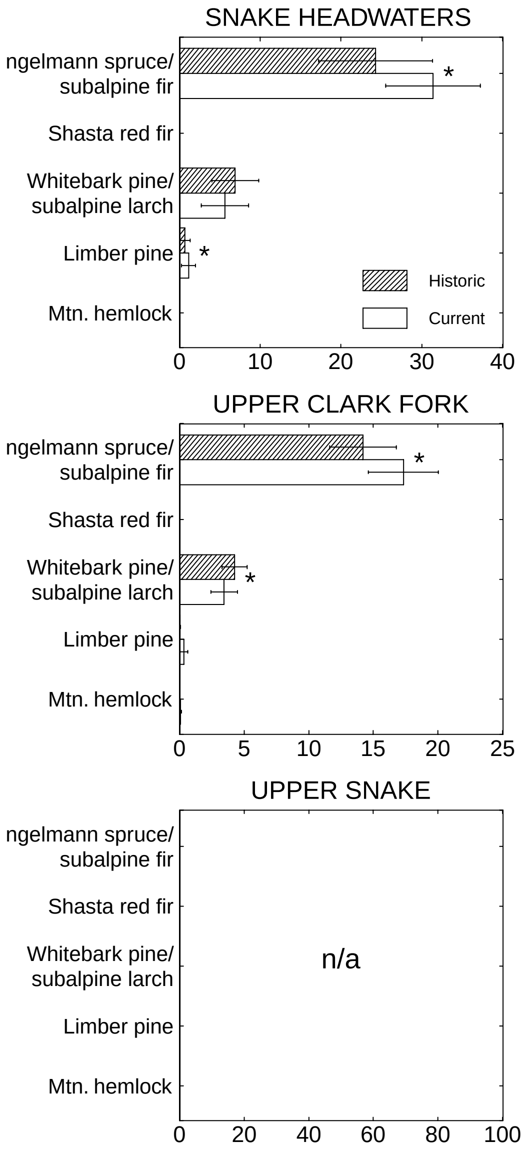


Figure 28—Historical and current distribution of forest cover types expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) difference between historical and current conditions.

Mean patch sizes declined from an average of 136.2 to 54.7 ha, and from 64.8 to 40 ha, respectively. Although there was no significant change in area of western larch, connectivity declined; patch density of the existing condition (7.8 patches per 10 000 ha) was nearly double that of the historical condition (3.8 patches).

In the Blue Mountains, the whitebark pine-subalpine larch cover type was minor among forest cover types. But in the last 40 to 50 years, area in this cover type increased by 0.7 percent from 0, and mean patch size increased by 15.9 ha from 0. Overall, connectivity of the whitebark pine-subalpine larch cover type increased. Total area occupied by the ponderosa pine cover type changed little in the last 40 to 50 years, but connectivity declined; patch density doubled over that period from 12.2 to 24 patches per 10 000 ha. Juniper increased in both area and connectivity; average area increased from 2.7 percent to 4.2 percent of the ERU, and mean patch size increased from 17.6 to 29.6 ha.

Shrubland—Colline low-medium shrub cover type decreased in area from an average of 7.2 to 4.7 percent of the area of the ERU, and connectivity declined dramatically; patch density increased from an average of 2 to 266.4 patches per 10 000 ha, and mean patch size declined from 116.9 to 2.7 ha (figs. 29 to 31 and appendix 2). Among shrubland cover types, change in area and connectivity of colline low-medium shrublands was most significant. Connectivity of montane low-medium shrub cover also decreased, with average patch size declining from 47.7 to 32.3 ha.

Herbland—Area in dry meadows declined significantly from 6.2 percent of the ERU area in the historical condition to 5.3 percent in the existing condition, and connectivity declined with increased patch density (figs. 29, 32, and 33 and appendix 2). Patch density of dry meadows increased from 11 to 14.6 patches per 10 000 ha. Although there was no significant increase in area of colline bunchgrasses, connectivity increased; patch density declined from an average 1.6 to 1.0 patch per 10 000 ha, and mean patch size increased from 83.7 to 146.7 ha. In contrast, connectivity of montane bunchgrasses declined; patch density increased from an average of 5.9 to 8.4 patches per 10 000 ha.

Area in colline exotic grasses and forbs increased from an average of 0.3 percent of the ERU area in the historical condition to 1.3 percent in the current condition. Connectivity of this cover type increased as well; average patch size increased from 6.3 ha to 34.4 ha during the sample period (i.e., during the period between our historical and current vegetation samples). Wet meadow area declined; percentage of area fell from 0.2 to 0 percent of the ERU, patch density declined from 0.5 to 0.1 patch per 10 000 ha, and mean patch size declined from 3.6 ha to an average of 0.2 ha. Finally, patch area comprised of seral grasses and forbs after logging entry (postlogging-grass-forbs) increased, and connectivity of area declined. Area increased from 0 to 0.1 percent, patch density increased from 0.1 to 5.6 patches per 10 000 ha, and mean patch size declined from an average of 1.8 to 0.1 ha.

Nonforest-nonrange and other anthropogenic cover types—Cropland area declined significantly during the sample period from an average of 2.3 to 1.8 percent of the area; connectivity of cropland area also declined (figs. 34 and 35 and appendix 2). Connectivity of pasture lands increased, with patch density declining from 1.0 to 0.7 patch per 10 000 ha. Area and connectivity of patches of bare ground burned after logging (postlogging-bare ground-burned) also increased. Area increased 0.6 percent from 0, patch density rose from 0 to 0.7 patch per 10 000 ha, and mean patch size increased from an average of 5.3 to 10.5 ha.

Structural classes—

Forest—Much change was evident in the pattern and distribution of forest structural classes; all but one structural class changed significantly in area (fig. 36 and appendix 2). Area in stand initiation and young multistory structures increased, and area in stem-exclusion open canopy, understory reinitiation, old multistory, and old single-story forest structures declined. Nearly all changes in connectivity of forest structures were significant reductions, with the exception of stand-initiation structures. Patch density of stand-initiation structures increased from an average of 10.2 to 17.9 patches per 10 000 ha. Percentage of area in stand-initiation structures increased from 3.9 to 6.5 percent of the ERU area during the sample period. Area of stem-exclusion open canopy structures declined from 14.3 to 9.6 percent of the ERU area. Patch density and mean patch size also declined significantly, from 29.6 to 25.7 patches per 10 000 ha, and from 51.5 to 41.5 ha, respectively. Area in understory reinitiation structures declined from an average of 13.6 percent of the ERU area in the historical condition to 11.2 percent. Area in young multistory structures increased from an average 21.3 to 29.6 percent. This increase likely ws associated with historical selective harvest and removal cutting of medium and large overstory trees of early seral species such as ponderosa pine and Douglas-fir.

One of the most significant changes to forest structure in the Blue Mountains was that occurring in old forests. Area in old multistory structures declined from an average of 2.2 to 1.0 percent of the ERU area. Area in old single-story structures declined by nearly 63 percent, from 2.7 to 0.9 percent. In the historical vegetation map, about 8 percent of Blue Mountains forests were comprised of old multistory and old single-story structures. Currently, 3 percent of the forest area is comprised of old forest, a 64-percent reduction in area.

Woodland—Area and connectivity of woodland stem-exclusion structures increased. Percentage of area increased from 2.4 to 4.0 percent of the ERU area; patch density increased from an average of 4.8 to 6.0 patches per 10 000 ha, and mean patch size increased from 14.9 to 28.6 ha (fig. 37 and appendix 2). Understory reinitiation structures exhibited reduced connectivity; patch density declined from an average of 1.3 to 0.5 patch per 10 000 ha, and mean patch size declined from 9.7 to 4.6 ha.

Shrubland—The most significant change occurring in shrubland structures was that exhibited by open low-medium shrub structures (fig. 38 and appendix 2). Area in this shrubland structure declined from an average of 11 to 8.3 percent of the area of the ERU. Connectivity of open low-medium shrubs also declined; mean patch size declined from an average of 96.6 to 61.0 ha. Connectivity of closed low-medium shrub and closed tall shrub structures also declined; mean patch size of sampled subwatersheds declined from an average of 19.8 to 12.1 ha and from 4.5 to 2.1 ha, respectively.

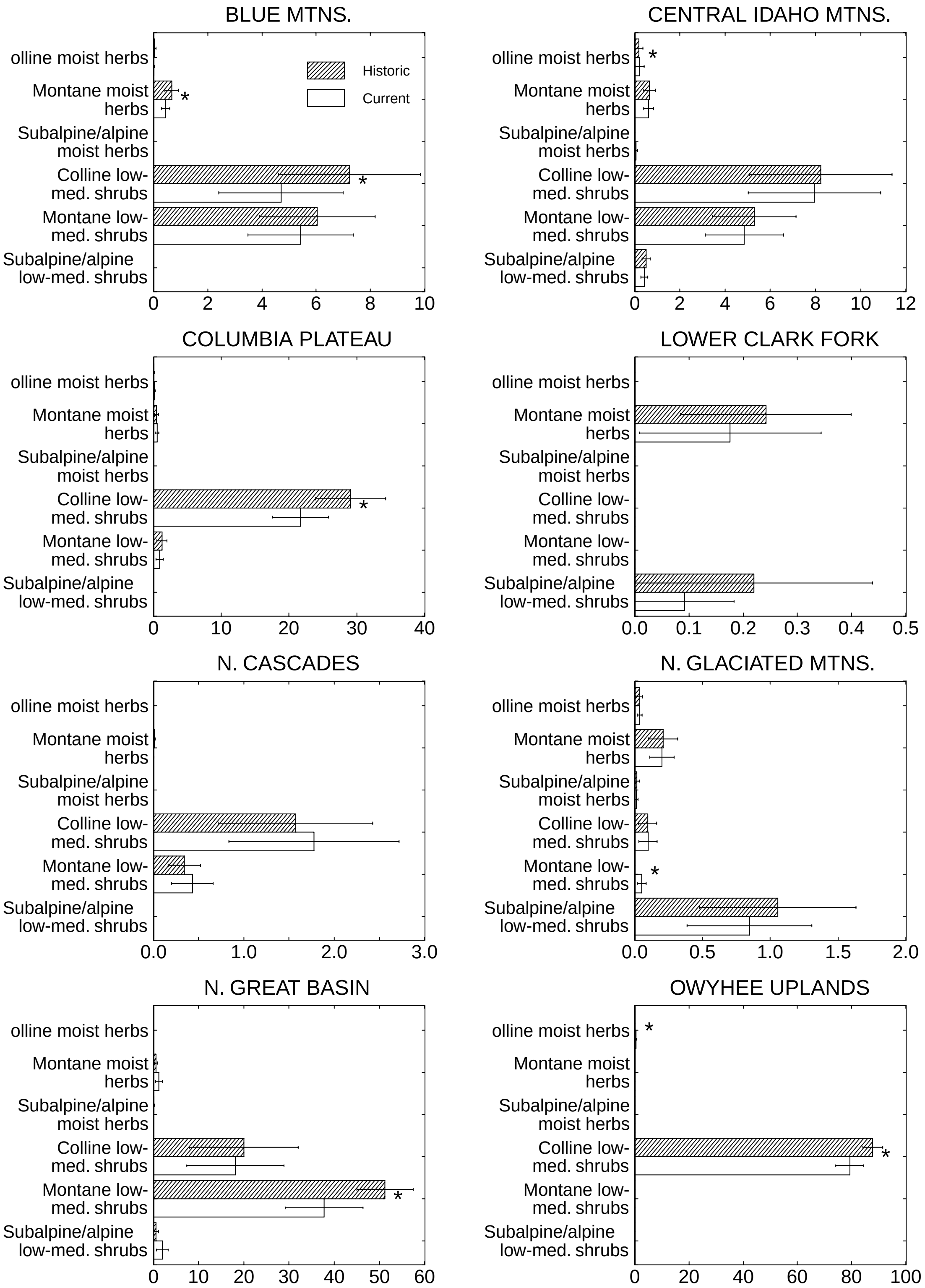
Herbland—Significant change also occurred in herbland structures: open herbland area increased from an average of 6.4 to 8.5 percent, and closed herbland area declined from an average of 3.2 to 2.5 percent of the ERU area (fig. 38 and appendix 2). Connectivity of open herblands increased with significantly increased patch density and mean patch size; patch density increased from an average of 7.6 to 9.8 patches per 10 000 ha, and mean patch size increased from 40.8 to 67.3 ha.

Nonforest-nonrange and other types—Area in nonforest-nonrange and other anthropogenic types declined from 11.1 to 10.0 percent, and patch density increased from 17.2 to 21.1 patches per 10 000 ha, indicating an overall decline in connectivity of these types (fig. 38 and appendix 2).

Central Idaho Mountains ERU—Subbasins sampled within the Central Idaho Mountains ERU (figs. 11, 14, 17, 18, and 22) included the Boise-Mores (BOM), Big Wood (BWD), Lemhi (LMH), Lochsa (LOC), Medicine Lodge (MDL), South Fork Clearwater (SFC), South Fork Salmon (SFS), and Upper Middle Fork Salmon (UMS). Among these subbasins, 43 historical and current subwatershed pairs were sampled.

Physiognomic types—Area in the forest physiognomic type remained constant over the sample period but connectivity of forests was enhanced; mean patch size increased from an average of 2,983.7 to 3,457.6 ha, a 16-percent average increase in size over historical conditions (fig. 25 and appendix 2). The most significant change in area of any physiognomic type occurred in shrubland, where shrubland area declined from an average of 19.2 to 17.1 percent of the ERU area, an 11-percent loss of historical shrublands. Shrubland losses occurred in both forest and range environments. Loss of early seral shrub structures in forest settings likely was the result of fire suppression. Change in shrubland connectivity was insignificant at $P \leq 0.2$, but mean patch size declined from an average of 218.6 to 158.3 ha, which suggests more fragmented conditions. Herbland area increased from an average of 3.2 to 4.5 percent of the ERU area, but connectivity of herblands declined. Patch density increased from an average of 9.0 to 13.7 patches per 10 000 ha. Average area in nonforest-nonrange and other anthropogenic types also increased from 4.2 to 4.9 percent of the ERU area.

Text continues on page 106


BLUE MTNS.
CENTRAL IDAHO MTNS.
COLUMBIA PLATEAU
LOWER CLARK FORK
N. CASCADES
N. GLACIATED MTNS.
N. GREAT BASIN
OWYHEE UPLANDS
Historic
Current
olline moist herbs
Montane moist herbs
Subalpine/alpine moist herbs
Colline low-med. shrubs
Montane low-med. shrubs
Subalpine/alpine low-med. shrubs
*

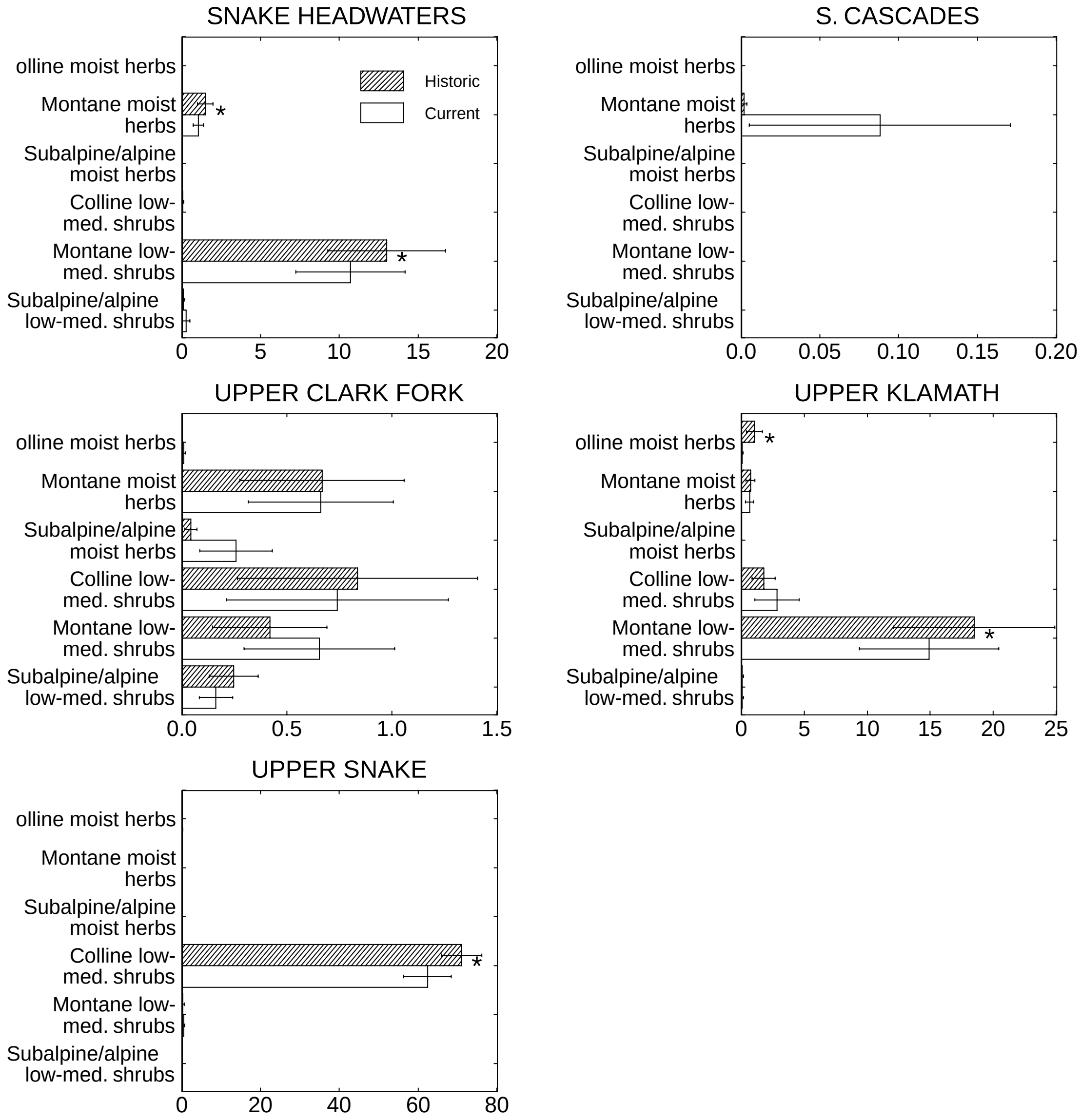
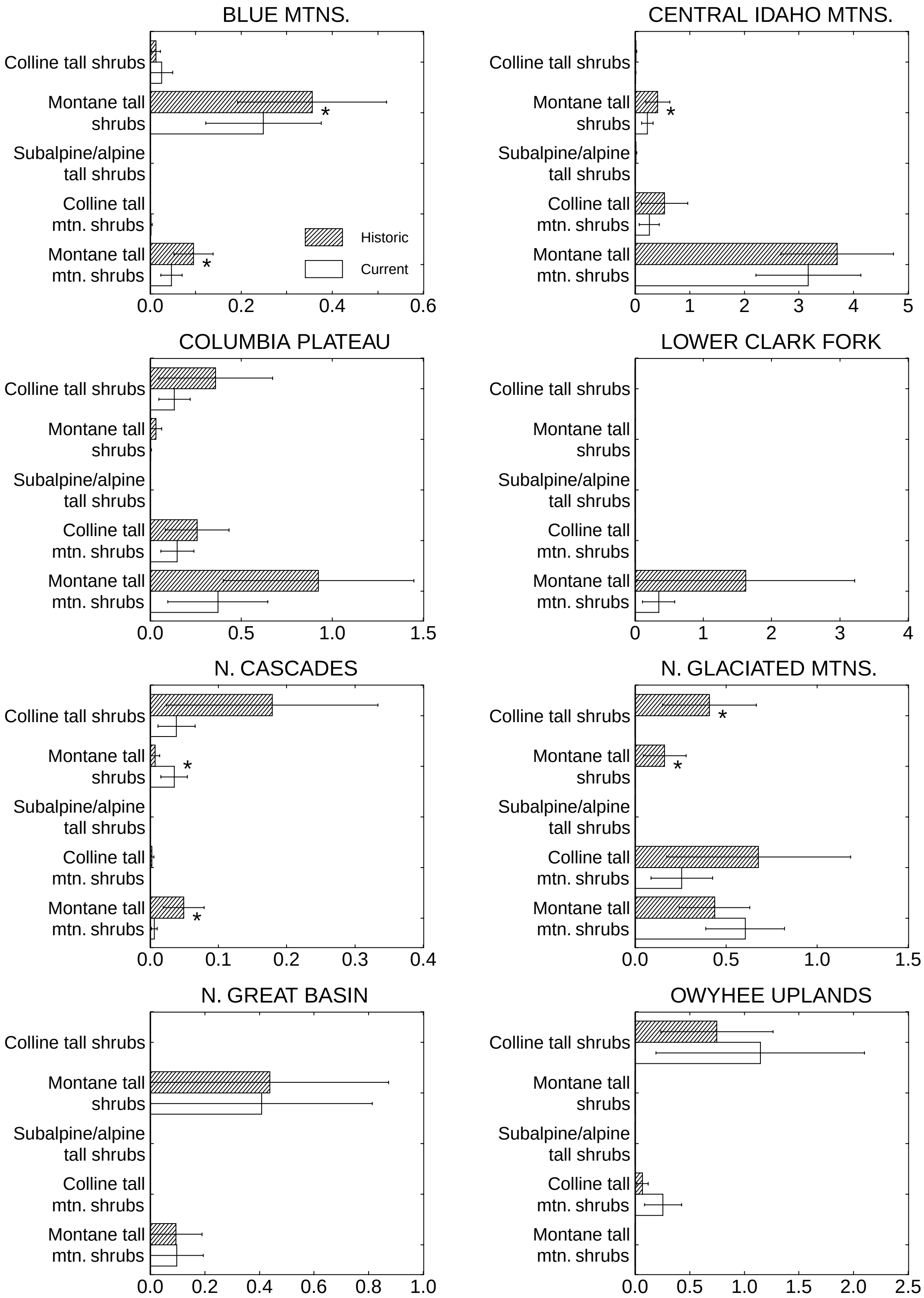


Figure 29—Historical and current distribution of herbland and shrubland cover types expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) difference between historical and current conditions.


BLUE MTNS.
CENTRAL IDAHO MTNS.
COLUMBIA PLATEAU
LOWER CLARK FORK
N. CASCADES
N. GLACIATED MTNS.
N. GREAT BASIN
OWYHEE UPLANDS
Colline tall shrubs
Montane tall shrubs
Subalpine/alpine tall shrubs
Colline tall mtn. shrubs
Montane tall mtn. shrubs
Historic
Current
*

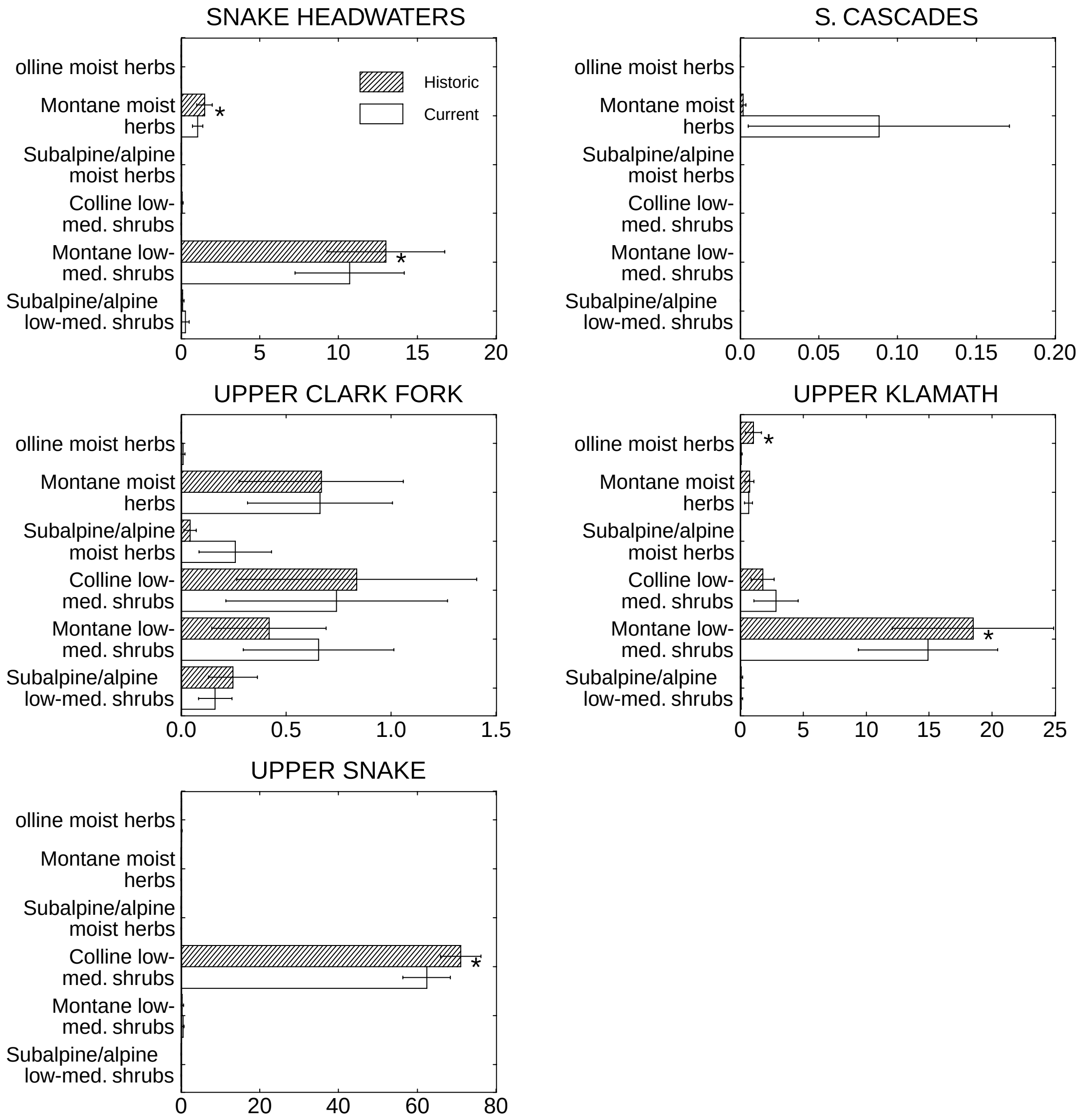
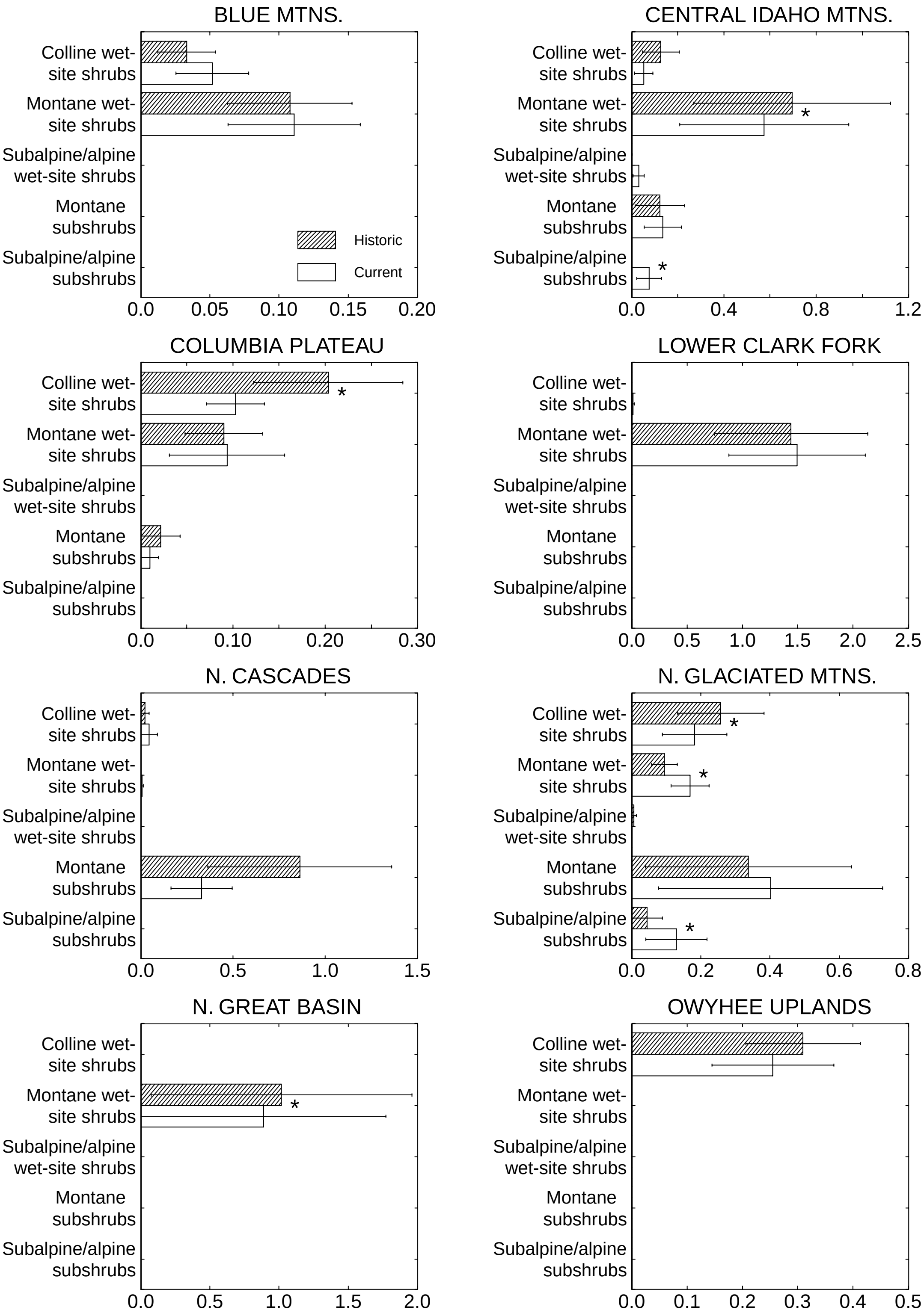


Figure 30—Historical and current distribution of herbland and shrubland cover types expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) difference between historical and current conditions.


BLUE MTNS.
CENTRAL IDAHO MTNS.
COLUMBIA PLATEAU
LOWER CLARK FORK
N. CASCADES
N. GLACIATED MTNS.
N. GREAT BASIN
OWYHEE UPLANDS
Colline wet-site shrubs
Montane wet-site shrubs
Subalpine/alpine wet-site shrubs
Montane subshrubs
Subalpine/alpine subshrubs
Historic
Current
0.0 0.05 0.10 0.15 0.20
0.0 0.4 0.8 1.2
0.0 0.10 0.20 0.30
0.0 0.5 1.0 1.5 2.0 2.5
0.0 0.5 1.0 1.5
0.0 0.2 0.4 0.6 0.8
0.0 0.5 1.0 1.5 2.0
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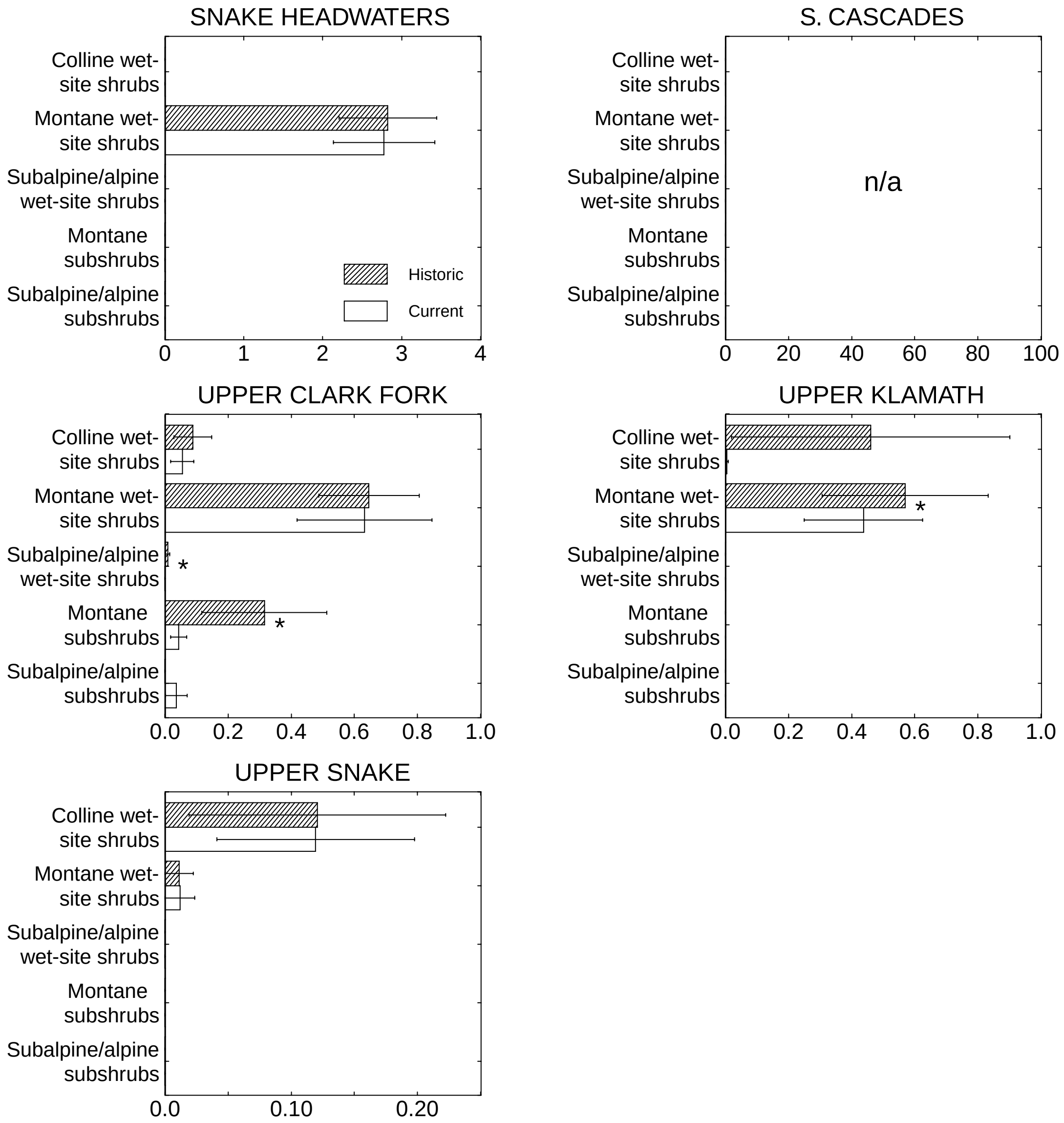
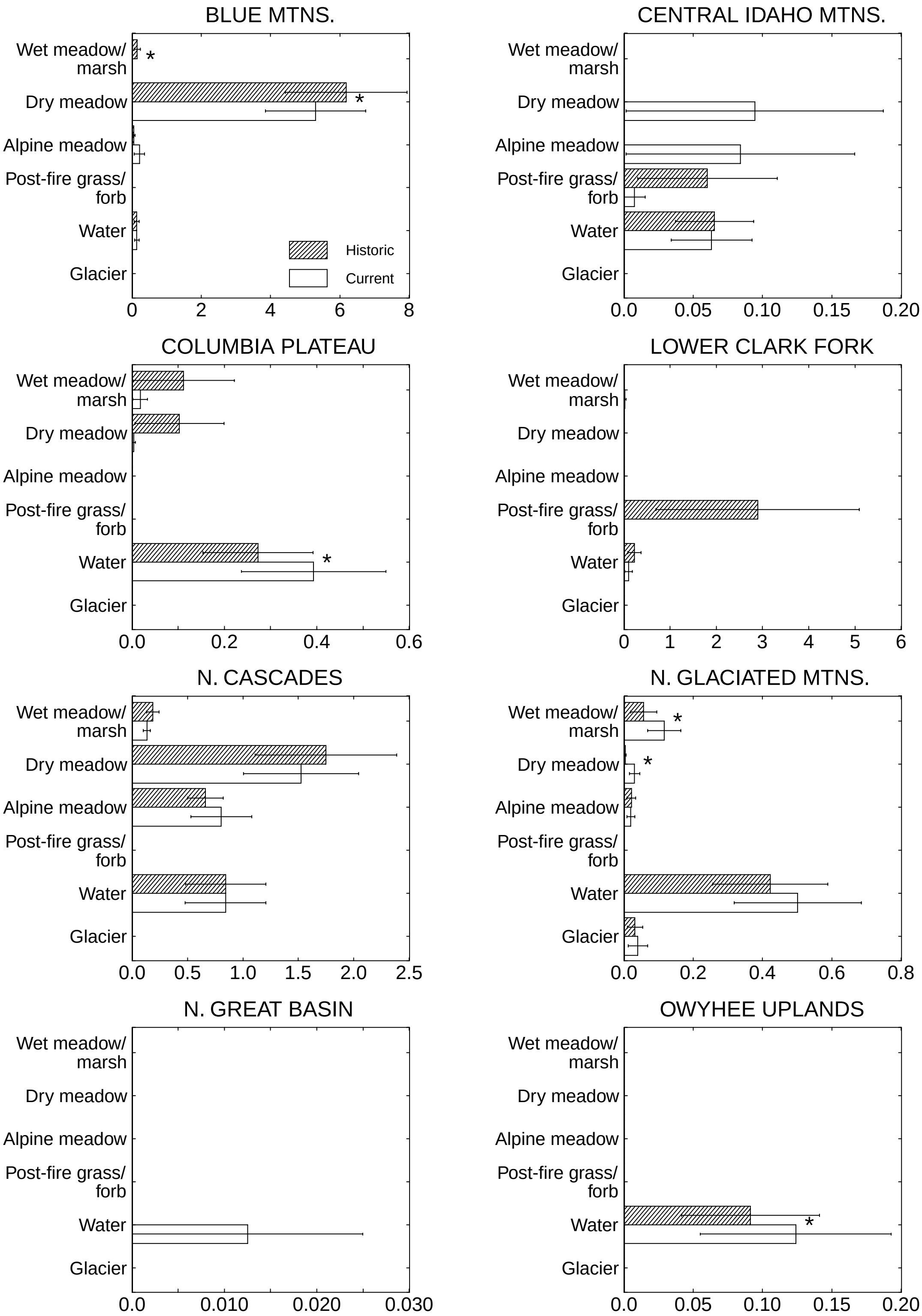


Figure 31—Historical and current distribution of shrubland cover types expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) difference between historical and current conditions.


BLUE MTNS.
CENTRAL IDAHO MTNS.
COLUMBIA PLATEAU
LOWER CLARK FORK
N. CASCADES
N. GLACIATED MTNS.
N. GREAT BASIN
OWYHEE UPLANDS
Wet meadow/ marsh
Dry meadow
Alpine meadow
Post-fire grass/ forb
Water
Glacier
Historic
Current
*

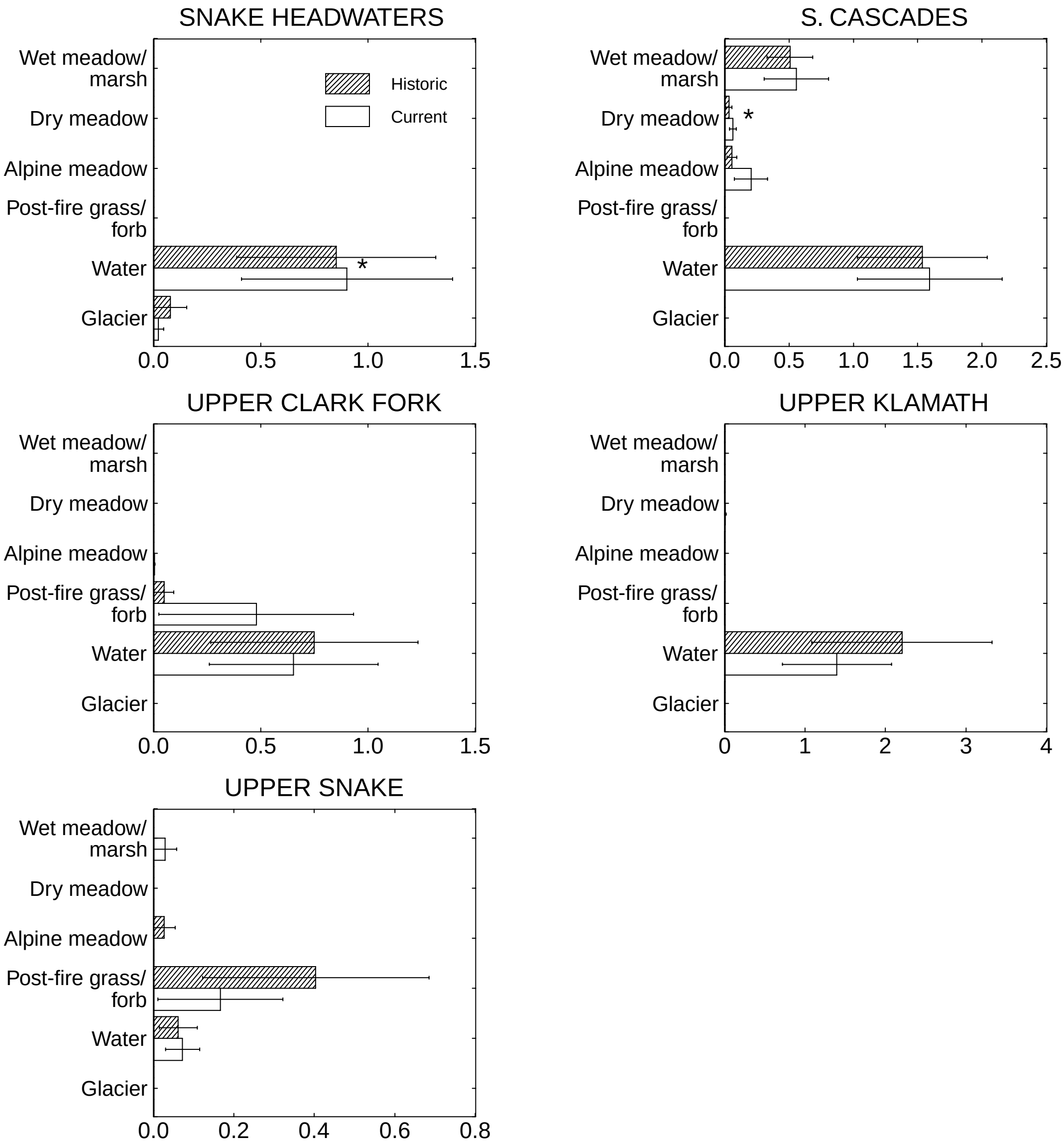
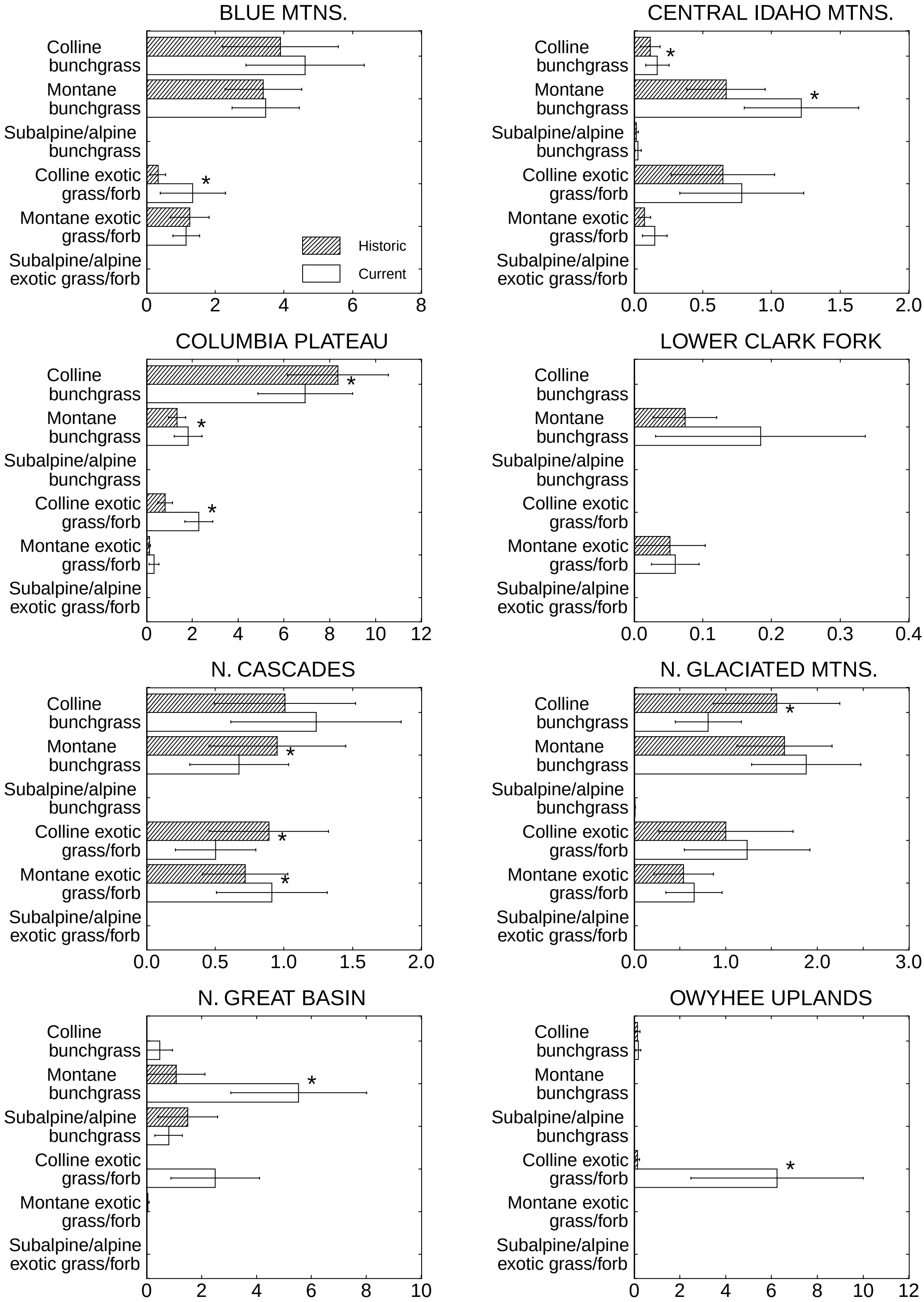


Figure 32—Historical and current distribution of herbland and nonforest-nonrange cover types expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) difference between historical and current conditions.


BLUE MTNS.
CENTRAL IDAHO MTNS.
COLUMBIA PLATEAU
LOWER CLARK FORK
N. CASCADES
N. GLACIATED MTNS.
N. GREAT BASIN
OWYHEE UPLANDS
Colline bunchgrass
Montane bunchgrass
Subalpine/alpine bunchgrass
Colline exotic grass/forb
Montane exotic grass/forb
Subalpine/alpine exotic grass/forb
Historic
Current

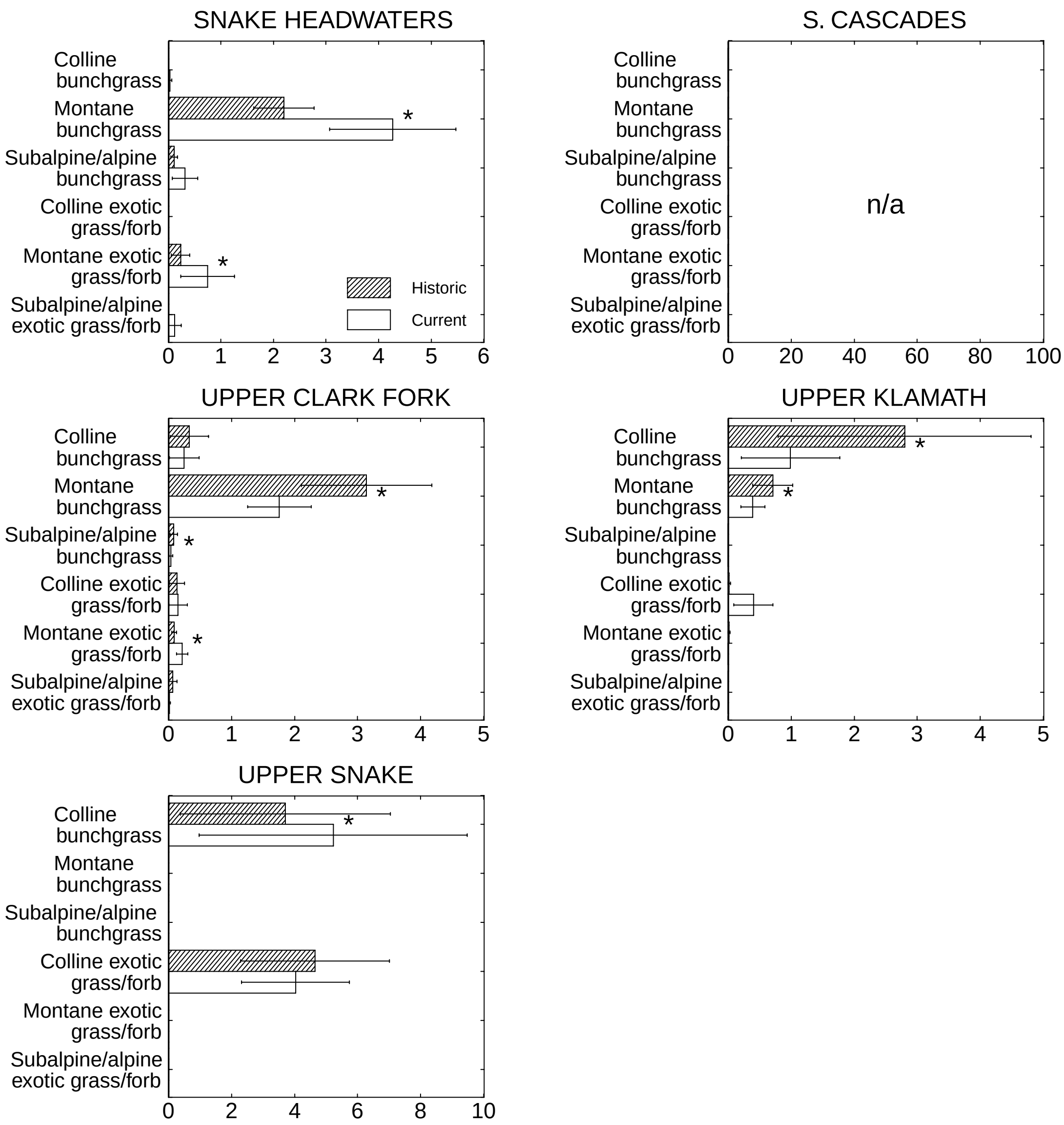
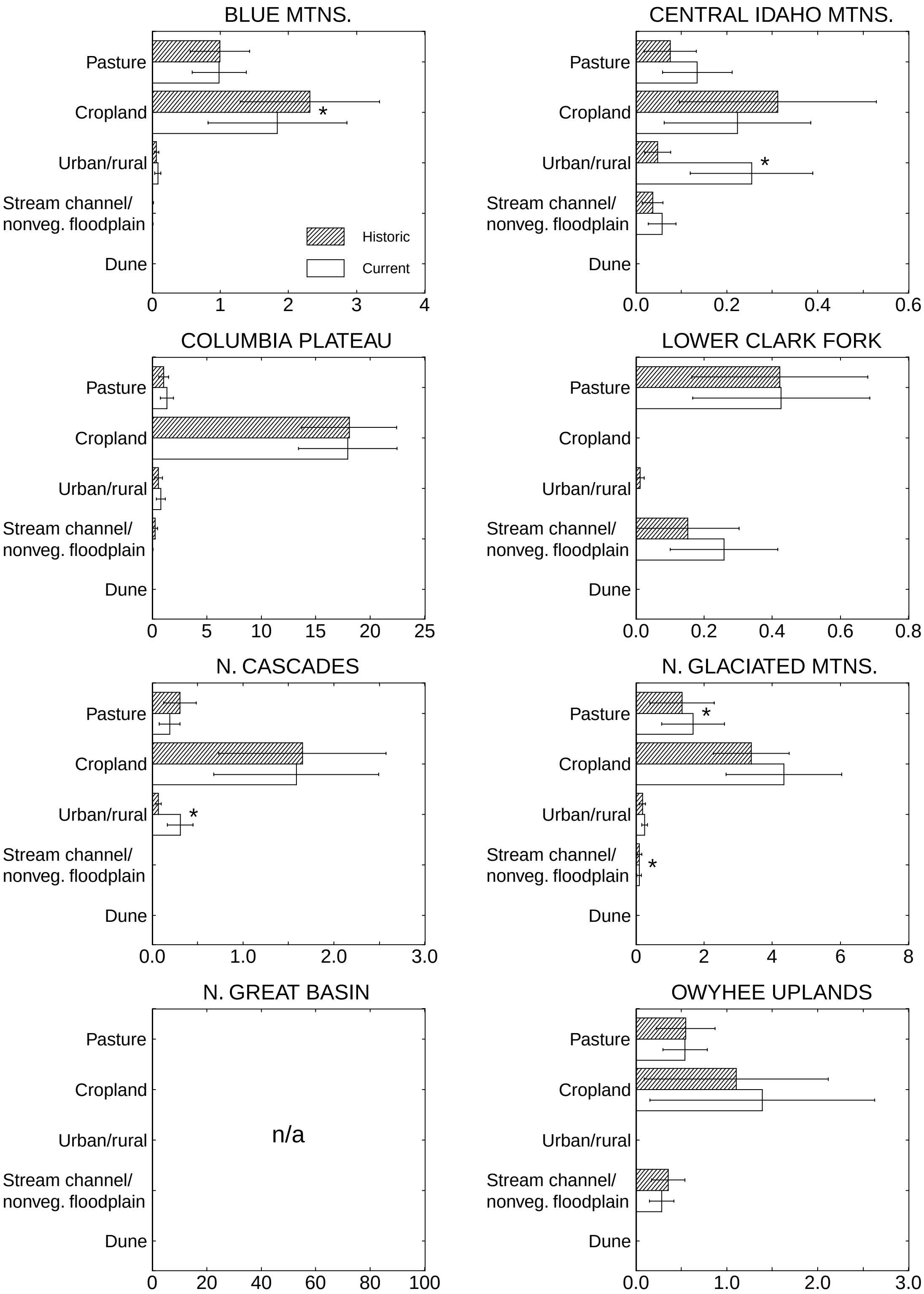


Figure 33—Historical and current distribution of herbland cover types expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) difference between historical and current conditions.



BLUE MTNS.
CENTRAL IDAHO MTNS.
COLUMBIA PLATEAU
LOWER CLARK FORK
N. CASCADES
N. GLACIATED MTNS.
N. GREAT BASIN
OWYHEE UPLANDS
Pasture
Cropland
Urban/rural
Stream channel/
nonveg. floodplain
Dune
Historic
Current
n/a

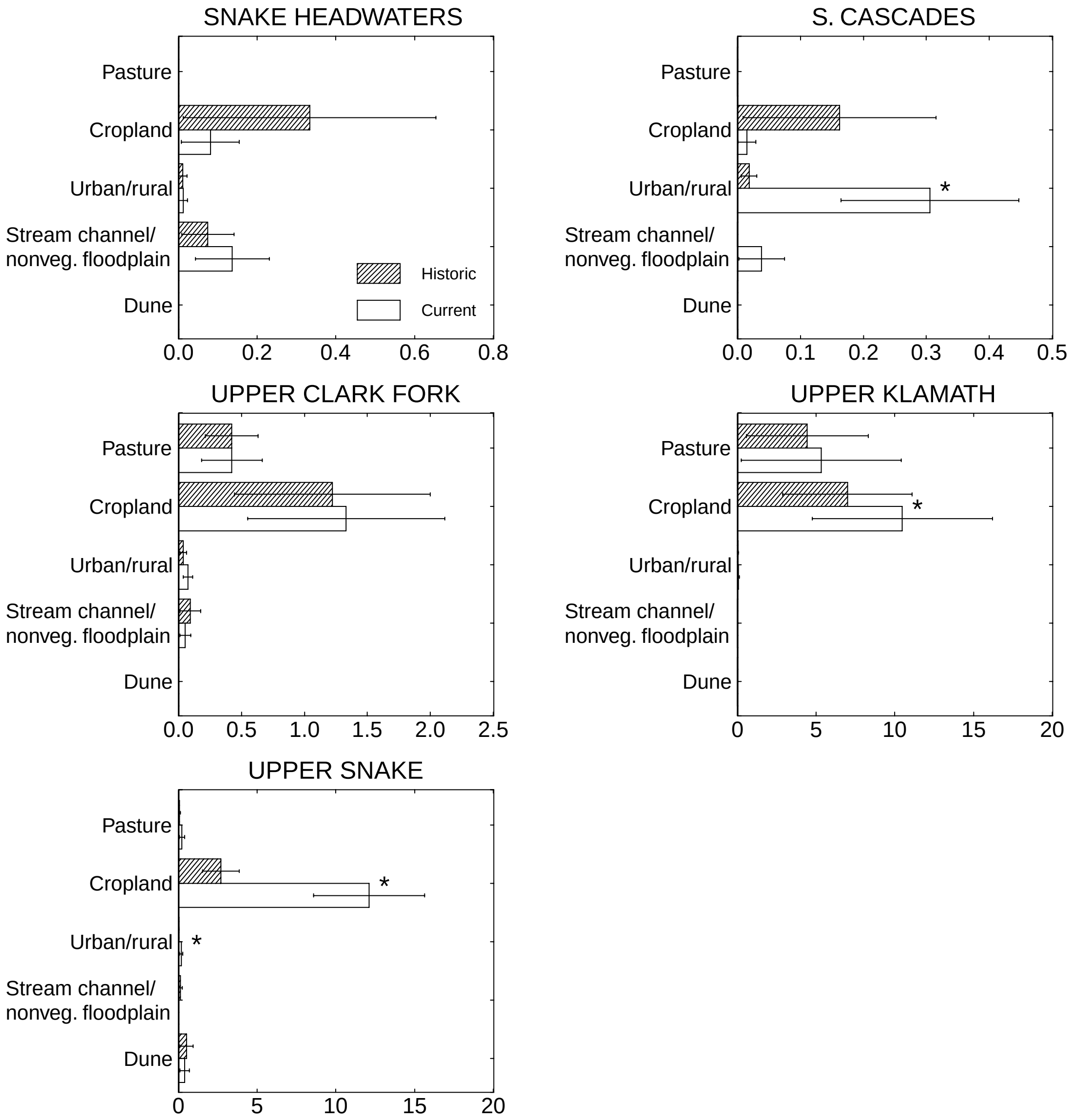
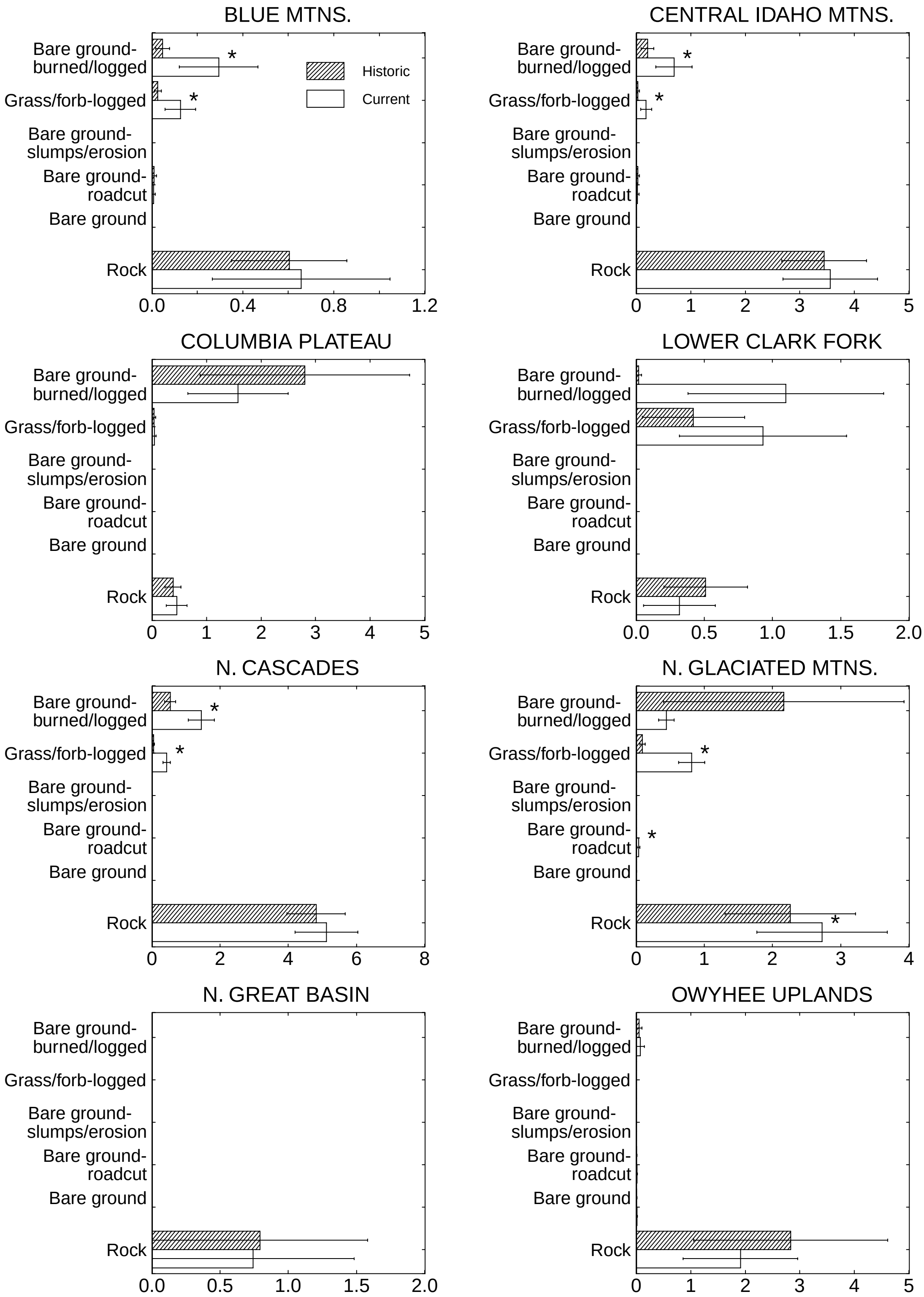


Figure 34—Historical and current distribution of anthropogenic and other nonforest-nonrange cover types expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) difference between historical and current conditions.


BLUE MTNS.
CENTRAL IDAHO MTNS.
COLUMBIA PLATEAU
LOWER CLARK FORK
N. CASCADES
N. GLACIATED MTNS.
N. GREAT BASIN
OWYHEE UPLANDS
Historic
Current
Bare ground-burned/logged
Grass/forb-logged
Bare ground-slumps/erosion
Bare ground-roadcut
Bare ground
Rock

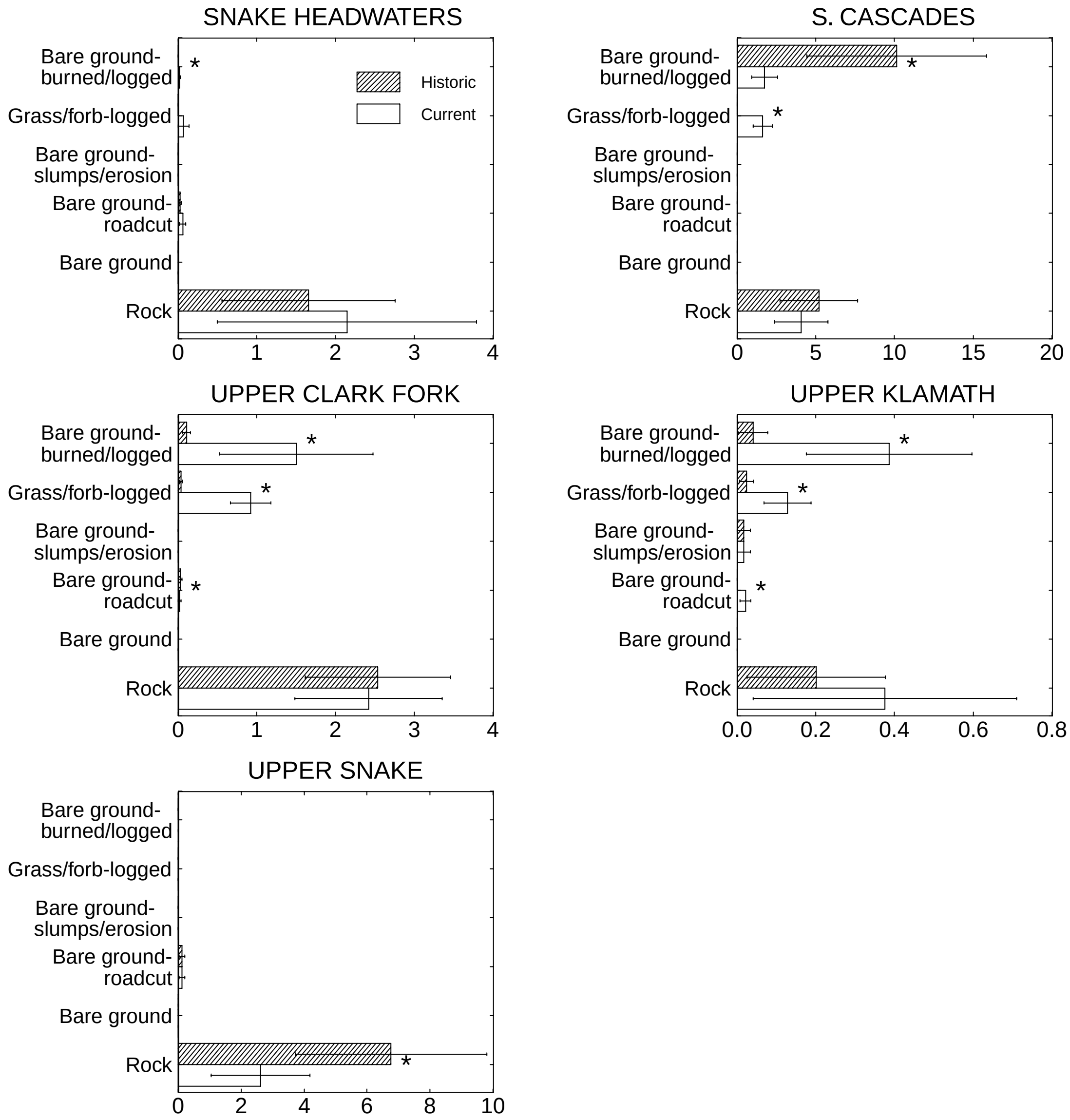
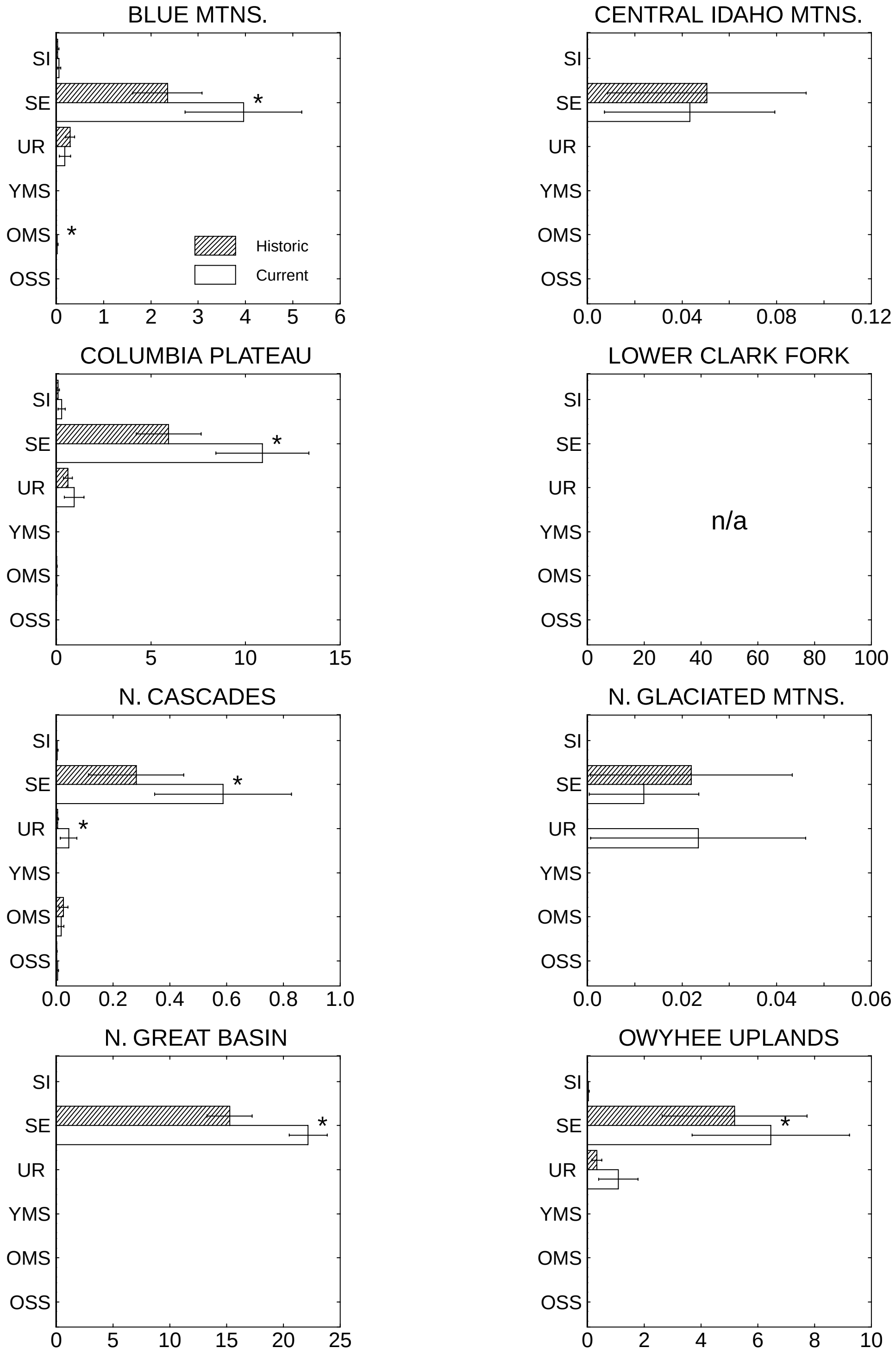


Figure 35—Historical and current distribution of anthropogenic and other nonforest-nonrange cover types expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) difference between historical and current conditions.


BLUE MTNS.
CENTRAL IDAHO MTNS.
COLUMBIA PLATEAU
LOWER CLARK FORK
N. CASCADES
N. GLACIATED MTNS.
N. GREAT BASIN
OWYHEE UPLANDS
SI
SE
UR
YMS
OMS
OSS
Historic
Current
n/a
*

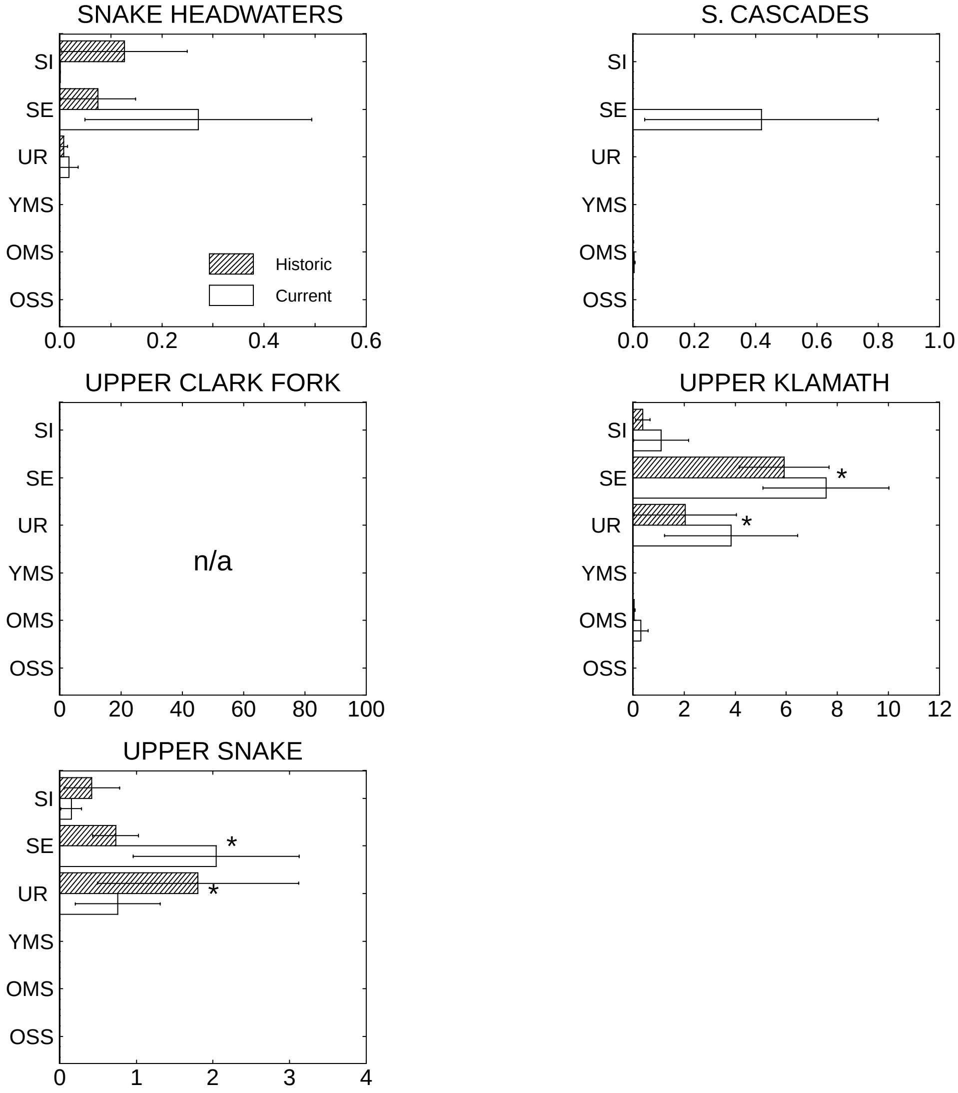
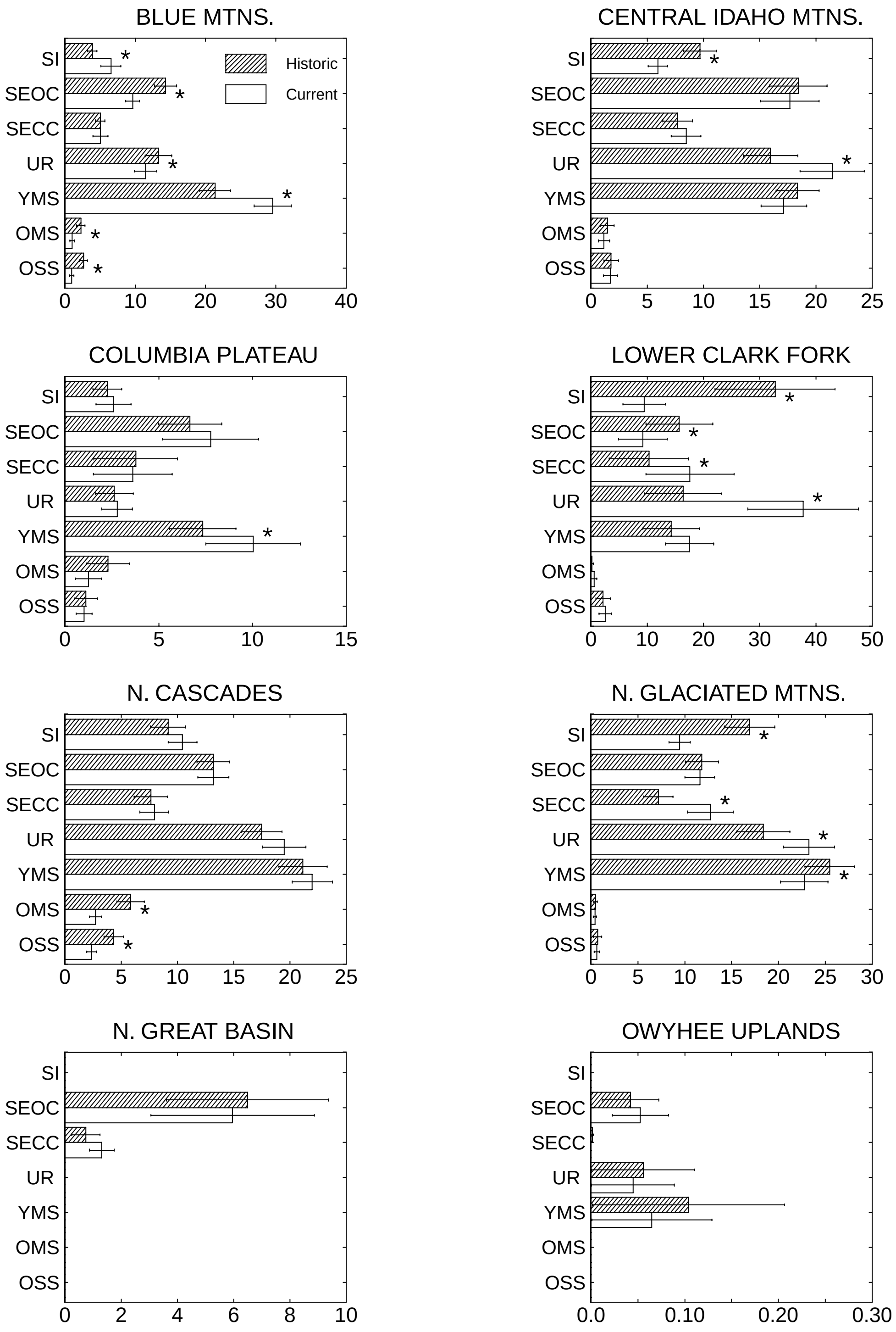


Figure 36—Historical and current distribution of forest structural classes expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) difference between historical and current conditions. Structural class codes are SI = stand initiation; SEOC = stem exclusion, open canopy; SECC = stem exclusion, closed canopy; UR = understory reinitiation; YMS = young multistory; OMS = old multistory; and OSS = old single story.


BLUE MTNS.
CENTRAL IDAHO MTNS.
COLUMBIA PLATEAU
LOWER CLARK FORK
N. CASCADES
N. GLACIATED MTNS.
N. GREAT BASIN
OWYHEE UPLANDS
Historic
Current
SI
SEOC
SECC
UR
YMS
OMS
OSS

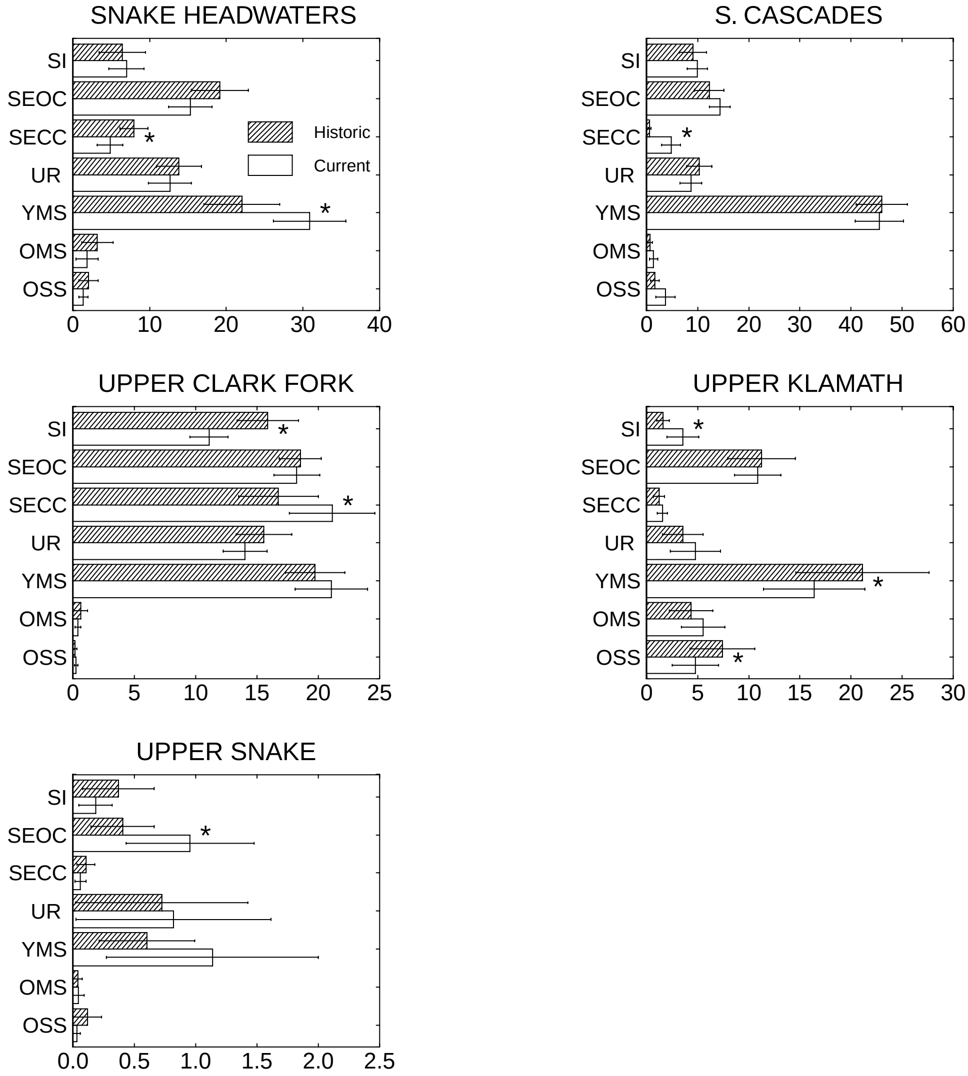
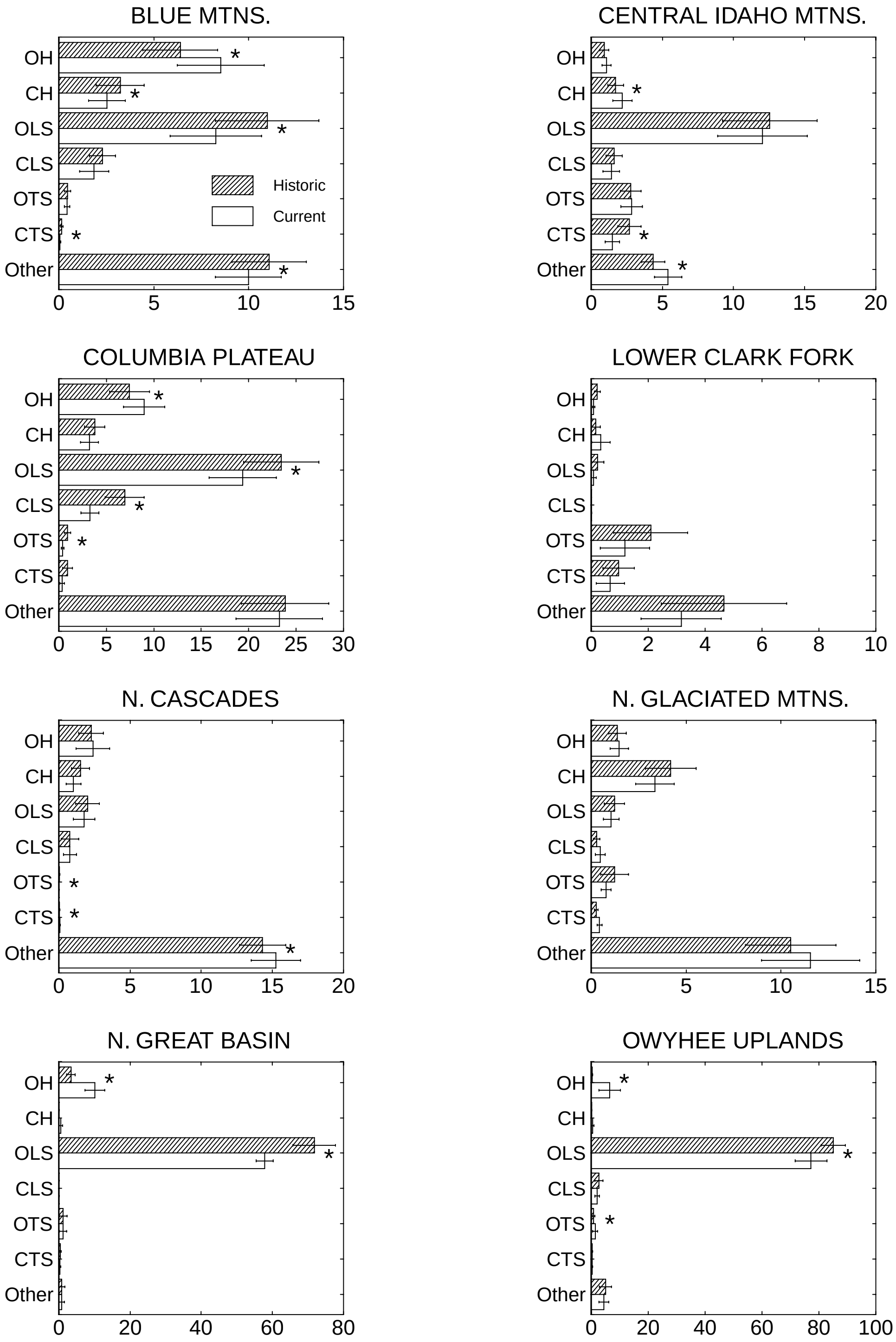


Figure 37—Historical and current distribution of woodland structural classes expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) difference between historical and current conditions. Structural class codes are SI = stand initiation; SE = stem exclusion; UR = understory reinitiation; YMS = young multistory; OMS = old multistory; and OSS = old single story.


BLUE MTNS.
CENTRAL IDAHO MTNS.
COLUMBIA PLATEAU
LOWER CLARK FORK
N. CASCADES
N. GLACIATED MTNS.
N. GREAT BASIN
OWYHEE UPLANDS
OH
CH
OLS
CLS
OTS
CTS
Other
Historic
Current

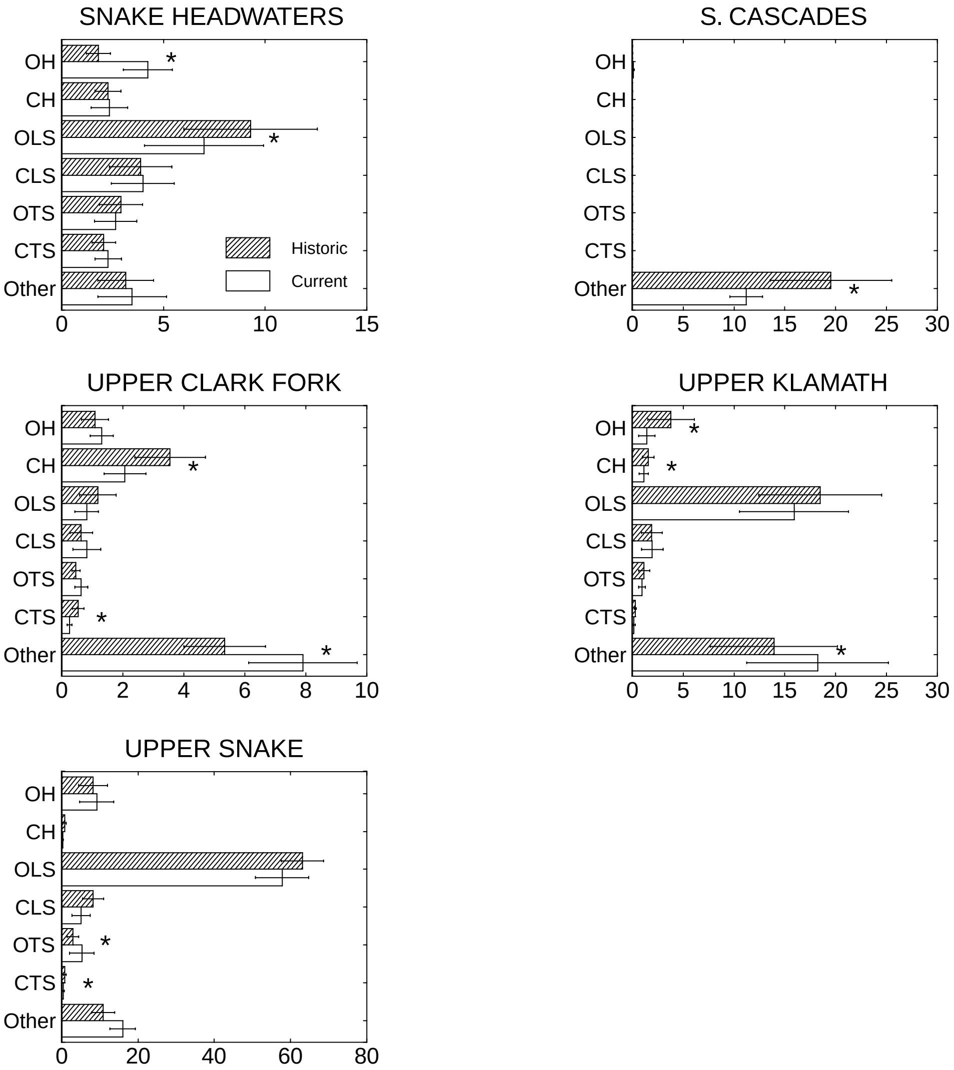


Figure 38—Historical and current distribution of herbland, shrubland, and other structural classes expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant ($P \leq 0.2$) difference between historical and current conditions. Structural class codes are OH = open herb; CH = closed herb; OLS = open low-medium shrub; CLS = closed low-medium shrub; OTS = open tall shrub; CTS = closed tall shrub; and Other = nonforest-nonrange and anthropogenic type structures.

Cover types—

Forest—The Central Idaho Mountains ERU exhibited relatively minimal change in forest cover types (figs. 26 to 28 and appendix 2). Only western larch and whitebark pine-subalpine larch cover types declined in area. For the latter, percentage of area decreased from an average of 5.1 to 2.5 percent of the ERU area. This change was not statistically significant at $P \leq 0.2$, but we found it ecologically significant when we considered transition analyses and median 75-percent range information. Average patch size for the cover type also declined from 170.8 to 18.3 ha. The noted loss of whitebark pine-subalpine larch cover amounted to a 51-percent reduction from historical levels. Area of western larch cover also declined from an average of 0.5 to 0.3 percent. Douglas-fir area and connectivity of area increased but change in area was not significant. Connectivity of Douglas-fir cover increased with increased patch density; patch density increased from an average of 16.0 to 19.2 patches per 10 000 ha. Connectivity of lodgepole pine, ponderosa pine, aspen-cottonwood-willow, and western hemlock-western redcedar cover types declined.

Shrubland—There were few significant changes in area, and nearly all changes in shrubland cover types were losses (figs. 29 to 31 and appendix 2). Colline low-medium shrub types exhibited dramatically reduced connectivity; patch density increased from an average of 1.3 to 571.5 patches per 10 000 ha, and mean patch size declined from an average of 186.4 to 5.7 ha. This change in connectivity of colline low-medium shrub types was the most significant occurring in shrubland cover types. Area and connectivity of montane mahogany species declined. Percentage of area fell from an average of 0.4 to 0.2 percent, and patch density declined from an average of 1.3 to 0.5 patch per 10 000 ha. Montane tall and colline wet-site shrub types exhibited reduced connectivity as well; mean patch sizes declined from 35.4 to 17.7 and from 3.9 to 1.7 patches per 10 000 ha, respectively. Average area in the subalpine-alpine subshrub cover type, although a minor type, increased significantly, and connectivity also increased. Transition analysis revealed that noted increases in the subalpine-alpine subshrub and subalpine fir-Engelmann spruce cover types partially compensated for losses observed in the whitebark pine-subalpine larch cover type.

Herbland—Three significant increases in area were apparent in central Idaho herblands: average area in colline and montane bunchgrasses increased during the sample period from 0.1 to 0.2 percent, and from 0.7 to 1.2 percent of the ERU area, respectively, and area in postlogging grasses and forbs increased from 0 to 0.2 percent of the ERU area (figs. 29, 32, and 33 and appendix 2). Connectivity of montane bunchgrasses increased with mean patch size increasing from 6.4 to 11.0 ha. Connectivity of postlogging-grasses and forbs declined with declining mean patch size. Increase in area of montane exotic grass and forbs cover was not significant, but increased connectivity of this cover type was significant; patch density increased from an average of 0.5 to 1.1 patches per 10 000 ha. Connectivity of postfire-grasses and forbs declined likely as a result of fire exclusion in forest settings; mean patch size declined from 1.7 to 0.8 ha during the sample period.

Nonforest-nonrange and other anthropogenic cover types—Area in urban and rural developments increased from an average of 0 to 0.3 percent of the ERU area (figs. 34 and 35 and appendix 2). Connectivity of this type also increased; patch density increased from an average of 0.2 to 0.4 patch per 10 000 ha, and mean patch size increased from 1.8 to 7.7 ha. Connectivity of pasture lands also increased, with average patch size increasing from 1.5 to 3.4 ha. Area of postlogging-bare ground-burned cover types increased from an average of 0.2 to 0.7 percent of the ERU area. Connectivity of this type also increased with patch density, rising from 0.7 to 2.7 patches per 10 000 ha.

Structural classes—

Forest—The most significant changes among forest structures were those occurring to stand-initiation and understory reinitiation structures (fig. 36 and appendix 2). Area in stand-initiation structures declined from a 9.7-percent historical level to 5.9 percent in the existing condition. Less than three-quarters of the Central Idaho Mountains ERU was historically or is currently comprised of forest. Of that forested area, 13.2 percent was historically comprised of stand-initiation structures. Currently, 8 percent of the forested area is comprised of stand-initiation structures, nearly a 40-percent reduction. This dramatic change is likely attributable to the exclusion of stand-replacing fires associated with mixed severity and lethal fire regimes. Connectivity of area in stand-initiation structures also declined. In the historical condition, average mean patch size of stand-initiation structures was 61.1 ha. In the current condition, mean patch size was 30.5 ha, which represents a 50-percent reduction.

In contrast, area in understory reinitiation structures increased from an average of 16 to 21.4 percent. Connectivity of understory reinitiation structures increased, with patch sizes increasing from 102.1 to 151.7 ha. Connectivity of young and old multistory structures declined significantly; mean patch size of young multistory structures decreased from 75.1 to 62 ha, patch density of old multistory structures increased from 1.8 to 2.7 patches per 10 000 ha, and mean patch size declined from 32.6 to 9.3 ha.

Woodland—No significant changes in area or connectivity of woodland structures were evident at this reporting scale (fig. 37 and appendix 2). Total woodland area was 0.1 percent of the total ERU area in the historical condition, and 0 percent in the current condition.

Shrubland—Among shrubland structures few changes were significant. Only area of closed tall shrub structures declined, with percentage of area declining from 2.7 to 1.5 percent, a 44-percent reduction over the sample period (fig. 38 and appendix 2). Connectivity of open low-medium and closed tall shrub structures declined.

Herbland—Area in closed herbland structures increased from a historical level of 1.7 percent to 2.2 percent in the existing condition, nearly a 30-percent increase (fig. 38 and appendix 2). Connectivity of open and closed herbland structures declined; patch density increases were 2.4 to 3.6 and 4.8 to 6.5 patches per 10 000 ha, respectively.

Nonforest-nonrange types—Nonforest-nonrange and other anthropogenic types increased in both area and connectivity of area (fig. 38 and appendix 2). Average area increased from 4.4 to 5.4 percent, and patch density increased by 23 percent, from 12.8 to 15.8 patches per 10 000 ha.

Columbia Plateau ERU—Subbasins sampled within the Columbia Plateau ERU (figs. 9, 10, 12, and 15) included the Lower Crooked (LCR), Lower John Day (LJD), Lower Yakima (LYK), Palouse (PLS), and Upper Yakima (UYK). Among these subbasins, 38 historical and current subwatershed pairs were sampled.

Physiognomic types—Vast areas of what were formerly dry grasslands and dry shrublands have been converted to dryland or irrigated agriculture in the 20th century in the Columbia Plateau ERU (fig. 25 and appendix 2). By the time of our historical photointerpretation, most land cover conversion had already taken place. Still, considerable change in physiognomic conditions was evident. Forest area increased from an average of 26.1 to 29.1 percent of the ERU area, representing an 11-percent increase from the historical condition, but average patch size declined from 1116.2 to 930 ha (ns).

Woodland area increased from a historical level of 6.7 percent to 12.2 percent in the existing condition, representing an 82-percent rise overall. Woodland connectivity also increased, with mean patch size more than tripling from an average of 69.9 ha in the historical condition to 220.6 ha in the existing condition. The most significant decline in area of any physiognomic type occurred in shrublands, where area declined from 32.2 to 23.4 percent, representing a 27-percent reduction from historical levels. Decline in connectivity of shrublands was equally dramatic; mean patch size fell from 842.8 to 265.9 ha, for an average decrease of 576.9 ha.

Cover types—
Forest—Area in ponderosa pine, Douglas-fir, and western hemlock-western redcedar cover types increased significantly (figs. 26 to 28 and appendix 2). Ponderosa pine cover increased from 19.2 to 21.4 percent, and area in the Douglas-fir cover type increased from 3 to 3.9 percent of the ERU area. Western hemlock-western redcedar cover increased from 0.4 to 2.2 percent of the ERU area, representing a fivefold increase. Western

larch, a relatively minor cover type, declined in area by 90 percent from a 1-percent historical level to 0.1 percent in the existing condition. As expected with fire exclusion, connectivity of the Douglas-fir and western hemlock-western red-cedar cover types increased. Average patch density of Douglas-fir cover increased by 50 percent, from 2.4 to 3.6 patches per 10 000 ha. Average patch density of western hemlock-western red-cedar cover increased threefold, from 0.3 to 0.9 patch per 10 000 ha.

Woodland—Juniper cover increased by 85 percent, from an average of 6.5 percent in the historical condition, to 12 percent of the land cover in the existing condition (fig. 26 and appendix 2). Connectivity of juniper cover also increased significantly; average patch size increased from 60.6 to 208.4 ha.

Shrubland—Only colline low-medium and colline wet-site shrub cover types declined in area. Colline low-medium shrub cover declined from 29.1 to 21.7 percent, for a 25-percent decrease (figs. 29 to 31 and appendix 2). Area in colline wet-site shrubs declined by 50 percent, from 0.2 to 0.1 percent of the ERU area. Connectivity of colline low-medium shrubs also declined. Patch density increased from 5.2 to 1,405.2 patches per 10 000 ha for an average increase of 1,400.1 patches per 10 000 ha, and mean patch size declined from a historical level of 838.4 ha to 14.1 ha. In contrast, connectivity of montane low-medium shrub cover increased. Connectivity of montane tall shrub cover also declined, with mean patch sizes dropping from 12.3 to 2.8 ha.

Herbland— Area in colline bunchgrass cover declined from an 8.3-percent historical level to 6.9 percent of the ERU area (figs. 29, 32, and 33 and appendix 2). Area in montane bunchgrass cover and colline exotic grasses and forbs increased. Montane bunchgrass cover increased from 1.3 to 1.8 percent, and colline exotic cover increased from 0.8 to 2.3 percent of the ERU area, representing a threefold increase. Connectivity of colline exotic grass and forb cover also increased; patch density increased from 2.4 to 4.2 patches per 10 000 ha, and mean patch size increased from an 11.3-ha historical level to 29.3 ha. Connectivity of postlogging grasses and forbs declined; patch density increased twelvefold from 0.2 to 2.4 patches per 10 000 ha, and mean patch size declined by 98 percent.

Nonforest-nonrange and other anthropogenic cover types—There were no significant changes in area in this ERU (figs. 34 and 35 and appendix 2). Connectivity of cropland cover increased; patch density declined from 7.8 to 4.8 patches per 10 000 ha, and mean patch size increased from 708.9 to 815.4 ha. Connectivity of urban and rural development areas declined. Uniquely, area in water cover increased significantly as did connectivity of that area. The Columbia Plateau ERU is crisscrossed by ditches and canals constructed by farmers, ranchers, and the Bureau of Reclamation for irrigation; it is rife with water-holding “tanks” and ponds. Average area in water cover increased by 44 percent from 0.3 to 0.4 percent of the ERU area; average patch density of water area increased by 64 percent from 0.5 to 0.9 patch per 10 000 ha; and average patch size increased 26 percent from 13 to 16.4 ha (ns). Finally, connectivity of exposed rock (such as scree, talus, cliffs, rimrock) increased; mean patch size increased from 4.5 to 9.6 ha.

Structural classes—

Forest—Among forest structures, there were many changes but few were significant at $P \leq 0.2$ owing to high inherent variability of conditions throughout the ERU (fig. 36 and appendix 2). The most significant change in forest structure was that occurring to young multistory structures; area increased from 7.3 to 10.0 percent of the ERU area, a 37-percent increase from recent historical conditions: average patch size increased from 54.6 to 81.4 ha, a 48-percent increase from historical conditions.

Woodland—As noted earlier, area in woodland increased by more than 5 percent of the area of the ERU; that is, an 82-percent increase over historical levels (fig. 37 and appendix 2). Most of the noted increase in area occurred in stem-exclusion structures, which increased from 5.9 to 10.9 percent of the ERU area. Connectivity of stem-exclusion structures also increased; mean patch size increased from 63.8 to 152.7 ha, a 139-percent increase from historical conditions. No other significant structural changes were observed among Columbia Plateau woodland structures.

Shrubland—Among all forest and range structures, the most significant changes occurring during the sample period occurred to shrubland structures, where area in all structural classes declined (fig. 38 and appendix 2). It is important to note here that changes to historical dry herblands of the Columbia Plateau have been equally significant, but most native herblands had already been lost to dryland wheat production before the period of historical photointerpretation (see also Hann and others 1997).

Area of open low-medium and closed low-medium shrub structures declined as did area of open tall shrubs. Area of open low-medium shrubs declined from 23.4 to 19.4 percent of the ERU area, a 17-percent drop. Area of closed low-medium shrub structures declined from 6.9 to 3.3 percent, a 53-percent drop. Connectivity of both low-medium shrub structural classes also declined. Mean patch size of open low-medium shrub structures declined from 435.1 to 172.9 ha, representing a 60-percent reduction; patch density of closed low-medium shrub structures declined from 5.2 to 2.9 patches per 10 000 ha, a 43-percent drop from recent historical levels. Likewise, connectivity of closed tall shrub structures declined; mean patch size decreased from 14.7 to 3.7 ha.

Herbland—Among open and closed herbland structures, only area in open herbland structures increased during the sample period (fig. 38 and appendix 2). Although this increase was statistically significant, most native herblands have been lost to agriculture, and the noted increase is relatively small in comparison. Area in open herbland structures increased from 7.4 to 9.0 percent. Connectivity of closed herb structures continued to decline; mean patch size declined from 41.5 to 23.1 ha.

Nonforest-nonrange and other types—No significant change in area of nonforest-nonrange types was observed but connectivity declined (fig. 38 and appendix 2). Patch density decreased from 11.8 to 9.3 patches per 10 000 ha.

Lower Clark Fork ERU—The Upper Coeur d'Alene (UCD) was the only subbasin sampled within the Lower Clark Fork ERU (fig. 7); five historical and current subwatershed pairs were sampled.

Physiognomic types—Changes observed among physiognomic types were not statistically significant because of the small sample size (fig. 25 and appendix 2).

Cover types—

Forest—Few changes in area were observed among forest cover types. Douglas-fir cover declined from 26.4 to 21.1 percent (figs. 26 to 28 and appendix 2). Although not statistically significant, we gauged the change as ecologically significant given results of transition analysis and comparison to existing conditions with the historical median 75-percent range. Connectivity of the aspen-cottonwood-willow cover type increased; patch density increased from 0.6 to 2.2 patches per 10 000 ha, and mean patch size increased from 3 to 14.2 ha. Connectivity of the western larch cover type also increased; patch density increased from 2.6 to 4.8 patches per 10 000 ha. Area of the mountain hemlock cover type declined from 1.3 to 0.6 percent of the ERU area, a 54-percent drop, and connectivity of the cover type declined; patch density fell from 1.6 to 0.6 patch per 10 000 ha.

Shrubland—Shrubland area in this ERU is apparently small (< 2 percent of the area of the ERU) based on our sample, and only one change in shrubland cover types was significant: connectivity of montane wet-site shrubs declined (figs. 29 to 31 and appendix 2). Patch density increased from 4.2 to 8.8 patches per 10 000 ha, and mean patch size fell from 63.9 to 20.0 ha (ns).

It is interesting that historical area of montane tall shrubs declined from 1.6 to 0.3 percent of the ERU area. This is not a statistically significant change, but it would be worthwhile to explore this relation in greater detail to determine whether early seral shrub components of forest communities have been minimized as a consequence of excluding stand-replacing fires from montane settings.

Herbland—Only one significant change was noted among herbland cover types: connectivity of the postfire grass and forb cover type declined (figs. 29, 32, and 33 and appendix 2). Patch density fell from 8.8 to 0 patch per 10 000 ha, and mean patch size dropped from 13.3 to 0 ha. Historical area of this cover type was 2.9 percent of the ERU area based on this small sample and current area is zero, but the change was not statistically significant. As noted above, it would be worthwhile to explore this relation in greater detail to determine whether early seral herb and forb cover types of forest communities have been minimized as a consequence of excluding stand-replacing fires.

Nonforest-nonrange and other anthropogenic cover types—Only one change was noted as significant: connectivity of the postlogging bare ground-burned cover type increased (figs. 34 and 35 and appendix 2). Mean patch size increased from 0.8 to 6.3 ha.

Structural classes—

Forest—Many significant changes were in evidence among forest structures of the Lower Clark Fork ERU (fig. 36 and appendix 2). In general, structures associated with early seral forest development declined in area, and those associated with midseral development increased. In the historical condition, one-third of the ERU was comprised of stand-initiation structures, based on our sample; stand-initiation represented the dominant structural condition. Area in stand-initiation structures declined from 32.7 to 9.5 percent of the ERU area, and connectivity declined as well; mean patch size dropped from 208.3 to 24.2 ha.

Average area in stem exclusion-open canopy structures declined from 15.7 to 9.2 percent, and connectivity of this structure likewise declined. Patch density fell from 28 to 23 patches per 10 000 ha, and mean patch size dropped from 52.4 to 25.9 ha. In contrast, ERU area in stem exclusion-closed canopy structures substantially increased from 10.3 to 17.6 percent, an increase of nearly 71 percent over historical conditions. Connectivity of stem exclusion-closed canopy structures also increased with mean patch size by more than doubling during the sample period. Mean patch size increased from 31.8 to 64.4 ha.

Area in understory reinitiation structures increased from a historical level of 16.4 percent to 37.7 percent of the ERU area. The noted 230-percent rise in area of understory reinitiation structures precipitated replacement of stand initiation as the dominant structural feature of current-day Lower Clark Fork landscapes. Connectivity of understory reinitiation structures likewise increased; average patch density increased from 24 to 33.8 patches per 10 000 ha. Area in young multistory structures increased from 14.3 to 17.5 percent (ns), further indicating an overall trend toward middle-aged, intermediate forests across the ERU. Area of old single-story and old multistory structures increased but changes were not significant. Connectivity of old single-story structures declined significantly, though; patch density increased from 2.8 to 8.2 patches per 10 000 ha, and mean patch size declined from 39.4 to 18.6 ha.

Shrubland—All changes in shrub structures indicated declining presence, but no changes in area or connectivity were significant (fig. 38 and appendix 2)

Herbland—No changes in herbland structure were significant at this reporting scale (fig. 38 and appendix 2).

Nonforest-nonrange and other anthropogenic types—No change was significant at this reporting scale (fig. 38 and appendix 2).

Northern Cascades ERU—Subbasins sampled within the Northern Cascades ERU (figs. 5 and 9) included the Methow (MET), Wenatchee (WEN), Naches (NAC), Upper Yakima (UYK), and Lower Yakima (LYK). Among these subbasins, 48 historical and current subwatershed pairs were sampled.

Physiognomic types—Many changes in area and connectivity of physiognomic types were significant in the Northern Cascades ERU, but forest area and connectivity remained relatively stable during the sample period (fig. 25 and appendix 2). Woodland, though a minor type in the ERU, increased in area by 100 percent; percentage of area increased from 0.3 to 0.7 percent during the sample period. Connectivity of woodlands also increased; patch density rose from 1.1

to 1.8 patches per 10 000 ha, and mean patch size doubled, increasing from 3.2 to 6.5 ha. Shrubland area and connectivity both declined but only the latter change was significant. Patch density rose from 7.2 to 8.7 patches per 10 000 ha, and mean patch size declined (ns). Connectivity of herblands declined dramatically; patch density increased from 7.6 to 11.0 patches per 10 000 ha, representing a 43-percent rise over the sample period, and mean patch size dropped from 78.5 to 55.0 ha. Finally, area and connectivity of nonforest-nonrange and other anthropogenic types increased; area increased from 9.4 to 10.6 percent of the ERU area, and patch density increased from 13.5 to 19.0 patches per 10 000 ha.

Cover types—

Forest—Significant change in area or connectivity occurred in most forest cover types. Area of ponderosa pine cover declined from 16.5 to 13.2 percent of the area of the ERU (figs. 26 to 28 and appendix 2). In the historical condition, ponderosa pine comprised 21 percent of all forest cover (in the historical condition, 78.8 percent of the ERU area was comprised of the forest physiognomic type). Currently, ponderosa pine comprises 17 percent of forest cover, representing an overall decline of 4 percent. Connectivity of ponderosa pine cover also fell dramatically: patch density rose from 7.3 to 8.2 patches per 10 000 ha, and mean patch size declined from an average of 241.3 to 156.1 ha. Concurrently, area in Douglas-fir cover increased from 23.8 to 25.8 percent, and connectivity declined. Density of Douglas-fir patches increased from 10.9 to 13.3 patches per 10 000 ha, and mean patch size fell from an average of 294.1 to 254 ha (ns).

No change in area of the western larch cover type was evident at this reporting scale, but connectivity of the type declined; patch density increased from 1.2 to 1.7 patches per 10 000 ha, and mean patch size remained relatively constant. Though a relatively minor cover type within the northern Cascades ERU, area in the western white pine-sugar pine cover type (western white pine in the northern Cascades) increased from 0.1 to 0.3 percent of the ERU area. Connectivity of western white pine cover also increased; patch density rose from an average of 0.2 to 0.5 patch per 10 000 ha, and mean patch size increased from 2.4 to 6.5 ha. Western white pine occurs as a minor seral component in mixed coniferous forests in the northern portion of the Cascade Range. Noted increases likely were the result of management efforts in the Wenatchee and Okanogan National Forests to deploy white pine blister rust-resistant stock (personal observation, senior author). Outplanting strategies have emphasized both phenotypic and genotypic resistance in multiline arrangements and mixed species plantings.

Area in the whitebark pine-subalpine larch cover type increased from 3.3 to 4.7 percent of the ERU area. Connectivity of the type also rose during the sample period; patch density increased from 4.0 to 4.9 patches per 10 000 ha, and mean patch size increased from 35.4 to 63.3 ha. Recent observations from studies of subalpine forests of the Wenatchee National Forest[23] indicate that mortality of whitebark pine due to white pine blister rust is evident throughout the cover type, but it is unknown whether mortality rate and disease progress match that observed in the Rocky Mountains (Keane and Arno 1993).

Area in the Pacific silver fir and grand fir-white fir (grand fir in the Northern Cascades ERU) cover types increased from 6.0 to 8.3 percent, and from 1.0 to 2.2 percent, respectively. But connectivity of Pacific silver fir cover declined; patch density increased from 4.0 to 359.8 patches per 10 000 ha, representing nearly a hundredfold increase, and mean patch size declined from an average of 61.5 to 3.6 ha, a 94-percent decrease from the historical condition. In contrast, connectivity of grand fir cover rose from the historical condition; patch density more than tripled, increasing from 1.1 to 3.7 patches per 10 000 ha, and mean patch size increased from 25.7 to 33.6 ha, a 31-percent increase from the historical condition.

Area and connectivity of subalpine fir-Engelmann spruce cover both declined during the sample period; area fell from an average of 16.8 to 13.6 percent of the ERU area. Patch density increased

[23] Personal communication. 1997. Paul Flanagan, entomologist, U.S. Department of Agriculture, Forest Service, Wenatchee National Forest, 215 Melody Lane, Wenatchee, WA 98801.

slightly from 10 to 11.2 patches per 10 000 ha, and mean patch size declined by almost half from 283.8 to 158.2 ha. Area and connectivity of western hemlock-western redcedar cover also declined during the sample period. Area fell from 3 to 2.4 percent, patch density increased from 1.3 to 2.2 patches per 10 000 ha, and mean patch size declined from 62.9 to 40.2 ha. Finally, connectivity of mountain hemlock cover declined with mean patch size dropping from 30.4 to 22.8 ha.

Woodland—Although a relatively minor cover type in the ERU, area in Oregon white oak cover increased from 0.6 to 0.9 percent of the ERU area, and patch density rose from 2.1 to 2.8 patches per 10 000 ha (fig. 26 and appendix 2). No significant change in western juniper cover was evident at this reporting scale.

Shrubland—No change in area of shrubland cover types was significant, but several changes in connectivity were significant (figs. 29 to 31 and appendix 2). Connectivity of colline low-medium shrub cover declined; patch density increased a hundredfold from 1.1 to 105.4 patches per 10 000 ha, and mean patch size declined by 91 percent from an average of 12.7 to 1.1 ha. Similarly, connectivity of montane low-medium shrub cover declined but change was less striking; mean patch size declined from an average of 5.5 to 4.2 ha. Connectivity of colline mahogany species cover declined with patch density increasing eightfold. Connectivity of montane mahogany species cover increased; patch density rose from 0 to 0.2 patch per 10 000 ha, and mean patch size increased from 0.4 to 1.1 ha. Connectivity of montane tall shrub cover declined with patch density falling from 0.1 to 0 patch per 10 000 ha, and mean patch size declined from 2.6 to 0.7 ha.

Herbland—Changes in herbland cover types occurred with mixed results. Area and connectivity of montane exotic grasses and forbs increased; area increased from 0.7 to 0.9 percent of the ERU area, patch density declined from 0.9 to 0.7 patch per 10 000 ha, and mean patch size rose from 8.2 to 12.8 ha (figs. 29, 32, and 33 and appendix 2). Area in postlogging grass and forb cover also increased but connectivity declined; area increased fourfold from 0.1 to 0.4 percent, patch density increased from 0.2 to 19.2 patches per 10 000 ha, and mean patch size fell from 1.6 to 0.2 ha. Harvest practices in recent decades favored extensive partial cutting, and numerous small harvest units likely account for these changes.

Area and connectivity of montane bunchgrass cover both declined; area dropped from 1.0 to 0.7 percent of the ERU, and patch density increased from 0.9 to 1.5 patches per 10 000 ha. Connectivity of colline bunchgrass cover also declined; patch density rose from 0.7 to 1.9 patches per 10 000 ha, and mean patch size fell from 13.7 to 6.7 ha. Of special interest, area and connectivity of colline exotic grass and forb cover declined; area dropped from 0.9 to 0.5 percent, and mean patch size declined from 16.6 to 4.5 ha. Transition analysis indicated that loss in area of the type was the result of many minor transitions to other range cover types. It is quite possible that severely degraded conditions of some herblands in the Northern Cascades ERU (caused by sheep in the late 1880s and early 1900s; Wissmar and others 1994a, 1994b) improved over the last half of the 20th century with the advent of improved grazing management, thereby producing the observed decline in this cover type.

Nonforest-nonrange and other anthropogenic cover types—Area and connectivity of urban and rural developments increased during the sample period; area rose from 0.1 to 0.3 percent of the ERU area, patch density increased from 0.2 to 0.7 patch per 10 000 ha, and mean patch size rose from an average of 4.6 to 9.0 ha (figs. 34 and 35 and appendix 2). Most increase in this type was associated with fire-prone forest and range ecotones and dry and mesic forest PVTs. Such an increase in the wildland-urban interface in the Northern Cascades ERU will pose significant new challenges to restoring fire regimes and expanding cover of pyrophytic species.

Area and connectivity of pasturelands declined, but the former change was not significant. Patch density of pasture cover increased from 0.3 to 0.4 patch per 10 000 ha, and mean patch size declined from 7.0 to 2.8 ha. Connectivity of postlogging-bare ground-slumps and erosion cover declined with patch density, increasing from 2.9 to 3.5 patches per 10 000 ha. These changes indicate that new road construction or reconstruction over the sample period has affected more areas, but affected areas exhibit slightly less exposed soil. Similarly, percentage of area in postlogging-bare ground-burned cover increased from 0.5 to 1.5 percent of the ERU area, and connectivity of the type declined; patch density increased from 0.8 to 5.7 patches per 10 000 ha.These changes indicate that regeneration timber harvest type activities have affected more areas over the sample period, but each affected area exhibits less exposed soil than was apparent from the historical vegetation condition. Finally, connectivity of exposed rock cover increased, with mean patch size rising from 62.4 to 84.2 ha.

Structural classes—

Forest—Considering all structural classes of forest and nonforest, changes among forest structures were the most significant in the Northern Cascades ERU (fig. 36 and appendix 2). Connectivity of all forest structures changed significantly, and in most cases, connectivity declined. Area and connectivity of understory reinitiation structures increased; percentage of area increased from 17.5 to 19.5 percent in the historical condition, and patch density increased from 15.7 to 19.5 patches per 10 000 ha. Increase in understory reinitiation structures was the only significant increase observed. Although the change was not statistically significant, we gauged it as ecologically significant given results of transition analysis and comparison of existing conditions with the historical median 75-percent range.

Area and connectivity of old single-story and multistory structures declined. Percentage of area in old single-story structures fell from 4.3 to 2.4 percent, representing a 46-percent decline from historical conditions. In the historical vegetation coverage, old single-story structures comprised 5.5 percent of the area of the forest physiognomic condition: in the current vegetation coverage, old single-story structures comprised 3 percent of the area of forests. Mean patch size declined by more than 52 percent from 81.9 to 38.9 ha. Percentage of area in old multistory structures fell from 5.8 to 2.7 percent, representing a 54-percent decline from historical conditions. In the historical vegetation coverage, old multistory structures comprised 7.4 percent of the area of forests, and in the current vegetation coverage, old multistory structures comprised 3.5 percent of the area of forests. Patch density of old multistory structures increased from 4.5 to 4.9 patches per 10 000 ha (ns), and mean patch size declined by 74 percent from 145.0 to 37.5 ha.

Connectivity of stand-initiation, stem-exclusion open and closed canopy, and young multistory structures declined with significant increases in patch density, in all cases. Mean patch size declined for each structural class, but only declines in stem-exclusion open canopy and young multistory structures were significant. In general, the most significant changes among forest structures were the significant declines in area of old-forest structures and dramatically increased fragmentation of all structural classes except understory reinitiation.

Woodland—Among woodland cover types, only the Oregon white oak cover type is well distributed in the Northern Cascades ERU (fig. 37 and appendix 2). Because the range of western juniper does not extend into this ERU, the juniper cover type is not represented. Area and connectivity of oak stem-exclusion structures increased significantly during the sample period. Percentage of area increased from 0.3 to 0.6 percent, patch density increased from an average of 1.0 to 1.7 patches per 10 000 ha, and mean patch size increased from 2.3 to 6.3 ha. Overall, it appeared that oak woodland structures encroached on other shrubland and herbland types. Results of transition analysis reflected this general trend, but no single transition was dominant.

Shrubland—The shrubland physiognomic type comprised less than 5 percent of the area of this ERU (fig. 38 and appendix 2). Among shrubland structures, no change in area of any structural class was significant, but connectivity of most shrub structures declined. Connectivity of open and closed low-medium structures declined with increasing patch density. Patch density of open low-medium structures increased from 2.8 to 3.3 patches per 10 000 ha, and patch density of closed low-medium structures increased threefold from 0.4 to 1.3 patches per 10 000 ha. Mean patch size of open tall structures declined from 3.5 to 0.6 ha.

Herbland—The herbland physiognomic type comprised less than 7 percent of the area of this ERU in both the historical and current conditions (fig. 38 and appendix 2). Among herbland structures, no change in area of any structural class was significant, but connectivity of all herbland structures declined. Connectivity of open herbland structures declined with increasing patch density; patch density of open herb structures increased from 1.4 to 2.0 patches per 10 000 ha, and patch density of closed herb structures increased from 1.6 to 2.3 patches per 10 000 ha. Mean patch size of open herb structures declined from 21.8 to 11.5 ha and mean patch size of closed herb structures declined from 14.3 to 6.5 ha.

Nonforest-nonrange and other anthropogenic types—Nonforest-nonrange types increased in area from an average of 14.3 to 15.2 percent of the ERU area (fig. 38 and appendix 2). Connectivity of these types declined, with patch density increasing from 17.9 to 25.2 patches per 10 000 ha, and mean patch size fell from 117.0 to 104.3 ha.

Northern Glaciated Mountains ERU—
Subbasins sampled within the Northern Glaciated Mountains ERU (figs. 6 to 8) included the Lower Flathead (LFH), Kettle (KET), Pend Oreille (PEN), Sanpoil (SPO), Swan (SWN), and Yaak (YAA). Among these subbasins, 41 historical and current subwatershed pairs were sampled.

Physiognomic types—No change in percentage of area of any physiognomic type was significant in this ERU, but connectivity of shrubland, herbland, and nonforest-nonrange and other types declined (fig. 25 and appendix 2). Patch density of shrublands increased by 190 percent from an average of 5 to 9.5 patches per 10 000 ha, and mean patch size declined by 49 percent from 40.6 to 20.6 ha. Patch density of herblands increased by 62 percent from 11.1 to 18.0 patches per 10 000 ha, and mean patch size declined from 93.8 to 65.9 ha (ns). Patch density of nonforest-nonrange and other anthropogenic types increased from an average of 12.4 to 17.9 patches per 10 000 ha, and mean patch size declined from 86.4 to 58.6 ha (ns).

Cover types—
Forest—Many significant changes in area as well as connectivity were noted among forest cover types (figs. 26 to 28 and appendix 2). Percentage of area of shade-tolerant cover species such as grand fir-white fir (grand fir in the Northern Glaciated Mountains), subalpine fir-Engelmann spruce, and western hemlock-western redcedar cover increased, and area in fire-tolerant and shade-intolerant western larch and ponderosa pine cover declined. Area in the grand fir cover type rose from 0 to 1.2 percent of the ERU. Connectivity of grand fir cover also increased; patch density rose from 0.1 to 2.3 patches per 10 000 ha, and mean patch size increased by 525 percent from 3.6 to 18.9 ha. Percentage of area in subalpine fir-Engelmann spruce cover rose from 11.5 to 13.2 percent of the ERU. Connectivity of subalpine fir-Engelmann spruce cover declined; patch density rose by 80 percent from 6.1 to 11.0 patches per 10 000 ha, and mean patch size fell by 22 percent from 177.6 to 138.9 ha.

Percentage of area in western larch cover dropped by 23 percent from 14.8 to 11.4 percent; connectivity of the type declined as well. Patch density increased from 9.6 to 13.7 patches per 10 000 ha, and mean patch size fell by 55 percent from 134.4 to 61.1 ha. Similarly, percentage of area in ponderosa pine cover dropped by 15 percent from 13.4 to 11.4 percent of the ERU area; connectivity of the type declined as well. Patch density increased from 7.7 to 10.3 patches per 10 000 ha, and mean patch size fell by 28 percent from 151.9 to 108.8 ha (ns).

Percentage of area in western hemlock-western redcedar cover increased from 0.7 to 2.8 percent of the ERU area, a fourfold increase in the cover type. Connectivity of hemlock-redcedar cover declined; patch density rose from 1.1 to 4.4 patches per 10 000 ha, and mean patch size fell by 2.1 ha from 19.1 ha (ns). Connectivity of the Douglas-fir, lodgepole pine, and western white pine-sugar pine (western white pine in this ERU) cover types declined; patch density of Douglas-fir cover rose from 16.1 to 23.0 patches per 10 000 ha, patch density of lodgepole pine cover rose from 9.7 to 13.3 patches per 10 000 ha, and mean patch size dropped from 68.8 to 52.4 ha. Percentage of area in western white pine cover declined from 1.5 to 0 percent; patch density of western white pine cover declined from 0.6 to 0.2 patch per 10 000 ha, and mean patch size fell by 92 percent from 21.5 to 1.7 ha. In the historical vegetation coverage, the western white pine cover type comprised 2 percent of all forest cover in the Northern Glaciated Mountains ERU. In the current vegetation coverage, the cover type comprised <0.1 percent of forest cover. Historical photo coverages of sampled subwatersheds in the Kettle, Sanpoil, Pend Oreille, Yaak, Swan, and Lower Flathead subbasins span the period of 1932 to 1963, with the bulk of the aerial photography coming from the 1930s and 1940s (see table 3). Prior to that time, significant partial cutting of western white pine had occurred, and by the late 1930s and 1940s, white pine blister rust already was causing widespread mortality (Monnig and Byler 1992). Our estimates of the historical extent of this cover type likely were conservative, but even at that, subsequent harvest and mortality due to white pine blister rust have significantly minimized this ecologically and commercially important cover species during the period of our sample.

Finally, connectivity of the aspen-cottonwood-willow (includes maples and birches in this ERU) cover type increased; patch density rose from 1.2 to 2.6 patches per 10 000 ha, and mean patch size increased from 8 to 40.8 ha (ns).

Woodland—Woodland cover types represented a small area in our sample of this ERU. No significant changes in area or connectivity were noted (fig. 26 and appendix 2).

Shrubland—Shrubland cover types comprised about 3 percent of the area of the ERU (figs. 29 to 31 and appendix 2). Although a small area, many changes in area and connectivity of shrub cover types were significant. Area and connectivity of montane low-medium shrub cover increased; percentage of area increased from 0 to 0.1 percent of the ERU area, patch density rose from 0 to 0.2 patch per 10 000 ha, and mean patch size increased from 0 to 2.2 ha. These results suggested that a modest recovery from earlier heavy sheep and cattle grazing may be underway in midelevation shrub cover types. Connectivity of colline low-medium shrub cover declined during the sample period; patch density rose from 0.3 to 5.4 patches per 10 000 ha, and mean patch size declined from 1.8 to 0.1 ha. Connectivity of subalpine and alpine low-medium shrub cover also declined; patch density rose from 1.4 to 2.0 patches per 10 000 ha, and mean patch size declined from 8.4 to 5.1 ha (ns).

Area and connectivity of colline and montane mahogany cover types declined during the sample period. Percentage of area of colline mahogany cover fell from 0.4 to 0 percent, patch density dropped from 0.4 to 0 patch per 10 000 ha, and mean patch size declined from 7.2 to 0 ha. Colline mahogany cover was undetected in the current vegetation of sampled subwatersheds. Likewise, percentage of area of montane mahogany cover fell from 0.2 to 0 percent, patch density dropped from 0.3 to 0 patch per 10 000 ha, and mean patch size declined from 3.1 to 0 ha. Montane mahogany cover also was undetected in the current vegetation of sampled subwatersheds.

Area of colline wet-site shrub cover declined from 0.3 to 0.2 percent, and mean patch size declined by 43 percent from 9.0 to 5.1 ha. Conversely, area and connectivity of montane wet-site shrub cover increased; percentage of area rose from 0.1 to 0.2 percent of the ERU area, patch density increased from 0.3 to 0.6 patch per 10 000 ha, and mean patch size nearly doubled increasing from 4.7 to 8.6 ha. Connectivity of montane tall shrub cover declined with patch density increasing threefold from 1.0 to 3.4 patches per 10 000 ha. Area of subalpine and alpine subshrubs (beargrass) increased 0 to 0.1 percent, patch density increased from 0 to 10.0 patches per 10 000 ha, and mean patch size fell from 2.2 to 0.1 ha. Connectivity of montane subshrubs also declined with mean patch size falling from 2.8 to 1.2 ha.

Herbland—Few significant changes were noteworthy among herbland cover types (figs. 29, 32, and 33 and appendix 2). Connectivity of dry meadow cover increased during the sample period; patch density increased from 0.1 to 0.4 patch per 10 000 ha, and mean patch size rose sevenfold from 0.3 to 2.1 ha. Area and connectivity of colline bunchgrasses declined; percentage of area fell by 50 percent from 1.6 to 0.8 percent of the ERU area. Patch density doubled from 0.7 to 1.5 patches per 10 000 ha, and mean patch size de-clined by 72 percent from 34.9 to 9.8 ha. Area and connectivity of colline exotic grasses and forbs both increased, but the change in area was not significant. Patch density rose from 0.9 to 1.9 patches per 10 000 ha, and mean patch size increased from 11.8 to 14.0 ha. Area and connectivity of wet meadow cover increased. Percentage of area rose from 0 to 0.1 percent; patch density increased from 0.2 to 0.8 patch per 10 000 ha, and mean patch size increased from 2 to 4.1 ha (ns). Finally, area in postlogging grasses and forbs increased and connectivity declined, indicating increasing number and decreasing size of harvest units during the sample period. Percentage of area increased from 0.1 to 0.8 percent of the ERU area; patch density rose thirtyfold from 0.7 to 21.2 patches per 10 000 ha, and mean patch size fell from 4.1 to 0.2 ha.

Nonforest-nonrange and other anthropogenic cover types—Several changes among the nonforest nonrange and anthropogenic types are noteworthy (figs. 34 and 35 and appendix 2). Cropland area increased by 26 percent from 3.4 to 4.3 percent of the ERU area, but the change was not significant at P≤0.2. Connectivity of cropland area declined with patch density falling from 4.1 to 3.2 patches per 10 000 ha, and mean patch size declined from 49 to 47.3 ha (ns). Area and connectivity of pasture lands increased; percentage of area increased by 21 percent from 1.4 to 1.7 percent of the ERU area, patch density fell from 1.4 to 1.1 patches per 10 000 ha (ns), and mean patch size increased more than fourfold from 11.2 to 49.1 ha. These results suggested that additional native shrublands had been converted to irrigated pasture during the sample period; transition analysis confirmed the trend. Area in urban and rural developments increased from 0.2 to 0.3 percent, but the change was not significant. Connectivity of urban and rural development areas increased significantly during the sample period with patch density rising from 0.8 to 1.3 patches per 10 000 ha, and mean patch size doubled from 4.1 to 8.1 ha.

Percentage of area of exposed rock increased from 2.3 to 2.7 percent of the ERU area, but connectivity of rock area declined; patch density nearly doubled, rising from 4.9 to 9.2 patches per 10 000 ha, and mean patch size declined from 32.5 to 29.2 ha (ns). Finally, area and connectivity of postlogging-bare ground-burned cover declined from 2.2 to 0.4 percent, patch density rose from 1.3 to 3.1 patches per 10 000 ha, and mean patch size declined from 24.9 to 7.2 ha (ns). These results further suggest increasing number and decreasing size of harvest units during the sample period.

Structural classes—

Forest—Most changes in area and connectivity of forest structures were significant (fig. 36 and appendix 2). Area in stand-initiation and young multistory structures declined, and area in stem-exclusion closed canopy and understory reinitiation structures increased. Nearly all changes in connectivity reflected drastically increased fragmentation. Percentage of area in stand-initiation structures fell from 16.9 to 9.4 percent of the ERU area. In the historical vegetation condition, stand-initiation structures comprised 21 percent of all forest cover. In the current condition, stand-initiation structures comprise 11.6 percent of forest cover, a 44-percent decline during the sample period. Patch density increased from 18.3 to 26.5 patches per 10 000 ha, and mean patch size decreased by 63 percent, falling from 103.6 to 38.5 ha. These results indicated declining abundance of new forest structure as a consequence of excluding stand-replacing fires and increasing number and decreasing size of harvest units during the sample period.

Conversely, area and connectivity of stem exclusion-closed canopy structures increased. Percentage of area rose from 7.2 to 12.8 percent, representing a 78-percent increase, patch density increased from 8.6 to 15.0 patches per 10 000 ha, and mean patch size rose from 61.2 to 71.4 ha (ns). Connectivity of stem-exclusion open canopy structures declined with patch density, rising from 18.0 to 27.8 patches per 10 000 ha, and mean patch size declined by 35 percent from 75.3 to 49.1 ha. Area in understory reinitiation structures increased from 18.4 to 23.3 percent of the ERU, and connectivity of area declined; patch density increased from 12.9 to 22.1 patches per 10 000 ha, and mean patch size declined from 170.6 to 150.7 ha (ns). Area and connectivity of young multistory structures both declined. Percentage of area fell from 25.5 to 22.8 percent, patch density increased by 46 percent, rising from 22.2 to 32.4 patches per 10 000 ha, and mean patch size declined by 51 percent, falling from 218.1 to 106.3 ha, but the change was not significant at this reporting scale.

Declines in area of old single-story and multistory structures were not significant at the scale of the ERU, but connectivity of old multistory structures declined significantly. Patch density increased from 0.5 to 1.2 patches per 10 000 ha, and mean patch size declined from 22.7 to 7.8 ha.

Shrubland—Only two changes in shrub structures were significant at this scale: connectivity of closed low-medium structures declined (patch density rose from 0.6 to 1.3 patches per 10 000 ha), and mean patch size fell, from 5.6 to 4.5 ha (ns) (fig. 38 and appendix 2). Connectivity of open tall structures also declined; patch density rose from 1.7 to 3.2 patches per 10 000 ha, and mean patch size fell from 22.9 to 12.5 ha (ns).

Herbland—One change in herb structure was significant at this scale: connectivity of closed structures declined; patch density rose from 6.9 to 7.9 patches per 10 000 ha, and mean patch size fell from 38.3 to 27.7 ha (ns) (fig. 38 and appendix 2).

Nonforest-nonrange and other anthropogenic types—These types changed significantly in both area and connectivity (fig. 38 and appendix 2). Percentage of area of nonforest-nonrange and other anthropogenic types increased by 10 percent, rising from 10.5 to 11.6 percent of the ERU, patch density increased from 14.7 to 25.1 patches per 10 000 ha, and mean patch size increased by 245 percent, rising from 90.3 to 221.4 ha, but the change was not significant at this scale.

Northern Great Basin ERU—The Donner und Blitzen (DUB) subbasin was the only one sampled within the Northern Great Basin ERU (fig. 16); four historical and current subwatershed pairs were sampled.

Physiognomic types—Changes in shrubland, herbland, and woodland physiognomic types were highly significant, and it is difficult to say which change was most significant (fig. 25 and appendix 2). Area in woodland increased from 15.3 to 22.2 percent of the ERU, representing a 45-percent increase during the sample period. Conversely, percentage of area in shrubland declined from 72.8 to 57.6 percent of the ERU area, a 21-percent decline from historical conditions. Patch density of shrublands rose from 11.8 to 21.0 patches per 10 000 ha (ns), and mean patch size declined by 64 percent, falling from 934.1 to 337.1 ha. Herbland area and connectivity each rose dramatically; area increased threefold, rising from 3.9 to 12.2 percent of the ERU. Patch density of herblands increased from 15.0 to 21.5 patches per 10 000 ha (ns), and mean patch size nearly tripled, increasing from 24.4 to 68.6 ha. Patches interpreted as wet meadow, alpine meadow, dry meadow, grasses and forbs after logging, pasture, grassland, and grasses and forbs after burning (wildfire or prescribed) were classified along with native herblands as "herbland." Only 7 percent of the ERU area is forested according to our small sample, and changes to area and connectivity of forest were insignificant.

Cover types—

Forest—No significant change in area or connectivity of a forest cover type was evident at the ERU reporting scale (figs. 26 to 28 and appendix 2).

Woodland—Most woodlands in the Northern Great Basin ERU are juniper woodlands (fig. 26 and appendix 2). Area of juniper cover increased by 55 percent during the sample period; percentage of area rose from 14.1 to 21.8 percent. Mean patch size increased from 139.9 to 180.4 ha, but the change was not significant.

Shrubland—Nearly all loss of shrubland cover occurred in the montane low-medium cover type, where area declined by 26 percent, falling from 51.2 to 37.7 percent (figs. 29 to 31 and appendix 2). Patch density of montane low-medium shrub cover rose from 16.8 to 22.5 patches per 10 000 ha, and mean patch size declined from 316.1 to 248.1 ha, but neither change was significant at this reporting scale. Connectivity of colline low-medium shrub cover declined significantly; patch density rose from 1.3 to 1411.3 patches per 10 000 ha, and mean patch size declined modestly from 20.0 to 18.1 percent, but the change was not significant. These results indicated that colline low-medium shrub cover area changed little during the sample period, but that the area has become highly fragmented. Area in montane wet-site shrub cover declined from 1.0 to 0.9 percent of the ERU, patch density dropped from 5.3 to 4.0 patches per 10 000 ha, and mean patch size declined from 8.7 to 5.5 ha (ns).

Herbland—Area and connectivity of montane bunchgrass cover increased significantly; percentage of area rose from 1.1 to 5.5 percent of the

ERU area, patch density increased from 3.0 to 5.3 patches per 10 000 ha (ns), and mean patch size rose eightfold from 11.2 to 92.6 ha (figs. 29, 32 and 33 and appendix 2). Area and connectivity of colline exotic grass and forb cover also rose sharply; percentage of area rose from 0 to 2.5 percent of the ERU, patch density increased from 0 to 3.3 patches per 10 000 ha, and mean patch size rose from 0 to 38.5 ha. Area of montane moist-site herb cover doubled, increasing from 0.6 to 1.2 percent (ns), patch density increased from 4.8 to 6.0 patches per 10 000 ha, and mean patch size rose from 8.9 to 14.2 ha (ns).

Nonforest-nonrange and other anthropogenic cover types—Area with this collection of types was small in our sample, and observed changes were insignificant (figs. 34 and 35 and appendix 2).

Structural classes—

Forest—No change in area of forest structures was significant at this scale, but connectivity of closed canopy stem-exclusion structures increased (fig. 36 and appendix 2). Patch density increased from 2.5 to 3.8 patches per 10 000 ha, and mean patch size rose from 22.5 to 31.7 ha (ns).

Woodland—Area in stem-exclusion structures increased significantly; percentage of area rose from 15.3 to 22.2 percent, a 45-percent increase in this structure (fig. 37 and appendix 2). Stem exclusion was the only woodland structure classified in this ERU. Changes in patch density and mean patch size of stem-exclusion structures were insignificant.

Shrubland—Area and connectivity of open low-medium shrub structures declined quite significantly; percentage of area fell by 19 percent, declining from 71.8 to 57.8 percent of the ERU area; mean patch size fell from 903.8 to 346.1 ha, for a 62-percent overall decline in mean patch size during the sample period (fig. 38 and appendix 2). Transition analysis indicated that losses to shrubland structure were primarily associated with woodland and herbland expansion.

Herbland—Area and connectivity of open herb structures rose dramatically; percentage of area increased threefold, rising from 3.4 to 10.1 percent, and mean patch size more than doubled, rising from 28.3 to 64.8 ha (fig. 38 and appendix 2).

Owyhee Uplands ERU—Subbasins sampled within the Owyhee Uplands ERU (figs. 21 to 22) included the Big Wood (BWD), Crooked Rattlesnake (CRT), and Upper Owyhee (UOW). Among these subbasins, 21 historical and current subwatershed pairs were sampled.

Physiognomic types—Many significant changes occurred among physiognomic types (fig. 25 and appendix 2). The most dramatic change in physiognomic types in the Owyhee Uplands ERU occurred to shrublands, where area and connectivity both sharply declined. Percentage of area in shrublands dropped from 88.8 to 81.0 percent. Nearly 90 percent of the ERU was comprised of shrublands in the historical condition; the observed decline reflected a net loss of 9 percent. Connectivity of shrublands declined with patch density, dropping from 7.9 to 5.7 patches per 10 000 ha; mean patch size fell from an average of 4695.3 to 3439.3 ha, a 27-percent decline in average patch size. Herbland area increased more than sevenfold from 1.0 to 7.4 percent of the ERU area; patch density rose from 3.0 to 4.5 patches per 10 000 ha, and mean patch size increased ninefold from 22.2 to 202.0 ha (ns). Patches interpreted as wet meadow, alpine meadow, dry meadow, grasses and forbs after logging, pasture, grassland, and grasses and forbs after burning (wildfire or prescribed) were classified along with native herblands as “herbland.” Transition analyses indicated that loss of shrubland area was associated with expanded woodland and herbland area. Gain in herbland area occurred primarily in open herbland structures (see next page).

Woodland area rose from 5.5 to 7.6 percent; connectivity of woodlands also increased. Patch density of woodland declined by more than half from 9.0 to 4.4 patches per 10 000 ha, and mean patch size increased from 15.9 to 64.4 ha. Increase in woodland was likely the result of historical fire exclusion and domestic livestock grazing practices (see Hann and others 1997). Area in forest was small in this ERU, and no significant change in area or connectivity was observed. Connectivity of nonforest-nonrange and other anthropogenic types increased during the sample period. Patch density fell from 6.7 to 4.5 patches per 10 000 ha, and mean patch size rose from 53.2 to 86.0 ha.

Cover types—

Forest—Only two forest cover types were observed in our sample of this ERU: Douglas-fir and aspen cottonwood-willow (figs. 26 to 28 and appendix 2). No significant change in area or connectivity was noted for either cover type, but mean patch size of aspen-cottonwood-willow cover declined from 11.7 to 5.4 ha (ns). Because these hardwood species reside primarily in riparian settings in this ERU, this observation suggests that agricultural and grazing practices may have minimized the average extent of patches of this cover type. Closer examination of this relation is warranted.

Woodland—Area and connectivity of the juniper cover type increased during the sample period (fig. 26 and appendix 2). Percentage of area increased by 36 percent, rising from 5.5 to 7.5 percent of the ERU area, patch density fell from 9.0 to 4.4 patches per 10 000 ha, and mean patch size rose fourfold from 15.8 to 64.3 ha.

Shrubland—Only one change in shrubland cover types was significant: area and connectivity of colline low-medium shrub cover declined during the sample period (figs. 29 to 31 and appendix 2). Percentage of area dropped from 87.7 to 79.3 percent, representing a 10-percent decline; patch density increased sharply by more than seven hundredfold from 8.9 to 7007.0 patches per 10 000 ha, and average patch size fell from 4443.5 to 70.1 ha, for a 98-percent decline in mean patch size.

Herbland—Among herbland cover types, two changes were significant (figs. 29, 32, and 33 and appendix 2). Most significant was the increase in area and connectivity of colline exotic grass and forb cover. Percentage of area of colline exotic grass and forb cover rose thirtyfold from 0.2 to 6.2 percent of the ERU area; patch density increased from 0.6 to 2.0 patches per 10 000 ha, and mean patch size increased more than thirtyfold from 5.8 to 195.8 ha. Area and connectivity of colline moist-site herb cover also increased. Percentage of area rose fivefold from 0.1 to 0.5 percent of the ERU area; patch density increased sixfold from 0.1 to 0.6 patch per 10 000 ha, and mean patch size climbed fourfold from 7.4 to 29.9 ha.

Nonforest-nonrange and other anthropogenic cover types—Cropland area increased from 1.1 to 1.4 percent, but the change was not significant at $P \leq 0.2$ (figs. 34 and 35 and appendix 2). But cropland connectivity increased significantly during the sample period; patch density dropped from 0.5 to 0.3 patch per 10 000 ha, and mean patch size increased by 45 percent from 21.8 to 31.7 ha. Area of exposed rock declined from 2.8 to 1.9 percent (ns), and connectivity of exposed rock area also declined. Mean patch size fell from 34.3 to 23.5 ha, suggesting substantial recent colonization of rock area by vegetation.

Connectivity of stream channel and nonvegetated flood-plain cover increased; patch density dropped from 2.3 to 0.7 patch per 10 000 ha, for a 65-percent decline, and mean patch size increased from 6.5 to 8.3 ha (ns). These observations suggest that current flood plains contain fewer areas of exposed soil than occurred in the historical vegetation coverage, but areas that occur tend to be larger. Finally, connectivity of water cover area increased with mean patch size, rising from 2.9 to 4.2 ha and representing a 45-percent increase in average patch size during the sample period. Area of water cover also increased significantly, but we are not able to show the increase because we rounded all values to one decimal place. Increase in water cover area and connectivity likely is associated with creation by ranchers of irrigation ditches, water holding “tanks,” and stock ponds.

Structural classes—

Forest—No significant change in area or connectivity of forest structures was in evidence at this reporting scale (fig. 36 and appendix 2).

Woodland—Among woodland structures, one change was significant (fig. 37 and appendix 2). Percentage of area of stem-exclusion structures rose from 5.2 to 6.5 percent of the ERU area; patch density declined from 8.8 to 5.3 patches per 10 000 ha, and mean patch size rose nearly threefold from 15.4 to 42.2 ha.

Shrubland—Several important changes were observed among shrubland structures (fig. 38 and appendix 2). Most noteworthy were changes in area and connectivity of open low-medium shrub structures. Percentage of area of open low-medium shrub structures declined by 9 percent, falling from 85.1 to 77.2 percent of the ERU area; patch density declined by 35 percent, dropping from 10.0 to 6.5 patches per 10 000 ha, and mean patch size decreased by 30 percent from 4607.3 to 3232.1 ha. Connectivity of closed low-medium structures sharply increased. Patch density fell from 4.7 to 1.6 patches per 10 000 ha, and mean patch size rose fourfold from 24.3 to 103.8 ha. Area of open tall shrub structures increased from 0.8 to 1.4 percent of the ERU, nearly a twofold rise.

Herbland—Area and connectivity of open herbland structures rose dramatically (fig. 38 and appendix 2). Percentage of area increased from 0.3 to 6.4 percent of the ERU, a twentyfold rise during the sample period; patch density rose from 1.9 to 3.5 patches per 10 000 ha, an 84-percent increase. Mean patch size of open herbland structures rose nearly thirtyfold from 6.3 to 183.0 ha.

Nonforest-nonrange and other types—Overall, area in these types declined from 5.0 to 4.4 of the ERU area but the change was not significant at this reporting scale (fig. 38 and appendix 2). Connectivity of nonforest-nonrange structures increased significantly; patch density dropped from 6.6 to 4.9 patches per 10 000 ha, and mean patch size rose more than 50 percent from 63.2 to 96.0 ha.

Snake Headwaters ERU—Subbasins sampled within the Snake Headwaters ERU (fig. 19) included the Lower Henry's (LHE), Palisades (PSD), and Snake Headwaters (SHW). Among these subbasins, 15 historical and current subwatershed pairs were sampled.

Physiognomic types—Three-quarters of the ERU is comprised of forest. Changes to area and connectivity of forest were insignificant, but changes to shrubland and herbland physiognomic types were significant (fig. 25, and appendix 2). Area and connectivity of shrublands declined; percentage of area declined from 16.3 to 13.9 percent, and mean patch size fell from 56.7 to 43.5 ha. Conversely, area and connectivity of herbland increased; percentage of area rose by over 40 percent, from an average of 6.1 to 8.7 percent of the ERU area, and patch density increased 37 percent, from 21.3 to 29.1 patches per 10 000 ha. Connectivity of nonforest-nonrange and other anthropogenic types increased; patch density dropped from 7.6 to 5.2 patches per 10 000 ha, and mean patch size rose from 26.6 to 34.2 ha.

Cover types—

Forest—Among forest cover types, several changes were significant during the sample period (figs. 26 to 28 and appendix 2). Area of subalpine fir-Engelmann spruce and limber pine cover types increased significantly, and area in aspen-cottonwood-willow and lodgepole pine cover declined. Area of subalpine fir-Engelmann spruce cover increased 29 percent from 24.3 to 31.4 percent of the ERU area, and area of limber pine increased 57 percent, rising from 0.7 to 1.1 percent of the ERU. Connectivity of limber pine cover also increased; mean patch size increased from an average of 2.3 to 9.9 ha, representing a fourfold increase in average patch size.

Aspen-cottonwood-willow cover declined from 8.8 to 5.7 percent of the ERU, a 35-percent drop, and area of lodgepole pine cover fell from 15.6 to 11.3 percent of the ERU area. Connectivity of aspen-cottonwood-willow cover declined with reduced mean patch size; average patch size fell from 38.3 to 26.2 ha. Despite declining area, connectivity of lodgepole pine cover increased; patch density fell from 19.1 to 15.4 patches per 10 000 ha, and mean patch size increased from 93.8 to 125.1 ha (ns). Connectivity of whitebark pine-subalpine larch cover declined significantly; patch density dropped from 6.0 to 4.1 patches per 10 000 ha, and mean patch size declined from 57.0 to 37.8 ha (ns). Finally, connectivity of Douglas-fir cover increased; mean patch size increased by 45 percent, rising from 96.3 to 139.3 ha.

Woodland—Although juniper is a relatively minor cover species, its area rose from 0.2 to 0.3 percent; changes in connectivity of juniper cover were not significant (fig. 26 and appendix 2).

Shrubland—Few significant changes were apparent among shrub cover types, and only the montane low-medium shrub cover type declined in area (figs. 29 to 31 and appendix 2). Percentage of area in montane low-medium shrub cover fell by 18 percent from 13.0 to 10.7 percent of the ERU area; changes in connectivity were not significant. Connectivity of montane mahogany species cover increased during the sample period; patch density rose from 0 to 0.4 patch per 10 000 ha, and mean patch size increased from 0 to 2.4 ha. Connectivity of montane wet-site shrub cover fell with declining mean patch size; average patch size dropped from 66.1 ha to 49.1 ha during the sample period, a 26-percent decline.

Herbland—Area and connectivity of montane bunchgrass cover increased, and area of montane exotic grass and forb cover and subalpine-alpine moist-site herb cover declined (figs. 29, 32, and 33 and appendix 2). Percentage of area in montane bunchgrass cover increased nearly twofold from 2.2 to 4.3 percent of the ERU, and patch density increased from 12.8 to 19.7 patches per 10 000 ha. Percentage of area in montane exotic grass and forb cover rose from 0.2 to 0.7 percent, and mean patch size increased sevenfold from 5.9 to 41.7 ha (ns). Finally, area in montane moist-site herb cover fell from an average of 1.5 to 1.1 percent of the ERU.

Nonforest-nonrange and other anthropogenic cover types—Few changes were significant among nonforest-nonrange types (figs. 34 and 35 and appendix 2). Area of postlogging-bare ground-burned cover increased significantly, but we are not able to show the increase because we rounded all values to one decimal place. Connectivity of this cover type also increased. Patch density increased from 0 to 0.3 patch per 10 000 ha, and mean patch size rose from an average of 0 to 1.1 ha. Connectivity of bare ground associated with roadcuts and sidecast (bare ground-roadcut) also increased, with patch density rising from 0.4 to 0.8 patch per 10 000 ha.

Structural classes—

Forest—Changes among forest structural classes were highly significant (fig. 36 and appendix 2). Stem-exclusion and old-forest structures declined significantly in area; only area in young multistory structures increased. Percentage of area of stem-exclusion open canopy structures dropped from an average of 19.1 to 15.3 percent of the ERU, and that of stem-exclusion closed canopy structures fell from 7.9 to 4.8 percent. Connectivity of the latter also declined; patch density declined by 30 percent from 19.7 to 13.8 patches per 10 000 ha, and mean patch size dropped by 38 percent from 40.9 to 25.3 ha. Connectivity of stand-initiation structures increased during the sample period; patch density rose from 14.9 to 19.8 patches per 10 000 ha (ns), and mean patch size doubled from 26.5 to 50.1 ha.

The most substantial change among forest structures in the ERU was that occurring to young multistory structures, which increased in area and connectivity of area. Percentage of area increased 40 percent, rising from 22.0 to 30.9 percent of the ERU during the sample period; patch density increased by 46 percent from 23.9 to 34.8 patches per 10 000 ha, and mean patch size rose from 145.3 to 269.6 ha, an 86-percent increase. Area of old multistory structures fell from 3.2 to 1.8 percent of the ERU area, and area of old single-story structures fell from 2.0 to 1.3 percent. Connectivity of old multistory structures also declined; mean patch size fell by 49 percent from 27.5 to 13.9 ha during the sample period. During the time represented by our remotely sensed historical vegetation map, old multistory structures comprised 4.3 percent of forest structure (the forest physiognomy represented 74.5 percent of the total ERU area); old single-story structures comprised 2.7 percent of all forest cover. In the existing condition, those values were 2.4 and 1.8 percent, respectively. Our sample of the ERU indicated that 40 percent of the historical area of old-forest structures has been lost.

Woodland—Area of stem-exclusion structures rose from 0.1 to 0.3 percent of the ERU, but the change was not significant (fig. 37 and appendix 2). Connectivity of stem-exclusion structures changed significantly; patch density rose from 0.4 to 0.6 patch per 10 000 ha, and mean patch size rose from 1.2 to 7.3 ha (ns). No other change in woodland structures was significant at this scale.

Shrubland—Only one change in shrub structures was significant; area of open low-medium shrub structure declined by 25 percent, dropping from 9.3 to 7.0 percent of the ERU (fig. 38 and appendix 2).

Herbland—Only one change in herb structures was significant; area and connectivity of open herb structures increased (fig. 38 and appendix 2). Percentage of area increased more than twofold, rising from 1.8 to 4.2 percent of the ERU; patch density increased by 76 percent from 10.0 to 17.6 patches per 10 000 ha, and mean patch size rose more than sevenfold from 12.6 to 90.2 ha.

Nonforest-nonrange and other anthropogenic types—Connectivity of nonforest-nonrange types increased; patch density dropped from 7.7 to 5.4 patches per 10 000 ha, and mean patch size increased by more than 50 percent, rising from 25.1 to 37.9 ha (fig. 38 and appendix 2).

Southern Cascades ERU—Subbasins sampled within the Southern Cascades ERU (fig. 15) included the Little Deschutes (LDS) and Upper Deschutes (UDS). Between these subbasins, 16 historical and current subwatershed pairs were sampled.

Physiognomic types—Many changes among physiognomic types occurred in this ERU (fig. 25 and appendix 2). Two of the most significant changes were highly correlated. Area of forest increased from 80.5 to 88.3 percent of the ERU, and area of nonforest-nonrange and other anthropogenic types declined from 18.4 to 8.1 percent. Increase in forest area and decline in nonforest-nonrange area was associated with forest regrowth from extensive tractor logging of ponderosa pine cover types conducted before the time of the historical photointerpretations.

Woodland area rose from 0 to 0.4 percent during the sample period. Although this change was not statistically significant, we regarded it as ecologically significant, given results of transition analysis and the comparison of existing conditions with the historical median 75-percent range. Connectivity of woodland also increased; patch density rose from 0 to 0.2 patch per 10 000 ha, and mean patch size increased from 0.1 to 21.1 ha (ns). As noted in many other ERUs, connectivity of shrubland declined; patch density rose from 0.9 to 1.9 patches per 10 000 ha, and mean patch size fell from 49.6 to 11.8 ha (ns).

Herbland area and connectivity increased during the sample period. Percentage of area climbed more than fourfold, rising from an average of 0.6 to 2.7 percent of the ERU area, patch density rose more than fivefold from 3.6 to 19.4 patches per 10 000 ha, and mean patch size remained stable. Most increase in herbland was associated with increased area in the postlogging-grass and forb cover type. Less than 1 percent (0.5 percent) of the area of the ERU was comprised of shrubland in the historical condition. Percentage of area remained relatively stable during the sample period, but connectivity of shrubland declined; patch density increased from 0.9 to 1.9 patches per 10 000 ha, and mean patch size fell from 49.6 to 11.8 ha (ns). Because shrublands were a relatively minor type, they are not addressed further in this section.

Cover types—

Forest—Few significant changes in forest cover types occurred during the sample period (figs. 26 to 28 and appendix 2). Area and connectivity of subalpine fir-Engelmann spruce cover increased; percentage of area rose from an average of 0 to 0.2 percent of the ERU area; patch density rose from 0 to 0.4 patch per 10 000 ha, and mean patch size increased from 0 to 8.9 ha. Area of Shasta red fir increased from 0.2 to 0.4 percent, but the change was not significant. Connectivity of red fir declined significantly; patch density rose from 0.1 to 1.3 patches per 10 000 ha, and mean patch size fell from an average of 14.4 to 4.1 ha. Area and connectivity of whitebark pine-subalpine larch cover increased; percentage of area rose from 0 to 0.8 percent. Although the change in area was not statistically significant, we regarded it as ecologically significant given results of transition analysis and comparison of existing conditions with the historical median 75-percent range. Patch density of whitebark pine-subalpine larch cover rose from 0 to 0.3 patch per 10 000 ha, and mean patch size increased from 0 to 20.5 ha (ns).

Connectivity of lodgepole pine cover increased significantly; patch density rose from 5.2 to 7.3 patches per 10 000 ha, and mean patch size remained stable. Connectivity of sugar pine-western white pine cover (both species occur in the

Southern Cascades ERU) declined significantly; patch density rose from 0.6 to 1.1 patches per 10 000 ha, and mean patch size remained stable.

Area of ponderosa pine cover rose and connectivity declined during the sample period. Percentage of area in ponderosa pine cover increased from 22.7 to 28.1 percent. The change in area was not statistically significant at $P \leq 0.2$, but we regarded it as ecologically significant given results of transition analysis and comparison of existing conditions with the historical median 75-percent range. The observed increase in ponderosa pine cover was associated with regrowth of forest (described above). Connectivity of ponderosa pine decreased significantly; patch density rose from 5.8 to 10.9 patches per 10 000 ha, and mean patch size declined. Connectivity of Douglas-fir cover also declined; patch density doubled from 0.9 to 1.8 patches per 10 000 ha, and mean patch size declined.

Woodland—Juniper cover increased from 0 to 0.4 percent, and mean patch size rose from 0 to 20.8 ha, but neither change was significant at $P \leq 0.2$ (fig. 26 and appendix 2).

Herbland—Dry meadows comprised a relatively small area of the ERU, but area and connectivity of dry meadows both increased during the sample period (figs. 29, 32, and 33 and appendix 2). Percentage of area rose from 0 to 0.1 percent, patch density rose from 0.4 to 0.8 patch per 10 000 ha, and mean patch size remained stable. Connectivity of wet meadows also increased; patch density rose from 2.6 to 4.3 patches per 10 000 ha, and mean patch size remained unchanged. Area in postlogging grass and forb cover increased from an average of 0 to 1.6 percent of the ERU, and patch density rose from 0 to 42.1 patches per 10 000 ha.

Nonforest-nonrange and other anthropogenic cover types—Area and connectivity of urban and rural developments increased; percentage of area rose during the sample period from 0 to 0.3 percent of the ERU, patch density increased fourfold from 0.1 to 0.4 patch per 10 000 ha, and mean patch size increased more than fourfold from 4.1 to 18.6 ha (figs. 34 and 35 and appendix 2). As noted above in the discussion of changes among physiognomic types, the principal decline in nonforest-nonrange types was that occurring to postlogging-bare ground-burned areas. Percentage of area declined during the sample period from 10.1 in the historical vegetation coverage to 1.8 percent in the existing condition; decline was associated with regrowth of ponderosa pine as noted above. Patch density increased more than threefold, rising from 2.8 to 10.6 patches per 10 000 ha, and mean patch size dropped from 749.3 to 8.5 ha (ns), a 99-percent decline in average patch size from historical conditions.

Structural classes—

Forest—Two changes in area were significant, but most significant were changes to connectivity of forest structures (fig. 36 and appendix 2). With few exceptions, forest structures were more highly fragmented in the current condition than in the historical condition, with large changes noted to both mean patch size and patch density. Area in stand-initiation structures increased slightly, but the change was not significant. Connectivity of stand-initiation structures declined. Patch density rose by more than 350 percent, from an average of 6.8 to 24.3 patches per 10 000 ha, and mean patch size dropped from 171.5 to 75.4 ha (ns). Connectivity of stem-exclusion open canopy structures also declined. Patch density more than doubled from 8.6 to 19.2 patches per 10 000 ha, and mean patch size dropped by 43 percent from 150.5 to 86.5 ha. In contrast, area and connectivity of stem-exclusion closed canopy structures increased substantially; percentage of area rose nearly tenfold from 0.5 to 4.8 percent as a result of the regrowth of ponderosa pine; patch density rose from 0.9 to 4.8 patches per 10 000 ha, and mean patch size increased from 19.2 to 116.7 ha.

Area and connectivity of understory reinitiation structures declined; percentage of area fell from 10.3 to 8.7 percent (ns); patch density rose from 5.6 to 9.2 patches per 10 000 ha, and mean patch size dropped by 54 percent from 232.6 to 106.6 ha. Connectivity of young multistory structures also declined. Patch density rose from 7.6 to 17.3 patches per 10 000 ha, and mean patch size remained stable.

Area of old single-story structure increased during the sample period. This likely occurred because a considerable area of the sampled subbasins resides in congressionally designated wilderness, is administratively withdrawn from the timber base, or is otherwise roadless and has not been entered for timber harvest. The primary effect of management in these areas is that of forest aging with the exclusion of most fire disturbances. Percentage of area of old single-story structures rose from 1.6 to 3.7 percent of the ERU, a 131-percent increase during the sample period, and patch density rose from 1.1 to 2.9 patches per 10 000 ha.

Woodland—Area and connectivity of woodland stem-exclusion structures increased (fig. 37 and appendix 2). Percentage of area rose from 0 to 0.4 percent, and patch density rose from 0 to 0.2 patch per 10 000 ha.

Shrubland—No changes in area or connectivity of shrubland structures were significant at this reporting scale (fig. 38 and appendix 2).

Herbland—No changes in area or connectivity of herbland structures were significant at this reporting scale (fig. 38 and appendix 2).

Nonforest-nonrange and other anthropogenic types—As noted earlier, area and connectivity of nonforest-nonrange structures declined significantly (fig. 38 and appendix 2). Percentage of area fell from an average of 19.5 to 11.2 percent of the ERU area; patch density rose from 14.4 to 40.5 patches per 10 000 ha, and mean patch size declined from 856.6 to 40.4 ha (ns). This decline of nonforest–nonrange structures was associated with regrowth of forest structures on postlogging-bare ground-burned cover types.

Upper Clark Fork ERU—Subbasins sampled within the Upper Clark Fork ERU (figs. 8 and 11) included the Blackfoot (BFM), Bitterroot (BTR), and Flint Rock (FLR). Among these subbasins, 32 historical and current subwatershed pairs were sampled.

Physiognomic types—Few changes in physiognomic conditions were noteworthy (fig. 25 and appendix 2). More than 85 percent of the historical and current area of the ERU was forested. Area and connectivity of forests remained relatively stable during the sample period. As with most other ERUs, connectivity of shrubland and herbland declined; shrubland patch density rose from 3.7 to 4.6 patches per 10 000 ha, and mean patch size fell from 60.5 to 31.4 ha (ns). Shrublands comprised less than 3 percent of the historical or current area. Herbland patch density rose from 13.8 to 18.2 patches per 10 000 ha, and mean patch size fell from 33.6 to 28.7 ha (ns). Herblands comprised less than 6 percent of the historical or current area. Area and connectivity of nonforest-nonrange and other anthropogenic types increased during the sample period, but change in area was not significant at $P \leq 0.2$. Patch density rose from 8.0 to 10.5 patches per 10 000 ha, and mean patch size was relatively stable.

Cover types—

Forest—Few changes in area of forest cover types were significant at this reporting scale (figs. 26 to 28 and appendix 2). The most significant increase was that occurring to area of subalpine fir-Engelmann spruce; percentage of area rose from 14.2 to 17.3 percent. Connectivity of subalpine fir-Engelmann spruce cover declined; patch density increased from 13.6 to 16.5 patches per 10 000 ha, and mean patch size remained unchanged. Connectivity of western larch cover also declined; patch density rose from 3.8 to 6.6 patches per 10 000 ha, a 74-percent increase, and mean patch size remained unchanged.

Area of whitebark pine-subalpine larch cover declined by 19 percent from 4.3 to 3.5 percent of the ERU area. The most significant decrease in area observed for any forest cover type was that occurring to area of ponderosa pine; percentage of area declined from 12.3 to 9.5 percent of the ERU area, a 23-percent decrease during the sample period. Connectivity of ponderosa pine cover also declined; patch density remained relatively stable, and mean patch size declined by 50 percent from 155.6 to 78.2 ha.

Area and connectivity of limber pine cover increased but the change in area was not significant; percentage of area rose from 0 to 0.4 percent, patch density increased from 0.1 to 0.3 patch per 10 000 ha, and mean patch size increased from 3.4 to 7.7 ha (ns). Area of the Douglas-fir cover type remained stable during the sample period but connectivity declined; patch density increased from 14.8 to 17.6 patches per

10 000 ha, and mean patch size declined by 37 percent, falling from 417.1 to 262.9 ha. Finally, connectivity of mountain hemlock cover increased; patch density increased from 0 to 0.1 patch per 10 000 ha, and mean patch size rose from 0 to 4.5 ha.

Shrubland—Overall, area and connectivity of shrub cover types declined in the Upper Clark Fork ERU, but only a few changes were significant (figs. 29 to 31 and appendix 2). Areas of montane mahogany species cover and montane subshrub (beargrass) cover both declined. Percentage of area of montane mahogany species cover fell from 0.1 to 0 percent, and connectivity declined. Patch density of montane mahogany cover fell from an average of 0.3 to 0 patch per 10 000 ha, and mean patch size declined from an average of 1.9 to 0.6 ha, for a 68-percent decrease in average patch size. Percentage of area in montane subshrub cover likewise fell from 0.3 to 0 percent, and connectivity declined. Patch density of montane subshrub cover declined by 87 percent, falling from 0.8 to 0.1 patch per 10 000 ha, and mean patch size remained stable.

Connectivity of colline low-medium shrub cover declined; patch density rose more than fortyfold from 0.5 to 21.1 patches per 10 000 ha, and mean patch size declined by 98 percent from 9.7 to 0.2 ha. Connectivity of montane low-medium shrub cover increased during the sample period; patch density increased from 0.5 to 0.7 patch per 10 000 ha, and mean patch size more than tripled from 6.3 to 19.8 ha (ns). Connectivity of montane tall shrub cover likewise increased during the sample period; patch density increased from 0.5 to 0.9 patch per 10 000 ha, and mean patch size remained constant. Finally, area of subalpine and alpine wet-site shrub cover, a relatively minor cover component, increased, and connectivity declined; percentage of area increased from 0 percent in the historical condition by an amount less than 0.1 percent; patch density declined from 0.1 to 0 patch per 10 000 ha, and mean patch size fell from 0.8 to 0 ha, for 100-percent declines in patch density and average patch size.

Herbland—Several changes in area and connectivity of herbland cover types were significant (figs. 29, 32, and 33 and appendix 2). Area and connectivity of montane bunchgrass cover declined. Percentage of area declined by 42 percent during the sample period, dropping from 3.1 to 1.8 percent of the ERU area. Patch density of montane bunchgrass cover fell from 8.4 to 7.3 patches per 10 000 ha, and mean patch size dropped from 23.9 to 13.6 ha, for a 43-percent decline in average patch size. Area of montane exotic grass and forb cover increased and connectivity declined. Percentage of area rose from 0.1 to 0.2 percent of the ERU, representing a doubling in area. Patch density of montane exotic grass and forb cover tripled, rising from 0.4 to 1.2 patches per 10 000 ha, and mean patch size remained relatively stable.

Connectivity of montane and subalpine-alpine moist-site herb cover types increased; patch density increases were from 1.8 to 2.3, and from 0.1 to 0.6 patch per 10 000 ha, respectively. Mean patch sizes of both cover types also increased, but changes were not significant at $P \leq 0.2$. Finally, area of herb cover resulting from harvest activities (postlogging-grasses and forbs) increased but connectivity of that area declined. Percentage of area of postlogging-grass and forb cover rose from 0 to 0.9 percent of the ERU area; patch density increased more than one hundredfold from 0.3 to 40.5 patches per 10 000 ha, and mean patch size fell by 79 percent from 1.9 to 0.4 ha. These latter changes indicate that during the sample period, harvest activities within the ERU affected many more areas, but harvest units are typically smaller today (79 percent smaller) than was apparent in the historical photos.

Nonforest-nonrange and other anthropogenic cover types—Area of urban and rural development increased slightly, but the change was not significant (figs. 34 and 35 and appendix 2). Connectivity of urban and rural development areas increased; patch density doubled during the sample period from 0.3 to 0.6 patch per 10 000 ha, and mean patch size increased from 1.2 to 2.0 ha (ns).

Area and connectivity of postlogging-bare ground-burned cover increased. Percentage of area rose from 0.1 to 1.5 percent of the ERU area, representing a fifteenfold increase; patch density increased more than fourfold from 0.5 to 2.3 patches per 10 000 ha, and mean patch size rose fivefold from 3.1 to 15.9 ha. Finally, connectivity of water cover increased; patch density rose from 1.5 to 1.8 patches per 10 000 ha, and mean patch size remained constant.

Structural classes—

Forest—The most significant loss of area was associated with stand-initiation structures, which fell by 30 percent, from 15.9 to 11.1 percent of the ERU area (fig. 36 and appendix 2). Stand-initiation structures historically comprised 18 percent of forest structure; currently they comprise 13 percent of forest structure. Patch density of stand-initiation structures remained constant and mean patch size declined from 69.8 to 50.8 ha, indicating declining connectivity. This loss in area and connectivity of stand-initiation structures most likely was associated with effective fire prevention and suppression and the substitution of small regeneration cutting units for larger stand-replacing fires.

Connectivity of stem-exclusion open canopy structures also declined; patch density rose from 27.5 to 35.3 patches per 10 000 ha; mean patch size declined by 28 percent, falling during the sample period from 78.2 to 56.3 ha. In contrast, area and connectivity of stem-exclusion closed canopy structures increased; percentage of area swelled by 26 percent, rising from 16.7 to 21.1 percent of the ERU area, patch density remained stable, and mean patch size rose by 255 percent from 157.9 to 402.9 ha. Both area and connectivity of understory reinitiation structures declined, but only the change in connectivity was significant. Percentage of area fell from 15.6 to 14.0 percent (ns); patch density rose from 16.3 to 19.8 patches per 10 000 ha, and mean patch size declined by 30 percent, falling from an average of 97.6 to 68.6 ha.

Area of old multistory structures declined slightly from 0.6 to 0.4 percent of the ERU, and area of old single-story structures increased slightly from 0.2 to 0.3 percent, but neither change was significant at $P \leq 0.2$. Connectivity of old single-story structures increased significantly. Patch density rose from 0.5 to 1.0 patch per 10 000 ha (ns) and mean patch size increased fourfold from 1.1 ha to 4.5 ha.

Shrubland—Only one significant decline in shrub structure was observed: area of closed tall shrub structures fell from 0.5 to 0.3 percent of the ERU area (fig. 38 and appendix 2). No significant change in connectivity of these structures was observed. Connectivity of open tall shrub structures increased; patch density increased from 2.0 to 2.7 patches per 10 000 ha, and mean patch size remained relatively constant.

Herbland—Area and connectivity of closed herb structures declined; percentage of area fell from 3.5 to 2.1 percent of the ERU area, patch density remained stable, and mean patch size declined from an average of 25.9 to 15.3 ha, for an average decline of 41 percent (fig. 38 and appendix 2).

Nonforest-nonrange and other anthropogenic types—Area and connectivity of these types increased (fig. 38 and appendix 2). Percentage of area increased by 49 percent, rising from 5.3 to 7.9 percent of the ERU, patch density increased by 68 percent, rising from 8.7 to 14.6 patches per 10 000 ha, and mean patch size remained stable. The observed rise in area and connectivity was mostly driven by increasing area of postlogging-bare ground-burned cover.

Upper Klamath ERU—Subbasins sampled within the Upper Klamath ERU (fig. 20) included the Lost (LST) and Upper Klamath Lake (UKL). Between these subbasins, 12 historical and current subwatershed pairs were sampled.

Physiognomic types—About one-half of the area of this ERU was forested in both the historical and current vegetation coverages; shrublands comprised one-fifth of the area; and herblands, woodlands, and other nonforest-nonrange types each comprised about one-tenth of the area (fig. 25 and appendix 2). Percentage of area of forest declined by 6 percent, falling from 50.5 to 47.5 percent of the ERU area. Connectivity of forest also declined; patch density fell from 7.8 to 5.9 patches per 10 000 ha, and mean patch size remained stable. Woodland area and connectivity increased. Percentage of woodland area rose sharply by 52 percent from 8.4 to 12.8 percent of the ERU area. Woodland patch density fell from 10.6 to 9.0 patches per 10 000 ha, and mean patch size increased threefold from 58.0 to 189.2 ha.

Shrubland area and connectivity both declined, but neither change was significant. Percentage of area declined from 21.4 to 18.8 percent (ns); patch density fell from 20.5 to 18.1 patches per 10 000 ha (ns), and mean patch size dropped from 275.8 to 116.8 ha (ns). These seemingly large changes were not statistically significant because highly dissimilar subwatersheds were pooled at this large reporting scale. Similarly, herbland area and connectivity declined, but none of the changes was significant. Area and connectivity of nonforest-nonrange and other anthropogenic types both increased significantly. Percentage of area of nonforest-nonrange climbed by 32 percent from 9.1 to 12.0 percent; patch density rose from 3.9 to 6.9 patches per 10 000 ha, and mean patch size more than doubled, increasing from 160.2 to 338.7 ha.

Cover types—

Forest—Ponderosa pine comprised 53 percent of the historical forest vegetation and 49 percent of the current forest vegetation, for a net decline of 4 percent during the sample period (figs. 26 to 28 and appendix 2). Percentage of area of ponderosa pine cover dropped from 26.7 to 23.5 percent of the ERU area. Change in connectivity of ponderosa pine cover was not significant at this reporting scale, but mean patch size fell from 387.3 to 256.7 ha. Connectivity of Douglas-fir cover declined; patch density remained stable, and mean patch size dropped by 68 percent from 31.9 to 10.3 ha. Connectivity of mountain hemlock cover also declined; patch density remained stable, and mean patch size dropped by 21 percent from 308.0 to 242.9 ha. No other change in area or connectivity of forest cover types was significant at this reporting scale.

Woodland—Virtually all woodland identified through photointerpretation was juniper woodland (fig. 26 and appendix 2). Area and connectivity of juniper woodlands increased significantly during the sample period. Percentage of area climbed by 52 percent, from 8.4 to 12.8 percent of the ERU area, patch density declined from 10.6 to 8.9 patches per 10 000 ha, and mean patch size rose threefold from 58 to 189.2 ha.

Shrubland—Few changes among shrub cover types were significant (figs. 29 to 31 and appendix 2). Area and connectivity of montane low-medium shrub cover declined, but connectivity changes were not significant at $P \leq 0.2$. Percentage of area of montane low-medium shrub cover fell by 19 percent, from 18.5 to 14.9 percent of the ERU area. Connectivity of colline low-medium shrub cover declined; patch density rose sharply by nearly thirtyfold, from 4.7 to 139.0 patches per 10 000 ha, and mean patch size plummeted by 90 percent from 13.4 to 1.4 ha. Finally, area and connectivity of montane wet-site shrub cover declined significantly during the sample period. Percentage of area fell from an average of 0.6 to 0.4 percent of the ERU area, patch density declined from 1.5 to 0.8 patch per 10 000 ha, and mean patch size dropped from 35.8 to 29.5 ha (ns).

Herbland—Many area and connectivity changes were significant among herbland cover types (figs. 29, 32, and 33 and appendix 2). Area and connectivity of montane bunchgrass cover declined significantly during the sample period. Percentage of area fell from an average of 0.7 to 0.4 percent of the ERU; patch density remained unchanged, and mean patch size dropped by 65 percent, from an average of 26.3 to 9.1 ha. Area of colline bunchgrass cover also declined during the sample period. Percentage of area fell from 2.8 to 1.0 percent of the ERU, for a net loss of 64 percent of the cover type area. Area of colline exotic grass and forb cover increased from 0 to 0.4 percent of the ERU area, but the change was not statistically significant at $P \leq 0.2$. But connectivity of colline exotic grass and forb cover increased significantly; patch density rose from 0.1 to 0.4 patch per 10 000 ha, and mean patch size increased from 1.5 to 18.8 ha (ns). Because of our relatively small sample size of 12 subwatershed pairs, observed changes in percentage of area and mean patch size of colline exotic grass and forb cover were not significant at $P \leq 0.2$, but the changes suggest increasing area and connectivity of exotic grass and forb cover in colline elevation settings and warrant a closer look.

Area and connectivity of colline moist-site herb cover declined significantly during the sample period. Percentage of area fell by 91 percent from an average of 1.1 to 0.1 percent of the ERU area; patch density remained unchanged, and mean patch size dropped from an average of 49.2 to

3.2 ha, for a net decline in mean patch size of 93 percent. Connectivity of montane moist-site herb cover also declined; patch density rose from an average of 1.9 to 2.9 patches per 10 000 ha, and mean patch size remained unchanged. Finally, area of postlogging grass and forb cover increased and connectivity of that cover declined. Percentage of area rose from 0 to 0.1 percent of the ERU area, patch density climbed more than seventyfold from 0.1 to 7.4 patches per 10 000 ha, and mean patch size plummeted from 1.9 to 0.1 ha, for a net decline of more than 95 percent.

Nonforest-nonrange and other anthropogenic cover types—Connectivity of most anthropogenic cover types increased, and area in only a few significantly increased (figs. 34 and 35 and appendix 2). The most dramatic increase in area was associated with cropland cover; percentage of area rose sharply by 50 percent from an average of 7.0 to 10.5 percent of the ERU area. Connectivity of cropland area also increased; patch density remained stable, but mean patch size climbed from 187.0 to 384.8 ha, for a net rise in average patch size of 106 percent. Connectivity of pasture cover increased; patch density dropped from 0.3 to 0 patch per 10 000 ha, and mean patch size rose from an average of 702.3 ha in the historical condition to 898.1 ha in the existing condition (ns).

Connectivity of urban and rural developments increased; patch density remained unchanged, and mean patch size rose threefold from 1.2 to 3.8 ha. Area and connectivity of postlogging-bare ground-burned cover increased; percentage of area rose from an average of 0 to 0.4 percent of the ERU area, patch density rose from 0.1 to 2.9 patches per 10 000 ha, and mean patch size remained unchanged.

Structural classes—

Forest—Several changes in area and connectivity of forest structures were significant (fig. 36 and appendix 2). Area of stand-initiation structures increased by 89 percent, but the observed change in area was not statistically significant at $P \leq 0.2$; percentage of area rose from an average of 1.9 to 3.6 percent of the ERU area. Connectivity of stand-initiation structures increased significantly; patch density remained unchanged, and mean patch size doubled from 31.2 to 62.1 ha. Because half of the forest cover is ponderosa pine, we would expect that the dominant disturbance influence on vegetation patterns in the historical condition would be nonlethal surface fires and area in stand-initiation structures would be small, as was observed. Increased connectivity of stand-initiation structures likely is the result of expanding area of stand-replacing fires and regeneration harvest.

Connectivity of stem-exclusion closed canopy structures declined; patch density rose by 76 percent from an average of 2.1 to 3.7 patches per 10 000 ha, and mean patch size remained unchanged. Area and connectivity of understory reinitiation structures increased. Change in area was not statistically significant at $P \leq 0.2$, but we regarded the change as ecologically significant given results of transition analysis and comparison of existing conditions with the historical median 75-percent range. Percentage of area rose by 45 percent from an average of 5.6 to 8.1 percent of the ERU area; patch density increased by 52 percent from an average of 6.9 to 10.5 patches per 10 000 ha; and mean patch size rose nearly sevenfold from an average of 42.9 to 292.3 ha, but the change was not statistically significant at $P \leq 0.2$. In contrast, area of young multistory structures declined; percentage of area dropped 22 percent from an average of 21.1 to 16.4 percent of the ERU area. Mean patch size of young multistory structures dropped sharply from 401.1 to 163.9 ha, but the change was not statistically significant at $P \leq 0.2$.

Perhaps the most significant changes to area and connectivity of forest structure occurred to old-forest structures. Percentage of area of old multistory structures rose from 4.3 to 5.5 percent of the ERU area (ns); patch density nearly doubled, increasing from an average of 3.5 to 6.6 patches per 10 000 ha, and mean patch size fell from 46.1 to 34.1 ha (ns). Area and connectivity of old single-story structures declined significantly. Percentage of area fell by 35 percent, declining from an average of 7.4 to 4.8 percent of the ERU area. Patch density of old single-story structures increased by 82 percent, from an average of 3.9 to

7.1 patches per 10 000 ha, and mean patch size fell by 67 percent, dropping from 69.6 to 22.7 ha. In the historical vegetation coverage, old multistory structures comprised 8.5 percent of forest structure; they currently comprise 11.6 percent, but the difference is not statistically significant. In the historical vegetation coverage, old single-story structures comprised 14.5 percent of forest structure; they currently comprise 10 percent. Overall, old-forest structures comprised 23 percent of forest structure in the historical vegetation coverage. In the current coverage, old-forest structures comprise 21.7 percent of forest structure.

Woodland—Nearly all changes in area and connectivity of woodland structures indicated expanding woodlands (fig. 37 and appendix 2). Area of stand-initiation, stem-exclusion, understory reinitiation, and old multistory structures increased during the sample period, but the observed change in area of old multistory structures was not significant. Percentage of area of stand-initiation structure rose nearly threefold, from 0.4 to 1.1 percent of the ERU area. Change in area was not statistically significant at $P \leq 0.2$, but we regarded the change as ecologically significant given results of transition analysis and comparison of existing conditions with the historical median 75-percent range. Area of stem-exclusion structure increased; percentage of area rose from 5.9 to 7.6 percent of the ERU area. Area and connectivity of understory reinitiation structure also increased. Percentage of area rose nearly twofold from 2 to 3.8 percent; patch density increased from 2.8 to 3.4 patches per 10 000 ha, and mean patch size rose more than sixtyfold from 5.3 to 330.1 ha (ns).

Shrubland—No significant change in area of any shrub structure was apparent in the Upper Klamath ERU (fig. 38 and appendix 2). The most substantial change occurring to area of shrub structures was associated with open low-medium structure; percentage of area declined from 18.5 to 15.9 percent. Connectivity of closed low-medium and open tall structures increased significantly. Patch density of closed low-medium structures fell from an average of 3.6 to 1.4 patches per 10 000 ha, and mean patch size rose threefold from 24.8 to 73.1 ha. Patch density of open tall structures declined from 3.2 to 1.9 patches per 10 000 ha, and mean patch size remained unchanged. Connectivity of closed tall structures declined; patch density declined from 1.3 to 0.6 patches per 10 000 ha, and mean patch size dropped from an average of 9.2 to 4.3 ha, for a net decrease of 53 percent.

Herbland—Area of open and closed herbland structures declined during the sample period (fig. 38 and appendix 2). Percentage of area of open herbland fell by 63 percent from an average of 3.8 to 1.4 percent of the ERU area. Percentage of area in closed herbland fell by 31 percent from an average of 1.6 to 1.1 percent of the ERU area.

Nonforest-nonrange and other anthropogenic types—Area and connectivity of these types rose sharply (fig. 38 and appendix 2). The observed increase in area was associated with expanded cropland area during the sample period. Percentage of area in nonforest-nonrange and other anthropogenic types rose by 31 percent from an average of 13.9 to 18.2 percent of the ERU area. Patch density doubled, increasing from 4.5 to 9.1 patches per 10 000 ha, and mean patch size climbed sharply by 85 percent, rising from an average of 340.8 to 630.1 ha.

Upper Snake ERU—Subbasins sampled within the Upper Snake ERU (figs. 18 to 19 and 22) included the Lower Henry's (LHE), Lake Walcott (LWC), and Medicine Lodge (MDL). Among these subbasins, 15 historical and current subwatershed pairs were sampled.

Physiognomic types—According to our sample of remotely sensed historical vegetation conditions, three-quarters of the area of the Upper Snake ERU was shrubland, 10 percent of the area was herbland, 10 percent was comprised of nonforest-nonrange and other anthropogenic types, and the combined area of forest and woodland was about 5 percent (fig. 25 and appendix 2). The most substantial change in area of any physiognomic type occurred in shrublands; percentage of area fell from 73.8 to 68.5 percent, representing a net loss of 7 percent of the historical area of the type. The observed change in area was not statistically significant at $P \leq 0.2$, but we regarded the change as ecologically significant given results of transition analysis and comparison of existing conditions with the historical median 75-percent range. Native shrublands were lost primarily to expanding cropland area. Area of nonforest-nonrange and other anthropogenic types increased by a corresponding amount owing to the noted increase in croplands. Percentage of cropland area rose from an average of 10.3 to 15.4 of the ERU area. Although forests represented a relatively minor area, forest area and connectivity both increased significantly. Percentage of area rose from an average of 2.4 to 3.2 percent of the ERU, and mean patch size increased by 60 percent, rising from 26.6 to 42.5 ha.

Cover types—

Forest—No change in area of any forest cover type was significant, but connectivity of aspen-cottonwood-willow cover increased (figs. 26 to 28 and appendix 2). Patch density remained unchanged, and mean patch size increased from 5.5 to 7.0 ha. Connectivity of Douglas-fir cover also increased; patch density declined from an average of 2.7 to 1.3 patches per 10 000 ha, and mean patch size increased threefold from an average of 13.0 to 39.8 ha (ns).

Woodland—Upper Snake ERU woodlands were comprised of juniper and pinyon-juniper cover types. No significant changes in area or connectivity were noted for either cover type (fig. 26 and appendix 2).

Shrubland—Area and connectivity of colline low-medium shrub cover declined sharply; percentage of area fell by 12 percent from an average of 71.0 to 62.3 percent of the ERU area (figs. 29 to 31 and appendix 2). Patch density of colline low-medium shrub cover increased nearly eight hundredfold, rising from 7.3 to 5,679.9 patches per 10 000 ha, and mean patch size declined by 98 percent, falling from an average of 3,639.5 to 56.8 ha.These data suggest that remaining colline low-medium shrub cover is a highly fragmented remnant of a once expansive cover type. Connectivity of colline tall shrub cover increased; patch density declined by 38 percent from 5.8 to 3.6 patches per 10 000 ha, and mean patch size increased by 70 percent from an average of 29.9 to 50.9 ha.

Herbland—Among herbland cover types, only two changes were significant (figs. 29, 32, and 33 and appendix 2). Area of colline bunchgrass cover increased; percentage of area rose by 40 percent from 3.7 to 5.2 percent. Connectivity of colline exotic grass and forb cover increased; patch density remained stable during the sample period, and mean patch size increased about 2 1/2-fold from an average of 29.3 to 75.4 ha.

Nonforest-nonrange and other anthropogenic cover types—Two changes were significant among anthropogenic cover types: cropland area and connectivity increased, as did area and connectivity of urban and rural developments (figs. 34 and 35 and appendix 2). Percentage of area of cropland rose more than fourfold from an average of 2.7 to 12.1 percent of the ERU area; patch density remained stable, and mean patch size increased fourfold, rising from an average of 52.1 to 229.4 ha. Likewise, percentage of area of urban and rural developments rose from an average of 0 to 0.2 percent of the ERU area; patch density increased from 0.6 to 1.7 patches per 10 000 ha, and mean patch size more than tripled, rising from 1.1 to 3.8 ha.

Area of exposed rock (cliffs, scree slopes, talus, rimrock, outcrops) declined; percentage of area dropped from an average of 6.8 to 2.6 percent of the ERU area, a net loss of 62 percent of the historical area of the cover type; patch density remained stable; and mean patch size fell sharply from an average of 1,884.0 to 182.3 ha (ns), for a net decline in average patch size of 90 percent of the historical area.

Structural classes—

Forest—Because forests were a relatively minor physiognomic type in this ERU, changes among forest structures were few (fig. 36 and appendix 2). Area of stand-initiation structure declined and connectivity increased. Percentage of area fell from an average of 0.8 to 0.3 percent of the ERU, patch density declined from 4.9 to 1.7 patches per 10 000 ha, and mean patch size remained unchanged. Area and connectivity of stem-exclusion open canopy structures increased; percentage of area rose from an average of 0.4 to 1.0 percent of the ERU area, patch density remained stable, and mean patch size rose from 6.9 to 11.9 ha.

Connectivity of young multistory structures also increased; patch density declined from 2.7 to 1.2 patches per 10 000 ha, and mean patch size rose threefold from an average of 7.5 to 22.6 ha (ns).

Woodland—As noted above, no significant change in area or connectivity of woodland cover types was observed, but structure of Upper Snake woodlands did change significantly (fig. 37 and appendix 2). Area and connectivity of stem-exclusion structures increased; percentage of area rose threefold from an average of 0.7 to 2.0 percent of the ERU area, patch density increased from 4.0 to 6.2 patches per 10 000 ha, and mean patch size more than doubled, rising from an average of 8.7 to 17.9 ha. Area of understory reinitiation structures declined by a comparable amount; percentage of area fell from 1.8 to 0.8 percent of the ERU. Connectivity of understory reinitiation structures also declined with patch density remaining unchanged and mean patch size declining from an average of 7.9 to 4.4 ha.

Shrubland—Considering all forest and range structures, shrub structures changed most significantly (fig. 38 and appendix 2). Area and connectivity of open tall structures increased; percentage of area rose by 73 percent from an average of 3.0 to 5.2 percent of the ERU area, patch density was unchanged, and mean patch size rose from an average of 35.6 to 54.5 ha. Area and connectivity of closed tall structures declined; percentage of area fell from 0.7 to 0.4 percent of the ERU; patch density dropped nearly 50 percent from 4.0 to 2.1 patches per 10 000 ha, and mean patch size declined from 13.3 to 2.5 ha (ns).

Area of open and closed low-medium shrub structures declined, but connectivity of remaining closed low-medium structure increased during the sample period. The observed loss of area of both open and closed low-medium shrub structures was not statistically significant at $P \leq 0.2$, but we regarded it as ecologically significant given primary transitions and comparison of the median value in the existing condition with the historical median 75-percent range. Percentage of area of open low-medium shrub structure fell from 63.1 to 57.8 percent, and percentage of area of closed low-medium structure declined from 8.2 to 5.0 percent. Patch density of closed low-medium structures declined by 74 percent, dropping from 11.1 to 2.9 patches per 10 000 ha, and mean patch size rose threefold from 73.9 to 217.3 ha (ns).

Herbland—No significant change in area or connectivity was noted for open or closed herb structures (fig. 38 and appendix 2).

Nonforest-nonrange and other anthropogenic types—As noted above, area of nonforest-nonrange and other anthropogenic types increased significantly owing to expanding cropland area (fig. 38 and appendix 2). Percentage of cropland area rose from an average of 10.8 to 16.0 percent of the ERU area (ns). The observed rise in area was not statistically significant at $P \leq 0.2$ but was ecologically significant given primary transitions and historical median 75-percent range information.

Landscape Patterns

In this second set of analyses, we evaluated the effects on landscape vegetation patterns of management activities occurring during the period between our historical and current vegetation samples. Our null hypothesis was no significant difference in landscape vegetation patterns between historical and current photointerpreted vegetation conditions. We speculated that managed forest and range landscapes become structurally more complex, diverse, and fragmented as a result of historical timber harvest and grazing activities and effective exclusion of fire. We further speculated that forest landscapes comprised of large wilderness and roadless area become less diverse and exhibit increased connectivity owing to the dominant role of effective fire prevention and suppression strategies and grazing activities in these areas. Table 19 displays results of 10 landscape metrics summarized by ERU.

We describe significant change in each ERU for an array of pattern metrics that highlight landscape-scale change in the kind and number of unique patch types, the distribution and equitability of land area among patch types, the degree of dispersion of patch type area, the extent to which patch types are interspersed with and juxtaposed against each other patch type, and the degree of edge contrast occurring between edges

Table 19—Landscape metric results for 13 ecological reporting units in the midscale assessment of the interior Columbia River basin where patch types were cover type-structural class doublets

	Ecological reporting units												
Landscape metrics	Blue Mts.	C. Idaho Mts.	Col. Plateau	L. Clark Fork	No. Cascade	N. Glac. Mts.	N. Great Basin	Owyhee Uplands	Snake Headw.	So. Cascade	U. Clark Fork	Upper Klamath	Upper Snake
Richness and diversity:													
RPR_h[a,b]	11.4	11.3	7.8	15.8	13.9	11.6	4.8	2.9	11.8	7.7	11.6	9.6	5.1
RPR_c	12.1	12.5	8.2	15.5	16.0	14.3	5.3	2.9	11.9	10.6	13.5	9.5	5.2
RPR_md	0.7	1.2*[c]	0.3	-0.3	2.0*	2.7*	0.5	0.0	0.1	3.0*	1.9*	-0.1	0.1
PR_h	22.8	22.3	15.2	30.6	27.0	22.6	9.3	5.6	22.9	14.9	22.5	18.6	9.8
PR_c	23.5	24.7	15.8	30.0	31.0	27.9	10.3	5.6	23.0	20.6	26.1	18.5	10.1
PR_md	0.7	2.4*	0.6	-0.6	4.0*	5.3*	1.0	0.0	0.0	5.8*	3.7*	-0.1	0.3
SHDI_h	2.1	2.2	1.5	2.5	2.5	2.2	1.3	0.4	2.3	1.7	2.4	1.8	1.0
SHDI_c	2.2	2.3	1.5	2.6	2.6	2.4	1.5	0.5	2.4	2.1	2.5	1.9	1.1
SHDI_md	0.0	0.1*	0.0	0.1	0.1*	0.2*	0.3*	0.1*	0.1*	0.3*	0.1*	0.0	0.0
N1_h	10.0	10.1	5.2	12.9	13.3	10.3	3.6	1.7	10.7	6.0	11.7	7.4	3.4
N1_c	9.9	10.6	5.5	14.5	15.1	12.7	4.6	2.0	11.6	9.2	12.3	8.2	3.4
N1_md	-0.1	0.4*	0.2	1.6*	1.8*	2.3*	1.1*	0.3*	0.9*	3.1*	0.6	0.8	0.0
N2_h	6.8	7.0	3.8	8.2	9.4	7.2	2.6	1.4	7.7	4.5	8.6	5.2	2.4
N2_c	6.8	7.1	3.8	10.2	10.6	8.9	3.5	1.6	8.5	6.8	8.7	6.1	2.5
N2_md	0.0	0.1	0.1	2.0*	1.3*	1.6*	0.9*	0.2*	0.8*	2.3*	0.0	0.8*	0.0
Evenness:													
MSIEI_h[d]	0.58	0.60	0.46	0.61	0.66	0.61	0.44	0.15	0.62	0.55	0.67	0.51	0.34
MSIEI_c	0.58	0.58	0.46	0.67	0.68	0.63	0.54	0.20	0.65	0.60	0.65	0.54	0.35
MSIEI_md	0.00	-0.01	0.00	0.06*	0.01*	0.02	0.11*	0.05*	0.03*	0.04	-0.03*	0.04	0.00
R21_h	0.64	0.64	0.63	0.62	0.67	0.65	0.65	0.44	0.66	0.69	0.71	0.62	0.61
R21_c	0.64	0.62	0.61	0.69	0.68	0.66	0.68	0.46	0.68	0.68	0.67	0.66	0.59
R21_md	0.00	-0.02*	-0.01	0.07*	0.01	0.00	0.03*	0.01	0.02	-0.01	-0.04*	0.04*	-0.02
Contagion and interspersion:													
CONTAG_h	58.2	57.3	66.3	56.6	55.8	58.1	65.8	86.1	56.2	63.3	55.1	63.3	73.3
CONTAG_c	57.9	57.6	65.8	54.2	54.9	56.4	60.6	74.0	54.8	59.7	55.8	62.1	73.6
CONTAG_md	-0.3	0.3	-0.5	-2.4*	-0.9*	-1.7*	-5.2*	-12.1*	-1.4*	-3.6*	0.7	-1.2	0.3
IJI_h	65.9	67.6	60.2	69.0	68.8	67.6	56.0	42.6	70.1	64.0	70.6	61.5	47.1
IJI_c	65.2	67.1	58.8	71.7	69.7	68.2	56.5	52.4	71.1	65.1	68.7	63.0	56.7
IJI_md	-0.7	-0.6	-1.4	2.7	1.0*	0.6	0.6	9.8*	1.0	1.0	-1.9*	1.5	9.6*
Edge contrast:													
AWMECI_h	37.8	37.3	28.0	33.5	38.8	35.5	24.7	10.5	41.1	37.3	34.7	33.9	17.3
AWMECI_c	38.5	38.3	29.0	38.6	39.1	37.7	24.8	11.4	41.2	40.4	35.3	33.6	18.9
AWMECI_md	0.7	1.1*	1.0	5.1*	0.3	2.2*	0.1	0.9*	0.1	3.1*	0.6	-0.3	1.6*

[a] RPR values represent percentage of relative patch richness where the observed number of patch types (cover type-structural classes) in an ERU is scaled against a realistic maximum number of patch types possible across the entire basin assessment area. PR values simply represent the total number of patch types present within an ERU. N1 is a transformation of SHDI; rare patch types are weighted less than in PR. N2 also counts numbers of patch types like RPR, but N2 gives dominant patch types increased weight and can be considered a count of the average number of dominant patch types in an ERU. With N2, rare patch types are weighted less than in N1.

[b] Suffix **h** = average historical value among subwatersheds of an ERU; **c** = average current value among subwatersheds of an ERU; and **md** = mean difference of pairwise comparisons of sampled subwatersheds within an ERU. RPR = relative patch richness; PR = patch richness; SHDI = Shannon-Weaver diversity index; N1 = Hill's index N1 = e^{SHDI}; N2 = Hill's index N2 = 1/(1/SIDI); MSIEI = modified Simpson's evenness index; R21 = Alatalo's evenness index = (N2-1)/(N1-1); CONTAG = contagion index; IJI = interspersion and juxtaposition index; AWMECI = area-weighted mean edge contrast index (see also tables 17 and 18, and McGarigal and Marks 1995).

[c] * indicates statistical significance at $P \leq 0.2$.

[d] MSIEI is more sensitive to change in abundance among all patch types, whereas R21 is more sensitive to change in abundance of the dominant patch types. Increases indicate that area distributed among patch types is increasingly even. Declines indicate that some patch types are more abundant than others within an ERU. Significant figures are computed to 2 decimal places.

of differing patch types to emphasize changes and reveal major differences in pattern attributes of landscapes. In our analysis, landscape metrics were computed for a broad variety of patch types, such as physiognomic types, cover types, structural classes, cover-structure class doublets, potential vegetation type-cover-structure class triplets, fuel loading classes, fireline intensity classes, insect and pathogen vulnerability classes, and so forth. Here, we report only results of landscape pattern analyses where patch types are cover-structure class doublets (for example, stand initiation-western larch, old forest single-story-ponderosa pine, or open structured-montane low-medium shrubs), because this combination is most appropriate for understanding and visualizing simultaneous change in patterns of structural and compositional attributes (table 19). We do not discuss changes in Hill's index N1, because that index is a simple transformation of SHDI, and we discuss changes in SHDI Index. N1 is shown because it was used to compute R21, Alatalo's evenness index. Conventional and spatial statistics were computed to eight decimal places; we report significant figures to one decimal place unless otherwise indicated.

Blue Mountains ERU—No significant ($P \leq 0.2$) change in any landscape metric was evident in the Blue Mountains ERU, although trends for most metrics were similar to those observed in other ERUs having a history of widespread domestic livestock grazing and timber management (table 19). Lack of significant difference for all metrics was the result of high variability within and among sampled subwatersheds pooled in this ERU. To improve on this analysis and indeed reveal masked changes in landscape pattern metrics, it would be appropriate to derive mid-scale statistical pooling strata that would partition environmental variation by grouping subwatersheds similar in their climate and environmental attributes.

The Blue Mountains ERU is roughly two-thirds forest and one-third rangeland with large wilderness and roadless areas. Elsewhere in the basin, landscape pattern trends in ERUs with significant wildland area were clearly different from those observed in ERUs comprised primarily of managed forests. In general, landscape patterns of wilderness subwatersheds became less diverse and less fragmented, while landscape patterns of managed subwatersheds became more diverse and fragmented. This difference also was observed by Lehmkuhl and others (1994). The magnitude of landscape pattern change also was quite different between forest- and range-dominated ERUs (table 19); we suspect the same is true at the subwatershed scale within the Blue Mountains ERU, and additional investigation is warranted. Furthermore, landscape pattern changes more often were significant at smaller scales where a homogenous area was considered. We believe that landscape pattern evaluations will have greater meaning and become more revealing when they are conducted for smaller ecological subregions comprised of similar biophysical environments (see "Ecological Regionalization," below).

One additional observation is noteworthy; the Blue Mountains ERU was one of only three where the sign of the mean difference value for both the contagion index (CONTAG) and the interspersion index (IJI) was the same, but changes were not significant at $P \leq 0.2$ (table 19). Contagion and interspersion usually are inversely related to each other. A high value for CONTAG means that a landscape is contagious; that is, the distribution of area within one or more patch types is aggregated or clumped, and dispersion is low. If the value of contagion declines, it means that fewer, larger contiguous patches were replaced by more, smaller, dispersed patches, and dispersion increased. In such cases, we would often, but not always expect an increasing value of IJI.

Central Idaho Mountains ERU—Patch richness (the number of cover-structure patch types) in the Central Idaho Mountains ERU increased by more than 10 percent. The Shannon-Weaver diversity index (SHDI; Shannon and Weaver 1949) indicated slightly but significantly increased patch type diversity, which was confirmed by the noted increase in Hill's index N1, but the inverse of Simpson's λ (N2) (Simpson 1949), an indicator of diversity and changing dominance, did not change significantly. The SHDI is more sensitive to changes in richness than evenness; Simpson's λ and N2 are less sensitive to changes in richness and the presence of rare patch types. The value of Simpson's λ represents the probability that any two patches selected at random will be the same patch types; it is an expression of dominance exerted by individual patch types. One minus that value expresses the probability that any two patches selected at random will be different patch types; the higher the value, the greater the diversity. The inverse of Simpson's λ rescales the solution for ease of interpretation; the higher the number, the greater the diversity and the lower the dominance of any one patch type. For example, in table 19, the average historical value of N2 (N2_h) for sampled subwatersheds in the Central Idaho Mountains was 7.0, which is equal to the inverse of Simpson's λ (SIDI). So the value of Simpson's $\lambda = 0.143$, and 1 - Simpson's $\lambda = 0.857$, indicating a low degree of dominance and a high degree of diversity.

Evenness measures are attempts to assess how equitably area is distributed among a given number of patch types. Both evenness measures (MSIEI and R21) index relative change in the distribution of "abundance," or in this case area, among patch types. Values for both evenness metrics declined, but only the decline in Alatalo's evenness index was significant at $P \leq 0.2$. Evenness indices (table 19) indicated that the average distribution of area among patch types of subwatersheds in the historical condition was 60 and 64 percent of the maximum evenness for the given number of patch types, respectively; the average distribution of area among patch types of subwatersheds in the current condition was 58 and 62 percent of the maximum evenness for the given number of patch types, respectively. Decline in R21 indicated that the distribution of area among cover-structure patch types became less even during the sample period, or some types became more dominant (see also cover type and structural class changes for the Central Idaho Mountains ERU in appendix 2).

Finally, increase in AWMECI was quite significant; in fact, it was the sixth largest change occurring for that index among all ERUs. In this analysis, we based edge contrast difference mostly on physiognomic and structural conditions, and we minimized the effect of differing composition. This was done in deference to edge-sensitive and edge-dependent species, and their typically greater sensitivity to structural rather than compositional differences of edges; for example, we made stem exclusion-Douglas-fir and stem exclusion-ponderosa pine equivalent conditions (see table 18 for edge contrast weights). The noted increase in area-weighted mean edge contrast indicated that the percentage of edge that was maximum contrast edge increased by an amount equivalent to 1.1 percent of the total edge. Maximum contrast edge would be like that occurring between old-forest multistory structures and urban developments or croplands.

Columbia Plateau ERU—No significant ($P \leq 0.2$) change in any landscape metric was evident in the Columbia Plateau ERU, although trends for most metrics were similar to those observed in other ERUs having a history of domestic livestock grazing and timber management (table 19). Lack of significant difference for all metrics was the result of high inherent variability within and among sampled subwatersheds. The Columbia Plateau is roughly two-thirds rangeland and one-third forest. As was observed in the Blue Mountains, the sign of the mean difference value for both the contagion index (CONTAG) and the interspersion index (IJI) was the same, but values were not significant.

Lower Clark Fork ERU—Several landscape metrics changed significantly within the Lower Clark Fork ERU (table 19). Historical patch richness (PR_h) was the highest observed among all ERUs, and current patch richness (PR_c) was the second highest observed. Overall, there was an average of 30 unique cover-structure patch types in sampled subwatersheds representing the ERU in both the historical and current samples. Patch richness as indicated by RPR and PR did not change significantly, but dominance and diversity as indicated by the inverse of Simpson's λ (N2) increased significantly. The mean difference for N2 was 2.0; that is, the average number of dominant patch types per subwatershed increased from 8.2 to 10.2. The mean difference value for N2 represented an average increase in dominance of 24.4 percent during the average historical level, the third largest increase observed among all

ERUs. Significant reductions in area of stand initiation (minus 23.3 percent) and stem exclusion-open canopy structures (minus 6.5 percent) and significant rises in area of understory reinitiation (21.3 percent) and stem exclusion-closed canopy (7.3 percent) structures no doubt fueled the observed increase in dominance (appendix 2).

Both evenness measures increased significantly during the sample period. Evenness indices (R21 and MSIEI in table 19) indicate that the average distribution of area among patch types of subwatersheds in the historical condition was 61 to 62 percent of the maximum evenness for the given number of historical patch types, and the average distribution of area among patch types of subwatersheds in the current condition was 67 to 69 percent of the maximum evenness for the given number of current patch types. Increases in both indices indicated that the distribution of area among cover-structure patch types became more even during the sample period, that historical Lower Clark Fork landscapes (which were primarily forested) were structurally and compositionally simpler, and patch type area was not evenly distributed. This is reasonable given the historical dominance of stand-replacing and mixed-severity fires (Hann and others 1997) and associated stand-initiation structures (appendix 2). We compared area distributions of historical and current cover-structure patch type combinations to confirm that increased evenness was associated with dominant patch types.

Contagion (CONTAG) decreased significantly from 56.6 to 54.2 percent with no significant change in IJI, thereby indicating increased dispersion without consistently increased interspersion. We expected a reduced contagion value in this ERU, because we observed significantly increased dispersion of stand-initiation, stem exclusion-open canopy, and understory reinitiation structures during the sample period (see patch density and mean patch size values of forest structures for the Lower Clark Fork ERU in appendix 2). The AWMECI increased significantly from 33.5 to 38.6 percent—the largest absolute increase among all ERUs. The noted increase in mean edge contrast indicated that the percentage of edge that was maximum contrast edge increased by an amount equivalent to 5.1 percent of the total edge.

Northern Cascades ERU—Significant change was evident in 8 of 10 landscape metrics. Absolute patch richness, as indicated by PR, increased an average of 14.8 percent during the sample period; relative patch richness (RPR), which computes the observed number of cover-structure patch types over a realistic potential maximum number of patch types, increased by a comparable amount. Average current patch richness (PR_c) was the highest observed among all ERUs. Likewise, the average current SHDI diversity value (SHDI_c) was the highest value observed. The mean difference value of the SHDI was 0.1, and that of the inverse of Simpson's λ (N2) was 1.3; both increases were significant. The mean difference value of SHDI represented an average increase in patch type diversity of 4 percent over the average historical level. The mean difference value of N2 represented an average increase in dominance of 13.8 percent over the average historical level, and indicated that the average number of dominant patch types per subwatershed increased from 9.4 to 10.6.

Of the two evenness indices used, significant change was noted only for the modified MSIEI. Values for MSIEI in the Northern Cascades indicated that the average distribution of area among patch types of subwatersheds in the historical condition was 66 percent of the maximum evenness for the given number of historical patch types; the average distribution of area among patch types of subwatersheds in the current condition was 68 percent of the maximum evenness for the given number of current patch types (table 19). Although small, the noted increase indicated that the distribution of area among cover-structure patch types of sampled subwatersheds became consistently more even during the sample period. We compared area distributions of historical and current cover-structure patch type combinations to confirm that increased evenness was associated with dominant patch types.

Contagion decreased significantly from 55.8 to 54.9 percent and IJI increased significantly from 68.8 to 69.7 percent. Observed CONTAG values indicated that dispersion had dropped to 54.9 percent of the maximum possible dispersion given the total number of patch types. Observed IJI values indicated that interspersion had increased to

69.7 percent of the maximum possible interspersion given the total number of patch types. These changes suggested significantly reduced connectivity of cover-structure patch types or increasing landscape fragmentation. We anticipated these pattern changes because we observed significantly increased patch density and reduced mean patch size for most major cover types and structural classes (see also appendix 2). Mean edge contrast as indicated by the AWMECI, increased slightly, but the change was not significant at P≤0.2. The historical edge contrast value for the ERU (AWMECI_h) was the second highest value observed among all ERUs. The historical value of 38.8 percent indicated that of all the edge shared among patch types, an amount equivalent to 38.8 percent of all edge was maximum contrast edge of the kind occurring at the boundary of a stand-replacing fire. The mean difference value (AWMECI_md) of 0.3 indicated that despite significant timber harvesting during the sample period, current edge contrast (AWMECI_c) is equivalent to historical.

Northern Glaciated Mountains ERU— Significant change was evident in 7 of 10 landscape metrics in the Northern Glaciated Mountains. Absolute patch richness, as indicated by PR, increased an average of 23.4 percent during the sample period; relative patch richness increased by a comparable amount. This was the second largest richness increase among ERUs. Average current patch richness (PR_c) was the third highest observed among all ERUs. The mean difference value of the SHDI was 0.2, and that of the inverse of Simpson's λ (N2) was 1.6; both increases were significant. The mean difference value of SHDI represented an average increase in patch type diversity of 9.1 percent over the average historical level. The mean difference value of N2 represented an average increase in dominance of 24 percent over the average historical level and indicated that the average number of dominant patch types per subwatershed increased from 7.2 to 8.9. This was the fourth largest increase in dominance among ERUs.

As with many extensively managed forest ERUs, both evenness measures increased during the sample period, but neither change was significant at P≤0.2. Contagion decreased significantly from 58.1 to 56.4 percent with a corresponding but insignificant increase in IJI. Observed CONTAG values indicated that patch type dispersion had dropped to 56.4 percent of the maximum possible dispersion given the total number of patch types. The IJI values indicated that interspersion had increased to 68.2 percent of the maximum possible interspersion given the total number of patch types, but the change was not significant at P≤0.2. We expected a reduced CONTAG value in this ERU, because we observed significantly increased patch density and reduced mean patch size for most major cover types and structural classes (see also appendix 2). Lack of significant increase in IJI with decreasing contagion, meant that patch type area in the average current condition was more dispersed than in the average historical condition, but patch area still tended to be clumpy or aggregated rather than highly interspersed and evenly juxtaposed with other patch types. (Note: This interspersion index is not affected by the number, size, contiguity or dispersion of patches per se, as is the contagion index.) This means that building blocks for improving contagion, or more specifically, reducing patch density and increasing mean patch size, reside in existing landscapes of the ERU.

The AWMECI increased significantly from 35.5 to 37.7 percent; the third largest absolute increase among all ERUs. The noted increase in mean edge contrast indicated that the percentage of edge that was maximum contrast edge increased by an amount equivalent to 2.2 percent of the total edge. We anticipated increasing edge contrast because we noted significantly increasing patch density and edge density (not reported here) for most major cover types and structural classes.

Northern Great Basin ERU—Significant change was evident in 6 of 10 landscape metrics. Absolute PR increased an average of 10.8 percent during the sample period; relative patch richness increased comparably, but neither change was significant at P≤0.2. Average current patch richness (PR_c) was the second lowest observed among all ERUs. We would expect this because the Northern Great Basin ERU is dominated by shrubland and woodland patch types and lacks patch type diversity contributed by forests.

The mean difference value of the SHDI was 0.3, and that of the inverse of Simpson's λ (N2) was 0.9; both increases were significant (table 19). The mean difference value of SHDI represented an average increase in patch type diversity of 23 percent over the average historical level. This was the second largest increase in patch type diversity among ERUs. A small richness change contributed to great change in diversity in this ERU because Northern Great Basin range landscapes are relatively simple to begin with. The mean difference value of N2 represented an average increase in dominance of 35 percent over the average historical level. This was the second largest increase in dominance among ERUs. Change in N2 values between historical and current conditions indicated that the average number of dominant patch types per subwatershed increased from 2.6 to 3.5.

Evenness of patch type area in Northern Great Basin landscapes increased during the sample period. Change in MSIEI values indicated that the average distribution of area among patch types of subwatersheds in the historical condition was 44 percent of the maximum evenness for the given number of historical patch types; and the average distribution of area among patch types of subwatersheds in the current condition was 54 percent of the maximum evenness for the given number of current patch types. The R21 values indicated that the average distribution of area among dominant patch types of subwatersheds in the historical condition was 65 percent of the maximum evenness for the given number of historical patch types; the average distribution of area among dominant patch types of subwatersheds in the current condition was 68 percent of the maximum evenness for the given number of current patch types. Alatalo's R21 metric is sensitive to changing distribution of area among dominant patch types, whereas the modified Simpson's evenness index reflects changing distribution of area among all patch types regardless of their dominance or rarity. Differences in average historical, average current, and mean difference values for the two metrics suggested that increased richness (albeit nonsignificant) was associated with relatively rare patch types; Alatalo's R21 metric may provide clearer insight into evenness changes occurring during the sample period. We compared area distributions of historical and current cover-structure patch type combinations to confirm this observation. Evenness results suggest that historical Great Basin landscapes (which are primarily rangeland) were structurally and compositionally simpler and patch type area was less evenly distributed than it is today.

Contagion decreased significantly from 65.8 to 60.6 percent with a corresponding increase in IJI, but the latter change was not significant at $P \leq 0.2$. Significantly reduced CONTAG without significant change in IJI suggested increased dispersion without consistently increased interspersion among sampled subwatersheds. We expected a reduced CONTAG value in this ERU because we observed significantly increased dispersion of shrubland cover types and structural classes during the sample period (see patch density and mean patch size values in appendix 2).

Owyhee Uplands ERU—Significant change was evident in 7 of 10 landscape metrics in the Owyhee Uplands. No change in relative or absolute patch richness was evident, but diversity increased significantly. The mean difference value of the SHDI was 0.1 and that of the inverse of Simpson's λ (N2) was 0.2; both increases were significant (table 19). The mean difference value of SHDI represented an average increase in patch type diversity of 25 percent over the average historical level. This was the largest increase in patch type diversity among ERUs. The mean difference value of N2 represented an average increase in dominance of 14.3 percent over the average historical level. This was the sixth largest increase in dominance among ERUs. The observed change in values of N2 during the sample period indicated that the average number of dominant patch types per subwatershed increased from 1.4 to 1.6.

Evenness of patch type area in Owyhee Uplands landscapes remained relatively constant during the sample period. Change in MSIEI values indicated that the average distribution of area among patch types of subwatersheds in the historical condition was 15 percent of the maximum evenness for the given number of historical patch types; and the average distribution of area among patch types of subwatersheds in the current condition was 20 percent of the maximum evenness for the given number of current patch types. The R21 values also indicated increasing evenness, but the change was not significant at $P \leq 0.2$. Differences in average historical, average current, and mean difference values for the two metrics suggested that increased evenness was associated with relatively rare patch types. We compared area distributions of historical and current cover-structure patch type combinations and confirmed this observation.

Contagion decreased significantly from 86.1 to 74 percent, and IJI increased significantly from 42.6 to 52.4 percent. Among all ERUs in the historical condition, range landscapes of the Owyhee Uplands were the most contagious because they were dominated by the fewest dominant cover-structure patch types (see also the value for N2_h in table 19). Observed contagion values indicated that dispersion had dropped to 74 percent of the maximum possible dispersion given the total number of patch types. Observed IJI values indicated that interspersion had increased to 52.4 percent of the maximum possible interspersion given the total number of patch types. These changes indicated significantly increased fragmentation of cover-structure patch types during the sample period. We anticipated these changes in landscape metrics because we observed significantly increased patch density and reduced mean patch size of shrubland cover types and structural classes, which comprise more than 80 percent of the area in both the historical and current vegetation coverages (see also appendix 2).

The AWMECI increased significantly from 10.5 to 11.4 percent. The noted increase in edge contrast indicated that the percentage of edge that was maximum contrast edge increased by an amount equivalent to 0.9 percent of the total edge. We anticipated increasing edge contrast because we noted significantly increasing patch density, edge density (not reported here) and decreasing mean patch size for shrubland cover-structure patch types.

Snake Headwaters ERU—Significant change was evident in 5 of 10 landscape metrics in the Snake Headwaters. No change in relative or absolute patch richness was in evidence, but diversity increased significantly. The mean difference value of the SHDI was 0.1, and that of the inverse of Simpson's λ (N2) was 0.9; both increases were significant (table 19). The mean difference value of SHDI represented an average increase in patch type diversity of 4.3 percent over the average historical level. The mean difference value of N2 represented an average increase in dominance of 10.4 percent over the average historical level. This was the eighth largest increase in dominance among ERUs. The observed change in values of N2 during the sample period also indicated that the average number of dominant patch types per subwatershed increased from 7.7 to 8.5.

Evenness of patch type area in Snake Headwaters landscapes also increased during the sample period. Change in MSIEI values indicated that the average distribution of area among patch types of subwatersheds in the historical condition was 62 percent of the maximum evenness for the given number of historical patch types; and the average distribution of area among patch types of subwatersheds in the current condition was 65 percent of the maximum evenness for the given number of current patch types. The R21 values also indicated increasing evenness but the change was not significant. We compared area distributions of historical and current cover-structure patch type combinations to confirm that increased evenness was associated with dominant patch types.

Contagion decreased significantly by 1.4 percent, and IJI increased by 1.0 percent, but the latter change was not significant at $P \leq 0.2$. Observed contagion values indicated that dispersion had dropped to 54.8 percent of the maximum possible dispersion given the total number of patch types. Observed interspersion and juxtaposition values indicated that interspersion of patch types had increased to 71.1 percent of the maximum possible interspersion given the total number of patch types. These changes indicated significantly increased fragmentation and shuffling of cover-structure patch types during the sample period.

Southern Cascades ERU—The Southern Cascades displayed the greatest change in richness and dominance of all ERUs. Significant change was evident in 7 of 10 landscape metrics. Absolute patch richness as indicated by PR, increased an average of 38 percent during the sample period; relative patch richness increased by a comparable amount. The mean difference value of the SHDI was 0.3 and that of the inverse of Simpson's λ (N2) was 2.3; both increases were significant. The mean difference value of SHDI represented an average increase in patch type diversity of 17.6 percent over the average historical level. The mean difference value of N2 represented an average increase in dominance of 51.1 percent over the average historical level. The observed change in values of N2 during the sample period indicated that the average number of dominant patch types per subwatershed increased from 4.5 to 6.8.

Evenness did not change significantly according to either MSIEI or R21, but CONTAG decreased significantly by 3.6 percent with a corresponding but statistically insignificant increase in IJI. Observed contagion values indicated that patch type dispersion had dropped to 59.7 percent of the maximum possible dispersion given the total number of patch types. Observed IJI values indicated that interspersion had increased to 65.1 percent of the maximum possible interspersion given the total number of patch types, but the change was not significant at $P \leq 0.2$. We expected a reduced contagion value in this ERU because we observed significantly increased patch density and reduced mean patch size for most major cover types and structural classes in the Southern Cascades (appendix 2). The lack of significant increase in IJI with decreasing CONTAG meant that patch type area in the average current condition was more dispersed than in the average historical condition, but patch area still tended to be clumpy or aggregated rather than highly interspersed and evenly juxtaposed with other patch types. This means that building blocks for reducing patch density and increasing mean patch size still reside in existing forest landscapes.

The AWMECI increased significantly from 37.3 to 40.4 percent, the second largest absolute increase among all ERUs. The noted increase in edge contrast indicated that the percentage of edge in maximum contrast edge increased by an amount equivalent to 3.1 percent of the total edge.

Upper Clark Fork ERU—Significant change was evident in 6 of 10 landscape metrics. Absolute PR increased an average of 16.4 percent during the sample period; relative PR increased comparably (table 19). The mean difference value of the SHDI was 0.1, which represented an average increase in patch type diversity of 4.2 percent over the average historical level. There was no significant change in dominance as indicated by N2. This was reflected in both evenness measures, as both decreased significantly. The Upper Clark Fork was the only ERU that experienced significant reductions in patch type evenness.

Contagion also did not change significantly, but IJI decreased significantly by 1.9 percent. Observed historical and current values indicated that interspersion had declined to 68.7 percent of the maximum possible interspersion given the total number of patch types. We observed no significant change in AWMECI.

Upper Klamath ERU—The Upper Klamath ERU posted some of the smallest changes in richness and diversity among all ERUs, and among the 10 computed landscape pattern metrics, only two changes were significant. The inverse of Simpson's λ (N2) was the only diversity index to change significantly. The mean difference value of N2 was 0.8, which represented an average increase in dominance of 15.4 percent over the average historical level. The observed change in values of N2 between the historical and current conditions indicated that the average number of dominant patch types per subwatershed increased from 5.2 to 6.1 (table 19).

The only other landscape metric to change significantly was Alatalo's evenness index, R21. Change in R21 values indicated that the average distribution of area among patch types of subwatersheds in the historical condition was 62 percent of the maximum evenness for the given number of historical patch types; and the average distribution of area among patch types of subwatersheds in the current condition was 66 percent of the maximum evenness for the given number of current patch types. We compared area distributions of historical and current cover-structure patch type combinations to confirm that increased evenness was associated with dominant patch types.

Simultaneous examination of CONTAG, N2, R21, and IJI metrics revealed that Upper Clark Fork landscapes are dominated by several patch types evenly distributed rather than contagiously clumped, with a highest degree of patch type interspersion and juxtaposition; that is, landscape patterns were dominated by several well-mixed patch types.

Upper Snake ERU—Significant change was evident in only 2 of 10 landscape metrics in the Upper Snake. No change in richness, diversity, dominance, evenness, or contagion was in evidence. Although there was no change in CONTAG, interspersion increased dramatically by 9.6 percent. Observed historical and current values indicated that interspersion had increased to 56.7 percent of the maximum possible interspersion given the total number of patch types. The noted increase in interspersion without a compensating decline in contagion (dispersion) could be explained rather simply. Two-thirds of the area of the ERU is comprised of open shrubland structures in colline settings, most of which are low-medium shrub cover types (appendix 2). Patch density and mean patch size of open low-medium shrub structures did not change significantly, but patch density of colline low-medium shrub cover types increased radically, and mean patch size plunged precipitously. Most of the area of open structured-colline low-medium patch type is still spatially aggregated, but many herbland and cropland patches of small area are currently interspersed. Change in the AWMECI reflects this transition as well. The AWMECI increased significantly from 17.3 to 18.9 percent. The noted increase in mean edge contrast indicated that the percentage of edge in maximum contrast edge increased by an amount equivalent to 1.6 percent of the total edge. The resultant proportion of the total edge that is currently the equivalent of maximum contrast edge is still a relatively low number because edge contrast between shrubland and herbland, or shrubland and cropland, is low (see table 18 for edge contrast weights).

Forest and Woodland Area With Medium and Large Trees

In this third set of analyses, we evaluated the effects of management activities on the distribution of medium and large trees in forest and woodland settings. Our null hypothesis was no significant difference in percentage of area with medium and large trees between historical and current photointerpreted vegetation conditions. We conducted this analysis because we speculated that managed forest and woodland landscapes became structurally more intermediate, or more crudely, “middle-aged,” and lacking in dominance of large trees as a result of effective fire exclusion and historical selection and regeneration timber harvest activities that often targeted the largest trees for removal.

To be classified as old-forest structure in our classification (table 6), overstory crown cover of large trees (trees > 63.5 cm d.b.h.) was at least 30 percent (that is, the overstory crown cover class was at least 30 percent, actual crown cover was at least 25 percent, and the overstory size class was large trees). Remember that remotely sensed total and overstory crown covers were interpreted in 10-percent increments, and classes were expressed as midpoints; for example, the 30-percent overstory crown cover class corresponded with the 25- to 34-percent range of actual overstory crown covers. In our classification of forest structures other than old forest (table 6), we allowed large trees to comprise an overstory crown cover class of up to 20 percent (that is, ≤ 24 percent actual crown cover), but large tree cover was generally subordinate to other structural features that reflected more dominant effects of disturbance. For example, if fire or timber harvest had replaced a former ponderosa pine overstory of medium and large trees with seedlings and saplings comprising an actual crown cover of 82 percent and remnant large trees comprising an actual crown cover of 16 percent, the structure would be classified as stand initiation, with 100 percent total crown cover, 20 percent remnant large tree overstory crown cover, and 80 percent understory seedling and sapling crown cover.

Table 20—Percentage comparison of area of remnant large trees, old single story, and old multistory forest structures for ecological reporting units in the midscale assessment of the interior Columbia River basin

	Remnant large trees[a] (large tree crown cover[b] ≤ 20 percent)			Old multistory structure (large tree crown cover ≥ 30 percent)			Old single-story structures (large tree crown cover ≥ 30 percent)		
Ecological reporting unit	Historical	Current	Mean difference[c]	Historical	Current	Mean difference[c]	Historical	Current	Mean difference[c]
					Percent				
Blue Mountains	3.7	1.9	-1.8*	2.2	1.0	-1.3*	2.7	0.9	-1.7*
Central Idaho Mountains	1.7	1.9	0.2	1.4	1.2	-0.3	1.8	1.7	-0.1
Columbia Plateau	1.3	2.1	0.8	2.3	1.2	-1.0	1.1	1.0	-0.1
Lower Clark Fork	0.4	0.0	-0.4	0.2	0.5	0.3	2.2	2.5	0.3
Northern Cascades	4.6	3.6	-1.0	5.8	2.7	-3.1*	4.3	2.4	-1.9*
Northern Glaciated Mountains	1.3	1.2	-0.1	0.5	0.4	-0.1	0.7	0.6	-0.1
Northern Great Basin	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Owyhee Uplands	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Snake Headwaters	1.5	1.4	-0.1	3.2	1.8	-1.4	2.0	1.3	-0.7
Southern Cascades	5.2	3.0	-2.2	0.7	1.4	0.7	1.6	3.7	2.1
Upper Clark Fork	0.7	0.6	-0.2	0.6	0.4	-0.2	0.2	0.3	0.1
Upper Klamath	7.7	6.7	-0.9	4.3	5.5	1.2	7.4	4.7	-2.6*
Upper Snake	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	-0.1

[a] Large trees were > 63.5 centimeters in diameter at breast height (d.b.h.).

[b] Crown cover values represent class midpoints: 10 percent crown cover = 5 to 14 percent actual crown cover; 20 percent crown cover = 15 to 24 percent actual crown cover; 30 percent actual crown cover = 25 to 34 percent actual crown cover; etc. See also table 6 for structural class and tree size class definitions.

[c] * indicates statistical significance at P≤0.2.

In appendix 2, we show change in area and connectivity of forest structural classes for each ERU. But we also wanted to discover any change in the disposition of medium (40.5 to 63.5 cm d.b.h.) and large trees regardless of their structural affiliation. When we speak of structures that are not old forest, we refer to large trees as "remnant large trees," because in these structures large trees typically occur as a remnant or residuum of a former structural condition after a stand-replacing disturbance. Table 20 compares area of sampled historical and current subwatersheds with remnant large trees, old single-story structure, and old multistory structure by ERU.

A number of "old-growth" definitions in use today use 50.8 cm d.b.h. and even smaller diameters as the lower limit for large trees; 50.8 cm d.b.h. is roughly the midpoint of our medium tree size class (40.5 to 63.5 cm d.b.h.). It appears that managers have at least two compelling arguments for using relatively small lower diameter limits: (1) over the last 90 years, most of the largest trees (pathologically old emergents much larger than 50.8 cm) have been removed through selective timber harvest; and (2) given what remains, old forests as they are currently defined appear to retain the greatest available measure of structural and functional complexity of presettlement old forests. For these reasons, we ran an additional analysis to determine the disposition of medium and large tree crown cover regardless of structural affiliation. But we caution that it is imprudent to revise or simplify definitions of old forest by reducing the lower diameter limit of large trees simply because much larger trees are no longer available. The immeasurable biological legacy associated with those largest trees is too large to surrender with so simple a classification assumption. Table 21 displays change in percentage of area of medium and large trees during the sample period. Area occupied by medium and large trees was divided into five crown cover

Table 21—Percentage comparison of area of medium and large trees for ecological reporting units in the midscale assessment of the interior Columbia River basin

	Area with medium and large trees[a b c]														
	Crown cover (< 10 percent)			Crown cover (10 to 30 percent)			Crown cover (40 to 60 percent)			Crown cover (> 60 percent)			Total		
Ecological reporting unit	H	C	MD[d]	H	C	MD[d]	H	C	MD[d]	H	C	MD[d]	H	C	MD[d]
	Percent														
Blue Mountains	60.4	72.8	12.4*	23.3	18.4	-4.8*	11.9	6.7	-5.2*	4.5	2.1	-2.4*	39.6	27.2	-12.4*
Central Idaho Mountains	76.5	74.2	-2.3*	12.9	10.9	-1.9*	8.4	9.3	0.8	2.2	5.6	3.4*	23.5	25.8	2.3*
Columbia Plateau	84.8	85.9	1.1	9.6	9.5	-0.1	5.2	2.7	-2.5*	0.4	1.9	1.5*	15.2	14.1	-1.1
Lower Clark Fork	78.3	63.3	-15.0*	5.5	3.8	-1.7	11.1	15.4	4.2*	5.1	17.6	12.5*	21.8	36.8	15.0*
Northern Cascades	58.1	62.1	4.0*	18.2	18.2	0.1	15.0	12.7	-2.3*	8.8	6.9	-1.8*	41.9	37.9	-4.0*
Northern Glaciated Mountains	78.0	75.8	-2.1	11.2	11.2	0.0	7.1	6.7	-0.4	3.8	6.3	2.5*	22.0	24.2	2.1
Northern Great Basin	99.6	97.9	-1.7	0.3	0.5	0.2	0.1	1.6	1.5	0.0	0.0	0.0	0.4	2.1	1.7
Owyhee Uplands	99.3	99.8	0.5*	0.7	0.2	-0.5*	0.1	0.0	0.0*	0.0	0.0	0.0	0.7	0.2	-0.5*
Snake Headwaters	71.3	73.4	2.1	13.2	13.2	0.1	11.5	11.4	-0.1	4.0	1.9	-2.0*	28.7	26.6	-2.1
Southern Cascades	59.7	55.7	-4.0	23.3	17.9	-5.4	15.1	18.9	3.8	2.0	7.5	5.5*	40.3	44.3	4.0
Upper Clark Fork	80.3	82.8	2.4	12.6	10.6	-2.0	4.0	4.5	0.5	3.0	2.1	-0.9	19.7	17.2	-2.4
Upper Klamath	56.7	72.6	15.9*	28.7	14.6	-14.1*	10.4	9.0	-1.4	4.2	3.8	-0.5	43.3	27.4	-15.9*
Upper Snake	98.7	98.1	-0.6*	0.8	0.6	-0.2	0.4	0.8	0.4*	0.1	0.6	0.5	1.3	1.9	0.6*

[a] Medium trees were 40.5 to 63.5 cm d.b.h.; large trees were > 63.5 cm d.b.h. See also table 6.

[b] Crown cover values represent class midpoints: 10 percent crown cover = 5 to 14 percent actual crown cover, 20 percent actual crown cover = 15 to 24 percent actual crown cover, 30 percent actual crown cover = 25 to 34 percent actual crown cover, etc.

[c] H = historical; C = current; MD = mean difference of pairwise comparisons of historical and current subwatersheds.

[d] * indicates statistical significance at P≤0.2.

classes: < 10 percent (none), 10 to 30 percent, 40 to 60 percent, > 60 percent; and total (≥ 10 percent).

Blue Mountains ERU—In the Blue Mountains, area of old single-story and old multi-story structures declined significantly during the sample period (table 20 and appendix 2). Area occupied by remnant large trees also declined significantly; percentage of area fell from a historical level of 3.7 percent of the ERU to 1.9 percent. In the historical condition, 62.8 percent of the ERU area was forest. Of that area, 5.9 percent was comprised of structures with remnant large trees, 3.5 percent was comprised of old multistory structures, and 4.3 percent was comprised of old single-story structures. About 13.7 percent of the historical forest area of the ERU was comprised of old and other forest structures containing large trees. In the current condition, 64.1 percent of the ERU area was forest. Of that area, 3 percent was comprised of structures with remnant large trees, 1.6 percent was comprised of old multistory structures, and 1.4 percent was comprised of old single-story structures. About 6 percent of the current forest area of the ERU was comprised of old and other forest structures containing large trees. The difference amounts to a net decline in forest area with large trees of 56 percent.

Table 21 shows change in area ERU with medium and large trees. Percentage of area with no medium and large trees (where overstory crown cover class is < 10 percent, and actual large tree crown cover < 5 percent) increased during the sample period from 60.4 to 72.8 percent, and area in the 10- to 30-percent, 40- to 60-percent, and > 60-percent medium and large tree crown cover classes declined. Percentage of area in the 10- to 30-percent medium and large tree crown cover class fell from 23.3 to 18.4 percent, and area in the 40- to 60-percent and > 60-percent crown cover classes declined from 11.9 to 6.7 percent, and from 4.5 to 2.1 percent, respectively. Total area with medium and large trees fell by 31 percent during the sample period.

Central Idaho Mountains ERU—In the Central Idaho Mountains, area of old single-story and old multistory forest structures declined slightly during the sample period (appendix 2 and table 20), but change was not significant at $P \leq 0.2$. Area occupied by remnant large trees increased slightly, but again change was not statistically significant; percentage of area rose from 1.7 to 1.9 percent. In the historical vegetation condition, 73.4 percent of the area of the ERU was forest. Of that area, 2.3 percent was comprised of structures with remnant large trees, 1.9 percent was comprised of old multistory structures, and 2.4 percent was comprised of old single-story structures. About 6.6 percent of the historical forest area of the ERU was comprised of old and other forest structures containing large trees. In the current condition, 73.5 percent of the area of the ERU was forest. Of that area, 2.6 percent was comprised of structures with remnant large trees, 1.6 percent was comprised of old multistory structures, and 2.3 percent was comprised of old single-story structures. Of the current forest area of the ERU, 6.5 percent was comprised of old and other forest structures containing large trees.

Percentage of area with no medium and large trees (< 10 percent overstory crown cover) decreased during the sample period from 76.5 to 74.2 percent, and area in the > 60-percent medium and large tree crown cover class rose (table 21). Percentage of area in the 10- to 30-percent medium and large tree crown cover class fell from 12.9 to 10.9 percent, and area in the 40- to 60-percent and > 60-percent medium and large tree crown cover classes rose from 8.4 to 9.3 percent (ns), and from 2.2 to 5.6 percent, respectively. Total area with medium and large trees increased by 9.8 percent during the sample period.

Columbia Plateau ERU—Area of old single-story and old multistory structures declined (table 20 and appendix 2) during the sample period, but change was not significant at $P \leq 0.2$. Area occupied by remnant large trees increased, but again change was not statistically significant; percentage of area rose from 1.3 to 2.1 percent of the ERU area. In the historical condition, 26.1 percent of the area of the Columbia Plateau ERU was forest. Of that area, 5 percent was comprised of structures with remnant large trees, 8.8 percent was comprised of old multistory structures, and 4.2 percent was comprised of old single-story structures. About 18 percent of the historical forest area of the ERU was comprised of old and other forest structures containing large trees. In the current condition, 29.1 percent of the area of the ERU was forest. Of that area, 7.2 percent was comprised of structures with remnant large trees, 4.1 percent was comprised of old multistory structures, and 3.4 percent was comprised of old single-story structures. Of the current forest area of the ERU, 14.7 percent was comprised of old and other forest structures containing large trees. The difference amounts to a net decline in forest area with large trees of 18 percent, but the difference is not significant at $P \leq 0.2$.

Percentage of area with no medium and large trees (overstory crown cover < 10 percent) increased from 84.8 to 85.9 percent (ns), and area in the 40- to 60-percent medium and large tree crown cover class declined from 5.2 to 2.7 percent of the ERU area, and ERU area in the > 60-percent medium and large tree crown cover class rose from 0.4 to 1.9 percent (table 21). Percentage of area in the 10- to 30-percent medium and large tree crown cover class fell from 9.6 to 9.5 percent (ns). Total ERU area with medium and large trees dropped by 7.2 percent during the sample period (ns).

Lower Clark Fork ERU—In the Lower Clark Fork ERU, area of old single-story and old multistory structures increased slightly (table 20 and appendix 2) during the sample period, but change was not significant at $P \leq 0.2$. Area occupied by remnant large trees declined slightly, but again change was not statistically significant. Percentage of area fell from 0.4 to 0 percent of the ERU. In the historical condition, 91.7 percent of the area of the ERU was forest according to our small sample. Of that area, 0.4 percent was comprised of structures with remnant large trees, 0.2 percent was comprised of old multistory structures, and 2.4 percent was comprised of old single-story structures. About 3 percent of the historical forest area of the ERU was comprised of old and other forest structures containing large trees. In the current condition, 94.5 percent of the area of the ERU was forest. Of that area, 0 percent was comprised of structures with remnant large trees, 0.5 percent was comprised of old multistory structures, and 2.6 percent was comprised of old single-story structures. Of the current forest area of the ERU, 3.1 percent was comprised of old and other forest structures containing large trees.

Percentage of area with no medium and large trees (overstory crown cover < 10 percent) decreased during the sample period from 78.3 to 63.3 percent, and area in the 40- to 60-percent, and > 60-percent medium and large tree crown cover classes rose from 11.1 to 15.4 percent, and from 5.1 to 17.6 percent, respectively (table 21). Percentage of area in the 10- to 30-percent medium and large tree crown cover class fell from 5.5 to 3.8 percent (ns). Total area with medium and large trees increased by 68.8 percent during the sample period.

Northern Cascades ERU—In the Northern Cascades ERU, area of old single-story and old multistory structures declined significantly ($P \leq 0.2$) during the sample period (table 20 and appendix 2). Area occupied by remnant large trees also declined, but the change was not statistically significant; percentage of area fell from 4.6 to 3.6 percent. In the historical vegetation condition, 78.8 percent of the area of the ERU was forest. Of that area, 5.8 percent was comprised of structures with remnant large trees, 7.4 percent was comprised of old multistory structures, and 5.5 percent was comprised of old single-story structures. About 18.7 percent of the historical forest area of the ERU was comprised of old and other forest structures containing large trees. In the current condition, 78.2 percent of the area of the ERU was forest. Of that area, 4.6 percent was comprised of structures with remnant large trees, 3.5 percent was comprised of old multistory structures, and 3.1 percent was comprised of old single-story structures. About 11.2 percent of the current forest area of the ERU was comprised of old and other forest structures containing large trees. The difference amounts to a net decline in forest area with large trees of 40 percent.

Percentage of area with no medium and large trees (crown cover < 10 percent) increased during the sample period from 58.1 to 62.1 percent of the ERU area, and area in the 40- to 60-percent, and > 60-percent medium and large tree crown cover classes declined (table 21). Percentage of area in the 10- to 30-percent medium and large tree crown cover class remained stable, and area in the 40- to 60-percent and > 60-percent medium and large tree crown cover classes declined from 15.0 to 12.7 percent, and from 8.8 to 6.9 percent, respectively. Total area with medium and large trees fell by 9.5 percent during the sample period.

Northern Glaciated Mountains ERU—In the Northern Glaciated Mountains ERU, area of old single-story and old multistory structures declined slightly (table 20 and appendix 2) during the sample period, but the change was not significant at $P \leq 0.2$. Area occupied by remnant large trees also declined slightly, but the change was not statistically significant; percentage of area fell from 1.3 to 1.2 percent of the ERU area. In the historical vegetation condition, 81 percent of the ERU area was forest. Of that area, 1.6 percent was comprised of structures with remnant large trees, 0.6 percent was comprised of old multistory structures, and 0.9 percent was comprised of old single-story structures. About 3.1 percent of the historical forest area of the ERU was comprised of old and other forest structures containing large trees. In the current condition, 80.8 percent of the ERU area was forest. Of that area, 1.5 percent was comprised of structures with remnant large trees, 0.5 percent was comprised of old multistory structures, and 0.7 percent was comprised of old single-story structures. Of the current forest area of the ERU, 2.7 percent was comprised of old and other forest structures containing large trees.

Percentage of area with no medium and large trees (overstory crown cover < 10 percent) decreased during the sample period from 78.0 to 75.8 percent, and area in the > 60-percent medium and large tree crown cover class rose from 3.8 to 6.3 percent (table 21). Percentage of area in the 10- to 30-percent and 40- to 60-percent medium and large tree crown cover classes remained stable. Total area with medium and large trees increased by 9.5 percent (ns) during the sample period.

Northern Great Basin ERU—Forests of the Northern Great Basin ERU occupied about 7 percent of the land area, and large trees were not present in any sampled subwatersheds in either the historical or current conditions. Medium tree crown cover was observed. Area with medium tree crown cover increased during the sample period, but the change was not statistically significant. Percentage of area with no medium trees (overstory crown cover < 10 percent) decreased during the sample period from 99.6 to 97.9 percent (ns), and area in the 40- to 60-percent medium tree crown cover class rose from 0.1 to 1.6 percent (ns). Percentage of area in the 10- to 30-percent medium tree crown cover class increased slightly from 0.3 to 0.5 percent (ns). Total area with medium trees increased fivefold (ns) during the sample period.

Owyhee Uplands ERU—Forests of the Owyhee Uplands ERU occupied < 1 percent of the land area, and large trees were not present in any sampled subwatersheds in either the historical or current vegetation conditions. Medium tree crown cover was observed, but scarcely so. Area with medium tree crown cover declined during the sample period. Percentage of area with no medium trees (overstory crown cover < 10 percent) rose from 99.3 to 99.8 percent of the ERU area, and area in the 10- to 30-percent crown cover class fell from 0.7 to 0.2 percent. Total area with medium trees declined by 71 percent.

Snake Headwaters ERU—In the Snake Headwaters ERU, area of old single-story and old multistory forest structures declined, but the change was not significant at $P \leq 0.2$ (table 20 and appendix 2). Area occupied by remnant large trees also declined and the change was not significant; percentage of area fell from 1.5 to 1.4 percent of the ERU area. In the historical vegetation condition, 74.5 percent of the area of the ERU was forest. Of that area, 2 percent was comprised of structures with remnant large trees, 4.3 percent was comprised of old multistory structures, and 2.7 percent was comprised of old single-story structures. About 9 percent of the historical forest area of the ERU was comprised of old and other forest structures containing large trees. In the current condition, 73.8 percent of the area of the ERU was forest. Of that area, 1.9 percent was comprised of structures with remnant large trees, 2.4 percent was comprised of old multistory structures, and 1.8 percent was comprised of old single-story structures. Of the current forest area of the ERU, 6.1 percent was comprised of old and other forest structures containing large trees.

Percentage of area with no medium and large trees (overstory crown cover < 10 percent) increased from 71.3 to 73.4 percent of the ERU area, but the change was not statistically significant (table 21). Percentage of area in the > 60-percent medium and large tree crown cover class fell from 4.0 to 1.9 percent of the ERU area. Percentage of area in the 10- to 30-percent and 40- to 60-percent medium and large tree crown cover classes remained stable. Total area with medium and large trees declined by 7.3 percent (ns).

Southern Cascades ERU—Area of old single-story and old multistory structures increased (table 20 and appendix 2), but the change was not significant at $P \leq 0.2$. Area occupied by remnant large trees declined, but again, the change was not statistically significant; percentage of area fell from 5.2 to 3.2 percent of the ERU area. In the historical condition, 80.5 percent of the area of the ERU was forest. Of that area, 6.5 percent was comprised of structures with remnant large trees, 0.9 percent was comprised of old multistory structures, and 2 percent was comprised of old single-story structures. About 9.4 percent of the historical forest area of the ERU was comprised of old and other forest structures containing large trees. In the current condition, 88.3 percent of the area of the ERU was forest. Of that area, 3.4 percent was comprised of structures with remnant large trees, 1.6 percent was comprised of old multistory structures, and 4.2 percent was comprised of old single-story structures. Of the current forest area of the ERU, 9.2 percent was comprised of old and other forest structures containing large trees.

Percentage of area with no medium and large trees (overstory crown cover < 10 percent) declined during the sample period from 59.7 to 55.7 percent of the ERU area, and area in the > 60-percent medium and large tree crown cover class rose from 2.0 to 7.5 percent of the ERU. Percentage of area in the 10- to 30-percent medium and large tree crown cover class fell from 23.3 to 17.9 percent (ns), and area in the 40- to 60-percent medium and large tree crown cover class increased from 15.1 to 18.9 percent (ns). Total area with medium and large trees increased by 9.9 percent, but the change was not significant. We note that considerable selection and regeneration harvest activity was visible in the aerial photographs representing the historical vegetation condition. It is likely that combined historical old forest area and area with remnant large trees was as much as 50 percent greater than what we were able to portray. We discuss this further in "Change in Area Affected by Visible Logging Activity," below.

Upper Clark Fork ERU—In the Upper Clark Fork ERU, area of old multistory structures declined and area of old single-story structures increased, but neither change was significant at $P \leq 0.2$ (table 20 and appendix 2). Area occupied by remnant large trees declined slightly, but the change was not statistically significant; percentage of area fell from 0.7 to 0.6 percent of the ERU area. In the historical condition, 87.2 percent of the area of the ERU was forest. Of that area, 0.8 percent was comprised of structures with remnant large trees, 0.6 percent was comprised of old multistory structures, and 0.2 percent was comprised of old single-story structures. About 1.6 percent of the historical forest area of the ERU was comprised of old and other forest structures containing large trees. In the current condition, 86.2 percent of the area of the ERU was forest. Of that area, 0.7 percent was comprised of structures with remnant large trees, 0.5 percent was comprised of old multistory structures, and 0.3 percent was comprised of old single-story structures. Of the current forest area of the ERU, 1.5 percent was comprised of old and other forest structures containing large trees.

There were no significant changes in area with medium and large tree cover. Percentage of area with no medium and large trees (overstory crown cover < 10 percent) increased from 80.3 to 82.8 percent of the ERU area, but the change was not statistically significant. Percentage of area in the > 60-percent medium and large tree crown cover class fell from 3.0 to 2.1 percent (ns). Percentage of area in the 10- to 30-percent medium and large tree crown cover class declined from 12.6 to 10.6 percent of the ERU area, and area in the 40- to 60-percent medium and large tree crown cover class rose from 4.0 to 4.5 percent (ns). Total area with medium and large trees declined by 12.2 percent (ns) during the sample period. Nearly all the observed change was associated with declining area occupied by medium trees.

Upper Klamath ERU—In the Upper Klamath ERU, area of old single-story structures decreased from 7.4 to 4.7 percent of the ERU area, and area of old multistory structures remained stable (table 20 and appendix 2). Area occupied by remnant large trees also declined; percentage of area fell from 7.7 to 6.7 percent (ns). In the historical condition, 50.5 percent of the area of the ERU was forest. Of that area, 15.2 percent was comprised of structures with remnant large trees, 8.5 percent was comprised of old multistory structures, and 14.7 percent was comprised of old single-story structures. About 38.4 percent of the historical forest area of the ERU was comprised of old and other forest structures containing large trees. In the current condition, 47.5 percent of the area of the ERU was forest. Of that area, 14.1 percent was comprised of structures with remnant large trees, 11.6 percent was comprised of old multistory structures, and 9.9 percent was comprised of old single-story structures. About 35.6 percent of the current forest area of the ERU was comprised of old and other forest structures containing large trees.

Table 21 shows change in area with medium and large trees. Percentage of area with no medium and large trees (overstory crown cover < 10 percent) increased from 56.7 to 72.6 percent of the ERU area, and area in the 10- to 30-percent, 40- to 60-percent, and > 60-percent medium and large tree crown cover classes declined. Percentage of area in the 10- to 30-percent crown cover class fell from 28.7 to 14.6 percent. Total area with medium and large trees declined by 36.7 percent during the sample period.

Upper Snake ERU—Forests of the Upper Snake ERU occupied about 3 percent of the land area, and large trees were present only in sampled subwatersheds of the historical condition in trace amounts. Medium tree crown cover was observed; percentage of area with medium tree crown cover increased during the sample period. Area with no medium trees (overstory crown cover < 10 percent) decreased from 98.7 to 98.1 percent of the ERU area, and area in the 40- to 60-percent medium tree crown cover class rose from 0.4 to 0.8 percent. Total area with medium trees increased by 46 percent during the sample period, from 1.3 to 1.9 percent of the ERU area.

Forest and Woodland Crown Cover, Canopy Layers, and Cover of Understory Tree Species

In this section, we report results of analyses assessing change in total tree crown cover, number of canopy layers, and cover of understory species to evaluate several potential effects of fire exclusion and timber harvest during the last half century. Our null hypothesis was no significant difference in tree cover, canopy layers, and cover of understory species during the interval between our historical and current photointerpreted vegetation conditions. We speculated that fire prevention and suppression activities and selective harvesting caused an increase in total tree crown cover, canopy layers, and area in shade-tolerant, fire-intolerant understory species during decades when they were featured management strategies.

Table 22 and figure 39 display change in percentage of area of five total crown cover classes during the sample period. Total crown cover classes were < 10 percent (nonforest and nonwoodland environmental settings), 10 to 30 percent total crown cover; 40 to 50 percent total crown cover; 60 to 80 percent total crown cover; and 90 to 100 percent total crown cover. Table 23 and figure 40 display change during the sample period in percentage of area in three canopy layer classes. Canopy layer classes were one layer, two layers, and more than two layers. Table 24 and figures 41 and 42 display change during the sample period in percentage of cover by understory species.

Understory species classes were (1) PIPO–ponderosa pine; (2) LAOC/PICO–western larch or lodgepole pine or both; (3) PSME/ABGR/ABCO/ABAM–Douglas-fir or grand fir or white fir or Pacific silver fir and combinations; (4) TSHE/THPL–western hemlock or western redcedar, or both; (5) TSME–mountain hemlock; (6) ABLA2/ PIEN–subalpine fir or Engelmann spruce, or both; (7) PIAL/LALY–whitebark pine or subalpine larch, or both; (8) hardwood; (9) juniper; (10) other (including grass and forb, shrub, and bare ground understories, and those comprised of Shasta red fir, incense-cedar, western white pine, limber pine, pinyon pine, or beargrass); and (11) nonforest-nonwoodland.

Tree cover increased in 9 of 13 ERUs, and the observed increased was statistically significant in 8 of 13 ERUs (table 22). Tree cover increased in the Blue Mountains, Central Idaho Mountains, Columbia Plateau, Lower Clark Fork, Northern Glaciated Mountains, Northern Great Basin, Owyhee Uplands, Southern Cascades, and Upper Snake ERUs and declined in the Snake Headwaters, Upper Clark Fork, and Upper Klamath ERUs. Tree cover in the Northern Cascades ERU did not change significantly.

Canopy layering increased significantly in 9 of 13 ERUs. Canopy layering increased in the Blue Mountains, Columbia Plateau, Lower Clark Fork, Northern Glaciated Mountains, Northern Great Basin, Owyhee Uplands, Snake Headwaters, Southern Cascades, and Upper Snake ERUs and declined in the Upper Clark Fork and Upper Klamath ERUs (table 23). Canopy layering in the Central Idaho Mountains and Northern Cascades ERUs remained relatively constant at this reporting scale. Because these latter two ERUs are comprised of highly dissected mountain ranges with steep terrain and steep environmental gradients, it is likely that differences in canopy layering may be detected at smaller subregional scales.

Forest area with shade-tolerant understories increased significantly in 7 of 13 ERUs. Area with shade-intolerant understories declined significantly in two ERUs. Shade-tolerant understories (for example, including such species as Douglas-fir, grand fir, white fir, and subalpine fir) increased

Table 22—Percentage comparison of area of forest and woodland in 5 total crown cover classes for ecological reporting units in the midscale assessment of the interior Columbia River basin

	Area														
	Forest and woodland crown cover[a][b]												Nonforest-nonwoodland crown cover		
	10 to 30 percent			40 to 50 percent			60 to 80 percent			90 to 100 percent			(< 10 percent)		
Ecological reporting unit	H	C	MD[c]	H	C	MD[c]	H	C	MD[c]	H	C	MD[c]	H	C	MD[c]
	Percent														
Blue Mountains	12.5	12.5	0.0	17.7	21.0	3.3*	27.5	29.4	2.0	7.8	5.4	-2.3*	34.6	31.6	2.9*
Central Idaho Mountains	8.9	8.3	-0.5	18.6	16.8	-1.8*	33.6	32.6	-1.0	12.3	15.9	3.6*	26.6	26.4	-0.2
Columbia Plateau	9.5	11.3	1.9	8.8	15.4	6.6*	10.5	9.9	-0.6	4.0	4.6	0.7*	67.2	58.8	-8.4*
Lower Clark Fork	6.3	2.7	-3.6*	21.5	9.7	-11.8*	44.2	38.6	-5.5	19.7	43.4	23.7*	8.3	5.5	-2.8
Northern Cascades	9.2	9.5	0.4	17.3	18.7	1.5	33.6	30.3	-3.3*	19.0	20.1	1.1	20.9	21.2	0.3
Northern Glaciated Mountains	9.2	8.7	-0.5	19.1	18.0	-1.1	31.2	29.9	-1.2	21.5	24.2	2.6	19.0	19.2	0.2
Northern Great Basin	7.1	10.5	3.4	11.5	15.6	4.1*	3.7	3.1	-0.6*	0.2	0.2	0.0	77.5	70.6	-6.9*
Owyhee Uplands	4.2	5.4	1.2*	1.3	2.2	1.0*	0.2	0.1	-0.1	0.0	0.0	0.0	94.3	92.3	-2.0*
Snake Headwaters	11.7	11.9	0.2	15.8	19.2	3.5*	35.7	35.4	-0.2	11.5	7.5	-4.0*	25.3	25.9	0.6
Southern Cascades	8.0	12.9	4.9*	37.1	36.6	-0.6	35.1	35.8	0.7	0.2	3.5	3.2*	19.5	11.3	-8.2*
Upper Clark Fork	7.4	9.5	2.1*	18.8	20.3	1.6	45.3	41.2	-4.1*	15.8	15.2	-0.6	12.8	13.8	1.0
Upper Klamath	11.8	10.9	-0.9	17.5	26.1	8.5*	27.4	19.9	-7.5*	2.1	3.4	1.2	41.1	39.7	-1.3
Upper Snake	1.7	1.7	0.0	1.9	2.4	0.5*	1.2	1.3	0.1	0.4	0.7	0.3	94.7	93.8	-0.9

[a] Crown cover values represent class midpoints: 10 percent crown cover = 5 to 14 percent actual crown cover, 20 percent actual crown cover = 15 to 24 percent actual crown cover, 30 percent actual crown cover = 25 to 34 percent actual crown cover, etc.

[b] H = historical; C = current; MD = mean difference of pairwise comparisons of historical and current subwatersheds.

[c] * indicates statistical significance at $P \leq 0.2$.

significantly in the Blue Mountains, Central Idaho Mountains, Columbia Plateau, Lower Clark Fork, Northern Glaciated Mountains, Snake Headwaters, and Upper Clark Fork ERUs. Shade-intolerant understories (for example, including ponderosa pine, western larch, and lodgepole pine) declined in the Blue Mountains, Central Idaho Mountains, Columbia Plateau, Northern Cascades, Northern Glaciated Mountains, Snake Headwaters, Upper Clark Fork, and Upper Klamath ERUs, but declines were significant at $P \leq 0.2$ only in the Northern Glaciated Mountains and Upper Clark Fork ERUs (table 24).

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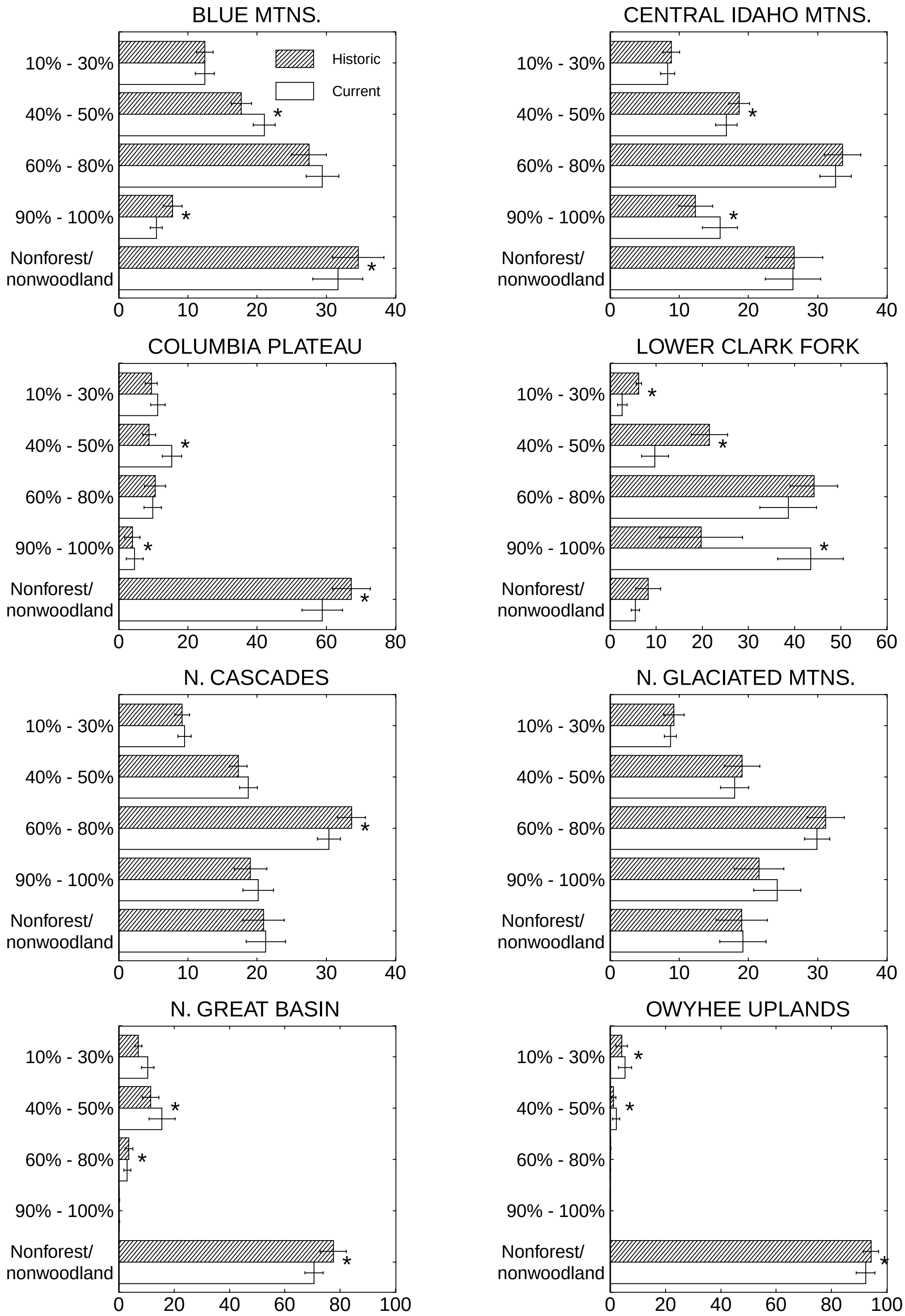
Table 23—Percentage comparison of area of forest and woodland with 1, 2, or more than 2 canopy layers for ecological reporting units in the midscale assessment of the interior Columbia River basin

	Area[a]											
	Canopy layers-forest and woodland									Nonforest-nonwoodland		
	1 layer			2 layers			> 2 layers					
Ecological reporting unit	H	C	MD[b]	H	C	MD[b]	H	C	MD[b]	H	C	MD[b]
	Percent											
Blue Mountains	16.0	12.5	-3.6*	37.8	39.5	1.7	11.6	16.4	4.9*	34.6	31.6	-2.9*
Central Idaho Mountains	24.7	24.4	-0.3	40.7	42.1	1.5	8.1	7.0	-1.0	26.6	26.4	-0.2
Columbia Plateau	14.3	17.6	3.3*	14.2	17.2	3.0	4.3	6.4	2.2*	67.2	58.8	-8.4*
Lower Clark Fork	38.7	30.0	-8.7*	52.9	61.8	8.9	0.1	2.7	2.6	8.3	5.5	-2.8
Northern Cascades	17.3	17.5	0.2	51.1	50.9	-0.2	10.7	10.4	-0.3	20.9	21.2	0.3
Northern Glaciated Mountains	20.7	22.6	1.9	54.6	48.0	-6.6*	5.7	10.2	4.5*	19.0	19.2	0.2
Northern Great Basin	21.9	28.6	6.7*	0.6	0.8	0.2	0.0	0.0	0.0	77.5	70.6	-6.9*
Owyhee Uplands	3.3	4.4	1.1	2.1	3.0	0.9*	0.3	0.3	-0.0	94.3	92.3	-2.0*
Snake Headwaters	26.4	19.7	-6.7*	45.1	50.6	5.5	3.2	3.8	0.6	25.3	25.9	0.6
Southern Cascades	9.7	14.1	4.4	60.0	55.0	-5.0	10.7	19.6	8.9*	19.5	11.3	-8.2*
Upper Clark Fork	32.4	37.7	5.3*	41.0	37.2	-3.8*	13.8	11.4	-2.5*	12.8	13.8	1.0
Upper Klamath	10.8	14.5	3.7	38.2	39.8	1.6	10.0	6.0	-4.0	41.1	39.7	-1.3
Upper Snake	1.6	2.7	1.1*	3.4	3.3	-0.1	0.3	0.2	-0.1	94.7	93.8	-0.9

[a] H = historical; C = current; MD = mean difference of pairwise comparisons of historical and current subwatersheds.

[b] * statistically significant difference at P≤0.2; all values rounded to 1 decimal place.


BLUE MTNS.
CENTRAL IDAHO MTNS.
COLUMBIA PLATEAU
LOWER CLARK FORK
N. CASCADES
N. GLACIATED MTNS.
N. GREAT BASIN
OWYHEE UPLANDS
Historic
Current
10% - 30%
40% - 50%
60% - 80%
90% - 100%
Nonforest/
nonwoodland

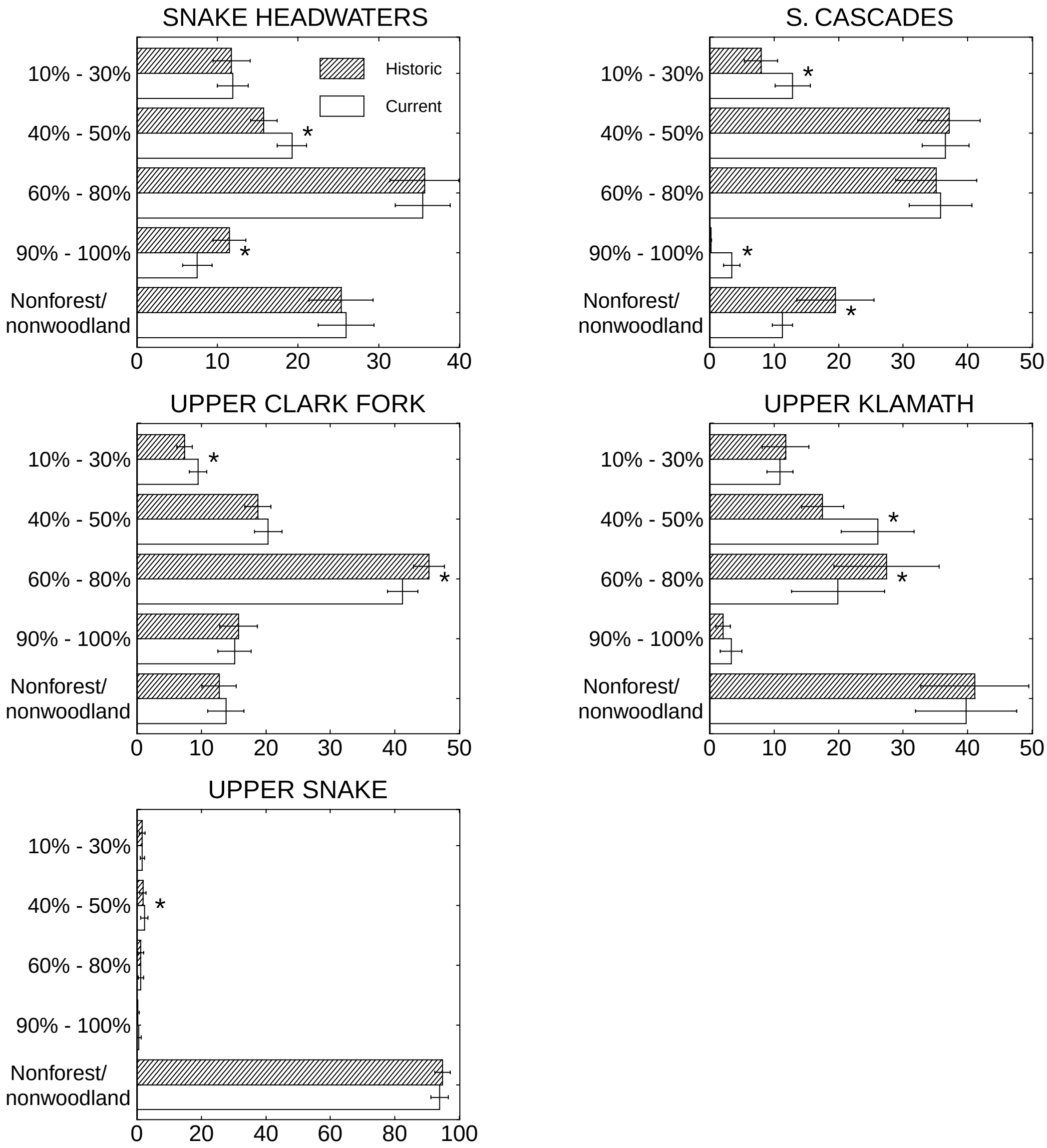
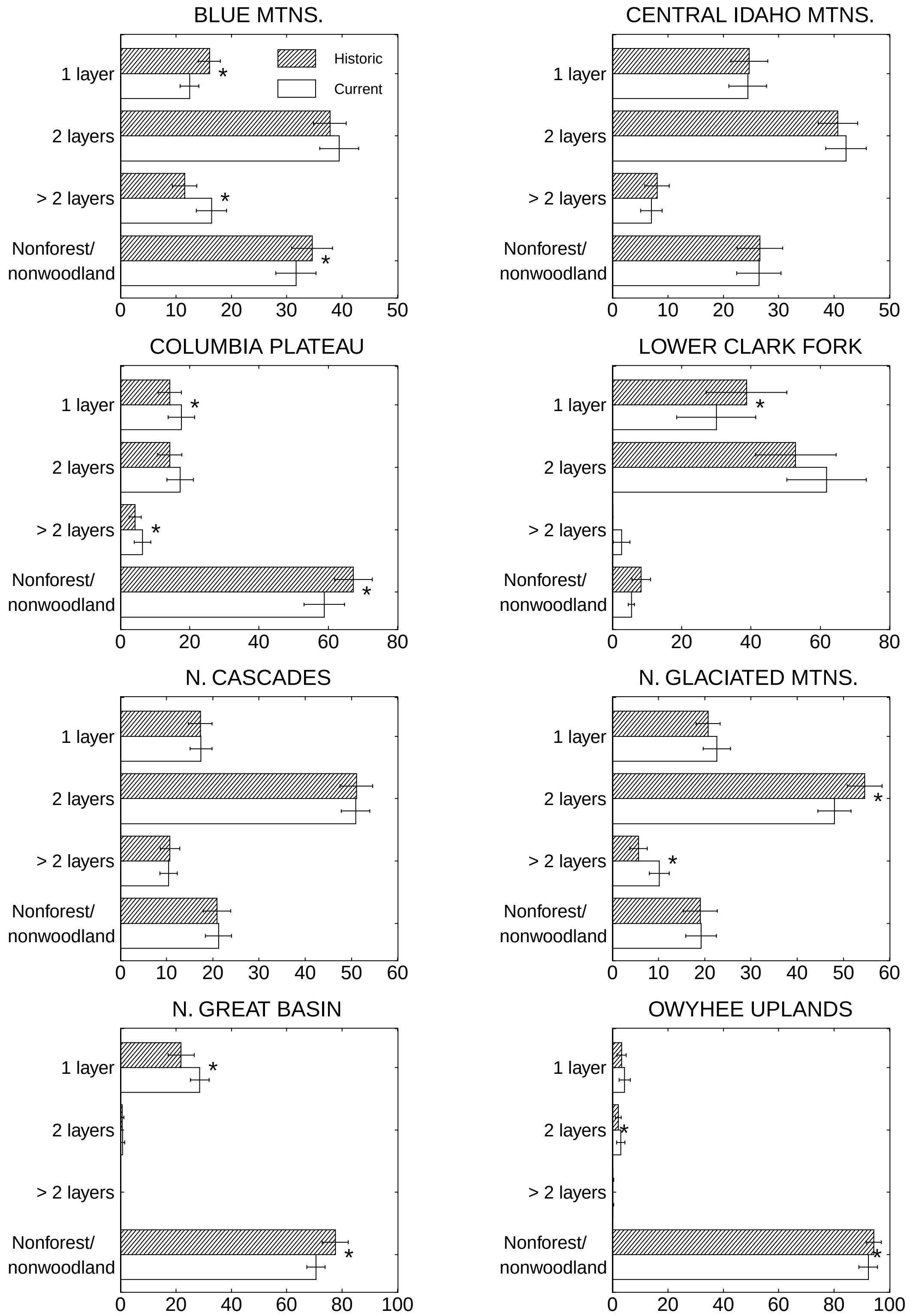


Figure 39—Historical and current distribution of forest and woodland total crown cover classes expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) difference between historical and current conditions.


BLUE MTNS.
Historic
Current
1 layer
2 layers
> 2 layers
Nonforest/
nonwoodland
0
10
20
30
40
50
CENTRAL IDAHO MTNS.
COLUMBIA PLATEAU
0
20
40
60
80
LOWER CLARK FORK
N. CASCADES
0
10
20
30
40
50
60
N. GLACIATED MTNS.
N. GREAT BASIN
0
20
40
60
80
100
OWYHEE UPLANDS

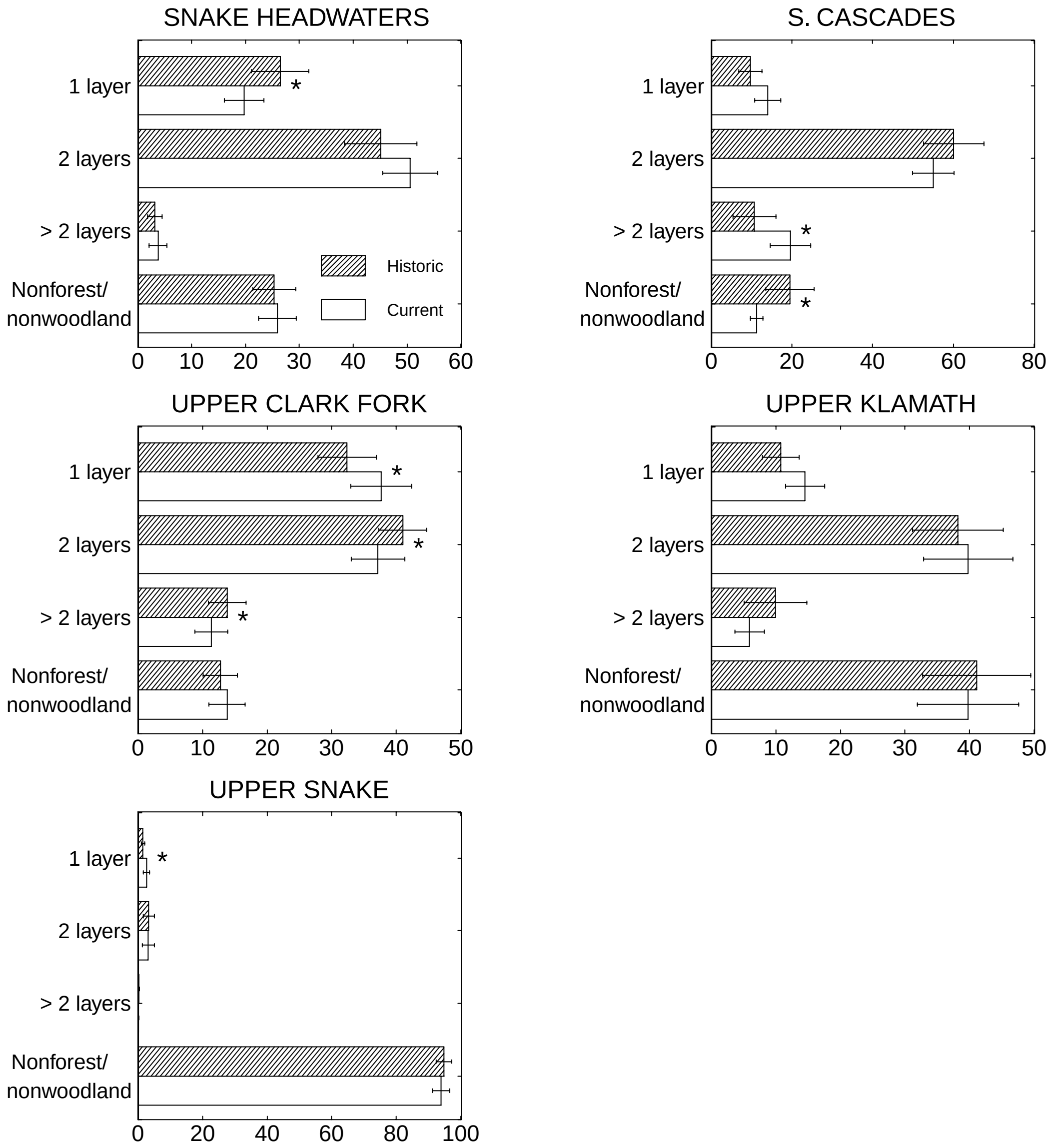


Figure 40—Historical and current distribution of forest and woodland canopy layer classes expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) difference between historical and current conditions.

Table 24—Percentage comparison of area of forest and woodland understory species classes for ecological reporting units in the midscale assessment of the interior Columbia River basin

	Area[a]											
	Ponderosa pine			Western larch-lodgepole pine			Douglas fir-grand fir-Pacific silver fir			Western hemlock-western redcedar		
Ecological reporting unit	H	C	MD[b]	H	C	MD[b]	H	C	MD[b]	H	C	MD[b]
	Percent											
Blue Mountains	18.0	19.4	1.3	4.1	3.4	-0.7	21.0	25.2	4.2*	0.0	0.0	0.0
Central Idaho Mountains	2.9	2.4	-0.4	11.6	11.0	-0.6	15.2	15.0	-0.2	0.6	0.7	0.1
Columbia Plateau	13.1	12.6	-0.5	0.9	1.1	0.2	2.0	2.9	0.9*	0.0	0.3	0.3
Lower Clark Fork	2.6	3.3	0.8	3.9	7.3	3.4	29.1	31.5	2.4	13.5	17.3	3.8*
Northern Cascades	8.9	7.5	-1.4	4.5	4.7	0.1	31.8	31.7	-0.1	1.1	1.4	0.4
Northern Glaciated Mountains	9.9	7.4	-2.5*	21.4	13.6	-7.8*	14.9	19.2	4.3*	2.1	5.6	3.5*
Northern Great Basin	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Owyhee Uplands	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Snake Headwaters	0.0	0.1	0.1	13.5	9.0	-4.5	3.0	3.4	0.4	0.0	0.0	0.0
Southern Cascades	16.4	21.9	5.5	17.0	15.6	-1.3	7.1	10.0	2.9	0.0	0.0	0.0
Upper Clark Fork	7.8	5.8	-2.1*	32.5	24.0	-8.4*	5.4	8.4	3.1*	0.0	0.0	0.0
Upper Klamath	16.4	15.0	-1.4	3.0	2.4	-0.6	11.4	11.8	0.5	0.0	0.0	0.0
Upper Snake	0.0	0.0	0.0	0.2	0.3	0.1	0.4	1.2	0.8	0.0	0.0	0.0

	Area[a]											
	Mountain Hemlock			Subalpine fir-Engelmann spruce			Whitebark pine-subalpine larch			Hardwood		
	H	C	MD[b]	H	C	MD[b]	H	C	MD[b]	H	C	MD[b]
	Percent											
Blue Mountains	0.0	0.1	0.1*	3.9	5.3	1.4	0.0	0.0	0.0	0.2	0.2	0.0
Central Idaho Mountains	0.0	0.0	0.0*	14.7	16.6	1.8*	1.2	1.1	-0.1	0.3	0.3	0.0
Columbia Plateau	0.0	0.0	0.0	0.0	0.0	0.0*	0.0	0.0	0.0	0.2	0.2	0.0
Lower Clark Fork	0.9	0.8	-0.1	1.1	1.5	0.4*	0.0	0.0	0.0	0.0	0.0	0.0
Northern Cascades	0.4	0.7	0.2*	12.6	11.6	-1.0	0.7	1.4	0.8	0.6	0.8	0.2
Northern Glaciated Mountains	0.2	0.1	-0.1	10.3	10.8	0.5	0.0	0.0	0.0	0.1	0.9	0.8*
Northern Great Basin	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.7	0.1
Owyhee Uplands	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0
Snake Headwaters	0.0	0.0	0.0	22.7	32.8	10.1*	0.3	0.4	0.1	8.6	7.9	-0.7
Southern Cascades	27.5	25.3	-2.2	0.7	0.7	-0.1	0.0	0.0	0.0	0.0	0.0	0.0
Upper Clark Fork	0.0	0.1	0.1	6.6	7.4	0.8	0.5	0.5	-0.1	0.2	0.2	0.1
Upper Klamath	4.9	3.1	-1.7	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.6	0.6
Upper Snake	0.0	0.0	0.0	0.2	0.0	-0.2	0.0	0.0	0.0	1.0	0.7	-0.3

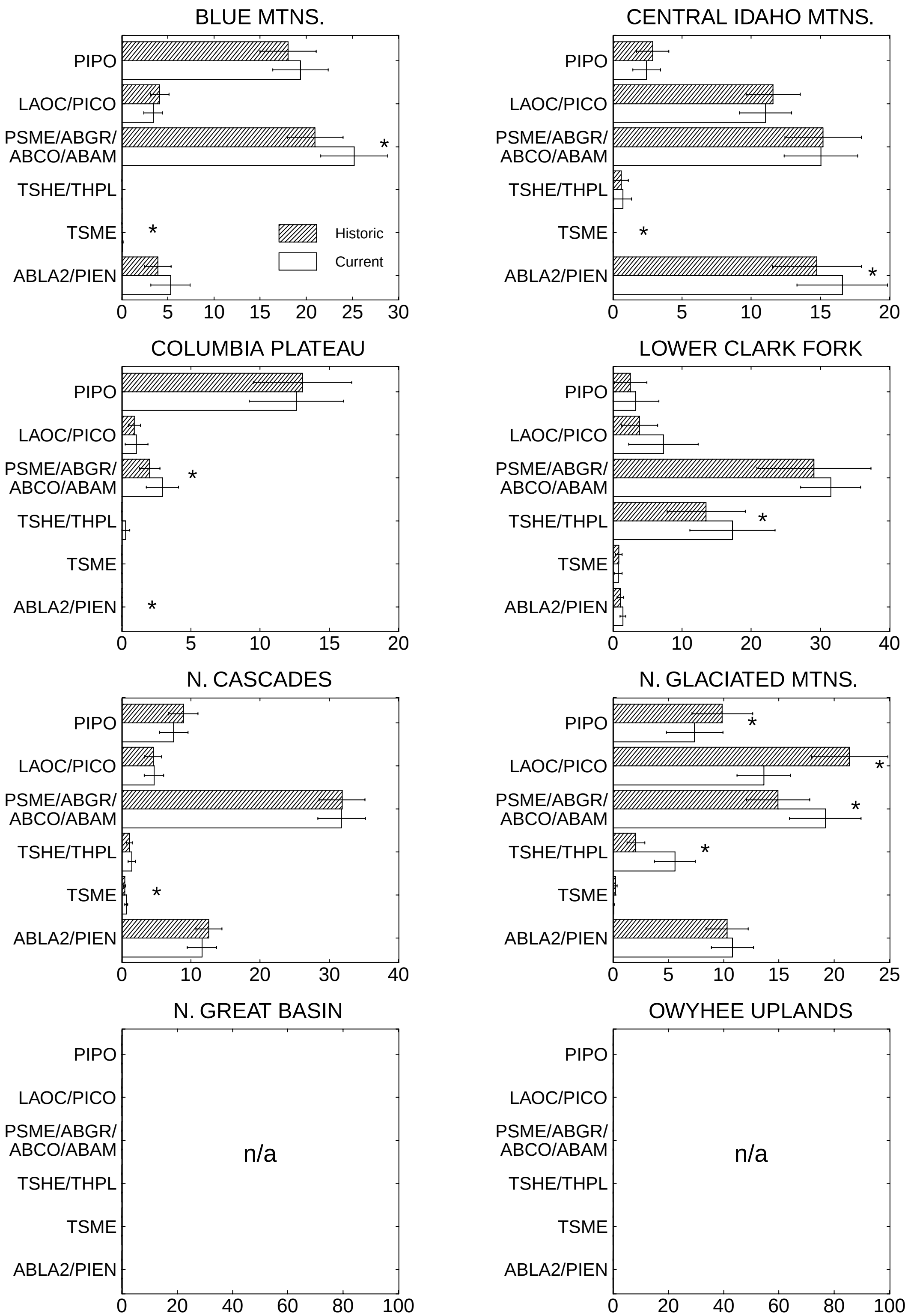
Table 24—Percentage comparison of area of forest and woodland understory species classes for ecological reporting units in the midscale assessment of the interior Columbia River basin (continued)

	Area[a]								
	Juniper			Other[c]			Nonforest-nonwoodland		
Ecological reporting unit	H	C	MD[b]	H	C	MD[b]	H	C	MD[b]
	Percent								
Blue Mountains	1.5	2.1	0.7	16.6	12.6	-4.0*	34.7	31.7	-3.0*
Central Idaho Mountains	0.0	0.0	0.0	26.8	26.3	-0.5	26.6	26.4	-0.2
Columbia Plateau	2.3	6.5	4.2*	14.4	17.7	3.3*	67.2	58.8	-8.5*
Lower Clark Fork	0.0	0.0	0.0	40.8	32.8	-8.0*	8.3	5.5	-2.8
Northern Cascades	0.0	0.0	0.0	18.4	19.0	0.6	20.9	21.2	0.3
Northern Glaciated Mountains	0.0	0.1	0.1	22.0	23.1	1.1	19.0	19.2	0.2
Northern Great Basin	0.0	0.1	0.1	21.9	28.6	6.7*	77.5	70.6	-6.9*
Owyhee Uplands	2.2	3.2	0.9*	3.3	4.4	1.1	94.3	92.3	-2.0*
Snake Headwaters	0.0	0.0	0.0	26.5	20.5	-6.1*	25.3	25.9	0.6
Southern Cascades	1.8	0.1	-1.7	9.9	15.1	5.1	19.5	11.3	-8.2*
Upper Clark Fork	0.0	0.0	0.0	34.3	39.8	5.5*	12.8	13.8	1.0
Upper Klamath	8.5	9.0	0.5	14.7	18.0	3.4	41.1	39.7	-1.3
Upper Snake	1.9	1.3	-0.6	1.6	2.7	1.1*	94.7	93.8	-0.9

[a] H = historical; C = current; MD = mean difference of pairwise comparisons of historical and current subwatersheds.

[b] * statistically significant difference at P≤0.2; all values rounded to 1 decimal place.

[c] The understory species class “other” includes grass-forb, shrub, and bare ground understories, and those comprised of Shasta red fir, incense cedar, western white pine, limber pine, pinyon pine, and beargrass.


BLUE MTNS.
CENTRAL IDAHO MTNS.
COLUMBIA PLATEAU
LOWER CLARK FORK
N. CASCADES
N. GLACIATED MTNS.
N. GREAT BASIN
OWYHEE UPLANDS
PIPO
LAOC/PICO
PSME/ABGR/
ABCO/ABAM
TSHE/THPL
TSME
ABLA2/PIEN
Historic
Current
n/a

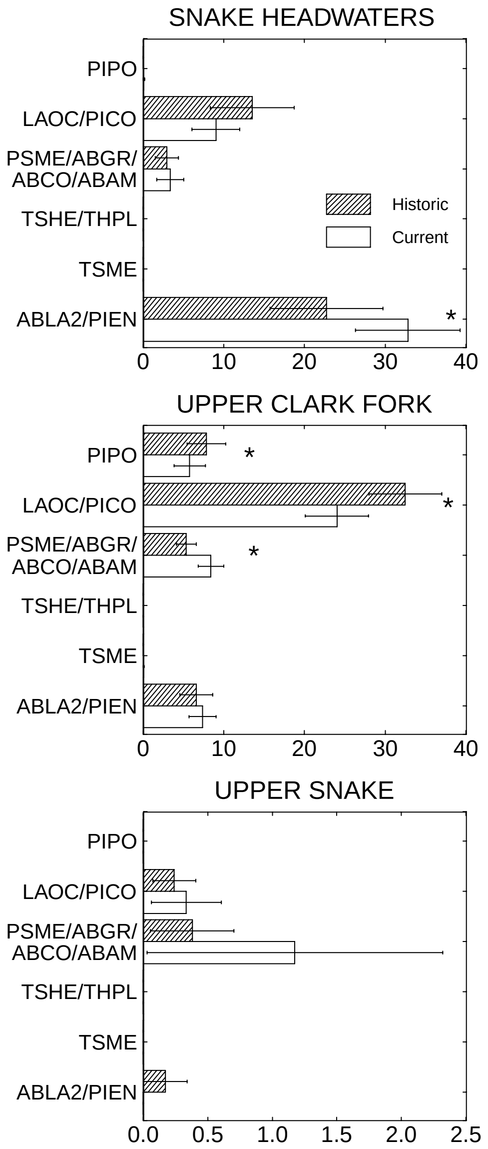
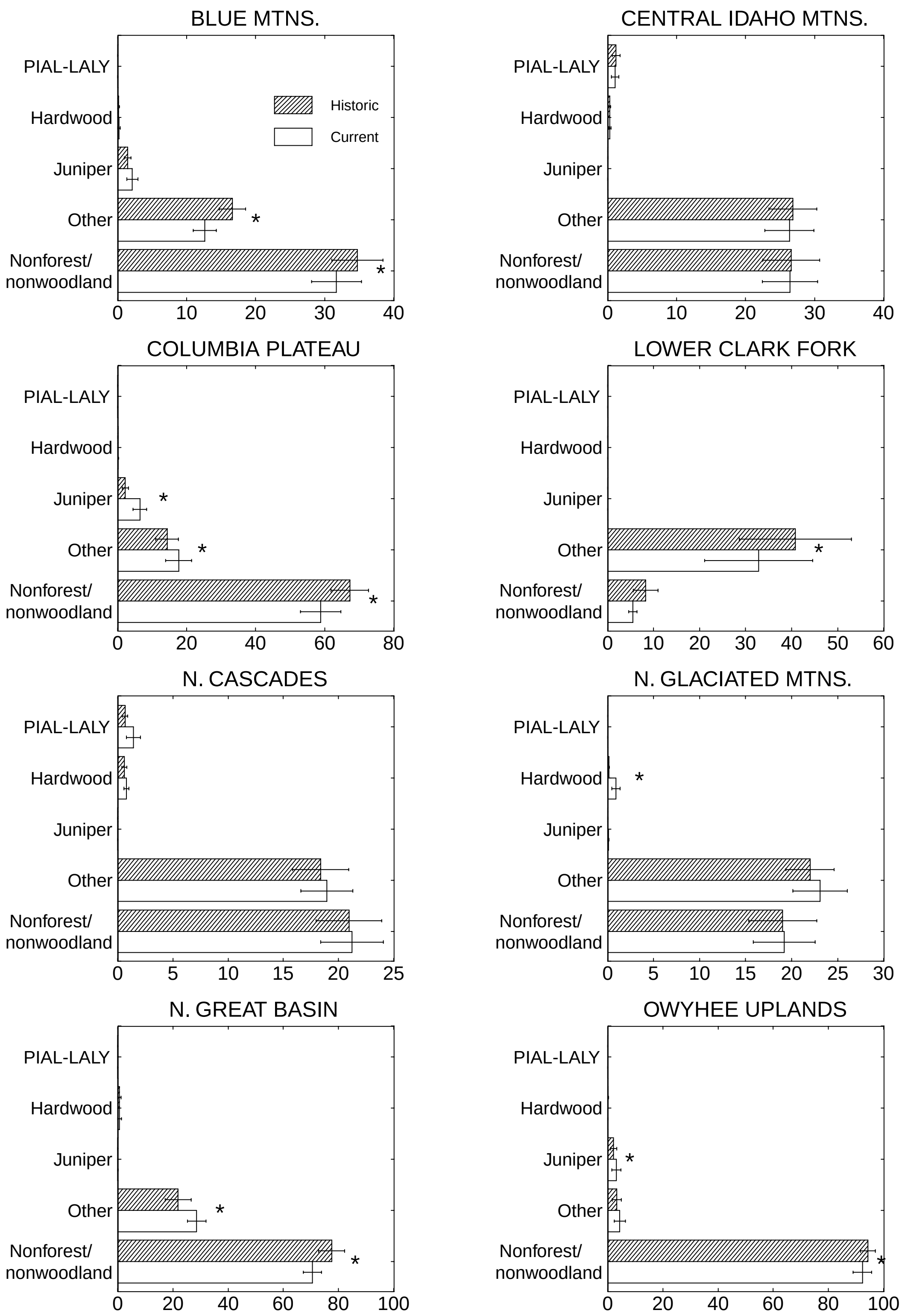


Figure 41—Historical and current distribution of forest and woodland understory species classes expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) difference between historical and current conditions. The understory species class “other” includes grass-forb, shrub, and bare ground understories and those comprised of Shasta red fir, incense-cedar, western white pine, limber pine, pinyon pine, and beargrass.


BLUE MTNS.
CENTRAL IDAHO MTNS.
COLUMBIA PLATEAU
LOWER CLARK FORK
N. CASCADES
N. GLACIATED MTNS.
N. GREAT BASIN
OWYHEE UPLANDS
PIAL-LALY
Hardwood
Juniper
Other
Nonforest/
nonwoodland
Historic
Current

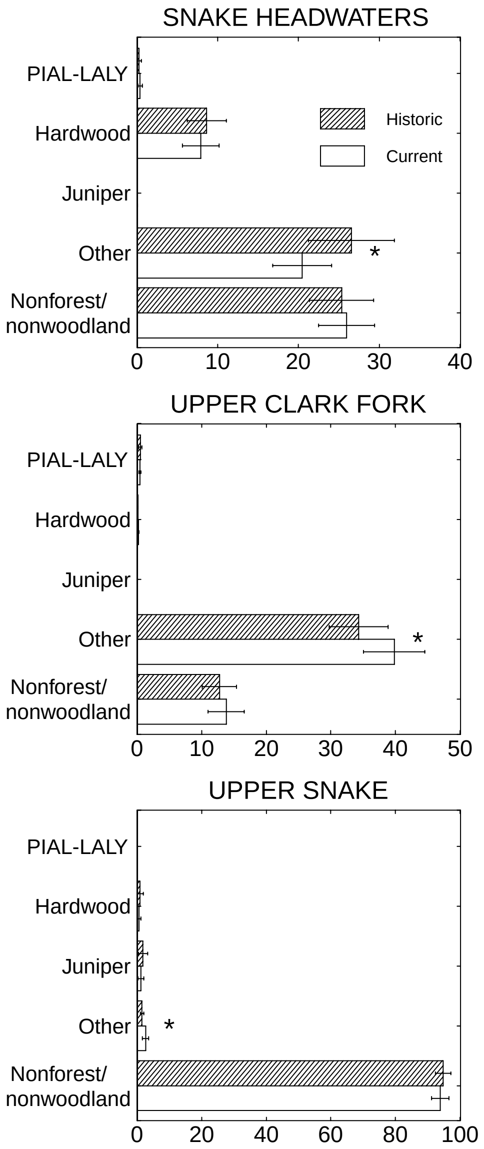


Figure 42—Historical and current distribution of forest and woodland understory species classes expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) difference between historical and current conditions. The understory species class “other” includes grass-forb, shrub, and bare ground understories and those comprised of Shasta red fir, incense-cedar, western white pine, limber pine, pinyon pine, and beargrass.

Table 25—Percentage comparisons of historical and current areas of grass-forb-shrub-bare ground and conifer or hardwood understories for ecological reporting units in the midscale assessment of the interior Columbia River basin

	Area[a]								
	Grass-forb-shrub-bare ground understories			Nonforest-nonwoodland			Conifer or hardwood understories		
Ecological reporting unit	H	C	MD[b]	H	C	MD[b]	H	C	MD[b]
	Percent								
Blue Mountains	16.6	12.6	-4.0*	34.6	31.6	-2.9*	48.8	55.7	6.9*
Central Idaho Mountains	26.6	26.1	-0.5	26.6	26.4	-0.2	46.8	47.5	0.7
Columbia Plateau	14.4	17.7	3.3*	67.2	58.8	-8.5*	18.4	23.6	5.1*
Lower Clark Fork	40.8	32.3	-8.5*	8.3	5.5	-2.8	50.9	62.1	11.2
Northern Cascades	18.4	19.1	0.7	20.9	21.2	0.3	60.7	59.7	-1.0
Northern Glaciated Mountains	21.7	23.1	1.4	19.0	19.2	0.2	59.3	57.7	-1.6
Northern Great Basin	21.9	28.6	6.7*	77.5	70.6	-6.9*	0.6	0.8	0.2
Owyhee Uplands	3.3	4.4	1.1	94.3	92.3	-2.0*	2.4	3.3	0.9*
Snake Headwaters	26.5	20.1	-6.4*	25.3	25.9	0.6	48.2	54.0	5.8*
Southern Cascades	9.9	14.1	4.2	19.5	11.3	-8.2*	70.6	74.6	4.0
Upper Clark Fork	34.3	39.8	5.5*	12.8	13.8	1.0	52.9	46.4	-6.5*
Upper Klamath	10.8	14.5	3.7	41.1	39.7	-1.3	48.1	45.7	-2.4
Upper Snake	1.6	2.7	1.1*	94.7	93.8	-0.9	3.7	3.5	-0.2

[a] H = historical; C = current; MD = mean difference of pairwise comparisons of historical and current subwatersheds.

[b] * indicates statistically significant difference at P≤0.2; all values rounded to 1 decimal place.

Blue Mountains ERU—In the Blue Mountains ERU, forest and woodland tree cover increased in previously nonwooded areas. Area without tree cover (crown cover < 10 percent) declined from 34.6 to 31.6 percent of the ERU area, and area in the 40- to 50-percent crown cover class increased from 17.7 to 21.0 percent of the ERU (table 22 and fig. 39). Area in the 90- to 100-percent crown cover class declined from 7.8 to 5.4 percent. Canopy layering increased across the ERU as well. Area with one canopy layer fell from 16.0 to 12.5 percent, and area with more than two canopy layers increased from 11.6 to 16.4 percent of the ERU area (table 23 and fig. 40). In the historical condition, 65.5 percent of the ERU area was comprised of forest and woodland; 24 percent of that area was single canopy layer forest or woodland. In the current condition, 68.3 percent of the ERU was comprised of forest and woodland; 18.3 percent of that area was single canopy layer forest or woodland. In the historical condition, 17.7 percent of the forest and woodland area was comprised of canopies with more than two layers. In the current condition, 24 percent of the forest and woodland area was comprised of canopies with more than two layers.

Understory area with Douglas-fir or grand fir or white fir, or combinations (Pacific silver fir is absent), increased significantly in the ERU; percentage of area rose from 21.0 to 25.2 percent of the ERU. Understory area with mountain hemlock also increased significantly, but the change was relatively minor (table 24 and figs. 41 and 42). Area with understories classified as “other” (primarily grass and forb, shrub, or bare ground) declined from 16.6 to 12.6 percent of the ERU. These grass, forb, shrub, and bare ground understories currently support trees (table 25). In table 25, we see that area with grass-forb-shrub-bare ground understories fell and area with conifer or hardwood understories (primarily conifer) increased from 48.8 to 55.7 percent of the ERU area. During the sample period, it is likely that effective fire exclusion and grazing activities allowed conifer understories to develop on 11 percent of historical forest and woodland area.

Central Idaho Mountains ERU—In the Central Idaho Mountains ERU, there was no net increase in forest or woodland area, but total crown cover increased in existing forests and woodlands. Area without tree cover remained unchanged, but area in the 90- to 100-percent crown cover class increased from 12.3 to 15.9 percent, and area in the 40- to 50-percent crown cover class declined from 18.6 to 16.8 percent of the ERU area (table 22 and fig. 39). No significant changes in canopy layers were evident at this reporting scale (table 23 and fig. 40).

Understory area with subalpine fir-Engelmann spruce cover increased significantly in the ERU; percentage of area rose from 14.7 to 16.6 percent of the ERU area (table 24 and figs. 41 and 42). Understory area with mountain hemlock decreased significantly, but the change was relatively minor.

Columbia Plateau ERU—In the Columbia Plateau ERU, forest and woodland tree cover increased in previously nonwooded areas (table 22 and fig. 39). Area without tree cover (crown cover < 10 percent) declined from 67.2 to 58.8 percent of the ERU, and area in the 40- to 50-percent crown cover class increased from 8.8 to 15.4 percent of the ERU. Area in the 90- to 100-percent crown cover class increased from 4.0 to 4.6 percent of the ERU.

Canopy layering also increased in the ERU. Nonforest-nonwoodland area fell from 67.2 to 58.8 percent, thereby confirming previously noted changes in forest and woodland area. Area with one canopy layer increased; percentage of area rose from 14.3 to 17.6 percent, and area with more than two canopy layers increased from 4.3 to 6.4 percent of the ERU (table 23 and fig. 40).

Understory area with Douglas-fir-grand fir-white fir (Pacific silver fir is absent) cover increased significantly in the ERU; percentage of area rose from 2.0 to 2.9 percent of the ERU area. Understory area with subalpine fir-Engelmann spruce cover also increased significantly, but the change was relatively minor (table 24 and figs. 41 and 42). Area with understory juniper increased dramatically; percentage of area rose from 2.3 to 6.5 percent of the ERU. Area with understories classified as "other" (primarily grass-forb, shrub, or bare ground) increased significantly from 14.4 to 17.7 percent of the ERU. As noted in appendix 2, forest area in the Columbia Plateau ERU increased by 3 percent, and woodland area increased by 5.5 percent of the ERU. The observed increase in grass-forb, shrub, or bare ground understory area likely was associated with forest and woodland area expansion; that is, some historical herbland and shrubland areas are wooded in the current condition. In table 25, we see that nonforest-nonwoodland area fell from 67.2 to 58.8 percent, area with grass-forb-shrub-bare ground understories rose from 14.4 to 17.7 percent, and area with conifer or hardwood understories (primarily conifer) increased from 18.4 to 23.6 percent of the ERU. During the sample period, it is likely that effective fire exclusion and grazing activities allowed conifer understories to develop on 15.5 percent of historical forest and woodland area.

Lower Clark Fork ERU—In the Lower Clark Fork ERU, forest and woodland tree cover increased in previously nonwooded areas. Area in the 10- to 30-percent crown cover class declined from 6.3 to 2.7 percent of the ERU, and area in the 40- to 50-percent crown cover class also declined, falling from 21.5 to 9.7 percent. Area in the 90- to 100-percent crown cover class rose more than twofold from 19.7 to 43.4 percent of the ERU area. In the historical vegetation condition, roughly one-quarter of forest patches in the ERU exhibited a total crown cover ≤ 50 percent, and more than three-quarters of forest patches exhibited a total crown coverage ≤ 80 percent (table 22 and fig. 39). In the current condition, patches in the 90- to 100-percent crown cover class were most abundant, representing more than 45 percent of the forest area of the ERU. Canopy layering increased in the ERU as well; percentage of area with one canopy layer fell from 38.7 to 30.0 percent of the ERU, area with two canopy layers increased from 52.9 to 61.8 percent (ns) (table 23 and fig. 40), and area with more than two canopy layers increased from 0.1 to 2.7 percent of the ERU (ns).

Understory area with western hemlock-western redcedar cover increased significantly in the ERU; percentage of area rose from 13.5 to 17.3 percent of the ERU (table 24 and figs. 41 and 42). Area with understories as "other" (primarily grass-forb, shrub, or bare ground) declined significantly from 40.8 to 32.8 percent of the ERU. These understories currently support trees. In table 25, we see that nonforest-nonwoodland area fell from 8.3 to 5.5 percent (ns), area with grass-forb-shrub-bare ground understories fell from 40.8 to 32.3 percent of the ERU, and area with conifer or hardwood understories (primarily conifer) increased from 50.9 to 62.1 percent of the ERU (ns). During the sample period, it is likely that effective fire exclusion allowed conifer understories to develop on 12 percent of the historical forest area.

Northern Cascades ERU—Overall, there was no significant trend in declining or increasing tree cover in the ERU (table 22 and fig. 39). Area in the 60- to 80-percent crown cover class fell from 33.6 to 30.3 percent (ns), but this decline was evenly offset by increases in the 90- to 100-percent and 40- to 50-percent crown cover classes. Neither were significant changes in canopy layers evident at this reporting scale (table 23 and fig. 40). Understory area with mountain hemlock cover increased significantly in the ERU; percentage of area rose from 0.4 to 0.7 percent of the ERU (table 24 and figs. 41 and 42). Understory area with ponderosa pine understory fell from 8.9 to 7.5 percent (ns). The Northern Cascades ERU is large and diverse with a wide array of biophysical environmental settings. It is likely that differences in crown cover, canopy layering, and understory species cover may be detected at smaller subregional scales.

Northern Glaciated Mountains ERU—No significant changes were observed in tree cover at this reporting scale (table 22 and fig. 39). Area in the 90- to 100-percent crown cover class increased from 21.5 to 24.2 percent, but the change was not significant at $P \leq 0.2$. Canopy layering increased significantly in the ERU. Area with two canopy layers declined from 54.6 to 48.0 percent of the ERU, and area with more than two canopy layers rose from 5.7 to 10.2 percent (table 23 and fig. 40).

Area with ponderosa pine or western larch-lodgepole pine understory cover declined significantly. Percentage of area with ponderosa pine understories fell from 9.9 to 7.4 percent of the ERU, and area with western larch-lodgepole pine understories dropped from 21.4 to 13.6 percent. Compensating increases were observed with Douglas-fir–grand fir and western hemlock-western redcedar understories (table 24 and figs. 41 and 42). Percentage of area with Douglas-fir–grand fir understories increased from 14.9 to 19.2 percent of the ERU area, and area with western hemlock-western redcedar understory cover increased from 2.1 to 5.6 percent of the ERU. Hardwood understory area also increased.

Northern Great Basin ERU—In the Northern Great Basin ERU, forest and woodland tree cover increased in previously nonwooded areas (table 22 and fig. 39). Percentage of area without tree cover (crown cover < 10 percent) declined from 77.5 to 70.6 percent of the ERU, and area in the 40- to 50-percent crown cover class increased from 11.5 to 15.6 percent. Percentage of area in the 60- to 80-percent crown cover class declined from 3.7 to 3.1 percent. Concurrent with increasing forest and woodland tree cover, area with one canopy layer rose from 21.9 to 28.9 percent of the ERU (table 23 and fig. 40).

Area with understories classified as "other" (primarily grass-forb, shrub, or bare ground) increased significantly from 21.9 to 28.6 percent of the ERU (table 24 and figs. 41 and 42). As noted in appendix 2, woodland area in the Northern Great Basin ERU increased from 15.3 to 22.2 percent of the ERU. The observed increase in grass-forb, shrub, or bare ground understory cover likely was associated with woodland area expansion; that is, some historical herbland and shrubland areas are wooded in the current condition (see also table 25).

Owyhee Uplands ERU—In the Owyhee Uplands ERU, woodland tree cover increased in previously nonwooded areas. Percentage of area without tree cover (crown cover < 10 percent) declined from 94.3 to 92.3 percent of the ERU, and percentage of area in the 10- to 30-percent crown cover class increased from 4.2 to 5.4 percent (table 22 and fig. 39). Area in the 40- to 50-percent crown cover class also increased, rising from 1.3 to 2.2 percent of the ERU area. Canopy layering also increased significantly in the ERU. Percentage of area with two canopy layers increased from 2.1 to 3.0 percent of the ERU (table 23 and fig. 40). Area with understory juniper cover also increased; percentage of area rose from 2.2 to 3.2 percent of the ERU (tables 24 and 25 and figs. 41 and 42).

Snake Headwaters ERU—In the Snake Headwaters ERU, there was no net increase in forest or woodland area, but unlike most other ERUs, total crown cover declined in existing forests and woodlands (table 22 and fig. 39). Percentage of area without tree cover remained unchanged, but area in the 90- to 100-percent crown cover class fell from 11.5 to 7.5 percent of the ERU, and percentage of area in the 40- to 50-percent crown cover class rose from 15.8 to 19.2 percent of the ERU. Canopy layering increased in the ERU (table 23 and fig. 40). Percentage of area with a single canopy layer declined from 26.4 to 19.7 percent of the ERU and area with two canopy layers increased from 45.1 to 50.6 percent of the ERU (ns).

Percentage of area with western larch-lodgepole pine understory cover fell from 13.5 to 9.0 percent of the ERU (ns), and area with subalpine fir-Engelmann spruce understory cover increased; percentage of area rose from 22.7 to 32.8 percent of the ERU, representing a 44-percent increase during the sample period (table 24 and figs. 41 and 42). Percentage of area with understories classified as "other" (primarily grass-forb, shrub, or bare ground) decreased significantly from 26.5 to 20.5 percent of the ERU. These understories currently support trees. In table 25, we see that percentage of area with grass-forb-shrub-bare ground understories fell by 6.4 percent, and area with conifer or hardwood understories (primarily conifer) increased by 5.8 percent, rising from 48.2 to 54.0 percent of the ERU area. It is likely that fire exclusion and domestic livestock grazing practices enabled conifer understories to develop on 7.8 percent of historical forest and woodland area.

Southern Cascades ERU—Forest and woodland tree cover increased in previously nonwooded areas. Percentage of area without tree cover (crown cover < 10 percent) fell sharply from 19.5 to 11.3 percent of the ERU, area in the 10- to 30-percent crown cover class increased from 8.0 to 12.9 percent, and area in the 90- to 100-percent crown cover class increased from 0.2 to 3.5 percent of the ERU (table 22 and fig. 39).

Perhaps the most significant change in canopy layering occurring among all ERUs was that observed for the Southern Cascades ERU. Nonforest-nonwoodland area fell sharply from 19.5 to 11.3 percent of the ERU, and area with more than two canopy layers increased by a compensating amount from 10.7 to 19.6 percent. Area with a single canopy layer also increased, but the change was not significant; percentage of area rose from 9.7 to 14.1 percent of the ERU. Area with two canopy layers fell from 60.0 to 55.0 percent but the change was not significant (table 23 and fig. 40).

Upper Clark Fork ERU—There was no net increase in forest or woodland area, but total crown cover declined in existing forests and woodlands (table 22 and fig. 39). Area without tree cover remained unchanged, but percentage of area in the 60- to 80-percent crown cover class fell from 45.3 to 41.2 percent of the ERU, and area in the 10- to 30-percent crown cover class rose from 7.4 to 9.5 percent. Canopy layering also declined in the Upper Clark Fork ERU (table 23 and fig. 40). Percentage of area with two layers and more than two layers declined significantly; percentage of area fell from 41.0 to 37.2 percent, and from 13.8 to 11.4 percent, respectively. Percentage of area with a single canopy layer rose sharply from 32.4 to 37.7 percent of the ERU.

Table 26—Percentage comparison of area of forest and woodland in dead tree and snag abundance classes

Ecological reporting unit	Area[a] No dead trees or snags apparent H	C	MD[b]	< 10 percent of trees dead or snags H	C	MD[b]
	Percent					
Blue Mountains	44.5	41.2	-3.3	20.1	20.2	0.1
Central Idaho Mountains	56.5	46.3	-10.2*	15.3	24.3	9.0*
Columbia Plateau	22.5	26.2	3.8*	10.2	2.7	2.5
Lower Clark Fork	66.0	62.7	-3.3	24.5	31.7	7.2
Northern Cascades	66.7	46.9	-19.8*	11.6	28.9	17.3*
Northern Glaciated Mountains	61.7	47.9	-13.8*	14.8	28.7	13.9*
Northern Great Basin	22.5	29.4	6.9*	0.0	0.0	0.0
Owyhee Uplands	4.9	6.4	1.4*	0.8	1.4	0.6
Snake Headwaters	51.8	34.2	-17.5*	22.0	23.7	1.6
Southern Cascades	76.8	76.9	0.1	3.7	9.9	6.2*
Upper Clark Fork	74.3	80.3	6.0*	10.6	5.2	-5.4*
Upper Klamath	21.7	24.1	2.4	36.7	34.1	-2.6*
Upper Snake	4.3	4.0	-0.3	1.0	1.7	0.8

[a] H = historical; C = current; MD = mean difference of pairwise comparisons of historical and current subwatersheds.

[b] * indicates statistically significant difference at $P \leq 0.2$; all values rounded to 1 decimal place.

The ERU area with ponderosa pine or western larch-lodgepole pine understory cover declined significantly. Percentage of area with ponderosa pine understories fell from 7.8 to 5.8 percent, and area with western larch-lodgepole pine understories dropped from 32.5 to 24.0 percent (table 24 and figs. 41 and 42). Area with Douglas-fir–grand fir understory cover increased significantly in the ERU; percentage of area rose from 5.4 to 8.4 percent of the ERU. Percentage of area with understories classified as "other" (primarily grass-forb, shrub, or bare ground) increased from 34.3 to 39.8 percent of the ERU. In table 25, we see that area with grass-forb-shrub-bare ground understories rose, and area with conifer or hardwood understories (primarily conifer) declined. During the sample period, it is likely that timber harvest activities reduced conifer understories on 7 percent of the historical forest and woodland area.

Upper Klamath ERU—In the Upper Klamath ERU, there was no net increase in forest or woodland area, but total crown cover declined in existing forests and woodlands (table 22 and fig. 39). Percentage of area without tree cover remained essentially unchanged, but area in the 60- to 80-percent crown cover class fell from 27.4 to 19.9 percent, and area in the 40- to 50-percent crown cover class rose sharply from 17.5 to 26.1 percent. Canopy layering in the Upper Klamath generally declined, but none of the observed changes was significant at $P \leq 0.2$ (table 23 and fig. 40).

Upper Snake ERU—In the Upper Snake ERU, forest tree cover increased slightly but significantly in previously nonwooded areas (table 22 and fig. 39). Percentage of area without tree cover (crown cover < 10 percent) remained unchanged, and area in the 40- to 50-percent crown cover class increased from 1.9 to 2.4 percent of the ERU area. Concurrent with increasing tree cover, forest area with a single canopy layer rose from 1.6 to 2.7 percent of the ERU (table 23 and fig. 40). Percentage of area with understories classified as "other" (primarily grass-forb, shrub, or bare ground) increased from 1.6 to 2.7 percent of the ERU (see also table 25).

for ecological reporting units in the midscale assessment of the interior Columbia River basin

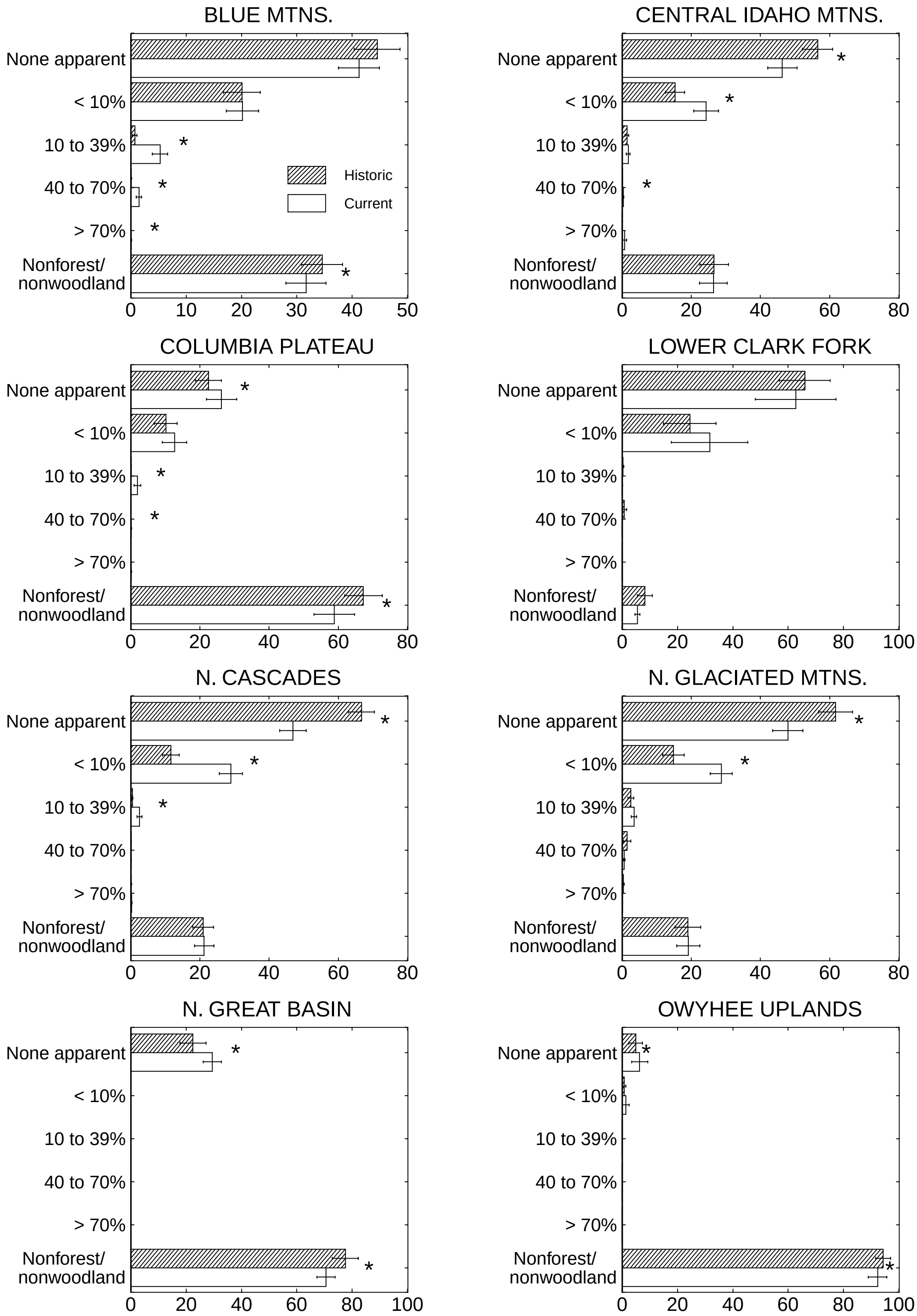
Area[a]											
10 to 39 percent of trees dead or snags			40 to 70 percent of trees dead or snags			> 70 percent of trees dead or snags			Nonforest-nonwoodland		
H	C	MD[b]	H	C	MD[b]	H	C	MD[b]	H	C	MD[b]
Percent											
0.8	5.3	4.5*	0.1	1.5	1.4*	0.0	0.1	0.1*	34.6	31.6	-2.9*
1.5	1.8	0.4	0.1	0.4	0.2*	0.0	0.8	0.8	26.6	26.4	-0.2
0.1	2.0	1.8*	0.0	0.2	0.2*	0.0	0.2	0.2	67.2	58.8	-8.4*
0.4	0.1	-0.3	0.9	0.0	-0.9	0.0	0.0	0.0	8.3	5.5	-2.8
0.5	2.6	2.1*	0.2	0.1	0.0	0.2	0.2	0.1	20.9	21.2	0.3
2.6	3.5	0.8	1.5	0.6	-0.9	0.4	0.1	-0.2	19.0	19.2	0.2
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	77.5	70.6	-6.9*
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	94.3	92.3	-2.0*
0.8	12.9	12.0*	0.0	1.2	1.2*	0.0	2.1	2.1*	25.3	25.9	0.6
0.0	1.4	1.3*	0.0	0.5	0.5	0.0	0.1	0.1*	19.5	11.3	-8.2*
1.8	0.2	-1.6*	0.1	0.1	0.0	0.4	0.3	-0.1	12.8	13.8	1.0
0.5	1.1	0.6	0.0	1.0	0.9	0.0	0.0	0.0	41.1	39.7	-1.3
0.0	0.2	0.2*	0.0	0.0	0.0	0.0	0.1	0.1	94.7	93.8	-0.9

Dead Tree and Snag Abundance

In this section, we report on changes in dead tree and snag abundances to evaluate direct effects of insect and pathogen infestation and mortality and indirect effects of fire exclusion, dead tree salvage, and timber harvest during the last half century. Our null hypothesis was no significant difference in dead tree and snag abundance between historical and current photointerpreted vegetation conditions. We speculated that fire prevention and suppression activities, salvage logging, and selective timber harvesting created increased abundance of snags and dead trees in sapling, pole, and small-tree size classes. We further speculated that abundance of medium and large dead trees and snags declined with widespread decline of live medium and large trees (see also tables 20 and 21).

Table 26 and figure 43 display changes during the sample period in percentage of area of five dead tree and snag abundance classes. Dead tree and snag classes were none apparent, < 10 percent of trees dead or snags, 10 to 39 percent of trees dead or snags, 40 to 70 percent of trees dead or snags, and > 70 percent of trees dead or snags.

Dead tree and snag abundance increased significantly in the Blue Mountains, Central Idaho Mountains, Columbia Plateau, North Cascades, Northern Glaciated Mountains, Snake Headwaters, and Southern Cascades ERUs and declined significantly in the Upper Clark Fork and Upper Klamath ERUs. Two patterns of change were observed. High concentrations of dead trees within patches (≥ 10 percent of trees dead or snags) were found in the Blue Mountains, Snake Headwaters, and Southern Cascades ERUs, but affected areas comprised less than 10 to 15 percent of the ERU area. In the Central Idaho Mountains, Northern Cascades, and Northern Glaciated Mountains ERUs, dead trees were less concentrated within patches (< 10 percent of trees dead or snags than in the aforementioned ERUs), but this condition occurred over relatively large areas of each ERU, affecting 10 to 20 percent of the land area.


BLUE MTNS.
CENTRAL IDAHO MTNS.
COLUMBIA PLATEAU
LOWER CLARK FORK
N. CASCADES
N. GLACIATED MTNS.
N. GREAT BASIN
OWYHEE UPLANDS
None apparent
< 10%
10 to 39%
40 to 70%
> 70%
Nonforest/
nonwoodland
Historic
Current

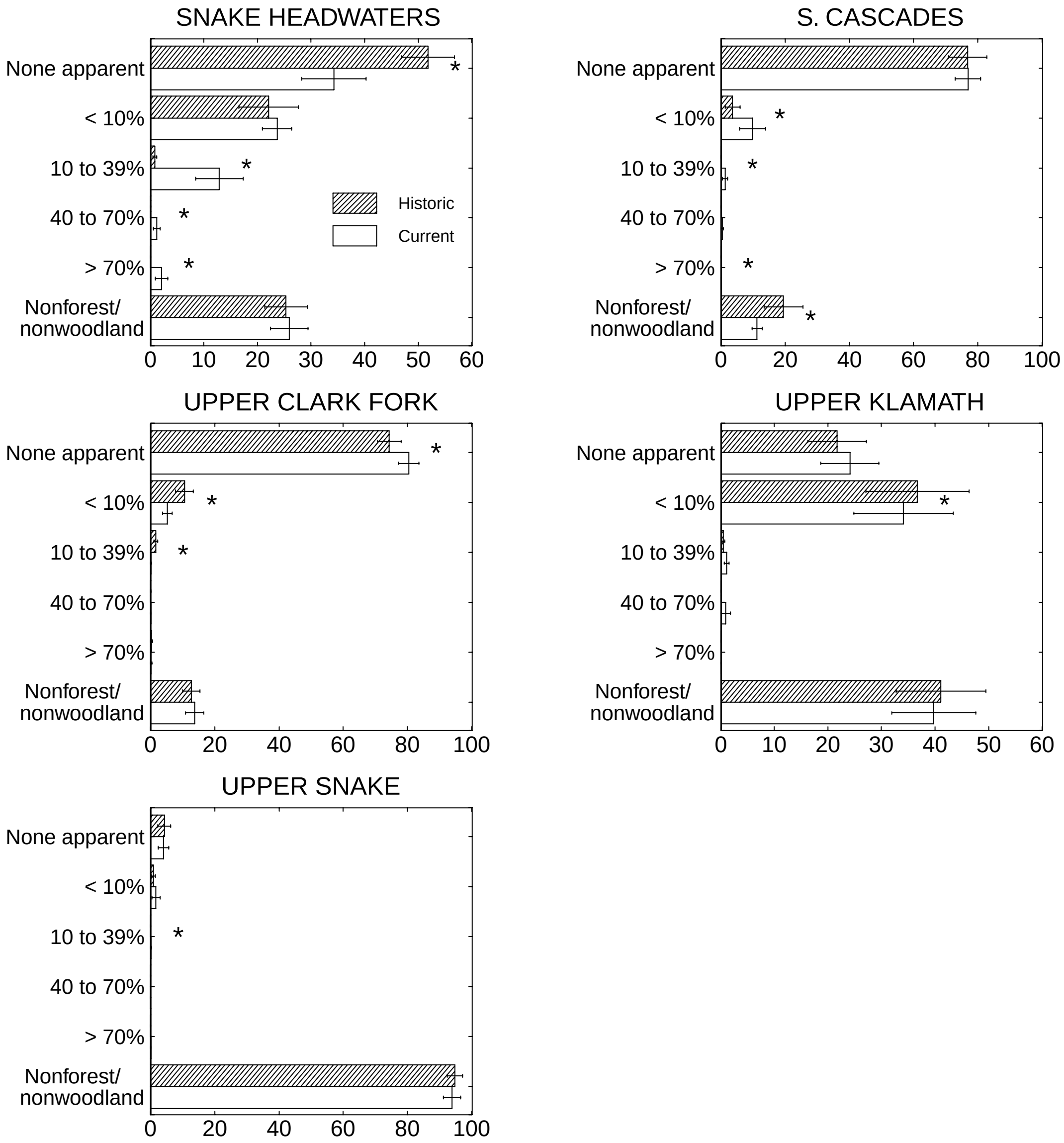


Figure 43—Historical and current distribution of forest and woodland dead tree and snag abundance classes expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) difference between historical and current conditions. Dead tree and snag classes were none apparent, < 10 percent of trees dead or snags, 10 to 39 percent of trees dead or snags, 40 to 70 percent of trees dead or snags, and > 70 percent of trees dead or snags.

Table 27—Percentage comparison of area of forest and woodland in visible logging activity classes for

	Area[a]					
	No logging apparent			Regeneration harvest		
Ecological reporting unit	H	C	MD[b]	H	C	MD[b]
	Percent					
Blue Mountains	51.4	49.0	-2.5	3.9	5.1	1.2
Central Idaho Mountains	70.5	67.9	-2.6*	0.5	2.7	2.2*
Columbia Plateau	25.1	27.5	2.4	1.4	1.5	0.1
Lower Clark Fork	67.5	67.0	-0.6	2.3	9.5	7.2*
Northern Cascades	71.3	61.4	-9.9*	0.4	4.1	3.7*
Northern Glaciated Mountains	74.0	59.4	-14.6*	2.3	7.9	5.6*
Northern Great Basin	22.5	29.4	6.9*	0.0	0.0	0.0
Owyhee Uplands	5.7	7.7	2.0*	0.0	0.0	0.0
Snake Headwaters	74.7	72.4	-2.3	0.0	0.1	0.1*
Southern Cascades	65.1	54.7	-10.3*	5.5	7.5	2.0
Upper Clark Fork	77.0	63.8	-13.2*	5.5	11.6	6.1*
Upper Klamath	48.9	35.2	-13.7*	1.0	3.8	2.8*
Upper Snake	4.1	6.0	1.9*	0.0	0.0	-0.0

[a] H = historical; C = current; MD = mean difference of pairwise comparisons of historical and current subwatersheds.

[b] * indicates statistically significant difference at P≤0.2; all values rounded to 1 decimal place.

Area Affected by Visible Logging Activity

In this section, we report on changes in area affected by visible logging activity to evaluate extent and effects of timber harvest activities during the sample period. Our null hypothesis was no significant difference in percentage of area within logging activity classes between historical and current vegetation conditions. We hypothesized that area affected by selective and regeneration harvest activities would increase during the sample period. Table 27 and figure 44 display changes in percentage of area of five visible logging entry classes. Logging entry classes were no logging apparent, regeneration harvest, selective harvest, thinned, and small patch clearcut.

As would be expected, logging activity increased significantly in all forested ERUs. Percentage of area with no visible logging activity declined significantly in 6 of 13 ERUs, and increased in 3 herbland- and shrubland-dominated ERUs. The most commonly increasing logging activity was selective harvesting, which increased significantly in the Blue Mountains, Columbia Plateau, Northern Cascades, Northern Glaciated Mountains, Snake Headwaters, Southern Cascades, Upper Clark Fork, and Upper Klamath ERUs and declined in the Lower Clark Fork (ns) and Upper Snake ERUs. In all but one forested ERU, selective harvesting had affected less than 10 percent of the historical condition. But, in the Lower Clark Fork ERU, nearly 22 percent of the area had been affected by selective harvesting in the historical condition. During the sample period, apparent selective harvested area increased from 9.6 to 13.2 percent of the ERU in the Blue Mountains, from 6.1 to 11.3 percent in the Columbia Plateau, from 7.2 to 11.5 percent in the Northern Cascades, from 4.5 to 11.4 percent in the Northern Glaciated Mountains, from 0 to 0.3 percent in the Snake Headwaters, from 9.2 to 23.2 percent in the Southern Cascades, from 4.6 to 9.7 percent in the Upper Clark Fork, and from 7.0 to 19.3 percent in the Upper Klamath ERU.

ecological reporting units in the midscale assessment of the interior Columbia River basin

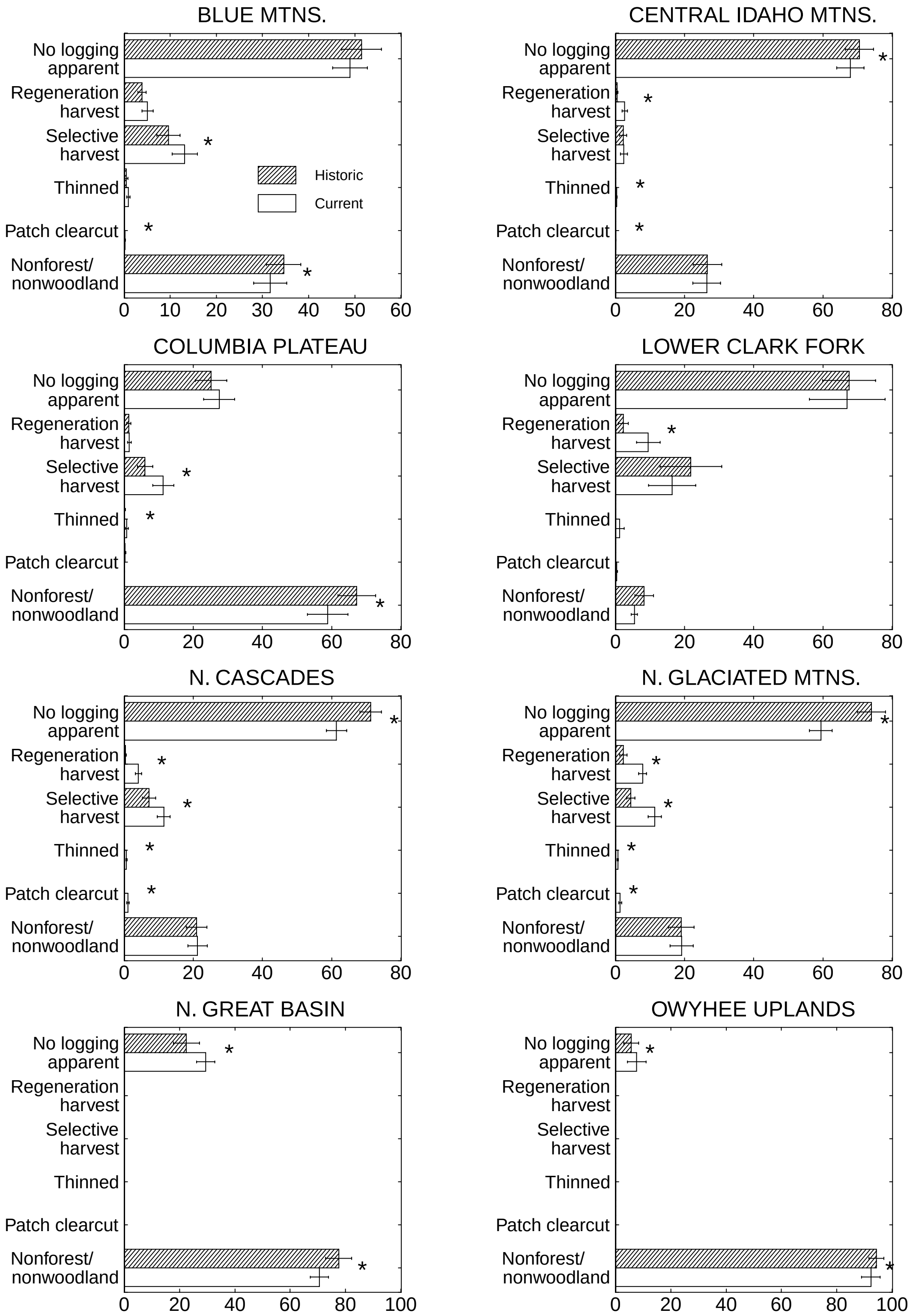
Area[a]											
Selective harvest			Thinned			Patch clearcut			Nonforest-nonwoodland		
H	C	MD[b]	H	C	MD[b]	H	C	MD[b]	H	C	MD[b]
Percent											
9.6	13.2	3.5*	0.5	0.9	0.4	0.0	0.2	0.2*	34.6	31.6	-2.9*
2.3	2.5	0.2	0.0	0.4	0.3*	0.0	0.1	0.1*	26.6	26.4	-0.2
6.1	11.3	5.3*	0.2	0.8	0.6*	0.3	0.1	-0.2	67.2	58.8	-8.4*
21.8	16.4	-5.5	0.0	1.3	1.2	0.0	0.4	0.4	8.3	5.5	-2.8
7.2	11.5	4.3*	0.1	0.7	0.6*	0.0	1.1	1.1*	20.9	21.2	0.3
4.5	11.4	6.9*	0.0	0.7	0.7*	0.0	1.4	1.4*	19.0	19.2	0.2
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	77.5	70.6	-6.9*
0.0	0.0	-0.0	0.0	0.0	0.0	0.0	0.0	0.0	94.3	92.3	-2.0*
0.0	0.3	0.3*	0.0	0.0	0.0	0.0	1.3	1.3*	25.3	25.9	0.6
9.2	23.2	14.0*	0.7	2.8	2.1*	0.0	0.5	0.5*	19.5	11.3	-8.2*
4.6	9.7	5.1*	0.0	0.6	0.6*	0.0	0.5	0.5*	12.8	13.8	1.0
7.0	19.3	12.2*	2.0	1.9	0.0	0.0	0.1	0.1	41.1	39.7	-1.3
1.2	0.2	-1.1*	0.0	0.0	0.0	0.0	0.0	0.0	94.7	93.8	-0.9

Area affected by regeneration harvests increased most significantly in the Central Idaho Mountains, Lower Clark Fork, Northern Cascades, Northern Glaciated Mountains, Upper Clark Fork, and Upper Klamath ERUs. During the sample period, apparent regeneration-harvested area increased from 0.5 to 2.7 percent of the ERU in the Central Idaho Mountains, from 2.3 to 9.5 percent in the Lower Clark Fork, from 0.4 to 4.1 percent in the Northern Cascades, from 2.3 to 7.9 percent in the Northern Glaciated Mountains, from 0 to 0.1 percent in the Snake Headwaters, from 5.5 to 11.6 percent in the Upper Clark Fork, and from 1.0 to 2.8 percent in the Upper Klamath ERU. Thinned and small patch clearcut areas also increased significantly in about one-half of the ERUs, but affected areas were considerably smaller than those affected by regeneration and selective harvests.

In the Blue Mountains' historical vegetation coverage, 65.5 percent of the land area of the ERU was forested or woodland (appendix 2), 78.5 percent of the forest and woodland area exhibited no apparent sign of visible logging activity, and 21.4 percent of the forest and woodland area was visibly logged (table 27). In our current vegetation coverage, 68.3 percent of the land area was forested or in woodland, 71.7 percent of the forest and woodland area exhibited no apparent sign of visible logging activity, and 28.4 percent of the forest and woodland area was visibly logged.

Historically, 73.5 percent of the land area of the Central Idaho Mountains ERU was forested or woodland, 95.9 percent of the forest and woodland area exhibited no sign of visible logging activity, and 3.8 percent of the forest and woodland area was visibly logged. In our current vegetation coverage, 73.5 percent of the land area was again forested or in woodland, 92.4 percent of the forest and woodland area exhibited no apparent sign of visible logging activity, and 7.8 percent of the forest and woodland area was visibly logged.

For the Columbia Plateau ERU, 32.8 percent of the land area was forested or woodland in historical vegetation coverage, 76.5 percent of the forest and woodland area exhibited no sign of visible logging activity, and 24.4 percent of the forest



BLUE MTNS.
CENTRAL IDAHO MTNS.
COLUMBIA PLATEAU
LOWER CLARK FORK
N. CASCADES
N. GLACIATED MTNS.
N. GREAT BASIN
OWYHEE UPLANDS
No logging apparent
Regeneration harvest
Selective harvest
Thinned
Patch clearcut
Nonforest/ nonwoodland
Historic
Current
0 10 20 30 40 50 60
0 20 40 60 80
0 20 40 60 80 100

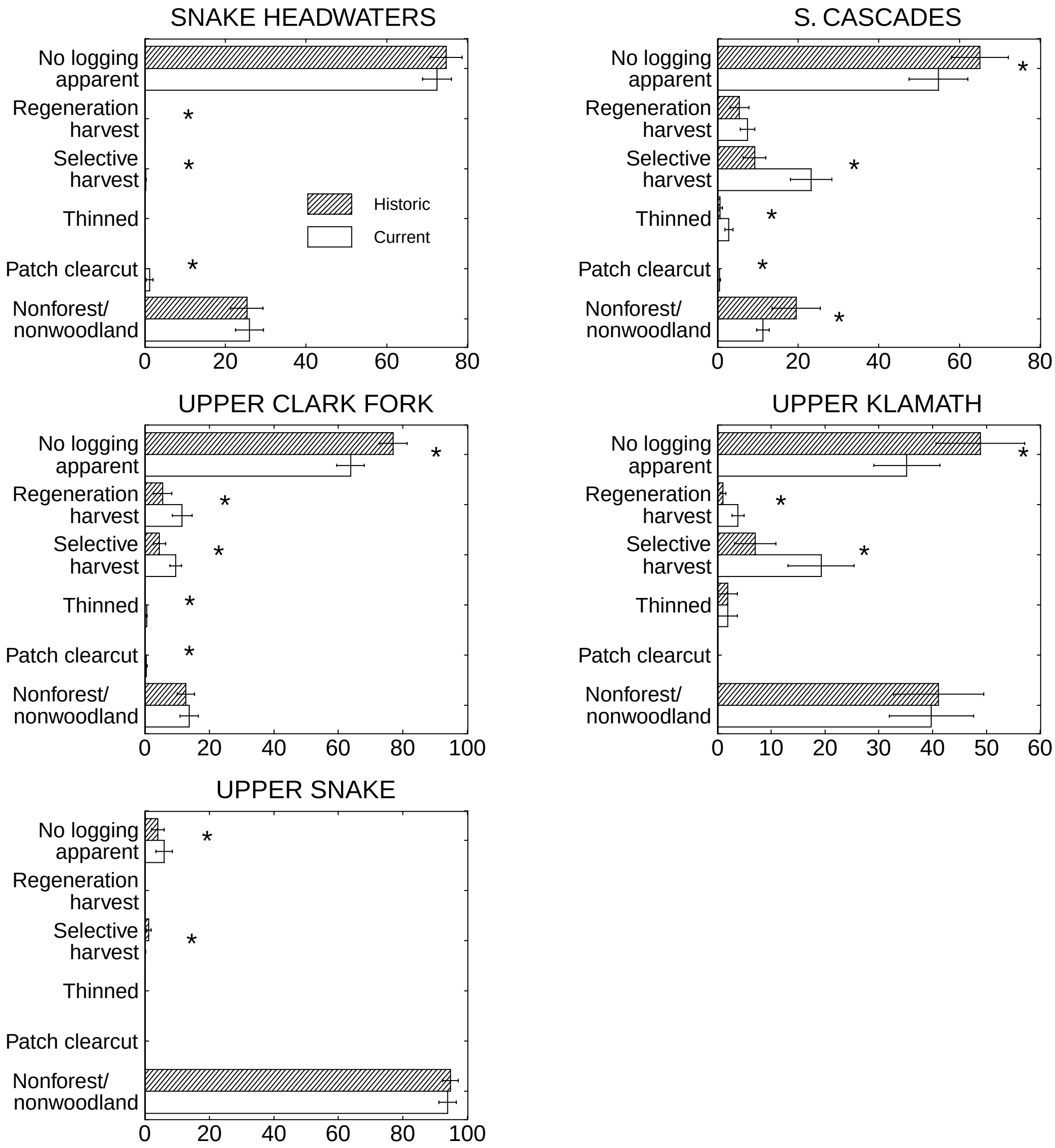


Figure 44—Historical and current distribution of forest and woodland apparent logging entry classes expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) difference between historical and current conditions. Logging entry classes were no logging apparent, regeneration harvest, selective harvest, thinned, patch clearcut, and nonforest-nonwoodland.

and woodland area was visibly logged. In the current condition, 41.3 percent of the land area was forested or in woodland, 66.6 percent of the forest and woodland area exhibited no apparent sign of visible logging activity, and 33.2 percent of the forest and woodland area was visibly logged.

Historically, 93.6 percent of the land area of the Lower Clark Fork ERU was forested or woodland, 72.1 percent of the forest and woodland area exhibited no apparent sign of visible logging activity, and 25.7 percent of the forest and woodland area was visibly logged. In the current condition, 95.1 percent of the land area was forested or in woodland, 70.5 percent of the forest and woodland area exhibited no apparent sign of visible logging activity, and 29 percent of the forest and woodland area was visibly logged.

For the Northern Cascades ERU historical vegetation coverage, 79.1 percent of the land area was forested or in woodland, 90.1 percent of the forest and woodland area exhibited no apparent sign of visible logging activity, and 9.7 percent of the forest and woodland area was visibly logged. In the current condition, 78.9 percent of the land area was forested or in woodland, 77.8 percent of the forest and woodland area exhibited no apparent sign of visible logging activity, and 22.1 percent of the forest and woodland area was visibly logged.

In the Northern Glaciated Mountains ERU, 81 percent of the land area was forested or woodland in historical vegetation coverage, 91.4 percent of the forest and woodland area exhibited no apparent sign of visible logging activity, and 8.4 percent of the forest and woodland area was visibly logged. In the existing condition, 80.8 percent of the land area was forested or in woodland, 73.5 percent of the forest and woodland area exhibited no apparent sign of visible logging activity, and 26.5 percent of the forest and woodland area was visibly logged.

Historically, 74.7 percent of the land area of the Snake Headwaters ERU was forested or woodland, and no forest and woodland area exhibited any sign of visible logging activity. In the current condition, 74.1 percent of the land area was forested or in woodland, 97.7 percent of the forest and woodland area exhibited no apparent sign of visible logging activity, and 2.3 percent of the forest and woodland area was visibly logged.

In the Southern Cascades ERU, 80.5 percent of the land area was forested or woodland in historical vegetation coverage, 80.9 percent of the forest and woodland area exhibited no apparent sign of visible logging activity, and 19.1 percent of the forest and woodland area was visibly logged. In the current condition, 88.7 percent of the land area was forested or in woodland, 61.7 percent of the forest and woodland area exhibited no apparent sign of visible logging activity, and 38.3 percent of the forest and woodland area was visibly logged.

Nearly 90 percent (87.2) of the land area of the Upper Clark Fork ERU was forested or woodland in historical vegetation coverage, 88.3 percent of the forest and woodland area exhibited no apparent sign of visible logging activity, and 11.6 percent of the forest and woodland area was visibly logged. In the current condition, 86.2 percent of the land area was forested or in woodland, 74 percent of the forest and woodland area exhibited no apparent sign of visible logging activity, and 26 percent of the forest and woodland area was visibly logged.

Finally, in the Upper Klamath ERU historical vegetation coverage, 58.9 percent of the land area was forested or woodland, 83 percent of the forest and woodland area exhibited no apparent sign of visible logging activity, and 17 percent of the forest and woodland area was visibly logged. In the existing condition, 60.3 percent of the land area was forested or in woodland, 58.4 percent of the forest and woodland area exhibited no apparent sign of visible logging activity, and 41.6 percent of the forest and woodland area was visibly logged.

Table 28—Comparison of riparian-wetland area abundance in ecological reporting units in the midscale assessment of the interior Columbia River basin

	Area[a]					
	Riparian or wetland area			Not a riparian or wetland area		
Ecological reporting unit	H	C	MD[b]	H	C	MD[b]
	Percent			*Percent*		
Blue Mountains	3.3	5.3	2.0*	96.7	94.7	-2.0*
Central Idaho Mountains	2.8	3.7	0.9*	97.2	96.3	-0.9*
Columbia Plateau	3.5	2.5	-1.0*	96.5	97.5	1.0*
Lower Clark Fork	3.3	3.6	0.3*	96.7	96.4	-0.3*
Northern Cascades	5.5	7.2	1.7*	94.5	92.8	-1.7*
Northern Glaciated Mountains	4.5	4.6	0.1	95.6	95.4	-0.1
Northern Great Basin	4.2	2.6	-1.5	95.8	97.4	1.5
Owyhee Uplands	1.5	1.1	-0.4	98.5	98.9	0.4
Snake Headwaters	5.9	6.5	0.5	94.1	93.5	-0.5
Southern Cascades	4.1	6.1	1.9*	95.9	93.9	-1.9*
Upper Clark Fork	8.0	7.5	-0.5	92.0	92.5	0.5
Upper Klamath	15.1	12.7	-2.4	84.9	87.3	2.4
Upper Snake	0.3	0.5	0.1	99.7	99.5	-0.1

[a] H = historical; C = current; MD = mean difference of pairwise comparisons of historical and current subwatersheds.

[b] * indicates statistically significant difference at $P \leq 0.2$; all values rounded to 1 decimal place.

Riparian and Wetland Area

In this section, we report on changes in distribution of riparian and wetland area to evaluate extent and effects of timber harvest activities and fire exclusion during the sample period. Our null hypothesis was no significant difference in percentage of riparian or wetland area between historical and current vegetation conditions. We speculated that riparian and wetland area within forested ERUs declined as a result of increased density and areal extent of forests and woodlands and their dewatering effects on wet areas. We further speculated that riparian and wetland area in nonforest also declined as a result of extensive agricultural use of historical herbland and shrubland riparian areas and ditching efforts in wetlands. Table 28 and figure 45 display change in riparian and wetland area during the sample period.

As was expected, riparian and wetland area declined in ERUs with significant nonforest area, but surprisingly, area increased in forested ERUs.

We suspect that the observed increase in riparian and wetland area in forested ERUs was a function of two unrelated factors. First, in the absence of more regular fire disturbance to both riparian and adjacent upslope environments, differences between valley bottom environments and adjacent slopes had time to develop and be expressed over a period of six or seven decades without fire. Camp (1995) and Camp and others (1997) show that 74 percent of the riparian environments in the Wenatchee Mountains of Washington display the fire regime of adjacent side slopes. Second, scale of photos of current vegetation conditions was somewhat larger than that for the historical conditions, and most historical photography was black and white. Steps were taken to minimize effects of these differences on remotely sensed interpretations, but interpreters noted that interpreting vegetation attributes from black and white, 1:20,000-scale, historical photographs was somewhat more difficult than interpreting 1:12,000-scale, current color photography. It is therefore possible that photointerpreters were

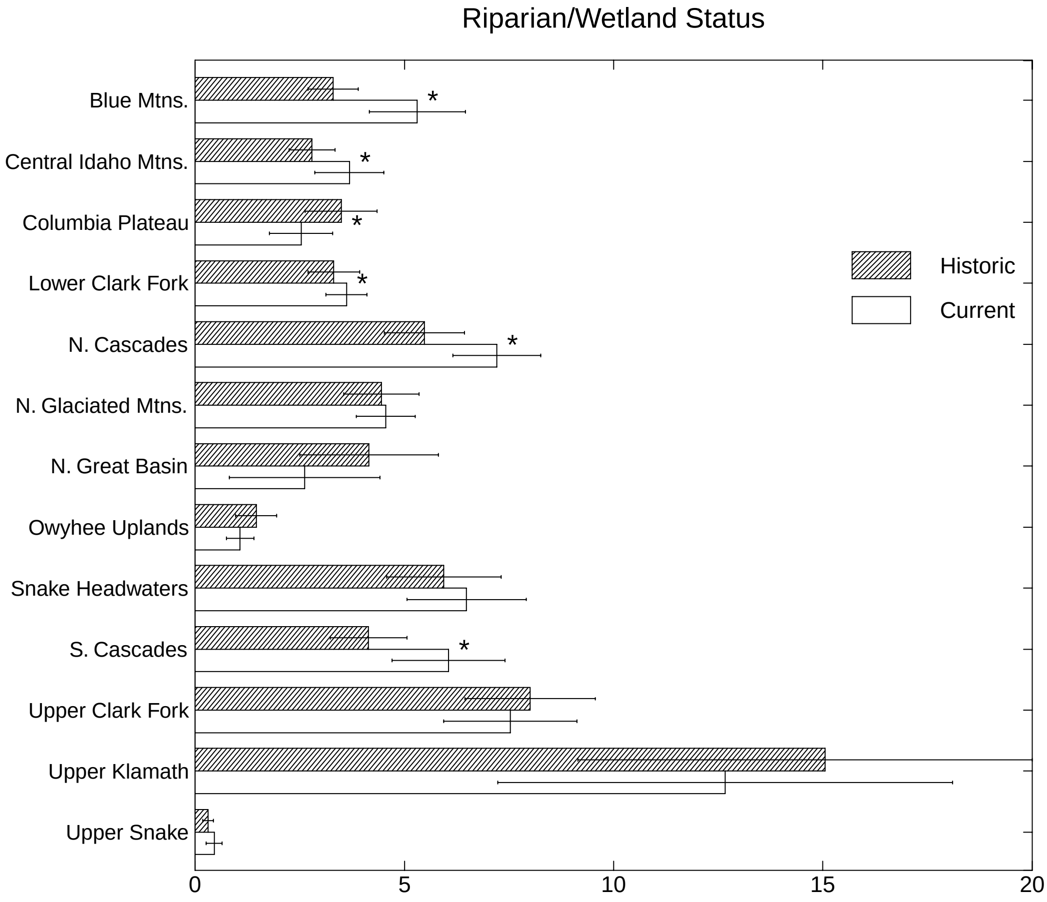


Figure 45—Historical and current distribution of riparian and wetland area expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) difference between historical and current conditions.

able to see more riparian and wetland areas in the current photography. We believe that this source of error was minimized, though, because high-quality mirrored stereoscopes were used with adequate lighting and variable ocular magnification.

Riparian and wetland area increased significantly in the Blue Mountains, Central Idaho Mountains, Lower Clark Fork, Northern Cascades, and Southern Cascades ERUs and decreased significantly in the Columbia Plateau ERU. During the sample period, riparian and wetland area increased from 3.3 to 5.3 percent of the ERU in the Blue Mountains, from 2.8 to 3.7 percent in the Central Idaho Mountains, from 3.3 to 3.6 percent in the Lower Clark Fork, from 5.5 to 7.7 percent in the Northern Cascades, and from 4.1 to 6.1 percent in the Southern Cascades. Riparian and wetland area declined from 3.5 to 2.5 percent of the ERU in the Columbia Plateau. A general trend of declining riparian and wetland area also was noted in the Northern Great Basin, Owyhee Uplands, Upper Clark Fork, and Upper Klamath ERUs, but changes were not significant at this reporting scale.

Vulnerability of Forest Landscapes to Potential Insect and Pathogen Disturbances

In this section, we describe significant change in area and connectivity of patch types between historical and current vegetation conditions, where patch types were insect and pathogen disturbance vulnerability classes (hereafter, vulnerability classes). Our null hypothesis was no significant difference in area or connectivity of area vulnerable to insect and pathogen disturbances between historical and current vegetation conditions. We speculated that both significant increases and declines in vulnerability would be observed as a consequence of timber harvest, domestic livestock grazing activities, and fire exclusion. All results are summarized by ERU, and ecologically significant change is the primarily emphasis. Appendix 3 provides complete tabular results of all analyses summarized in this section. Comparisons among ERUs are provided in the "Discussion."

Vulnerability to potential insect and pathogen disturbances changed less than expected because variation among paired subwatershed samples was considerable at the ERU scale. Large changes in vulnerability to insect and pathogen disturbances were common at the subwatershed scale, thereby indicating that statistical pooling at the subwatershed scale was more appropriate for reporting midscale trends in vulnerability.

Blue Mountains ERU—Subbasins sampled within the Blue Mountains ERU (figs. 12 to 14 and 16) included the Burnt (BUR), Lower Grande Ronde (LGR), Silvies (SIL), Upper Grande Ronde (UGR), Upper John Day (UJD), and Wallowa (WAL). Among these subbasins, 46 historical and current subwatershed pairs were sampled.

Insect disturbance vulnerabilities—
Defoliators—There was no significant change in percentage of area vulnerable to western spruce budworm disturbance at this reporting scale (fig. 46), but connectivity of vulnerable area declined (appendix 3). Patch density of the high vulnerability class increased from 12.4 to 14.7 patches per 10 000 ha, and mean patch size declined from an average of 568.4 to 516.4 ha (ns). Loss of grand fir and white fir cover and increased area in Douglas-fir cover were apparently compensating effects of management (appendix 2).

Barkbeetles—Area vulnerable to the Douglas-fir beetle disturbance increased, and connectivity of vulnerable area also increased. Percentage of area in the high vulnerability class rose from 5.2 to 7.8 percent of the ERU (fig. 46), patch density increased from 4.5 to 8.9 patches per 10 000 ha (appendix 3), and mean patch size remained unchanged. Patch density of the moderate vulnerability class also increased from 17.7 to 22.8 patches per 10 000 ha, and mean patch size remained unchanged. Percentage of area in the low vulnerability class declined from 75.0 to 69.8 percent. Increased area in the high vulnerability class was associated primarily with increased area of Douglas-fir cover.

Area vulnerable to western pine beetle (type 1) disturbance of mature and old ponderosa pine declined (fig. 47); loss of area was observed in the moderate vulnerability class where percentage of area dropped from 18.8 to 16.5 percent of the ERU. As noted earlier, there was little appreciable loss of area in the ponderosa pine cover type, but area of old multistory and old single-story structures declined, as did area of understory reinitiation and stem-exclusion open canopy structures (appendix 2). Decline in area vulnerable to western pine beetle (type 1) was apparently associated with declining abundance of medium and large ponderosa pine in overstories associated with understory reinitiation, stem-exclusion open canopy, and old single-story and multistory forest structures (tables 20 and 21). Patch density of the moderate vulnerability class also increased from 11.3 to 15.2 patches per 10 000 ha, and mean patch size dropped from 304.5 to 128.5 ha (ns), indicating declining connectivity of host types. Declining connectivity of the ponderosa pine cover type also was observed (appendix 2).

Modeling rules for western pine beetle (type 2) and mountain pine beetle (type 2) patch vulnerabilities were identical, and results of change analyses were likewise identical. Here and following,

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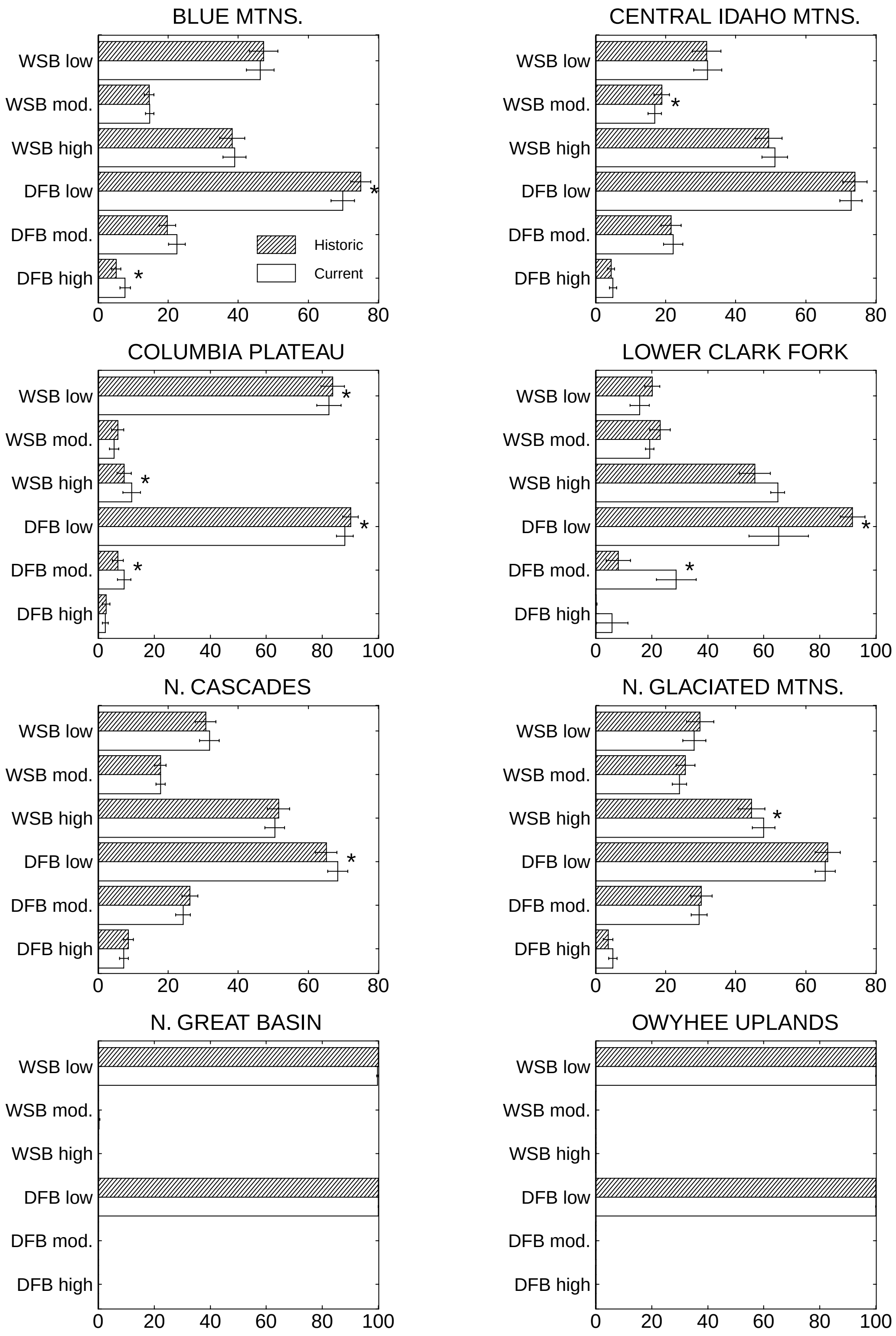
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LOWER CLARK FORK
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N. GLACIATED MTNS.
N. GREAT BASIN
OWYHEE UPLANDS
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DFB low
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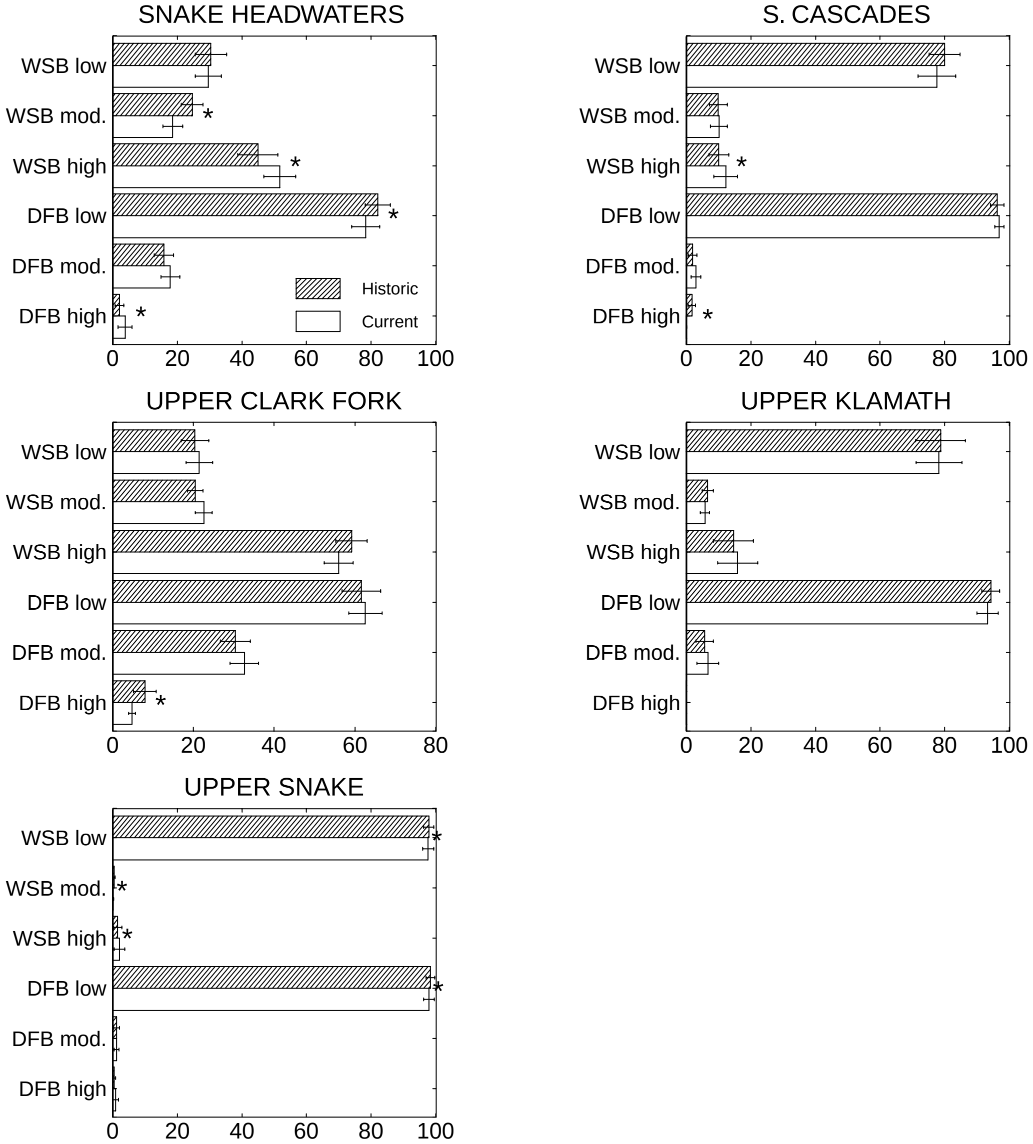
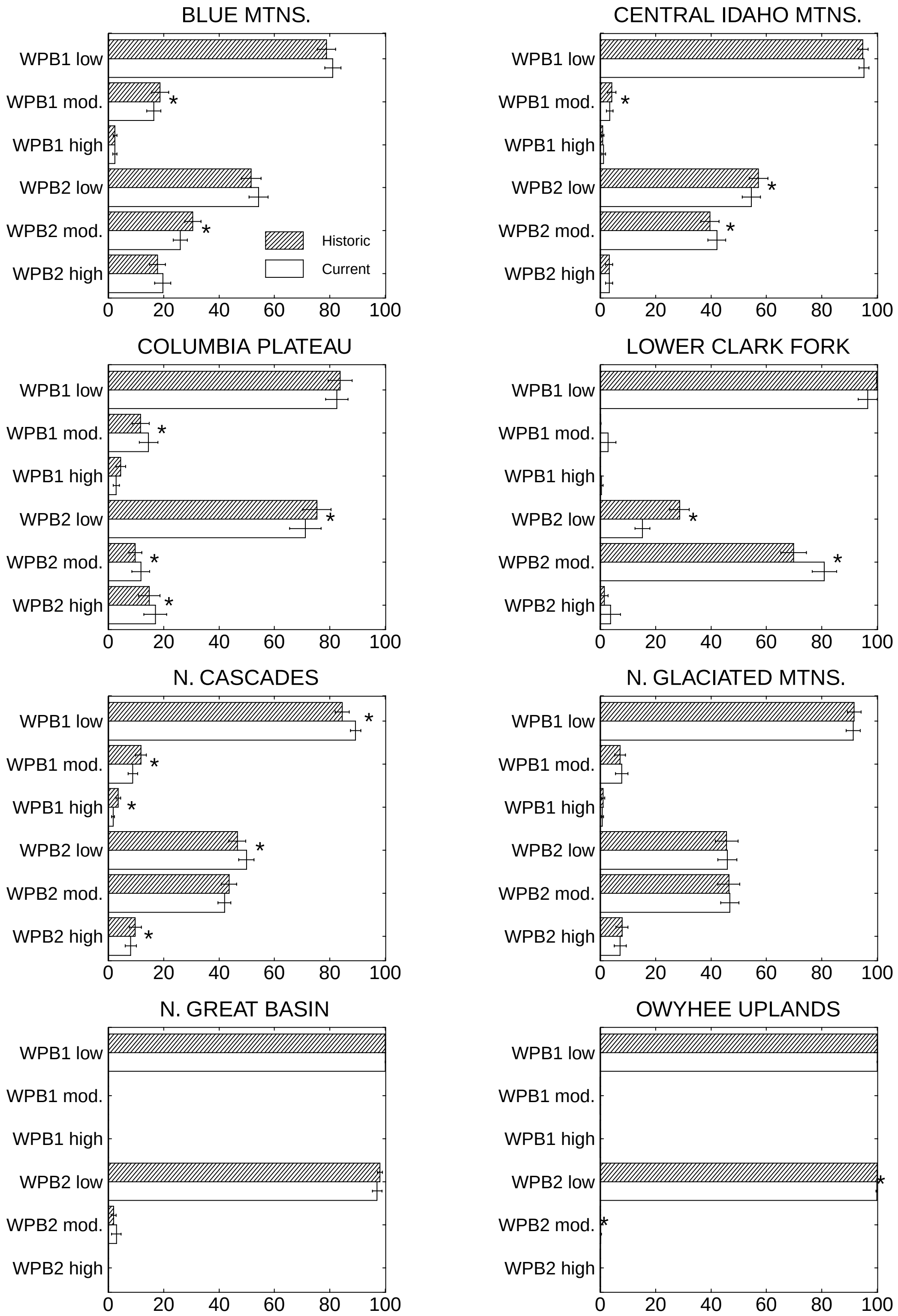


Figure 46—Historical and current distribution of western spruce budworm and Douglas-fir beetle disturbance vulnerability classes expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) difference between historical and current conditions. Insect disturbance abbreviations are WSB = western spruce budworm and DFB = Douglas-fir beetle. Vulnerability class codes are low, moderate, and high.



BLUE MTNS.
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N. CASCADES
N. GLACIATED MTNS.
N. GREAT BASIN
OWYHEE UPLANDS
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WPB1 mod.
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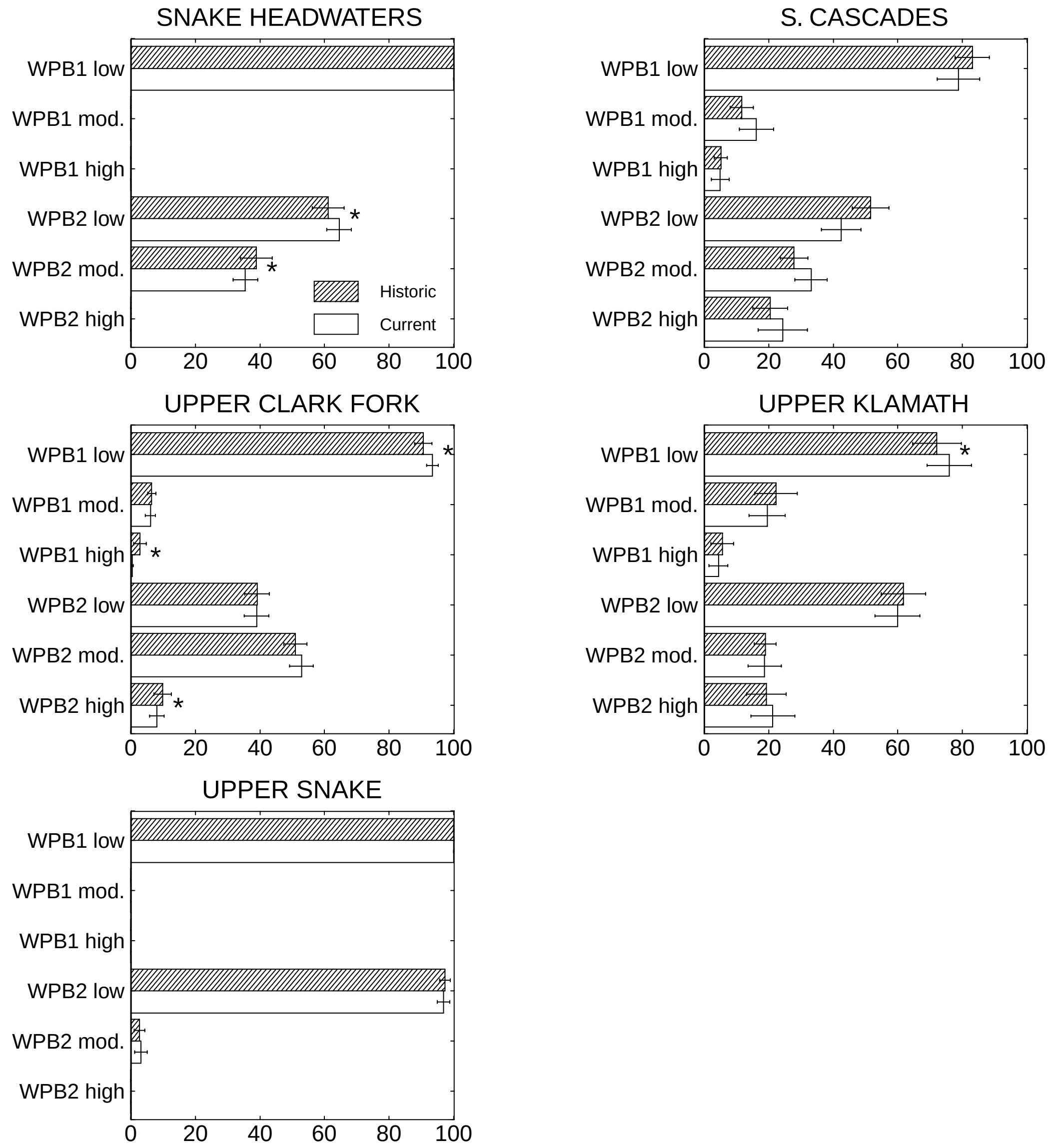

Figure 47—Historical and current distribution of western pine beetle type-1 and type-2 disturbance vulnerability classes expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) difference between historical and current conditions. Insect disturbance abbreviations are WPB1=western pine beetle (type 1) of mature and old ponderosa pine, and WPB2=western pine beetle (type 2) of immature and high density ponderosa pine. Vulnerability class codes are low, moderate, and high.

we report them together. Percentage of area highly vulnerable to western pine beetle (type 2) and mountain pine beetle (type 2) disturbance of immature, high-density ponderosa pine remained unchanged during the sample period (figs. 47 and 48). Patch density increased from 10.5 to 13.7 patches per 10 000 ha, and mean patch size increased from 166.9 to 254.5 ha. These results, and results from analysis of change in forest cover types and structural classes indicated that young and middle-aged patches vulnerable to this disturbance were only slightly more numerous in the current vegetation condition than in the historical condition, but the average size of highly vulnerable patches had increased by 52 percent. Conversely, area and connectivity of the moderate vulnerability class declined; percentage of area fell from 30.6 to 26.0 percent of the ERU, patch density rose by 30 percent from 20.6 to 26.7 patches per 10 000 ha, and mean patch size declined by 45 percent from 259.7 to 141.8 ha.

Another significant change in area vulnerable to bark beetle disturbance was associated with mountain pine beetle (type 1) disturbance of high density lodgepole pine. Percentage of area in the high vulnerability class fell from 6.7 to 5.1 percent, a 24-percent loss of vulnerable area during the sample period (fig. 48). Because no significant change in area of the lodgepole pine cover type was observed where lodgepole pine was the principal cover species (appendix 2), these results suggest that the percentage of area of lodgepole pine in mixed species cover types declined during the sample period. As modeled, both pure and mixed species cover types with lodgepole pine were host types (see Hessburg and others, in press).

Area and connectivity of the fir engraver high vulnerability class declined (fig. 49); change was correlated with observed declines in grand fir-white fir and subalpine fir-Engelmann spruce cover type area (appendix 2). Percentage of area in the high vulnerability class fell from 24.6 to 15.0 percent, patch density rose from 9.0 to 12.4 patches per 10 000 ha, and mean patch size declined by 67 percent from 428.3 to 142.2 ha (appendix 3). Percentage of area in low and moderate vulnerability rose from 65.0 to 70.4 percent and from 10.3 to 14.6 percent of the ERU, respectively.

Mean patch size of low vulnerability areas declined from 1907.4 to 1409.0 ha, and mean patch size of moderate vulnerability areas rose from 65.3 to 81.4 ha, indicating that areas of fir engraver host and nonhost type are more highly fragmented in the current condition.

Finally, area and connectivity of the spruce beetle high vulnerability class declined (fig. 49); change was correlated with observed declines in subalpine fir-Engelmann spruce cover type area (appendix 2). Percentage of area in the high vulnerability class fell from 2.6 to 0.7 percent of the ERU, and percentage of area in the low vulnerability class rose from 63.3 to 66.0 percent. Observations of Gast and others (1991) suggest that declining vulnerability to spruce beetle in the Blue Mountains ERU was associated with spruce beetle outbreaks of the last decade that already have claimed many old Engelmann spruce patches observed in the historical vegetation coverage.

Pathogen disturbance vulnerabilities—
Dwarf mistletoes—Area and connectivity of patches vulnerable to Douglas-fir dwarf mistletoe disturbance increased (fig. 50). Percentage of area rose sharply by 63 percent from 10.1 to 16.5 percent, patch density more than doubled from 9.3 to 19.6 patches per 10 000 ha, and mean patch size rose by 44 percent from 87.5 to 125.7 ha (appendix 3). Increased area in the high vulnerability class was associated with expanded area of the Douglas-fir cover type, increased canopy layering, and contiguity of host patches apparently brought about by fire exclusion and selective harvesting.

Area and connectivity of patches vulnerable to western (ponderosa pine) dwarf mistletoe disturbance declined (fig. 51). Percentage of area fell from 10.4 to 8.1 percent of the ERU, patch density rose from 9.6 to 12.7 patches per 10 000 ha, and mean patch size remained unchanged. Because no significant change in area of the ponderosa pine cover type was observed where ponderosa pine was the principal cover species (appendix 2), these results suggest that patch area of ponderosa pine in mixed species cover types with multilayered canopies declined significantly during the sample period.

Connectivity of patches vulnerable to western larch dwarf mistletoe disturbance declined (appendix 3); patch density rose from 1.8 to 3.6 patches per 10 000 ha, and mean patch size declined from 16.0 to 9.8 ha. Area in the low vulnerability class increased from 95.9 to 96.5 percent.

Root diseases—Area and connectivity of patches vulnerable to laminated root rot disturbance increased during the sample period, but the observed change in area was not significant at $P \leq 0.2$ (fig. 52). Percentage of area rose from 34.5 to 37.0 percent (ns), and mean patch size increased from 376.7 to 572.4 ha (appendix 3), indicating increased contiguity of susceptible host patches. The observed increase in vulnerability was primarily associated with increased area of the Douglas-fir cover type, which rose from 7.7 to 17.1 percent of the ERU area (appendix 2).

Area and connectivity of patches vulnerable to S-group annosum disturbance declined (fig. 53). Percentage of area declined from 24.3 to 16.9 percent of the ERU, patch density increased from 11.0 to 15.0 patches per 10 000 ha, and mean patch size declined by 52 percent from 238.3 to 114.7 ha (appendix 3). The apparent change in vulnerability of Blue Mountains landscapes to S-group annosum was associated with observed declines in area of grand fir-white fir, and subalpine fir-Engelmann spruce cover types, where these species represented the principal overstory cover (appendix 2). But the story of change is perhaps more complex than these results suggest. Although it is apparent that a dramatic reduction in dominance of overstory true firs has occurred, grand fir, white fir, and subalpine fir have significantly increased in area where they occur as primary understory species occupying lower and intermediate crown classes (see also Lehmkuhl and others 1994). Because spores of this pathogen readily infect freshly cut stumps, and because the majority of stands with true fir understories have experienced timber harvest, we suggest that expression of S-group annosum root disease disturbance in the foreseeable future will be far greater than that occurring in our photo-interpreted historical or current condition.

Connectivity of area vulnerable to P-group annosum also declined (fig. 53); patch density remained relatively stable, and mean patch size declined from 110.7 to 75.2 ha. The observed decline in connectivity was associated with reduced connectivity of patches with medium and large ponderosa pine in pure and mixed compositions (table 21 and appendix 2).

Area vulnerable to tomentosus root and butt rot disturbance declined, but we suggest that the change is temporary and superficial; percentage of area fell from 4.4 to 2.5 percent of the ERU (fig. 54). Spruce beetle outbreaks during the 1980s resulted in mortality of many old patches of Engelmann spruce (Gast and others 1991). With increasing age and declining vitality, remaining patches of mature and old spruce with tomentosus (and other) root diseases eventually will experience a period of heightened gap disturbance where trees collapse and are windthrown as a consequence of a resident root pathogen and strong winds. Windthrown trees usually are infested by the spruce beetle. As patches subsequently regenerate, many again will be comprised of Engelmann spruce in pure and mixed compositions, and tomentosus root disease inoculum already will be resident in the patch.

Area and connectivity of patches vulnerable to Schweinitzii root and butt rot disturbance increased during the sample period (fig. 54); percentage of area in the high vulnerability class rose from 46.7 to 52.1 percent of the ERU, patch density dropped from 12.7 to 10.5 patches per 10 000 ha, and mean patch size increased by 149.1 ha from 807.1 ha (ns). The observed increase in vulnerability was associated primarily with increased cover and contiguity of Douglas-fir (appendix 2). Percentage of area in the moderate vulnerability class declined by a corresponding amount.

Central Idaho Mountains ERU—Subbasins sampled within the Central Idaho Mountains ERU (figs. 11, 14, 17, 18, and 22) included the Boise-Mores (BOM), Big Wood (BWD), Lemhi (LMH), Lochsa (LOC), Medicine Lodge (MDL), South Fork Clearwater (SFC), South Fork Salmon (SFS), and Upper Middle Fork Salmon (UMS). Among these subbasins, 43 historical and current subwatershed pairs were sampled.

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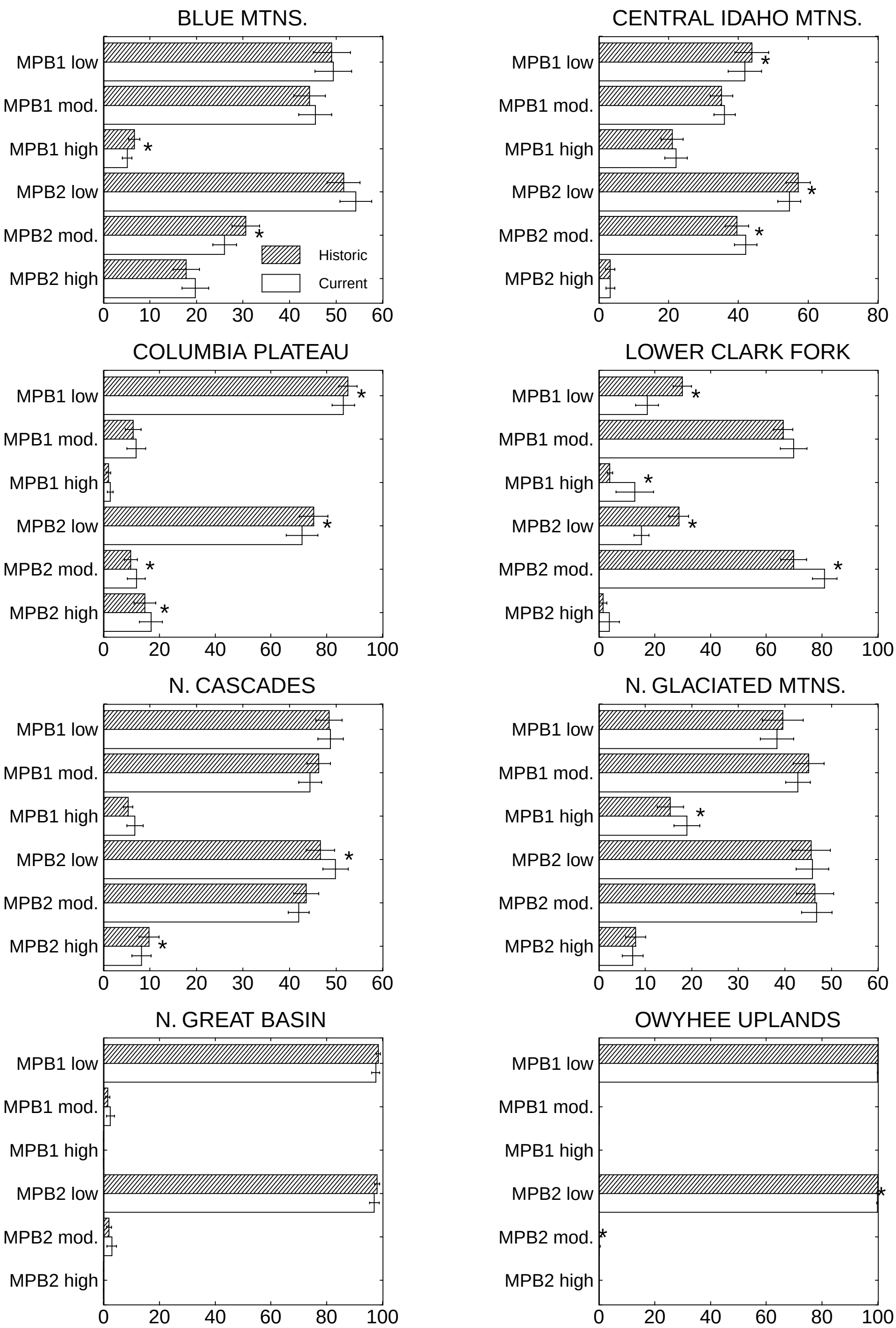
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N. GREAT BASIN
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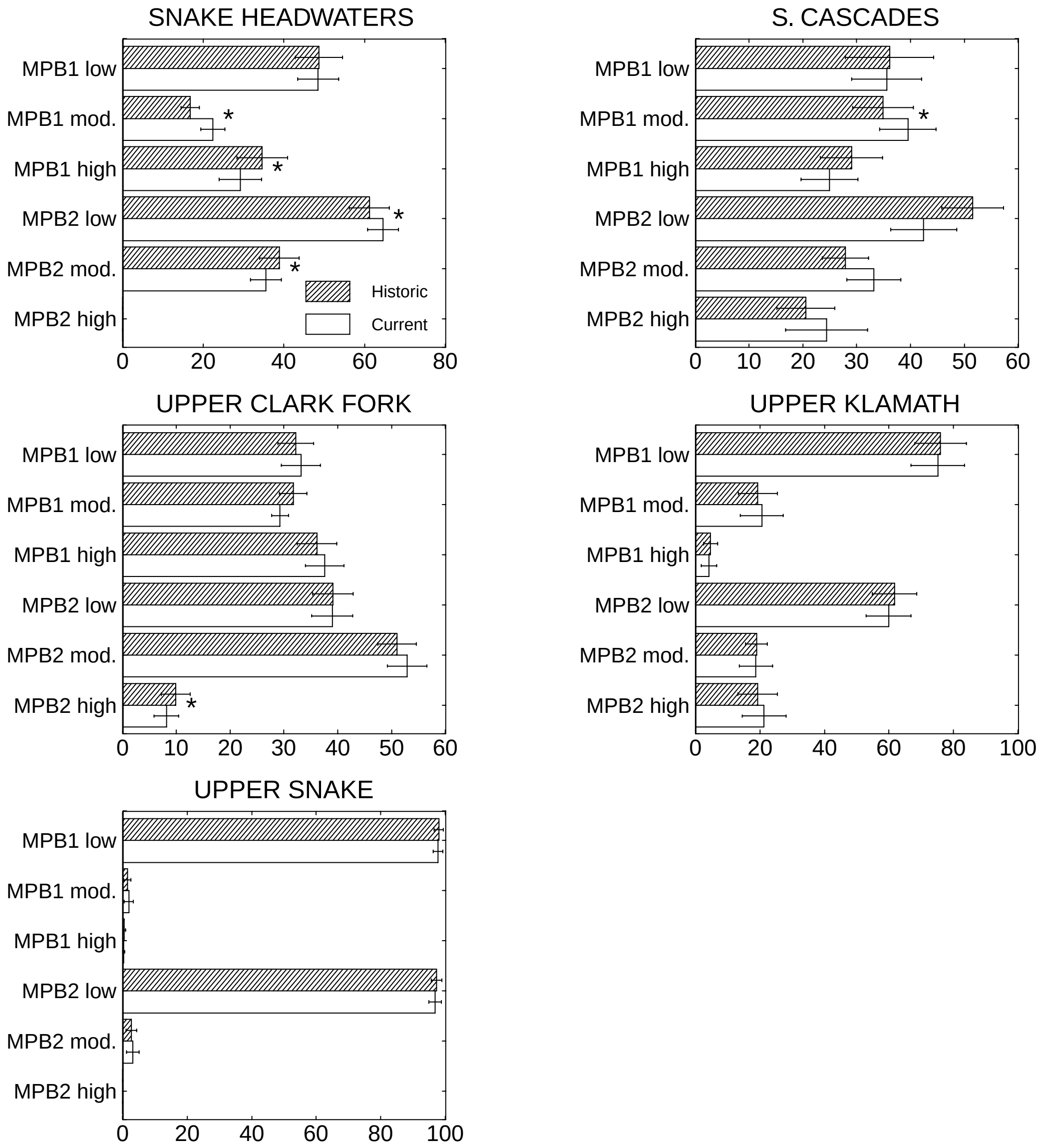
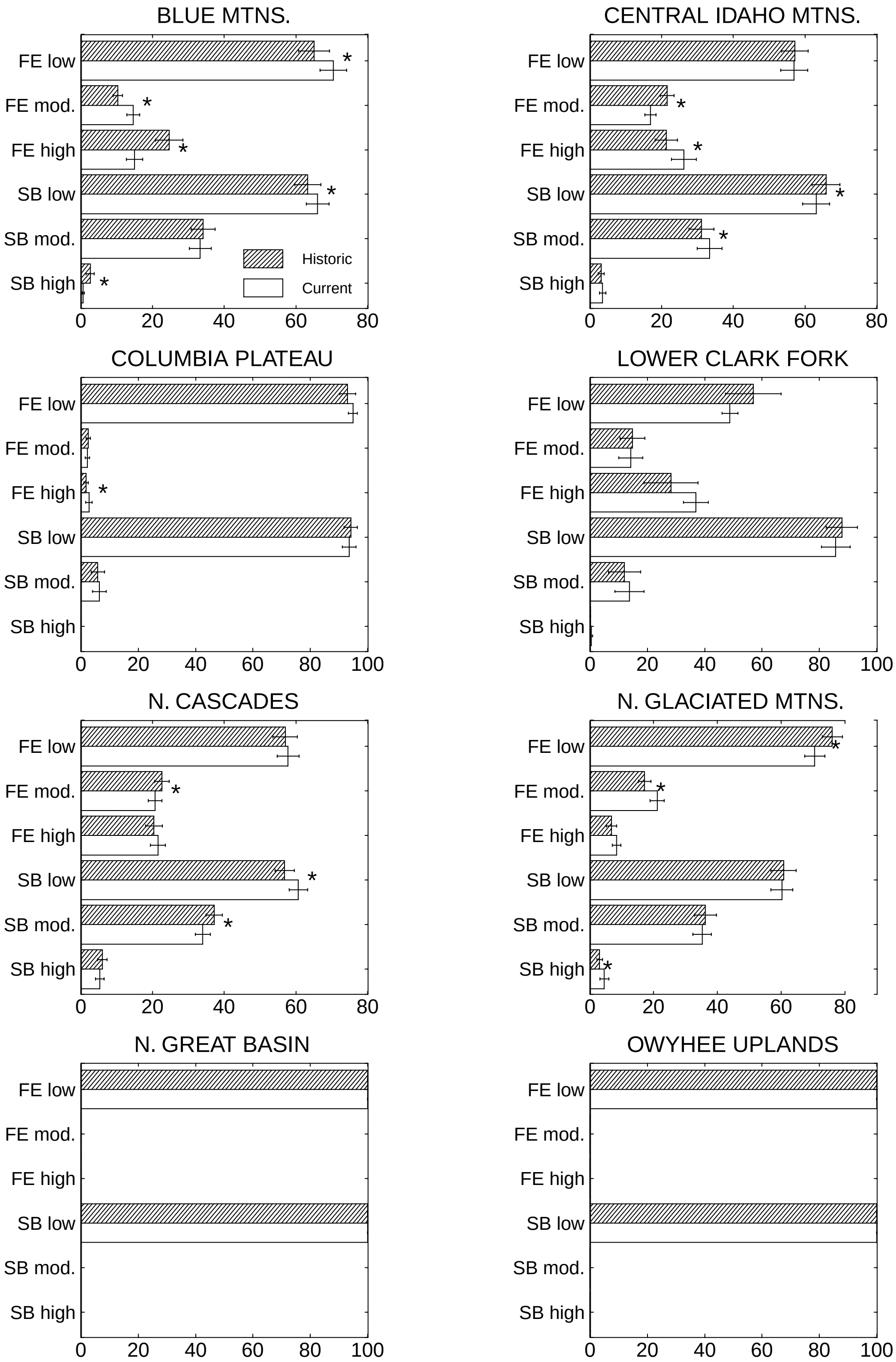


Figure 48—Historical and current distribution of mountain pine beetle type-1 and type-2 disturbance vulnerability classes expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) difference between historical and current conditions. Insect disturbance abbreviations are MPB1=mountain pine beetle (type 1) of high-density lodgepole pine, and MPB2=mountain pine beetle (type 2) of immature and high-density ponderosa pine. Vulnerability class codes are low, moderate, and high.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N. GREAT BASIN
OWYHEE UPLANDS
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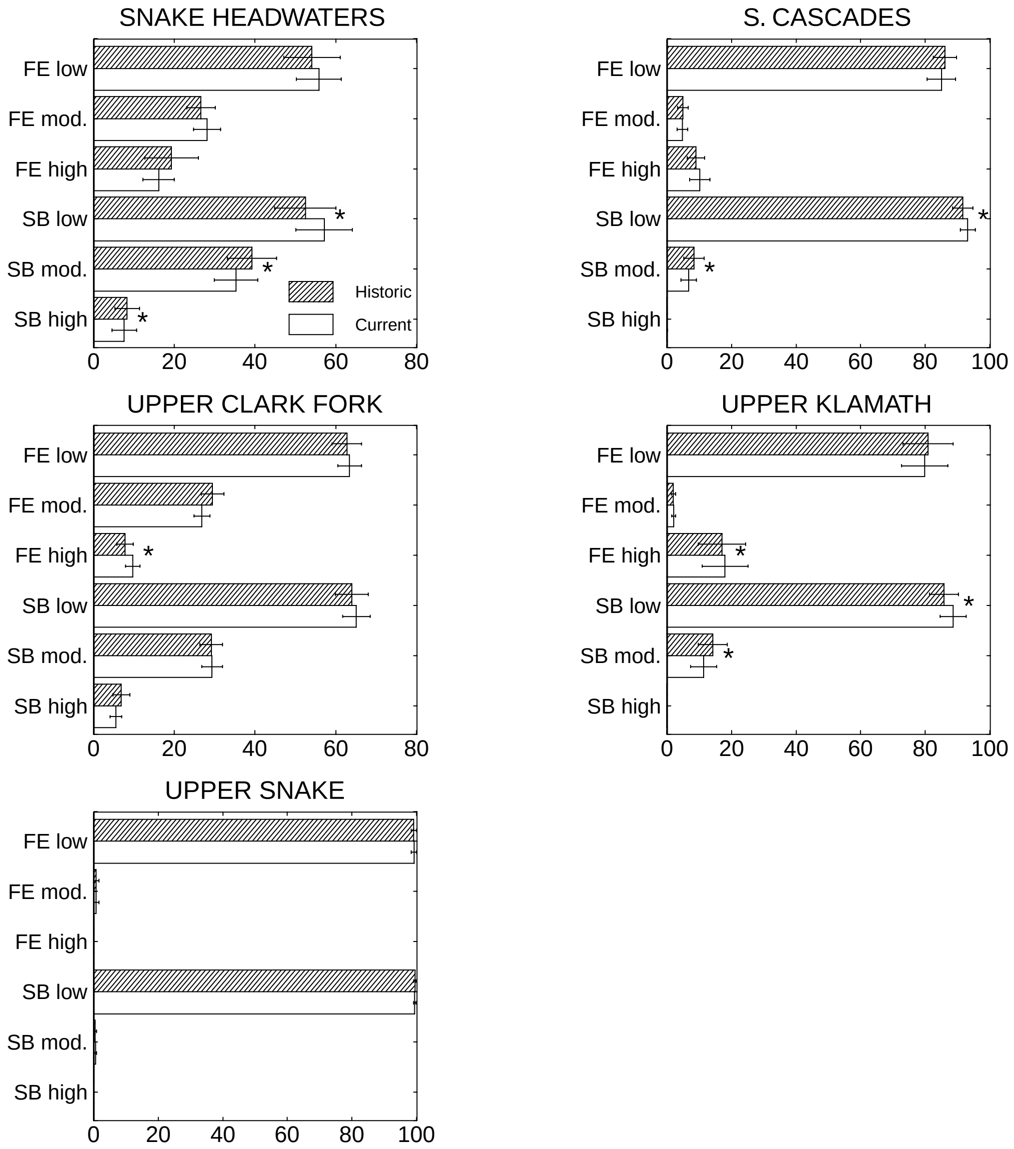
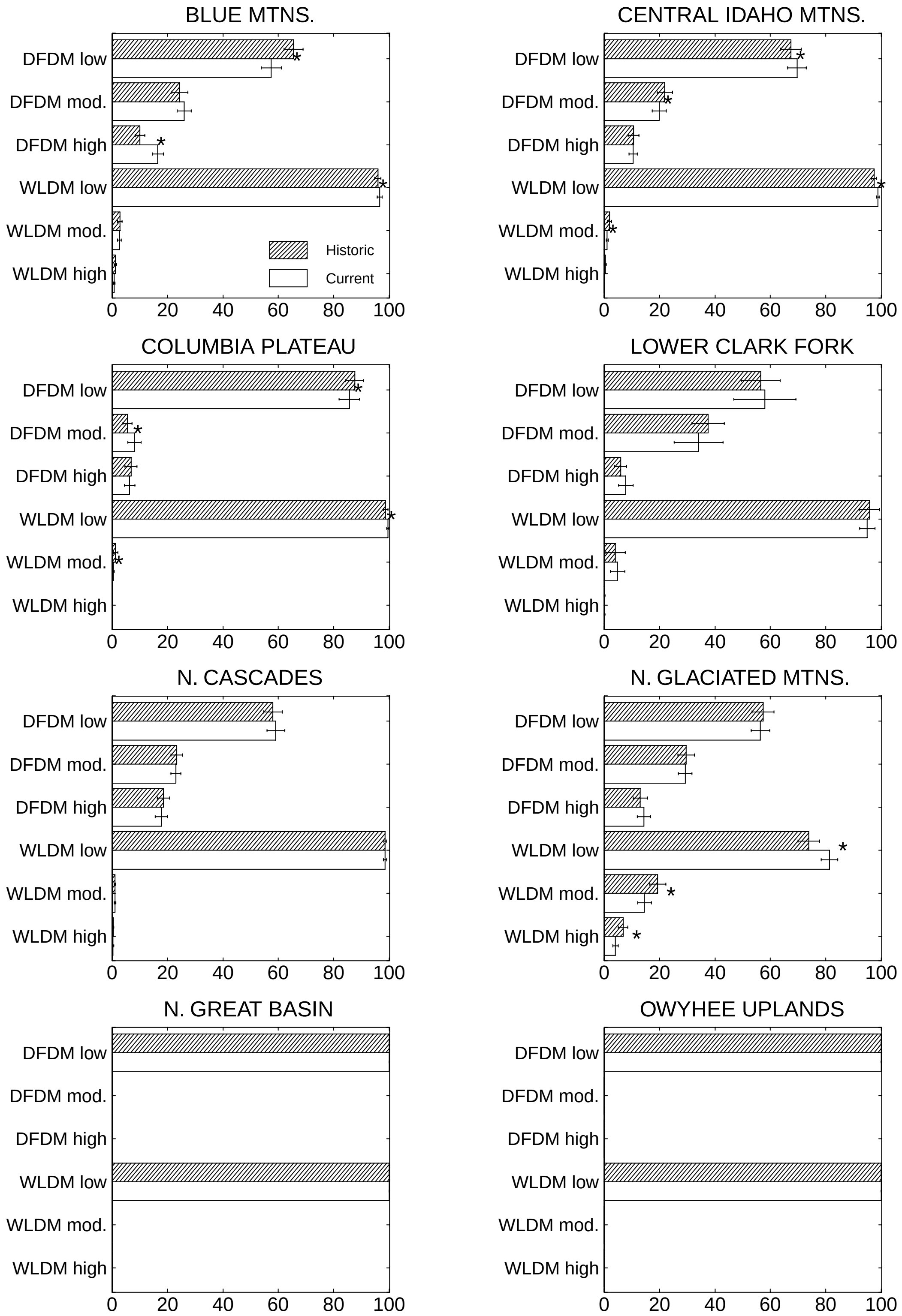


Figure 49—Historical and current distribution of fir engraver and spruce beetle disturbance vulnerability classes expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) difference between historical and current conditions. Insect disturbance abbreviations are FE = fir engraver and SB = spruce beetle. Vulnerability class codes are low, moderate, and high.



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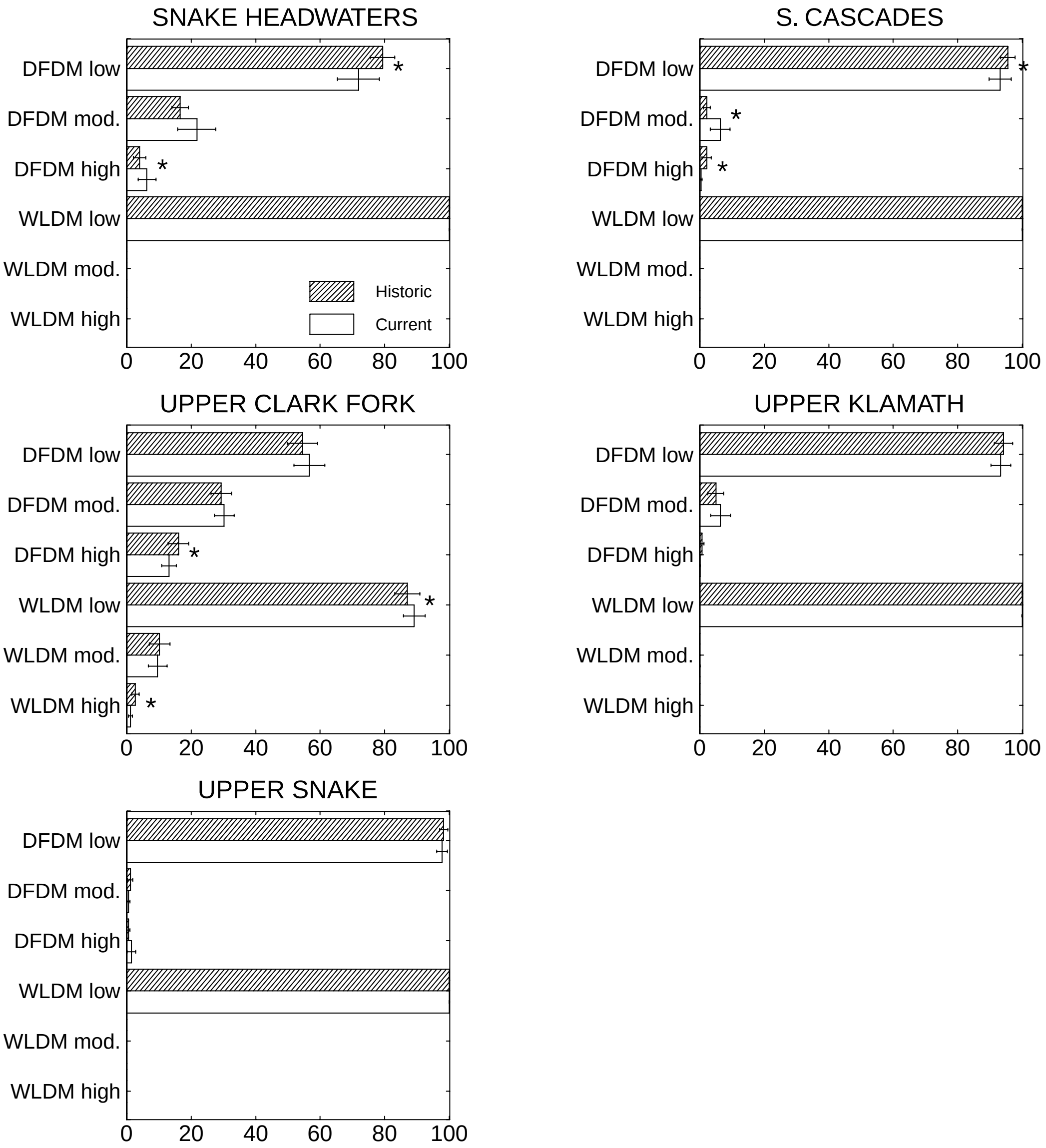
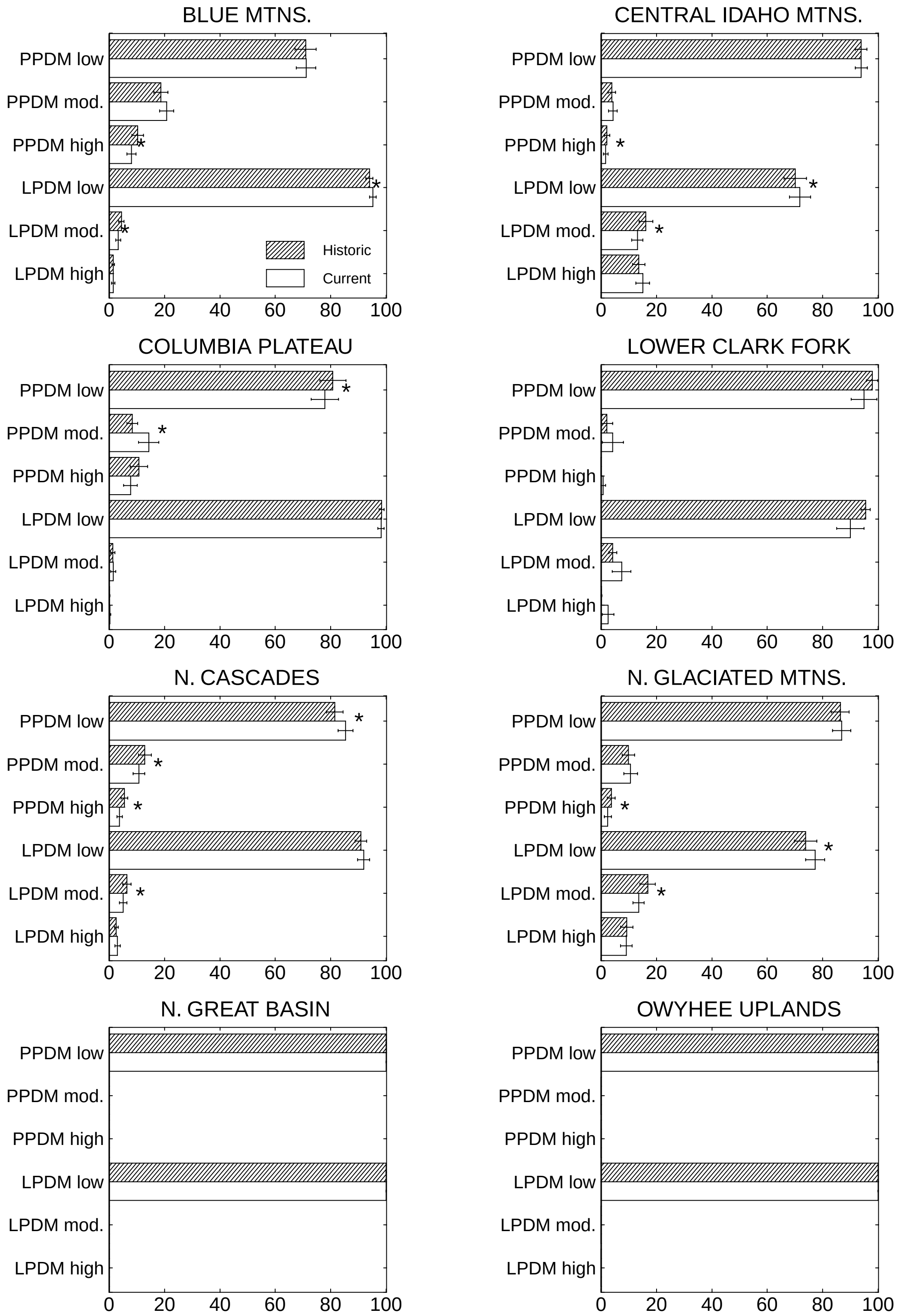


Figure 50—Historical and current distribution of Douglas-fir and western larch dwarf mistletoe disturbance vulnerability classes expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant ($P \leq 0.2$) difference between historical and current conditions. Pathogen disturbance abbreviations are DFDM = Douglas-fir dwarf mistletoe and WLDM = western larch dwarf mistletoe. Vulnerability class codes are low, moderate, and high.



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PPDM low
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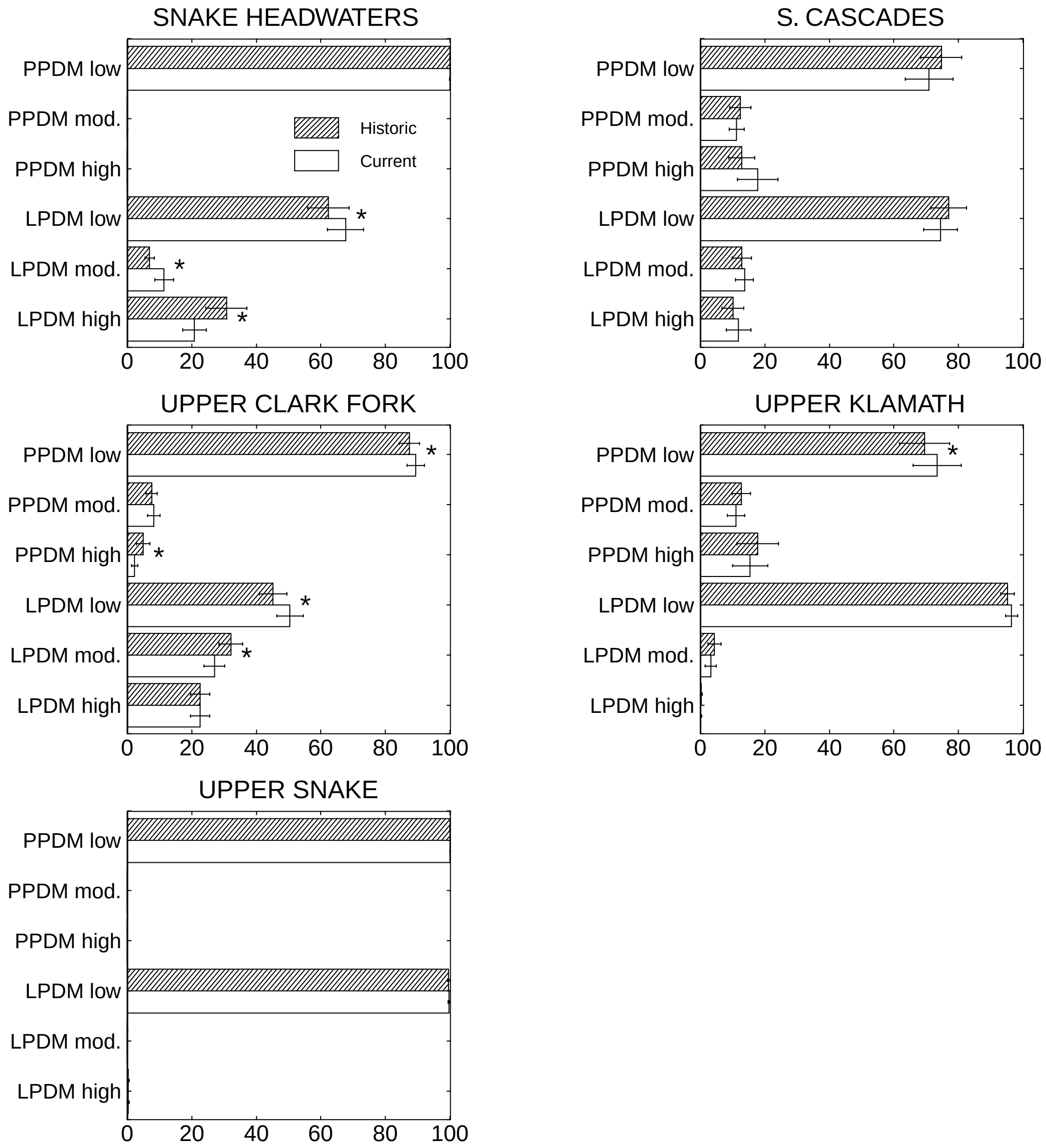
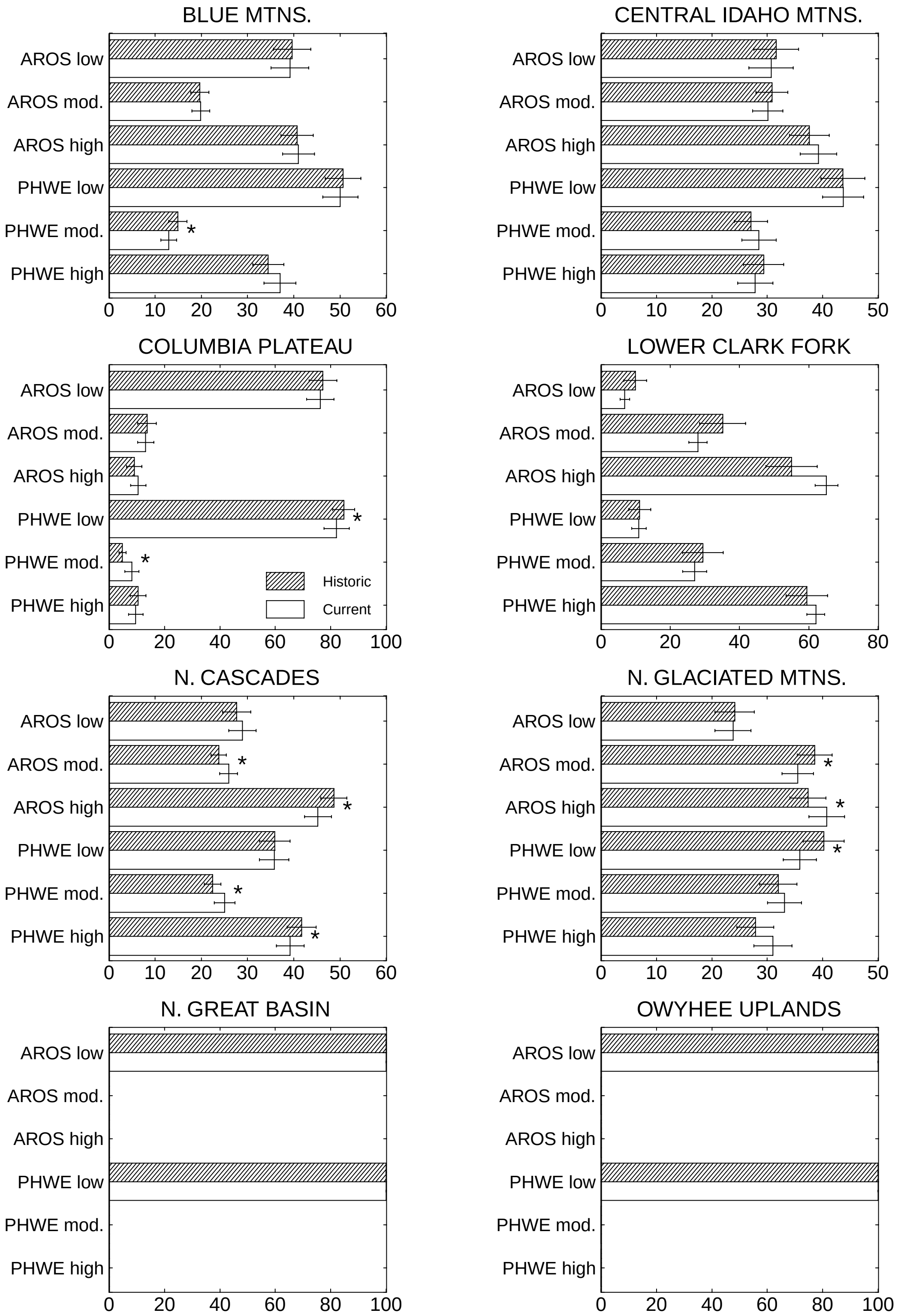


Figure 51—Historical and current distribution of ponderosa pine and lodgepole pine dwarf mistletoe disturbance vulnerability classes expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) difference between historical and current conditions. Pathogen disturbance abbreviations are PPDM = ponderosa pine dwarf mistletoe and LPDM = lodgepole pine dwarf mistletoe. Vulnerability class codes are low, moderate, and high.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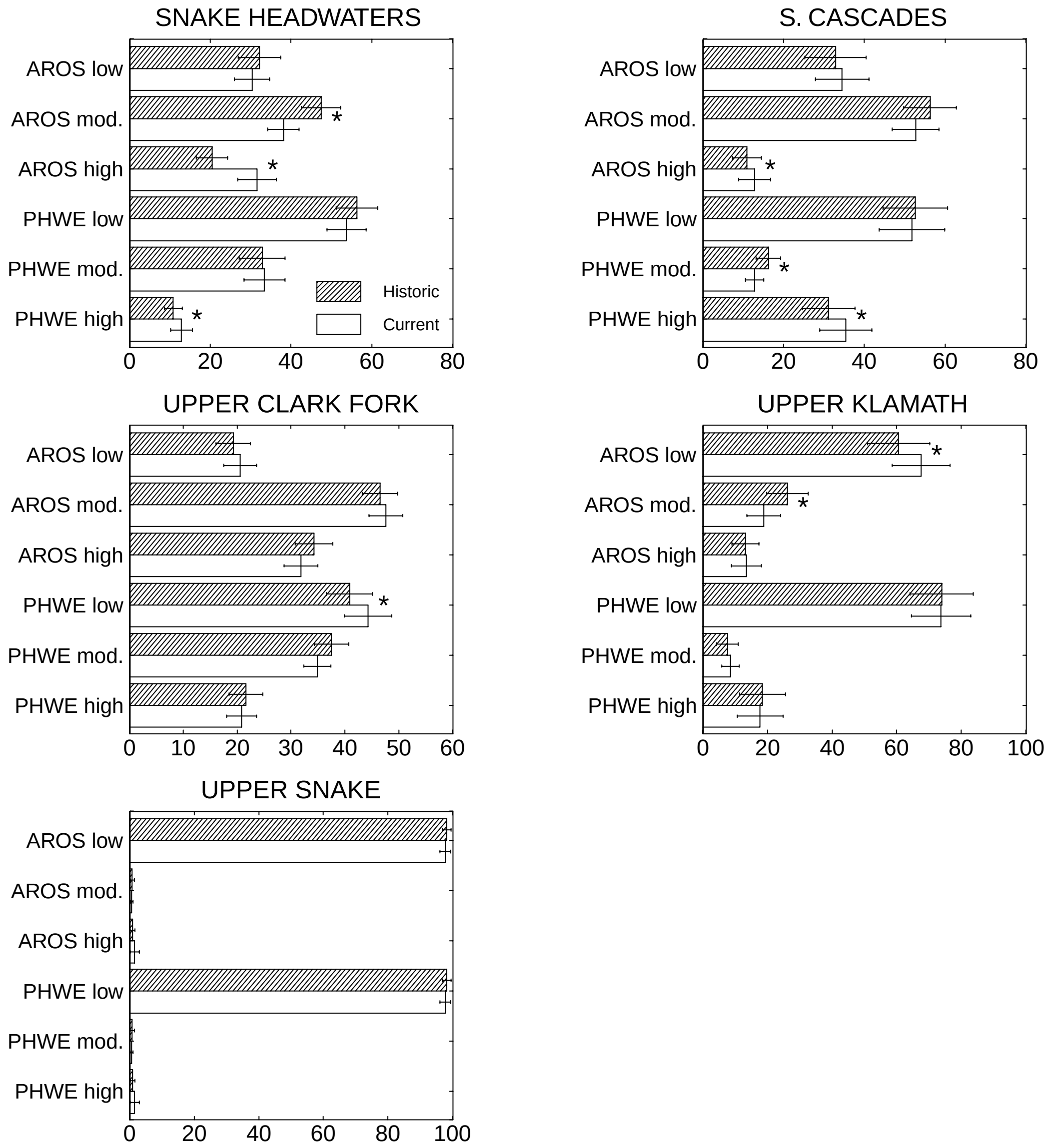
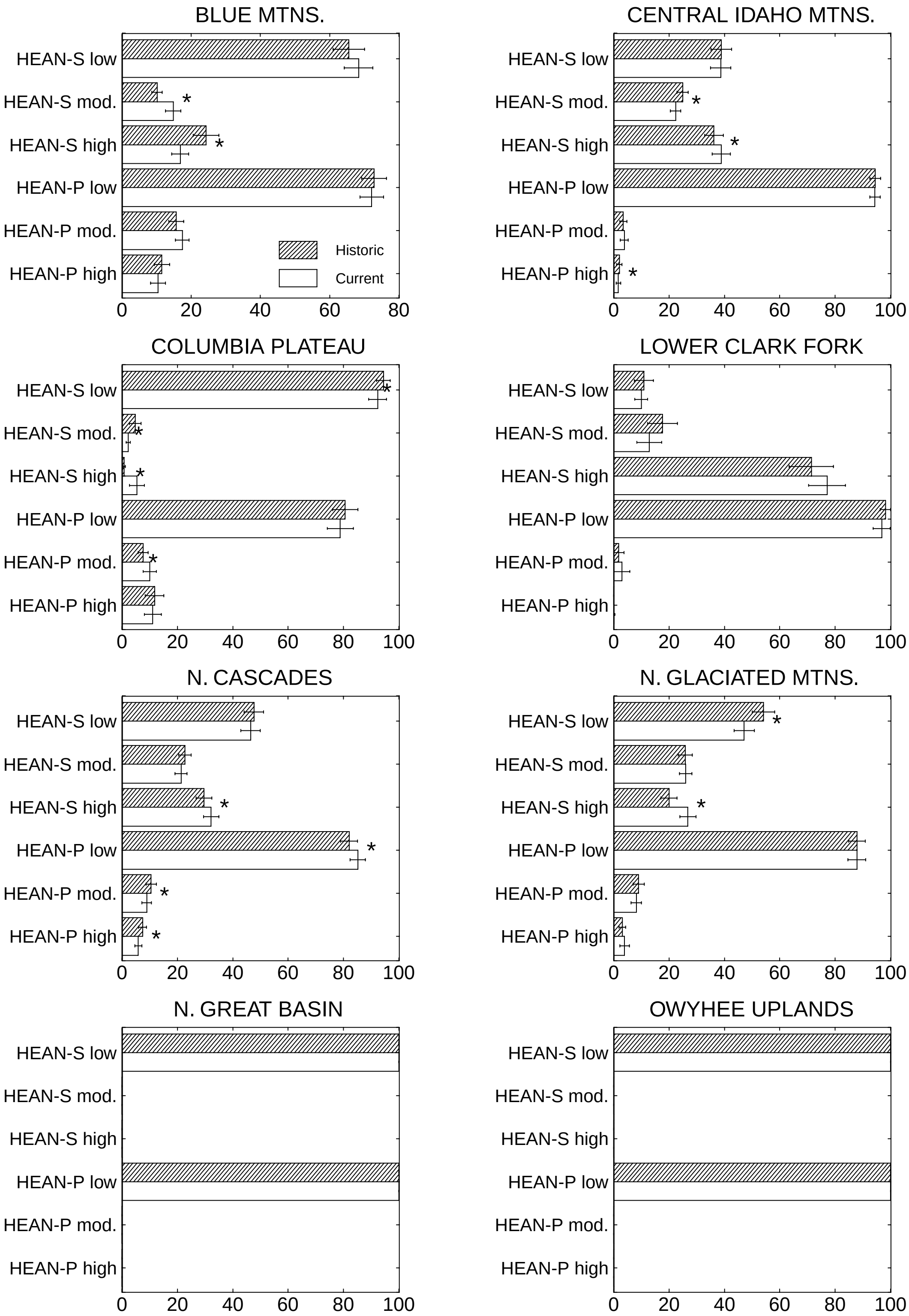


Figure 52—Historical and current distribution of *Armillaria* root disease and laminated root rot disturbance vulnerability classes expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant ($P \leq 0.2$) difference between historical and current conditions. Pathogen disturbance abbreviations are AROS = *Armillaria* root disease and PHWE = laminated root rot. Vulnerability class codes are low, moderate, and high.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LOWER CLARK FORK
N. CASCADES
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N. GREAT BASIN
OWYHEE UPLANDS
HEAN-S low
HEAN-S mod.
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HEAN-P low
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0 20 40 60 80 100
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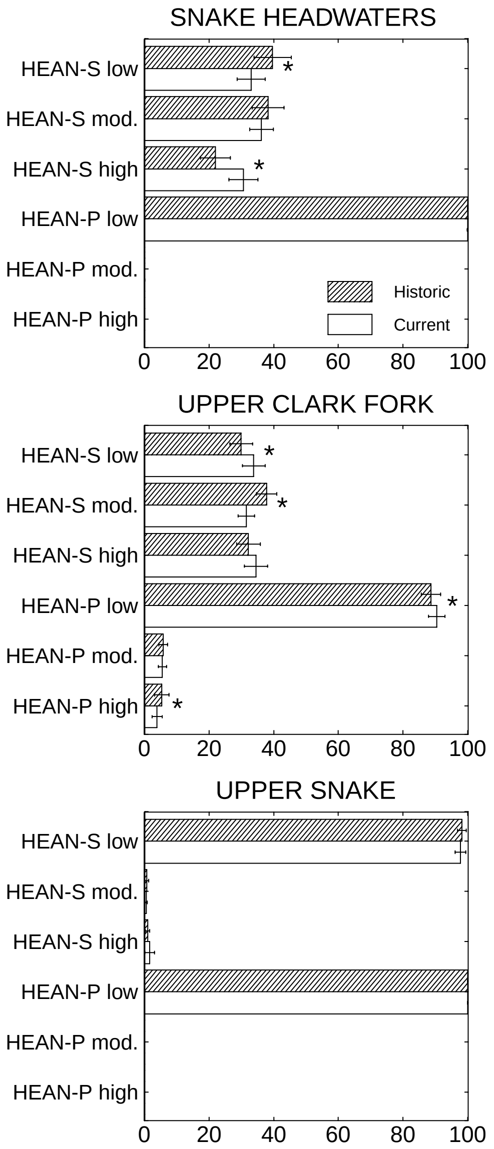
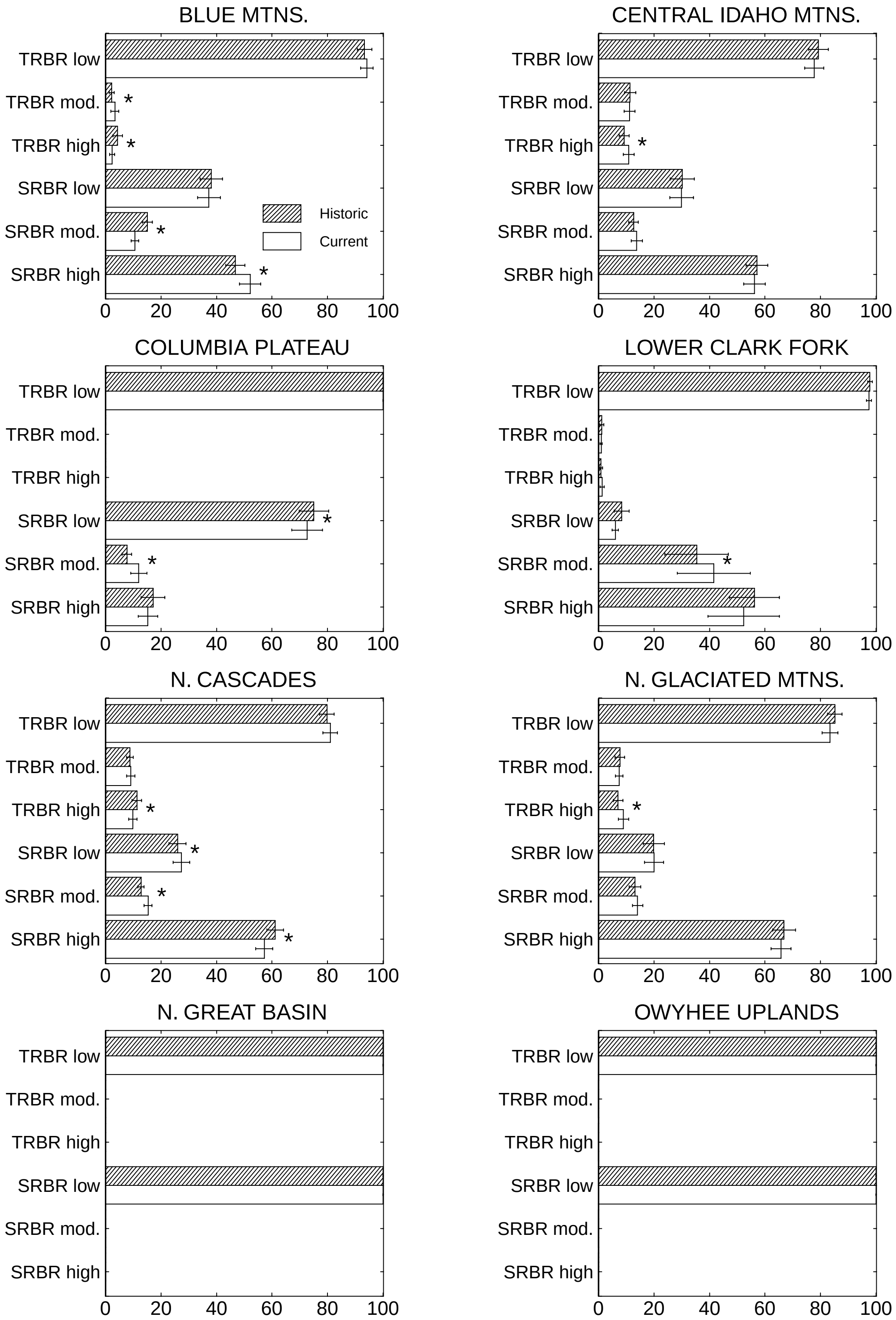


Figure 53—Historical and current distribution of S- and P-group annosum root disease disturbance vulnerability classes expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) difference between historical and current conditions. Pathogen disturbance abbreviations are HEAN-S = S-group annosum root disease and HEAN-P = P-group annosum root disease. Vulnerability class codes are low, moderate, and high.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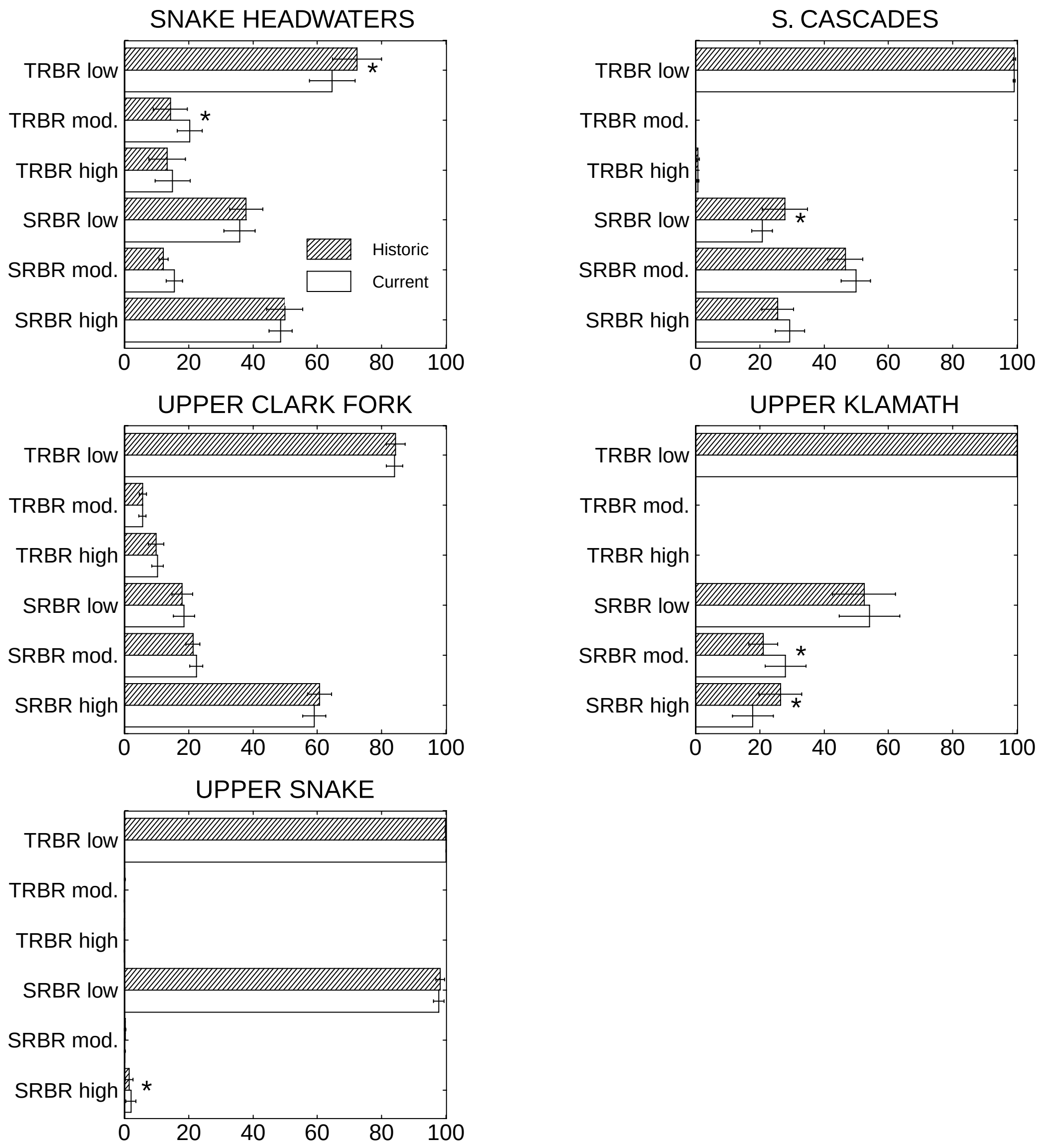


Figure 54—Historical and current distribution of tomentosus and Schweinitzii root and butt rot disturbance vulnerability classes expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) difference between historical and current conditions. Pathogen disturbance abbreviations are TRBR = tomentosus root and butt rot and SRBR = Schweinitzii root and butt rot. Vulnerability class codes are low, moderate, and high.

Insect disturbance vulnerabilities—
Defoliators—There were no statistically significant changes in percentage of area or connectivity of patches vulnerable to western spruce budworm disturbance at this reporting scale (appendix 3). Percentage of area in the high vulnerability class rose from 49.4 to 51.1 percent (ns), and area in the moderate vulnerability class declined from 18.9 to 16.9 percent (fig. 46).

Bark beetles—Percentage of area vulnerable to western pine beetle (type 1) disturbance of mature and old ponderosa pine remained relatively constant during the sample period, but connectivity of vulnerable patches declined significantly owing to the relatively limited area of the ponderosa pine cover type. Patch density of the high vulnerability class rose from 1.6 to 2.8 patches per 10 000 ha, and mean patch size remained unchanged. Mean patch size of the moderate vulnerability class declined from an average of 34.3 to 20.1 ha.

Patch area vulnerable to the fir engraver disturbance increased during the sample period (fig. 49); percentage of area in the high vulnerability class rose from 21.3 to 26.2 percent of the ERU, and area in the moderate vulnerability class declined by a corresponding amount (appendix 3). Connectivity of patches vulnerable to fir engraver disturbance increased; patch density remained stable, and mean patch size rose from 156.7 to 254.6 ha. Enhanced connectivity of vulnerable patches was associated with increased patch size and contiguity of subalpine fir patches (appendix 2).

Pathogen disturbance vulnerabilities—
Dwarf mistletoes—Area and connectivity of patches vulnerable to western dwarf mistletoe disturbance declined during the sample period (fig. 51); percentage of area fell from an average of 2.2 to 1.8 percent of the ERU, and mean patch size declined from 17.2 to 11.4 ha (appendix 3). Because no significant change in area of the ponderosa pine cover type was observed where ponderosa pine was the principal cover species, these results suggest that area of ponderosa pine in mixed species cover types with multilayered canopies declined during the sample period.

Root diseases—Connectivity of patches vulnerable to laminated root rot disturbance declined (appendix 3); patch density in the high vulnerability class rose by 33 percent, from 14.5 to 19.3 patches per 10 000 ha, and mean patch size declined from 321.5 to 253.2 ha. Reduced connectivity of vulnerable patches was associated with declining connectivity of host cover.

Area vulnerable to S-group annosum root disease disturbance increased; percentage of area in the high vulnerability class rose from an average of 36.2 to 38.9 percent of the ERU (fig. 53), and area in the moderate vulnerability class declined by a corresponding amount. Increase in vulnerable area was associated with expanding grand fir, Douglas-fir, subalpine fir-Engelmann spruce, and western hemlock-western redcedar cover type area (appendix 2) and increased area with visible logging entry (table 27). In contrast, area and connectivity of patches vulnerable to P-group annosum root disease disturbance declined during the sample period (fig. 53); percentage of area fell from an average of 2.1 to 1.7 percent, and mean patch size declined from 15.0 to 12.4 ha. As noted earlier, because no significant change in ponderosa pine-dominated cover was observed, these results suggest that area of ponderosa pine in mixed species cover types declined significantly during the sample period.

Area and connectivity of patches vulnerable to tomentosus root disease disturbance increased (fig. 54). Percentage of area in the high vulnerability class increased by 18 percent, rising from an average of 9.3 to 11.0 percent of the ERU, thereby indicating that area comprised of medium and large Engelmann spruce increased during the sample period. Patch density rose from 12.4 to 15.0 patches per 10 000 ha, and mean patch size remained stable.

Columbia Plateau ERU—Subbasins sampled within the Columbia Plateau ERU (figs. 9, 10, 12, and 15) included the Lower Crooked (LCR), Lower John Day (LJD), Lower Yakima (LYK), Palouse (PLS), and Upper Yakima (UYK). Among these subbasins, 38 historical and current subwatershed pairs were sampled.

Insect disturbance vulnerabilities—
Defoliators—Area vulnerable to western spruce budworm disturbance increased during the sample period (fig. 46). Percentage of area in the high vulnerability class increased by 29 percent, rising from an average of 9.3 to 12.0 percent of the ERU. In the Columbia Plateau, forests comprise less than one-third of the area (appendix 2). In the historical condition, 36 percent of the forested area was classified as high vulnerability area, and in the current condition, 41 percent was classified as high vulnerability (appendix 3). Cover type changes alone did not account for the observed increase in vulnerability; increased vulnerability was associated with increased area of Douglas-fir cover in pure and mixed types (appendix 2) and increased area of Douglas-fir and grand fir in multilayered understories.

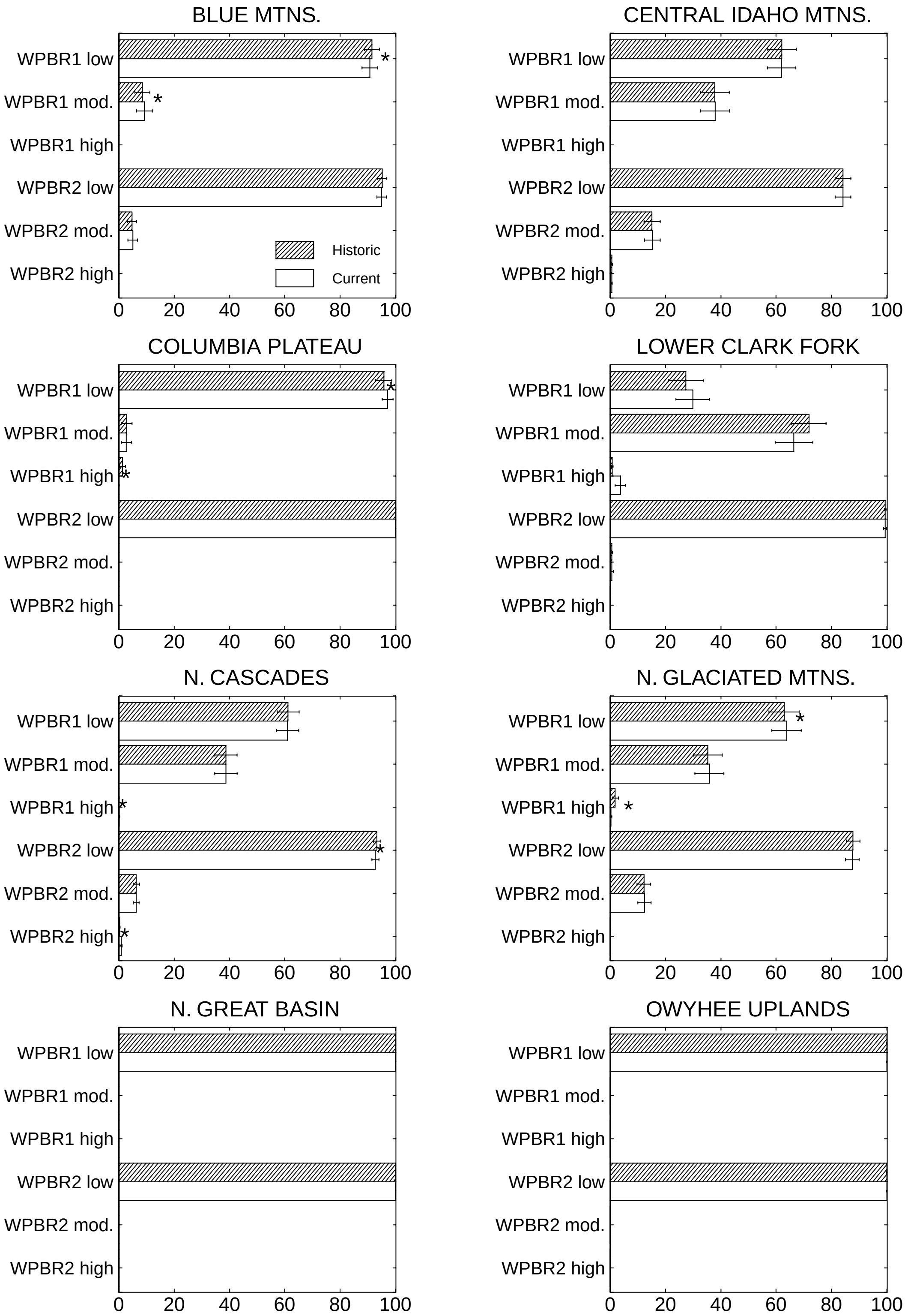
Bark beetles—Area vulnerable to western pine beetle (type 1) disturbance of mature and old ponderosa pine declined (fig. 47), but the change was not significant at $P \leq 0.2$. Percentage of area in the high vulnerability class fell from an average of 4.6 to 2.9 percent of the ERU (ns). Connectivity of area in the high vulnerability class declined significantly; mean patch size declined by 48 percent, dropping from an average of 50.8 to 26.6 ha. Area in the ponderosa pine cover type actually increased during the sample period, rising from 19.2 to 21.4 percent, but area in old multistory and old single-story structures declined (appendix 2). These results suggest that contiguity of patches with medium and large ponderosa pine in mixed species overstories declined (tables 20 and 21). (Note that large tree structure was potentially associated with all classified forest structures; see also table 6.) Because total area in old forest structures declined by 1.1 percent (appendix 2), some of the loss in connectivity of the high vulnerability class was associated with reduced abundance of scattered medium and large ponderosa pine in structural classes other than old forest.

Area vulnerable to western pine beetle (type 2) and mountain pine beetle (type 2) disturbance of immature, high-density ponderosa pine increased during the sample period (figs. 47 and 48). Percentage of area in the high vulnerability class rose from an average of 14.9 to 17.1 percent of the ERU, and area in the moderate vulnerability class rose from 9.8 to 11.8 percent of the ERU. Increasing vulnerability was associated with expanded area of ponderosa pine cover in young and middle-aged structures (appendix 2).

Finally, area vulnerable to fir engraver disturbance increased (fig. 49); percentage of area in the high vulnerability class rose from 1.8 to 2.9 percent. Area where grand fir was the principal cover species actually declined by a small amount during the sample period (appendix 2), but area where grand fir occurred in mixed species cover types and as understory species cover increased as a probable result of fire exclusion and harvest of seral species.

Pathogen disturbance vulnerabilities—
Root diseases—Area and connectivity of patches vulnerable to S-group annosum root disease disturbance increased (fig. 53); percentage of area climbed sharply, nearly sevenfold, rising from an average of 0.8 to 5.4 percent of the ERU. Area in moderate and low vulnerability classes declined significantly by a corresponding amount. Patch density of high vulnerability areas rose from 1.3 to 2.2 patches per 10 000 ha, and mean patch size increased more than eightfold from 15.6 to 132.1 ha. Increase in area of host cover types alone did not account for the dramatic rise in vulnerable area. Our results indicated that area of grand fir and western hemlock in mixed species cover types and occurring as understory species increased during the sample period, as did area in these susceptible host types having visible logging entry.

Rusts—Area vulnerable to white pine blister rust (type 1) disturbance of western white pine declined (fig. 55 and appendix 3); percentage of area in the high vulnerability class plummeted by 93 percent, declining from an average of 1.4 to 0.1 percent of the ERU. In similar fashion, mean patch size declined from 45.6 to 4.3 ha, but the change was not significant at $P \leq 0.2$. The observed decline in high vulnerability area was likely the result of more than eight decades of blister rust mortality and selective harvest of western white pine early in the 20th century.


BLUE MTNS.
CENTRAL IDAHO MTNS.
COLUMBIA PLATEAU
LOWER CLARK FORK
N. CASCADES
N. GLACIATED MTNS.
N. GREAT BASIN
OWYHEE UPLANDS
WPBR1 low
WPBR1 mod.
WPBR1 high
WPBR2 low
WPBR2 mod.
WPBR2 high
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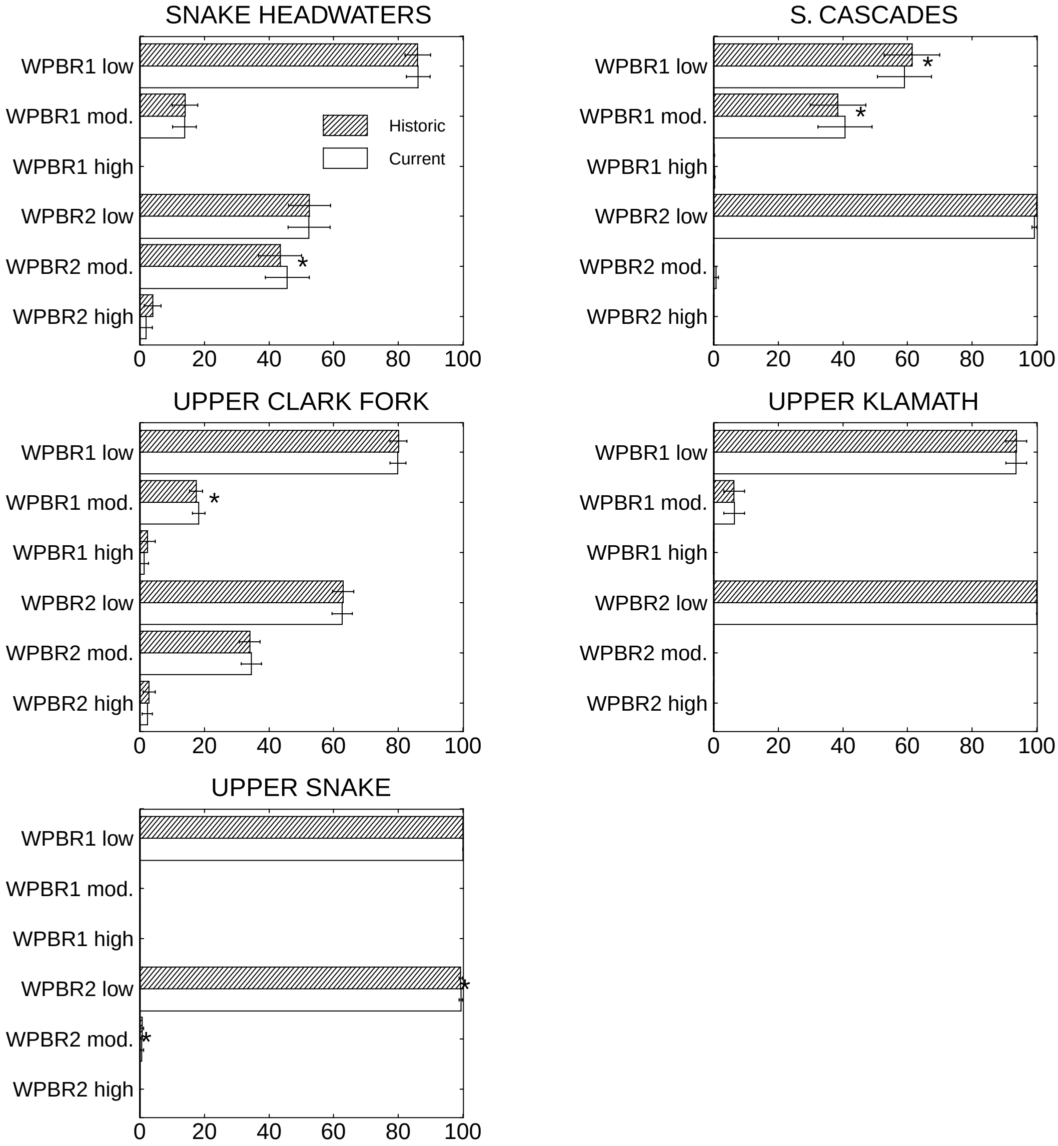


Figure 55—Historical and current distribution of white pine blister rust type-1 and type-2 disturbance vulnerability classes expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) difference between historical and current conditions. Pathogen disturbance abbreviations are WPBR1 = white pine blister rust (type 1) of western white and sugar pine and WPBR2 = white pine blister rust (type 2) of whitebark pine. Vulnerability class codes are low, moderate, and high.

Lower Clark Fork ERU—The Upper Coeur d'Alene (UCD) was the only subbasin sampled within the Lower Clark Fork ERU (fig. 7). Many changes in area and connectivity of vulnerability classes were observed, but few were significant at P≤0.2 owing to the small sample size.

Insect disturbance vulnerabilities—
Defoliators—Area vulnerable to western spruce budworm disturbance increased during the sample period, but the change was not significant at P≤0.2 (fig. 46); percentage of area in the high vulnerability class rose from 56.8 to 65.0 percent (ns). Further sampling and study are needed to establish the trend.

Bark beetles—Area vulnerable to the mountain pine beetle (type 1) disturbance of high density lodgepole pine increased dramatically. Percentage of area in the high vulnerability class rose more than threefold from an average of 4.0 to 12.9 percent of the ERU (fig. 48). Area in the low vulnerability class declined from an average of 30.0 to 17.3 percent of the ERU, patch density rose nearly twofold from 28.8 to 49.4 patches per 10 000 ha, and mean patch size fell from 150.1 to 36.4 ha. Our results indicated that total patch area comprised of lodgepole pine in pure and mixed compositions has changed little during the sample period, but patches in the existing condition are comprised of larger and older host trees.

Area and connectivity of patches vulnerable to fir engraver disturbance increased, but changes were not significant at P≤0.2 (fig. 49). Percentage of area in the high vulnerability class rose from an average of 28.3 to 37.0 percent (ns), and mean patch size increased from 129.7 to 171.8 ha (ns). Further sampling and study are needed to establish the trend.

Pathogen disturbance vulnerabilities—
Dwarf mistletoes—Area and connectivity of area vulnerable to lodgepole pine dwarf mistletoe disturbance increased, but change in area was not significant at P≤0.2 (fig. 51). Percentage of area in the high vulnerability class rose more than tenfold from an average of 0.2 to 2.6 percent of the ERU (ns), and mean patch size increased more than threefold from 9.1 to 31.2 ha. Further sampling and study are needed to establish the trend.

Root diseases—Area vulnerable to *Armillaria* root disease disturbance increased dramatically, but the change was not significant at P≤0.2 (fig. 52). Percentage of area in the high vulnerability class rose from 55.0 to 65.1 percent of the ERU (ns). Further sampling is needed to establish the trend.

Northern Cascades ERU—Subbasins sampled within the Northern Cascades ERU (figs. 5 and 9) included the Methow (MET), Wenatchee (WEN), Naches (NAC), Upper Yakima (UYK), and Lower Yakima (LYK). Among these subbasins, 48 historical and current subwatershed pairs were sampled.

Insect disturbance vulnerabilities—
Bark beetles—Connectivity of patches vulnerable to Douglas-fir beetle disturbance declined; patch density rose from 6.2 to 8.2 patches per 10 000 ha, and mean patch size declined by 40 percent from 149.9 to 89.2 ha (appendix 3). Connectivity of patches in the moderate vulnerability class also declined; patch density rose from 11.8 to 15.2 patches per 10 000 ha, and mean patch size declined from 376.5 to 274.8 ha. Percentage of area in the low vulnerability class rose from 65.1 to 68.4 percent of the ERU (fig. 46). Overall, area comprised of Douglas-fir cover increased, but reduced area in the high vulnerability class was the result of reduced patch area with medium and large Douglas-fir in old forest and other structures (tables 20 and 21).

Area and connectivity of area vulnerable to western pine beetle (type 1) disturbance of mature and old ponderosa pine declined (fig. 47). Percentage of area in the high vulnerability class fell from an average of 3.7 to 1.8 percent of the ERU, and mean patch size declined from 74.5 to 42.8 ha (appendix 3). Area and connectivity of patches in the moderate vulnerability class also declined; percentage of area fell from 11.8 to 8.9 percent, and mean patch size declined from 153.9 to 89.4 ha. Percentage of area in the low vulnerability class rose by a corresponding amount. The observed decline in area of high vulnerability was the result of significantly reduced area of ponderosa pine cover and reduced patch area with medium and large ponderosa pine in old forest and other structures (appendix 2).

Area and connectivity of area vulnerable to western pine beetle (type 2) and mountain pine beetle (type 2) disturbance of immature, high density ponderosa pine also declined (figs. 47 and 48). Percentage of area in the high vulnerability class fell from an average of 9.8 to 8.2 percent of the ERU, and mean patch size declined from an average of 227.4 to 96.8 ha (appendix 3). Connectivity of patches in the moderate vulnerability class also declined; patch density rose from 13.5 to 17.4 patches per 10 000 ha, and mean patch size declined from 631.7 to 369.6 ha. Decline in area of high vulnerability was the result of significantly reduced area of ponderosa pine cover in pure and mixed composition and young and middle-aged structures.

Pathogen disturbance vulnerabilities—

Dwarf mistletoes—Area and connectivity of area vulnerable to western (ponderosa pine) dwarf mistletoe disturbance declined (fig. 51); percentage of area in the high vulnerability class fell from 5.6 to 3.9 percent of the ERU, patch density remained unchanged, and mean patch size declined by 51 percent from 87.0 to 42.5 ha (appendix 3). Area and connectivity of area in the moderate vulnerability class also declined; percentage of area fell from 13.0 to 10.8 percent, patch density rose from 7.1 to 9.2 patches per 10 000 ha, and mean patch size declined by 42 percent from 156.3 to 90.4 ha. The observed decline in area of high vulnerability was the result of significantly reduced area of ponderosa pine cover and reduced patch area with medium and large ponderosa pine in multilayered, pine-dominated structures. In many cases, ponderosa pine overstories were absent in the current condition; in others, pine-dominated understories gave way to those dominated by shade-tolerant Douglas-fir and grand fir.

Root diseases—Results of root disease analyses were quite interesting in the Northern Cascades ERU. Area and connectivity of patches vulnerable to *Armillaria* root disease disturbance declined (fig. 52); percentage of area in the high vulnerability class fell from 48.6 to 45.2 percent of the ERU, patch density rose from 10.7 to 12.4 patches per 10 000 ha, and mean patch size declined by 17 percent from an average of 681.2 to 563.9 ha (appendix 3). Rules for classifying patch vulnerability to root diseases (including root and butt rots) rated patches with larger host trees as more vulnerable to disturbance (that is, more vulnerable to change in structure and composition as a consequence of disturbance) than those with small host trees. The reason was simple: when medium and large overstory host trees succumb to root disease, canopy gaps develop, and patch structure and composition are altered; when small host trees are killed by root disease either in the overstory or understory, there is little or no substantive alteration of structure or composition. The observed decline in area of high vulnerability to *Armillaria* root disease disturbance was the result of declining area occupied by large host trees, primarily Douglas-fir. Patches comprised of hosts in the current vegetation condition will tend to be less vulnerable to structural or compositional change until host species are large enough to dominate patch structure and composition.

Area and connectivity of patches vulnerable to laminated root rot disturbance declined similarly (fig. 52); percentage of area in the high vulnerability class fell from an average of 41.7 to 39.2 percent of the ERU, patch density rose from 8.5 to 10.4 patches per 10 000 ha, and mean patch size declined by 35 percent from an average of 837.9 to 541.1 ha (appendix 3). As noted above, the observed decline in area of high vulnerability to laminated root rot disturbance was the result of declining area occupied by large host trees, primarily Douglas-fir.

Area vulnerable to S-group annosum root disease disturbance increased during the sample period (fig. 53). Percentage of area in the high vulnerability class rose by 9 percent from an average of 29.6 to 32.2 percent of the ERU. The observed increase in high vulnerability area was associated with increased area and stature of grand fir and Pacific silver fir cover (appendix 2) and increased area with visible logging entry. Area and connectivity of patches vulnerable to P-group annosum root disease disturbance declined (fig. 53); percentage of area in the high vulnerability class fell by 21 percent from an average of 7.5 to 5.9 percent of the ERU, and mean patch size fell by 34 percent from 114.1 to 74.9 ha. Area and connectivity of area in the moderate vulnerability class also declined. The observed decline in area of high vulnerability was the result of significantly reduced area of the ponderosa pine cover type and reduced patch area with medium and large ponderosa pine in single-layered and multilayered, pine-dominated structures.

Area vulnerable to tomentosus root and butt rot disturbance declined during the sample period (fig. 54); percentage of area fell from an average of 11.4 to 9.9 percent of the ERU. Decline in vulnerable area was associated with the loss of subalpine fir-Engelmann spruce cover and declining abundance of medium and large Engelmann spruce. Similarly, area and connectivity of patches vulnerable to Schweinitzii root and butt rot disturbance declined; percentage of area in the high vulnerability class fell from an average of 61.2 to 57.2 percent of the ERU (fig. 54), patch density rose from 5.9 to 7.6 patches per 10 000 ha, and mean patch size dropped sharply by 32 percent from 1855.9 to 1266.6 ha. The observed decline in area of high vulnerability to Schweinitzii root and butt rot disturbance was the result of declining area occupied by large host trees, primarily Douglas-fir, ponderosa pine, and Engelmann spruce.

Rusts—Area and connectivity of patches vulnerable to white pine blister rust (type 1) disturbance of sugar and western white pine (western white pine in the Northern Cascades ERU) increased (fig. 55); percentage of area in the high vulnerability class rose from 0.1 to 0.2 percent of the ERU, and mean patch size increased from 2.2 to 6.7 ha. The slight but significant increase in area in the high vulnerability class was likely the result of management efforts by the Wenatchee and Okanogan National Forests to outplant white pine blister rust-resistant stock (personal observation of the senior author). Area and connectivity of patches vulnerable to white pine blister rust (type 2) disturbance of whitebark pine also increased (fig. 55); percentage of area in the high vulnerability class rose from an average of 0.4 to 0.9 percent of the ERU, patch density rose from an average of 0.8 to 1.1 patches per 10 000 ha, and mean patch size more than doubled, increasing from 11.5 to 24.5 ha (appendix 3). Increase in high vulnerability area was associated with the observed increase in percentage of area in the whitebark pine-subalpine larch cover type (appendix 2).

Stem decays—Area vulnerable to rust-red stringy rot gap disturbance increased during the sample period (fig. 56). Percentage of area in the high vulnerability class rose from an average of 0.6 to 1.1 percent of the ERU. The observed increase in high vulnerability area was associated with increased area and stature of grand fir and Pacific silver fir cover (appendix 2).

Northern Glaciated Mountains ERU—

Subbasins sampled within the Northern Glaciated Mountains ERU (figs. 6 to 8) included the Lower Flathead (LFH), Kettle (KET), Pend Oreille (PEN), Sanpoil (SPO), Swan (SWN), and Yaak (YAA). Among these subbasins, 41 historical and current subwatershed pairs were sampled.

Insect disturbance vulnerabilities—

Defoliators—Area vulnerable to western spruce budworm disturbance increased during the sample period (fig. 46). Percentage of area in the high vulnerability class increased by 8 percent from 44.5 to 47.9 percent of the ERU. The observed increase in high vulnerability area was associated with increased area of grand fir and subalpine fir-Engelmann spruce cover (appendix 2). Connectivity of high vulnerability area declined; patch density rose from 12.2 to 16.5 patches per 10 000 ha, and mean patch size declined by 64.4 ha from 806.8 ha (ns).

Bark beetles—Perhaps the most significant change in area vulnerable to bark beetle disturbance was associated with mountain pine beetle (type 1) disturbance of high density lodgepole pine. Percentage of area in the high vulnerability class rose by 23 percent from an average of 15.4 to 18.9 percent of the ERU (fig. 48). Patch density rose by 70 percent from an average of 9.3 to 15.8 patches per 10 000 ha (appendix 3), and mean patch size was unchanged. No significant change in area of the lodgepole pine cover type was observed where lodgepole pine was the principal cover species (appendix 2), but our results suggested that current areas of lodgepole pine exhibit larger host size, poorer overstory crown differentiation, higher total crown cover, and greater contiguity of these characteristics than occurred in the historical condition. It appears that large areas became synchronously more vulnerable to mountain pine beetle (type 1) disturbance during the sample period.

Area and connectivity of patches vulnerable to spruce beetle disturbance increased (fig. 49); percentage of area in the high vulnerability class rose from an average of 3.0 to 4.5 percent of the ERU, patch density increased from 2.6 to 4.7 patches per 10 000 ha, and mean patch size increased by 71 percent from 46.6 to 79.9 ha (appendix 3). Increased area in high vulnerability patches was associated with increased area and stature of spruce in the subalpine fir-Engelmann spruce cover type.

Pathogen disturbance vulnerabilities—
Dwarf mistletoes—Area and connectivity of patches vulnerable to western (ponderosa pine) dwarf mistletoe disturbance declined (fig. 51); percentage of area in the high vulnerability class fell by 34 percent from an average of 3.8 to 2.5 percent of the ERU area, patch density remained unchanged, and mean patch size declined by 72 percent from an average of 57.1 to 16.0 ha (appendix 3). The observed decline in area of high vulnerability was the result of significantly reduced area of ponderosa pine cover (appendix 2) and reduced patch area with medium and large ponderosa pine in multilayered, pine-dominated structures. In many patches, ponderosa pine overstories were absent in the current condition; in others, pine-dominated understories gave way to shade-tolerant Douglas-fir and grand fir.

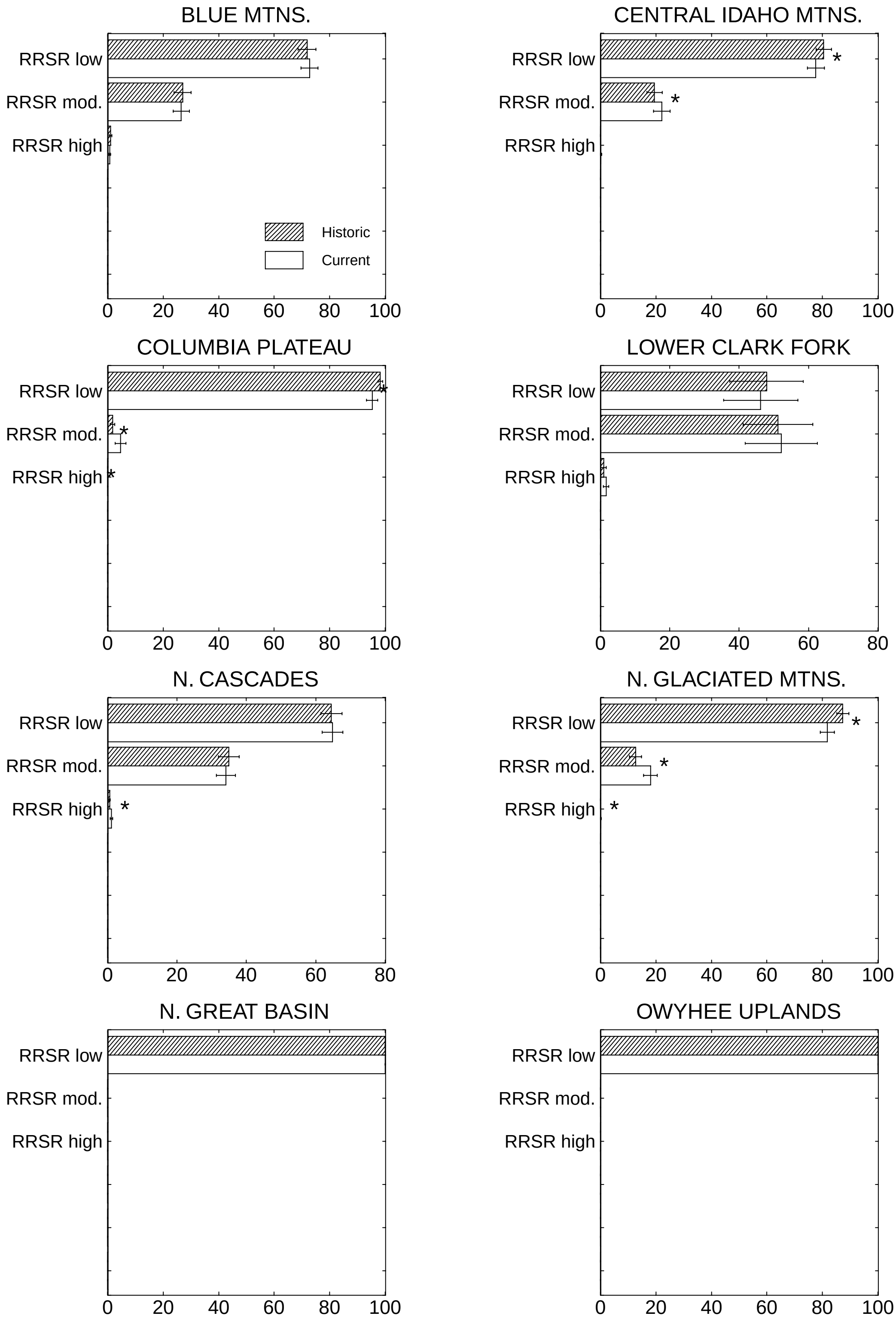
Area vulnerable to western larch dwarf mistletoe disturbance declined (fig. 50); percentage of area in the high vulnerability class declined by 39 percent, falling from 6.9 to 4.2 percent, and mean patch size declined from an average of 57.6 to 38.5 ha (appendix 3). Area and connectivity of patches in the moderate vulnerability class also declined. The observed decline in area of high vulnerability was the result of significantly reduced area of western larch cover, and reduced patch area with medium and large western larch in multilayered, larch-dominated structures (appendix 2). In many patches, western larch overstories were absent in the current condition; in others, larch understories gave way to shade-tolerant Douglas-fir, grand fir, subalpine fir, western hemlock, and western redcedar.

Root diseases—Area vulnerable to *Armillaria* root disease disturbance increased (fig. 52) and connectivity of vulnerable patches declined (appendix 3). Percentage of area in the high vulnerability class rose from an average of 37.3 to 40.7 percent of the ERU, patch density rose from an average of 14.1 to 20.8 patches per 10 000 ha, and mean patch size remained relatively stable. The observed increase in area of high vulnerability was the result of significantly increased area of grand fir and subalpine fir-Engelmann spruce cover types.

Area and connectivity of patches vulnerable to S-group annosum root disease disturbance increased (fig. 53); percentage of area in the high vulnerability class rose by 34 percent from 20.0 to 26.8 percent of the ERU, patch density more than doubled from an average of 9.3 to 20.5 patches per 10 000 ha from 9.3 patches, and mean patch size was unchanged. The observed increase in area of high vulnerability was the result of increased area of grand fir, subalpine fir-Engelmann spruce, and western hemlock-western redcedar cover (appendix 2); increased patch area with understories comprised of shade-tolerant Douglas-fir, grand fir, subalpine fir, and western hemlock; and increased area with visible logging entry.

Area and connectivity of area vulnerable to tomentosus root and butt rot disturbance also increased (fig. 54); percentage of area in the high vulnerability class rose from 7.1 to 9.0 percent, patch density rose from 5.9 to 10.8 patches per 10 000 ha (appendix 3), and mean patch size was unchanged. The observed increase in area of high vulnerability was the result of increased area of the subalpine fir-Engelmann spruce cover type with medium and large Engelmann spruce.

Rusts—Area and connectivity of patches vulnerable to white pine blister rust (type 1) disturbance of sugar and western white pine (western white pine in the Northern Glaciated Mountains) declined significantly (fig. 55); percentage of area


BLUE MTNS.
CENTRAL IDAHO MTNS.
COLUMBIA PLATEAU
LOWER CLARK FORK
N. CASCADES
N. GLACIATED MTNS.
N. GREAT BASIN
OWYHEE UPLANDS
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RRSR mod.
RRSR high
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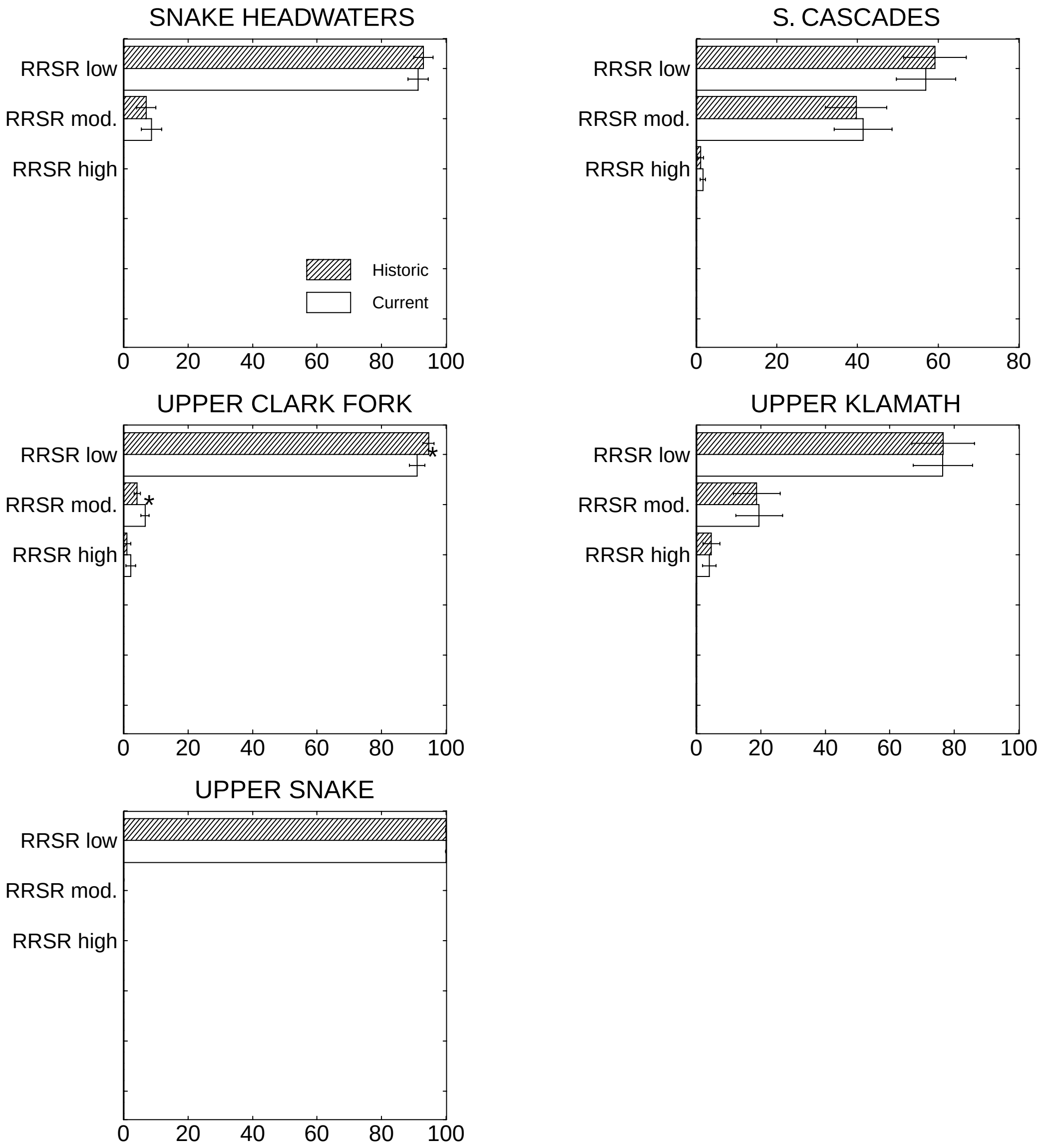

Figure 56—Historical and current distribution of rust-red stringy rot disturbance vulnerability classes expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) difference between historical and current conditions. RRSR = rust-red stringy rot. Vulnerability class codes are low, moderate, and high.

in the high vulnerability class fell by 84 percent from an average of 1.9 to 0.3 percent of the ERU. Mean patch size declined by the same proportion, falling from an average of 26.3 to 4.2 ha (appendix 3). The observed decline in high vulnerability area was likely the result of more than eight decades of blister rust mortality and early selective harvest of western white pine.

Stem decays—Area and connectivity of area vulnerable to rust-red stringy rot disturbance increased slightly; percentage of area in the high vulnerability class rose from an average of 0 to 0.2 percent of the ERU (fig. 56 and appendix 3). The observed increase in area of high vulnerability was the result of increased area of grand fir and subalpine fir-Engelmann spruce cover and increased patch area with understories comprised of shade-tolerant grand fir and subalpine fir.

Northern Great Basin ERU—The Donner und Blitzen (DUB) is the only subbasin sampled within the Northern Great Basin ERU (fig. 16); four historical and current subwatershed pairs were sampled. Forests of the ERU represented a minor area and were comprised of aspen, cottonwood, and juniper. Hosts of the insects and pathogens modeled were not present in the ERU.

Owyhee Uplands ERU—Subbasins sampled within the Owyhee Uplands ERU (figs. 21 and 22) included the Big Wood (BWD), Crooked Rattlesnake (CRT), and Upper Owyhee (UOW). Among these subbasins, 21 historical and current subwatershed pairs were sampled. Forests of the ERU represented a minor area and were comprised chiefly of aspen and cottonwood. Woodland cover was dominated by juniper. With the exception of juniper, which is host to P-group annosum root disease, hosts of the insects and pathogens modeled were not present in the ERU.

Snake Headwaters ERU—Subbasins sampled within the Snake Headwaters ERU (fig. 19) included the Lower Henry's (LHE), Palisades (PSD), and Snake Headwaters (SHW). Among these subbasins, 15 historical and current subwatershed pairs were sampled.

Insect disturbance vulnerabilities—

Defoliators—Area and connectivity of patches vulnerable to western spruce budworm disturbance increased during the sample period (fig. 46). Percentage of area in the high vulnerability class rose from an average of 45.0 to 51.8 percent of the ERU area, patch density remained unchanged, and mean patch size increased by 37 percent from an average of 333.1 to 455.5 ha (appendix 3). The observed increase in high vulnerability area was associated with dramatically increased area of subalpine fir-Engelmann spruce cover in multilayered structural arrangements (tables 23 and 24 and appendix 2).

Bark beetles—Area and connectivity of patches vulnerable to Douglas-fir beetle disturbance increased during the sample period. Percentage of area in the high vulnerability class increased by 86 percent from an average of 2.1 to 3.9 percent of the ERU (fig. 46), patch density increased from 5.1 to 7.1 patches per 10 000 ha, and mean patch size increased by 80 percent from an average of 17.5 to 31.6 ha (appendix 3). Because total area in old forest structures declined from 5.2 to 3.1 percent of the ERU (appendix 2), most of the increased area in the high vulnerability class was likely associated with increased abundance of medium and large Douglas-fir in structural classes other than old forest.

The most significant change in area vulnerable to bark beetle disturbance was associated with mountain pine beetle (type 1) of high density lodgepole pine. Percentage of area in the high vulnerability class fell by 16 percent from an average of 34.6 to 29.2 percent of the ERU (fig. 48). Percentage of area in the moderate vulnerability class rose by a corresponding amount. Area of the lodgepole pine cover type declined during the sample period from 15.6 to 11.3 percent of the ERU. These results suggest that area of pole-sized and larger lodgepole pine in both pure and mixed compositions declined during the sample period, perhaps as a consequence of historical mountain pine beetle disturbance.

Connectivity of patches vulnerable to fir engraver disturbance declined (fig. 49); patch density increased from an average of 10.8 to 18.1 patches per 10 000 ha, and mean patch size declined by 38 percent from an average of 211.3 to 131.9 ha (appendix 3). Percentage of area highly vulnerable to fir engraver disturbance declined from an average of 19.3 to 16.1 percent of the ERU, but the change was not significant at this reporting scale. Area vulnerable to spruce beetle disturbance declined significantly (fig. 49); percentage of area in the high vulnerability class fell from 8.3 to 7.6 percent of the ERU. Percentage of area in the moderate vulnerability class fell from 39.2 to 35.3 percent. Area of subalpine fir-Engelmann spruce cover increased by 30 percent during the sample period from an average of 24.3 to 31.4 percent of the ERU area. These results suggest that area of medium and large Engelmann spruce in mixed compositions declined during the sample period.

Pathogen disturbance vulnerabilities— *Dwarf mistletoes*—Area and connectivity of patches vulnerable to Douglas-fir dwarf mistletoe disturbance increased (fig. 50). Percentage of area rose from 4.1 to 6.4 percent of the ERU, representing a 56-percent increase from the historical condition, and mean patch size sharply increased more than twofold from 19.2 to 49.6 ha (appendix 3). Increased area in the high vulnerability class was associated with expanded area of Douglas-fir in mixed species compositions, increased canopy layering, and contiguity of host patches. Area and connectivity of patches vulnerable to lodgepole pine dwarf mistletoe declined (fig. 51). Percentage of area in the high vulnerability class fell sharply by 32 percent from an average of 30.8 to 20.9 percent of the ERU, and mean patch size declined from 274.3 to 186.6 ha (appendix 3). Area in the low and moderate vulnerability classes increased by a corresponding amount. Area of lodgepole pine cover declined during the sample period, but not enough to account for the observed decline in high vulnerability area. Our results indicated that area in lodgepole pine occurring in pure and mixed compositions and in multilayered structures declined significantly during the sample period.

Root diseases—Area and connectivity of patches vulnerable to *Armillaria* root disease disturbance increased significantly (fig. 52); percentage of area increased by 54 percent from an average of 20.4 to 31.5 percent of the ERU area, and mean patch size nearly doubled from 106.6 to 205.4 ha (appendix 3). Increased area in the high vulnerability class was associated with expanded area of subalpine fir and Douglas-fir in pure and mixed species compositions, increased crown cover of host species, and increased contiguity of host patches. Area and connectivity of patches vulnerable to laminated root rot disturbance also increased; percentage of area rose from 10.9 to 12.8 percent of the ERU, and mean patch size increased from an average of 71.4 to 100.8 ha.

Area and connectivity of patches vulnerable to S-group annosum root disease disturbance increased (fig. 53). Percentage of area rose sharply by 39 percent from an average of 22.0 to 30.6 percent of the ERU area, and mean patch size increased from an average of 141.1 to 204.0 ha. Area of the low and moderate vulnerability class changed by a compensating amount. Increased area in the high vulnerability class was associated with expanded area of subalpine fir in pure and mixed species compositions, increased crown cover of host species, increased contiguity of host patches, and increased area with visible logging entry.

Southern Cascades ERU—Subbasins sampled within the Southern Cascades ERU (fig. 15) included the Little Deschutes (LDS), and Upper Deschutes (UDS). Within these subbasins, 16 historical and current subwatershed pairs were sampled.

Insect disturbance vulnerabilities— *Defoliators*—Area vulnerable to western spruce budworm disturbance increased; percentage of area in the high vulnerability class increased by 22 percent from an average of 10.1 to 12.3 percent of the ERU (fig. 46). Connectivity declined significantly in all vulnerability classes (appendix 3), indicating that highly vulnerable areas were fewer and larger historically, but today are more numerous and interspersed.

Bark beetles—Area vulnerable to Douglas-fir beetle disturbance declined (fig. 46); percentage of area fell by 94 percent from an average of 1.8 to 0.1 percent of the ERU. Decline in high vulnerability area was associated with reduced area and connectivity of patches having large Douglas-fir in structures other than old forest (table 20).

The most significant change in area vulnerable to bark beetle disturbance was associated with mountain pine beetle (type 1) of high density lodgepole pine. Percentage of area in the high vulnerability class fell from an average of 29.0 to 24.9 percent of the ERU (ns); percentage of area in the moderate vulnerability class rose from 34.9 to 39.5 percent (fig. 48). Area of the lodgepole pine cover type actually increased slightly during the sample period from 19.4 to 20.6 percent, but the change was not significant at $P \leq 0.2$. Our results suggest that area of lodgepole pine in historically mixed compositions declined during the sample period as a result of well-documented mountain pine beetle outbreaks in central Oregon (Mitchell 1987, Mitchell and Preisler 1991, and references therein) and fire exclusion.

Pathogen disturbance vulnerabilities—
*Dwarf mistletoes—*Area and connectivity of patches vulnerable to Douglas-fir dwarf mistletoe disturbance declined (fig. 50); percentage of area in the high vulnerability class declined by 78 percent, from an average of 2.3 to 0.5 percent of the ERU, and mean patch size declined by a similar proportion from an average of 95.1 to 24.1 ha (appendix 3). The observed decline in area of high vulnerability was the result of significantly reduced patch area and contiguity with medium and large Douglas-fir in multilayered structures.

Root diseases—Area vulnerable to *Armillaria* root disease disturbance increased (fig. 52). Percentage of area rose 17 percent from an average of 10.9 to 12.8 percent of the ERU, patch density increased from an average of 3.5 to 6.1 patches per 10 000 ha, and mean patch size declined from 230.0 to 171.4 ha (ns). Area vulnerable to laminated root rot disturbance also increased (fig. 52); percentage of area rose by 14 percent from an average of 31.1 to 35.4 percent of the ERU. Increased area in *Armillaria* root disease and laminated root rot high vulnerability classes was associated with expanded area of subalpine fir, grand fir, and Douglas-fir in mixed species compositions, expanded area of shade-tolerant understories, and increased crown cover of host species (table 24 and appendix 2).

Area and connectivity of patches vulnerable to P-group annosum root disease disturbance increased (fig. 53). Percentage of area rose 70 percent from an average of 13.8 to 23.4 percent of the ERU area, patch density increased from 3.6 to 5.8 patches per 10 000 ha, and mean patch size increased by 51 percent from 541.6 to 816.2 ha (ns). Increased area in the high vulnerability class was associated with regrowth of ponderosa pine in pure and mixed species compositions, increased crown cover of host species, and increased contiguity of host patches.

Upper Clark Fork ERU—Subbasins sampled within the Upper Clark Fork ERU (figs. 8 and 11) included the Blackfoot (BFM), Bitterroot (BTR), and Flint Rock (FLR). Among these subbasins, 32 historical and current subwatershed pairs were sampled.

Insect disturbance vulnerabilities—
Bark beetles—Area and connectivity of patches vulnerable to Douglas-fir beetle disturbance declined during the sample period. Percentage of area in the high vulnerability class fell by 40 percent from an average of 8.0 to 4.8 percent of the ERU (fig. 46), patch density increased from 5.4 to 10.0 patches per 10 000 ha, and mean patch size declined by 61 percent from 114.6 to 44.4 ha. Loss of area in the high vulnerability class was the result of reduced crown cover of large and medium Douglas-fir across all forest structural classes.

Another significant change in area vulnerable to bark beetle disturbance was associated with western pine beetle (type 1) disturbance of mature and old ponderosa pine. Percentage of area in the high vulnerability class declined sharply by 83 percent from an average of 2.9 to 0.5 percent of the ERU (fig. 47). Area of ponderosa pine cover decreased from 12.3 to 9.5 percent of the ERU (appendix 2). Loss of high vulnerability area was primarily associated with reduced area in the ponderosa pine cover type and reduced crown cover of medium and large ponderosa pine across all forest structural classes.

Area vulnerable to western pine beetle (type 2) and mountain pine beetle (type 2) disturbance of immature, high-density ponderosa pine also declined during the sample period (figs. 47 and 48). Percentage of area in the high vulnerability class fell from 9.9 to 8.1 percent, an 18-percent loss of area during the sample period. Loss of high vulnerability area was associated primarily with reduced area in the ponderosa pine cover type and reduced area of stem-exclusion, understory reinitiation, and young multistory structures with ponderosa pine in pure or mixed compositions.

Area and connectivity of patches vulnerable to fir engraver disturbance increased during the sample period (fig. 49); percentage of area in the high vulnerability class rose by 24 percent from an average of 7.8 to 9.7 percent of the ERU, patch density increased from 6.4 to 8.7 patches per 10 000 ha, and mean patch size increased from 88.0 to 111.0 ha (ns). High vulnerability area increased as consequence of increased area in the subalpine fir-Engelmann spruce cover type in all forest structural classes but stand initiation.

Pathogen disturbance vulnerabilities—
Dwarf mistletoes—Area and connectivity of patches vulnerable to the Douglas-fir, ponderosa pine, and western larch dwarf mistletoes disturbance declined during the sample period (figs. 50 and 51). Percentage of area in the Douglas-fir dwarf mistletoe high vulnerability class fell by 19 percent from an average of 16.2 to 13.2 percent of the ERU (fig. 50), patch density increased 25 percent from an average of 12.3 to 15.4 patches per 10 000 ha, and mean patch size declined by 50 percent from an average of 154.0 to 75.1 ha (appendix 3). The observed decline in area of high vulnerability was the result of significantly reduced patch area and contiguity with medium and large Douglas-fir in multilayered structures. Area and connectivity of area vulnerable to western (ponderosa pine) dwarf mistletoe disturbance also declined (fig. 51); percentage of area in the high vulnerability class fell by 54 percent from an average of 5.0 to 2.3 percent of the ERU, and mean patch size declined 59 percent from an average of 50.2 to 20.4 ha. The observed decline in area of high vulnerability was the result of significantly reduced patch area and contiguity with medium and large ponderosa pine in multilayered structures. Area and connectivity of patches vulnerable to western larch dwarf mistletoe disturbance followed a similar pattern (fig. 50).

Root diseases—Area and connectivity of patches vulnerable to P-group annosum root disease disturbance declined (fig. 53); percentage of area in the high vulnerability class fell from 5.4 to 4.0 percent of the ERU, patch density increased from 3.3 to 4.5 patches per 10 000 ha, and mean patch size declined from an average of 51.8 to 39.4 ha (ns). The observed decline in area of high vulnerability was the result of reduced patch area and contiguity with medium and large ponderosa pine.

Upper Klamath ERU—Subbasins sampled within the Upper Klamath ERU (fig. 20) included the Lost (LST) and Upper Klamath Lake (UKL). Among these subbasins, 12 historical and current subwatershed pairs were sampled.

Insect disturbance vulnerabilities—
Bark beetles—Area and connectivity of patches vulnerable to western pine beetle (type 1) disturbance of mature and old ponderosa pine declined, but only change in connectivity was significant (fig. 47). Percentage of area in the high vulnerability class fell from an average of 5.7 to 4.5 percent of the ERU, patch density increased from 3.5 to 4.9 patches per 10 000 ha, and mean patch size declined from 67.6 to 51.1 ha (ns). Decline in connectivity of high vulnerability patches was the result of significantly reduced area of ponderosa pine cover and reduced patch area with medium and large ponderosa pine, especially in old single-story forest structures (tables 20 and 21).

Area and connectivity of patches vulnerable to fir engraver disturbance increased during the sample period; percentage of area in the high vulnerability class rose from an average of 17.1 to 18.0 percent of the ERU (fig. 49), patch density declined from 3.7 to 2.0 patches per 10 000 ha (appendix 3), and mean patch size rose from 586.7 to 700.1 ha (ns). High vulnerability area increased as consequence of expanded area in the grand fir-white fir and Shasta red fir cover types.

Pathogen disturbance vulnerabilities—
Root diseases—Area vulnerable to Schweinitzii root and butt rot disturbance declined sharply by 32 percent, falling from an average of 26.4 to 17.9 percent of the ERU (fig. 54). Decline in area of high vulnerability to Schweinitzii root and butt rot disturbance was the result of declining area occupied by medium and large host trees, primarily Douglas-fir and ponderosa pine in old-forest single-story and other forest structures (tables 20 and 21 and appendix 2).

Upper Snake ERU—Subbasins sampled within the Upper Snake ERU (figs. 18, 19, and 22) included the Lower Henry's (LHE), Lake Walcott (LWC), and Medicine Lodge (MDL). Among these subbasins, 15 historical and current subwatershed pairs were sampled. Less than 5 percent of the area of the ERU is comprised of forest cover types. Forest settings are cold and dry, occurring in upper montane and subalpine settings. Two significant vulnerability changes were associated with increased area of Douglas-fir.

Insect disturbance vulnerabilities—
Defoliators—Area and connectivity of patches vulnerable to western spruce budworm disturbance increased (fig. 46). Percentage of area in the high vulnerability class rose from 1.6 to 2.1 percent, representing a 31-percent increase from the historical condition. Patch density declined from 1.1 to 0.5 patch per 10 000 ha, and mean patch size increased threefold from an average of 32.4 to 95.4 ha (appendix 3).

Pathogen disturbance vulnerabilities—
Dwarf mistletoes—Area and connectivity of patches vulnerable to Douglas-fir dwarf mistletoe increased but only the change in connectivity was significant (fig. 50). Percentage of area in the high vulnerability class rose from 0.6 to 1.5 percent of the ERU (ns), patch density declined from 1.8 to 1.1 patches per 10 000 ha, and mean patch size more than tripled from an average of 5.3 to 18.8 ha, but the increase was not statistically significant at this scale.

Root diseases—Area and connectivity of patches vulnerable to *Armillaria* root disease increased, but only change in connectivity was statistically significant (fig. 52). Patch density declined from 2.1 to 1.1 patches per 10 000 ha, and mean patch size more than doubled from 9.2 to 21.0 ha (ns). Connectivity of patches vulnerable to S-group annosum root disease increased similarly (appendix 3); patch density declined from 2.3 to 0.9 patch per 10 000 ha, and mean patch size tripled from 10.2 to 31.7 ha (ns).

Area and connectivity of patches vulnerable to Schweinitzii root and butt rot disturbance increased. Percentage of area in the high vulnerability class rose from an average of 1.5 to 2.1 percent (fig. 54), and mean patch size jumped from 20.4 to 57.8 ha (appendix 3). Area in the Douglas-fir cover type increased most significantly in stem-exclusion open canopy and young multistory structures.

Discussion

Detecting Ecosystem Change

To detect significant vegetation change of forest or rangeland ecosystems, vegetation attributes must change similarly across sampled subwatersheds of a statistical pooling stratum. Despite our efforts to sample large landscapes to minimize area bias in landscape metrics and a sampling intensity of at least 15 percent of subbasin area, our sample size was still relatively small given the geographic extent and spatial heterogeneity of subbasins within ERUs. Even though we detected many significant changes at the ERU scale, we learned that likelihood was high of falsely accepting that no difference exists between historical and current conditions of some attributes of ERUs. We suggest that much greater change has occurred than we were able to detect at the scale of the ERU, and that the change analysis will be more potent and revealing where subwatersheds of similar climate, biophysical environment, and potential vegetation conditions are grouped for analysis.

Ecological reporting units were developed by the Science Team in response to an executive decision to summarize results of all broad-scale ecological, social, and economic assessments of the project by province-scale units. That decision also dictated that results of midscale analysis would be summarized by ERU rather than by our initial sample strata. Summarization by ERUs enabled comparison of results between broadscale (Hann and others 1997) and midscale landscape assessments, but it also pooled tremendous environmental variation and redistributed some of the sampled subwatersheds in a less than optimal manner.

Throughout the discussion, we suggest likely causes of change based on our best interpretation of the empirical evidence, but alternative explanations are possible for the changes we detected, and these are worthy of further exploration. Some changes we observed may be the result of random chance, climate change, environmental, climate, disturbance stochasticity, or interactions among a variety of disturbance and successional processes.

Our remotely sensed current conditions were fixed reasonably well in time within sampled subbasins, but historical vegetation conditions, which provided the basis for change detection, were variable among subwatersheds, even within subbasins. On balance, we believe that a variable historical starting point was more desirable that a single historical starting point, because it gave us the potential to observe greater variability in historical vegetation attributes and patterns stemming from climatic, environmental, and disturbance stochasticity, thereby strengthening our estimation of ecologically significant change. Still, historical fires, insect outbreaks, logging activities, wild ungulate and domestic livestock grazing, other disturbance factors, and differences in landscape patterns of biophysical environments created widely differing patterns of vegetation structure and composition. Such differences in historical conditions obscured our ability to detect some changes at the ERU scale and even at smaller spatial scales, such as the subbasin. Differences associated with biophysical environmental conditions, and to some extent management history, could be minimized with regionalization—a multivariate classification and environmental mapping procedure we will present below (see “Ecological Regionalization”).

Variation in historical conditions was the result of many factors. Perhaps greatest among them was high variability in the variety and intensity of historical management activities. Within ERUs, some entire historical subwatersheds were unlogged wilderness or unburned or burned wilderness, and others had been intensively managed. In landscape-scale studies such as this one (see also Lehmkuhl and others 1994), amount, timing, and kind of management activity are difficult if not impossible factors to account for or control. We expected to observe large differences in the rate and type of change between subwatersheds managed primarily for wilderness and those managed for multiple resource objectives. But it is important not to carry the comparison too far. Throughout the basin, most wilderness watersheds occur in upper montane and subalpine environmental settings, and watersheds managed for multiple uses typically occur in low and middle montane settings. Fundamental differences in dominant potential vegetation types, disturbance and climatic regimes, and other biophysical characteristics are enormous, as are differences in response to management activities.

Throughout the basin, fire suppression, fire exclusion, and timber harvest of early seral species had the effect of dramatically advancing forest succession on a collapsed time scale, in both species composition and structural attributes. But in the current condition, other typical and essential attributes of late seral forests often are absent, including large, pathologically old live trees, native epiphytic and hypogeous flora, large standing dead and down woody structures, and native understory shrub and herbaceous communities.

As seen in wilderness and roadless areas, fire exclusion alone produced a similar effect on succession, but it occurred over a longer time frame; that is, the temporal scale was not collapsed. Fire exclusion affected change by removing a disturbance agent that normally reset one or more ecosystem components episodically; for example, in dry ponderosa pine ecosystems, exclusion of fire precipitated accumulation of high tree densities and woody residue volumes that were absent or rare under native fire regimes. At a landscape scale, fire exclusion enabled the accumulation of mid- and late-seral forests habitable by the northern spotted owl (*Strix occidentalis*), which is now apparent east of the crest of the Cascades (Everett and others 1997). Areas once dominated by early seral species, such as ponderosa pine, and frequented by surface fires are now dominated by grand fir and dwarf mistletoe-infested Douglas-fir and are infrequently visited by stand-replacing fires.

Effects of fire exclusion, although more subtle than those produced by timber harvesting, differed substantially among sampled historical subwatersheds of an ERU. Reasons for this were fairly obvious: fire regimes differ quite predictably by PVT, PVTs differ somewhat predictably with biophysical environmental setting, and subwatershed patterns of biophysical environments and potential vegetation differ greatly. Exclusion of fire for six to eight decades in settings historically visited by frequent surface fires (every 0 to 25 years) would transform nonlethal surface fire regimes to lethal crown fire regimes. But exclusion of fire for a similar period in settings historically visited by infrequent crown fires at intervals averaging 150 to 300 years would have, by comparison, an as yet negligible effect on fire regime.

Other potential sources of variation included differences in quality and photo scale between historical and current aerial photographic coverages, differences in quality and consistency of interpretations among photointerpreters, and differing period length among sampled subwatersheds within an ERU (see table 3). Quality control steps were taken to minimize these sources of variation, but the latter contributed nonetheless. Lack of significant difference for some variables between historical and current subwatershed conditions also could be related to high inherent natural variability within and among subwatersheds.

Observations of significant change, or its lack, in the period between our historical and current samples were not and should not be interpreted as effects from a pristine pre-European settlement initial condition. We assumed in this study that considerable change in forest and range vegetation structure and composition had already taken place throughout the 58-million-hectare basin assessment area before the time of our historical starting point sample (Anderson and others 1987; Antos 1977; Antos and Habeck 1981; Arno 1976, 1980; Arno and Davis 1980; Arno and Peterson 1983; Barrett and Arno 1982; Barrett and others 1991; Bevins and Barney 1980; Bork 1985; Christensen 1985, 1988; Cooper 1926, 1961a, 1961b; Daubenmire 1968; Daubenmire and Daubenmire 1968; Davis and others 1980; Dickman and Cook 1989; Fahnestock 1976; Finch 1984; Franklin and others 1971; Galbraith and Anderson 1991; Gara and others 1985; Geiszler and others 1980; Gruell and others 1982; Hall 1976; Kauffman 1990; Keen 1937; Knudsen 1980; Martin and others 1976; McNeil and Zobel 1980; Morris 1934a, 1934b; Nordin 1958; Oliver 1981; Oliver and Larson 1990; Pyne 1982; Savage and Swetnam 1990; Soeriaatmadja 1966; Stuart and others 1989; Vale 1975; Weaver 1959, 1961; Wischnofske and Anderson 1983; Wright and Klemmedson 1965; Young and Evans 1981; Young and others 1987). Rates, magnitudes, and locations of older historical changes are poorly known today and will continue to be poorly understood in most areas of the basin. The historical photographs we used simply represented the oldest photographic coverages of interpretable quality and of continuous subwatershed coverage available from the Forest Service, Bureau of Land Management, or National Archives or held in private ownership. In this manner, we provide previously unavailable quantitative estimates of direction, rate, and partial magnitude of changes.

Near the start of the 20th century, the Forest Service and Bureau of Land Management inherited highly altered forest and range ecosystems. Grazing had radically changed rangeland vegetation structure and composition and forest understories, and forest burning by miners and sheep herders was a relatively common occurrence (Robbins and Wolf 1994, Wissmar 1994a, Woods and Horstman 1996). Extensive logging on Federal forest lands was uncommon in most areas of the basin until after World War II. Throughout the five decades of management and resource extraction that followed, these ecosystems were further altered, disturbed, and reconfigured.

Whether current conditions of any subwatershed in our sample are nearly natural considering the climatic regime, biophysical environmental conditions, and inherent disturbance regimes is as yet unknown to us. Information we provide on the partial magnitude and direction of change during a relatively long period of comparable climate and across a large geographic area contributes valuable insights into rates of change that can be expected both temporally and spatially. It also provides a framework from which management alternatives can be developed, tested, and monitored.

Vegetation Composition and Structure

Physiognomic types—Many predicted changes in vegetative structure and composition of basin forests and ranges associated with past management activities were largely borne out by our analysis. Causal connections, however, were difficult to establish because the timing, duration, and intensity of various management activities were not directly measured; it also was not possible to evaluate correlations between effects and potential causative factors. Increased forest cover in the Blue Mountains, Columbia Plateau, Southern Cascades, and Upper Snake ERUs (table 29 and appendix 2) suggested that effective fire exclusion resulted in forest establishment on areas that were previously bare ground or shrubland, or on herbland areas previously maintained by fire or created by early logging. Figure 57, A, provides an example of increased forest cover in a subwatershed of the Lower Grande Ronde subbasin in the Blue Mountains ERU. Significantly reduced forest cover in the Upper Klamath ERU suggested that timber harvest activities during the sample period resulted in a net depletion of forest area. Cover type and structure analysis corroborated this observation. Figure 57, B, provides an example of reduced forest cover in a subwatershed of the Upper Klamath subbasin in the Upper Klamath ERU.

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Table 29—Historical and current percentage of area for physiognomic types, cover types, and structural classes of 13 ecological reporting units in the midscale assessment of the interior Columbia River basin

	Change in percentage of area among ERUs														
	Blue Mountains[a,b]			Central Idaho Mountains[a,b]			Columbia Plateau[a,b]			Lower Clark Fork[a,b]			Northern Cascades[a,b]		
Patch types	H	C	MD[c]	H	C	MD[c]	H	C	MD[c]	H	C	MD[c]	H	C	MD[c]
	Percent														
Physiognomic types:															
Forest	62.8	64.1	1.4*	73.4	73.5	0.2	26.1	29.1	3.0*	91.7	94.5	2.8	78.8	78.2	-0.6
Woodland	2.7	4.2	1.6*	0.1	0.0	0.0	6.7	12.2	5.5*	--	--	--	0.3	0.7	0.3*
Shrubland	14.1	10.7	-3.4*	19.2	17.1	-2.0*	32.2	23.4	-8.8*	1.9	0.6	-1.4	4.8	4.1	-0.7
Herbland	17.4	18.0	0.6	3.2	4.5	1.0*	12.7	14.0	1.4	5.4	3.2	-2.3	6.7	6.5	-0.3
Other[d]	3.0	2.9	-0.1	4.2	4.9	1.0*	22.4	21.4	-1.0	0.9	1.8	0.8	9.4	10.6	1.2*
Cover types-forest and woodland:															
Pacific silver fir	--	--	--	--	--	--	--	--	--	--	--	--	6.0	8.3	2.3*
Grand fir-white fir	15.3	8.4	-6.9*	9.6	10.2	0.5	1.1	0.4	-0.7	40.4	42.5	2.1	1.0	2.2	1.3*
Engelmann spruce-subalpine fir	6.3	4.4	-1.9*	22.7	24.1	1.4	0.0	0.0	0.0	2.5	2.2	-0.3	16.8	13.6	3.2*
Aspen-cottonwood-willow	0.1	0.1	0.0	1.1	0.8	-0.2	0.3	0.3	0.0	0.1	0.7	0.6	--	--	--
Oregon white oak	--	--	--	--	--	--	--	--	--	--	--	--	0.6	0.9	0.3*
Juniper	2.7	4.2	1.5*	0.1	0.0	0.0	6.5	12.0	5.5*	--	--	--	0.0	0.0	0.0
Western larch	2.6	2.2	-0.4	0.5	0.3	-0.2*	1.0	0.1	-0.9*	0.8	2.6	1.7	1.0	1.0	0.0
Whitebark pine-subalpine larch	0.0	0.7	0.7*	5.1	2.5	-2.5	--	--	--	--	--	--	3.3	4.7	1.4*
Lodgepole pine	2.4	2.3	-0.1	9.7	9.5	-0.2	1.3	0.9	-0.4	2.1	1.8	-0.3	5.9	5.2	-0.6
Limber pine	0.0	0.0	0.0	0.4	0.4	-0.1	--	--	--	0.0	0.0	0.0	--	--	--
Sugar pine-western white pine	--	--	--	--	--	--	--	--	--	0.3	0.6	0.2	0.1	0.3	0.1*
Ponderosa pine	28.4	28.9	0.5	6.0	5.9	-0.2	19.2	21.4	2.3*	3.0	5.1	2.1	16.5	13.2	-3.2*
Douglas-fir	7.7	17.1	9.4*	17.6	18.5	1.0	3.0	3.9	0.9*	26.4	21.1	-5.3	23.8	25.8	2.0*
Western hemlock with redcedar	--	--	--	0.9	1.3	0.4	0.4	2.2	1.9*	14.7	17.3	2.6	3.0	2.4	-0.6*
Mountain hemlock	--	--	--	0.0	0.0	0.0*	0.0	0.0	0.0	1.3	0.6	-0.7*	1.3	1.2	-0.1
Cover types-shrubland:															
Colline low-medium	7.2	4.7	-2.5*	8.2	8.0	-0.3	29.1	21.7	-7.4*	--	--	--	1.6	1.8	0.2
Montane low-medium	6.0	5.4	-0.6	5.3	4.9	-0.4	1.3	0.9	-0.3	--	--	--	0.3	0.4	0.1
Subalpine-alpine low-medium	--	--	--	0.5	0.4	-0.1	--	--	--	0.2	0.1	-0.1	--	--	--
Colline mahogany species	--	--	--	0.0	0.0	0.0	0.4	0.1	-0.2	--	--	--	0.2	0.0	-0.1
Montane mahogany species	0.4	0.2	-0.1*	0.4	0.2	-0.2*	0.0	0.0	0.0	--	--	--	0.0	0.0	0.0*
Subalpine-alpine mahogany species	--	--	--	0.0	0.0	0.0	--	--	--	--	--	--	--	--	--
Colline tall	0.0	0.0	0.0	0.5	0.3	-0.3	0.3	0.1	-0.1	--	--	--	0.0	0.0	0.0
Montane tall	0.1	0.0	-0.1*	3.7	3.2	-0.5	0.9	0.4	-0.6	1.6	0.3	-1.3	0.0	0.0	0.0*
Colline wet-site	0.0	0.1	0.0	0.1	0.1	-0.1	0.2	0.1	-0.1*	0.0	0.0	0.0	0.0	0.0	0.0
Montane wet-site	0.1	0.1	0.0	0.7	0.6	-0.1*	0.1	0.1	0.0	1.4	1.4	0.1	0.0	0.0	0.0
Subalpine-alpine wet-site	--	--	--	0.0	0.0	0.0	--	--	--	--	--	--	--	--	--
Montane subshrub	--	--	--	0.1	0.1	0.0	0.0	0.0	0.0	--	--	--	0.9	0.3	-0.5
Subalpine-alpine subshrub	--	--	--	0.0	0.1	0.1*	--	--	--	--	--	--	--	--	--
Cover types-herbland:															
Alpine meadow	0.1	0.2	0.2	0.0	0.1	0.1	--	--	--	--	--	--	0.7	0.8	0.1
Dry meadow	6.2	5.3	-0.9*	0.0	0.1	0.1	0.1	0.0	-0.1	--	--	--	1.7	1.5	-0.2
Colline bunchgrass	3.9	4.6	0.7	0.1	0.2	0.1*	8.3	6.9	-1.4*	--	--	--	1.0	1.2	0.2
Montane bunchgrass	3.4	3.5	0.1	0.7	1.2	0.6*	1.3	1.8	0.5*	0.1	0.2	0.1	1.0	0.7	-0.3*
Subalpine-alpine bunchgrass	--	--	--	0.0	0.0	0.0	--	--	--	--	--	--	--	--	--
Colline exotic grasses-forbs	0.3	1.3	1.0*	0.6	0.8	0.1	0.8	2.3	1.5*	--	--	--	0.9	0.5	-0.4*

Table 29—Historical and current percentage of area for physiognomic types, cover types, and structural classes of 13 ecological reporting units in the midscale assessment of the interior Columbia River basin (continued)

	Change in percentage of area among ERUs														
	Blue Mountains[a b]			Central Idaho Mountains[a b]			Columbia Plateau[a b]			Lower Clark Fork[a b]			Northern Cascades[a b]		
Patch types	H	C	MD[c]	H	C	MD[c]	H	C	MD[c]	H	C	MD[c]	H	C	MD[c]
							Percent								
Montane exotic grasses-forbs	1.3	1.2	-0.1	0.1	0.2	0.1	0.1	0.3	0.2	0.1	0.1	0.0	0.7	0.9	0.2*
Colline moist-site herbs	0.1	0.0	0.0	0.2	0.2	0.0*	0.1	0.2	0.1	--	--	--	0.0	0.0	0.0
Montane moist-site herbs	0.7	0.5	-0.2*	0.7	0.6	0.0	0.5	0.5	0.1	0.2	0.2	-0.1	0.0	0.0	0.0
Subalpine-alpine moist-site herbs	--	--	--	0.0	0.1	0.1	--	--	--	--	--	--	--	--	--
Wet meadow	0.2	0.0	-0.2*	--	--	--	0.1	0.0	-0.1	0.0	0.0	0.0	0.2	0.1	-0.1
Postfire-grasses	--	--	--	0.1	0.0	-0.1	--	--	--	2.9	0.0	-2.9	--	--	--
Postlogging grasses-forbs	0.0	0.1	0.1*	0.0	0.2	0.2*	0.0	0.0	0.0	0.4	0.9	0.5	0.1	0.4	0.4*
Cover type-agricultural-rural-urban:															
Cropland	2.3	1.8	-0.5*	0.3	0.2	-0.1	18.1	17.9	-0.1	--	--	--	1.7	1.6	-0.1
Pasture	1.0	1.0	0.0	0.1	0.1	0.1	1.1	1.4	0.3	0.4	0.4	0.0	0.3	0.2	-0.2
Urban-rural	0.1	0.1	0.0	0.0	0.3	0.2*	0.6	0.8	0.2	0.0	0.0	0.0	0.1	0.3	0.2*
Cover type-other:															
Bare ground-road	0.0	0.0	0.0	0.0	0.0	0.0	--	--	--	--	--	--	--	--	--
Rock	0.6	0.7	0.1	3.4	3.6	0.1	0.4	0.5	0.1	0.5	0.3	-0.2	4.8	5.1	0.3
Postlogging-bare ground-burned	0.0	0.3	0.6*	0.2	0.7	0.5*	2.8	1.6	-1.2	0.0	1.1	1.1	0.5	1.5	0.9*
Postlogging-bare ground-slumps	0.1	0.0	-0.1	0.0	0.0	0.0	0.0	0.1	0.1	--	--	--	1.5	1.3	-0.2
Stream channel-nonvegetated flood plain	0.0	0.0	0.0	0.0	0.1	0.0	0.3	0.0	-0.2	0.2	0.3	0.1	--	--	--
Water	0.1	0.1	0.0	0.1	0.1	0.0	0.3	0.4	0.1*	0.2	0.1	-0.1	0.8	0.8	0.0
Structural classes-forest:															
Stand initiation	3.9	6.5	2.6*	9.7	5.9	-3.8*	2.3	2.8	0.5	32.7	9.5	-23.3*	9.2	10.4	1.3
Stem exclusion, open canopy	14.3	9.6	-4.7*	18.4	17.7	-0.8	6.7	7.8	1.1	15.7	9.2	-6.5*	13.2	13.2	0.0
Stem exclusion, closed canopy	5.0	5.0	0.0	7.7	8.5	0.8	3.8	3.6	-0.2	10.3	17.6	7.3*	7.6	7.9	0.3
Understory reinitiation	13.6	11.2	-2.4*	16.0	21.4	5.5*	3.1	3.3	0.2	16.4	37.7	21.3*	17.5	19.5	2.0
Young multistory	21.3	29.6	8.2*	18.4	17.1	-1.2	7.3	10.0	2.7*	14.3	17.5	3.2	21.2	22.0	0.8
Old multistory	2.2	1.0	-1.3*	1.4	1.2	-0.3	2.3	1.3	-1.0	0.2	0.5	0.3	5.8	2.7	-3.1*
Old single story	2.7	0.9	-1.7*	1.8	1.7	-0.1	1.1	1.0	-0.1	2.2	2.5	0.4	4.3	2.4	-1.9*
Structural classes-woodland:															
Stand initiation	0.0	0.1	0.0	--	--	--	0.1	0.3	0.2	--	--	--	0.0	0.0	0.0
Stem exclusion	2.4	4.0	1.6*	0.1	0.0	0.0	5.9	10.9	5.0*	--	--	--	0.3	0.6	0.3*
Understory reinitiation	0.3	0.2	-0.1	--	--	--	0.6	1.0	0.3	--	--	--	0.0	0.0	0.0*
Young multistory	--	--	--	--	--	--	0.0	0.0	0.0	--	--	--	--	--	--
Old multistory	0.0	0.0	0.0	--	--	--	0.0	0.0	0.0	--	--	--	0.0	0.0	0.0
Old single story	--	--	--	--	--	--	--	--	--	--	--	--	0.0	0.0	0.0
Structural classes-shrubland:															
Open low-medium	11.0	8.3	-2.7*	12.6	12.0	-0.5	23.4	19.4	-4.1*	0.2	0.1	-0.1	2.0	1.8	-0.2
Closed low-medium	2.3	1.8	-0.4	1.6	1.4	-0.2	6.9	3.3	-3.7*	0.0	0.0	0.0	0.8	0.8	0.0
Open tall	0.5	0.4	0.0	2.8	2.8	0.1	0.9	0.4	-0.6*	2.1	1.2	-0.9	0.0	0.0	0.0*
Closed tall	0.2	0.1	-0.1*	2.7	1.5	-1.2*	0.9	0.4	-0.6	1.0	0.7	-0.3	0.0	0.1	0.0*
Structural classes-herbland:															
Open	6.4	8.5	2.1*	0.9	1.1	0.1	7.4	9.0	1.5*	0.2	0.1	-0.1	2.3	2.4	0.1
Closed	3.2	2.5	-0.7*	1.7	2.2	0.5*	3.8	3.2	-0.5	0.2	0.3	0.2	1.5	1.0	-0.5
Structural classes-other:															
Nonforest-nonrange	11.1	10.0	-1.1*	4.4	5.4	1.1*	23.8	23.2	-0.6	4.7	3.2	-1.5	14.3	15.2	0.9*

Table 29—Historical and current percentage of area for physiognomic types, cover types, and structural classes of 13 ecological reporting units in the midscale assessment of the interior Columbia River basin (continued)

	Change in percentage of area among ERUs														
	Northern Glaciated Mountains[a b]			Northern Great Basin[a b]			Owyhee Uplands[a b]			Snake Headwaters[a b]			Southern Cascades[a b]		
Patch types	H	C	MD[c]	H	C	MD[c]	H	C	MD[c]	H	C	MD[c]	H	C	MD[c]
								Percent							
Physiognomic types:															
Forest	81.0	80.8	-0.2	7.2	7.3	0.0	0.2	0.2	0.0	74.5	73.8	-0.7	80.5	88.3	7.8
Woodland	0.0	0.0	0.0	15.3	22.2	6.9*	5.5	7.6	2.1*	0.2	0.3	0.1*	0.0	0.4	0.4
Shrubland	3.1	2.5	-0.5	72.8	57.6	-15.2*	88.8	81.0	-7.8*	16.3	13.9	-2.4*	0.5	0.5	0.1
Herbland	7.4	8.1	0.7	3.9	12.2	8.3*	1.0	7.4	6.4*	6.1	8.7	2.6*	0.6	2.7	2.1*
Other[d]	8.5	8.5	0.0	0.8	0.8	0.0	4.5	3.8	-0.6	3.0	3.3	0.4	18.4	8.1	-10.4*
Cover types-forest and woodland:															
Pacific silver fir	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Grand fir-white fir	0.0	1.2	1.2*	--	--	--	--	--	--	--	--	--	5.9	6.5	0.6
Engelmann spruce-subalpine fir	11.5	13.2	1.7*	--	--	--	--	--	--	24.3	31.4	7.1*	0.0	0.2	0.2*
Shasta red fir	--	--	--	--	--	--	--	--	--	--	--	--	0.2	0.4	0.2*
Aspen-cottonwood-willow	0.3	1.9	1.6	8.4	7.7	-0.8	0.2	0.2	0.0	8.8	5.7	-3.1*	0.0	0.0	0.0
Juniper	0.0	0.0	0.0	14.1	21.8	7.7*	5.5	7.5	2.0*	0.2	0.3	0.1*	0.0	0.4	0.4
Western larch	14.8	11.4	-3.4*	--	--	--	--	--	--	--	--	--	0.0	0.0	0.0
Whitebark pine-subalpine larch	0.3	0.2	-0.1	--	--	--	--	--	--	6.9	5.7	-1.3	0.0	0.8	0.8
Lodgepole pine	8.0	8.3	0.3	--	--	--	--	--	--	15.6	11.3	-4.3*	19.4	20.6	1.2
Pinyon pine-juniper	--	--	--	--	--	--	--	--	--	0.0	0.0	0.0	--	--	--
Limber pine	--	--	--	--	--	--	--	--	--	0.7	1.1	0.4*	--	--	--
Sugar pine-western white pine	1.5	0.0	-1.4*	--	--	--	--	--	--	--	--	--	0.3	0.3	0.0
Ponderosa pine	13.4	11.4	-2.0*	--	--	--	--	--	--	0.0	0.0	0.0	22.7	28.1	5.4
Douglas-fir	30.3	30.2	-0.1	--	--	--	0.0	0.0	0.0	18.2	18.6	0.4	1.5	1.7	0.2
Western hemlock with redcedar	0.7	2.8	2.5*	--	--	--	--	--	--	--	--	--	--	--	--
Mountain hemlock	--	--	--	--	--	--	--	--	--	--	--	--	30.5	29.7	-0.8
Cover types-shrubland:															
Colline low-medium	0.1	0.1	0.0	20.0	18.1	-1.8	87.7	79.3	-8.5*	0.1	0.0	-0.1	--	--	--
Montane low-medium	0.0	0.1	0.1*	51.2	37.7	-13.5*	--	--	--	13.0	10.7	-2.3*	--	--	--
Subalpine-alpine low-medium	1.1	0.8	-0.2	0.6	2.0	1.4	--	--	--	0.1	0.3	0.2	--	--	--
Colline mahogany species	0.4	0.0	-0.4*	--	--	--	0.8	1.1	0.4	--	--	--	--	--	--
Montane mahogany species	0.2	0.0	-0.2*	0.4	0.4	0.0	--	--	--	0.0	0.1	0.1	--	--	--
Colline tall	0.7	0.3	-0.4	--	--	--	0.1	0.3	0.2	0.0	0.0	0.0	--	--	--
Montane tall	0.4	0.6	0.2	0.1	0.1	0.0	--	--	--	2.1	2.1	-0.1	--	--	--
Colline wet-site	0.3	0.2	-0.1*	--	--	--	0.3	0.3	-0.1	--	--	--	--	--	--
Montane wet-site	0.1	0.2	0.1*	1.0	0.9	-0.1*	--	--	--	2.8	2.8	0.0	--	--	--
Subalpine-alpine wet-site	0.0	0.0	0.0	--	--	--	--	--	--	--	--	--	--	--	--
Montane subshrub	0.3	0.4	0.1	--	--	--	--	--	--	--	--	--	--	--	--
Subalpine-alpine subshrub	0.0	0.1	0.1*	--	--	--	--	--	--	--	--	--	--	--	--
Russian olive	--	--	--	--	--	--	0.1	0.0	-0.1	--	--	--	--	--	--
Cover types-herbland:															
Alpine meadow	0.0	0.0	0.0	--	--	--	--	--	--	--	--	--	0.1	0.2	0.1
Dry meadow	0.0	0.0	0.0*	--	--	--	--	--	--	--	--	--	0.0	0.1	0.0*
Colline bunchgrass	1.6	0.8	-0.8*	0.0	0.5	0.5	0.2	0.2	0.0	0.0	0.0	0.0	--	--	--
Montane bunchgrass	1.6	1.9	-.2	1.1	5.5	4.5*	--	--	--	2.2	4.3	2.1*	--	--	--
Subalpine-alpine bunchgrass	0.0	0.0	0.0	1.5	0.8	-0.7	--	--	--	0.1	0.3	0.2	--	--	--
Colline exotic grasses-forbs	1.0	1.2	0.2	0.0	2.5	2.5*	0.2	6.2	6.1*	--	--	--	--	--	--

Table 29—Historical and current percentage of area for physiognomic types, cover types, and structural classes of 13 ecological reporting units in the midscale assessment of the interior Columbia River basin (continued)

	Change in percentage of area among ERUs														
	Northern Glaciated Mountains[ab]			Northern Great Basin[ab]			Owyhee Uplands[ab]			Snake Headwaters[ab]			Southern Cascades[ab]		
Patch types	H	C	MD[c]	H	C	MD[c]	H	C	MD[c]	H	C	MD[c]	H	C	MD[c]
								Percent							
Montane exotic grasses-forbs	0.5	0.7	0.1	0.0	0.0	0.0	--	--	--	0.2	0.7	0.5*	--	--	--
Subalpine-alpine exotic grasses-forbs	--	--	--	--	--	--	--	--	--	0.0	0.1	0.1	--	--	--
Colline moist-site herbs	0.0	0.0	0.0	--	--	--	0.1	0.5	0.4*	--	--	--	--	--	--
Montane moist-site herbs	0.2	0.2	0.0	0.6	1.2	0.6	--	--	--	1.5	1.1	-0.4*	0.0	0.1	0.1
Subalpine-alpine moist-siteherbs	0.0	0.0	0.0	0.1	0.0	-0.1	--	--	--	0.0	0.0	0.0	--	--	--
Wet meadow	0.1	0.1	0.1*	--	--	--	--	--	--	--	--	--	0.5	0.6	0.0
Postlogging grasses-forbs	0.1	0.8	0.7*	--	--	--	--	--	--	0.0	0.1	0.1	0.0	1.6	1.6*
Cover type-agricultural-rural-urban:															
Cropland	3.4	4.3	0.9	--	--	--	1.1	1.4	0.3	0.3	0.1	-0.3	0.2	0.0	-0.1
Pasture	1.4	1.7	0.3*	--	--	--	0.5	0.5	0.0	--	--	--	--	--	--
Urban-rural	0.2	0.3	0.1	--	--	--	--	--	--	--	--	--	0.0	0.3	0.3*
Cover types-other:															
Bare ground	0.0	0.0	0.0	--	--	--	0.0	0.0	0.0	--	--	--	--	--	--
Bare ground-road	--	--	--	--	--	--	0.0	0.0	0.0	0.0	0.1	0.0	--	--	--
Glacier	0.0	0.0	0.0	--	--	--	--	--	--	0.1	0.0	-0.1	--	--	--
Rock	2.3	2.7	0.5*	0.8	0.7	-0.1	2.8	1.9	-0.9	1.7	2.1	-.5	5.2	4.1	-1.1
Postlogging-bare ground-burned	2.2	0.4	-1.7*	--	--	--	0.1	0.1	0.0	0.0	0.0	0.0*	10.1	1.8	-8.4*
Postlogging-bare ground-slumps	0.0	0.0	0.0	--	--	--	--	--	--	0.1	0.0	-0.1	0.4	0.2	-0.2
Stream channel-nonvegetated flood plain	0.1	0.1	0.0*	--	--	--	0.4	0.3	-0.1	0.1	0.1	0.1	0.0	0.0	0.0
Water	0.4	0.5	0.1	0.0	0.0	0.0	0.1	0.1	0.0*	0.9	0.9	0.1*	1.5	1.6	0.1
Structural classes-forest:															
Stand initiation	16.9	9.4	-7.5*	--	--	--	0.0	0.0	0.0	6.4	7.0	0.6	9.1	9.9	0.8
Stem exclusion, open canopy	11.8	11.6	-0.2	6.5	6.0	-0.5	0.0	0.1	0.0	19.1	15.3	-3.8*	12.3	14.3	2.1
Stem exclusion, closed canopy	7.2	12.8	5.6*	0.7	1.3	-0.6	0.0	0.0	0.0	7.9	4.8	-3.1*	0.5	4.8	4.2*
Understory reinitiation	18.4	23.3	4.9*	--	--	--	0.4	1.1	0.7	13.8	12.6	-1.2	10.3	8.7	-1.7
Young multistory	25.5	22.8	-2.7*	--	--	--	0.1	0.1	0.0	22.0	30.9	8.9*	46.0	45.6	-0.4
Old multistory	0.5	0.4	-0.1	--	--	--	--	--	--	3.2	1.8	-1.4*	0.7	1.4	0.7
Old single story	0.7	0.6	-0.1	--	--	--	--	--	--	2.0	1.3	-0.7*	1.6	3.7	2.1
Structural classes-woodland:															
Stand initiation	--	--	--	--	--	--	0.0	0.0	0.0	0.1	0.0	-0.1	--	--	--
Stem exclusion	0.0	0.0	0.0	15.3	22.2	6.9*	5.2	6.5	1.3*	0.1	0.3	0.2	0.0	0.4	0.4
Understory reinitiation	0.0	0.0	0.0	--	--	--	0.3	1.1	0.8	0.0	0.0	0.0	--	--	--
Old multistory	--	--	--	--	--	--	--	--	--	--	--	--	0.0	0.0	0.0
Structural classes-shrubland:															
Open low-medium	1.2	1.1	-0.2	71.8	57.8	-13.9*	85.1	77.2	-7.8*	9.3	7.0	-2.3*	--	--	--
Closed low-medium	0.3	0.5	0.2	--	--	--	2.7	2.1	-0.6	3.9	4.0	0.1	--	--	--
Open tall	1.2	0.8	-0.4	1.2	1.2	0.0	0.8	1.4	0.6*	2.9	2.6	-0.3	--	--	--
Closed tall	0.3	0.4	0.2	0.4	0.2	-0.1	0.3	0.3	0.0	2.1	2.3	0.2	--	--	--
Structural classes-herbland:															
Open	1.4	1.5	0.1	3.4	10.1	6.7*	0.3	6.4	6.1*	1.8	4.2	2.4*	0.0	0.1	0.1
Closed	4.2	3.4	-0.8	0.0	0.5	0.5	0.1	0.5	0.4	2.3	2.3	0.1	--	--	--
Structural classes-other:															
Nonforest-nonrange	10.5	11.6	1.1*	0.8	0.8	0.0	5.0	4.4	-0.6	3.1	3.5	0.3	19.5	11.2	-8.3*

Table 29—Historical and current percentage of area for physiognomic types, cover types, and structural classes of 13 ecological reporting units in the midscale assessment of the interior Columbia River basin (continued)

	Change in percentage of area among ERUs								
	Upper Clark Forks[a b]			Upper Klamath[a b]			Upper Snake[a b]		
Patch types	H	C	MD[c]	H	C	MD[c]	H	C	MD[c]
					Percent				
Physiognomic types:									
Forest	87.2	86.2	-1.0	50.5	47.5	-3.1*	2.4	3.2	0.9*
Woodland	--	--	--	8.4	12.8	4.4*	3.0	2.9	0.0
Shrubland	2.5	2.1	-0.4	21.4	18.8	-2.6	73.8	68.5	-5.3
Herbland	5.5	5.7	0.2	10.6	9.0	-1.6	10.6	9.9	-0.7
Otherd	4.8	6.0	1.2	9.1	12.0	2.9*	10.3	15.4	5.1
Cover types-forest and woodland:									
Grand fir-white fir	0.0	0.1	0.1	7.8	8.1	0.3	--	--	--
Engelmann spruce-subalpine fir	14.2	17.3	3.1*	0.1	0.1	0.0	0.0	0.0	0.0
Shasta red fir	--	--	--	7.8	8.5	0.7	--	--	--
Aspen-cottonwood-willow	0.3	0.3	0.0	0.0	0.1	0.0	0.9	1.0	-.1
Juniper	--	--	--	8.4	12.8	4.4*	2.6	2.5	-0.1
Western larch	2.5	3.0	0.6	0.0	0.1	0.1	--	--	--
Whitebark pine-subalpine larch	4.3	3.5	-0.8*	0.0	0.0	0.0	--	--	--
Lodgepole pine	20.9	19.5	-1.3	1.4	1.7	0.3	0.1	0.2	0.1
Pinyon pine-juniper	--	--	--	--	--	--	0.4	0.5	0.1
Limber pine	0.0	0.4	0.3	--	--	--	--	--	--
Sugar pine-western white pine	--	--	--	0.0	0.0	0.0	--	--	--
Ponderosa pine	12.3	9.5	-2.9*	26.7	23.5	-3.2*	--	--	--
Mountain hemlock	0.0	0.1	0.1	4.7	4.2	-0.5	--	--	--
Cover types-shrubland:									
Colline low-medium	0.8	0.7	-0.1	1.8	2.9	1.1	71.0	62.3	-8.6*
Montane low-medium	0.4	0.7	0.2	18.5	14.9	-3.6*	0.3	0.5	0.2
Subalpine-alpine low-medium	0.2	0.2	-0.1	0.1	0.1	0.0	--	--	--
Colline mahogany species	--	--	--	0.0	0.1	0.1	0.4	0.0	-0.4
Montane mahogany species	0.1	0.0	-0.1*	0.1	0.1	0.0	0.1	0.1	0.0
Colline tall	--	--	--	0.0	0.0	0.0	3.4	5.1	1.6
Montane tall	0.2	0.2	-0.1	0.3	0.4	0.2	0.1	0.4	0.3
Colline wet-site	0.1	0.1	0.0	0.5	0.0	-0.5	0.1	0.1	0.0
Montane wet-site	0.6	0.6	0.0	0.6	0.4	-0.1*	0.0	0.0	0.0
Subalpine-alpine wet-site	0.0	0.0	0.0*	--	--	--	--	--	--
Montane subshrub	0.3	0.0	-0.3*	--	--	--	--	--	--
Subalpine-alpine subshrub	0.0	0.0	0.0	--	--	--	--	--	--
Cover types-herbland:									
Alpine meadow	0.0	0.0	0.0	--	--	--	0.0	0.0	0.0
Dry meadow	--	--	--	0.0	0.0	0.0	--	--	--
Colline bunchgrass	0.3	0.3	-0.1	2.8	1.0	-1.8*	3.7	5.2	1.5*
Montane bunchgrass	3.1	1.8	-1.4*	0.7	0.4	-0.3*	--	--	--
Subalpine-alpine bunchgrass	0.1	0.0	0.0*	--	--	--	--	--	--
Colline exotic grasses-forbs	0.1	0.2	0.0	0.0	0.4	0.4	4.6	4.0	-0.6
Montane exotic grasses-forbs	0.1	0.2	0.1*	0.0	0.0	0.0	--	--	--
Subalpine-alpine exotic grasses-forbs	0.1	0.0	-0.1	--	--	--	--	--	--
Colline moist-site herbs	0.0	0.0	0.0	1.1	0.1	-1.0*	0.1	0.2	0.0
Montane moist-site herbs	0.7	0.7	0.0	0.8	0.7	-0.1	--	--	--
Subalpine-alpine moist-site herbs	0.0	0.3	0.2	--	--	--	--	--	--

Table 29—Historical and current percentage of area for physiognomic types, cover types, and structural classes of 13 ecological reporting units in the midscale assessment of the interior Columbia River basin (continued)

	Change in percentage of area among ERUs								
	Upper Clark Forks[a b]			Upper Klamath[a b]			Upper Snake[a b]		
Patch types	H	C	MD[c]	H	C	MD[c]	H	C	MD[c]
	Percent								
Wet meadow	--	--	--	--	--	--	0.0	0.0	0.0
Post fire-grasses	0.0	0.5	0.4	--	--	--	0.4	0.2	-0.2
Postlogging grasses-forbs	0.0	0.9	0.9*	0.0	0.1	0.1*	--	--	--
Cover types-agricultural-rural-urban:									
Cropland	1.2	1.3	0.1	7.0	10.5	3.5*	2.7	12.1	9.4*
Pasture	0.4	0.4	0.0	4.4	5.3	0.9	0.1	0.2	0.2
Urban-rural	0.0	0.1	0.0	0.0	0.1	0.1	0.0	0.2	0.2*
Cover types-other:									
Bare ground-road	0.0	0.0	0.0*	0.0	0.0	0.0*	0.1	0.1	0.0
Rock	2.5	2.4	-0.1	0.2	0.4	0.2	6.8	2.6	-4.1*
Postlogging-bare ground-burned	0.1	1.5	1.4*	0.0	0.4	0.4*	--	--	--
Postlogging-bare ground-slumps	0.0	0.0	0.0	0.0	0.0	0.0	--	--	--
Sand dune	--	--	--	--	--	--	0.5	0.4	-0.1
Stream channel-nonvegetated flood plain	0.1	0.1	0.0	--	--	--	0.1	0.0	-0.1
Water	0.8	0.7	-0.1	2.2	1.4	-0.8	0.1	0.1	0.0
Structural classes-forest:									
Stand initiation	15.9	11.1	-4.8*	1.9	3.6	1.6	0.8	0.3	-0.5*
Stem exclusion, open canopy	18.5	18.2	-0.3	11.3	10.9	-0.4	0.4	1.0	0.6*
Stem exclusion, closed canopy	16.7	21.1	4.4*	1.2	1.6	0.3	0.1	0.1	0.0
Understory reinitiation	15.6	14.0	-1.5	5.6	8.1	2.5	2.5	1.6	-1.0
Young multistory	19.7	21.1	1.3	21.1	16.4	-4.7*	0.6	1.1	0.5
Old multistory	0.6	0.4	-0.2	4.3	5.5	1.2	0.0	0.0	0.0
Old single story	0.2	0.3	0.1	7.4	4.8	-2.6*	0.1	0.0	-0.1
Structural classes-woodland:									
Stand initiation	--	--	--	0.4	1.1	0.7	0.4	0.2	-0.3
Stem exclusion	--	--	--	5.9	7.6	1.6*	0.7	2.0	1.3*
Understory reinitiation	--	--	--	2.0	3.8	1.8*	1.8	0.8	-1.1*
Old multistory	--	--	--	0.0	0.3	0.3	--	--	--
Structural classes-shrubland:									
Open low-medium	1.2	0.8	-0.4	18.5	15.9	-2.6	63.1	57.8	-5.3
Closed low-medium	0.6	0.8	0.2	1.9	2.0	0.1	8.2	5.0	-3.2
Open tall	0.5	0.6	0.2	1.1	0.9	-0.2	3.0	5.2	2.3*
Closed tall	0.5	0.3	-0.3*	0.3	0.2	-0.1	0.7	0.4	-0.4*
Structural classes-herbland:									
Open	1.1	1.3	0.2	3.8	1.4	-2.4*	8.1	9.1	1.0
Closed	3.5	2.1	-1.5*	1.6	1.1	-0.4*	-.7	0.3	-0.4
Structural classes-other:									
Nonforest-nonrange	5.3	7.9	2.6*	13.9	18.2	4.3*	10.8	16.0	5.1

[a] Ecological reporting units of the interior Columbia River basin.

[b] H = historical; C = current; MD = mean difference of pairwise comparisons of historical and current subwatersheds.

[c] * indicates significant difference at $P \leq 0.2$.

[d] Other includes anthropogenic cover types and other nonforest and nonrange types.

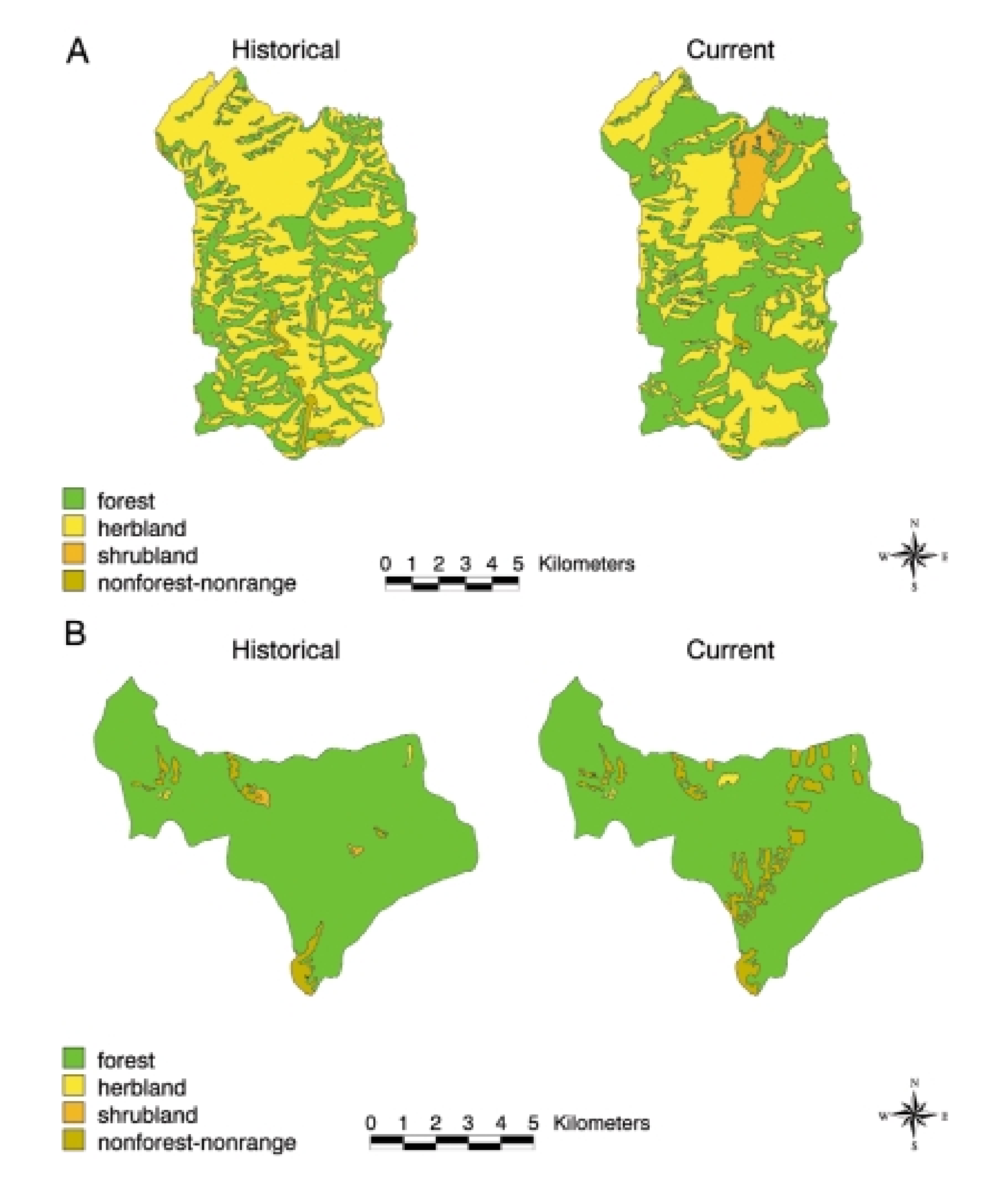


Figure 57—Historical and current maps of physiognomic types: (A) subwatershed 21 in the Lower Grande Ronde subbasin of the Blue Mountains ERU, and (B) subwatershed 0402 in the Upper Klamath subbasin of the Upper Klamath ERU.

Connectivity of forests (as a physiognomic condition) increased in the Central Idaho Mountains and Upper Snake ERUs (appendix 2). The Central Idaho Mountains ERU contains large areas of congressionally or administratively designated wilderness or roadless areas. Across much of the area of this ERU, the primary management activity has been fire prevention and suppression. It is likely that increased connectivity of forests has occurred as a consequence of fire exclusion. Connectivity of forests declined significantly in the Upper Klamath ERU where evidence of timber harvest was widespread.

Woodland area increased in virtually all ERUs that had a significant woodland component in our historical starting point condition, and in some where woodland was apparently a minor component (table 29). Woodland cover increased significantly in the Blue Mountains, Columbia Plateau, Northern Cascades, Northern Great Basin, Owyhee Uplands, Snake Headwaters, and Upper Klamath ERUs, suggesting that fire exclusion and grazing indeed enabled expansion at the expense of declining herblands and shrublands (see Hann and others 1997). Figure 58, A, provides an example of expanded woodland cover in a subwatershed of the Lower Crooked subbasin in the Columbia Plateau ERU.

Perhaps most dramatic of all changes in physiognomic conditions was the across-the-board regional decline in area of shrublands. Shrubland area declined in all ERUs but the Southern Cascades, which had little to begin with (table 29); no ERU exhibited increased shrubland area. Ecologically significant reduction was observed in the Blue Mountains, Central Idaho Mountains, Columbia Plateau, Northern Great Basin, Owyhee Uplands, and Snake Headwaters ERUs. Transition analyses indicated that losses to native shrublands resulted from various factors, including forest or woodland expansion as observed in the Blue Mountains and Northern Great Basin ERUs, cropland expansion as observed in the Northern Great Basin ERU, and conversion to seminative or nonnative herbland as observed in the Owyhee Uplands and Snake Headwaters ERUs (see also fig. 58, A).

Herbland area increased significantly in the Central Idaho Mountains, Northern Great Basin, Owyhee Uplands, Snake Headwaters, and Southern Cascades ERUs and declined in no ERU (table 29). This observation is somewhat misleading when viewed superficially: for example, in the Central Idaho Mountains, herbland area apparently increased from an average of 3.2 to 4.5 percent of the ERU (appendix 2), and increases were primarily to colline and montane bunchgrass cover types (table 29); but in the Northern Great Basin, herbland area rose from an average of 3.9 to 12.2 percent of the ERU. In the latter instance, historical shrubland area declined by more than 15 percent of the ERU area. Half of the lost shrubland area is currently occupied by juniper woodland, 4.5 percent supports montane bunchgrass cover, and the remaining 2.5 percent currently supports exotic grass and forb cover.

In the Owyhee Uplands, herbland area rose from 1.0 to 7.4 percent of the ERU, but shrubland area fell from 88.8 to 81.0 percent of the ERU (appendix 2). Most increase in herbland area was the result of expanding colline exotic grass and forb cover with the conversion of shrublands. Figure 58, B, provides an example of increased herbland area in a subwatershed of the Upper Owyhee subbasin in the Owyhee Uplands ERU. Increased herbland area in the Snake Headwaters ERU also was associated with declining shrubland area. Increased herbland and forest area in the Southern Cascades ERU was associated with regrowth of vast dry ponderosa pine forests clearcut early in the 20th century before the historical photos were taken.

Area in "other" nonforest-nonrange types increased significantly in the Central Idaho Mountains, Northern Cascades, and Upper Klamath ERUs and declined in the Southern Cascades ERU for reasons cited immediately above. Figure 59 provides an example of recently increased forest area and reduced nonforest-nonrange area in a subwatershed of the Little Deschutes subbasin in the Southern Cascades ERU. In the Central Idaho Mountains and Northern Cascades ERUs, increased nonforest and nonrange area was the result of expanded

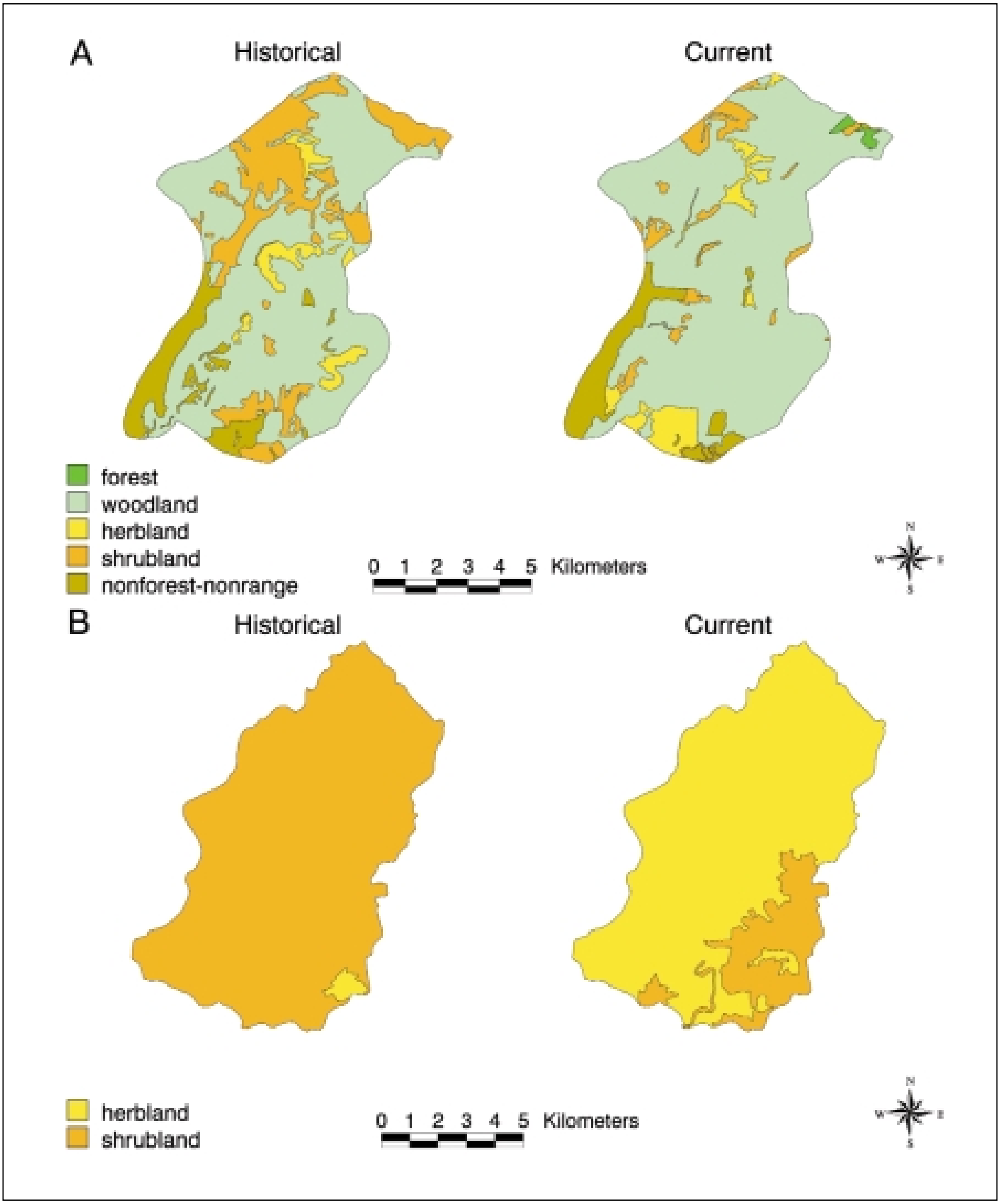


Figure 58—Historical and current maps of physiognomic types: (A) subwatershed o16 in the Lower Crooked subbasin of the Columbia Plateau ERU, and (B) subwatershed 0802 in the Upper Owyhee subbasin of the Owyhee Uplands ERU.

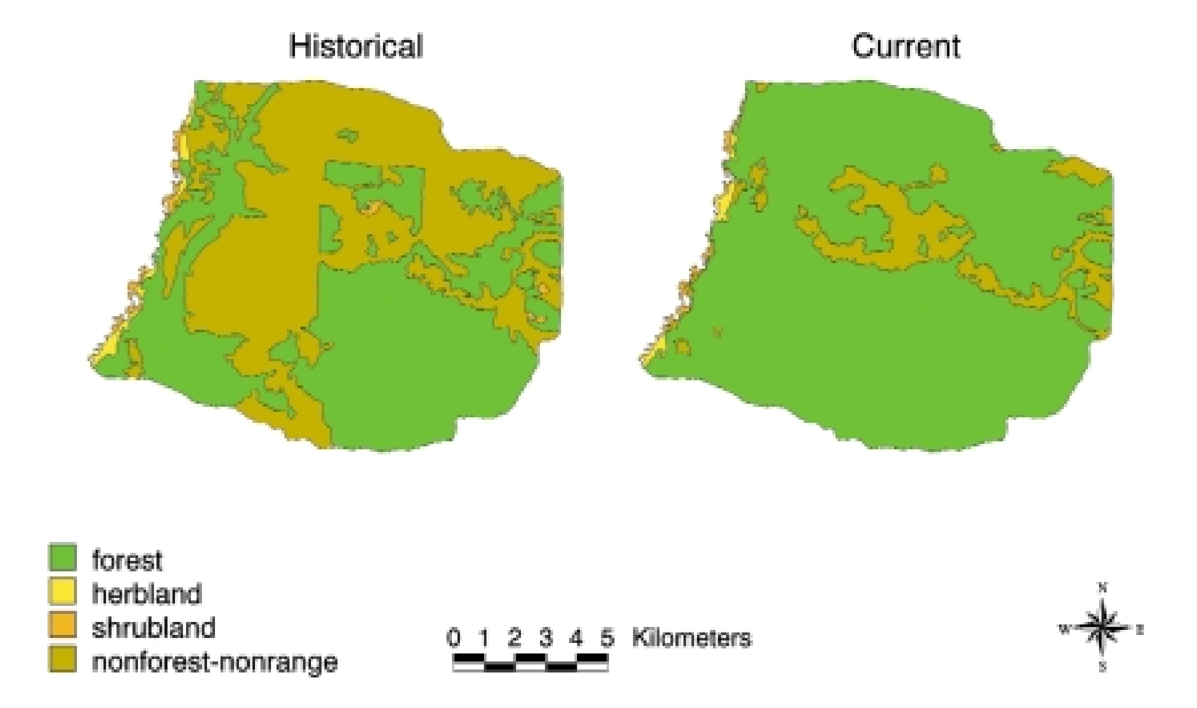


Figure 59—Historical and current maps of physiognomic types in subwatershed 45 in the Little Deschutes subbasin of the Southern Cascades ERU.

urban and rural development and increased bare ground area after logging (appendix 2). In the Upper Klamath ERU, increased nonforest and nonrange area was the result of expanded cropland area and increased bare ground area after logging (fig. 57, B, and table 29).

Forest and woodland cover types—Predicted shifts (Gast and others 1991; Harvey and others 1994, 1995; Hessburg and others 1994; Lehmkuhl and others 1994; O'Laughlin and others 1993; Wickman 1992) from early-seral species (such as ponderosa pine, western larch, lodgepole pine, western white pine, and sugar pine) to late-seral species (such as grand fir, white fir, subalpine fir, Engelmann spruce, western hemlock, and western redcedar) were evident in several ERUs. Of all forested ERUs, the most pronounced shifts from early to late seral cover types occurred in the Northern Glaciated Mountains (table 29). Figure 60 provides an example of declining area in early seral species and increasing area in late seral species cover types in a subwatershed of the Pend Oreille subbasin in the Northern Glaciated Mountains ERU.

Western larch cover declined significantly in the Central Idaho Mountains, Columbia Plateau (fig. 61), and Northern Glaciated Mountains ERUs, and ponderosa pine cover decreased in the Northern Cascades (fig. 62), Northern Glaciated Mountains, Upper Clark Fork, and Upper Klamath ERUs. Figure 61 provides an example of reduced area of western larch cover in a subwatershed of the Palouse subbasin in the Columbia Plateau ERU. Figure 62 provides an example of significantly reduced area of ponderosa pine cover in a subwatershed of the Lower Yakima subbasin in the Northern Cascades ERU. Ponderosa pine cover increased in the Southern Cascades from an average of 22.7 to 28.1 percent of the ERU as a result of regrowth of forests clearcut just prior to the period of our historical photo coverage (for example, see fig. 63, A). Lodgepole pine cover

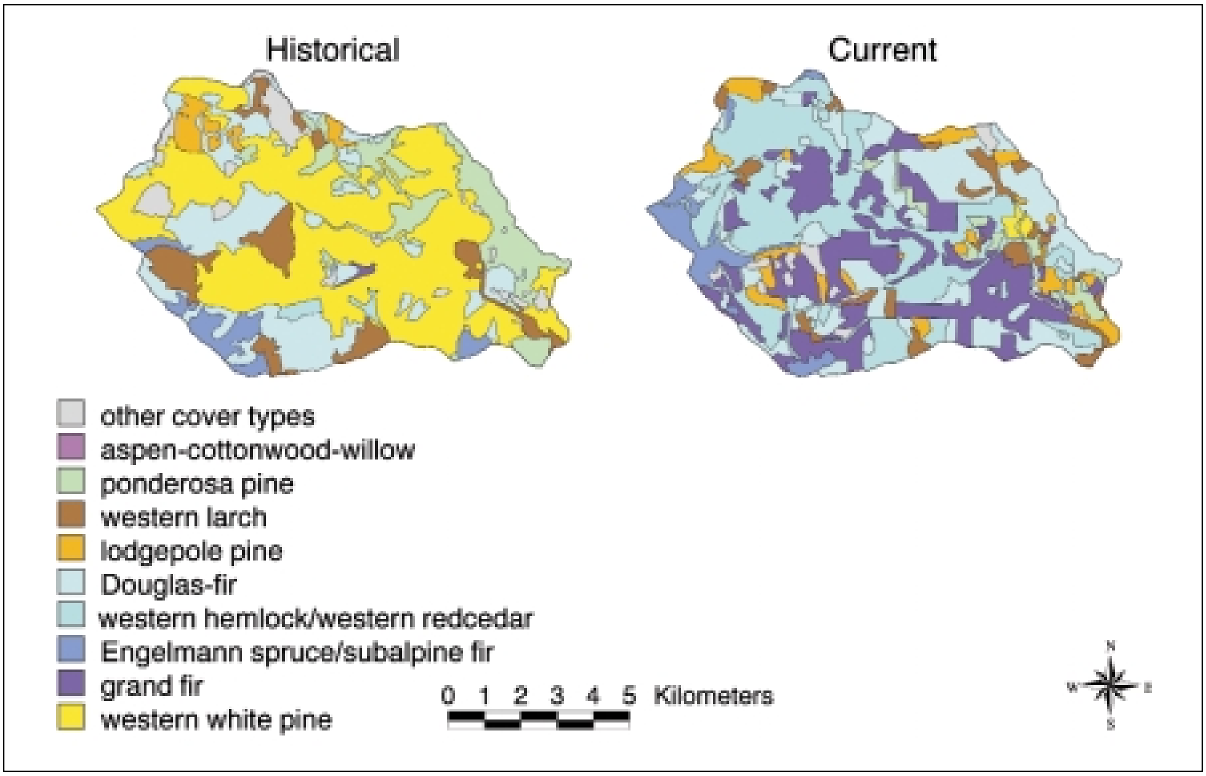


Figure 60—Historical and current maps of forest and woodland cover types in subwatershed 09 in the Pend Oreille subbasin of the Northern Glaciated Mountains ERU.

declined significantly in the Snake Headwaters ERU (see fig. 63, B), and in six other ERUs, but the latter changes were not significant at $P \leq 0.2$.

Western white pine cover decreased significantly in the Northern Glaciated Mountains ERU (fig. 60) as a consequence of blister rust and mountain pine beetle mortality and increased slightly in the Northern Cascades (see fig. 64, A). Whitebark pine-subalpine larch cover declined in the Central Idaho Mountains, Northern Glaciated Mountains, Snake Headwaters (see fig. 63, B), and Upper Clark Fork ERUs, but only the change in the Upper Clark Fork ERU was significant at $P \leq 0.2$; cover increased in the Blue Mountains and Northern Cascades ERUs. Decline in whitebark pine cover likely was the result of ongoing blister rust and mountain pine beetle mortality (Hagle and others 1989, Keane and Arno 1993, Keane and Morgan 1994).

In the Northern and Southern Cascades ERUs, western white pine and sugar pine occurred as relatively minor early seral species in mixed compositions. Large areas of pure type apparently were uncommon. In the Northern Glaciated Mountains ERU, large areas of pure type were relatively more common. Throughout the Inland Northwest, western white pine and sugar pine have long been prized as premium sawtimber species for their rapid growth rate, long straight boles, and superior physical properties and machining characteristics.

Accounts of the earliest logging in the West describe widespread selective harvest of large western white pine throughout northern Idaho, northwest Montana, and the Cascade Range of Oregon and Washington. The extent to which such selective harvest affected five-needle pine reserves in the Northern and Southern Cascades is poorly documented. Additionally, the fungus that causes

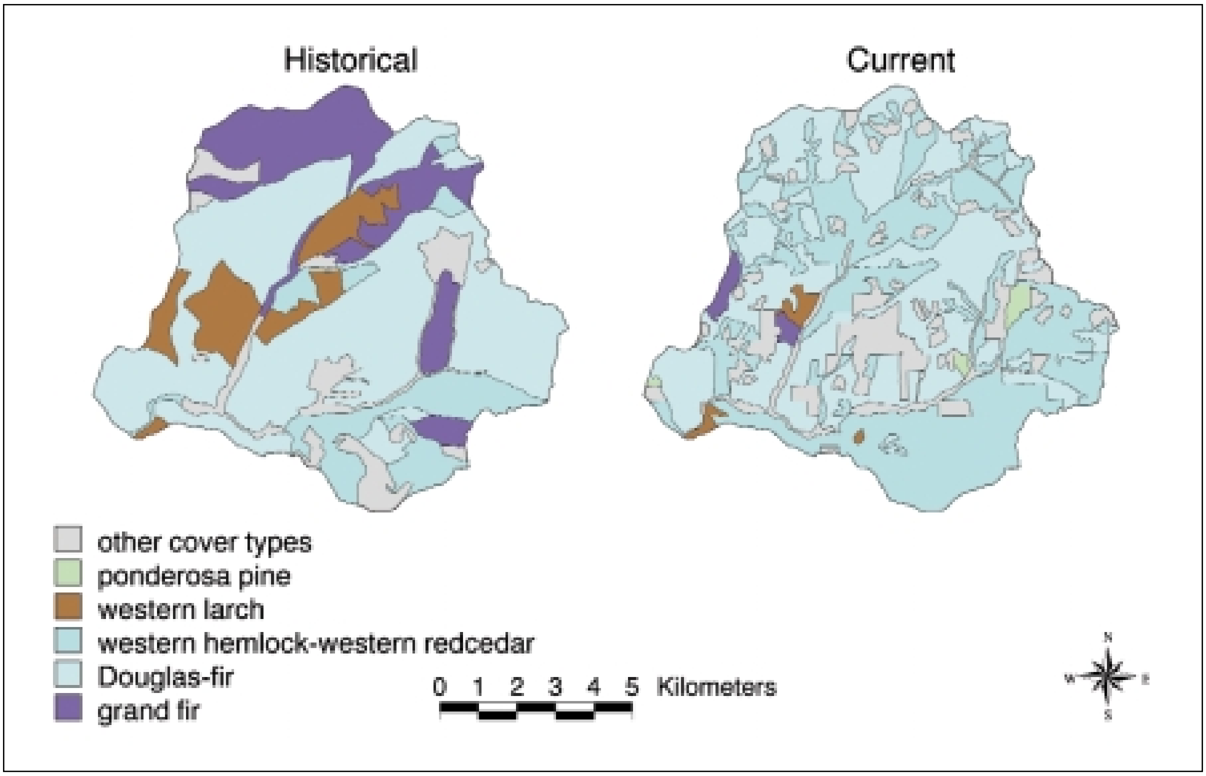


Figure 61—Historical and current maps of forest and woodland cover types in subwatershed 2002 in the Palouse subbasin of the Columbia Plateau ERU.

white pine blister rust was introduced to inland Northwest forests over the last 90 years. Widespread blister rust mortality is prevalent throughout the entire range of western white pine, sugar pine, whitebark pine, and limber pine. For these reasons, our estimates of the historical area of these cover types and other mixed types including these species for the Northern and Southern Cascades, Northern Glaciated Mountains, and Lower Clark Fork ERUs were probably quite conservative. Our results suggest that finer scale plot data and stand reconstructions are needed to improve estimates of historical distribution and abundance of five-needle pines. But focusing only on improved quantitative estimates of decline in reserves of five–needle pines misses the larger point, which our data clearly illustrate: five-needle pines have been decimated by blister rust, timber harvest, and bark beetles, and that has significant ecological and economic consequences for people.

Perhaps greatest among the risks associated with declining five-needle pine reserves is reduced genetic diversity where populations of western white pine and sugar pine have been minimized or eliminated. Across vast areas of the range of western white pine and sugar pine, these species occur as minor or associated early seral species. In many areas, such populations are now extinct or minimized to a remnant. In northern Idaho and northwest Montana, western white pine was a major early seral species across a significant forest area, especially within the western hemlock and western redcedar zones (Cooper and others 1987). As a consequence of blister rust, other coniferous species such as Douglas-fir and grand fir have replaced western white pine in that role, modifying successional trajectories and associated fire, insect, and pathogen ecology.

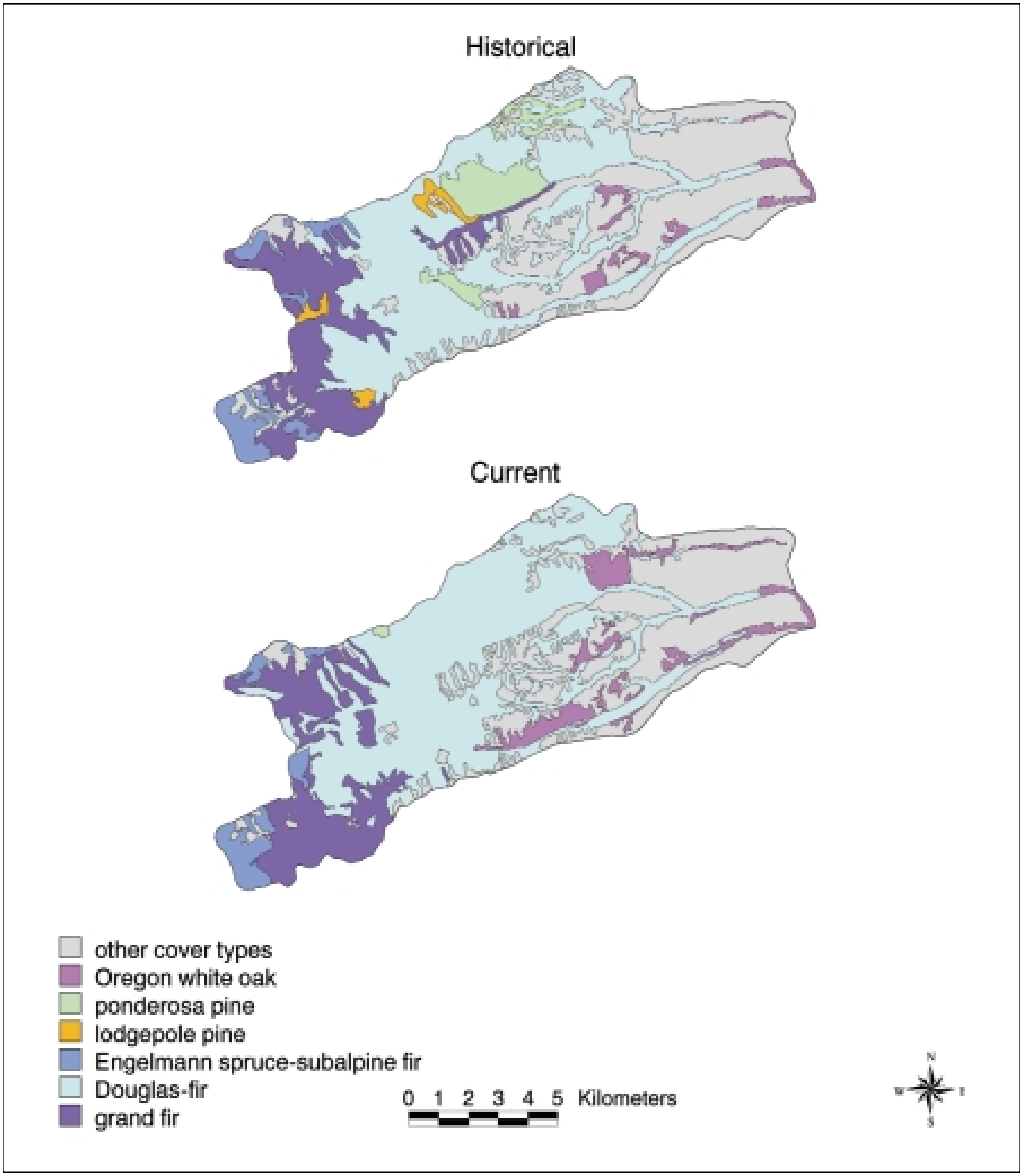


Figure 62—Historical and current maps of forest and woodland cover types in subwatershed 60 in the Lower Yakima subbasin of the Northern Cascades ERU.

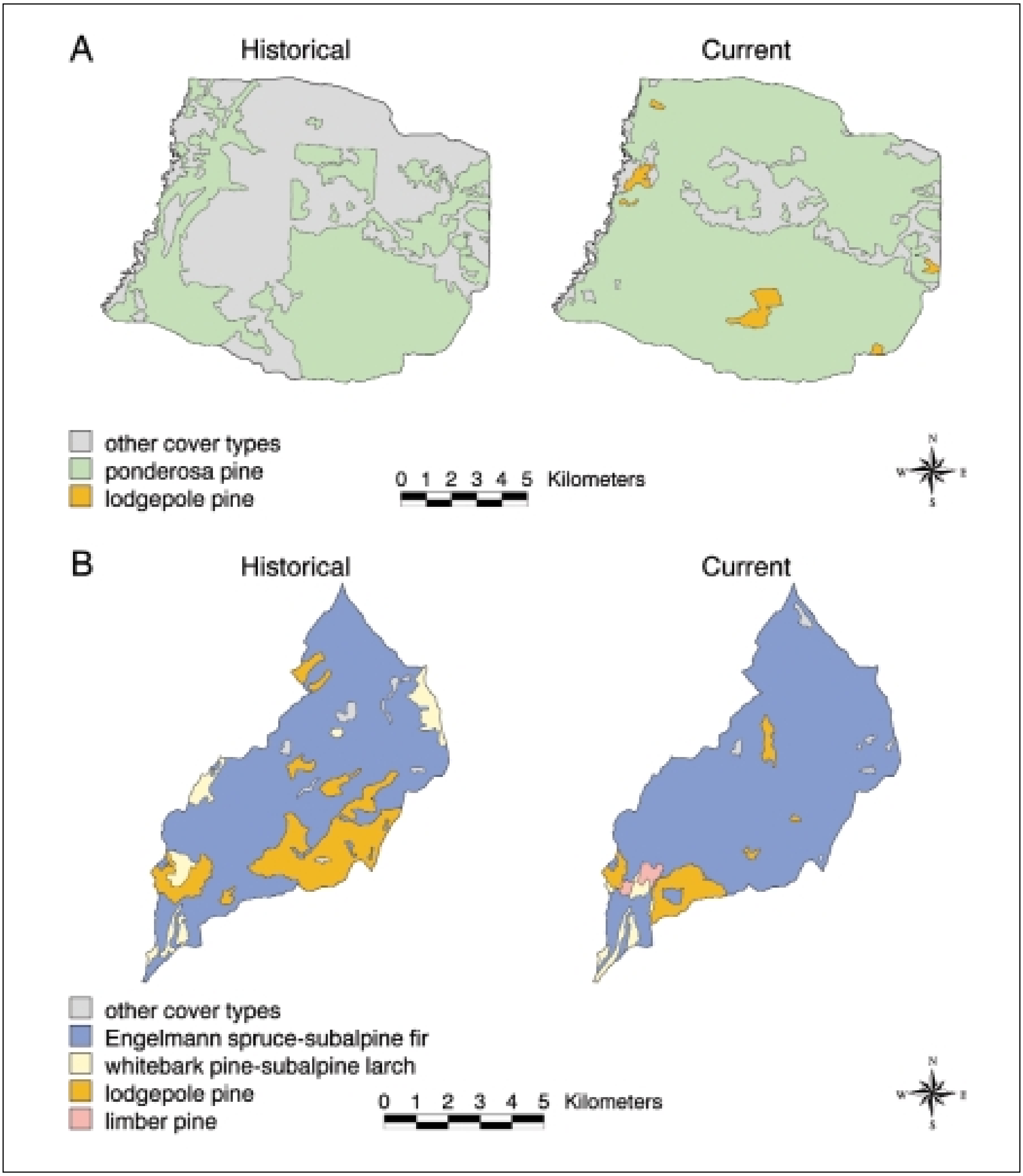


Figure 63—Historical and current maps of forest and woodland cover types: (A) subwatershed 45 in the Little Deschutes subbasin of the Southern Cascades ERU, and (B) subwatershed 0308 in the Snake Headwaters subbasin of the Snake Headwaters ERU.

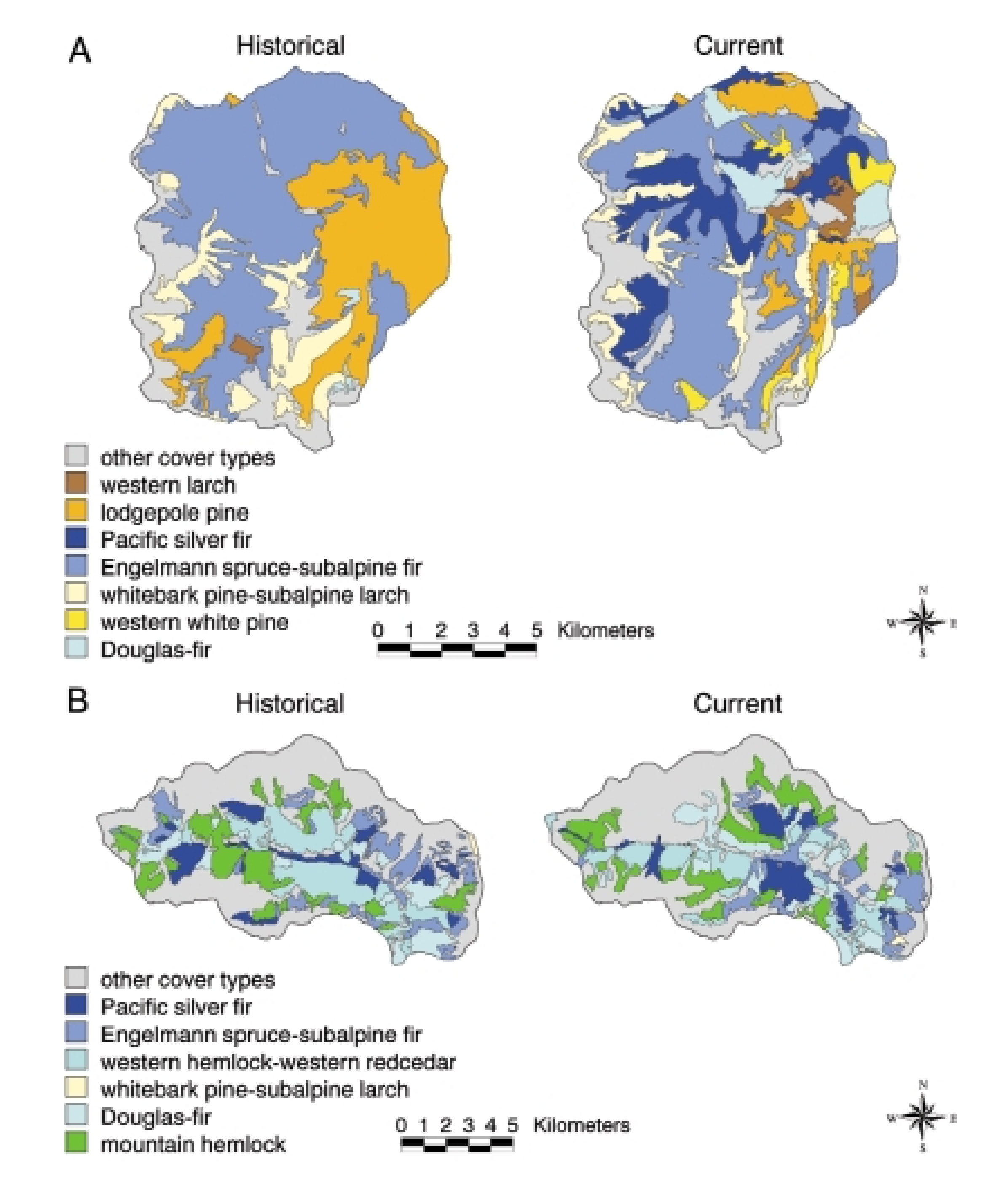


Figure 64—Historical and current maps of forest and woodland cover types: (A) subwatershed 55 in the Methow subbasin of the Northern Cascades ERU, and (B) subwatershed 06 in the Wenatchee subbasin of the Northern Cascades ERU.

Douglas-fir cover increased significantly in the Blue Mountains, Columbia Plateau, and Northern Cascades ERUs (see fig. 62); grand fir-white fir cover increased in the Northern Cascades and Northern Glaciated Mountains (see fig. 60); Pacific silver fir cover increased in the Northern Cascades ERU (see fig. 64, A); Engelmann spruce-subalpine fir cover increased in the Northern Glaciated Mountains, Snake Headwaters (see fig. 63, B), Southern Cascades, and Upper Clark Fork ERUs; and western hemlock-western redcedar cover increased in the Columbia Plateau (fig. 61), and Northern Glaciated Mountains ERUs. Figure 61 provides an example of dramatically increased area of western hemlock-western redcedar cover in a subwatershed of the Palouse subbasin in the Columbia Plateau ERU. Engelmann spruce-subalpine fir cover declined significantly in the Blue Mountains, and Engelmann spruce-subalpine fir (see fig. 64, A) and western hemlock-western redcedar cover decreased in the Northern Cascades. Figure 64, B, provides an example of reduced area and connectivity of western hemlock-western redcedar cover in a subwatershed of the Wenatchee subbasin in the Northern Cascades ERU. Our results suggest that noted increases in shade-tolerant cover types were the direct result of effective fire prevention and suppression programs, selective timber harvest, and fire exclusion and an indirect consequence of the development of extensive road networks, human settlement of interior valleys, movement of Native American Indians onto reservations, and extensive domestic livestock grazing.

Change in area and connectivity of the Douglas-fir cover type should be interpreted with caution because Douglas-fir can be early seral, mid-seral, or late-seral depending on the PVT: Douglas-fir is early seral in the western hemlock, subalpine fir, and Pacific silver fir series, early and mid-seral in the grand fir and white fir series, and late-seral in the Douglas-fir series. Analysis is underway to separate change in area and connectivity of Douglas-fir and other cover types by PVT for each ERU.

Among woodland cover types, juniper cover significantly increased in the Blue Mountains, Columbia Plateau, Northern Great Basin, Owyhee Uplands, Snake Headwaters, and Upper Klamath ERUs (table 29) and did not decrease in any ERU where it was a major cover type. Figure 65 provides an example of substantially increased area of western juniper cover in a subwatershed of the Lower John Day subbasin in the Columbia Plateau ERU. Oregon white oak cover increased in the Northern Cascades ERU (see fig. 62). Fire exclusion and grazing may be causes of the observed increase, but we were unable to directly test this hypothesis.

Shrubland and herbland cover types— Significant reductions in area and connectivity of shrubland cover types were noted in virtually every ERU, but effects were most dramatic where shrublands accounted for more than one-quarter of the land area of an ERU (table 29). The largest reductions in shrub cover types occurred in the Columbia Plateau, Northern Great Basin, Owyhee Uplands, and Upper Snake ERUs. Significant declines in shrub cover types also were observed in the Blue Mountains, Snake Headwaters, and Upper Klamath ERUs. In general, the most significant losses to shrublands were associated with forest or woodland expansion as observed in the Blue Mountains and Northern Great Basin ERUs, cropland expansion as observed in the Northern Great Basin ERU, and conversion to seminative or nonnative herbland as observed in the Owyhee Uplands or Snake Headwaters ERU.

Most shrubland cover in the Blue Mountains, Columbia Plateau, Owyhee Uplands, and Upper Snake ERUs resides below lower treeline, and in each case, the most significant losses of shrub cover occurred in these colline settings. Shrublands of the Northern Great Basin, Snake Headwaters, and Upper Klamath primarily occupy montane settings. Cover types of these elevation settings suffered the greatest losses.

In general, herbland cover increased throughout the basin as a result of declining shrubland area, but several important cover type losses were noteworthy. Bunchgrass cover declined significantly in several ERUs, notably the Columbia Plateau, Northern Cascades, Northern Glaciated Mountains, Upper Clark Fork, and Upper Klamath (table 29). Bunchgrass cover increased in the

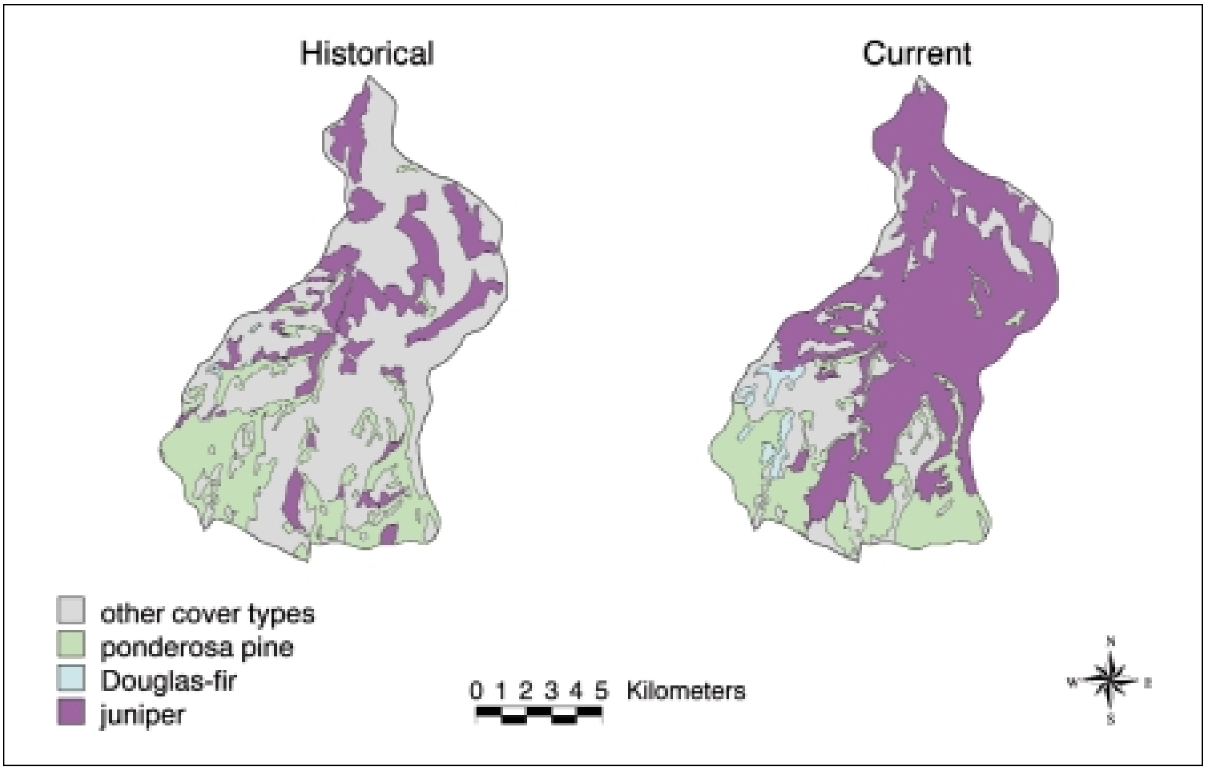


Figure 65—Historical and current maps of forest and woodland cover types in subwatershed 2701 in the Lower John Day subbasin of the Columbia Plateau ERU.

Central Idaho Mountains, Northern Great Basin, Snake Headwaters, and Upper Snake ERUs. Exotic grass and forb cover increased in 9 of 13 ERUs. Significant increases in exotics in either colline or montane settings occurred in the Blue Mountains, Columbia Plateau, Northern Cascades, Northern Great Basin, Owyhee Uplands, Snake Headwaters, and Upper Clark Fork ERUs. Figure 66 provides an example of substantially increased area of exotic grass and forb cover and reduced colline bunchgrass cover in a subwatershed of the Upper Yakima subbasin in the Northern Cascades ERU. Figure 67 provides an example of increased area of exotic grass and forb cover, reduced montane low-medium shrubland cover, and increased montane bunchgrass cover in a subwatershed of the Donner und Blitzen subbasin in the Northern Great Basin ERU. Ecological reporting units most affected by expansion of exotics were, in ascending order, the Columbia Plateau, Northern Great Basin, and Owyhee Uplands. Finally, postlogging grass-forb cover increased in all forested ERUs and increased significantly in all but the Lower Clark Fork and Snake Headwaters ERUs.

Nonforest-nonrange and other anthropogenic cover types—During the course of our aerial photo research, we learned that early historical photographs are rarely available for subwatersheds comprised primarily or entirely of private lands. We were usually able to obtain adequate photographic coverage of a subwatershed when 30 percent or more of the land area was publicly held. As a result, our analysis reflects, at a minimum, change in area and connectivity of nonforest-nonrange and other anthropogenic cover types when they occurred in subwatersheds having substantial public land area. For this reason, we are concerned that some of our results

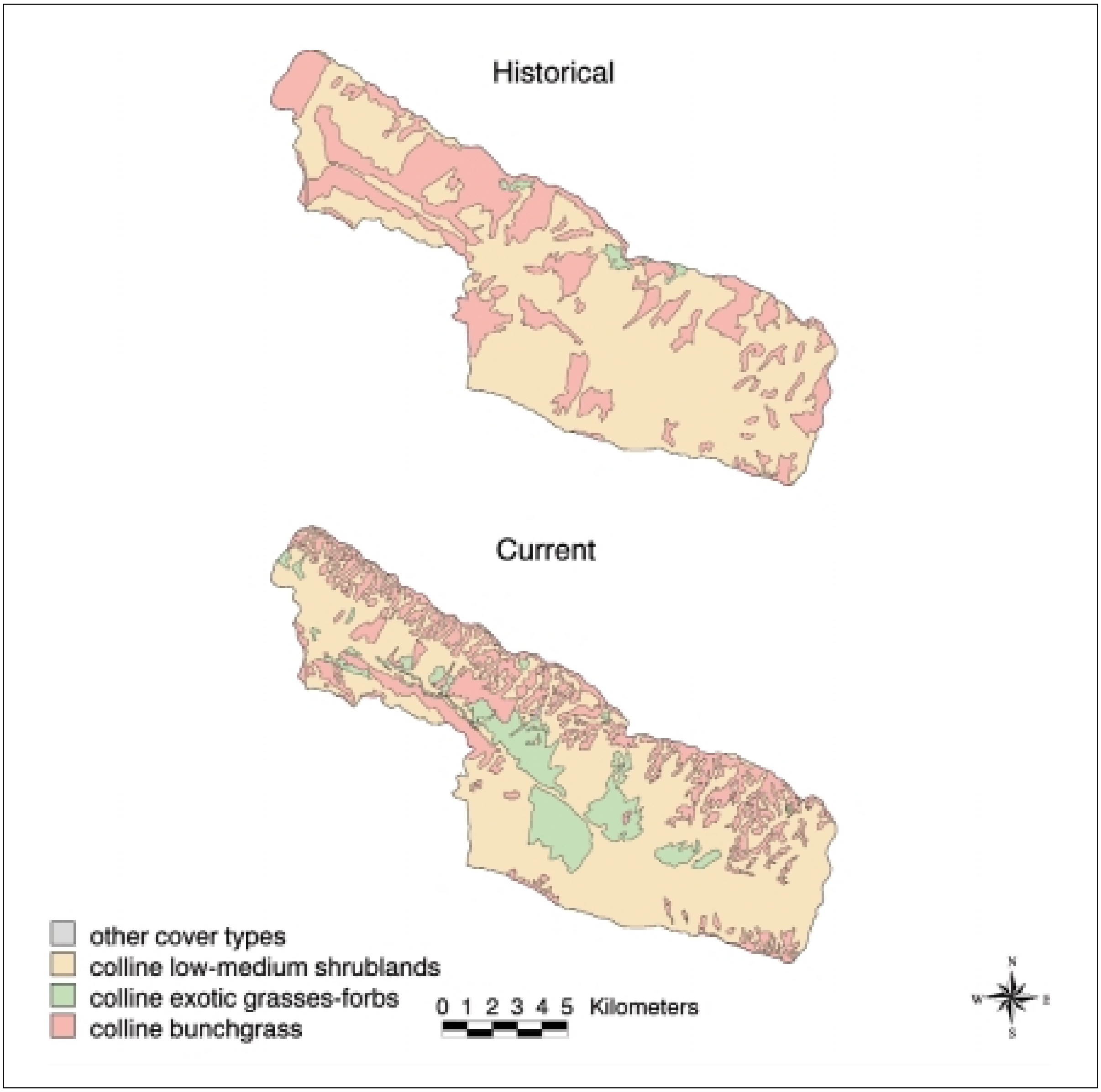


Figure 66—Historical and current maps of shrubland and herbland cover types in subwatershed y3 in the Upper Yakima sub-basin of the Northern Cascades ERU.

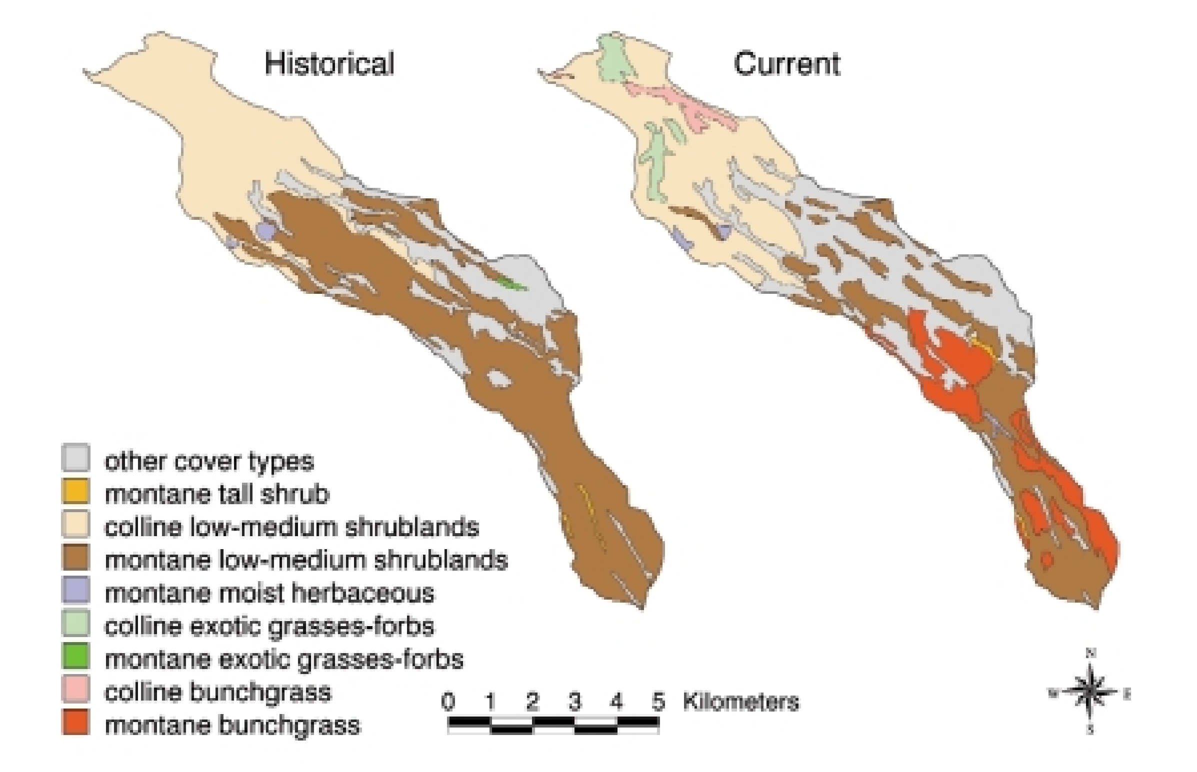


Figure 67—Historical and current maps of shrubland and herbland cover types in subwatershed 0402 in the Donner und Blitzen subbasin of the Northern Great Basin ERU.

may not truly represent changes occurring throughout the total area of each cover type, and they therefore should be interpreted with some caution.

Cropland area increased dramatically in two ERUs: the Upper Klamath and the Upper Snake. In the Upper Klamath, cropland area increased by 50 percent, rising from an average of 7.0 to 10.5 percent of the ERU; in the Upper Snake, cropland area rose more than fourfold (448 percent) from an average of 2.7 to 12.1 percent of the ERU. Figure 68 provides an example of substantially increased cropland area and reduced shrubland and herbland area in a subwatershed of the Lake Walcott subbasin in the Upper Snake ERU. Cropland area declined significantly only in the Blue Mountains. Area in irrigated pastures increased in several ERUs, but only the increase observed in the Northern Glaciated Mountains was significant at $P \leq 0.2$ (see fig. 69). Urban and rural developed area increased in half of the ERUs during the sample period; increase was significant in the Central Idaho Mountains, Northern Cascades, Southern Cascades, and Upper Snake ERUs.

Postlogging of bare ground-burned area increased significantly in several ERUs but, surprisingly, declined in several others. Percentage of area increased in the Blue Mountains, Central Idaho Mountains, Northern Cascades, Snake Headwaters, Upper Clark Fork, and Upper Klamath ERUs, and declined in the Northern Glaciated Mountains and Southern Cascades ERUs. These latter reductions suggested reduced slash burning of postharvest fuels during the sample period and regrowth of forests.

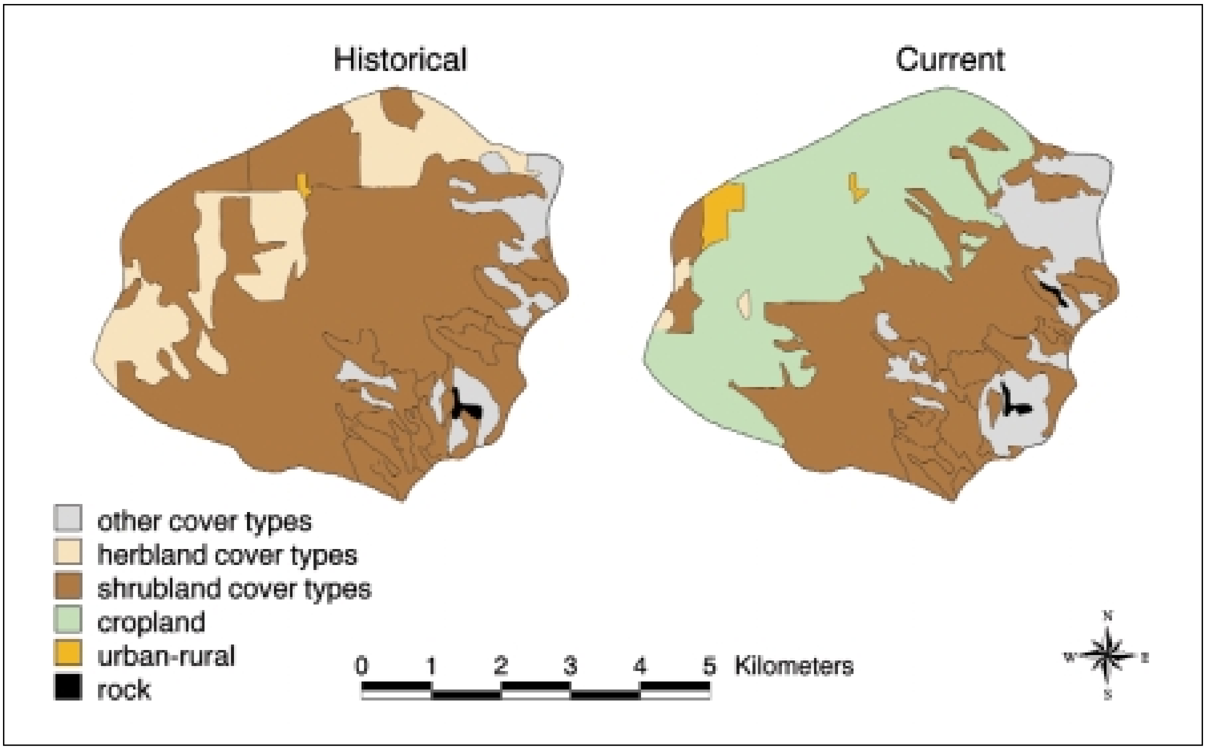


Figure 68—Historical and current maps of shrubland, herbland, and anthropogenic cover types in subwatershed 0203 in the Lake Walcott subbasin of the Upper Snake ERU.

Area of exposed rock declined in seven ERUs, but none so dramatically as the Upper Snake where exposed rock area fell from an average of 6.8 to 2.6 percent of the ERU. Rock areas were not converted directly to cropland as might be superficially indicated in table 29 and appendix 2. Transition analysis in the Upper Snake revealed multiway transitions resulting in declining rock area: areas of exposed rock were overgrown with open-structured low-medium shrubs, but total area in open low-medium shrubs transitioned to open structured seminative and nonnative herblands, colline tall shrublands, and croplands to result in a significant net decline.

Forest and woodland structure—In general, the structure of current forests of sampled ERUs was simpler when compared with historical forests, but causal links with management are difficult to establish because the amount of fire suppression or total timber harvest, for instance, was not directly measurable or quantifiable. Still, structural changes observed were consistent with management activities implicated as primary factors in the overall simplification of the structural complexity of basin forests; namely, timber harvest, fire suppression and exclusion, and grazing (Agee 1994, Everett and others 1994, Gast and others 1991, Hessburg and others 1994, Lehmkuhl and others 1994, O'Laughlin and others 1993).

Area in forest stand-initiation structures declined significantly in four of nine chiefly forested ERUs and increased significantly only in the Blue Mountains (table 29 and appendix 2). Area in stand-initiation structures declined significantly in the Central Idaho Mountains, Lower Clark Fork, Northern Glaciated Mountains, and Upper Clark Fork ERUs. Area in old-forest structures declined in most forested ERUs, but the most significant declines occurred in the Blue Mountains, Northern Cascades, Snake Headwaters, and Upper Klamath ERUs. In general, area in the

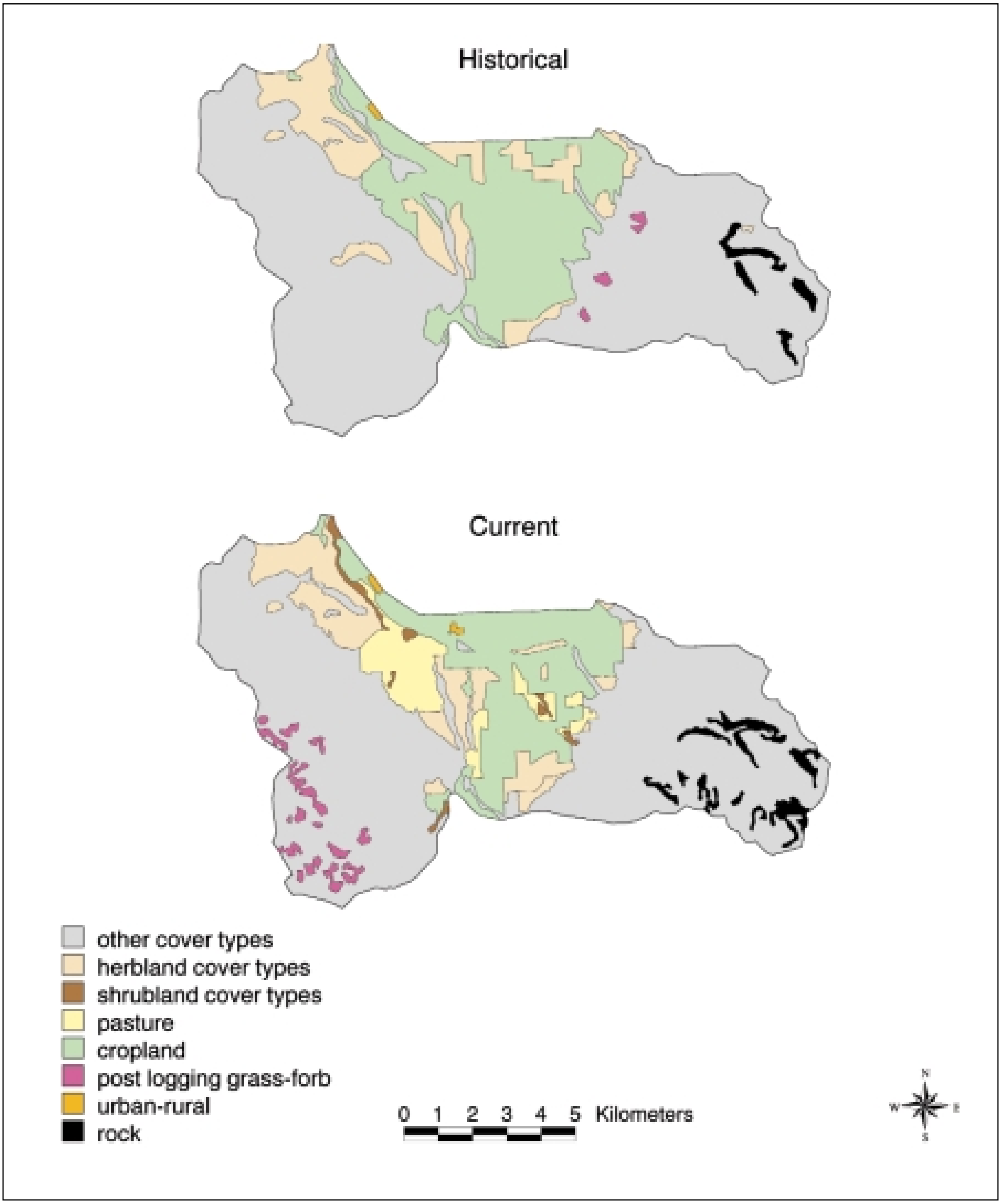


Figure 69—Historical and current maps of shrubland, herbland, and anthropogenic cover types in subwatershed 0701 in the Lower Flathead subbasin of the Northern Glaciated Mountains ERU.

middle-aged, or more precisely, intermediate (not new and not old forest) structural classes (stem exclusion, understory reinitiation, and young multistory) increased in most forested ERUs; the most notable increases occurred in the Blue Mountains, Central Idaho Mountains, Columbia Plateau, Lower Clark Fork, Northern Glaciated Mountains, Snake Headwaters, Southern Cascades, and Upper Clark Fork ERUs. Area in intermediate structural classes actually declined in the Upper Klamath ERU, where most evidence suggested extensive past harvesting.

Blue Mountains ERU—Forests of the Blue Mountains ERU are comprised primarily of dry and mesic potential vegetation types (see fig. 70 and Hann and others 1997). Historical fire regimes resulted in predominantly nonlethal surface fires with frequent (26 to 75 years) to very frequent (0 to 25 years) return intervals (see fig. 71, A and B, and Hann and others 1997). Nearly one-half of historical forest cover was ponderosa pine (table 29 and appendix 2).

Evidence from this analysis suggests that fire exclusion, timber harvest, and grazing each had a pronounced effect on current forest composition and structure. In the historical condition, we would have expected stand-initiation structures to occupy a relatively minor fraction of Blue Mountains forest landscapes, because surface fire regimes with frequent fire return typically regenerate forests continually via individual tree and small group killing. Area in stand-initiation structures increased from an average historical level of 3.9 to 6.5 percent of the ERU in the current condition, most likely as a result of regeneration harvests and removal cuttings (table 27) that occurred during the sample period. Figure 72 provides an example of increased area of stand-initiation structures in a subwatershed of the Lower Grande Ronde subbasin. In our historical vegetation condition, old forests comprised 4.9 percent of the ERU area, or 7.8 percent of the total forest. Selective harvests have diminished that area to a small remnant (fig. 72). Decline in area occupied by medium (40.5 to 63.5 cm d.b.h.) and large (> 63.5 cm d.b.h.) trees was perhaps the single greatest change occurring to all forest structures in the Blue Mountains (tables 21 and 22).

In the historical condition, 39.6 percent of the ERU area (63 percent of forest area) was occupied by forest structures comprised of medium and large trees. In the current condition, 27.2 percent of the ERU area (42 percent of the forest) is occupied by forest structures comprised of medium and large trees.

For the Blue Mountains, we predicted that stem exclusion-open canopy structures were common in the historical vegetation coverage because environmental settings that support dry PVTs often are severely moisture limited. Full site occupancy with less than 100 percent crown cover is the result of limited soil moisture, competition from native early seral grasses and shrubs, and frequent surface fires. Area in open-canopy, stem-exclusion structures declined significantly during the sample period. Results suggested that timber harvest, fire exclusion, and domestic livestock grazing activities were associated with the decline (see Oliver and others 1994; Skovlin and Thomas 1995; Wissmar and others 1994a, 1994b). Selective harvest of medium and large trees in a management context of fire control and extensive sheep and cattle grazing would promote development of more total crown cover (table 22), less grass-forb and shrub understory cover and greater conifer understory cover (table 25), increased vertical complexity of forest canopies (table 23), and increased cover of shade-tolerant understories (table 24). Each of these changes was observed. In addition, extensive grazing would minimize flashy fuel cover (Agee 1993, 1994), thereby increasing opportunities for conifer understory development via reduced competition for site resources and reducing the likelihood of surface fires from natural or human-caused ignitions.

Area in understory reinitiation structures declined for similar reasons. Repeated partial cutting in a context of cattle grazing and fire exclusion created increasing area of young multistory structure by encouraging pulsed regeneration and release of shade-tolerant conifers. During the sample period, area in young multistory structures increased from one-third to one-half of the forest area (table 29 and appendix 2). We were surprised to find such an extensive area in young multistory forest structures in our historical coverage. We suggest

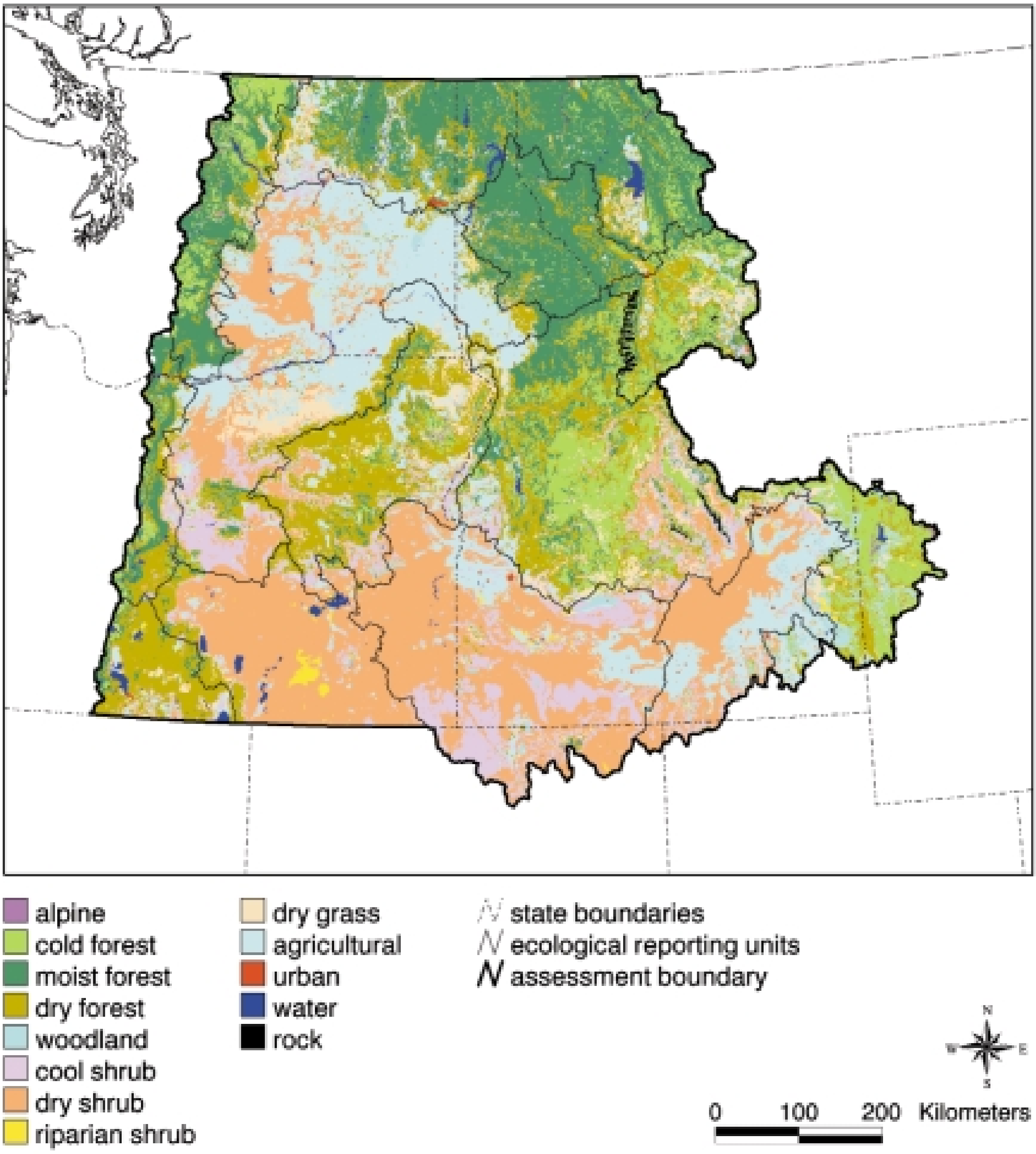


Figure 70—Broadscale (1-km^2 pixels) map of current potential vegetation groups within the interior Columbia River basin assessment boundary. See Hann and others (1997) for map development procedures.

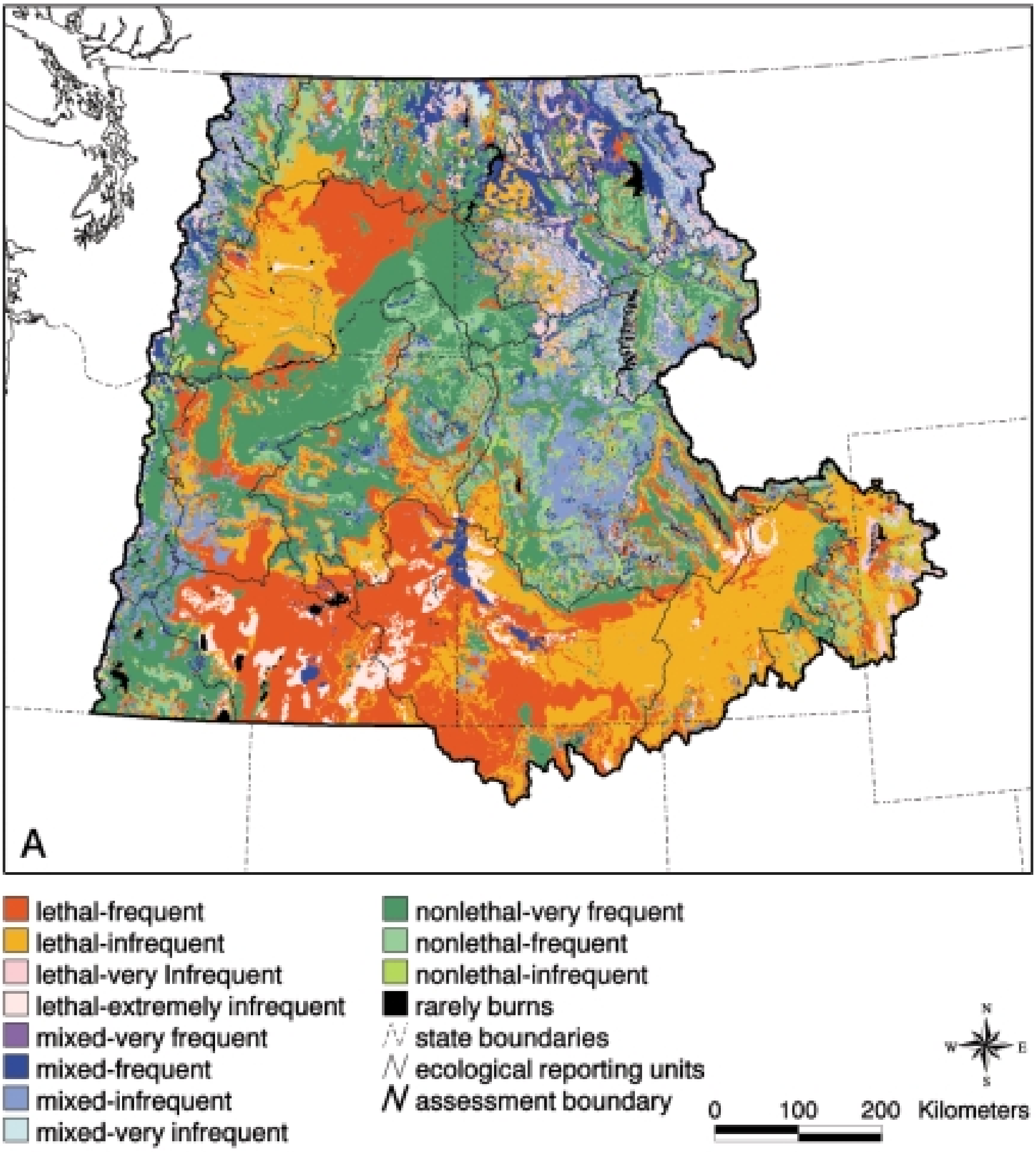
three possible explanations: (1) ongoing insect, pathogen, and fire disturbances exerted a greater mortality influence on overstory structure than we had anticipated, such that large tree structure was not dominant; (2) some areas were affected by partial cutting before the time of our historical coverage, and we were not able to determine by remote sensing any associated road, skid trail, or harvest signature; and (3) some structures classified as young multistory by virtue of their size may be older than they appear.

Blue Mountains woodlands are composed primarily of western juniper. During the sample period, stem-exclusion structure increased sharply by 67 percent from an average of 2.4 to 4.0 percent of the ERU. Connectivity of stem-exclusion structure also increased (appendix 2). We believe that expansion of western juniper cover and the associated stem-exclusion structure was the result of fire exclusion and grazing. Grazing minimized herbaceous competition and the possibility of surface fires, and fire exclusion enabled uninhibited expansion of juniper cover.

Central Idaho Mountains ERU—Forests of the Central Idaho Mountains are comprised primarily of cold and moist PVTs (see fig. 70 and Hann and others 1997). Historical fire regimes were predominantly of mixed severity with infrequent (76 to 150 years) to very infrequent (151 to 300 years) fire return intervals (see fig. 71, A and B, and Hann and others 1997). Historical forest cover was dominated by upper montane and subalpine species such as Engelmann spruce, subalpine fir, lodgepole pine, grand fir, and Douglas-fir (table 29 and appendix 2). Our results suggest that fire suppression and exclusion were primary factors responsible for current forest composition and structure. Road densities are among the lowest of any forested ERU (see fig. 73 and Hann and others 1997), and wilderness and roadless area is greatest of any forested ERU. In our historical vegetation condition, we would have expected stand-initiation structures to represent a relatively large fraction of Central Idaho Mountains forest landscapes because mixed severity fires with infrequent fire return typically create a mosaic of underburned and regenerated patches of new forest. Area in stand-initiation structures declined during the sample period by 39 percent, from an average historical level of 9.7 percent of the ERU to 5.9 percent. We believe the observed decline occurred primarily as a result of effective fire prevention and suppression efforts and secondarily as a consequence of fire exclusion. Although timber harvest activities and road network development were evident, most of these activities were associated with dry and moist forest settings of lower and middle montane environments or were in areas with extensive lodgepole pine cover that had been attacked by bark beetles and salvage logged or regenerated. A large, intact, interior core area of the ERU comprised mainly of cool and cold upper montane and subalpine forests was mostly unroaded and had not been entered for timber harvest.

In our historical vegetation condition, old forests comprised 3.2 percent of the ERU area, or 4.4 percent of the total historical forest. Old-forest area in the current condition was essentially unchanged. Likewise, area with large trees, whether in old forest or associated with other forest structures, was unchanged (table 20). Area with medium and large trees increased significantly during the sample period (table 21). In the historical condition, 23.5 percent of the ERU area (32 percent of the forest) was occupied by forest structures comprised of medium and large trees. In the current condition, 25.8 percent of the ERU (35 percent of the forest) is occupied by forest structures comprised of medium and large trees.

Area in understory reinitiation structures increased significantly during the sample period to become the dominant structural component of Central Idaho Mountains forests in the current condition. We believe that the observed increase in understory reinitiation structure was the result of fire exclusion: areas regenerated by fire before our historical coverage have regrown. In the absence of fire, we predict a correlated decline in area and connectivity of early seral shrub and herb structures in forest potential vegetation settings.


A
lethal-frequent
lethal-infrequent
lethal-very Infrequent
lethal-extremely infrequent
mixed-very frequent
mixed-frequent
mixed-infrequent
mixed-very infrequent
nonlethal-very frequent
nonlethal-frequent
nonlethal-infrequent
rarely burns
state boundaries
ecological reporting units
assessment boundary
0
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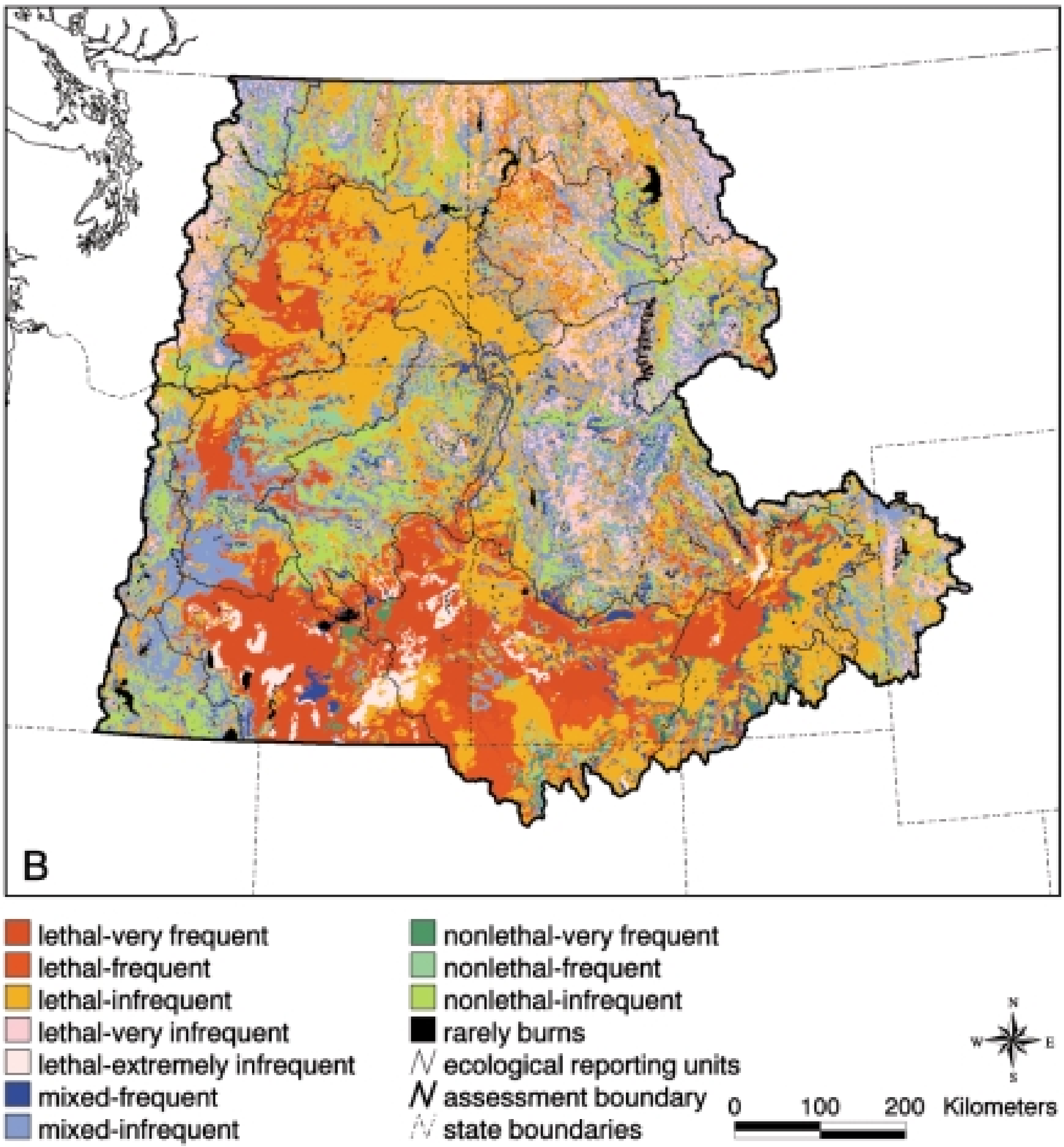

Figure 71—Broadscale (1-km^2 pixels) map of (A) historical and (B) current fire regimes within the interior Columbia River basin assessment boundary. See Hann and others (1997) for map development procedures. Lethal = stand-replacing fire that kills > 70 percent of the overstory tree basal area; nonlethal = fire that kills < 20 percent of the overstory tree basal area; mixed = fire that kills 20 to 70 percent of the overstory tree basal area; and rarely burns = fire seldom occurs. Very frequent = 0- to 25-year mean fire-return interval; frequent = 26- to 75-year mean fire-return interval; infrequent = 76- to 150-year mean fire-return interval; very infrequent = 151- to 300-year mean fire-return interval; and extremely infrequent = > 300-year mean fire-return interval.

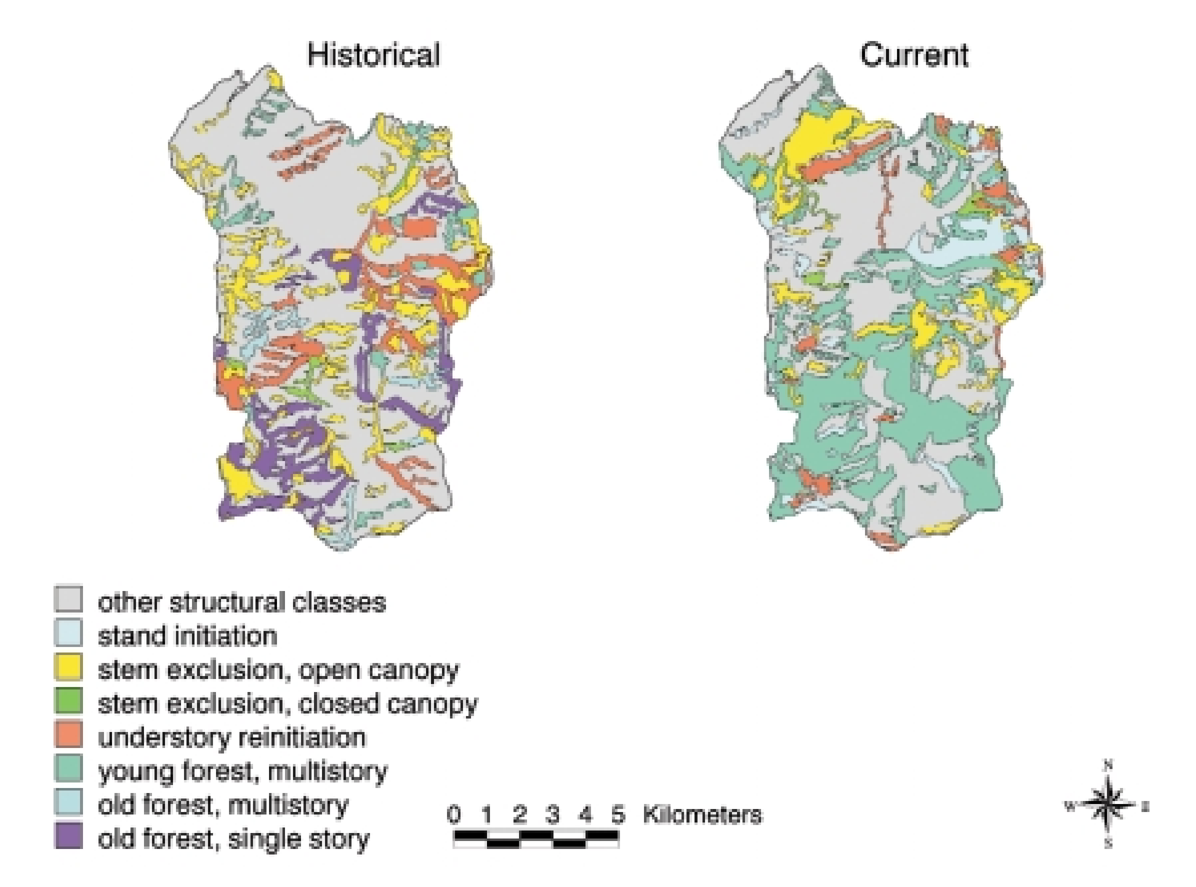

Figure 72—Historical and current maps of forest and woodland structural classes in subwatershed 21 in the Lower Grande Ronde subbasin of the Blue Mountains ERU.

Columbia Plateau ERU—Forests of the Columbia Plateau ERU are comprised of dry and moist potential vegetation types. Historical fire regimes were predominantly nonlethal with very frequent (0 to 25 years) fire return intervals (see fig. 70 and Hann and others 1997). The majority of historical forest cover was ponderosa pine and Douglas-fir (table 29 and appendix 2). Before European settlement, the Columbia Plateau contained the largest expanses of native grasslands in the whole of the Columbia River basin (see fig. 74 and Hann and others 1997). During the period of settlement, even to the current day, these grasslands and shrublands have been converted to dryland and irrigated agriculture and pasturelands (fig. 70). Presettlement herblands burned frequently, and fires often spread to lower and mid montane dry forests (Arno 1980). With herbland conversion to agriculture, dry and mesic forests of the Columbia Plateau became isolated from fires that had commonly originated in herbland and shrubland settings. Fire prevention and suppression efforts minimized the incidence of fires originating from within, especially adjacent to human settlements. In the absence of fires from once adjacent herblands, and in the context of aggressive fire suppression, forest area expanded by 11 percent, from an average of 26.1 to 29.1 percent of the ERU, and juniper woodlands expanded by 82 percent, from an average of 6.7 to 12.2 percent of the ERU. We expected to see significantly increased total tree crown cover in forest settings (table 22).

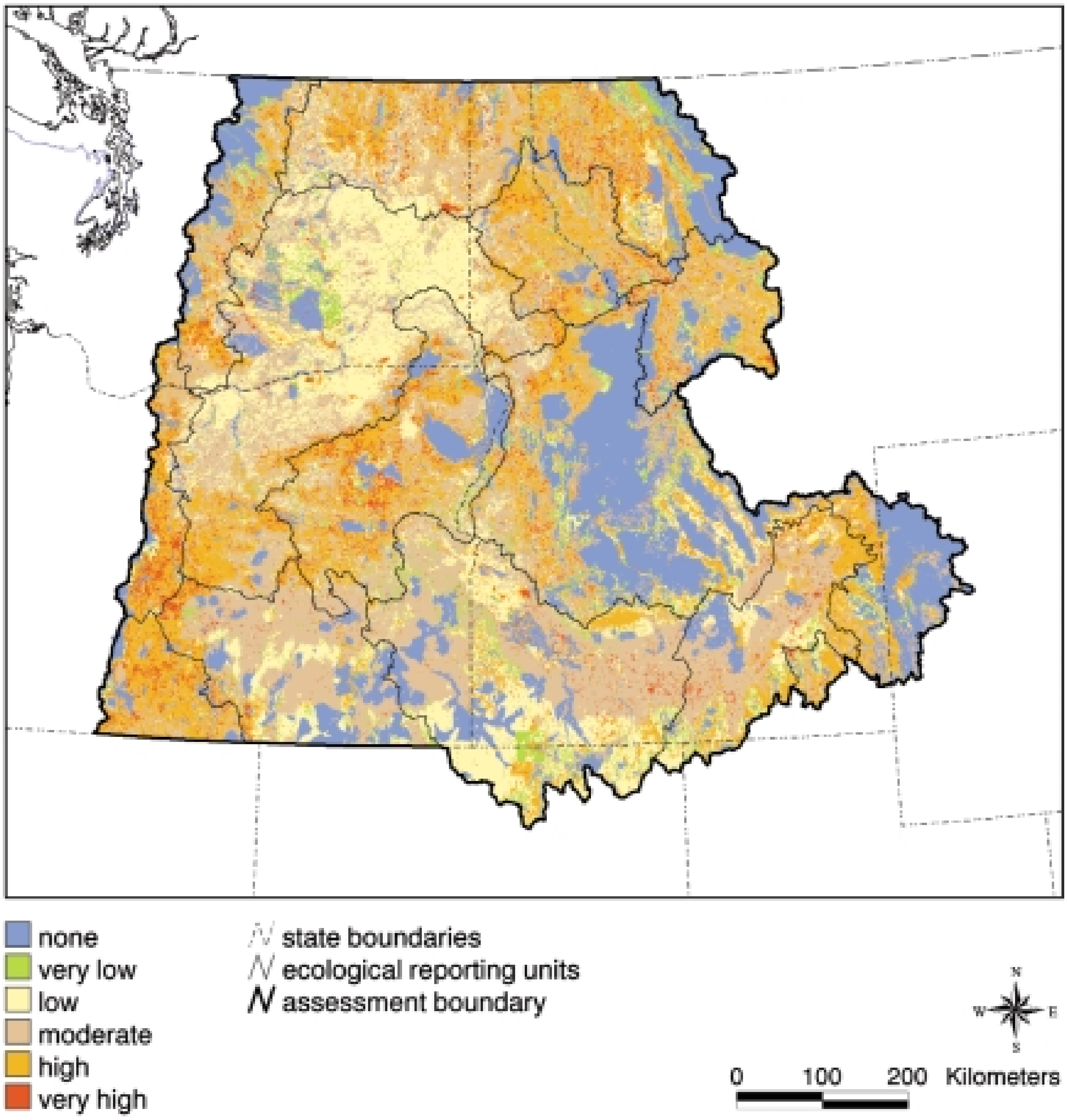

Figure 73—Broadscale (1-km^2 pixels) map of current predicted road density classes within the interior Columbia River basin assessment boundary. See Hann and others (1997) for map development procedures. None = 0 to 0.01 km/km^2; very low = 0.01 to 0.06 km/km^2; low = 0.06 to 0.43 km/km^2; moderate = 0.43 to 1.06 km/km^2; high = 1.06 to 2.92 km/km^2; and very high = > 2.92 km/km^2.

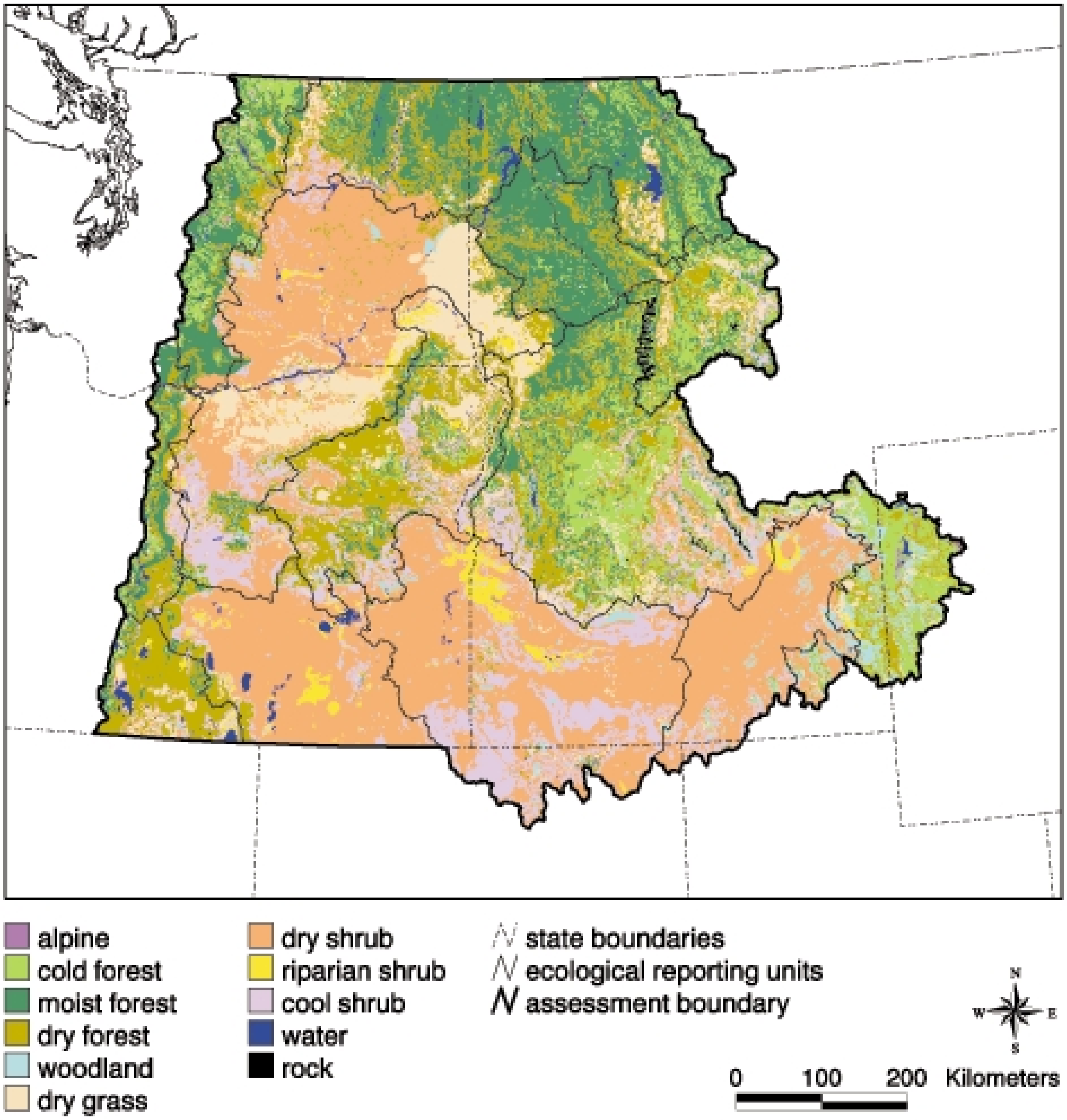

Figure 74—Broadscale (1-km^2 pixels) map of historical potential vegetation groups within the interior Columbia River basin assessment boundary. See Hann and others (1997) for map development procedures.

Evidence from these analyses suggests that agriculture, fire exclusion, timber harvest, and grazing each had an effect on existing forest structure. In the historical condition, we expected stand-initiation structures to occupy a minor fraction of Columbia Plateau forest landscapes because surface fire regimes continuously regenerated multicohort forests dominated by early seral species. Historical area in stand-initiation structures was 2.3 percent of the ERU and remained stable during the sample period. In our historical vegetation condition, old forests comprised 3.4 percent of the ERU, or 13 percent of the total forest. Selective harvests have diminished that area to a small remnant in the existing condition. Selective harvest of medium and large trees in a management context of fire control and grazing would promote development of more total crown cover (table 22), less grass-forb and shrub understory cover and greater conifer understory cover (table 25), increased vertical complexity of forest canopies (table 23), and increased cover of shade-tolerant understories (table 24). All but one of these changes were observed; grass-forb and shrub understory cover actually increased during the sample period. Transition analysis revealed that such increase was associated with expanding forest and woodland in former native herbland and shrubland areas (table 24 and appendix 2).

For the Columbia Plateau, we predicted that stem exclusion-open canopy structures were common in the historical condition because dry potential vegetation types are typically moisture limited, and surface fire regimes tend to maintain open stand conditions and dry site climate. Area in open canopy, stem-exclusion structures was 6.7 percent of the ERU in the historical condition and remained stable during the sample period. During the sample period, area in young multistory structures increased from 28 to 34 percent of the forest area (table 29 and appendix 2). Figure 75 provides an example of increased area of young multistory structure in a subwatershed of the Lower John Day subbasin. We were again surprised to find such an extensive area in young multistory forest structures in our historical coverage. As suggested for the Blue Mountains, we believe that it is likely that ongoing insect, pathogen, and fire disturbances exerted a greater mortality influence on overstory structure than we had anticipated, such that large tree structure was not dominant; that is, it did not exceed 24 percent crown cover. Large and medium trees are those most likely to be old and decadent or declining in vigor, and such trees are the most probable targets of tree-killing bark beetles that favor vigor-depressed hosts. Dry ponderosa pine forests often are afflicted with western dwarf mistletoe and S-group annosum root disease, pathogens of ponderosa pine of any age. Forests such as these are especially sensitive to dry growing seasons, winter desiccation injury, and protracted droughts. Pine bark beetles have ample opportunities to capitalize on hosts vigor-depressed from a variety of independent or interacting factors. It is also possible that some areas were affected by partial cutting before the period of our historical coverage, and we were not able to detect the logging entry, and some structures classified as young multistory by virtue of their size may be older than they appear.

Western juniper woodland cover in the Columbia Plateau nearly doubled in the interval between our historical and current vegetation conditions. Nearly all change in woodland structure was associated with stem-exclusion structures, which increased from an average of 5.9 to 10.9 percent of the ERU (fig. 75). Connectivity of woodland stem-exclusion structure also increased dramatically (appendix 2); mean patch size rose from 63.8 to 152.7 ha, representing a 239-percent rise for the period. In the absence of fire and under the influence of grazing, we expected increases in both the stem-exclusion and understory reinitiation structures (table 29).

Lower Clark Fork ERU—Forests of the Lower Clark Fork are comprised primarily of moist PVTs (see fig. 70 and Hann and others 1997). Historical fire regimes were predominantly lethal crown fires and of mixed severity with fire frequencies ranging broadly from very frequent (0 to 25 years) to extremely infrequent (> 300 years) (see fig. 71, A and B, and Hann and others 1997). Historical forest cover was dominated by grand fir, Douglas-fir, western hemlock, and western redcedar (table 29 and appendix 2). Our

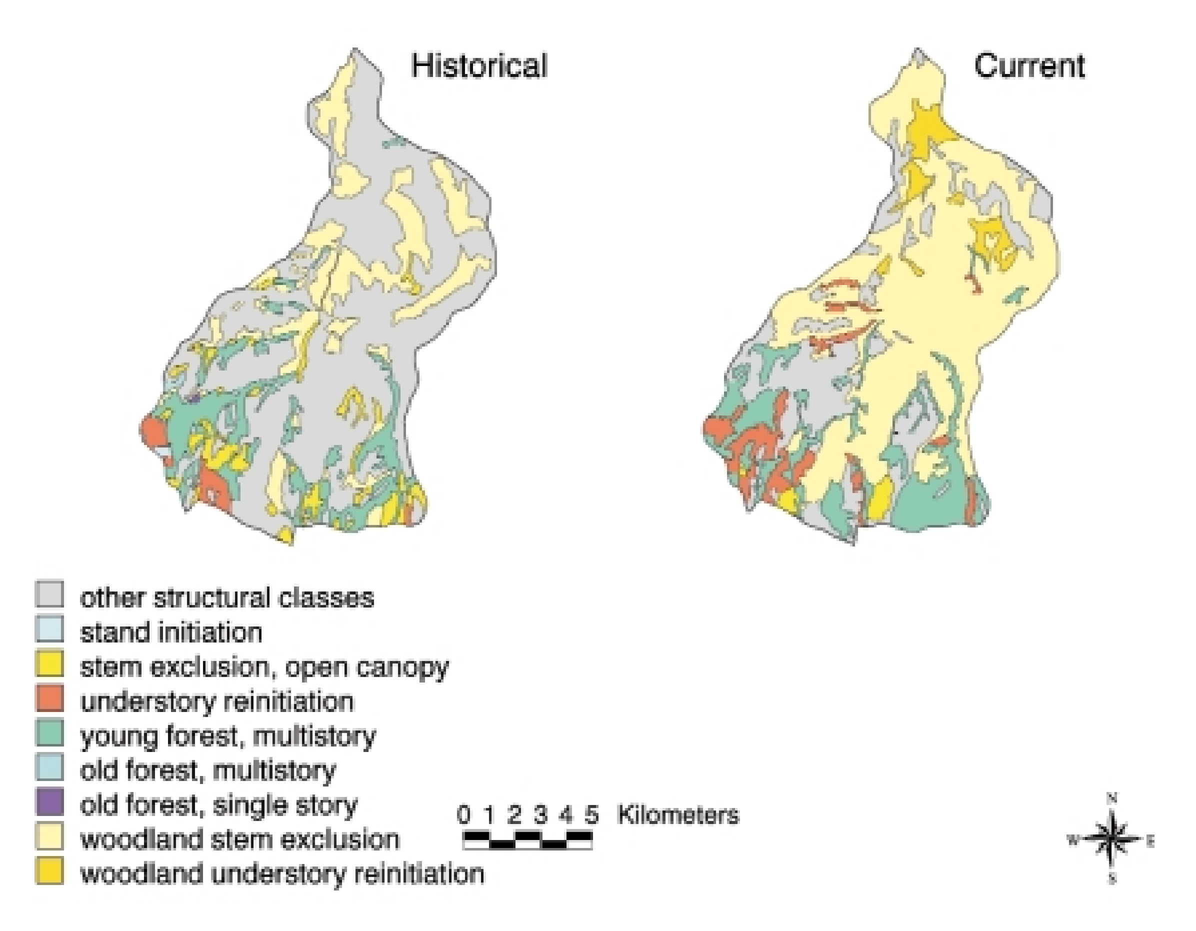

Figure 75—Historical and current maps of forest and woodland structural classes in subwatershed 2701 in the Lower John Day subbasin of the Columbia Plateau ERU.

results suggest that timber harvest, fire suppression, and fire exclusion were primary factors responsible for current forest composition and structure. Road densities are high throughout the ERU (see fig. 73 and Hann and others 1997), and there is scant roadless area.

From our historical vegetation condition, we expected stand-initiation structures to represent a large fraction of Lower Clark Fork forest landscapes, and indeed they did, because a sizable area was burned just before and after the start of the 20th century. In the historical condition, stand-initiation structures occupied 32.7 percent of the ERU area (35.7 percent of the forested area). Area in stand-initiation structures declined during the sample period by 71percent, plummeting to an average of 9.5 percent of the ERU in the current condition. We believe the observed decline occurred primarily as a result of effective fire prevention and suppression efforts. Figure 76 provides an example of substantially reduced area of stand-initiation structures in a subwatershed of the Upper Coeur d'Alene subbasin. Also noteworthy, among ERUs, area affected by regeneration harvesting increased most significantly in the Lower Clark Fork (table 27). While small staggered-setting clearcut and shelterwood harvest units were increasing in abundance, area of stand-initiation structure declined on nearly one-quarter of the land area of the ERU. These results clearly

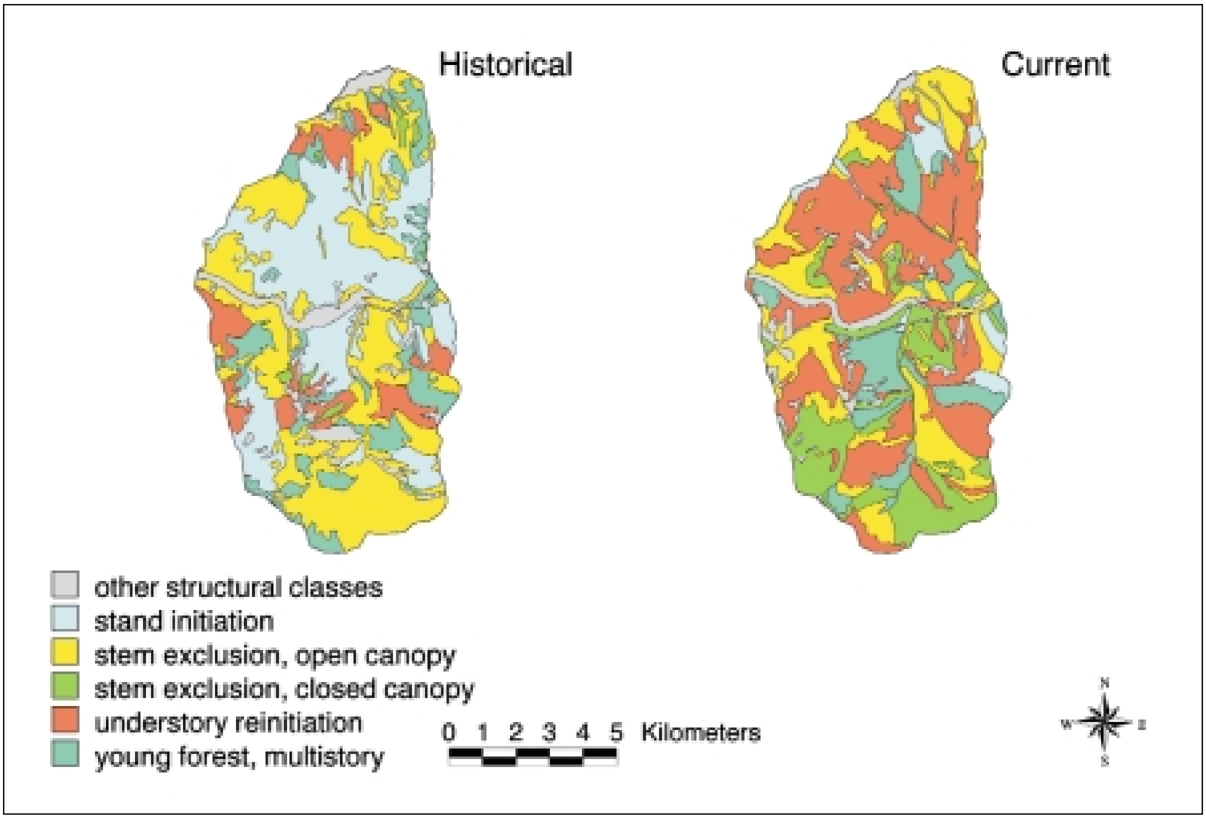

Figure 76—Historical and current maps of forest and woodland structural classes in subwatershed 1401 in the Upper Coeur d'Alene subbasin of the Lower Clark Fork ERU.

suggest that small, regularly sized and shaped clearcut harvest units are not an adequate substitute for larger scale disturbance events that leave coarse-grain patterns on affected landscapes.

In our historical vegetation condition, old forests comprised 2.4 percent of the ERU area, or 2.6 percent of the total historical forest. Area of old forest in the current condition was essentially unchanged (table 29 and appendix 2). Likewise, area with large trees, whether in old forest or associated with other forest structures, was unchanged (table 20). Area with medium and large trees increased significantly during the sample period (table 21); we believe the observed increase was associated with fire exclusion and subsequent succession and aging of forests. In the historical condition, 21.8 percent of the ERU area (23.8 percent of the forest) was occupied by forest structures comprised of medium and large trees. In the current condition, 36.8 percent of the ERU area (38.9 percent of the forest) was occupied by forest structures comprised of medium and large trees.

Area in understory reinitiation structures increased quite significantly during the sample period to become the dominant structural feature of Lower Clark Fork forests in the current condition. We believe, and transition analysis confirmed, that the observed increase in understory reinitiation structure was the result of fire exclusion: areas regenerated by fire before our historical coverage have regrown.

Table 27 shows that at the starting point of our historical vegetation coverage, nearly 22 percent of the ERU area had been influenced by selective harvest entry. In the current condition, area affected by selective harvesting fell to 16.4 percent, but the change was not statistically significant. Such extensive selective harvesting in a management context of fire suppression would promote development of more total crown cover (table 22), less grass-forb and shrub understory cover and greater conifer understory cover (table 25), increased vertical complexity of forest canopies (table 23), and increased cover of shade-tolerant understories (table 24). All these changes were observed.

Northern Cascades ERU—Forests of the Northern Cascades are comprised primarily of moist and cool to cold PVTs (see fig. 70 and Hann and others 1997), with dry and mesic types represented on the eastern fringe. Historical fire regimes were predominantly of mixed severity with infrequent (76 to 150 years) to frequent (26 to 75 years) fire return intervals (see fig. 71, A and B, and Hann and others 1997). Surface fire regimes represented a relatively modest area where ponderosa pine was a major early seral species. Fire return intervals in areas with surface fire regimes were frequent (26 to 75 years) and very frequent (0 to 25 years).

Forests of the Northern Cascades are among the most varied in composition of all forests in the basin, with most east- and west-slope Cascade Range conifers represented. Historical forest cover was dominated by Douglas-fir, Engelmann spruce, subalpine fir, ponderosa pine, lodgepole pine, Pacific silver fir, western hemlock, and western redcedar (appendix 2 and table 29). Results from our analysis suggest that fire exclusion and suppression and timber harvest were primary factors responsible for current forest composition and structure.

Road densities are very low in upper montane and subalpine settings, increasing in density with decreasing elevation (see fig. 73 and Hann and others 1997). Wilderness and roadless areas are associated with upper montane and subalpine settings. Change in area of forest structures in the Northern Cascades was relatively minor in comparison with that observed in other forested ERUs. But change in connectivity of forest structures was among the most significant (appendix 2). We speculate that the observed reduction in grain of Northern Cascades forest landscapes was the result of excluding fire, an agent of relatively coarse grain pattern formation, and introducing comparatively fine-grained selection cutting and staggered setting regeneration harvests (Franklin and Forman 1987).

Relative to fire disturbances, forest landscapes of the Northern Cascades appear to be more synchronous today than they were in the historical condition (Ottmar and others, in prep.). Here and elsewhere in the basin, many environments that once supported mixed severity fire regimes today support lethal crown fire regimes. Most environments that once supported lethal crown fire regimes still support lethal regimes, but it is as yet unknown whether fire behavior attributes under a wildfire burn scenario are any longer comparable with those of the historical condition. In the Northern Cascades, fire-free intervals have lengthened dramatically in nearly all environmental settings. Thus, in a management context of active fire prevention and suppression, climate-driven fires predominate. Climate cycles ordinarily drive fire cycles, especially in areas dominated by mixed and lethal crown fire regimes. But, in the historical condition, depending on the condition of forests in any given landscape, the results of an extended dry climatic period and its associated fires may have been large areas of old forest, a variable patchwork of forest structural conditions, or large areas of young, early seral forest or shrubland. In the current condition, the likelihood of extensive stand replacement is high.

From our historical vegetation condition, we expected that stand-initiation structures would represent a relatively large fraction of Northern Cascades forest landscapes because mixed severity fires typically regenerate patches of new forest. Area in stand-initiation structures remained relatively constant during the sample period as a result of regeneration harvests, patch clearcutting, and removal cutting (table 27). In the historical vegetation condition, old forests comprised 10.1 percent of the ERU area, or 12.8 percent of the total forest area. Selective and regeneration harvests have diminished that area by one-half. Decline in area occupied by medium and large trees associated with all forest structures also was significant (tables 20 and 21). In the historical condition, an average of 41.9 percent of the ERU (53 percent of the forest) was occupied by forest structures comprised of medium and large trees. In the current condition, 37.9 percent of the ERU (48.5 percent of the forest) is occupied by forest structures comprised of medium and large trees.

Oregon white oak woodland cover increased by 50 percent during the interval between our historical and current vegetation coverages, and total woodland area more than doubled, rising from 0.3 to 0.7 percent of the ERU. Nearly all change in area of woodland structure was associated with stem-exclusion structures, which increased from an average of 0.3 to 0.6 percent of the ERU. Connectivity of woodland stem-exclusion structure also increased; patch density rose from 1.0 to 1.7 patches per 10 000 ha, and mean patch size rose nearly threefold from 2.3 to 6.3 ha. In the absence of fire, and under the influence of grazing, we expected increases in both the stem-exclusion and understory reinitiation structures.

Northern Glaciated Mountains ERU— Forests of the Northern Glaciated Mountains are comprised primarily of moist and dry PVTs (see fig. 70, and Hann and others 1997), but cold types are present throughout and are especially dominant in the eastern portion of the ERU in the North, Middle, and South Fork Flathead River drainages. Historical fire regimes were predominantly of mixed severity in the eastern two-thirds of the ERU, with fire return intervals ranging from 0 to 300 years (see fig. 71, A and B, and Hann and others 1997). Surface fire regimes characterized the western third of the ERU, including the Okanogan Highlands, from the Okanogan River drainage east to the Kettle and Sanpoil River drainages in Washington State, and the Lower Flathead River area in northwestern Montana. Fire return intervals ranged from 0 to 150 years. Historical forest cover was dominated by species such as Douglas-fir, western larch, ponderosa pine, Engelmann spruce, subalpine fir, and lodgepole pine (table 29 and appendix 2). Our results suggest that fire exclusion and suppression and timber harvest were primary factors responsible for current forest composition and structure. Road densities are high throughout forests of the ERU (see fig. 73 and Hann and others 1997), and wilderness and roadless area of any consequence is present only in the Swan River drainage and in the North, Middle, and South Fork Flathead River drainages on the eastern edge of the ERU.

Given the historical vegetation condition, we expected stand-initiation structures to represent a relatively large fraction of Northern Glaciated Mountains forest landscapes because of the large area of mixed severity fire regimes. Area in stand-initiation structures declined during the sample period from an average historical level of 16.9 to 9.4 percent of the current ERU area. We believe the observed decline occurred primarily as a result of effective fire prevention and suppression efforts and fire exclusion. In our starting point historical coverage, stand-initiation structures occupied 21 percent of the forest area. In the current condition, stand-initiation structures occupied 12 percent of the forest area. Also noteworthy, area affected by regeneration harvests increased more than threefold from an average of 2.3 to 7.9 percent of the ERU (table 27). Small staggered-setting clearcut and shelterwood harvest units increased in abundance, and area of stand-initiation structures precipitously declined.

In our historical vegetation condition, old forests comprised 1.2 percent of the ERU, or 1.5 percent of the total historical forest. Area of old forest in the current condition was essentially unchanged. Likewise, area with large trees, whether in old forest or associated with other forest structures, was unchanged (table 20). Area with medium and large trees increased significantly during the sample period (table 21). In the historical condition, 22 percent of the ERU area (27 percent of the forest) was occupied by forest structures comprised of medium and large trees. In the current condition, 24.2 percent of the ERU (30 percent of the forest) was occupied by forest structures comprised of medium and large trees.

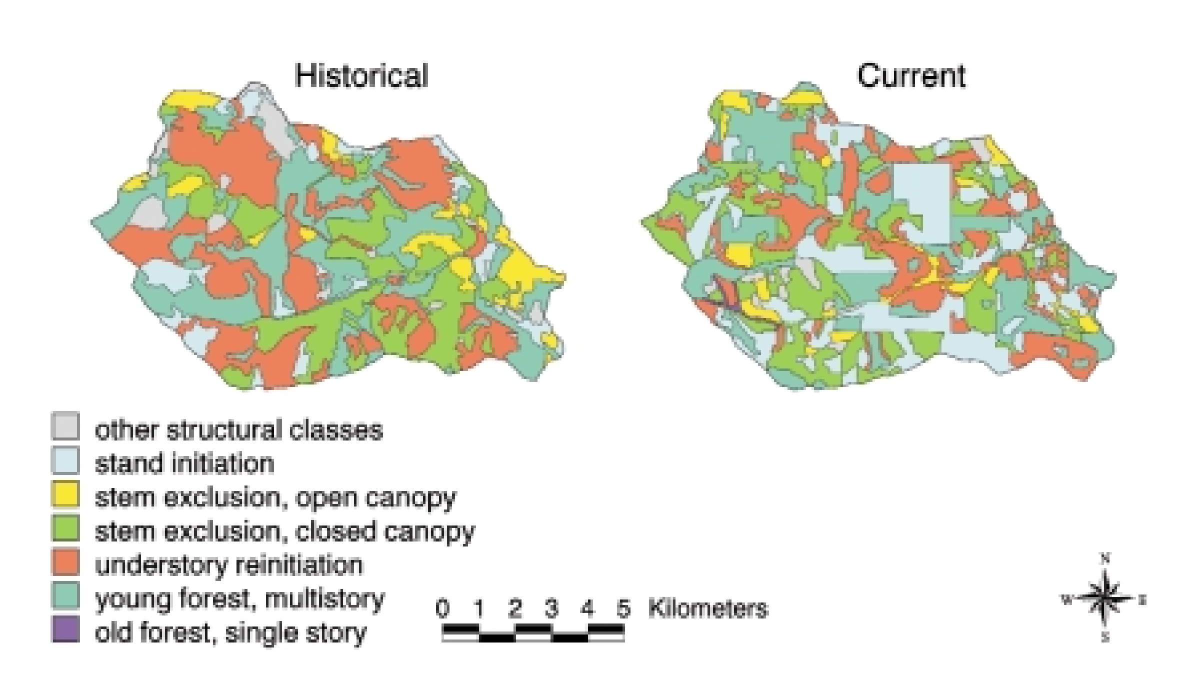

Figure 77—Historical and current maps of forest and woodland structural classes in subwatershed 09 in the Pend Oreille subbasin of the Northern Glaciated Mountains ERU.

Area in understory reinitiation structures increased significantly during the sample period to become the dominant structural feature of Northern Glaciated Mountains forests in the current condition. We believe that the observed increase in understory reinitiation structure is the result of fire exclusion and selective harvesting (table 27): areas regenerated by fire before the historical coverage have regrown, and partial cut areas have partially regenerated. Area in stem-exclusion closed canopy structures also increased significantly. In the current condition, 87 percent of forest structure is intermediate (stem-exclusion, understory reinitiation, or young multistory), 1 percent is old, and 12 percent is new forest. In appendix 2, we see that the connectivity of most major forest cover types and structural classes declined significantly. In most cases, patch density increased, and mean patch size declined. Our results suggest that these changes are characteristic of the combined effects of not only fire exclusion but also regeneration and selective harvesting at scales differing from natural disturbance patterns. Area and connectivity of most of the major early seral species declined (timber harvest), area of new forest structure declined, and area of intermediate forest structure increased (fire exclusion and timber harvest). Figure 77 provides an example of increased patch density and reduced patch size of forest structures in a subwatershed of the Pend Oreille subbasin.

Northern Great Basin ERU—In the portion of the Northern Great Basin that we sampled, forests were comprised primarily of hardwoods, which occupy about 7 percent of the ERU land area. Forest structure is open because growing conditions are severely moisture limited. No changes in forest structure were noteworthy, but woodland structure did change significantly (table 29 and appendix 2). Woodlands in this ERU are comprised of western juniper, and they are also severely moisture limited. In our historical coverage, most woodlands were characterized as stem-exclusion structure. Area in woodland stem-exclusion structure increased by 45 percent from an average of 15.3 to 22.2 percent of the ERU. We were surprised that we did not observe a significant reduction in patch density and a significant rise in mean patch size. In fact, connectivity of woodland structure did not change during the sample period.

Owyhee Uplands ERU—According to our sample, forests represent less than 1 percent of the ERU area. No changes in forest structure were significant or noteworthy, but woodland structure did change significantly (table 29 and appendix 2). Woodlands in this ERU are comprised of western juniper and are severely moisture limited. In our historical coverage, most woodlands were characterized as stem-exclusion structure. Area in woodland stem-exclusion structure increased 25 percent from an average of 5.2 to 6.5 percent of the ERU. Total area of juniper cover increased by 36 percent from a historical average of 5.5 to 7.5 percent of the ERU in the current condition. Most of the increase was from stem-exclusion structure. Patch density of stem-exclusion structure declined and mean patch size increased, as was expected. Our results suggest that under the influence of fire exclusion and grazing, most of the observed increase in woodland structure was associated with conversion of shrubland to woodland.

Snake Headwaters ERU—Forests of the Snake Headwaters are comprised primarily of cold and dry potential vegetation types (see fig. 70 and Hann and others 1997). Historical fire regimes were predominantly lethal crown fire with infrequent (76 to 150 years) to very infrequent (151 to 300 years) fire return intervals (see fig. 71, A and B, and Hann and others 1997). Forest cover was dominated by upper montane and subalpine species. Nearly two-thirds (63 percent) of historical forest cover consisted of subalpine fir, Engelmann spruce, lodgepole pine, and whitebark pine (table 29 and appendix 2). Montane environments were dominated by Douglas-fir and aspen. Our results suggest that fire exclusion and timber harvest were primary factors responsible for current forest composition and structure. Road densities are relatively low throughout much of the ERU (see fig. 73 and Hann and others 1997), and large wilderness and roadless areas are present in the Snake Headwaters, Gros Ventre, Lower Henry's, Grey's-Hobock, and Palisades subbasins.

In the historical condition, we would have expected stand-initiation structures to occupy a relatively small fraction of forest landscapes because fire return intervals were quite long and forest regeneration appears to be primarily event driven rather than continual. Area in stand-initiation structures remained unchanged (table 29), but connectivity of area increased (appendix 2). Area affected by regeneration harvests and small patch clearcutting increased from an average of 0 to 1.4 percent of the ERU (table 27). It was apparent that area affected by regeneration harvests increased during the sample period, and area with no visible logging declined from an average of 74.7 to 72.4 percent of the ERU (the forested proportion of the land area of the ERU); the change was not statistically significant at $P \leq 0.2$ (table 27). In our historical vegetation condition, old forests comprised 5.2 percent of the ERU area, or 7 percent of the total forest. Harvesting had diminished that area by 40 percent in the current condition (table 20).

For the Snake Headwaters, we predicted that stem exclusion-open canopy structures would be quite common in the historical vegetation coverage because both dry and cold PVTs of the area often are moisture limited. Area in open and closed canopy, stem-exclusion structures declined significantly during the sample period from an average of 19.1 to 15.3 percent and from 7.9 to 4.8 percent of the ERU, respectively. Results suggest that harvest of lodgepole pine and mountain pine beetle mortality were associated with the decline (tables 21, 22, and 25 and appendices 2 and 3). A management context of fire exclusion would have encouraged development of increased vertical complexity of forest canopies (table 23), greater conifer understory cover (table 25), less grass-forb and shrub understory cover, and increased cover of shade-tolerant understories (table 24). All these changes were observed.

During the sample period, area in young multistory structures increased from one-quarter to nearly one-third of the forest area (table 29). We were again surprised to find such an extensive area in young multistory forest structures in our historical coverage. We suggest that two of three aforementioned explanations apply: (1) ongoing insect and pathogen disturbances in the interval between fires exerted a greater influence on landscape structure than we had anticipated; and (2) structures classified as young multistory by virtue of their size are much older than they appear, especially in the cold upper montane and subalpine environments of this ERU.

Southern Cascades ERU—Forests of the Southern Cascades are comprised primarily of moist and dry potential vegetation types (see fig. 70 and Hann and others 1997), with cold types well represented on the western fringe adjacent to the crest of Cascade Range but accounting for less than one-third of the area. Historical fire regimes were predominantly nonlethal surface fire or of mixed severity with fire return intervals mostly ranging from 0 to 150 years (see fig. 71, A and B, and Hann and others 1997). Surface fire regimes represented a large area, especially where ponderosa pine was historically a major early seral species. Very frequent (0 to 25 years) fire return was common across more than half of the ERU in areas of surface and mixed severity fire.

As in the northern Cascades, forests of the southern Cascades are highly varied in composition, with many east- and west-slope Cascade Range conifers represented. Historical forest cover was dominated by mountain hemlock, ponderosa pine, lodgepole pine, grand fir, white fir, Douglas-fir, and a wide assortment of other less abundant species such as Shasta red fir, incense-cedar, sugar pine, western white pine, Engelmann spruce, and subalpine fir (table 29 and appendix 2). Our results suggest that timber harvest, fire suppression, and fire exclusion were primary factors responsible for current forest composition and structure. Road densities are very high throughout the ERU (see fig. 73 and Hann and others 1997). Wilderness and roadless areas are relatively small and are in subalpine and alpine environmental settings along the Cascade crest.

Change in area of forest structures was relatively minor in comparison with observed changes in other forested ERUs. Reduced connectivity of forest structures was quite significant (appendix 2). We speculate that the observed reduction in grain of Southern Cascades ERU forest landscapes was the result of several interacting factors, including extensive road network development (fig. 73 and Hann and others 1997), selection cutting (table 27), and fire exclusion (see fig. 71, A and B).

In the historical vegetation condition, we expected that stand-initiation structures would represent a relatively large fraction of Southern Cascades forest landscapes because mixed severity fires typically regenerate variable-sized patches of new forest. Despite fire suppression efforts, area in stand-initiation structures remained relatively constant during the sample period as a result of regeneration harvests, patch clearcutting, and removal or heavy selection cutting (table 27), but connectivity sharply declined (appendix 2). Patch density increased sharply by 357 percent from 6.8 to 24.3 patches per 10 000 ha, and mean patch size declined by 56 percent from 171.5 to 75.4 ha. Clearly, stand-replacement disturbances early in the 20th century occurred at a much larger scale than those witnessed today.

In our historical vegetation coverage, old forests comprised 2.3 percent of the ERU area, or 2.9 percent of the total forest area. Area of old single-story and old multistory forest structures more than doubled during the sampling period (appendix 2), but area with remnant large trees associated with structures other than old forest (table 20) declined by 42 percent from an average of 5.2 to 3.0 percent of the ERU (ns). Area occupied by medium and large trees associated with all forest structures increased by 10 percent during the sample period (table 21). In the historical condition, 40.3 percent of the ERU area (50.1 percent of the forest area) was occupied by structures with medium or large trees. In the current condition, 44.3 percent of the ERU (50.2 percent of the forest) is occupied by forest structures comprised of medium or large trees. But average area in the forest physiognomic type rose by 10 percent from an average of 80.5 to 88.3 percent of the ERU, mainly as a result of regrowth of large areas clearcut harvested before our historical vegetation coverage. We speculate that this area likely was dominated by patches with large ponderosa pine trees and old single-story structures.

Considering the dominant cover types and PVTs displayed in this ERU, we were surprised to see the relatively minor area in stem-exclusion closed canopy structures in the historical vegetation coverage. With regrowth of clearcut areas apparent in the historical vegetation coverage, we expected to see greater increase in area of this structure. About 20 percent of the ERU is currently comprised of the lodgepole pine cover type; a comparable portion was present in the historical starting point vegetation coverage (appendix 2). Much of the area of the lodgepole pine cover type resides on deep pumice flats where cold air ponding and early or late hard frosts are a common occurrence. In these locations, lodgepole pine is often described as an edaphic “climax” dominant. We expected to observe a considerable area of closed canopy stem-exclusion structure in these locations, but did not. We suspect that a rather simple explanation may account for the apparent absence of this structure in our historical coverage: we know that large landscape-scale mountain pine beetle outbreaks are responsible for coarse- and medium-grain pattern changes in lodgepole forests, but fine-grain, patch-scale mountain pine beetle disturbances may be more common than we suspected and may sum to highly significant change in landscape patterns. We, and others, perhaps have simplified our understanding of the relation between lodgepole pine forests, mountain pine beetles, and regenerative fires. Indeed, we observed that 46 percent of the ERU (57 percent of the forest) was comprised of young multistory structures in the historical coverage, and a comparable amount was present in the current condition. Young multistory structure is the structure we expected in great abundance where fine-grain disturbances are the norm and overstory dominance of large trees is seldom achieved.

Nearly all change in woodland was associated with stem-exclusion structures that increased in area from 0 to 0.4 percent of the ERU. Connectivity of woodland stem-exclusion structures also increased. In the absence of fire, and under the influence of domestic livestock grazing, we expected increases in both the woodland stem-exclusion and understory reinitiation structures.

Table 27 shows that at the start of our historical vegetation coverage, 9.2 percent of the ERU area had been influenced by selective harvest entry. In the current condition, area affected by selective harvesting rose to an average of 23.2 percent of the ERU. Such extensive selective harvesting in a management context of fire prevention and suppression promotes development of more total tree crown cover (table 22), increased vertical complexity of forest canopies (table 23), and increased cover of shade-tolerant understories (table 24). All these changes were observed.

Upper Clark Fork ERU—Forests of the Upper Clark Fork are comprised primarily of cold and dry PVTs (see fig. 70 and Hann and others 1997). Historical fire regimes were predominantly nonlethal surface fire or of mixed severity with fire return intervals typically ranging from 0 to 150 years (see fig. 71, A and B, and Hann and others 1997). Surface fire regimes represented a large area, especially where ponderosa pine or Douglas-fir historically were major early-seral species. Very frequent (0 to 25 years) and frequent (26 to 75 years) fire return was common over more than half of the ERU in areas prone to surface and mixed severity fire.

Historical forest cover was dominated by species such as Douglas-fir, lodgepole pine, Engelmann spruce, subalpine fir, ponderosa pine, whitebark pine, subalpine larch, and western larch (table 29 and appendix 2). Our results suggest that fire exclusion and suppression and timber harvest were primary factors responsible for current forest composition and structure. Road densities are moderately high throughout montane forests of the ERU (see fig. 73 and Hann and others 1997), and wilderness or roadless areas are small and in subalpine and alpine environmental settings.

In the historical vegetation condition, we expected stand-initiation structures to represent a relatively large fraction of Upper Clark Fork forest landscapes because of the large area of mixed severity fire regimes with infrequent fire return intervals. Area in stand-initiation structures declined during the sample period by 30 percent from a historical level of 15.9 to 11.1 percent of the ERU in the current condition. Evidence suggests that the observed decline occurred primarily as a result of fire suppression and fire exclusion. In our historical coverage, stand-initiation structures occupied 18 percent of the forest area. In the current condition, stand-initiation structures occupied 12.9 percent of the forest area. Also noteworthy, area affected by regeneration harvesting increased significantly from an average of 5.5 to 11.6 percent of the ERU (table 27). Small, staggered-setting clearcut and shelterwood harvest units increased in abundance, and area of stand-initiation structures declined.

In the historical condition, old forests comprised 0.8 percent of the ERU, or 0.9 percent of the total historical forest. Area of old forests in the current condition was essentially unchanged. Likewise, area with large trees, whether in old forest or associated with other forest structures, was unchanged (table 20). Area with medium and large trees declined slightly during the sample period (table 21), but the change was not significant. In the historical condition, 19.7 percent of the ERU (22.6 percent of the forest) was occupied by forest structures comprised of medium and large trees. In the current condition, 17.2 percent of the ERU (20 percent of the forest) was occupied by forest structures comprised of medium and large trees.

Area in stem-exclusion closed canopy structures increased significantly during the sample period to become the codominant structural feature of Upper Clark Fork forests in the current condition. Our results suggest that the observed increase in stem-exclusion closed canopy structures is the result of fire exclusion and selective harvesting (table 27): areas regenerated by fire before our historical coverage have regrown. In the current condition, 86 percent of forest structure is intermediate (stem exclusion, understory reinitiation, or young multistory), 1 percent is old, and 13 percent is new forest. In appendix 2, we observe that the connectivity of most major forest cover types and structural classes declined significantly. In most cases, patch density increased, and average patch size declined. These changes are characteristic of the combined effects of fire exclusion and regeneration and selective harvesting. Area and connectivity of major early seral species cover declined (timber harvest), area of new forest structure declined, and area of intermediate forest structure increased (fire exclusion and timber harvest).

Upper Klamath ERU—Forests of the Upper Klamath ERU are comprised primarily of dry and mesic PVTs (see fig. 70 and Hann and others 1997). Historical fire regimes were predominantly nonlethal surface fire with frequent (26 to 75 years) to very frequent (0 to 25 years) fire return intervals (see fig. 71, A and B, and Hann and others 1997). More than one-half of historical forest cover was ponderosa pine (table 29 and appendix 2). Results from our analysis suggest that timber harvest, fire exclusion, and grazing each had a pronounced effect on current forest composition and structure.

In the historical condition, we expected stand-initiation structures to occupy only a minor fraction of Upper Klamath forest landscapes because surface fire regimes with frequent fire return typically regenerate forests continually via individual tree and small group killing. Area in stand-initiation structures increased from a historical level of 1.9 to 3.6 percent of the ERU (ns) as a result of regeneration and selective harvests or removal cutting (table 27) that occurred during the sample period. In the historical condition, old forests comprised 11.7 percent of the ERU, or 23.2 percent of the total forest area. In the current condition, old forests comprised 10.3 percent of the ERU, or 21.7 percent of the total forest area. Selective harvests have diminished that area significantly (appendix 2). Decline in area occupied by medium and large trees was perhaps the single greatest change occurring to all forest structures in the Upper Klamath (tables 20 and 21). In the historical condition, 43.3 percent of the ERU (86 percent of the forest) was occupied by forest structures comprised of medium and large trees. In the current condition, 27.4 percent of the ERU (58 percent of the forest) was occupied by forest structures with medium and large trees. Selection cutting of medium and large trees in a management context of fire control and extensive cattle grazing would have promoted development of more total crown cover (table 22), less

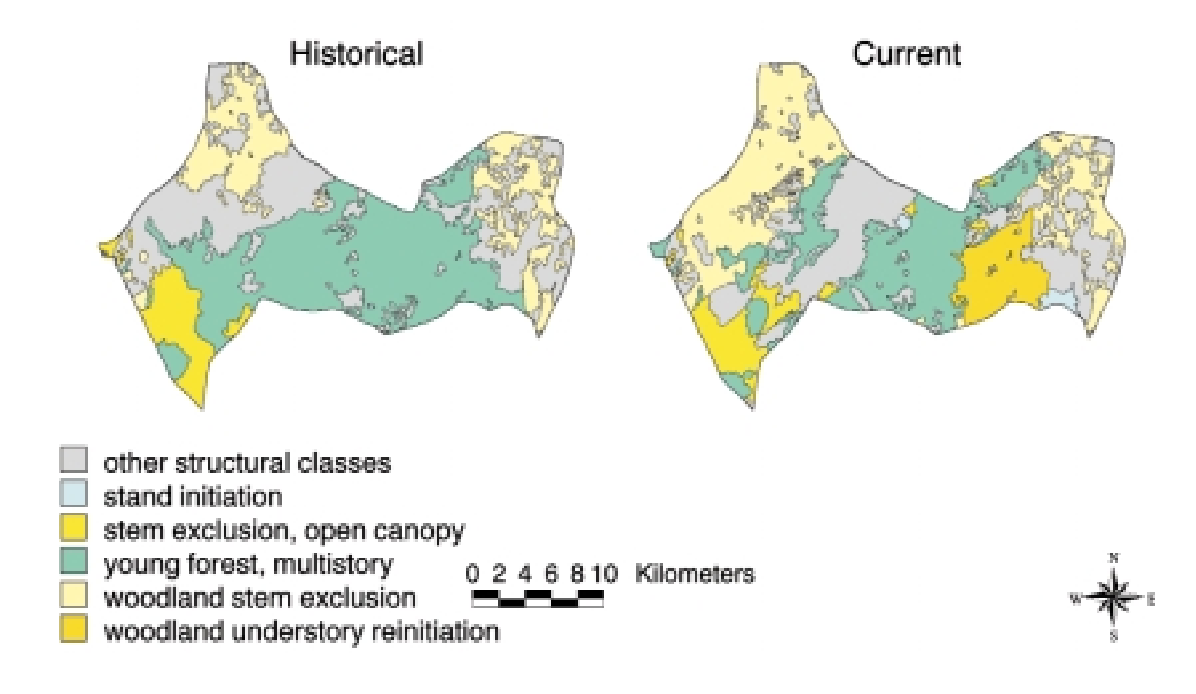

Figure 78—Historical and current maps of forest and woodland structural classes in subwatershed 0903 in the Lost subbasin of the Upper Klamath ERU.

grass-forb and shrub understory cover and greater conifer understory cover (table 25), increased vertical complexity of forest canopies (table 23), and increased cover of shade-tolerant understories (table 24). None of these changes was observed. In addition, extensive grazing would have minimized flashy fuel cover (Agee 1994), increasing opportunities for conifer understory development via reduced competition and reducing the likelihood of surface fires from natural or human-caused ignitions. Our findings suggest that for the period of our sample, the primary management influence in the Upper Klamath ERU was extensive and heavy timber harvest.

Area in young multistory structures declined for similar reasons (fig. 78). Repeated heavy partial cutting reduced forest crown cover (table 22), canopy layering (table 23), and conifer understory development (tables 24 and 25), thereby depleting area of young multistory structure (table 29).

Upper Klamath woodlands are composed chiefly of western juniper. During the sample period, area of stem-exclusion and understory reinitiation structures increased sharply (appendix 2 and fig. 78). We believe that expansion of the western juniper cover type and its associated stem-exclusion structure was the result of fire exclusion and grazing. Grazing minimized herbaceous competition and the possibility of surface fires, and fire exclusion enabled uninhibited expansion of juniper cover.

Upper Snake ERU—According to our sample, forests comprise about 3 percent of the ERU area. No changes in forest structures were particularly noteworthy, but two changes were statistically significant: area in stand-initiation structures declined, and area in stem-exclusion open canopy structures increased by a compensating amount. We speculate that fire exclusion was primarily responsible for the shift (see also tables 22, 23, 25, and 27).

Woodland structure also changed significantly (table 29 and appendix 2). Woodlands in this ERU are juniper and mixed pinyon and juniper, and they are severely moisture limited. In our historical coverage, most woodlands were characterized

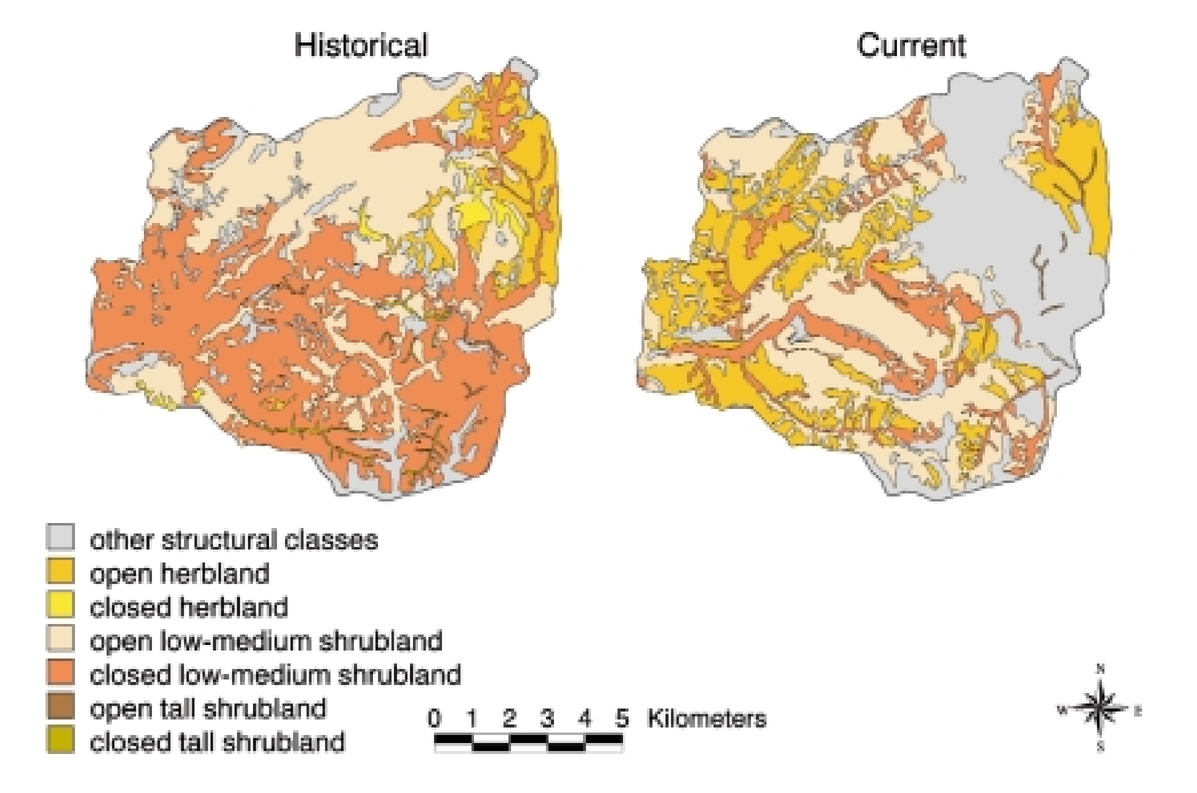

Figure 79—Historical and current maps of shrubland and herbland structural classes in subwatershed 1101 in the Lower John Day subbasin of the Columbia Plateau ERU.

as understory reinitiation structure. Area in woodland understory reinitiation structures declined, and area in stem-exclusion structures increased by a compensating amount. We speculate that this minor change in structure may have been associated with ongoing insect disturbance (table 25).

Shrubland and herbland structure—Area of open or closed shrub structure declined in every ERU where the shrubland physiognomic type comprised more than 0.5 percent of the area. The most significant loss of shrub structure occurring in the basin was the loss of open low-medium structures (primarily sagebrushes, rabbitbrush, and bitterbrush). Significant reductions in open low-medium shrub structures were noted in the Blue Mountains, Columbia Plateau, Northern Great Basin, Owyhee Uplands, and Snake Headwaters ERUs (table 29). Significant reduction in closed low-medium shrub structure was observed in the Columbia Plateau ERU. Figure 79 provides an excellent illustration of increased open herbland structure and reduced open and closed low-medium shrub structure in a subwatershed of the Lower John Day subbasin in the Columbia Plateau ERU. In general, the most significant losses to shrublands were associated with forest or woodland expansion as observed in the Blue Mountains and Northern Great Basin ERUs, cropland expansion as observed in the Northern Great Basin ERU, and conversion to seminative or nonnative herbland as observed in the Owyhee Uplands or Snake Headwaters ERUs.

Decline in shrubland area was the most significant change we observed during the sample period in the whole of the midscale assessment. Change was most conspicuous in ERUs where shrublands were a dominant physiognomic condition, such as in the Blue Mountains, Columbia Plateau, Northern Great Basin, Owyhee Uplands, and Upper Snake ERUs (table 29 and appendix 2). In the Blue Mountains, shrublands occupied 14.1 percent of the area in the historical condition. Shrubland area declined by 24 percent to 10.7 percent of the ERU, and most of the loss was to open low-medium structures. In the Columbia Plateau, shrublands occupied 32.2 percent of the area in the historical condition. Shrubland area declined by 27 percent to 23.4 percent of the ERU, and most of the loss was to open and closed canopy low-medium shrub structures. In the Northern Great Basin, shrublands occupied 72.8 percent of the area in the historical condition. Shrubland area declined by 21 percent to 57.6 percent of the ERU, and virtually all the loss was to open low-medium structures. In the Owyhee Uplands, shrublands occupied 88.8 percent of the area in the historical condition. Shrubland area declined during the sample period by 9 percent to 81.0 percent of the ERU, and most of the loss was to open low-medium structures. Finally, in the Upper Snake, shrublands occupied 73.8 percent of the area in the historical condition. Shrubland area declined by 7 percent to 68.5 percent of the ERU (ns), and most of the loss was to open and closed canopy low-medium structures. It is apparent that shrublands as a physiognomic condition, and that open low-medium shrub structures in particular, have been significantly diminished across the entire basin. We speculate that such a dramatic and expansive change must have produced equally significant and deleterious consequences for terrestrial species that rely on the presence of vast unbroken shrubland areas.

In general, open herbland area increased in most ERUs where significant reduction in open low-medium shrub structure occurred. We speculate that active range management activities to improve domestic livestock forage production were responsible for much of the noted expansion of open herbland area.

Landscape Patterns

The size and scale of ERUs as a pooling stratum preclude their use for project-level planning, but they are quite useful in providing context of individual watersheds and displaying significant province-scale change in vegetation patterns. When conditions of any watershed are examined, it is essential to understand the importance of various changes relative to the broader picture, not only the type but also the degree of change. Information of the sort we have provided answers questions on the rarity or uniqueness of any given patch type within a subwatershed or larger domain, currently and historically. And it enables one to gauge how representative current landscape patterns are compared with recent historical conditions. Additionally, when determining landscape changes, it is often difficult to understand the marriage of management and environmental causes behind observed changes. Comparative study of change in highly similar and differing ERUs, given their management histories, biophysical environment composition, climatic conditions, and disturbance regimes, enables us to better understand the relative contributions of each factor to the observed changes. These observations aid the understanding of the past and help to interpret or predict alternative management and climate futures. An even richer contribution to our understanding is the comparative study of landscape change at multiple scales, including pooling strata as large as ERUs and using smaller subregional strata and those in between. Such multiscale analyses provide insight to the magnitude and effects of changes at several relevant scales and contexts.

We conducted our landscape pattern analyses by using cover type-structural class couplets as the patch type because this combination is most intuitive for understanding simultaneous changes in patterns of structural and compositional attributes and terrestrial habitats. We first discuss change occurring across all ERUs for a given subset of metrics, and then we discuss changes across metrics by ERU.

Richness, diversity, and evenness— Patch richness (PR), SHDI, and the inverse of Simpson's λ (N2) provide different views of the diversity of cover-structure patch types across any landscape. Richness simply tallies the number of different patch types present without regard for their relative abundance; a patch type represented by a single patch counts as much as another patch type comprising 95 percent of the subwatershed area. The SHDI and N2 incorporate abundance into the measurement of diversity, but N2 responds to abundance changes in the most dominant patch types. Relative patch richness (RPR) rescales PR as a percentage of the total cover-structure patch types present in the basin (there were 192 reasonable cover-structure patch types). The SHDI (or its transformed equivalent N1) is intermediate in responsiveness between RPR and N2. In general, for the three measures of richness and diversity (RPR and PR, SHDI and N1, and N2), all ERUs displayed a positive mean difference with only two notable exceptions (table 19): the Lower Clark Fork and Upper Klamath ERUs exhibited minor declines in PR. We attributed these declines to an extended history of widespread timber harvest activity. Five of thirteen ERUs (the Central Idaho Mountains, Northern Cascades, Northern Glaciated Mountains, Southern Cascades, and Upper Clark Fork) displayed significant change in PR, generally on the order of a 15- to 30-percent increase. Eight of thirteen ERUs displayed significantly increased dominance and diversity (N2), thereby indicating that patch type numbers were not only increasing but also that new patch types were occupying significant landscape area. Ecological reporting units displaying an increase were the Lower Clark Fork, Northern Cascades, Northern Glaciated Mountains, Northern Great Basin, Owyhee Uplands, Snake Headwaters, Southern Cascades, and Upper Klamath.

Evenness measures are attempts to assess how equitably area is distributed among a given number of patch types. Both evenness measures (MSIEI and R21) index relative change in the distribution of "abundance," or in this case area, among patch types. Many ERUs displayed increased diversity, richness, and dominance during the sample period for the diversity measures we used. That typically results in a modest increase in the evenness measures used, if any change in evenness occurs at all. Our results confirmed this relation; the MSIEI and R21 increased significantly in six of eight ERUs displaying significantly increased diversity and dominance. The Upper Clark Fork and the Central Idaho Mountains were the only two ERUs to decline in evenness; the Upper Clark Fork declined significantly in both evenness measures. In the Central Idaho Mountains, few cover type changes were significant, but the distribution of area in forest structures became increasingly uneven. Area in stand-initiation structures declined from 9.7 to 5.9 percent of the ERU, and area in understory reinitiation structures increased from an average of 16 to 21.4 percent of the ERU. A similar pattern of change was evident in the Upper Clark Fork ERU; few cover type changes were evident, but distribution of area in stand initiation, closed canopy stem-exclusion, and young multistory forest structures became increasingly uneven (appendix 2).

Landscape metrics (table 19) computed in FRAGSTATS (McGarigal and Marks 1995) were averaged across sampled subwatersheds; for example, the value of CONTAG_c computed for the Northern Cascades ERU was derived by averaging all CONTAG values of individual subwatersheds in that ERU in the current condition. Hence, values for all metrics in the historical and current condition reflect the average per subwatershed. Some questions come to mind: What is the total richness and diversity of patch types of each ERU? and Have those values changed during the sample period? Heltshe and Forrester (1983) describe a "jackknife" estimator for richness that attempts to estimate total richness for a geographic area of interest. We applied this technique and a related jackknife estimator for N2 (Burnham and Overton 1979) to the historical and current patch type data for each ERU to estimate difference in richness and dominance for each ERU (table 30). The jackknife technique results in estimates of the total and the standard error. We used these statistics in simple two-way t-tests to test for significant change in richness or dominance across each

Table 30—"Jackknife" estimates of total patch-type richness and dominance (N2) for 13 ecological reporting units in the midscale assessment of the interior Columbia River basin where patch types were cover type-structural class doublets

Ecological reporting unit	Sampled watersheds	Richness		Dominance (N2)	
		Historical (s.e.)[a]	Current (s.e.)[a]	Historical (s.e.)[b]	Current (s.e.)[bc]
	Number				
Blue Mountains	44	114 (6.0)	123 (4.3)	23 (3.5)	20 (2.4)
Central Idaho Mountains	43	142 (6.4)	135 (5.7)	32 (2.9)	29 (2.7)
Columbia Plateau	38	121 (7.7)	119 (5.5)	10 (1.7)	11 (1.7)
Lower Clark Fork	5	88 (9.5)	73 (2.9)	19 (1.6)	17 (1.8)
Northern Cascade Mountains	47	135 (5.1)	133 (3.8)	36 (4.5)	36 (3.8)
Northern Glaciated Mountains	41	127 (5.1)	136 (5.4)	25 (2.4)	26 (2.7)
Northern Great Basin	4	22 (2.6)	29 (3.6)	4 (0.4)	5 (0.6)
Owyhee Uplands	22	40 (6.0)	41 (4.1)	1 (0.2)	2 (0.3)*
Snake Headwaters	15	83 (5.4)	92 (5.9)	30 (3.2)	26 (3.1)
Southern Cascades	16	69 (5.7)	80 (8.1)	15 (1.3)	15 (2.6)
Upper Clark Fork	32	113 (5.8)	120 (4.9)	25 (1.9)	23 (2.2)
Upper Klamath	13	107 (7.0)	100 (5.7)	13 (3.9)	16 (3.0)
Upper Snake	15	67 (8.3)	71 (6.5)	3 (0.4)	3 (0.9)

[a] Estimates of total richness and standard error (s.e.) were computed by using the methods of Heltshe and Forrester (1983). Estimates for total richness were rounded to the nearest integer.

[b] Estimates of total dominance (N2) and its standard error were computed by using the methods of Burnham and Overton (1979). Estimates for total dominance were rounded to the nearest integer.

[c] * indicates significant difference at $P \leq 0.2$.

ERU. All changes but one were insignificant at the ERU scale. Eight ERUs displayed nonsignificant increase in richness.

Jackknife estimates of richness are very sensitive to sample size and coverage. It is best in this instance not to make comparisons among ERUs, but comparisons between current and historical values are appropriate. Jackknife estimates for N2 are not restricted in this way. The N2 values across ERUs range from a low of 1 in the Owyhee Uplands to 36 in the Northern Cascades. We expect forest-dominated ERUs to display much larger values of total N2 than range-dominated ERUs because of the former's greater PR and diversity.

Contagion and interspersion—Contagion and IJI metrics were designed to quantify the extent to which patches or pixels of differing types intermix with one another. The IJI considers length of edge between contrasting patch types, and CONTAG estimates patch-type dispersion and interspersion for data in raster format. Both metrics are rescaled as a percentage of the maximum possible value, given the total number of patch types, and range in value from 0 to 100. As mean patch size increases, total edge length tends to decrease. We then expect that mean differences values for IJI and CONTAG will differ in sign, although this is not always true.

Seven of thirteen ERUs displayed significant declines in CONTAG, and all significant mean differences values were negative (table 19). Ecological reporting units displaying a significant decline were the Lower Clark Fork, Northern Cascades, Northern Glaciated Mountains, Northern Great Basin, Owyhee Uplands, Snake Headwaters, and Southern Cascades. A negative mean difference value of CONTAG indicated that across a given ERU, cover-structure patches became smaller during the sample period and more dispersed. Three of six ERUs with nonsignificant mean difference values of CONTAG also exhibited a negative sign. These results point to a systematic basinwide decrease in contagion or connectivity of cover-structure patch types. With the exception of the Northern Great Basin and Owyhee Uplands ERUs, the magnitude of decrease was small relative to initial average historical values.

Only 4 of 13 ERUs displayed significant mean difference values for IJI; two were positive and two were negative (table 19). The Owyhee Uplands and Upper Snake ERUs were noteworthy because the magnitude of mean difference values for these two ERUs was especially large. Unlike CONTAG, there was no consistent pattern across ERUs for this metric, and most changes were small. We concluded that interspersion changes as measured by this metric were minimal at this reporting scale, and that changes in interspersion and patch type juxtaposition may be better observed at smaller scales where variability of biophysical environments is more readily controlled. For example, IJI values of subwatersheds pooled to subbasins indicated highly significant mean differences.

Edge contrast—The AWMECI uses a set of user-defined values ranging from 0 to 1 to represent relative edge contrast (table 18) between patch types, weighted by area, to evaluate change in edge contrast of a landscape or sample of landscapes. We based edge contrast on physiognomic and structural conditions in deference to edge-sensitive and -dependent terrestrial species, and their typically greater sensitivity to structural differences of edges. An increase in area-weighted mean edge contrast was indicated as the percentage of the total edge that was the equivalent of maximum contrast edge. The greater the difference in structure or physiognomic condition (for example, an old single-story forest patch adjacent to open herbland), the greater the edge contrast weight. Significant increase in AWMECI for a given landscape or sample of landscapes indicated that greater contrast in structural and physiognomic condition was occurring at patch edges. Six of thirteen ERUs displayed such a significant increase. Most increases were relatively modest except in the Lower Clark Fork ERU, where increase in maximum contrast edge averaged 5.1 percent of the total edge (table 19).

Pattern changes among ERUs—The Blue Mountains and Columbia Plateau ERUs displayed no significant change for any landscape metric. The sign of insignificant change was generally consistent with change occurring in other ERUs except as noted earlier for the contagion and interspersion indices. When we ranked the mean difference value for PR, SHDI, and N2 and then averaged the three ranking values, the Blue Mountains was 10th in overall change and the Columbia Plateau ERU was 12th. The jackknife index value of total richness increased in both ERUs, but insignificantly.

In the Central Idaho Mountains, significant changes in richness and SHDI were consistent with declining evenness as measured by R21. More patch types appeared on the landscape, yet the number of dominant types did not increase significantly. The Central Idaho Mountains ERU ranked seventh among ERUs in overall change in diversity and richness. Contagion and interspersion did not change significantly, but edge contrast rose significantly, thereby indicating increasing juxtaposition of dissimilar structural and physiognomic types. Rank in edge contrast change was fifth among ERUs.

The 24-percent rise in N2 was the only significant change in richness, dominance, and diversity noted in the Lower Clark Fork ERU. We anticipated the corresponding rise in evenness values (table 19). This ERU ranked sixth in overall change in diversity and richness. Contagion also increased significantly; in fact, the noted change was the fourth largest observed, but interspersion did not change significantly, perhaps owing to our small sample size after poststratification. The Lower Clark Fork displayed the largest overall increase in edge contrast of all ERUs, indicating a significant repatterning of structure and physiognomic condition and grain of the landscape. Further evaluation is needed before these observation can be accepted as representative of the Lower Clark Fork ERU at large because our sample was restricted to subwatersheds of the Upper Coeur d'Alene subbasin, which may not adequately represent the ERU.

The Northern Cascades ERU displayed one of the highest jackknife values for total richness and the highest value for the jackknifed N2 measure; significant increases were noted for all richness and diversity metrics. We expected and observed little or no change in evenness with across-the-board increase in richness, dominance, and diversity (table 19). The Northern Cascades ranked third in overall change in diversity and richness. Change in contagion and interspersion was significant. Decreasing contagion indicated that similar patch types were less likely to be adjacent to one another. Interspersion increase indicated reduced patch sizes and reduced connectivity of patch-type area.

The Northern Glaciated Mountains ERU ranked second in overall change in diversity and richness; richness, dominance, and diversity all increased significantly. Evenness did not change significantly given noted increases in PR, RPR, and N2. The jackknife N2 index of total diversity placed the Northern Glaciated Mountains in the third highest position among ERUs. Decreasing contagion indicated that similar patch types were less likely to be adjacent to one another; increase in edge contrast (AWMECI) was third largest among ERUs. Fire exclusion, timber harvest, and checkerboard ownerships in this ERU all contributed to the changes detected.

The Northern Great Basin and Owyhee Uplands ERUs were among the least diverse in cover-structure patch types from both an average per subwatershed (table 19) and an ERU perspective (table 30). Yet the Northern Great Basin ERU ranked fourth in overall change in diversity and richness. Diversity (SHDI and N2) and dominance (N2) both increased significantly, and as expected, evenness as measured by both MSIEI and R21 measures increased significantly. Decrease in contagion was second only in magnitude to the decrease observed in the Owyhee Uplands.

The Owyhee Uplands ranked ninth overall in richness and diversity changes. Diversity, dominance, and evenness increased in the manner expected, but the Owyhee Uplands was the least diverse among all ERUs from a total N2 perspective (table 30). Radically reduced contagion indicated that similar patch types were less likely than ever to be adjacent to one another, and interspersion increase indicated that patch sizes and connectivity of patch type area had been substantially reduced. Changes in contagion and interspersion were the largest observed among all ERUs. Mean edge contrast increased significantly, indicating increasing juxtaposition of dissimilar structural and physiognomic conditions. The magnitude of change in edge contrast was seventh highest among ERUs. Given the diminutive historical (10.5 percent) and current (11.4 percent) values of AWMECI as compared to values from forest-dominated ERUs, this increase was especially significant. It likely reflects the well-known and widespread conversion and fragmentation of native shrublands by seminative and nonnative grasslands.

The Snake Headwaters ERU ranked eighth overall in richness and diversity mean difference changes. Diversity (SHDI and N2) and dominance (N2) both increased significantly, and as expected, evenness as measured by MSIEI increased significantly. The Snake Headwaters ERU was moderately diverse from a jackknife N2 perspective, but total diversity had declined, albeit nonsignificantly, during the sample period. Contagion decreased, indicating that landscapes had become more fragmented and that similar patch types were less likely to be adjacent to one another.

The Southern Cascades ERU exhibited the greatest overall increase in diversity and richness as measured by ranked and averaged mean difference values, displaying nearly a 40-percent increase in patch richness alone. In fact, richness (PR and RPR), diversity (SHDI and N2), and dominance (N2) all increased significantly, and as expected, evenness as measured by either R21 or MSIEI remained relatively constant. As with most all ERUs, contagion decreased, indicating that landscapes had become more fragmented and that similar patch types were less likely to be adjacent to one another; edge contrast increased significantly, indicating increasing juxtaposition of dissimilar structural and physiognomic conditions. The magnitude of change in edge contrast was second among ERUs.

The Upper Clark Fork ERU displayed significant increases in richness and SHDI but not in dominance. Increased richness was a function of increased variety in cover type and structural class combinations during the sample period. Increasing patch type richness was commonly observed among forest-dominated ERUs. Results of transition analysis indicated that increase was most likely a consequence of timber harvest and fire exclusion. The Upper Clark Fork ranked fifth in overall change in richness and diversity as measured by ranked and averaged mean difference values. Large increases in richness led to a prediction that evenness would be reduced, and significant reductions were observed for both evenness metrics. The Upper Clark Fork was the only ERU exhibiting a significant decrease in both indices and the only ERU displaying a significant decline in interspersion not accompanied by an increase in contagion; the general trend among ERUs was inverse change.

The Upper Klamath and Upper Snake ERUs displayed few changes in landscape patterns. The Upper Klamath ranked 11th in overall change in diversity and richness as measured by ranked and averaged mean difference values. The N2 was the only diversity and dominance measure to increase significantly, and evenness of dominant patch types as measured by R21 displayed the expected increase. Increasing cropland area and juniper cover in woodlands was the likely cause of increased dominance. Increasing evenness among dominant patch types was most influenced by increasing evenness among forest structural classes.

The Upper Snake ERU ranked last in overall change in richness and diversity. No change in richness or diversity was in evidence. But interspersion increased significantly, with the second largest change observed among all ERUs. Increased interspersion was most influenced by sharply increased patch density and reduced mean patch size of colline low-medium shrublands (appendix 2). Surprisingly, change in contagion was insignificant, and the sign of change was positive. Mean edge contrast also increased significantly, indicating increasing juxtaposition of dissimilar structural and physiognomic conditions.

The magnitude of change in edge contrast was fourth largest among ERUs. Given the small historical (17.3 percent) and current (18.9 percent) values of AWMECI as compared to values from forest-dominated ERUs, this increase is especially significant. It reflects the widespread replacement and fragmentation of once vast native shrublands by cropland and seminative and nonnative grasslands.

Forest Vulnerability to Insect and Pathogen Disturbances

We found that vulnerability characterizations and associated change analysis revealed more of the complexity and subtlety of change in forest vegetation patterns than was possible with direct analysis of change in cover type, structural class, or physiognomic condition alone (appendix 2). This was true because vulnerability characterizations were based on raw interpreted data as well as derived attributes (see table 4 and Hessburg and others, in press). This difference enabled the discovery of changes within cover types and structural conditions and the recognition that they are truly varied rather than homogeneous as classifications tend to imply. Results of vulnerability characterizations were a less-than-subtle reminder that maps and classifications partially disguise the truth about what is mapped or classified. We were reminded that investigators must be wary of their own and others' maps and classifications—that perhaps more information may be cloaked than revealed.

Management practices significantly increased vulnerabilities in some subbasins and ERUs and decreased them in others. Vulnerability changes at the ERU scale often were insignificant or masked owing to high variation among sampled subwatersheds. High variability among subwatersheds within ERUs was a function of large geographic extent, high variability in vegetative communities and biophysical conditions, and variable climatic and disturbance regimes. We have learned that to detect change in vegetation patterns or associated changes in landscape vulnerability to various pathogen and insect disturbances, it is better to consider change among subwatersheds highly similar in climatic regime and biophysical environment composition (see "Ecological Regionalization," below). For these reasons, trends reported in "Results" are apt to be highly conservative estimates for ERUs.

In this section, we discuss some of the major changes in forest landscape vulnerability to insect and pathogen disturbances. We concentrate on the most significant changes and underlying probable causes. Because we were unable to directly measure levels and areal extent of management activities, we speculate on the most probable management activities responsible for the changes we observed and present evidence to support those speculations. We do not discuss broad vulnerability trends for the Northern Great Basin, Owyhee, and Upper Snake ERUs because of their small forest area, but results of vulnerability characterizations for all ERUs are discussed in the "Results," summarized in appendix 3, and displayed in figures 46 to 56. Table 31 allows the reader to review at a glance vulnerability changes among ERUs; significant and nonsignificant increases and decreases in vulnerability are indicated so that the reader can observe general trends in vulnerability among ERUs in addition to significant change.

Blue Mountains ERU—Our analysis indicated that forests of the Blue Mountains ERU have been influenced quite significantly and predictably by timber harvesting, fire suppression, fire exclusion, and grazing. In our historical vegetation coverage, 22 percent of the forest area exhibited obvious visible signs of logging (table 27). In the current condition, 28 percent of the forest area exhibited visible signs of logging. Timber harvest reduced old-forest area and area with remnant large trees to a fraction of the historical area (table 20) and, more significantly, restricted availability of medium and large trees in all structures (table 21). Medium and large trees were harvested from all major cover types including ponderosa pine, grand fir-white fir, Engelmann spruce-subalpine fir, and Douglas-fir (appendix 2). In the absence of frequent fires and under the influence of selective harvesting and grazing, Douglas-fir cover expanded (table 29 and appendix 2), forest structures became more layered (table 23), grass and shrub understories were replaced by those comprised of shade-tolerant conifers (tables 24 and 25), and forests and woodlands expanded substantially in areas formerly grasslands and shrublands (appendix 2).

In the Blue Mountains, area vulnerable to western spruce budworm did not change significantly; a relatively large proportion of the ERU (38.2 percent) was highly vulnerable in the historical coverage, and a similar proportion (38.9 percent) is vulnerable in the current condition. Furthermore, increased area vulnerable to budworm disturbance (ns) was associated with increased area of multilayered shade-tolerant understories (tables 23 and 24). At the ERU scale, it appears that a similar area is vulnerable to defoliation, but were defoliation to occur under current conditions, growth and mortality effects likely would be more pronounced. We believe that the lack of significant change in area vulnerable to budworm disturbance was primarily due to high inherent variability among subwatersheds pooled at the scale of the ERU. At a subbasin scale, we observed highly significant differences in vulnerability to western spruce budworm. Budworm vulnerability results (appendix 3) and fire regime changes (fig. 71, A and B) shown by Hann and others (1997) also suggest that a considerable amount of change in vegetation conditions was already set in motion during the 50 to 60 years before the start of the historical coverage (see also table 3). Domestic sheep and cattle grazing and selection cutting (Oliver and others 1994; Wickman 1992; Wissmar and others 1994a, 1994b) were the principal agents of change.

Area vulnerable to Douglas-fir beetle increased during the sample period because Blue Mountains landscapes in the current condition display increased cover and connectivity of Douglas-fir and increased stand densities. Figure 80, A, provides an example of increased area vulnerable to Douglas-fir beetle disturbance in a subwatershed of the Silvies subbasin.

Area vulnerable to western pine beetle (type 1) disturbance of mature and old ponderosa pine declined because medium and large ponderosa pine were selectively harvested from old and other forest structures (tables 20 and 21). We believe that this decline in vulnerability has had and will

Table 31—Insect and pathogen disturbance vulnerability changes in 13 ecological reporting units in the midscale assessment of the interior Columbia River basin

	Ecological reporting units												
Disturbance Agent[a]	Blue Mts.	Central Idaho Mts.	Col. Plateau	Lower Clark Fork	Nor. Cascade	Nor. Glac. Mts.	Nor. Great Basin	Owyhee Uplands	Snake Headw.	So. Cascade	Upper Clark Fork	Upper Klamath	Upper Snake
WSB	+[b]	+	+ +	+	-	- -	na	na	+ +	+ +	-	+	+
DFB	++	+	-	+	-	+	na	na	+ +	- -	- -	nc	+
WPB1	nc	+	-	na	- -	-	na	na	na	-	- -	-	na
WPB2	+	nc	+ +	+	- -	-	na	na	na	+	- -	+	na
MPB1	- -	+	+	+ +	+	+ +	na	na	- -	-	+	-	-
MPB2	+	nc	+ +	+	- -	-	na	na	na	+	- -	+	na
FE	- -	+ +	+ +	+	+	+	na	na	-	+	+ +	+ +	na
SB	- -	+	na	+	-	+ +	na	na	- -	nc	-	na	na
DFDM	+ +	-	-	+	-	+	na	na	+ +	- -	- -	-	+
PPDM	- -	- -	-	+	- -	- -	na	na	na	+	- -	-	na
WLDM	-	-	na	nc	nc	- -	na	na	na	na	- -	na	na
LPDM	nc	+	na	+	+	-	na	na	- -	+	-	nc	nc
AROS	+	+	+	+	- -	+ +	na	na	+ +	+ +	-	+	+
PHWE	+ +	-	-	+	- -	+	na	na	+ +	+ +	-	-	+
HEANs	- -	+ +	+ +	+	+ +	+ +	na	na	+ +	+	+	+	+
HEANp	-	- -	-	na	- -	+	na	na	na	+ +	- -	+	na
TRBR	- -	+ +	na	na	- -	+ +	na	na	+	nc	+	na	na
SRBR	+ +	-	-	-	- -	-	na	na	-	+	-	- -	+ +
WPBR1	na	nc	- -	+	+ +	- -	na	na	na	nc	-	na	na
WPBR2	na	nc	na	na	+ +	nc	na	na	-	na	-	na	na
RRSR	-	+	na	+	+ +	+ +	na	na	na	+	+	-	na

[a] WSB = western spruce budworm; DFB = Douglas-fir beetle; WPB1 = western pine beetle - type 1 attack of mature and old ponderosa pine; WPB2 = western pine beetle - type 2 attack of immature and overstocked ponderosa pine; MPB1 = mountain pine beetle - type 1 attack of overstocked lodgepole pine; MPB2 = mountain pine beetle - type 2 attack of immature and overstocked ponderosa pine; FE = fir engraver; SB = spruce beetle; DFDM = Douglas-fir dwarf mistletoe; PPDM = ponderosa pine dwarf mistletoe; WLDM = western larch dwarf mistletoe; LPDM = lodgepole pine dwarf mistletoe; AROS = *Armillaria* root disease; PHWE = laminated root rot; HEANs = S-group annosum root disease; HEANp = P-group annosum root disease; TRBR = tomentosus root and butt rot; SRBR = Schweintizii root and butt rot; WPBR1 = white pine blister rust - type 1 on western white pine/sugar pine; WPBR2 = white pine blister rust - type 2 on whitebark pine; RRSR = rust-red stringy rot. See also appendix A.

[b] + + = significant increase at P≤0.2; + = nonsignificant increase; - - = significant decrease at P≤0.2; - = nonsignificant decrease; “na” = not applicable; and nc = no change.

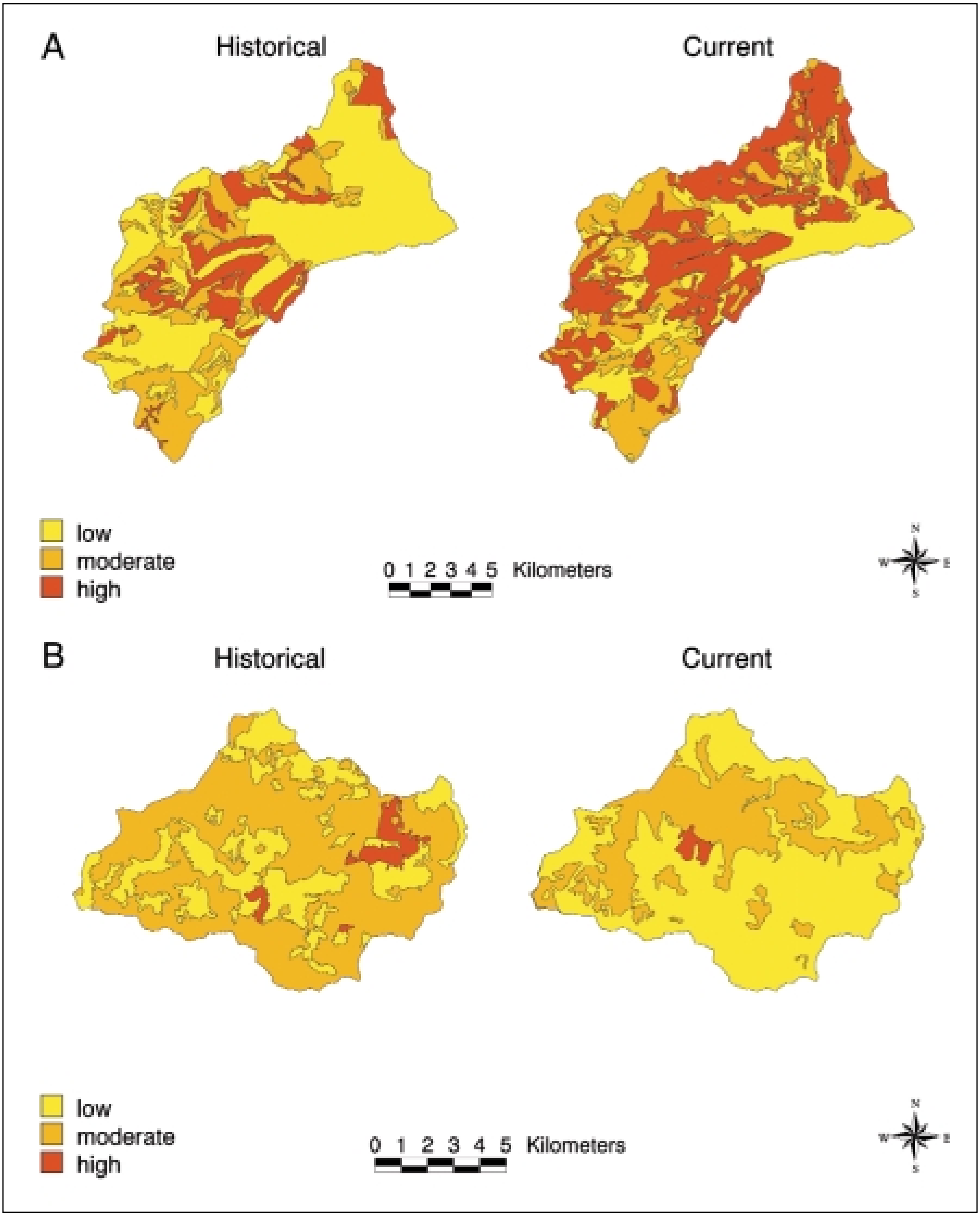

Figure 80—Historical and current maps of vegetation vulnerability to (A) Douglas-fir beetle disturbance in subwatershed 40C in the Silvies subbasin of the Blue Mountains ERU, and (B) mountain pine beetle type 1 disturbance in subwatershed 40 in the Wallowa subbasin of the Blue Mountains ERU.

continue to have important ecological ramifications. Ponderosa pine is the primary early seral species naturally occurring in the ERU. As such, it historically had the opportunity to achieve great age and stature under presettlement disturbance regimes, and large areas of the ERU (old forest or otherwise) supported some amount of ponderosa pine in the overstory. Ponderosa pine produces snags of excellent quality and potentially long residence time (Bull 1983; Keen 1929, 1955). Selective harvesting of live medium and large ponderosa pine has depleted the current and future availability of pine snags.

Area vulnerable to mountain pine beetle (type 1) disturbance of high-density lodgepole pine declined, but area of the lodgepole pine cover type did not change significantly. In the Blue Mountains, area where lodgepole pine comprises a pure cover type is small in comparison with the area where it occurs in mixed types. The observed decline in vulnerability is indicative of declining area where lodgepole pine occurs as a major early seral species in mixed types. With the exclusion of stand-regenerating fires, ongoing mountain pine beetle mortality has steadily removed lodgepole pine in many such stands (Schmitt and others 1991). Figure 80, B, provides an example of reduced area vulnerable to mountain pine beetle (type 1) disturbance in a subwatershed of the Wallowa subbasin.

Area vulnerable to fir engraver and spruce beetle disturbance also declined. In both cases, area of host cover declined as a result of timber harvest or salvage, extended drought, and western spruce budworm and prior bark beetle disturbance (Gast and others 1991, Schmitt and others 1991). Figure 81, A, illustrates reduced area vulnerable to fir engraver disturbance in a subwatershed of the Lower Grande Ronde subbasin. Figure 81, B, provides an example of reduced area vulnerable to spruce beetle disturbance in a subwatershed of the Upper Grande Ronde subbasin.

Area vulnerable to Douglas-fir dwarf mistletoe increased with expanded area of Douglas-fir cover and increased canopy layering and contiguity of host patches. In contrast, area vulnerable to ponderosa pine and western larch dwarf mistletoe disturbances declined; these declines were associated with reduced area of ponderosa pine and western larch overstory cover, respectively, from timber harvest. Figure 82, A, provides an example of increased area vulnerable to Douglas-fir dwarf mistletoe disturbance in a subwatershed of the Wallowa subbasin.

Even with declining area of grand fir, white fir, and subalpine fir overstory cover, area vulnerable to S-group annosum root disease likely increased. We believe this is true because (1) the total area occupied by host species actually increased (table 24), but hosts now more often occur in understories in intermediate and suppressed crown classes; and (2) a large percentage of the forest has been entered for timber harvest (table 27), and freshly cut stumps provide avenues for spread of this disease to new patches (Hadfield and others 1986).

Area and connectivity of area vulnerable to laminated root rot disturbance increased primarily as a result of increased cover and connectivity of Douglas-fir patches but also because of increasing area occupied by understory true firs. Area and connectivity of area vulnerable to Schweinitzii root and butt rot disturbance increased as a result of increased cover and connectivity of Douglas-fir patches. Figure 82, B, displays increased area vulnerable to Schweinitzii root and butt rot disturbance in a subwatershed of the Burnt subbasin.

Central Idaho Mountains ERU—Few significant changes in vulnerability were in evidence in the Central Idaho Mountains (table 31). For the most part, vulnerability characterizations indicated that the primary influence during the sample period was fire exclusion. Shade-tolerant true firs increased slightly in area and dominance, and insects and pathogens that specialize in attacking true firs were modestly favored by that increase. Area vulnerable to western spruce budworm increased but the change was not significant at this reporting scale; a large proportion of the ERU area (49.4 percent) was highly vulnerable in the historical coverage, and a similar proportion (51.1percent) is vulnerable in the current condition. Area vulnerable to fir engraver and S-group annosum root disease disturbance also increased. Figure 83, A, provides an example of increased area vulnerable to fir engraver disturbance in a subwatershed of the South Fork Clearwater subbasin.

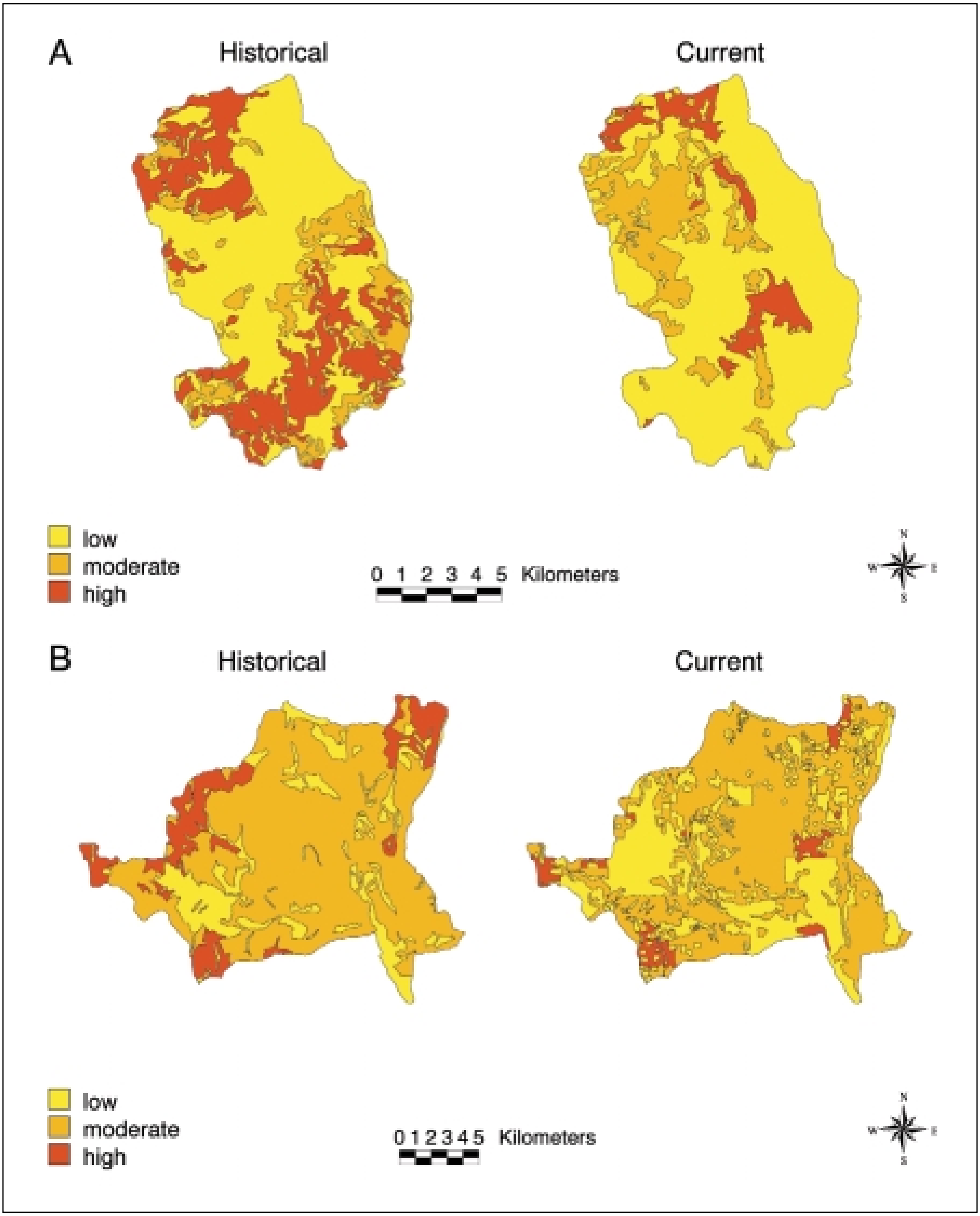

Figure 81—Historical and current maps of vegetation vulnerability to (A) fir engraver disturbance in subwatershed L2 in the Lower Grande Ronde subbasin of the Blue Mountains ERU, and (B) spruce beetle disturbance in subwatershed u28 in the Upper Grande Ronde subbasin of the Blue Mountains ERU.

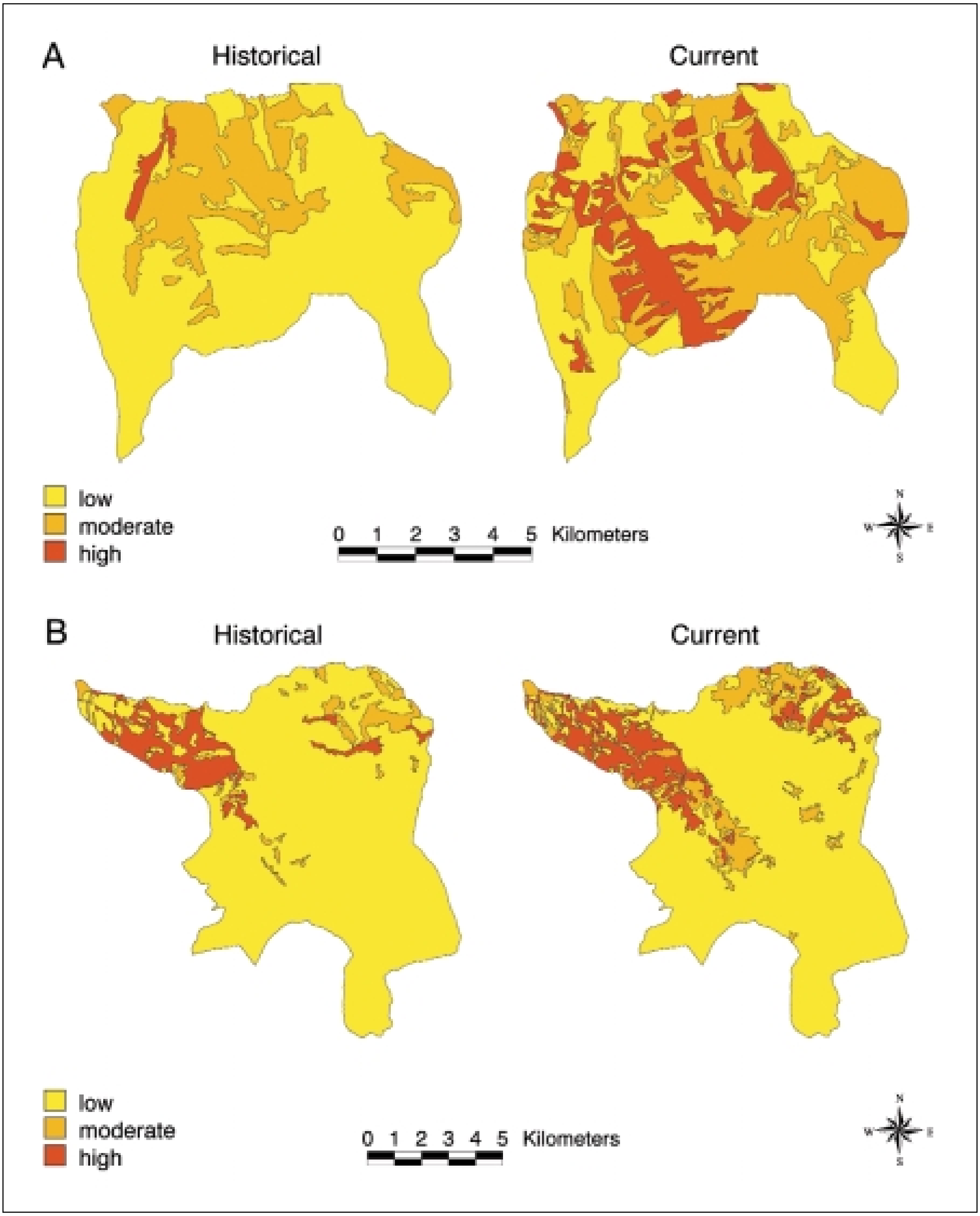

Figure 82—Historical and current maps of vegetation vulnerability to (A) Douglas-fir dwarf mistletoe disturbance in subwatershed 29 in the Wallowa subbasin of the Blue Mountains ERU, and (B) Schweinitzii root and butt rot disturbance in subwatershed 0901 in the Burnt subbasin of the Blue Mountains ERU.

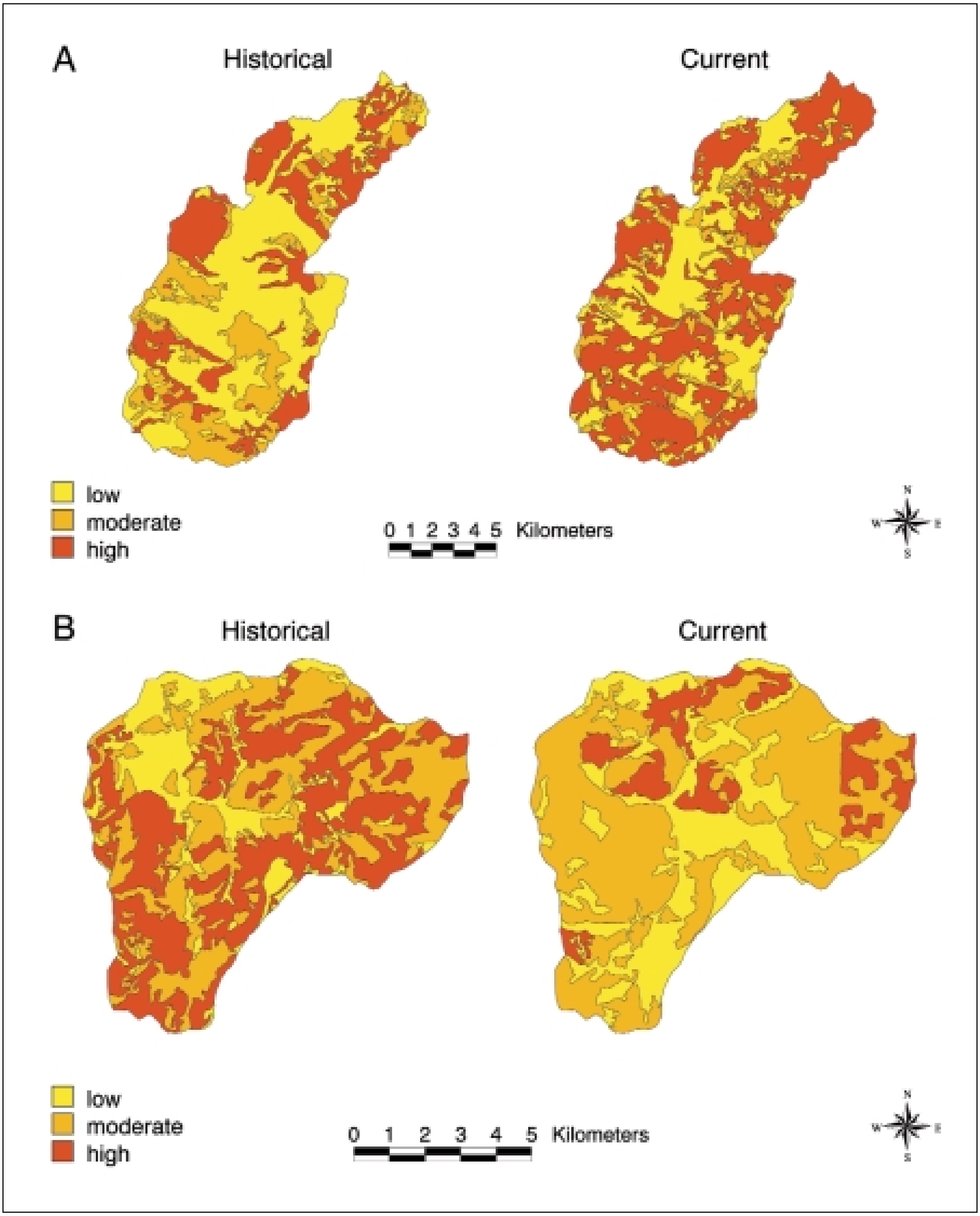

Figure 83—Historical and current maps of vegetation vulnerability to (A) fir engraver disturbance in subwatershed 0703 in the South Fork Clearwater subbasin of the Central Idaho Mountains ERU, and (B) western pine beetle type 1 disturbance in subwatershed 1303 in the Lower John Day subbasin of the Columbia Plateau ERU.

Columbia Plateau ERU—Our results indicated that dry and mesic forests of the Columbia Plateau have been influenced in a predictable manner by selective harvesting, fire suppression, and fire exclusion. Area highly vulnerable to western spruce budworm disturbance increased during the sample period from an average of 9.3 to 12.0 percent of the ERU (appendix 3). In the historical condition, 36 percent of the forest area was vulnerable to western spruce budworm disturbance. In the current condition, 41 percent of the forest area is vulnerable to budworm disturbance (appendices 2 and 3). Increased vulnerability was associated with expanded area of Douglas-fir cover (appendix 2 and table 29) and increased area of Douglas-fir and grand fir in multilayered understories (tables 23, 24, and 25), both predicted consequences of fire exclusion and selective harvesting (table 27).

Selective harvesting reduced area in old forest structures (table 20) and reduced abundance of medium and large trees in all structures (table 21). Consequently, we observed a modest decline in vulnerability to western pine beetle (type 1) disturbance of mature and old ponderosa pine. Figure 83, B, displays an example of reduced area vulnerable to western pine beetle (type 1) disturbance in a subwatershed of the Lower John Day subbasin. Area vulnerable to western pine beetle (type 2) and mountain pine beetle (type 2) disturbance of immature, high-density ponderosa pine increased during the sample period. Increased vulnerability was associated with expanded area of ponderosa pine cover in young multistory structures (appendix 2), a likely consequence of the combined effects of selective harvesting, fire exclusion and suppression, and domestic livestock grazing. Figure 84, A and B, provides illustrations of increased area vulnerable to western pine beetle (type 2) and mountain pine beetle (type 2) disturbances in subwatersheds of the Lower John Day and Palouse subbasins, respectively.

Area highly vulnerable to fir engraver disturbance increased as a consequence of increased area of grand fir understories. Area highly vulnerable to S-group annosum also increased because grand fir and western hemlock in mixed species cover types and occurring as understory species increased during the sample period, as did area in these types with visible logging entry. Area vulnerable to white pine blister rust (type 1) disturbance of western white pine declined; decline was likely the result of blister rust mortality and early selective harvest of western white pine.

Lower Clark Fork ERU—Analysis of cover type and structural changes, and vulnerability characterizations indicated that significant harvesting has occurred in highly productive forests of this ERU (table 27), but fire exclusion and fire suppression also have greatly affected conditions we observe today. In our sample, area with medium and large trees increased during the sample period (table 21), ERU area in the 90- to 100-percent crown cover class increased by 23.7 percent (table 22), and ERU area in multilayered canopies increased by more than 11 percent (tables 23 and 24). Each change was a predictable consequence of fire exclusion, especially in an area where stand-replacing fire historically played such a significant role.

Area vulnerable to western spruce budworm increased but the change was not significant at this reporting scale; a large proportion of the ERU (56.8 percent) was highly vulnerable in the historical coverage, and a similar proportion (65 percent) is vulnerable in the current condition. The 8.2-percent increase was not statistically significant because of our small sample size; further sampling is needed to establish the trend.

In the absence of fire, lodgepole pine-dominated landscapes of the Lower Clark Fork aged and became more synchronous in their vulnerability to bark beetle and fire disturbances. With increased overstory and understory grand fir cover (appendix 2 and table 24) developing during the sample period, vulnerability to fir engraver disturbance also increased (appendix 3 and table 31), but the 8.7-percent increase was not statistically significant because of our small sample size; further sampling is needed to establish the trend. Similarly, area vulnerable to *Armillaria* root disease increased by 10 percent, but the change was not significant because of our small sample size.

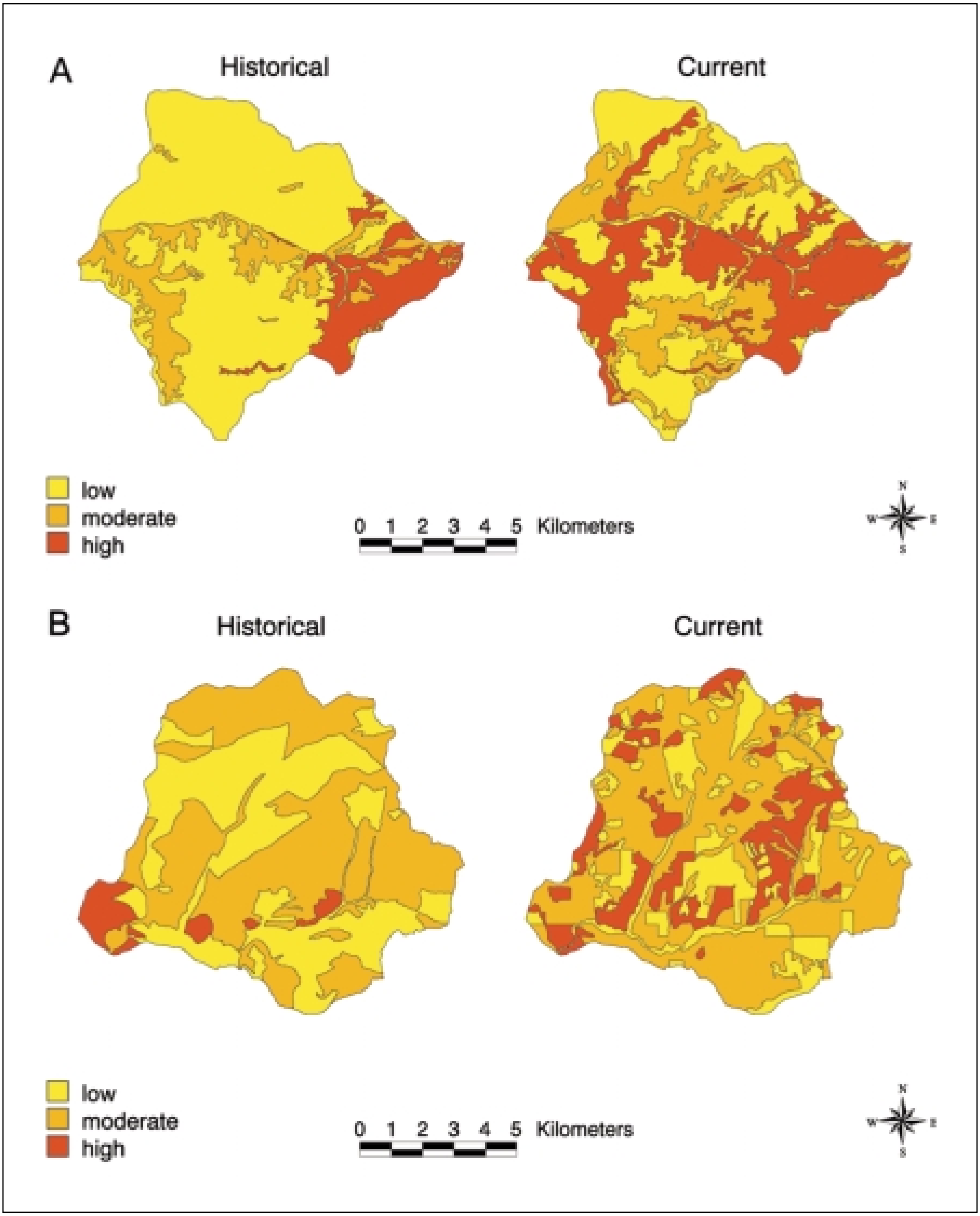

Figure 84—Historical and current maps of vegetation vulnerability to (A) western pine beetle type 2 disturbance in subwatershed 1903 in the Lower John Day subbasin of the Columbia Plateau ERU, and (B) mountain pine beetle type 2 disturbance in subwatershed 2002 in the Palouse subbasin of the Columbia Plateau ERU.

Northern Cascades ERU—Results of vulnerability characterizations for this ERU indicated that the primary effect of management during the sample period was probably timber harvest (table 27) followed by active fire suppression and fire exclusion. Area occupied by old-forest structures (table 20) and medium and large trees (table 21) declined significantly during the sample period, as did area of ponderosa pine cover (appendix 2 and table 29). Area of Douglas-fir cover increased significantly, but area of medium and large Douglas-fir declined. These results explain much of the change we observed in vulnerability to pathogen and insect disturbances.

Vulnerabilities to western pine beetle (type 1) disturbance of mature and old ponderosa pine and Douglas-fir beetle disturbance both declined with the loss of medium and large hosts. Connectivity of highly vulnerable area also declined, indicating that remaining distributions of medium and large ponderosa pine and Douglas-fir are fragmented. Area and connectivity of area vulnerable to western pine beetle (type 2) and mountain pine beetle (type 2) disturbance of immature, high-density ponderosa pine also declined owing to reduced area of ponderosa pine cover in young (new) and middle-aged (intermediate) structures. Figure 85, A and B, provides illustrations of increased area vulnerable to western pine beetle (type 2) and mountain pine beetle (type 2) disturbances in subwatersheds of the Naches and Methow subbasins, respectively.

Area vulnerable to western (ponderosa pine) dwarf mistletoe disturbance declined with the loss of ponderosa pine overstories (for example, see fig. 86, A). In contrast, area vulnerable to S-group annosum root disease disturbance increased during the sample period (fig. 53). The observed increase in high-vulnerability area was associated with increased area and stature of grand fir and Pacific silver fir cover (appendix 2) and increased area with visible logging entry (table 27).

Northern Glaciated Mountains ERU—
Results of our analysis indicated that fire suppression and exclusion and timber harvest together produced the changes in vulnerability we observed. In the historical vegetation coverage, visible logging entry was apparent on 8.6 percent of the forested area (table 27 and appendix 2). In the current condition, visible logging activity was apparent on 26.5 percent of the forested area. But old-forest area and area with remnant large trees did not decline during the sample period (table 20); furthermore, area occupied by medium and large trees actually increased. We speculate that because stand-replacing fires were once common in the ERU, regrowth of forest in the absence of fire apparently offset some of the effects of harvesting (note the substantial decline in area of stand-initiation structures in appendix 2). Predicted effects of fire exclusion also were observed: increased crown cover (table 22), increased canopy layering (table 23), and increased cover of shade-tolerant understory conifers (table 24).

Area vulnerable to western spruce budworm disturbance increased with increasing cover of grand fir and subalpine fir and increased canopy layering. In the absence of fire, lodgepole pine-dominated landscapes became more synchronous in their vulnerability to mountain pine beetle and fire disturbances. Area and connectivity of area vulnerable to spruce beetle disturbance also increased (fig. 49) with increased area, size, and stature of Engelmann spruce (see fig. 86, B).

As we would expect, area vulnerable to ponderosa pine and western larch dwarf mistletoe disturbances declined (appendix 3) with the reduction of ponderosa pine and western larch cover (table 29). Figure 87, A, illustrates reduced area vulnerable to western larch dwarf mistletoe disturbance in a subwatershed of the Swan subbasin. Area vulnerable to *Armillaria* (see fig. 87, B) and S-group annosum root diseases increased with increasing dominance of shade-tolerant overstories and understories (table 24 and appendix 2). Finally, area and connectivity of area vulnerable to white pine blister rust (type 1) disturbance of western white pine declined (fig. 55 and appendix 3) as a result of blister rust mortality and early selective harvest of western white pine (see fig. 88, A).

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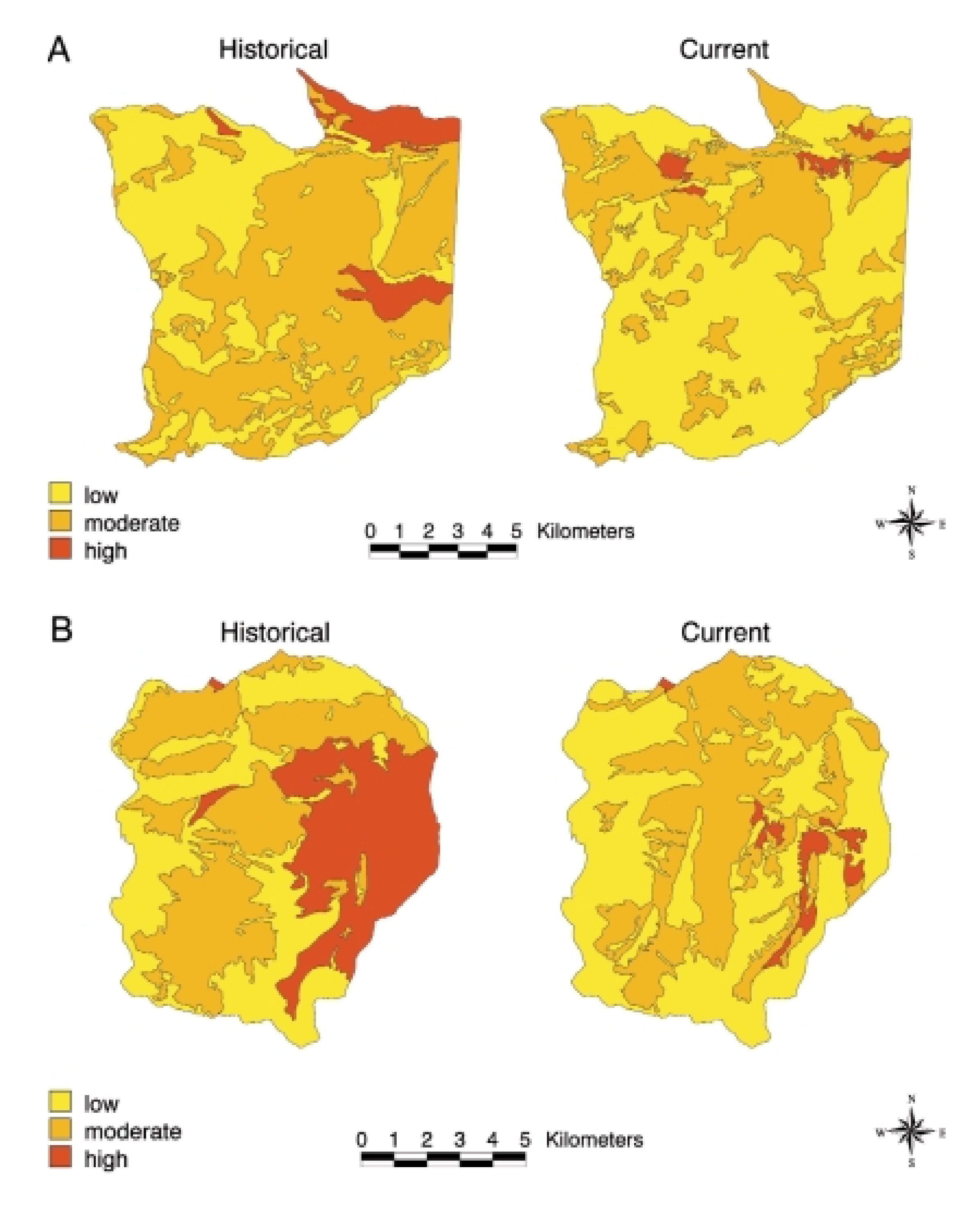

Figure 85—Historical and current maps of vegetation vulnerability to (A) western pine beetle type 2 disturbance in subwatershed 10 in the Naches subbasin of the Northern Cascades ERU, and (B) mountain pine beetle type 2 disturbance in subwatershed 55 in the Methow subbasin of the Northern Cascades ERU.

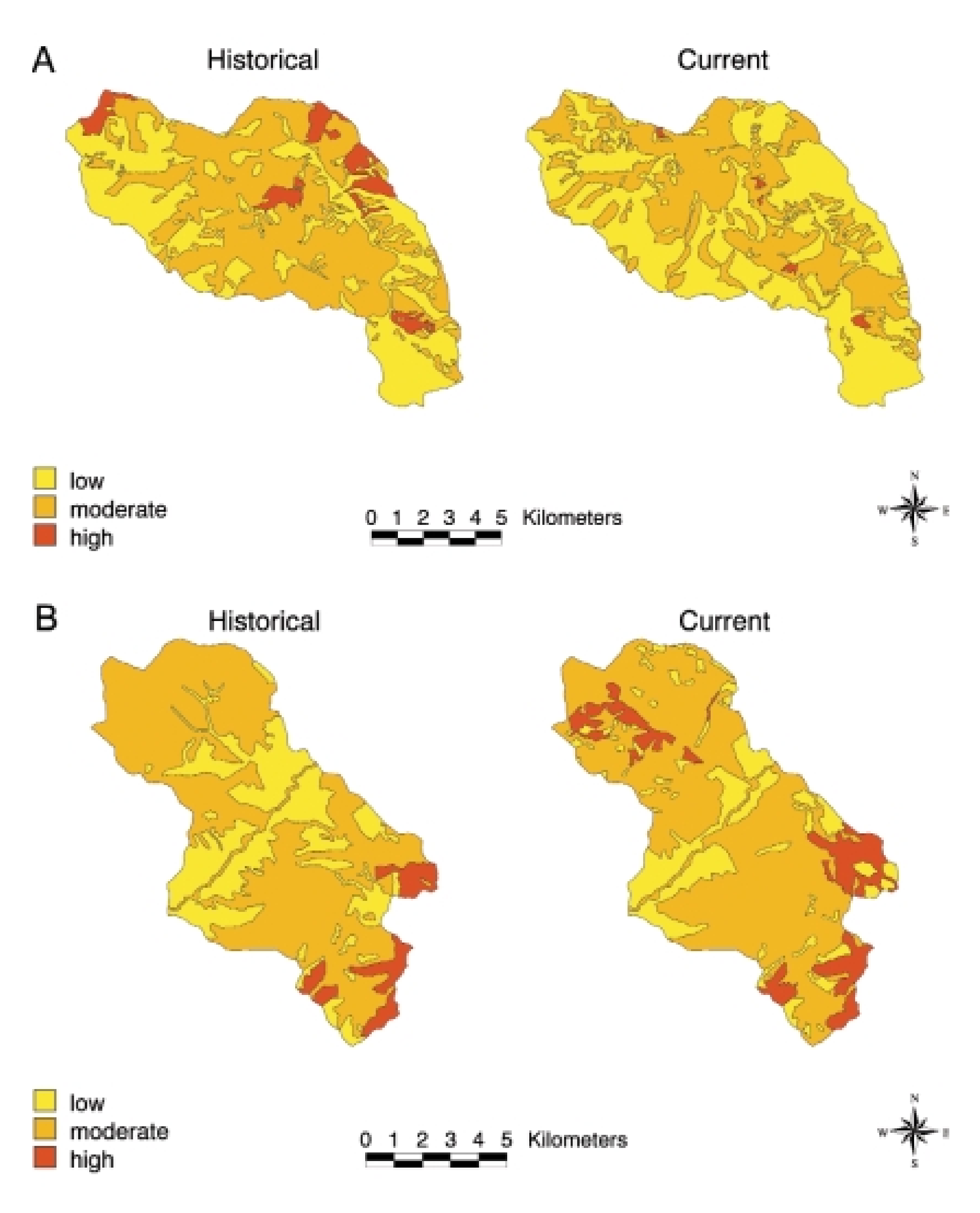

Figure 86—Historical and current maps of vegetation vulnerability to (A) western dwarf mistletoe disturbance in subwatershed 35 in the Wenatchee subbasin of the Northern Cascades ERU, and (B) spruce beetle disturbance in subwatershed 0801 in the Lower Flathead subbasin of the Northern Glaciated Mountains ERU.

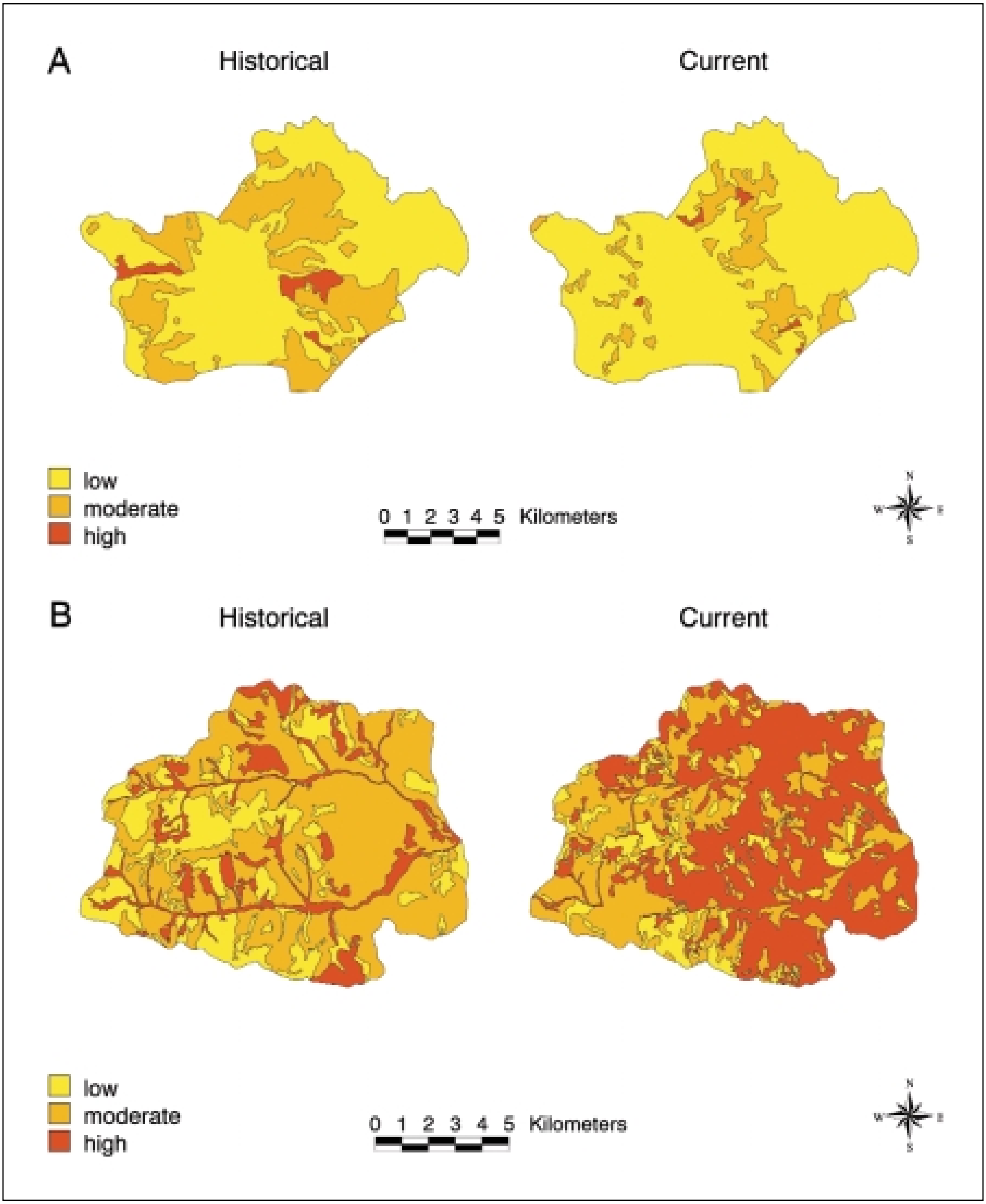

Figure 87—Historical and current maps of vegetation vulnerability to (A) western larch dwarf mistletoe disturbance in subwatershed 0202 in the Swan subbasin of the Northern Glaciated Mountains ERU, and (B) *Armillaria* root disease disturbance in subwatershed 20 in the Kettle subbasin of the Northern Glaciated Mountains ERU.

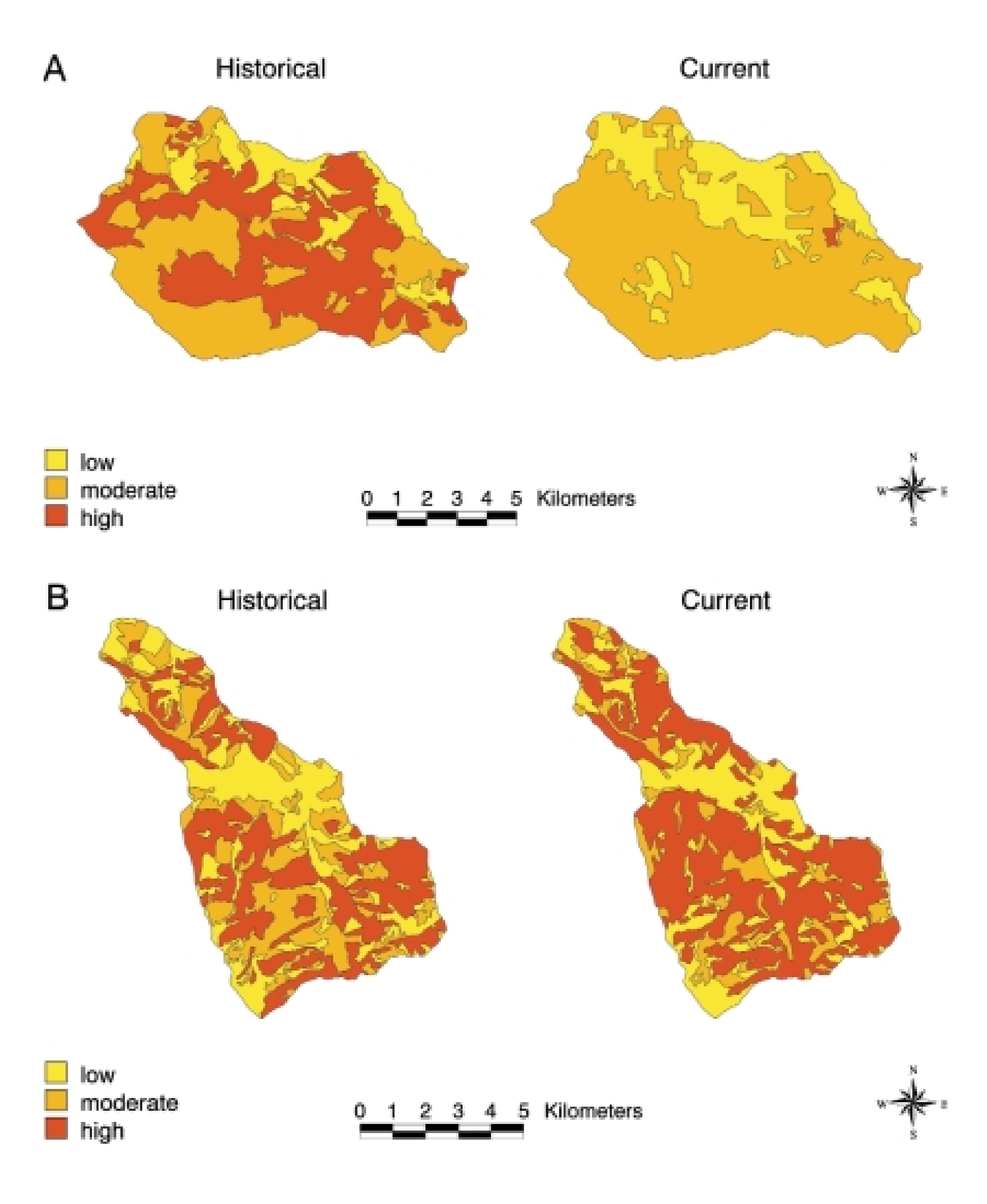

Figure 88—Historical and current maps of vegetation vulnerability to (A) white pine blister rust type 1 disturbance in subwatershed 09 in the Pend Oreille subbasin of the Northern Glaciated Mountains ERU, and (B) western spruce budworm disturbance in subwatershed 1102 in the Palisades subbasin of the Snake Headwaters ERU.

Snake Headwaters ERU—Our results suggest that fire suppression and exclusion, and to a lesser extent timber harvest, interacted to produce the changes in vulnerability we observed. In the historical vegetation coverage, no visible logging entry was apparent for 100 percent of the forested area (table 27 and appendix 2). In the current condition, signs of visible current or past logging were apparent for only 2 percent of the area. Old-forest area and area with remnant large trees declined during the sample period (table 20), but changes were not statistically significant. Area occupied by medium and large trees also declined. Overall, increased area with visible logging could not account for the changes in vulnerability we observed.

Area and connectivity of area vulnerable to western spruce budworm disturbance increased dramatically during the sample period (fig. 46 and appendix 3); increase was associated with increased area of Engelmann spruce-subalpine fir cover in multilayered canopy arrangements (tables 23 and 24 and appendix 2). Figure 88, B, illustrates increased area vulnerable to western spruce budworm disturbance in a subwatershed of the Palisades subbasin. Area and connectivity of area vulnerable to Douglas-fir beetle disturbance also increased (appendix 3). Because total area in old-forest structures declined by 40 percent from an average of 5.2 to 3.1 percent of the ERU (appendix 2), most of the increased area vulnerable to Douglas-fir beetle disturbance likely was associated with increased abundance of Douglas-fir larger than 22.9 cm d.b.h. in structural classes other than old forest.

Area vulnerable to mountain pine beetle (type 1) disturbance of high density lodgepole pine fell from an average of 34.6 to 29.2 percent of the ERU, and area of the lodgepole pine cover type declined from 15.6 to 11.3 percent of the ERU. Our results indicated that area of pole, small, and medium lodgepole pine in both pure and mixed compositions declined during the sample period. We know that before and during the period of our sample, large areas of lodgepole pine forest were attacked and killed by the mountain pine beetle. But these results suggest that salvage and regeneration efforts influenced, at best, less than half of that area (table 27). Beetle disturbance and fire exclusion have resulted in cover type conversion of some areas to Engelmann spruce and subalpine fir. This change was corroborated by transition analysis. Area vulnerable to *Armillaria* root disease and S-group annosum root disease increased significantly with increasing dominance of shade-tolerant overstories and understories (table 24 and appendix 2). Figure 89, A, illustrates increased area vulnerable to S-group annosum root disease disturbance in a subwatershed of the Snake Headwaters subbasin.

Southern Cascades ERU—Our vegetation analysis and disturbance vulnerability characterizations indicated that the Southern Cascades have been influenced quite significantly and predictably by timber harvest, fire suppression, and fire exclusion. In the historical vegetation coverage, 12 percent of the forest area exhibited visible signs of logging (table 27). In the current condition, 38 percent of the forest area exhibited visible signs of logging. During the sample period, forest and woodland area affected by selective harvesting alone jumped from less than 10 percent to nearly one-quarter of the area. Overall, the level of timber harvest had little effect on old-forest area, which increased modestly but nonsignificantly during the sample period. Area with remnant large trees declined, but the change was not significant (table 20).

Area with medium and large trees actually increased (table 21). In the absence of fires and under the influence of selective harvesting, forest crown cover increased (table 22), forest structures became highly layered (table 23), and large areas developed conifer understories (tables 24 and 25). Expansion of forest area was the result of regrowth of forests cut before our historical vegetation coverage (appendix 2). These results explain much of the change in vulnerability to pathogen and insect disturbances that we observed.

In the Southern Cascades, area vulnerable to western spruce budworm disturbance increased significantly; increased area was associated with increased area of multilayered shade-tolerant understories (tables 23 and 24). But area vulnerable to budworm disturbance amounted to little

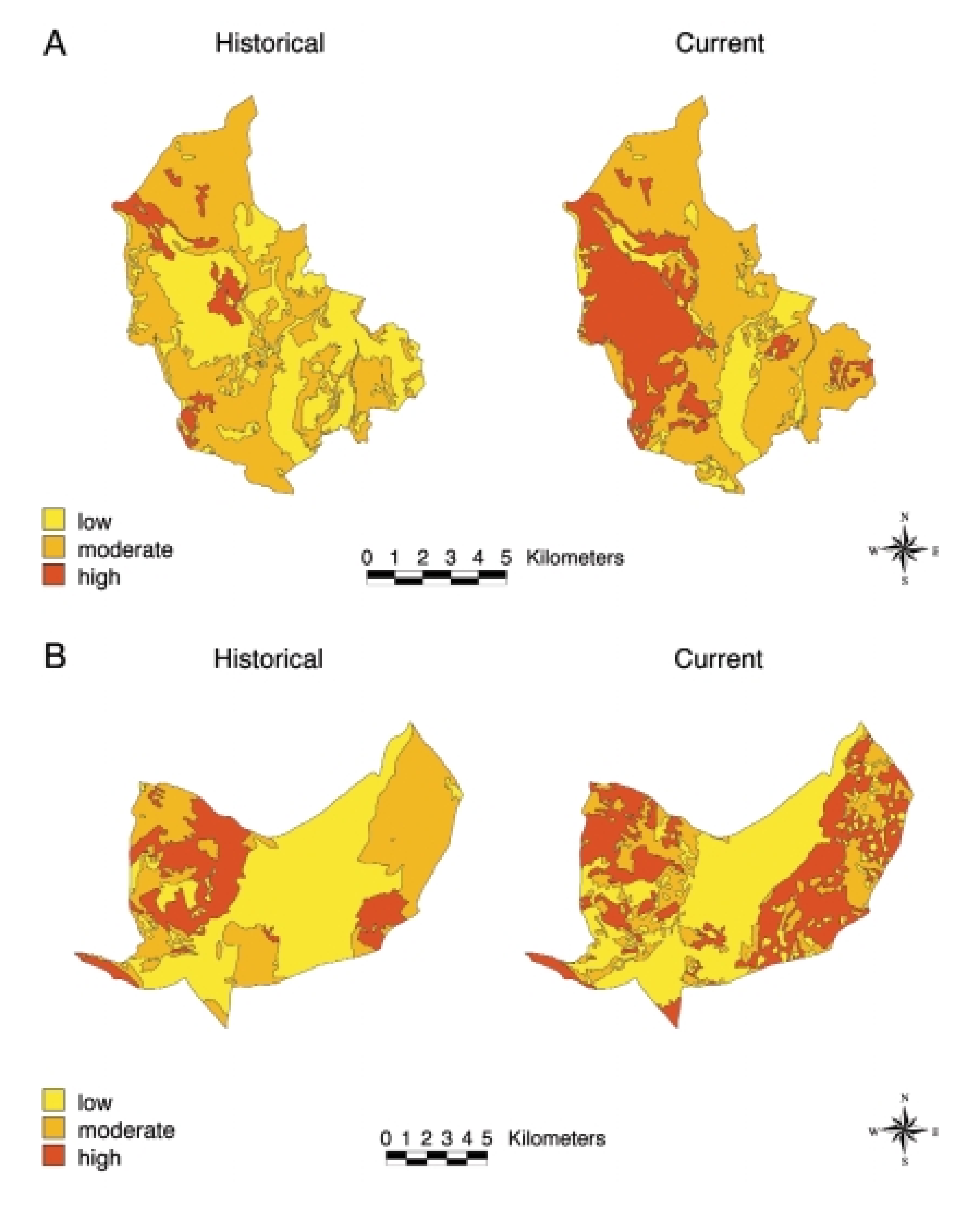

Figure 89—Historical and current maps of vegetation vulnerability to (A) S-group annosum root disease disturbance in subwatershed 0305 in the Snake Headwaters subbasin of the Snake Headwaters ERU, and (B) laminated root rot disturbance in subwatershed 30 in the Upper Deschutes subbasin of the Southern Cascades ERU.

more than 10 percent of the ERU, even in the current condition. Area vulnerable to Douglas-fir beetle and Douglas-fir dwarf mistletoe disturbances declined because area and connectivity of patches with medium and large Douglas-fir in old forest and other structures declined. In contrast, area vulnerable to mountain pine beetle (type 1) disturbance of high-density lodgepole pine declined by 14 percent from an average of 29.0 to 24.9 percent of the ERU, and area of the lodgepole pine cover type remained unchanged. As was the case in the Blue Mountains, our results indicate that area of lodgepole pine in historically mixed compositions declined during the sample period as a result of mountain pine beetle outbreaks and exclusion of regenerative fires.

Area vulnerable to *Armillaria* root disease and laminated root rot disturbance increased (fig. 52 and appendix 3); increased area was associated with expanded area of subalpine fir, grand fir, and Douglas-fir in pure and mixed species compositions, expanded area of shade-tolerant understories, and increased crown cover of host species. Figure 89, B, illustrates increased area vulnerable to laminated root disease disturbance in a subwatershed of the Upper Deschutes subbasin.

Upper Clark Fork ERU—Forest vegetation of the Upper Clark Fork ERU has been radically altered by timber harvest and, to a lesser extent, fire exclusion. In the historical vegetation coverage, 12 percent of the forest area exhibited visible signs of logging (table 27 and appendix 2). In the current condition, 37 percent of the forest area exhibited visible signs of logging. During the sample period, forest and woodland area affected by regeneration and selective harvesting alone jumped from 10 to 20 percent of the forest area. Overall, the level of timber harvest had little effect on old-forest area or area with remnant large trees (table 20 and appendix 2).

It was apparent from the area of stand-initiation structures in our historical vegetation coverage that stand-replacement fires played a major role in regenerating and patterning forests, and it is likely that large areas of new and intermediate structure were typical historically for these landscapes. Indeed, in the historical condition, 15.9 percent of the ERU area or 18.2 percent of the forest area was comprised of stand-initiation or new forest structures, and 70.5 percent of the ERU area or 80.8 percent of the forest area was comprised of intermediate (stem exclusion, understory reinitiation, and young multistory) forest structures.

Area with medium and large trees remained unchanged despite the level of timber harvest (table 21). In the historical condition, 19.7 percent of the ERU area or 22.6 percent of the forest area was comprised of forest patches with medium and large trees regardless of their structural affiliation. In the current condition, 17.2 percent of the ERU area or 20 percent of the forest area was comprised of forest patches with medium and large trees. In the absence of fires and under the influence of selective harvesting forest crown cover declined (table 22), forest structures became less layered (table 23), and large areas developed grass and shrub understories (tables 24 and 25) where conifer understories once were more typical. Forest area declined by an average of 1 percent of the ERU, but the change was not statistically significant (appendix 2). Even area with visible dead trees and snags declined significantly during the sample period (table 26).

Among forested ERUs, the Upper Clark Fork was one of those most heavily influenced by past timber harvest. It was not surprising that most vulnerability changes were declines (table 31 and appendix 3). Area and connectivity of area vulnerable to Douglas-fir beetle disturbance declined owing to reduced crown cover of large and medium Douglas-fir across all forest structural classes. Figure 90, A, provides an example of reduced area vulnerable to Douglas-fir beetle disturbance in a subwatershed of the Blackfoot subbasin. Area vulnerable to western pine beetle (type 1) disturbance of mature and old ponderosa pine also declined as a result of reduced area in the ponderosa pine cover type and reduced crown cover of medium and large ponderosa pine across all forest structural classes.

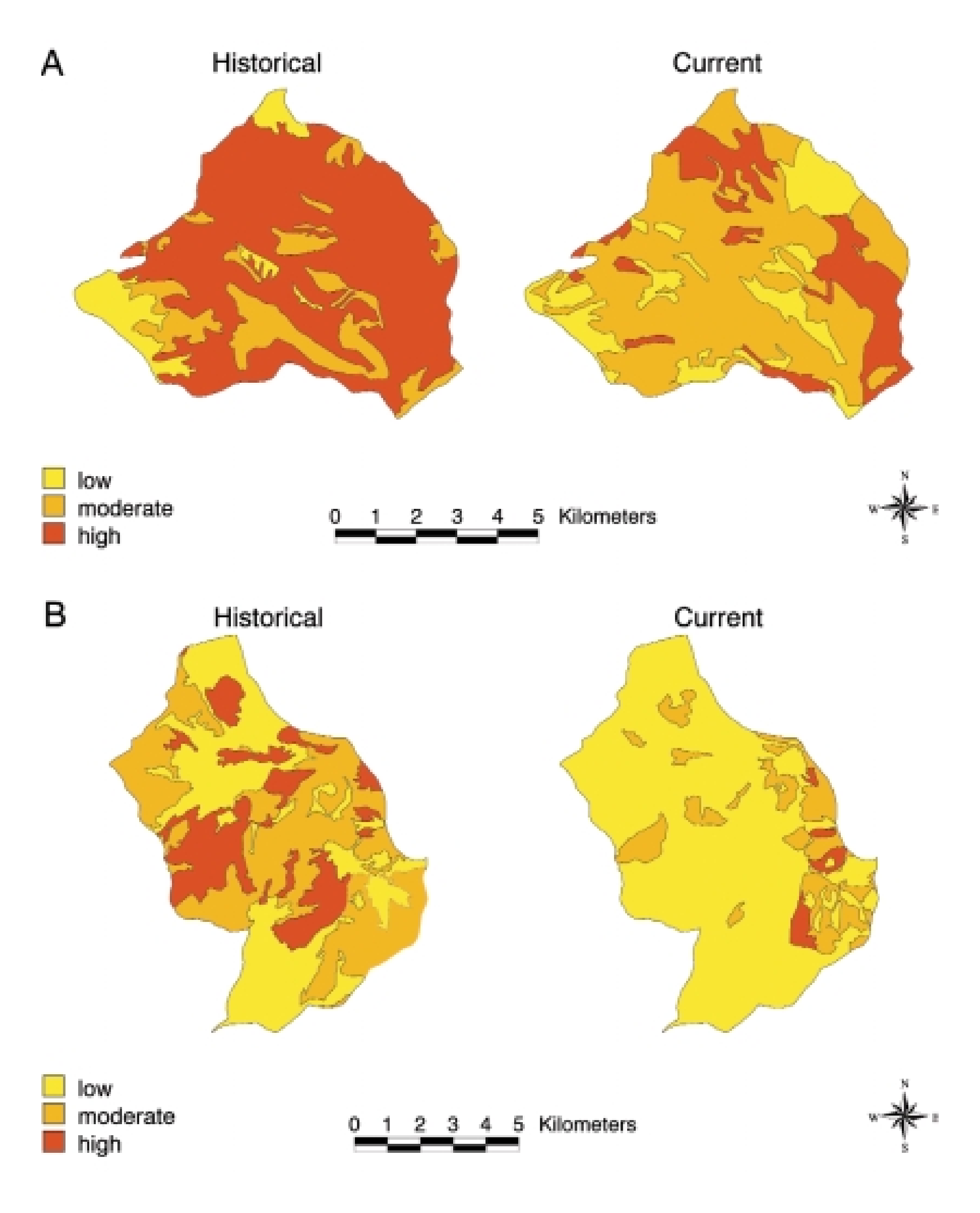

Figure 90—Historical and current maps of vegetation vulnerability to (A) Douglas-fir beetle disturbance in subwatershed 0103 in the Blackfoot subbasin of the Upper Clark Fork ERU, and (B) Douglas-fir dwarf mistletoe disturbance in subwatershed 0902 in the Flint Rock subbasin of the Upper Clark Fork ERU.

Area vulnerable to western pine beetle (type 2) and mountain pine beetle (type 2) disturbance of immature, high-density ponderosa pine declined as a result of reduced area in the ponderosa pine cover type and reduced area of stem-exclusion, understory reinitiation, and young multistory structures with ponderosa pine in pure or mixed compositions. In contrast, area and connectivity of area vulnerable to fir engraver disturbance increased during the sample period. High-vulnerability area increased primarily as a result of increased area in the subalpine fir-Engelmann spruce cover type in all forest structural classes but stand initiation.

Area vulnerable to Douglas-fir, ponderosa pine, and western larch dwarf mistletoe disturbances declined during the sample period. The observed decline in area of high vulnerability was the result of significantly reduced patch area and contiguity with medium and large hosts in multilayered structures (large trees in the overstory were removed). Figure 90, B, illustrates reduced area vulnerable to Douglas-fir dwarf mistletoe disturbance in a subwatershed of the Flint Rock subbasin.

Upper Klamath ERU—In the historical vegetation coverage, more than one-half (53 percent) of all forest cover was ponderosa pine (appendix 2), 23 percent of all forest structure was old forest (table 20), and 38 percent of all forest structures had at least 10 percent or more crown cover of large trees (table 20). In the current condition, 49 percent of all forest cover is ponderosa pine, 21 percent of all forest structure is old forest, and 36 percent of all forest structures have at least 10 percent or more crown cover of large trees, but crown cover of medium and large trees has been substantially reduced (table 21). Selection cutting reduced the crown cover of medium and large trees across 31 percent of the forest area (16 percent of the ERU). Much like the Upper Clark Fork, in the absence of fires and under the influence of heavy selective harvesting (table 27), forest crown cover declined (table 22), forest structures became less layered (table 23), and large areas developed grass and shrub understories (tables 24 and 25) where conifer understories were once more typical. Forest area declined by 6 percent from an average of 50.5 to 47.5 percent of the ERU (appendix 2). Likewise, area with visible dead trees and snags declined significantly during the sample period (table 26). Among forested ERUs, the Upper Klamath was probably the second most heavily influenced by past timber harvest after the Upper Clark Fork.

Few vulnerability changes were significant, but one change was particularly revealing (table 31 and appendix 3). Area vulnerable to Schweinitzii root and butt rot declined by 32 percent from 26.4 to 17.9 percent of the ERU. The observed decline in area of high vulnerability was the result of significantly reduced area in the ponderosa pine cover type and reduced patch area and contiguity with medium and large overstory ponderosa pine and Douglas-fir. Mean size of patches in the low vulnerability class rose by 77 percent from an average of 1551.8 to 2746.9 ha.

Ecological Regionalization

The midscale assessment was designed to evaluate change in patterns of structural and compositional attributes and links between landscape pattern change and associated change in insect, pathogen, and fire (Ottmar and others, in prep.) disturbance processes. Two criteria make midscale assessment data particularly relevant to land management planning:

1. The scale of observation in our assessment is equivalent to the scale at which management occurs; that is, vegetation data were collected at a patch scale similar to the scale of the "stand" used by managers to prescribe and evaluate management treatments.
2. Historical and current conditions and changes in conditions were characterized for areas much larger than forest planning and watershed analysis areas. Midscale assessment findings provide valuable contextual or "big picture" information for project planning, watershed analysis, and landscape restoration at these spatial scales.

Based on stated purposes (Jensen and Everett 1994, and references therein; Overbay 1992), ecosystem management activities in the 21st century likely will be motivated by the twin goals of providing goods, services, and values for people while conserving ecological integrity. By "conserving ecological integrity," we mean that ecosystem management designs do not intentionally encumber or minimize the capacity of any ecosystem to maintain its structure and organization through time, especially in the face of natural or human disturbance. And when designs are recognized via monitoring and evaluation that do not conserve integrity, they are quickly replaced with improved designs in a highly adaptive and learning mode. To succeed at ecosystem management, it will be important for land managers to understand the various contexts of ecosystems they will manage. Ecosystem management activities will be centered on accomplishing human goals framed, and to some extent redirected, by those larger ecological contexts. Each watershed and landscape will play a role in some larger context(s).

Forest and rangeland managers throughout the basin will need a repeatable method to (1) accurately diagnose the degree of departure in watershed or landscape pattern conditions from natural or more nearly representative conditions for their specific biophysical environments, and (2) develop management and investment priorities for allocating scarce resources. A mechanism is needed for differentiating high-priority areas from low-priority areas for conservation, rehabilitation, restoration, and production. Departure characterizations, such as we have provided, contribute critical reference information. They do not necessarily provide target or desired future conditions, but they do enable assessment of relative risks associated with greater or lesser departures from more typical or native biophysical environment conditions.

We assume that Forest Service and Bureau of Land Management administrative units within the basin assessment area are interested in evaluating current vegetation conditions within their boundaries to determine whether structure, composition, patterns, and associated disturbance regimes are more or less typical or atypical of what would occur within specific biophysical environments under inherent disturbance regimes. To do that, they must have the ability to differentiate typical from atypical, or more natural conditions from those less so. The diagnostic procedure must be the same for neighboring yet dissimilar watersheds in the same administrative area and for highly similar watersheds in differing administrative areas.

In this midscale assessment, results of change analysis were reported for province-scale ERUs, which offered many challenges in interpretation. High inherent variability of environments pooled at that very large scale masked considerable change, and it often was difficult to determine where sample variation in an ERU ended and change began. Grouping subwatersheds into "subregions" based on similarity of ecological attributes (regionalization) would organize environmental variability, make change detection more transparent, and refine estimates of historical variation in vegetation spatial patterns for each environment.

The basin assessment area contains more than 7,500 subwatersheds, which are not entirely unique. Many share similar biological and physical features such as geology, landform, hydrology, major soil taxa, current and potential vegetation, and climate. From available digital coverages of broadscale potential vegetation and climate attributes, such as mean annual temperature, total annual precipitation, and total annual solar radiation (for example, see Hann and others 1997, Thornton and others 1997), we can group similar subwatersheds in the basin into ecological subregions according to their similar composition of attributes by using a multivariate "fingerprinting" exercise.

Regionalization would employ both agglomerative and divisive analytical procedures, such as hierarchical cluster analysis and two-way indicator species analysis, to obtain and validate groupings. The end result would be a map of all subwatersheds in the basin with each one assigned to a particular ecological subregion. In this context, ecological subregions are comprised of a spatially disjunct population of similar subwatersheds. By grouping subwatersheds in this manner, we assume that vegetation and disturbance patterns are closely linked with climate and environment, and that environmental composition of subwatersheds and other large landscapes can be approximated by potential vegetation and climate attribute fingerprinting.

Once a map of ecological subregions of the basin is created, we can estimate historical variability of conditions within each subregion. The subregion map will provide the needed basis for poststratifying sampled subwatersheds and extrapolating information from sampled subwatersheds of a subregion to other subwatersheds of the same subregion. Because it is difficult and costly to sample historical vegetation structure, composition, and patterns continuously over large geographic areas, and in chronosequence over long historical time frames, we can substitute a sampling of space (that is, we can sample many similar biophysical environments) for a sampling of time (versus repeatedly sampling the same environments over many decades or centuries). If we sample enough areas that are similar in their biophysical features, we should be able to observe a cross-section or range of conditions typical for relatively short historical periods of similar climatic regime (Pickett 1989, and references therein).

We can estimate typical ranges of historical conditions in subregions for patch types, such as physiognomic types, forest and rangeland cover types, structural classes, successional stages, fuel condition classes, crown fire potential classes, fire behavior attribute classes, and insect and pathogen disturbance vulnerability classes. This approach assumes no all-pervasive influence that differs from the historical sample period to the present day. The typical range of historical conditions for subregions could be estimated by using a median 75- or 80-percent range or other similar range metric. We can then summarize the following by ecological subregion: mean, standard error, and range estimates of the historical condition for each patch type; class metrics, such as percentage area, patch density, mean patch size, edge density, and nearest neighbor distance; and other landscape pattern metrics that might be thought essential or informative.

Information on the range of condition can be used to diagnose departure in conditions of any subwatershed within an ecological subregion. It is desirable to develop range-of-condition information for the earliest historical conditions obtainable, because these are conditions under which large land areas were least affected by management during any observable period, and area and connectivity relations of patch types will likely be more rather than less typical of what would normally occur in each biophysical setting under a similar climatic regime.

Additional Validation and Research

To complete the landscape characterizations and analyses reported here, various methods were used. Some were tried and true, others were based on published theory or related applications, and still others were based partially on established literature and empirical study and partially on field experience and judgment. We believe that efforts to assess and refine the accuracy of raw and derived data and to validate new models and maps generated by this study would give us and the agencies benefitting directly from this work improved insight into the reliability of our characterizations and findings and provide tremendous future benefits for landscape analysis.

Validation—On this project, time and financial resources were severely constrained, and efforts were minimized to field verify interpreted attributes. This was done to meet short timelines and control costs but at the potential expense of reliability. We made every attempt to ensure quality and reliability in our data capture; to check for errors in remotely sensed raw attributes as vegetation coverages were assembled and as new attributes were derived; to check for errors in programs, scripts, and analysis protocols; and to run routine error checks for inconsistencies and miscalculations. Despite these efforts, we were unable to conduct field accuracy assessments of raw and derived attributes because of constraints. We believe that our data and methods are acceptably reliable, but the reliability of each should be evaluated. To that end, we suggest the following as priority validation needs:

- Assess the accuracy of the following abridged list of photointerpreted forest patch attributes: total and overstory crown cover, canopy layers, riparian and wetland status, visible logging entry, overstory and understory size class, overstory and understory species, and dead tree and snag abundance; and nonforest attributes: nonforest overstory species, overstory crown cover, and tree and shrub cover of herbland and shrubland types.

- Assess the accuracy of derived forest and range cover types, structural classes, and potential vegetation types; correct classification errors and revise map coverages as needed.
- Field verify by random sampling the patch vulnerability values for each insect and pathogen disturbance modeled, fuel conditions, and potential fire behavior and smoke production attributes (see Ottmar and others, in prep.).

Vegetation research—To develop vegetation management strategies (including no active management) and activities for ecosystems that conserve native species and natural processes and their effects, resource managers will need to be knowledgeable of the ecological ramifications of natural and management disturbances on landscape patterns and processes. Future Forest Service and Bureau of Land Management project planning may call for more intensive ecological characterization of planning areas than has occurred previously.

This study is a first attempt at a midscale ecological assessment of the basin. It represents a first characterization of the historical range variability of ERUs, and a first characterization of recent departure of forest and rangeland vegetation patterns and forest vulnerability to insect and pathogen disturbances. At the close of the study, many basic and applied research questions remain unanswered. Further analysis of this landmark data set will reveal new information useful to conservation and management of basin ecosystems. We propose the following additional research that can be accomplished by building on databases and models established through this study:

- Develop an ecological regionalization of all subwatersheds in the basin. Ecological subregions would provide a powerful basis for extrapolating information on reference conditions and a much improved basis for change detection analysis in either assessment or monitoring modes.
- Compute ranges of historical structure, composition, pattern, and disturbance vulnerability conditions for each ecological subregion.
- Evaluate through similarity analysis, structural and compositional change of current and historical subwatershed pairs to detect significant compositional change and determine direction and magnitude of change.
- Evaluate average similarity among all subwatershed pairs at several pooling scales, and test for differences between average historical and average current similarity to detect compositional trend of subwatersheds within a pooling stratum.
- Use compositional attribute data from the similarity analysis, above, to ordinate (DECORANA or CANOCO) and graphically display patterns of change in attribute space.
- Examine and contrast variation in landscape patterns and disturbance processes by PVT, topographic and physiographic setting, and management history.
- Evaluate pathways of vegetation change at a subregion scale, through detailed analysis of change in structure and composition and by using transition analysis, to improve predictive modeling of future landscape change.
- Evaluate the effects of recent change in spatial patterns of composition and structure on spatial patterns of vulnerability to insect, pathogen, and fire disturbances.
- Develop reliable, continuous, field-verified, midscale (1:24,000) ecological land unit and PVT maps for public lands in the basin.
- For ecological subregions, classify habitat values of cover-structure patch types for all historical and current subwatershed pairs, initially for threatened, endangered, sensitive, and candidate species and other terrestrial species where habitat and environmental correlations are reasonably well established. Use habitat and environmental correlates associated with other midscale GIS map coverages as needed to complete the classifications. For all pairs of midscale subwatersheds, evaluate and report trends

in area and connectivity of habitats. Quantify effects of predicted habitat changes on wildlife species diversity during the sample period. Correlate predicted results with known status of species, especially currently listed and candidate species.

- For ecological subregions, use historical and current subwatershed vegetation conditions and associated vulnerabilities to insect, pathogen, and fire disturbances as a basis for evaluating risks associated with alternative landscape configurations or desired future conditions. Rank subwatershed conditions within each subregion according to their risk of crown fires, disease, and insect disturbance vulnerabilities. This would be especially useful to land management planning, watershed assessment, and project planning efforts.
- Develop reliable, continuous, field-verified, midscale (1:24,000) fire regime maps for ecological and units of the basin, and link map units with potential fire behavior and smoke emissions information. Correlate fire regimes with biophysical environmental characteristics and potential vegetation.
- Assess the relative contribution of social and biophysical factors to landscape change. Also assess interactions among factors by relating landscape changes, their biophysical settings, or individually significant ecosystem elements to social and biophysical drivers of change. Significant ecosystem elements can be those things people care a great deal about, elements important to a great many species, or elements that have experienced great change and are particularly vulnerable to more change.
- Determine the best approaches for extrapolating broadscale (Hann and others 1997) and midscale landscape data from place to place. For example, determine the extent to which broadscale coverages can be used to guide extrapolation from one place to the next at the midscale, and the extent to which midscale coverages help to interpret past changes and vulnerability to future changes in project areas at the fine scale.
- Examine alternative approaches to characterizing natural or historical range variability in vegetation spatial patterns.
- Examine the geographical and biophysical settings of nonforest types to determine why some settings and types appear to be more prone than others to change.
- Develop alternative methods for characterizing the spatial distribution, predictability, area, and synergism among disturbance regimes and patch dynamics that incorporate (1) the different agents of disturbance, their interactions, their spatial patterning and extent; (2) disturbance effects on species richness, the distribution of dominance, community structure, and genetic diversity; (3) effects on filling and change within disturbed and undisturbed patches; (4) relations among patches of a given type and the matrix; and (5) flows of organisms, materials, and energy among patches (refer to the rich theoretical foundation developed in Pickett and White [1985]).
- Use these midscale data to validate and extend the utility of vegetation and disturbance dynamics simulation models such as CRBSUM (Keane and others 1996). The CRBSUM model already has a framework for simulating the effects of multiple agents of disturbance on landscape patterns and could be readily extended to include contagious spread and other spatial characteristics of disturbance, particularly if midscale vegetation change results were used to develop and test the new subroutines and related hypotheses.

Insect and pathogen research—For human valuation of ecosystem status, forest insect and pathogen disturbances can be viewed as producing favorable or unfavorable results. From the standpoint of ecological structures and functioning, disturbances at one level may provide great variety in living and dead structure, and the agents themselves are the key to many vital future processes. At a much higher level of disturbance, structure and process needs may be more than satisfied at the expense of other forest values important or essential to human needs.

In recent decades, resource managers have attempted to actively manipulate stand- and landscape-level insect and disease conditions (that is, the amount of insect or pathogen disturbance they wanted to allow) by using direct suppression and prevention strategies. Suppression activities typically employed chemical insecticides or biological control agents such as bacteria or viruses; prevention was accomplished through silvicultural manipulations of stand-level species composition and structure.

Little attention has been given to landscape vegetation patterns, processes, organisms, and interactions whose function is to naturally regulate disturbances and the agents responsible for them. For example, fires historically played a key role in regulating the density and composition of forests, especially dry and mesic forests. Fires were directly involved in determining where shade-tolerant true firs and Douglas-fir would typically grow, thereby shaping the population dynamics and disturbance regime characteristics of forest insects such as the western spruce budworm and the Douglas-fir tussock moth. Fires of varying intensity and extent determined, by influencing the landscape patterns of hosts, where *Armillaria* laminated root rot, and S- and P-group annosum root diseases played a significant role in snag production, canopy gap development, and coarse wood recruitment.

In addition, many forest insects and pathogens capable of altering forest structure and composition have numerous natural enemies, and little is known of the environmental factors, patch-scale vegetation conditions, and landscape patterns favoring their survival and prosperity. Critical gaps exist in our knowledge of (1) insect and pathogen population dynamics under managed, unmanaged, and "natural" conditions; (2) regulatory processes, organisms, and interactions associated with natural insect and pathogen disturbances; (3) interactions among insect, pathogen, and fire disturbance processes, climate, and management activities; and (4) functional roles of insects and pathogens under managed, unmanaged, and "natural" scenarios. Important research emphases follow:

- Develop decision-support tools for stand and landscape management to predict insect and pathogen responses to natural and management disturbances.
- Survey the natural enemies of native and important nonnative pathogens and insects. Learn their habitat requirements, associations, and responses to changing landscape patterns and environments; study immigration and emigration processes, and habitat and environmental constraints.
- Examine the community ecology of native and important nonnative insects and pathogens in each of the major forest plant associations. Discover changes in functional roles and dynamics along various successional trajectories.
- Study the functional roles of the major native and important nonnative root pathogens, dwarf mistletoes, bark beetles, defoliators, stem decays, and rusts in (1) forest succession, (2) wildlife habitat development, (3) coarse wood recruitment, and (4) carbon and nutrient cycling in each of the major plant associations of the basin.
- Experimentally examine options for developing replacement wildlife microhabitat structures by using native organisms and microbial successional processes in areas currently depauperate of such structures (Parks and others 1996a, 1996b).
- Study the effects of the more extreme oscillations in climatic conditions on native insect and pathogen population dynamics and associated disturbances for major plant-association groups of the basin. Learn also how such oscillations affect their natural enemies.
- For each of the major plant-association groups and their successional communities, study the effects of conventional management practices on insect and pathogen populations and their natural enemies.

- Evaluate conventional and new management techniques to determine the extent to which each can be used to modify forest structure and composition (living and dead), while the beneficial roles of pathogens and insects and their natural enemies are maintained and long-term adverse effects on soils, streams, and native species diversity are minimized.

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Conclusions

The primary utility of landscape assessments and change analysis summaries is in understanding the characteristics of ecosystems that we manage (Morgan and others 1994). Knowledge of landscape pattern change at regional, provincial, and subregional scales provides critical context for regional and forest planning and watershed analysis and project-level planning, and valuable insight for ecological restoration, conservation, and monitoring decisions and activities. Summaries of landscape pattern change provide answers to simple but vital questions, such as How important is the type and degree of change noted in one place relative to the broader picture? or How important is a particular patch type (for example, ponderosa pine-old forest, single story) within a given watershed, subbasin, or subregion? Landscape change analysis provides an essential empirical basis to evaluate the historical and current rarity of landscape pattern features and is an aid in determining how representative current patterns are in comparison with recent historical conditions.

The basin assessment area is large, and we have summarized a great many changes in vegetation condition and associated change in vulnerability to insect and pathogen disturbances. Ottmar and others (in prep.) will similarly summarize change in fire behavior attributes and potential smoke emissions associated with these same vegetation changes. But here we will focus on some of the most important generalities lest we lose them in a sea of detail.

Most dramatic of all changes in physiognomic conditions was the across-the-board regional decline in shrubland area. The greatest declines were to colline and montane low-medium shrub cover types in both open and closed structural conditions. Losses of native shrublands resulted from a variety of factors, including forest and woodland expansion as observed in the Blue Mountains and Northern Great Basin ERUs, cropland expansion as in the Northern Great Basin ERU, and conversion to seminative and nonnative herbland as in the Owyhee Uplands, Snake Headwaters, and Southern Cascades ERUs. Loss of historical dry herblands to agriculture was equally dramatic but had already been sustained by the start of our historical vegetation coverage (Hann and others 1997). During our sample period, herbland area actually increased modestly, but most increase was in the form of seminative or nonnative herbland, and it was to the detriment of native shrublands.

Forest cover increased substantially in several ERUs at the expense of shrubland and herbland, and woodland cover rose sharply in all ERUs where woodland was more than a minor physiognomic condition. It was clear that the distribution of forest and woodland physiognomies had been altered and that this change could be observed at subwatershed to regional scales; our results indicated that direct fire suppression, indirect exclusion of fire, and domestic livestock grazing were primary influences.

Predicted shifts from early to late seral species were evident in many ERUs. Most of the observed change in ponderosa pine, western larch, and Douglas-fir cover was associated with decline in area and connectivity of patches with medium and large trees of these species. We also observed precipitous decline in area and connectivity of western white pine cover in northern Idaho and northwestern Montana, the heart of the historical range. Loss of white pine cover was attributable to early selective and regeneration harvesting and mortality associated with white pine blister rust infection and mountain pine beetle infestation.

Overstories and understories comprised of shade-tolerant species were evident in many forested ERUs; across the basin, forests are now more contagiously dominated by shade-tolerant conifers than was true in the historical condition. Lacking significant forest pattern restoration, we can expect that insects and pathogens (for example, the western spruce budworm, Douglas-fir tussock moth, fir engraver, Douglas-fir dwarf mistletoe, *Armillaria* root disease, and S-group annosum root disease) favored by increased areal extent and contiguity of patches of shade-tolerant conifers will have an expanding role in shaping forest patterns by their direct disturbance influence, via mortality inputs, and by indirect but substantial influence on fire regimes.

Area in old-forest structures declined sharply in all forested ERUs where they historically occupied more than a minor area. The same was true of remnant large trees associated with structural classes other than old forest. But when we evaluated change in area with medium and large trees, regardless of their structural affiliation (tables 20 and 21), we observed what we believe was the most important change in structure in several ERUs. In the Blue Mountains, Northern Cascades, and Upper Klamath ERUs, decline in area with medium and large trees both overshadowed and augmented losses to historical old-forest area.

Our results suggested that 20th-century timber harvest activities did not target old forest; instead, timber harvest targeted medium- and large-sized trees regardless of their structural affiliation. They were most economical to harvest and most accessible, sawmills were tooled to handle them most efficiently and economically, and timber sales were most viable when offered volumes were in the form of medium and large trees. Our results indicated that medium and large trees were harvested wherever they stood; they were often but not always associated with old forest.

There are at least two important ramifications of this observation. First, it has been broadly assumed by forest managers and ecologists alike, that large trees are principally associated with old forest, where they obviously contribute important living and dead structure. But our results indicate that large (and medium) trees were, in several ERUs, widely distributed in other forest structures as a conspicuous remnant after stand-replacing disturbance. In some cases, large trees comprised as much as 24 percent of the crown cover of forest structures that were not old and, although subordinate to other features, contributed important living and dead structure. Hence, many non-old-forest structures of historical forest landscapes contributed some measure of late-successional functionality and connectivity with old forest. Second, in those ERUs where old-forest area and area with large trees has been depleted, the present and future supply of medium and large dead trees as snags and down logs has been substantially diminished. This is especially true of snags and down logs of early seral species, such as ponderosa pine, western larch, Douglas-fir, western white pine, and sugar pine—all preferred commercial species that have been the primary focus of 20th-century harvest activities. Owing to the magnitude of the deficit, it is likely that terrestrial and aquatic species and ecological processes requiring medium and large dead tree structure may be adversely influenced by this current and future reduction, unless steps are taken to remedy the shortfall through replacement.

Along with reduced area containing large overstory trees, we observed a marked reduction in landscape vulnerability to dwarf mistletoes of early seral species such as ponderosa pine and western larch. It was generally apparent from comparisons of historical and current subwatersheds that timber harvest reduced or eliminated overstory crown cover of large trees of early seral species while one or more (often shade-tolerant) coniferous understory strata developed.

As expected, we observed that area in stand-initiation (new forest) structures dramatically declined in several ERUs (Central Idaho Mountains, Lower Clark Fork, Northern Glaciated Mountains, and

Upper Clark Fork) where stand-replacing fires once were relatively common events. Such reduction was evident despite widespread timber harvest activity. Along with declining area in stand-initiation and old-forest structures, we observed sharply increased area and connectivity of intermediate forest structure, including stem-exclusion, understory reinitiation, and young multistory structures, across the basin.

Results from nearly all forested ERUs indicated that the absence of fire by direct suppression or exclusion has had profound effects on forest and woodland area and connectivity at subwatershed to regional scales. The history and legacy of fire suppression and prevention programs is well documented, but the effect of fire exclusion has been more difficult to pin down because many interacting factors played a role in excluding fire from fire-dependent ecosystems. As a result, it is possible and even likely that the efficacy of fire prevention and suppression programs has been overstated, and the role of factors responsible for exclusion of fire has been understated. Key factors responsible for fire exclusion were the widespread elimination of flashy fuels through extensive domestic livestock grazing and overgrazing, especially in the first half of the 20th century (Hann and other 1997, and references therein; Skovlin and Thomas 1995; Wissmar and others 1994a, 1994b); reduced connectivity of fire-prone landscapes through placement of extensive road networks; settlement of fire-prone interior valleys and subsequent conversion to agriculture by European immigrants; and the movement onto reservations of Native Americans, who frequently used fire as a management tool (Robbins and Wolf 1994, Woods and Horstman 1996).

Many direct effects of fire exclusion and fire suppression were observed in our results. In appendix 2 and figure 25, we show increased area and connectivity of forest and woodland physiognomies. Total forest and woodland crown cover increased in many forested ERUs (table 22 and fig. 39), as did area with more than two canopy layers (table 23 and fig. 40). Area with conifer understories increased (table 25), especially area with shade-tolerant conifer understories (table 24 and fig. 41).

Throughout the basin, current forests and rangelands are more fragmented than were landscapes of our historical condition. Whether patch types are cover types, structural classes, or cover type-structural class couplets, patch densities are now higher, mean patch sizes are smaller, the largest patch of any given cover type or structural class is generally smaller, and edge density is greater. These combined outcomes point to landscape fragmentation and reduced patch type connectivity, primarily as a consequence of timber harvest activities and road construction. Contagion, interspersion, and juxtaposition metrics displayed in table 19 confirm the presence of highly fragmented landscapes in the current condition and point to increased complexity in managed landscape patterns. The converse appears to be true in roadless area and wilderness-dominated subwatersheds, where patch type connectivity generally increased and landscape patterns were simplified.

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Task 1—Delineation of subwatersheds and watersheds within subbasins.

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English Conversions

When you know:	Multiply by:	To obtain:
centimeters	0.3937007874	inches
meters	3.280839895	feet
meters	0.04970960	chains
square meters	0.0002471054	acres
kilometers	0.6213711922	miles
square kilometers	247.1054	acres
hectares	2.471054073	acres

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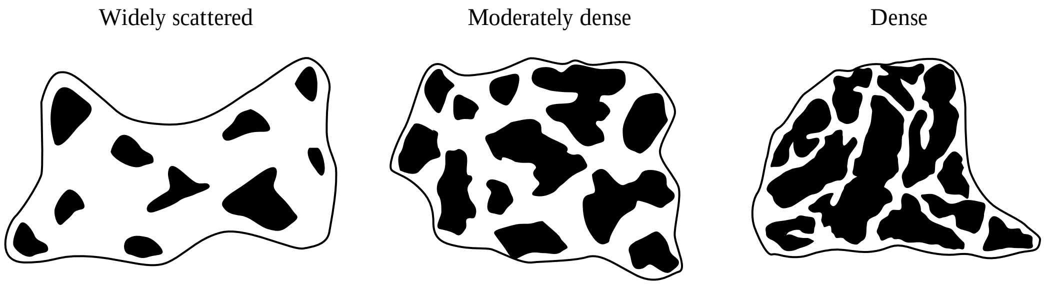
Appendix 1

Attributes of Forest and Nonforest Patches

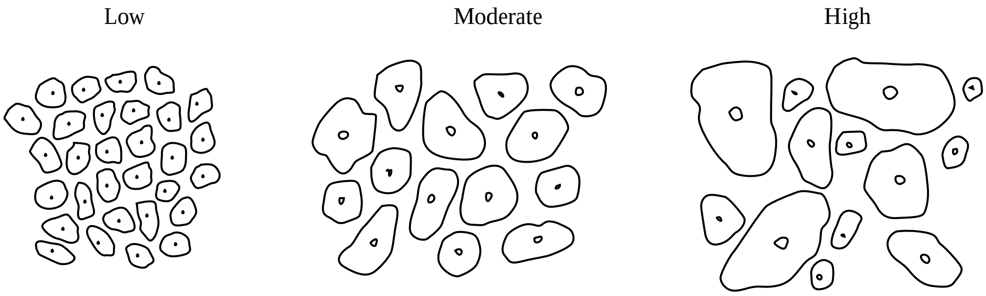
The following describes the attributes of forest and nonforest patches interpreted from aerial photographs in the midscale ecological assessment of the interior Columbia River basin.

Total crown cover and overstory crown cover—Total and overstory forest crown cover were estimated to the nearest 10 percent for all forest patches. Forest patches were defined as having at least 10 percent of their patch area under a forest canopy. A new patch was delineated by total crown cover alone when two adjacent patches similar in all attributes differed in average total crown cover by at least 20 percent.

Clumpiness—This term refers to the horizontal "patchiness" of tree cover within a patch. Patches were rated as (1) clumpy—yes or no; (2) if clumpy, clump distribution was widely scattered, moderately dense, or dense (see below); and (3) average clump size was < 0.4 ha, 0.4 to 2.0 ha, or > 2.0 ha, but < 4.0 ha.



Crown differentiation—Degree of differentiation among overstory tree crowns was estimated as low (< 30 percent difference), moderate (30 to 100 percent difference), and high (> 100 percent difference). Visual templates are shown.



Canopy layers—Canopy layers were estimated as 1, 2, or > 2 layers visible.

Riparian or wetland—These terms indicated whether a patch resided within a riparian or wetland setting and was used in conjunction with overstory vegetation to estimate forest and nonforest riparian and wetland area.

Nonforest type—A vegetation patch was interpreted as nonforest when total crown cover was < 10 percent. Categories were rock, water (lake or pond), wet meadow or marsh (soils saturated year-round), alpine meadow, dry meadow (soils saturated seasonally), grasses or forbs after logging, shrubland (with at least 5 percent shrub canopy cover), bare ground (burned or logged), bare ground (from slumps or erosion), agriculture cropland, urban or rural development, pasture (irrigated grasses or forbs), grassland (with at least 20 percent canopy cover), woodland (< 10 percent total crown cover and at least two trees per acre), bare ground (from roadcuts or sidecast adjacent to highways), stream channel and nonvegetated flood plains, grass or forbs after wildfire, sand dune, glacier, and bare ground (dry lake beds, playa).

Visible logging entry—Visible logging was interpreted as no logging apparent, regeneration harvested (clearcut, shelterwood, seedtree), selection harvested (overstory removal, final removal, selective harvest), thinned (commercial or precommercial), or patch clearcut (clearcut patches were < 4 ha). If patch clearcut, we estimated the percentage of patch area in clearcut patches to the nearest 10 percent.

Overstory and understory tree size classes—Tree sizes were estimated as seedlings and saplings (< 12.7 cm d.b.h.), poles (12.7 to 22.6 cm d.b.h.), small trees (22.7 to 40.4 cm d.b.h.), medium trees (40.5 to 63.5 cm d.b.h.), and large trees (> 63.5 cm d.b.h.).

Overstory and understory species—Dominant overstory and understory species were recorded. To be named as an overstory species in pure or mixed compositions, a species comprised at least 20 percent of the basal area. To be named as an understory species in pure or mixed compositions, a species comprised at least 20 percent of the trees per hectare.

Primary overstory species or species mixes were ponderosa pine; western larch; lodgepole pine; Douglas-fir; grand fir or white fir, or both; Pacific silver fir; subalpine fir or Engelmann spruce, or both; western hemlock or western redcedar, or both; mountain hemlock; whitebark pine or subalpine larch, or both; western white pine or sugar pine; hardwoods (Oregon and Washington subbasins only); juniper; noble fir; Shasta red fir; ponderosa pine and sugar pine; ponderosa pine and Douglas-fir; Douglas-fir and mountain hemlock; lodgepole pine and Engelmann spruce; mountain hemlock and white fir; Douglas-fir and Engelmann spruce; incense-cedar; western larch and lodgepole pine; Douglas-fir and western larch; limber pine; blue spruce; pinyon pine; white spruce; maple; birch; aspen; cottonwood; Douglas-fir and limber pine; pinyon pine and juniper; Douglas-fir and western white pine; grand fir and western white pine; subalpine fir and western white pine; western larch and western white pine; western larch, lodgepole pine, and western white pine; western larch and ponderosa pine; western larch and Engelmann spruce; lodgepole pine and subalpine fir; lodgepole pine and Douglas-fir; lodgepole pine and grand fir; subalpine fir and limber pine; grand fir and Engelmann spruce; Douglas-fir and aspen; lodgepole pine and aspen; subalpine fir and Douglas-fir; grand fir and ponderosa pine; grand fir and subalpine fir; grand fir and western larch; Russian olive; subalpine fir and whitebark pine.

Primary understory species or species mixes were ponderosa pine; western larch and lodgepole pine; Douglas-fir or grand fir or white fir or Pacific silver fir, or combinations; western hemlock or western redcedar, or both; mountain hemlock; subalpine fir or Engelmann spruce, or both; hardwood (Oregon and Washington subbasins only); juniper; grasses and forbs; shrubs; bare ground; lodgepole pine; ponderosa pine and lodgepole pine; ponderosa pine and Douglas-fir; grand fir or white fir; mountain hemlock and white fir; mountain hemlock and lodgepole pine; Douglas-fir and mountain hemlock; lodgepole pine and Engelmann spruce; whitebark pine or subalpine larch, or both; Shasta red fir; incense-cedar; western white pine; Douglas-fir and western larch; Douglas-fir and Engelmann spruce; limber pine; blue spruce; pinyon pine; white spruce; maple; aspen; cottonwood; Douglas-fir and limber pine; lodgepole pine and Douglas-fir; beargrass; and Pacific silver fir.

Dead trees and snags—Dead tree and snag abundance was estimated as none apparent, < 10 percent of trees dead, 10 to 39 percent of trees dead, 40 to 70 percent of trees dead, and > 70 percent of trees dead.

Elevation zones of nonforest types—Elevation zones were interpreted as colline (below lower timberline); lower montane (above lower timberline but not including such forest types as subalpine fir, lodgepole pine, Engelmann spruce, mountain hemlock, Pacific silver fir, noble fir, or Shasta red fir); upper montane (below upper timberline and including the forest types listed immediately above); subalpine (above upper timberline but with trees as islands or krummholz); and alpine (above upper treeline).

Nonforest overstory species—Dominant herbland and shrubland overstory species were recorded. The primary species groups were native bunchgrasses (for example, wildrye, bluebunch wheatgrass, Idaho fescue, alkali grass, bottlebrush squirreltail); annual grasses (for example, cheatgrass, medusahead); seeded wheatgrasses (for example, crested wheatgrass, other seeded dryland grasses); exotic forbs (for example, spotted knapweed, yellowstar thistle, leafy spurge); native moist site herbs (for example, sedges, rushes); low sagebrush (for example, low sagebrush, salt desert shrub); low alpine shrubs (for example, meadow heathers); sagebrush and bitterbrush (for example, basin big sagebrush, Wyoming sagebrush, mountain big sagebrush, silver sagebrush, bitterbrush, rabbitbrush); mahoganies (for example, mountain and curlleaf mahoganies); mountain shrubs (for example, serviceberry, rose, snowberry, Rocky Mountain maple, Scouler's willow, buffaloberry, chokeberry, bittercherry); wet site shrubs (for example, willow, alder, bog birch, dogwood); and beargrass.

Overstory canopy cover nonforest types—Canopy cover of herbland and shrubland patches was estimated to the nearest 15 percent. A new patch was delineated by canopy cover alone when two adjacent patches were similar in all attributes and differed in average total canopy cover by at least 15 percent. Cover classes were estimated as 0 to 15 percent canopy cover, 16 to 33 percent cover, 33 to 66 percent cover, and > 66 percent cover.

Tree cover of herbland and shrubland types—Tree cover was identified, where present, in herbland and shrubland patches.

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Appendix 2

Table 32—Historical and current percentage of area, patch density, and mean patch size for physiognomic types, cover types, and structural classes of sampled subwatersheds in the ERUs of the midscale ecological assessment of the interior Columbia River basin

	Trend[a]		Area			Patch density			Mean patch size		
Ecological reporting unit	Area	Con.[b]	H[c]	C	MD[d]	H	C	MD[d]	H	C	MD[d]
			------- *Percent* -------			*No./10 000 ha*			------- *Hectares* -------		
Blue Mountains ERU:											
Physiognomic types—											
Forest	+	nc	62.8	64.1	1.4*	9.3	137.6	-0.3	1984.3	1925.0	-59.3
Woodland	+	+	2.7	4.2	1.6*	5.9	6.2	0.3	17.4	29.8	12.5*
Shrubland	-	nc	14.1	10.7	-3.4*	7.9	7.9	0.0	128.0	90.3	-37.6
Herbland	nc	+	17.4	18.0	0.6	24.0	28.8	4.8*	89.5	103.8	14.3
Other[e]	nc	+	3.0	2.9	-0.1	5.5	4.6	-0.9*	37.7	45.9	8.2
Cover types-forest and woodland—											
Grand fir-white fir	-	-	15.3	8.4	-6.9*	8.0	11.0	3.0*	136.2	54.7	-81.5*
Engelmann spruce-subalpine fir	-	-	6.3	4.4	-1.9*	2.3	3.8	1.5*	64.8	40.0	-24.8*
Aspen-cottonwood-willow	nc	nc	0.1	0.1	0.0	0.3	0.4	0.1	4.7	3.1	-1.6
Juniper	+	+	2.7	4.2	1.5*	5.8	6.3	0.5	17.6	29.6	12.0*
Western larch	nc	-	2.6	2.2	-0.4	3.8	7.8	4.1*	21.2	15.8	-5.4
Whitebark pine-subalpine larch	+	+	0.0	0.7	0.7*	0.0	0.4	0.4*	0.0	15.9	15.9*
Lodgepole pine	nc	nc	2.4	2.3	-0.1	4.6	5.6	1.0	29.1	29.1	0.0
Limber pine	nc	nc	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	-0.6
Ponderosa pine	nc	-	28.4	28.9	0.5	12.2	24.0	11.8*	419.5	428.6	9.1
Douglas-fir	+	+	7.7	17.1	9.4*	11.7	20.6	8.9*	54.4	107.7	53.3*
Cover types-shrubland—											
Colline low-medium	-	-	7.2	4.7	-2.5*	2.0	266.4	264.7*	116.9	2.7	-114.2*
Montane low-medium	nc	-	6.0	5.4	-0.6	4.8	5.0	0.2	47.7	32.3	-15.4*
Montane mahogany	-	nc	0.4	0.2	-0.1*	1.2	0.9	-0.3*	6.4	4.4	-2.0
Colline tall	nc	nc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3
Montane tall	-	nc	0.1	0.0	-0.1*	0.5	0.2	-0.4*	3.3	2.7	-0.6
Colline wet-site	nc	nc	0.0	0.1	0.0	0.1	0.2	0.1*	1.9	2.3	0.4
Montane wet-site	nc	nc	0.1	0.1	0.0	0.8	0.5	-0.3	4.0	5.4	1.4
Cover types-herbland—											
Alpine	nc	nc	0.1	0.2	0.2	0.3	0.7	0.4*	2.9	2.3	-0.6
Dry-meadow	-	-	6.2	5.3	-0.9*	11.0	14.6	3.7*	24.5	24.6	0.2
Colline bunchgrass	nc	+	3.9	4.6	0.7	1.6	1.0	-0.6*	83.7	146.7	63.0*
Montane bunchgrass	nc	-	3.4	3.5	0.1	5.9	8.4	2.5*	27.4	23.5	-3.9
Colline exotic grasses-forbs	+	+	0.3	1.3	1.0*	0.6	0.4	-0.2	6.3	34.4	28.1*
Montane exotic grasses-forbs	nc	nc	1.3	1.2	-0.1	2.8	3.4	0.6	17.5	20.5	3.0
Colline moist-site	nc	nc	0.1	0.0	0.0	0.1	0.0	-0.1	6.5	2.6	-4.0
Montane moist-site	-	nc	0.7	0.5	-0.2*	2.7	2.1	-0.6	9.4	8.5	-0.9
Wet-meadow	-	-	0.2	0.0	-0.2*	0.5	0.1	-0.4	3.6	0.2	-3.4*
Postlogging grasses-forbs	+	-	0.0	0.1	0.1*	0.1	5.7	5.6*	1.8	0.1	-1.8*

Table 32—(continued)

Ecological reporting unit	Trend[a] Area	Trend[a] Con.[b]	Area H[c]	Area C	Area MD[d]	Patch density H	Patch density C	Patch density MD[d]	Mean patch size H	Mean patch size C	Mean patch size MD[d]
			------- *Percent* -------			*No./10 000 ha*			------- *Hectares* --------		
Cover types-agriculture-urban rural—											
Cropland	-	-	2.3	1.8	-0.5*	3.2	1.7	-1.6*	34.7	33.7	-1.0
Pasture	nc	+	1.0	1.0	0.0	1.0	0.7	-0.3*	25.1	50.3	25.2
Urban-rural	nc	nc	0.1	0.1	0.0	0.2	0.2	0.0	4.4	4.1	-0.3
Cover types-other—											
Bare ground-road	nc	nc	0.0	0.0	0.0	0.0	0.1	0.0	0.6	0.3	-0.3
Rock	nc	nc	0.6	0.7	0.1	1.6	1.6	0.0	9.3	8.9	-0.4
Postlogging-bare ground-burned	+	+	0.0	0.3	0.6*	0.0	0.7	0.7*	5.3	10.5	5.2
Postlogging-bare ground-slumps-erosion	nc	nc	0.1	0.0	-0.1	0.1	0.1	-0.1	3.3	0.7	-2.7
Stream channel-nonvegetated flood plain	nc	nc	0.0	0.0	0.0	0.1	0.1	0.0	0.6	0.4	-0.2
Water	nc	+	0.1	0.1	0.0	0.4	0.4	0.0	7.8	10.7	2.9*
Structural classes-forest—											
Stand initiation	+	+	3.9	6.5	2.6*	10.2	17.9	7.7*	34.1	41.8	7.6
Stem exclusion, open canopy	-	-	14.3	9.6	-4.7*	29.6	25.7	-3.9*	51.5	41.5	-10.0*
Stem exclusion, closed canopy	nc	nc	5.0	5.0	0.0	10.3	10.7	0.4	48.4	43.2	-5.3
Understory reinitiation	-	nc	13.6	11.2	-2.4*	15.7	16.8	1.0	90.8	83.5	-7.3
Young, multistory	+	nc	21.3	29.6	8.2*	25.9	27.8	1.9	112.3	130.5	18.2
Old, multistory	-	-	2.2	1.0	-1.3*	4.1	2.8	-1.3*	33.6	16.8	-16.8*
Old, single story	-	-	2.7	0.9	-1.7*	4.9	2.4	-2.5*	31.1	17.8	-13.3*
Structural classes-woodland—											
Stand initiation	nc	nc	0.0	0.1	0.0	0.2	0.1	0.0	1.5	4.0	2.6
Stem exclusion	+	+	2.4	4.0	1.6*	4.8	6.0	1.2*	14.9	28.6	13.7*
Understory reinitiation	nc	-	0.3	0.2	-0.1	1.3	0.5	-0.8*	9.7	4.6	-5.1*
Old, multistory	nc	nc	0.0	0.0	0.0	0.0	0.1	0.1	0.2	1.2	0.9
Structural classes-shrubland—											
Open low-medium	-	-	11.0	8.3	-2.7*	7.0	6.4	-0.6	96.6	61.0	-35.6
Closed low-medium	nc	-	2.3	1.8	-0.4	3.4	3.0	-0.4	19.8	12.1	-7.7*
Open tall	nc	nc	0.5	0.4	0.0	1.6	1.4	-0.2	9.9	12.4	2.4
Closed tall	nc	-	0.2	0.1	-0.1*	1.2	0.5	-0.7*	4.5	2.1	-2.4*
Structural classes-herbland—											
Open	+	+	6.4	8.5	2.1*	7.6	9.8	2.2*	40.8	67.3	26.6*
Closed	-	nc	3.2	2.5	-0.7*	5.1	3.9	-1.2	33.2	31.0	-2.2
Structural classes-other[e]—											
Nonforest-nonrange	-	-	11.1	10.0	-1.1*	17.2	21.1	3.9*	74.5	69.0	-5.5

Table 32—(continued)

Ecological reporting unit	Trend[a] Area	Trend[a] Con.[b]	Area H[c]	Area C	Area MD[d]	Patch density H	Patch density C	Patch density MD[d]	Mean patch size H	Mean patch size C	Mean patch size MD[d]
			------- *Percent* -------			*No. /10 000 ha*			------- *Hectares* -------		
Central Idaho Mountains:											
Physiognomic types—											
Forest	nc	+	73.4	73.5	0.2	7.7	8.1	0.4	2983.7	3457.6	474.9*
Woodland	nc	nc	0.1	0.0	0.0	0.3	0.4	0.0	0.3	0.3	-0.1
Shrubland	-	nc	19.2	17.1	-2.0*	13.4	14.7	1.3	218.6	158.3	-60.3
Herbland	+	-	3.2	4.5	1.0*	9.0	13.7	4.7*	42.4	37.3	-5.1
Other[e]	+	nc	4.2	4.9	1.0*	12.4	13.8	1.4	32.2	39.3	7.0
Cover types-forest and woodland—											
Grand fir-white fir	nc	nc	9.6	10.2	0.5	4.5	5.6	1.2	213.2	75.0	-138.2
Engelmann spruce-subalpine fir	nc	nc	22.7	24.1	1.4	13.0	14.4	1.4	231.1	350.5	119.4
Aspen-cottonwood-willow	nc	-	1.1	0.8	-0.2	1.8	2.4	0.6*	11.0	11.2	0.2
Juniper	nc	nc	0.1	0.0	0.0	0.3	0.4	0.0	0.3	0.3	-0.1
Western larch	nc	nc	0.5	0.3	0.0*	1.3	1.5	0.2	14.6	6.0	-8.6
Whitebark pine-subalpine larch	-	nc	5.1	2.5	-2.5	5.2	5.6	0.4	170.8	18.3	-152.6
Lodgepole pine	nc	-	9.7	9.5	-0.2	12.2	14.6	2.4*	53.6	47.5	-6.0
Limber pine	nc	nc	0.4	0.4	-0.1	0.7	0.4	-0.3	1.4	1.8	0.5
Ponderosa pine	nc	-	6.0	5.9	-0.2	3.7	4.9	1.2*	48.7	39.8	-8.9*
Douglas-fir	nc	+	17.6	18.5	1.0	16.0	19.2	3.2*	118.0	138.6	20.5
Western hemlock-western redcedar	nc	-	0.9	1.3	0.4	0.7	1.1	0.4*	10.4	8.4	-1.9*
Mountain hemlock	nc	+	0.0	0.0	0.0*	0.0	0.2	0.2*	0.3	1.1	0.8
Cover types-shrubland—											
Colline low-medium	nc	-	8.2	8.0	-0.3	1.3	571.5	570.2*	186.4	5.7	-180.7*
Montane low-medium	nc	nc	5.3	4.9	-0.4	6.4	7.0	0.6	32.5	46.8	14.3
Subalpine-alpine low-medium	nc	nc	0.5	0.4	-0.1	1.2	1.8	0.6	11.7	8.3	-3.4
Colline mahogany species	nc	nc	0.0	0.0	0.0	0.1	0.1	0.0	0.7	0.5	-0.2
Montane mahogany species	-	-	0.4	0.2	-0.2*	1.3	0.8	-0.5*	5.2	4.1	-1.1
Subalpine-alpine mahogany species	nc	nc	0.0	0.0	0.0	0.1	0.0	0.0	0.5	0.2	-0.3
Colline tall	nc	nc	0.5	0.3	-0.3	0.5	0.4	-0.1	7.0	14.6	7.6
Montane tall	nc	-	3.7	3.2	-0.5	7.0	8.8	1.8	35.4	17.7	-17.7*
Colline wet-site	nc	-	0.1	0.1	-0.1	0.4	0.3	-0.1	3.9	1.7	-2.2*
Montane wet-site	-	nc	0.7	0.6	-0.1*	1.9	1.6	-0.3	12.2	16.0	3.8
Subalpine-alpine wet-site	nc	nc	0.0	0.0	0.0	0.0	0.1	0.1	0.1	1.0	0.9
Montane subshrub	nc	+	0.1	0.1	0.0	0.4	0.5	0.1	1.3	2.6	1.3*
Subalpine-alpine subshrub	+	+	0.0	0.1	0.1*	0.0	6.2	6.2*	0.0	0.1	0.1*
Cover types-herbland—											
Alpine	nc	nc	0.0	0.1	0.1	0.0	0.0	0.0	0.0	3.5	3.5
Dry meadow	nc	nc	0.0	0.1	0.1	0.0	0.0	0.0	0.0	4.0	4.0
Colline bunchgrass	+	nc	0.1	0.2	0.1*	0.4	0.7	0.3	3.6	4.0	0.4
Montane bunchgrass	+	+	0.7	1.2	0.6*	3.3	4.3	1.0	6.4	11.0	4.6*
Subalpine-alpine bunchgrass	nc	+	0.0	0.0	0.0	0.1	0.1	0.0	0.6	1.2	0.6
Colline exotic grasses-forbs	nc	nc	0.6	0.8	0.1	0.5	0.6	0.1	10.8	10.9	0.1

Table 32—(continued)

Ecological reporting unit	Trend[a] Area	Trend[a] Con.[b]	Area H[c]	Area C	Area MD[d]	Patch density H	Patch density C	Patch density MD[d]	Mean patch size H	Mean patch size C	Mean patch size MD[d]
			------- *Percent* -------			*No./10 000 ha*			------- *Hectares* -------		
Montane exotic grasses-forbs	nc	+	0.1	0.2	0.1	0.5	1.1	0.6*	1.7	2.2	0.5
Colline moist-site	nc	nc	0.2	0.2	0.0*	0.2	0.2	0.0	3.7	6.0	2.3
Montane moist-site	nc	nc	0.7	0.6	0.0	2.2	3.0	0.8	9.9	8.4	-1.5
Subalpine-alpine moist-site	nc	nc	0.0	0.1	0.1	0.0	0.1	0.1	0.0	2.2	2.2
Postfire-grasses	nc	-	0.1	0.0	-0.1	0.1	0.0	-0.1	1.7	0.8	-0.9*
Postlogging-grasses-forbs	+	+	0.0	0.2	0.2*	0.3	4.3	4.0*	0.3	0.0	-0.2
Cover types-agriculture-rural-urban—											
Cropland	nc	nc	0.3	0.2	-0.1	0.4	0.3	-0.1	9.9	8.3	-1.6
Pasture	nc	+	0.1	0.1	0.1	0.3	0.4	0.1	1.5	3.4	1.8*
Urban-rural	+	+	0.0	0.3	0.2*	0.2	0.4	0.3*	1.8	7.7	5.9*
Cover types-other—											
Bare ground-road	nc	nc	0.0	0.0	0.0	0.1	0.1	0.0	1.2	1.1	-0.1
Rock	nc	nc	3.4	3.6	0.1	10.5	10.6	0.1	23.4	22.9	-0.5
Postlogging-bare ground-burned	+	+	0.2	0.7	0.5*	0.7	2.7	2.0*	4.5	6.8	2.3
Postlogging-bare ground-slumps-erosion	nc	nc	0.0	0.0	0.0	0.1	0.1	0.0	0.2	0.6	0.3
Stream channel-nonvegetated flood plain	nc	nc	0.0	0.1	0.0	0.2	0.3	0.1	2.0	3.3	1.4
Water	nc	nc	0.1	0.1	0.0	0.7	0.6	-0.1	1.9	2.4	0.4
Structural classes-forest—											
Stand initiation	-	-	9.7	5.9	-3.8*	19.0	18.0	-1.0	61.1	30.5	-30.6*
Stem exclusion, open canopy	nc	nc	18.4	17.7	-0.8	26.1	29.0	2.9	87.6	77.6	-10.0
Stem exclusion, closed canopy	nc	-	7.7	8.5	0.8	16.7	19.8	3.1*	42.0	34.5	-7.5
Understory reinitiation	+	+	16.0	21.4	5.5*	20.6	21.0	0.4	102.1	151.7	49.5*
Young, multistory	-	-	18.4	17.1	-1.2	30.3	31.5	1.2	75.1	62.0	-13.1*
Old, multistory	nc	-	1.4	1.2	-0.3	1.8	2.7	0.9*	32.6	9.3	-23.4*
Old, single story	nc	nc	1.8	1.7	-0.1	4.7	4.8	0.2	16.2	12.5	-3.7
Structural-woodland											
Stem exclusion	nc	nc	0.1	0.0	0.0	0.3	0.4	0.0	0.3	0.3	-0.1
Structural classes-shrubland—											
Open low-medium	nc	-	12.6	12.0	-0.5	7.0	8.8	1.7*	95.8	94.6	-1.2
Closed low-medium	nc	nc	1.6	1.4	-0.2	2.8	2.6	-0.2	21.8	21.3	-0.5
Open tall	nc	nc	2.8	2.8	0.1	7.0	8.0	1.1	25.0	27.7	2.7
Closed tall	-	-	2.7	1.5	-1.2*	6.5	6.2	-0.2	28.5	15.1	-13.4*
Structural classes-herbland—											
Open	nc	-	0.9	1.1	0.1	2.4	3.6	1.2*	25.6	16.7	-8.9
Closed	+	-	1.7	2.2	0.5*	4.8	6.5	1.6*	22.9	23.7	0.8
Structural classes-other[e]—											
Nonforest-nonrange	+	+	4.4	5.4	1.1*	12.8	15.8	3.0*	31.4	39.7	8.2

Table 32—(continued)

Ecological reporting unit	Trend[a]		Area			Patch density			Mean patch size		
	Area	Con.[b]	H[c]	C	MD[d]	H	C	MD[d]	H	C	MD[d]
			------- *Percent* -------			*No./10 000 ha*			------- *Hectares* -------		
Columbia Plateau ERU:											
Physiognomic types—											
Forest	+	nc	26.1	29.1	3.0*	5.6	4.9	-0.6	1116.2	930.0	-186.1
Woodland	+	+	6.7	12.2	5.5*	4.9	4.2	-0.7	69.9	220.6	150.8*
Shrubland	-	-	32.2	23.4	-8.8*	9.6	9.7	0.1	842.8	265.9	-576.9*
Herbland	nc	nc	12.7	14.0	1.4	17.1	18.7	1.6	205.1	155.4	-49.7
Other[e]	nc	nc	22.4	21.4	-1.0	11.3	9.8	-1.5	656.5	639.4	-17.1
Cover types-forest and woodland—											
Grand fir-white fir	nc	nc	1.1	0.4	-0.7	0.6	0.7	0.1	20.3	7.1	-13.2
Engelmann spruce-subalpine fir	nc	nc	0.0	0.0	0.0	0.0	0.0	0.0	6.1	1.5	-4.7
Aspen-cottonwood-willow	nc	nc	0.3	0.3	0.0	1.3	1.3	-0.1	10.8	7.5	-3.3
Juniper	+	+	6.5	12.0	5.5*	4.7	3.9	-0.8	60.6	208.4	147.8*
Western larch	-	nc	1.0	0.1	-0.9*	0.3	0.4	0.1	40.6	3.3	-37.3
Lodgepole pine	nc	nc	1.3	0.9	-0.4	0.7	1.1	0.4	93.9	11.9	-82.0
Ponderosa pine	+	nc	19.2	21.4	2.3*	5.2	5.3	0.1	752.8	334.4	-418.4
Douglas-fir	+	+	3.0	3.9	0.9*	2.4	3.6	1.2*	37.7	39.7	2.0
Western hemlock-western redcedar	+	+	0.4	2.2	1.9*	0.3	0.9	0.6*	5.7	14.7	9.0
Mountain hemlock	nc	nc	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.2	0.2
Cover types-shrubland—											
Colline low-medium	-	-	29.1	21.7	-7.4*	5.2	1405.2	1400.1*	838.4	14.1	-824.3*
Montane low-medium	nc	+	1.3	0.9	-0.3	1.8	0.7	-1.1*	10.4	20.1	9.7
Colline mahogany species	nc	nc	0.4	0.1	-0.2	0.5	0.2	-0.4	7.0	11.4	4.4
Montane mahogany species	nc	nc	0.0	0.0	0.0	0.4	0.1	-0.3	0.3	0.1	-0.2
Colline tall	nc	nc	0.3	0.1	-0.1	0.8	0.7	-0.1	3.2	2.9	-0.4
Montane tall	nc	-	0.9	0.4	-0.6	1.5	1.8	0.3	12.3	2.8	-9.5*
Colline wet-site	-	nc	0.2	0.1	-0.1*	0.7	0.6	-0.1	9.3	6.9	-2.4
Montane wet-site	nc	nc	0.1	0.1	0.0	0.3	0.3	-0.1	4.4	4.0	-0.4
Montane subshrub	nc	nc	0.0	0.0	0.0	0.1	0.2	0.0	0.5	0.3	-0.2
Cover types-herbland—											
Dry meadow	nc	nc	0.1	0.0	-0.1	0.1	0.1	0.0	3.5	0.3	-3.2
Colline bunchgrass	-	nc	8.3	6.9	-1.4*	8.8	8.3	-0.5	258.2	416.6	158.4
Montane bunchgrass	+	nc	1.3	1.8	0.5*	4.5	4.1	-0.4	15.9	22.8	6.9
Colline exotic grasses-forbs	+	+	0.8	2.3	1.5*	2.4	4.2	1.8*	11.3	29.3	18.0*
Montane exotic grasses-forbs	nc	nc	0.1	0.3	0.2	0.4	0.7	0.3	6.9	7.3	0.5
Colline moist-site	nc	nc	0.1	0.2	0.1	0.7	0.6	-0.1	1.8	3.5	1.7
Montane moist-site	nc	nc	0.5	0.5	0.1	2.6	2.7	0.1	5.0	4.7	-0.2
Wet meadow	nc	nc	0.1	0.0	-0.1	0.4	0.0	-0.3	0.8	2.8	2.0
Postlogging-grasses-forbs	nc	-	0.0	0.0	0.0	0.2	2.4	2.2*	1.3	0.0	-1.3*
Cover types-agriculture-rural-urban—											
Cropland	nc	+	18.1	17.9	-0.1	7.8	4.8	-3.0*	708.9	815.4	106.4
Pasture	nc	nc	1.1	1.4	0.3	0.9	1.5	0.6	27.1	36.9	9.8
Urban-rural	nc	-	0.6	0.8	0.2	1.2	2.7	1.4*	17.1	9.5	-7.6

Table 32—(continued)

Ecological reporting unit	Trend[a] Area	Trend[a] Con.[b]	Area H[c]	Area C	Area MD[d]	Patch density H	Patch density C	Patch density MD[d]	Mean patch size H	Mean patch size C	Mean patch size MD[d]
			Percent			*No./10 000 ha*			*Hectares*		
Cover types-other—											
Rock	nc	+	0.4	0.5	0.1	2.8	2.4	-0.4	4.5	9.6	5.1*
Postlogging-bare ground-burned	nc	-	2.8	1.6	-1.2	0.4	2.2	1.8*	39.5	25.2	-14.3
Postlogging-bare ground-slumps-erosion	nc	+	0.0	0.1	0.1	0.0	0.3	0.3*	0.2	1.2	1.1
Stream channel-nonvegetated flood plain	nc	nc	0.3	0.0	-0.2	0.3	0.2	-0.1	12.9	1.6	-11.3
Water	+	+	0.3	0.4	0.1*	0.5	0.9	0.3*	13.0	16.4	3.4
Structural classes-forest—											
Stand initiation	nc	nc	2.3	2.8	0.5	4.0	5.1	1.1	71.1	24.7	-46.4
Stem exclusion, open canopy	nc	nc	6.7	7.8	1.1	12.7	9.9	-2.9	35.4	103.9	68.5
Stem exclusion, closed canopy	nc	nc	3.8	3.6	-0.2	1.6	2.2	0.5	65.7	34.6	-31.1
Understory reinitiation	nc	nc	3.1	3.3	0.2	4.6	4.3	-0.3	35.2	42.7	7.5
Young, multistory	+	-	7.3	10.0	2.7*	8.6	7.7	-0.9	54.6	81.4	26.8*
Old, multistory	nc	+	2.3	1.3	-1.0	1.0	1.2	0.2	33.9	11.1	-22.8*
Old, single story	nc	nc	1.1	1.0	-0.1	2.1	2.4	0.3	10.0	9.9	0.0
Structural classes-woodland—											
Stand initiation	nc	nc	0.1	0.3	0.2	0.3	0.4	0.2	2.7	5.5	2.8
Stem exclusion	+	+	5.9	10.9	5.0*	4.6	4.4	-0.2	63.8	152.7	88.9*
Understory reinitiation	nc	nc	0.6	1.0	0.3	0.9	1.3	0.4	16.9	10.2	-6.7
Old multistory	nc	nc	0.0	0.0	0.0	0.2	0.1	0.0	1.7	1.8	0.1
Old single story	nc	nc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5
Structural classes-shrubland—											
Open low-medium	-	-	23.4	19.4	-4.1*	10.5	9.4	-1.1	435.1	172.9	-262.2*
Closed low-medium	-	-	6.9	3.3	-3.7*	5.2	2.9	-2.2*	61.4	54.2	-7.1
Open tall	-	nc	0.9	0.4	-0.6*	3.2	1.9	-1.4	13.4	9.1	-4.3
Closed tall	nc	-	0.9	0.4	-0.6	1.5	1.7	0.2	14.7	3.7	-11.0*
Structural classes-herbland—											
Open	+	nc	7.4	9.0	1.5*	11.6	11.5	-0.1	176.0	430.8	254.8
Closed	nc	-	3.8	3.2	-0.5	8.0	9.1	1.1	41.5	23.1	-18.4*
Structural classes-other[e]—											
Nonforest-nonrange	nc	-	23.8	23.2	-0.6	11.8	9.3	-2.5*	782.4	708.6	-73.9
Lower Clark Fork ERU:											
Physiognomic types—											
Forest	nc	nc	91.7	94.5	2.8	3.4	2.4	-1.0	4549.5	5749.1	1199.5
Shrubland	nc	nc	1.9	0.6	-1.4	6.6	4.2	-2.4	9.0	7.8	-1.2
Herbland	nc	nc	5.4	3.2	-2.3	13.6	18.6	5.0	48.9	43.3	-5.6
Other[e]	nc	nc	0.9	1.8	0.8	6.4	15.6	9.2	20.6	8.4	-12.3
Cover types-forest and woodland—											
Grand fir-white fir	nc	nc	40.4	42.5	2.1	20.8	23.8	3.0	210.4	206.6	-3.8

Table 32—(continued)

Ecological reporting unit	Trend[a] Area	Con.[b]	Area H[c]	C	MD[d]	Patch density H	C	MD[d]	Mean patch size H	C	MD[d]
			------- *Percent* -------			*No. /10 000 ha*			------- *Hectares* -------		
Engelmann spruce-subalpine fir	nc	nc	2.5	2.2	-0.3	6.2	5.2	-1.0	32.7	34.5	1.8
Aspen-cottonwood-willow	nc	+	0.1	0.7	0.6	0.6	2.2	1.6*	3.0	14.2	11.2*
Western larch	nc	+	0.8	2.6	1.7	2.6	4.8	2.2*	18.6	39.7	21.1
Lodgepole pine	nc	-	2.1	1.8	-0.3	4.8	5.0	0.2	38.7	18.3	-20.4*
Limber pine	nc	nc	0.0	0.0	0.0	0.4	0.0	-0.4	2.3	0.0	-2.3
Sugar pine-western white pine	nc	nc	0.3	0.6	0.2	2.6	2.6	0.0	8.5	23.5	15.1
Ponderosa pine	nc	nc	3.0	5.1	2.1	5.2	4.4	-0.8	29.1	43.8	14.7
Douglas-fir	-	nc	26.4	21.1	-5.3	26.2	24.6	-1.6	125.1	90.9	-34.1
Western hemlock-western redcedar	nc	nc	14.7	17.3	2.6	19.0	20.0	1.0	63.0	66.5	3.5
Mountain hemlock	-	-	1.3	0.6	-0.7*	1.6	0.6	-1.0*	41.1	23.9	-17.2
Cover types-shrubland—											
Subalpine-alpine low-medium	nc	nc	0.2	0.1	-0.1	0.8	0.6	-0.2	5.8	3.6	-2.1
Montane tall	nc	nc	1.6	0.3	-1.3	6.8	3.8	-3.0	5.9	4.3	-1.6
Colline wet-site	nc	nc	0.0	0.0	0.0	0.0	0.4	0.4	0.0	0.8	0.8
Montane wet-site	nc	-	1.4	1.5	0.1	4.2	8.8	4.6*	63.9	20.0	-43.9
Cover types-herbland—											
Montane bunchgrass	nc	nc	0.1	0.2	0.1	0.8	0.6	-0.2	4.3	12.7	8.4
Montane exotic grasses-forbs	nc	nc	0.1	0.1	0.0	0.2	0.8	0.6	4.1	4.8	0.6
Montane moist-site	nc	nc	0.2	0.2	-0.1	1.2	0.8	-0.4	12.3	11.5	-0.8
Wet meadow	nc	nc	0.0	0.0	0.0	0.0	0.2	0.2	0.0	2.1	2.1
Postfire-grasses	nc	-	2.9	0.0	-2.9	8.8	0.0	-8.8*	13.3	0.0	-13.3*
Postlogging-grasses-forbs	nc	nc	0.4	0.9	0.5	2.0	20.4	18.4	6.3	0.2	-6.1
Cover types-agriculture-rural-urban—											
Pasture	nc	nc	0.4	0.4	0.0	2.2	1.4	-0.8	7.4	17.9	10.5
Urban-rural	nc	nc	0.0	0.0	0.0	0.2	0.0	-0.2	0.9	0.0	-0.9
Cover types-other—											
Rock	nc	nc	0.5	0.3	-0.2	5.6	3.8	-1.8	4.9	4.7	-0.2*
Postlogging-bare ground-burned	nc	+	0.0	1.1	1.1	0.6	10.2	9.6	0.8	6.3	5.4*
Stream channel-nonvegetated flood plain	nc	nc	0.2	0.3	0.1	0.2	0.8	0.6	11.9	14.6	2.7
Water	nc	nc	0.2	0.1	-0.1	0.6	1.4	0.8	18.5	2.6	-15.9
Structural classes-forest—											
Stand initiation	-	-	32.7	9.5	-23.3*	22.8	31.8	9.0	208.3	24.2	-184.2*
Stem exclusion, open canopy	-	-	15.7	9.2	-6.5*	28.0	23.0	-5.0*	52.4	25.9	-26.6*
Stem exclusion, closed canopy	+	+	10.3	17.6	7.3*	17.2	17.4	0.2	31.8	64.4	32.6*
Understory reinitiation	+	+	16.4	37.7	21.3*	24.0	33.8	9.8*	68.2	189.6	121.4
Young, multistory	+	nc	14.3	17.5	3.2	29.4	34.4	5.0	48.8	51.4	2.6
Old, multistory	nc	nc	0.2	0.5	0.3	0.4	1.6	1.2	11.8	6.8	-5.0
Old, single story	nc	-	2.2	2.5	0.4	2.8	8.2	5.4*	39.4	18.6	-20.8*
Structural classes-shrubland—											
Open low-medium	nc	nc	0.2	0.1	-0.1	0.8	0.2	-0.6	5.8	6.7	0.9

Table 32—(continued)

Ecological reporting unit	Trend[a] Area	Trend[a] Con.[b]	Area H[c]	Area C	Area MD[d]	Patch density H	Patch density C	Patch density MD[d]	Mean patch size H	Mean patch size C	Mean patch size MD[d]
			Percent			*No. /10 000 ha*			*Hectares*		
Closed low-medium	nc	nc	0.0	0.0	0.0	0.0	0.2	0.2	0.0	0.6	0.6
Open tall	nc	nc	2.1	1.2	-0.9	4.8	4.4	-0.4	59.1	14.9	-44.2
Closed tall	nc	nc	1.0	0.7	-0.3	5.4	7.8	2.4	10.0	6.3	-3.7
Structural classes-herbland—											
Open	nc	nc	0.2	0.1	-0.1	1.8	1.0	-0.8	8.9	5.6	-3.3
Closed	nc	nc	0.2	0.3	0.2	0.4	0.8	0.4	10.3	21.9	11.6
Structural classes-other[e]—											
Nonforest-nonrange	nc	nc	4.7	3.2	-1.5	16.2	21.6	5.4	28.0	23.6	-4.4
Northern Cascades ERU:											
Physiognomic types—											
Forest	nc	nc	78.8	78.2	-0.6	3.8	3.6	-0.2	3769.5	3444.9	-324.6
Woodland	+	+	0.3	0.7	0.3*	1.1	1.8	0.7*	3.2	6.5	3.3*
Shrubland	nc	-	4.8	4.1	-0.7	7.2	8.7	1.5*	38.0	33.3	-4.7
Herbland	nc	-	6.7	6.5	-0.3	7.6	11.0	3.3*	78.5	55.0	-23.6*
Other[e]	+	+	9.4	10.6	1.2*	13.5	19.0	5.6*	79.4	86.6	7.3
Cover types-forest and woodland—											
Pacific silver fir	+	-	6.0	8.3	2.3*	4.0	359.8	355.7*	61.5	3.6	-57.9*
Grand fir-white fir	+	+	1.0	2.2	1.3*	1.1	3.7	2.5*	25.7	33.6	7.9
Engelmann spruce-subalpine fir	-	-	16.8	13.6	-3.2*	10.0	11.2	1.3*	283.8	158.2	-125.6*
Oregon white oak	+	+	0.6	0.9	0.3*	2.1	2.8	0.7*	10.8	12.1	1.3
Juniper	nc	nc	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	-0.2
Western larch	nc	-	1.0	1.0	0.0	1.2	1.7	0.5*	24.3	21.5	-2.8
Whitebark pine-subalpine larch	+	+	3.3	4.7	1.4*	4.0	4.9	0.9*	35.4	63.3	27.8*
Lodgepole pine	nc	nc	5.9	5.2	-0.6	3.6	3.9	0.3	101.9	93.4	-8.5
Sugar pine-western white pine	nc	+	0.1	0.3	0.1*	0.2	0.5	0.3*	2.4	6.5	4.1*
Ponderosa pine	-	-	16.5	13.2	-3.2*	7.3	8.2	1.0*	241.3	156.1	-85.2*
Douglas-fir	+	-	23.8	25.8	2.0*	10.9	13.3	2.4*	294.1	254.0	-40.1
Western hemlock-western redcedar	-	-	3.0	2.4	-0.6*	1.3	2.2	0.9*	62.9	40.2	-22.8*
Mountain hemlock	nc	-	1.3	1.2	-0.1	1.5	1.7	0.2	30.4	22.8	-7.7*
Cover types-shrubland—											
Colline low-medium	nc	-	1.6	1.8	0.2	1.1	105.4	104.4*	12.7	1.1	-11.7*
Montane low-medium	nc	-	0.3	0.4	0.1	0.7	1.0	0.3	5.5	4.2	-1.3*
Colline mahogany species	nc	-	0.2	0.0	-0.1	0.0	0.2	0.2*	23.6	1.2	-22.4
Montane mahogany species	nc	+	0.0	0.0	0.0*	0.0	0.2	0.2*	0.4	1.1	0.7*
Colline tall	nc	nc	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	-0.6
Montane tall	nc	-	0.0	0.0	0.0*	0.1	0.0	-0.1*	2.6	0.7	-1.9*
Colline wet-site	nc	nc	0.0	0.0	0.0	0.0	0.1	0.1	4.9	1.4	-3.5
Montane wet-site	nc	nc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
Montane subshrub	nc	nc	0.9	0.3	-0.5	1.5	1.4	-0.1	5.0	2.2	-2.9
Cover types-herbland—											
Alpine	nc	nc	0.7	0.8	0.1	2.1	2.4	0.3	17.9	13.9	-4.1

Table 32—(continued)

Ecological reporting unit	Trend[a] Area	Trend[a] Con.[b]	Area H[c]	Area C	Area MD[d]	Patch density H	Patch density C	Patch density MD[d]	Mean patch size H	Mean patch size C	Mean patch size MD[d]
			Percent			*No. /10 000 ha*			*Hectares*		
Dry meadow	nc	nc	1.7	1.5	-0.2	2.3	1.9	-0.4	47.1	36.6	-10.5
Colline bunchgrass	nc	-	1.0	1.2	0.2	0.7	1.9	1.2*	13.7	6.7	-7.0*
Montane bunchgrass	-	-	1.0	0.7	-0.3*	0.9	1.5	0.7*	9.3	5.5	-3.8
Colline exotic grasses-forbs	-	-	0.9	0.5	-0.4*	0.7	0.8	0.1	16.6	4.5	-12.1*
Montane exotic grasses-forbs	+	+	0.7	0.9	0.2*	0.9	0.7	-0.2*	8.2	12.8	4.6*
Colline moist-site	nc	nc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Montane moist-site	nc	nc	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.3	-0.8
Wet meadow	nc	nc	0.2	0.1	-0.1	1.2	0.9	-0.3	6.3	7.4	1.0
Postlogging-grasses-forbs	+	-	0.1	0.4	0.4*	0.2	19.2	19.0*	1.6	0.2	-1.4*
Cover types-agriculture-rural-urban—											
Cropland	nc	nc	1.7	1.6	-0.1	1.6	1.5	-0.1	29.7	25.0	-4.7
Pasture	nc	-	0.3	0.2	-0.2	0.3	0.4	0.2*	7.0	2.8	-4.2*
Urban-rural	+	+	0.1	0.3	0.2*	0.2	0.7	0.5*	4.6	9.0	4.5*
Cover types-other—											
Rock	nc	+	4.8	5.1	0.3	7.9	8.3	0.4	62.4	84.2	21.9*
Postlogging-bare ground-burned	+	-	0.5	1.5	0.9*	0.8	5.7	4.9*	29.1	17.5	-11.6
Postlogging-bare ground-slumps-erosion	nc	-	1.5	1.3	-0.2	2.9	3.5	0.6*	13.1	12.5	-0.6
Water	nc	nc	0.8	0.8	0.0	2.6	2.4	-0.2	26.4	24.7	-1.7
Structural classes-forest—											
Stand initiation	nc	-	9.2	10.4	1.3	11.8	18.8	7.0*	100.0	67.4	-32.5
Stem exclusion, open canopy	nc	-	13.2	13.2	0.0	16.3	20.7	4.4*	88.2	70.1	-18.1*
Stem exclusion, closed canopy	nc	-	7.6	7.9	0.3	7.4	11.2	3.8*	101.2	88.1	-13.2
Understory reinitiation	+	+	17.5	19.5	2.0	15.7	19.5	3.8*	153.0	195.9	42.9
Young, multistory	nc	-	21.2	22.0	0.8	21.5	25.0	3.5*	130.3	101.2	-29.1*
Old, multistory	-	-	5.8	2.7	-3.1*	4.5	4.9	0.4	145.0	37.5	-107.5*
Old, single story	-	-	4.3	2.4	-1.9*	4.3	4.5	0.3	81.9	38.9	-43.0*
Structural classes-woodland—											
Stand initiation	nc	nc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3
Stem exclusion	+	+	0.3	0.6	0.3*	1.0	1.7	0.7*	2.3	6.3	4.0*
Understory reinitiation	nc	nc	0.0	0.0	0.0*	0.0	0.2	0.1	0.5	1.5	1.0
Old multistory	nc	nc	0.0	0.0	0.0	0.1	0.1	0.0	2.7	2.4	-0.2
Old single story	nc	nc	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.3
Structural classes-shrubland—											
Open low-medium	nc	-	2.0	1.8	-0.2	2.8	3.3	0.5*	9.2	8.9	-0.2
Closed low-medium	nc	-	0.8	0.8	0.0	0.4	1.3	0.9*	11.7	7.2	-4.5
Open tall	nc	-	0.0	0.0	0.0*	0.1	0.0	0.0	3.5	0.6	-2.9*
Closed tall	nc	nc	0.0	0.1	0.0*	0.0	0.1	0.1*	2.9	2.8	-0.2
Structural classes-herbland—											
Open	nc	-	2.3	2.4	0.1	1.4	2.0	0.5*	21.8	11.5	-10.3*
Closed	nc	-	1.5	1.0	-0.5	1.6	2.3	0.7*	14.3	6.5	-7.8*
Structural classes-other[e]—											
Nonforest-nonrange	+	-	14.3	15.2	0.9*	17.9	25.2	7.2*	117.0	104.3	-12.7*

Table 32—(continued)

Ecological reporting unit	Trend[a] Area	Trend[a] Con.[b]	Area H[c]	Area C	Area MD[d]	Patch density H	Patch density C	Patch density MD[d]	Mean patch size H	Mean patch size C	Mean patch size MD[d]
			------- Percent -------			*No./10 000 ha*			*------- Hectares -------*		
Northern Glaciated Mountains ERU:											
Physiognomic types—											
Forest	nc	nc	81.0	80.8	-0.2	4.8	5.1	0.2	3749.4	3919.1	169.8
Woodland	nc	nc	0.0	0.0	0.0	0.0	0.1	0.1	1.8	1.0	-0.8
Shrubland	nc	-	3.1	2.5	-0.5	5.0	9.5	4.5*	40.6	20.6	-20.0*
Herbland	nc	-	7.4	8.1	0.7	11.1	18.0	6.9*	93.8	65.9	-27.9
Other[e]	nc	-	8.5	8.5	0.0	12.4	17.9	5.5*	86.4	58.6	-27.8
Cover types-forest and woodland—											
Grand fir-white fir	+	+	0.0	1.2	1.2*	0.1	2.3	2.2*	3.6	18.9	15.3*
Engelmann spruce-subalpine fir	+	-	11.5	13.2	1.7*	6.1	11.0	4.9*	177.6	138.9	-38.6*
Aspen-cottonwood-willow	nc	+	0.3	1.9	1.6	1.2	2.6	1.5*	8.0	40.8	32.8
Juniper	nc	nc	0.0	0.0	0.0	0.0	0.1	0.1	1.8	1.0	-0.8
Western larch	-	-	14.8	11.4	-3.4*	9.6	13.7	4.1*	134.4	61.1	-73.4*
Whitebark pine-subalpine larch	nc	nc	0.3	0.2	-0.1	0.6	0.4	-0.2	10.6	5.8	-4.8
Lodgepole pine	nc	-	8.0	8.3	0.3	9.7	13.3	3.6*	68.8	52.4	-16.4*
Sugar pine-western white pine	-	-	1.5	0.0	-1.4*	0.6	0.2	-0.4*	21.5	1.7	-19.8*
Ponderosa pine	-	-	13.4	11.4	-2.0*	7.7	10.3	2.6*	151.9	108.8	-43.1
Douglas-fir	nc	-	30.3	30.2	-0.1	16.1	23.0	6.8*	441.8	427.4	-14.4
Western hemlock-western redcedar	+	-	0.7	2.8	2.5*	1.1	4.4	3.3*	19.1	17.0	-2.1
Mountain hemlock	nc	nc	0.1	0.0	0.0	0.2	0.2	0.0	0.6	0.7	0.0
Cover types-shrubland—											
Colline low-medium	nc	-	0.1	0.1	0.0	0.3	5.4	5.1*	1.8	0.1	-1.7*
Montane low-medium	+	+	0.0	0.1	0.1*	0.0	0.2	0.2*	0.0	2.2	2.2*
Subalpine-alpine low-medium	nc	-	1.1	0.8	-0.2	1.4	2.0	0.6*	8.4	5.1	-3.4
Colline mahogany species	-	-	0.4	0.0	-0.4*	0.4	0.0	-0.4*	7.2	0.0	-7.2*
Montane mahogany species	-	-	0.2	0.0	-0.2*	0.3	0.0	-0.3*	3.1	0.0	-3.1*
Colline tall	nc	nc	0.7	0.3	-0.4	0.8	0.6	-0.2	9.7	4.9	-4.8
Montane tall	nc	-	0.4	0.6	0.2	1.0	3.4	2.4*	12.1	9.2	-2.9
Colline wet-site	-	-	0.3	0.2	-0.1*	0.4	0.5	0.1	9.0	5.1	-3.9*
Montane wet-site	+	+	0.1	0.2	0.1*	0.3	0.6	0.3*	4.7	8.6	3.9*
Subalpine-alpine wet-site	nc	nc	0.0	0.0	0.0	0.1	0.0	-0.1	0.2	0.0	-0.2
Montane subshrub	nc	-	0.3	0.4	0.1	0.7	2.3	1.6	2.8	1.2	-1.6*
Subalpine-alpine subshrub	+	-	0.0	0.1	0.1*	0.0	10.0	10.0*	2.2	0.1	-2.1
Cover types-herbland—											
Alpine	nc	nc	0.0	0.0	0.0	0.2	0.2	0.0	0.8	1.0	0.2
Dry meadow	nc	+	0.0	0.0	0.0*	0.1	0.4	0.3*	0.3	2.1	1.8*
Colline bunchgrass	-	-	1.6	0.8	-0.8*	0.7	1.5	0.8*	34.9	9.8	-25.0*
Montane bunchgrass	nc	nc	1.6	1.9	0.2	4.0	3.9	-0.1	22.0	41.4	19.4
Subalpine-alpine bunchgrass	nc	nc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.6
Colline exotic grasses-forbs	nc	+	1.0	1.2	0.2	0.9	1.9	1.0*	11.8	14.0	2.2

Table 32—(continued)

Ecological reporting unit	Trend[a] Area	Trend[a] Con.[b]	Area H[c]	Area C	Area MD[d]	Patch density H	Patch density C	Patch density MD[d]	Mean patch size H	Mean patch size C	Mean patch size MD[d]
			------- *Percent* -------			*No./10 000 ha*			------- *Hectares* -------		
Montane exotic grasses-forbs	nc	nc	0.5	0.7	0.1	2.6	2.3	-0.3	5.5	14.5	9.0
Colline moist-site	nc	nc	0.0	0.0	0.0	0.1	0.2	0.1	2.6	2.6	0.0
Montane moist-site	nc	nc	0.2	0.2	0.0	0.8	1.0	0.2	7.7	5.4	-2.3
Subalpine-alpine moist-site	nc	nc	0.0	0.0	0.0	0.1	0.1	0.0	0.4	0.3	-0.1
Wet meadow	nc	+	0.0	0.1	0.1*	0.2	0.8	0.6*	2.0	4.1	2.1
Postlogging-grasses-forbs	+	-	0.1	0.8	0.7*	0.7	21.2	20.6*	4.1	0.2	-3.9*
Cover types-agricultural-rural-urban—											
Cropland	nc	-	3.4	4.3	0.9	4.1	3.2	-0.9*	49.0	47.3	-1.7
Pasture	+	+	1.4	1.7	0.3*	1.4	1.1	-0.3	11.2	49.1	38.0*
Urban-rural	nc	+	0.2	0.3	0.1	0.8	1.3	0.5*	4.1	8.1	4.0*
Cover types-other—											
Bare ground	nc	nc	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	-0.2
Glacier	nc	nc	0.0	0.0	0.0	0.1	0.1	0.0	1.4	2.0	0.7
Rock	+	-	2.3	2.7	0.5*	4.9	9.2	4.3*	32.5	29.2	-3.4
Postlogging-bare ground-burned	-	-	2.2	0.4	-1.7*	1.3	3.1	1.8*	24.9	7.2	-17.7
Postlogging-bare ground-slumps-erosion	nc	+	0.0	0.0	0.0	0.1	0.1	0.0	0.3	0.7	0.4*
Stream channel-nonvegetated flood plain	nc	-	0.1	0.1	0.0*	0.0	0.0	0.0	11.8	10.8	-0.9*
Water	nc	nc	0.4	0.5	0.1	2.7	3.0	0.3	8.8	10.1	1.2
Structural classes-forest—											
Stand initiation	-	-	16.9	9.4	-7.5*	18.3	26.5	8.2*	103.6	38.5	65.1*
Stem exclusion, open canopy	nc	-	11.8	11.6	-0.2	18.0	27.8	9.9*	75.3	49.1	-26.2*
Stem exclusion, closed canopy	+	+	7.2	12.8	5.6*	8.6	15.0	6.5*	61.2	71.4	10.2
Understory reinitiation	+	-	18.4	23.3	4.9*	12.9	22.1	9.2*	170.6	150.7	-19.9
Young, multistory	-	-	25.5	22.8	-2.7	22.2	32.4	10.2*	218.1	106.3	-111.9*
Old, multistory	nc	-	0.5	0.4	-0.1	0.5	1.2	0.8*	22.7	7.8	-14.8*
Old, single story	nc	nc	0.7	0.6	-0.1	0.9	1.4	0.5	9.2	10.1	0.9
Structural classes-woodland—											
Stem exclusion	nc	nc	0.0	0.0	0.0	0.0	0.1	0.1	1.8	0.3	-1.5
Understory reinitiation	nc	nc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	1.9
Structural classes-shrubland—											
Open low-medium	nc	nc	1.2	1.1	-0.2	1.8	3.7	1.9	14.0	12.6	-1.3
Closed low-medium	nc	-	0.3	0.5	0.2	0.6	1.3	0.7*	5.6	4.5	-1.1
Open tall	nc	-	1.2	0.8	-0.4	1.7	3.2	1.5*	22.9	12.5	-10.4
Closed tall	nc	nc	0.3	0.4	0.2	0.8	1.9	1.1*	10.2	10.9	0.6
Structural classes-herbland—											
Open	nc	nc	1.4	1.5	0.1	2.7	2.6	-0.1	21.8	20.9	-0.8
Closed	nc	-	4.2	3.4	-0.8	6.9	7.9	1.0*	38.3	27.7	-10.6
Structural classes-other[e]—											
Nonforest-nonrange	+	+	10.5	11.6	1.1*	14.7	25.1	10.5*	90.3	221.4	131.0

Table 32—(continued)

Ecological reporting unit	Trend[a] Area	Trend[a] Con.[b]	Area H[c]	Area C	Area MD[d]	Patch density H	Patch density C	Patch density MD[d]	Mean patch size H	Mean patch size C	Mean patch size MD[d]
			Percent			*No./10 000 ha*			*Hectares*		
Northern Great Basin ERU:											
Physiognomic types—											
Forest	nc	nc	7.2	7.3	0.0	19.5	19.5	0.0	32.9	37.6	4.7
Woodland	+	nc	15.3	22.2	6.9*	12.8	11.5	-1.3	178.4	205.9	27.5
Shrubland	-	-	72.8	57.6	-15.2*	11.8	21.0	9.3	934.1	337.1	-597.0*
Herbland	+	+	3.9	12.2	8.3*	15.0	21.5	6.5	24.4	68.6	44.2*
Other[e]	nc	nc	0.8	0.8	0.0	3.0	3.8	0.8	6.5	5.1	-1.4
Cover types-forest and woodland—											
Aspen-cottonwood-willow	nc	nc	8.4	7.7	-0.8	20.0	19.0	-1.0	37.3	39.4	2.2
Juniper	+	nc	14.1	21.8	7.7*	12.3	12.3	0.0	139.9	180.4	40.5
Cover types-shrubland—											
Colline low-medium	nc	-	20.0	18.1	-1.8	1.3	1411.3	1410.0*	788.7	14.1	-774.6*
Montane low-medium	-	nc	51.2	37.7	-13.5*	16.8	22.5	5.8	316.1	248.1	-68.0
Subalpine-alpine low-medium	nc	nc	0.6	2.0	1.4	0.8	1.3	0.5	21.3	113.0	91.8
Montane mahogany species	nc	nc	0.4	0.4	0.0	0.3	0.3	0.0	32.4	30.2	-2.2
Montane tall	nc	nc	0.1	0.1	0.0	1.3	1.3	0.0	2.1	2.1	0.0
Montane wet-site	-	-	1.0	0.9	-0.1*	5.3	4.0	-1.3*	8.7	5.5	-3.3
Cover types-herbland—											
Colline bunchgrass	nc	nc	0.0	0.5	0.5	0.0	1.3	1.3	0.0	10.3	10.3
Montane bunchgrass	+	+	1.1	5.5	4.5*	3.0	5.3	2.3	11.2	92.6	81.4*
Subalpine-alpine bunchgrass	nc	nc	1.5	0.8	-0.7	1.8	2.0	0.3	40.2	21.9	-18.3
Colline exotic grasses-forbs	+	+	0.0	2.5	2.5*	0.0	3.3	3.3*	0.0	38.5	38.5*
Montane exotic grasses-forbs	nc	nc	0.0	0.0	0.0	0.5	0.0	-0.5	2.0	0.0	-2.0
Montane moist-site	nc	+	0.6	1.2	0.6	4.8	6.0	1.3*	8.9	14.2	5.3
Subalpine-alpine moist-site	nc	nc	0.1	0.0	-0.1	0.8	0.5	-0.3	4.6	2.3	-2.3
Cover types-other—											
Rock	nc	nc	0.8	0.7	-0.1	3.0	3.3	0.3	6.5	5.5	-1.0
Water	nc	nc	0.0	0.0	0.0	0.0	0.3	0.3	0.0	0.9	0.9
Structural classes-forest—											
Stem exclusion, open canopy	nc	nc	6.5	6.0	-0.5	19.8	18.8	-1.0	29.2	29.1	-0.1
Stem exclusion, closed canopy	nc	+	0.7	1.3	0.6	2.5	3.8	1.3*	22.5	31.7	9.2
Structural classes-woodland—											
Stem exclusion	+	nc	15.3	22.2	6.9*	12.8	11.5	-1.3	178.4	205.9	27.5
Structural classes-shrubland—											
Open low-medium	-	-	71.8	57.8	-13.9*	13.3	22.5	9.3	903.8	346.1	-557.8*
Open tall	nc	nc	1.2	1.2	0.0	3.3	3.5	0.3	14.0	13.3	-0.7
Closed tall	nc	nc	0.4	0.2	-0.1	3.5	2.0	-1.5	5.0	2.9	-2.1
Structural classes-herbland—											
Open	+	+	3.4	10.1	6.7*	11.0	17.0	6.0	28.3	64.8	36.5*
Closed	nc	nc	0.0	0.5	0.5	0.0	1.3	1.3	0.0	11.1	11.1
Structural classes-other[e]—											
Nonforest-nonrange	nc	nc	0.8	0.8	0.0	3.0	3.8	0.8	6.5	5.1	-1.4

Table 32—(continued)

Ecological reporting unit	Trend[a] Area	Trend[a] Con.[b]	Area H[c]	Area C	Area MD[d]	Patch density H	Patch density C	Patch density MD[d]	Mean patch size H	Mean patch size C	Mean patch size MD[d]
			------- *Percent* -------			*No./10 000 ha*			------- *Hectares* -------		
Owyhee Uplands ERU:											
Physiognomic types—											
Forest	nc	nc	0.2	0.2	0.0	0.2	0.4	0.2	10.2	6.4	-3.8
Woodland	+	+	5.5	7.6	2.1*	9.0	4.4	-4.6*	15.9	64.4	48.5*
Shrubland	-	-	88.8	81.0	-7.8*	7.9	5.7	-2.2*	4695.3	3439.3	-1256.0*
Herbland	+	+	1.0	7.4	6.4*	3.0	4.5	1.5*	22.2	202.0	179.7
Other[e]	nc	+	4.5	3.8	-0.6	6.7	4.5	-2.2*	53.2	86.0	32.8*
Cover types-forest and woodland—											
Aspen-cottonwood-willow	nc	nc	0.2	0.2	0.0	0.3	0.6	0.2	11.7	5.4	-6.3
Juniper	+	+	5.5	7.5	2.0*	9.0	4.4	-4.6*	15.8	64.3	48.5*
Douglas-fir	nc	nc	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.9	-0.8
Cover types-shrubland—											
Colline low-medium	-	-	87.7	79.3	-8.5*	8.9	7007.0	6998.1*	4443.5	70.1	-4373.4*
Colline mahogany species	nc	nc	0.8	1.1	0.4	2.3	0.6	-1.8*	4.1	18.9	14.8
Colline tall	nc	nc	0.1	0.3	0.2	0.4	0.7	0.3	1.9	4.7	2.7
Colline wet-site	nc	nc	0.3	0.3	-0.1	1.0	1.1	0.2	14.1	10.4	-3.7
Russian olive	nc	nc	0.1	0.0	-0.1	0.6	0.0	-0.6	1.0	0.0	-1.0
Cover types-herbland—											
Colline bunchgrass	nc	nc	0.2	0.2	0.0	1.3	1.2	0.0	3.4	4.1	0.6
Colline exotic grasses-forbs	+	+	0.2	6.2	6.1*	0.6	2.0	1.4*	5.8	195.8	190.0*
Colline moist-site	+	+	0.1	0.5	0.4*	0.1	0.6	0.5*	7.4	29.9	22.4*
Cover types-agricultural-rural-urban—											
Cropland	nc	+	1.1	1.4	0.3	0.5	0.3	-0.2*	21.8	31.7	10.0*
Pasture	nc	nc	0.5	0.5	0.0	0.8	0.7	0.0	13.4	24.7	11.2
Cover types-other—											
Bare ground	nc	nc	0.0	0.0	0.0	0.1	0.2	0.0	0.8	1.1	0.3
Bare ground-road	nc	nc	0.0	0.0	0.0	0.1	0.1	0.0	0.6	1.0	0.4
Rock	nc	-	2.8	1.9	-0.9	4.1	3.3	-0.8	34.3	23.5	-10.7*
Postlogging-bare ground-burned	nc	nc	0.1	0.1	0.0	0.0	0.1	0.0	4.7	3.1	-1.5
Stream channel-nonvegetated flood plain	nc	+	0.4	0.3	-0.1	2.3	0.7	-1.5*	6.5	8.3	1.8
Water	nc	+	0.1	0.1	0.0*	0.5	0.5	0.0	2.9	4.2	1.3*
Structural classes-forest—											
Stand initiation	nc	nc	0.0	0.0	0.0	0.0	0.1	0.1	0.0	1.7	1.7
Stem exclusion, open canopy	nc	nc	0.0	0.1	0.0	0.1	0.2	0.0	4.2	5.9	1.7
Stem exclusion, closed canopy	nc	nc	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	-0.3
Understory reinitiation	nc	nc	0.4	1.1	0.7	1.2	1.7	0.4	10.2	11.8	1.6
Young, multistory	nc	nc	0.1	0.1	0.0	0.0	0.2	0.1	20.1	1.8	-18.4
Structural classes-woodland—											
Stand initiation	nc	nc	0.0	0.0	0.0	0.0	0.1	0.1	0.0	1.7	1.7
Stem exclusion	+	+	5.2	6.5	1.3*	8.8	5.3	-3.6*	15.4	42.2	26.8*
Understory reinitiation	nc	nc	0.3	1.1	0.8	1.2	1.5	0.3	4.8	10.0	5.2

Table 32—(continued)

Ecological reporting unit	Trend[a]		Area			Patch density			Mean patch size		
	Area	Con.[b]	H[c]	C	MD[d]	H	C	MD[d]	H	C	MD[d]
			------- *Percent* -------			*No./10 000 ha*			------- *Hectares* -------		
Structural classes-shrubland—											
Open low-medium	-	-	85.1	77.2	-7.8*	10.0	6.5	-3.5*	4607.3	3232.1	-1375.2*
Closed low-medium	nc	+	2.7	2.1	-0.6	4.7	1.6	-3.1*	24.3	103.8	79.5*
Open tall	+	nc	0.8	1.4	0.6*	2.8	2.3	-0.6	14.0	20.8	6.8
Closed tall	nc	nc	0.3	0.3	0.0	1.5	0.7	-0.8*	7.1	9.4	2.3
Structural classes-herbland—											
Open	+	+	0.3	6.4	6.1*	1.9	3.5	1.6*	6.3	183.0	176.7*
Closed	nc	nc	0.1	0.5	0.4	0.1	0.3	0.2	3.4	8.6	5.2
Structural classes-other[e]—											
Nonforest-nonrange	nc	+	5.0	4.4	-0.6	6.6	4.9	-1.7*	63.2	96.0	32.8*
Snake Headwaters ERU:											
Physiognomic types—											
Forest	nc	nc	74.5	73.8	-0.7	18.1	19.9	1.8	982.4	1013.9	31.4
Woodland	+	nc	0.2	0.3	0.1*	0.8	0.6	-0.1	1.7	7.2	5.5
Shrubland	-	-	16.3	13.9	-2.4*	22.3	23.6	1.3	56.7	43.5	-13.3*
Herbland	+	+	6.1	8.7	2.6*	21.3	29.1	7.8*	30.4	36.7	6.3
Other[e]	nc	+	3.0	3.3	0.4	7.6	5.2	-2.4*	26.6	34.2	7.7*
Cover types-forest and woodland—											
Engelmann spruce-subalpine fir	+	nc	24.3	31.4	7.1*	19.9	23.7	3.8	173.5	236.1	62.6
Aspen-cottonwood-willow	-	-	8.8	5.7	-3.1*	25.4	25.4	0.1	38.3	26.2	-12.1*
Juniper	+	nc	0.2	0.3	0.1*	0.7	0.6	-0.1	1.8	7.1	5.3
Whitebark pine-subalpine larch	nc	-	6.9	5.7	-1.3	6.0	4.1	-1.9*	57.0	37.8	-19.1
Lodgepole pine	-	+	15.6	11.3	-4.3*	19.1	15.4	-3.7*	93.8	125.1	31.3
Pinyon pine-juniper	nc	nc	0.0	0.0	0.0	0.0	0.1	0.1	0.0	4.8	4.8
Limber pine	+	+	0.7	1.1	0.4*	3.1	2.8	-0.3	2.3	9.9	7.7*
Ponderosa pine	nc	nc	0.0	0.0	0.0	0.1	0.0	-0.1	0.3	0.0	-0.3
Douglas-fir	nc	+	18.2	18.6	0.4	19.3	18.8	-0.4	96.3	139.3	43.0*
Cover types-shrubland—											
Colline low-medium	nc	nc	0.1	0.0	-0.1	0.1	0.0	-0.1	6.5	0.0	-6.5
Montane low-medium	-	nc	13.0	10.7	-2.3*	22.7	22.4	-0.3	49.6	38.5	-11.1
Subalpine-alpine low-medium	nc	nc	0.1	0.3	0.2	0.3	0.2	-0.1	2.3	18.2	15.9
Montane mahogany species	nc	+	0.0	0.1	0.1	0.0	0.4	0.4*	0.0	2.4	2.4*
Colline tall	nc	nc	0.0	0.0	0.0	0.1	0.0	-0.1	0.9	0.0	-0.9
Montane tall	nc	nc	2.1	2.1	-0.1	7.3	9.4	2.1	10.9	10.6	-0.3
Montane wet-site	nc	-	2.8	2.8	0.0	5.3	4.9	-0.4	66.1	49.1	-17.0*
Cover types-herbland—											
Colline bunchgrass	nc	nc	0.0	0.0	0.0	0.0	0.2	0.2	0.0	1.1	1.1
Montane bunchgrass	+	+	2.2	4.3	2.1*	12.8	19.7	6.9*	17.1	88.8	71.7
Subalpine-alpine bunchgrass	nc	nc	0.1	0.3	0.2	0.5	0.5	0.0	4.9	13.5	8.6
Montane exotic grasses-forbs	+	nc	0.2	0.7	0.5*	0.8	0.9	0.1	5.9	41.7	35.8

Table 32—(continued)

Ecological reporting unit	Trend[a] Area	Trend[a] Con.[b]	Area H[c]	Area C	Area MD[d]	Patch density H	Patch density C	Patch density MD[d]	Mean patch size H	Mean patch size C	Mean patch size MD[d]
			Percent			*No./10 000 ha*			*Hectares*		
Subalpine-alpine exotic grasses-forbs	nc	nc	0.0	0.1	0.1	0.0	0.1	0.1	0.0	6.3	6.3
Montane moist-site	-	nc	1.5	1.1	-0.4*	6.6	6.4	-0.2	13.7	17.8	4.1
Subalpine-alpine moist-site	nc	nc	0.0	0.0	0.0	0.1	0.3	0.3	1.7	0.5	-1.2
Postlogging-grasses-forbs	nc	nc	0.0	0.1	0.1	0.0	3.1	3.1	0.0	0.0	0.0
Cover types-agricultural-rural-urban—											
Cropland	nc	nc	0.3	0.1	-0.3	0.2	0.1	-0.1	17.3	12.1	-5.2
Cover types-other—											
Bare ground-road	nc	+	0.0	0.1	0.0	0.4	0.8	0.3*	1.5	2.0	0.5
Glacier	nc	nc	0.1	0.0	-0.1	0.5	0.3	-0.3	1.0	0.6	-0.4
Rock	nc	nc	1.7	2.1	0.5	2.1	2.0	-0.1	13.2	18.0	4.8
Postlogging-bare ground-burned	+	+	0.0	0.0	0.0*	0.0	0.3	0.3*	0.0	1.1	1.1*
Postlogging-bare ground-slumps-erosion	nc	nc	0.1	0.0	-0.1	0.3	0.2	-0.1	5.3	0.5	-4.8
Stream channel-nonvegetated flood plain	nc	nc	0.1	0.1	0.1	0.2	0.1	-0.1	5.8	12.7	7.0
Water	nc	nc	0.9	0.9	0.1*	4.3	2.4	-1.9*	11.8	13.1	1.3
Structural classes-forest—											
Stand initiation	nc	+	6.4	7.0	0.6	14.9	19.8	4.9	26.5	50.1	23.5*
Stem exclusion, open canopy	-	nc	19.1	15.3	-3.8*	35.7	39.2	3.5	55.8	43.8	-12.1
Stem exclusion, closed canopy	-	-	7.9	4.8	-3.1*	19.7	13.8	-5.9*	40.9	25.3	-15.6*
Understory reinitiation	nc	-	13.8	12.6	-1.2	18.4	19.9	1.6	96.7	61.5	-35.2*
Young, multistory	+	+	22.0	30.9	8.9*	23.9	34.8	10.9*	145.3	269.6	124.3*
Old, multistory	-	-	3.2	1.8	-1.4*	2.0	2.0	0.0	27.5	13.9	-13.6*
Old, single story	-	nc	2.0	1.3	-0.7*	3.1	2.1	-0.9	18.5	21.7	3.1
Structural classes-woodland—											
Stand initiation	nc	nc	0.1	0.0	-0.1	0.4	0.1	-0.3	1.9	0.1	-1.9
Stem exclusion	nc	+	0.1	0.3	0.2	0.4	0.6	0.2*	1.2	7.3	6.1
Understory reinitiation	nc	nc	0.0	0.0	0.0	0.3	0.3	0.1	0.2	0.4	0.2
Structural classes-shrubland—											
Open low-medium	-	nc	9.3	7.0	-2.3*	18.1	16.8	-1.4	39.8	38.6	-1.2
Closed low-medium	nc	nc	3.9	4.0	0.1	7.6	7.6	0.0	25.9	28.7	2.7
Open tall	nc	nc	2.9	2.6	-0.3	8.5	9.8	1.3	31.0	26.6	-4.4
Closed tall	nc	nc	2.1	2.3	0.2	4.8	5.6	0.8	36.4	27.9	-8.5
Structural classes-herbland—											
Open	+	+	1.8	4.2	2.4*	10.0	17.6	7.6*	12.6	90.2	77.6*
Closed	nc	nc	2.3	2.3	0.1	10.6	10.6	0.0	17.1	15.0	-2.1
Structural classes-other[e]—											
Nonforest-nonrange	nc	+	3.1	3.5	0.3	7.7	5.4	-2.3*	25.1	37.9	12.9*

Table 32—(continued)

	Trend[a]		Area			Patch density			Mean patch size		
Ecological reporting unit	Area	Con.[b]	H[c]	C	MD[d]	H	C	MD[d]	H	C	MD[d]
			------- *Percent* -------			*No./10 000 ha*			------- *Hectares* -------		
Southern Cascades ERU:											
Physiognomic types—											
Forest	+	nc	80.5	88.3	7.8	3.1	2.0	-1.1	7716.4	7484.1	-232.4
Woodland	+	+	0.0	0.4	0.4	0.0	0.2	0.2*	0.1	21.1	21.0
Shrubland	nc	-	0.5	0.5	0.1	0.9	1.9	1.1*	49.6	11.8	-37.7
Herbland	+	-	0.6	2.7	2.1*	3.6	19.4	15.8*	14.9	15.8	1.0
Other[e]	-	-	18.4	8.1	-10.4*	11.8	22.3	10.5*	835.0	46.6	-788.5
Cover types-forest and woodland—											
Grand fir-white fir	nc	nc	5.9	6.5	0.6	3.3	3.9	0.6	108.6	109.8	1.2
Engelmann spruce-subalpine fir	+	+	0.0	0.2	0.2*	0.0	0.4	0.4*	0.0	8.9	8.9*
Shasta red fir	nc	-	0.2	0.4	0.2	0.1	1.3	1.1*	14.4	4.1	-10.3*
Aspen-cottonwood-willow	nc	nc	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.9	-0.8
Juniper	nc	nc	0.0	0.4	0.4	0.0	0.1	0.1	0.0	20.8	20.8
Western larch	nc	nc	0.0	0.0	0.0	0.0	0.1	0.1	0.3	2.5	2.1
Whitebark pine-subalpine larch	+	+	0.0	0.8	0.8	0.0	0.3	0.3	0.0	20.5	20.5
Lodgepole pine	nc	+	19.4	20.6	1.2	5.2	7.3	2.1*	340.8	387.3	46.5
Sugar pine-western white pine	nc	-	0.3	0.3	0.0	0.6	1.1	0.5*	3.6	2.9	-0.7
Ponderosa pine	+	-	22.7	28.1	5.4	5.8	10.9	5.1*	1531.6	671.5	-860.1
Douglas-fir	nc	-	1.5	1.7	0.2	0.9	1.8	0.9*	35.7	24.5	-11.1
Mountain hemlock	nc	nc	30.5	29.7	-0.8	2.9	2.8	-0.2	970.5	995.6	25.1
Cover types-herbland—											
Alpine	nc	nc	0.1	0.2	0.1	0.4	1.4	1.0*	3.3	3.2	0.0
Dry meadow	+	+	0.0	0.1	0.0*	0.4	0.8	0.4*	1.6	2.7	1.2
Montane moist-site	nc	nc	0.0	0.1	0.1	0.0	0.2	0.2	0.2	3.0	2.8
Wet meadow	nc	+	0.5	0.6	0.0	2.6	4.3	1.7*	18.5	25.6	7.1
Postlogging-grasses-forbs	+	-	0.0	1.6	1.6*	0.0	42.1	42.1*	3.3	0.4	-2.9
Cover types-agricultural-rural-urban—											
Cropland	nc	nc	0.2	0.0	-0.1	0.2	0.0	-0.2	4.8	4.0	-0.8
Urban-rural	+	+	0.0	0.3	0.3*	0.1	0.4	0.4*	4.1	18.6	14.6*
Cover types-other—											
Rock	nc	nc	5.2	4.1	-1.1	3.7	4.3	0.6	89.6	66.4	-23.1
Postlogging-bare ground-burned	-	-	10.1	1.8	-8.4*	2.8	10.6	7.9*	749.3	8.5	-740.8
Postlogging-bare ground-slumps-erosion	nc	nc	0.4	0.2	-0.2	0.4	0.3	-0.1	13.9	5.0	-8.9
Stream channel-nonvegetated flood plain	nc	nc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.3	10.3
Water	nc	nc	1.5	1.6	0.1	5.1	6.2	1.1	39.6	80.1	40.5
Structural classes-forest—											
Stand initiation	nc	-	9.1	9.9	0.8	6.8	24.3	17.6*	171.5	75.4	-96.2
Stem exclusion, open canopy	nc	-	12.3	14.3	2.1	8.6	19.2	10.6*	150.5	86.5	-64.0*
Stem exclusion, closed canopy	+	+	0.5	4.8	4.2*	0.9	4.8	3.9*	19.2	116.7	97.5*

Table 32—(continued)

Ecological reporting unit	Trend[a] Area	Trend[a] Con.[b]	Area H[c]	Area C	Area MD[d]	Patch density H	Patch density C	Patch density MD[d]	Mean patch size H	Mean patch size C	Mean patch size MD[d]
			Percent			*No./10 000 ha*			*Hectares*		
Understory reinitiation	nc	-	10.3	8.7	-1.7	5.6	9.2	3.6*	232.6	106.6	-126.1*
Young, multistory	nc	-	46.0	45.6	-0.4	7.6	17.3	9.8*	670.9	563.9	-106.9
Old, multistory	nc	nc	0.7	1.4	0.7	0.6	0.9	0.3	22.6	53.9	31.3
Old, single story	+	+	1.6	3.7	2.1	1.1	2.9	1.8*	52.9	54.5	1.6
Structural classes-woodland—											
Stem exclusion	+	+	0.0	0.4	0.4	0.0	0.2	0.2*	0.0	24.4	24.4
Old multistory	nc	nc	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.8	0.7
Structural classes-shrubland—											
Open	nc	nc	0.0	0.1	0.1	0.1	0.2	0.1	0.2	3.0	2.8
Structural classes-other[e]—											
Nonforest-nonrange	-	-	19.5	11.2	-8.3*	14.4	40.5	26.1*	856.6	40.4	-816.2
Upper Clark Fork ERU:											
Physiognomic types—											
Forest	nc	nc	87.2	86.2	-1.0	4.7	4.6	-0.1	4140.6	4436.8	296.3
Shrubland	nc	-	2.5	2.1	-0.4	3.7	4.6	0.9*	60.5	31.4	-29.0
Herbland	nc	-	5.5	5.7	0.2	13.8	18.2	4.4*	33.6	28.7	-4.9
Other[e]	nc	+	4.8	6.0	1.2	8.0	10.5	2.6*	44.3	50.4	6.1
Cover types-forest and woodland—											
Grand fir-white fir	nc	nc	0.0	0.1	0.1	0.0	0.0	0.0	0.7	14.3	13.6
Engelmann spruce-subalpine fir	+	-	14.2	17.3	3.1*	13.6	16.5	2.9*	126.7	120.1	-6.6
Aspen-cottonwood-willow	nc	nc	0.3	0.3	0.0	1.0	0.9	-0.1	9.8	11.2	1.3
Western larch	nc	-	2.5	3.0	0.6	3.8	6.6	2.8*	19.1	14.2	-4.8
Whitebark pine-subalpine larch	-	nc	4.3	3.5	-0.8*	6.6	5.3	-1.3	39.1	37.3	-1.9
Lodgepole pine	nc	nc	20.9	19.5	-1.3	17.8	16.4	-1.4	168.4	135.4	-33.0
Limber pine	nc	+	0.0	0.4	0.3	0.1	0.3	0.2*	3.4	7.7	4.3
Ponderosa pine	-	-	12.3	9.5	-2.9*	6.8	7.9	1.1	155.6	78.2	-77.3*
Douglas-fir	nc	-	32.7	32.5	-0.2	14.8	17.6	2.8*	417.1	262.9	-154.3*
Mountain hemlock	nc	+	0.0	0.1	0.1	0.0	0.1	0.1*	0.0	4.5	4.5*
Cover types-shrubland—											
Colline low-medium	nc	-	0.8	0.7	-0.1	0.5	21.1	20.5*	9.7	0.2	-9.5*
Montane low-medium	nc	+	0.4	0.7	0.2	0.5	0.7	0.2*	6.3	19.8	13.6
Subalpine-alpine low-medium	nc	nc	0.2	0.2	-0.1	1.0	0.9	-0.1	6.7	3.7	-3.0
Montane mahogany species	-	-	0.1	0.0	-0.1*	0.3	0.0	-0.3*	1.9	0.6	-1.3*
Montane tall	nc	+	0.2	0.2	-0.1	0.5	0.9	0.4*	8.0	8.1	0.1
Colline wet-site	nc	nc	0.1	0.1	0.0	0.2	0.3	0.0	2.5	1.6	-1.0*
Montane wet-site	nc	nc	0.6	0.6	0.0	2.8	3.0	0.2	14.0	12.8	-1.2
Subalpine-alpine wet-site	nc	-	0.0	0.0	0.0*	0.1	0.0	-0.1*	0.8	0.0	-0.8*
Montane subshrub	-	-	0.3	0.0	-0.3*	0.8	0.1	-0.7*	3.6	3.1	-0.6
Subalpine-alpine subshrub	nc	nc	0.0	0.0	0.0	0.0	1.6	1.6	0.0	0.0	0.0

Table 32—(continued)

Ecological reporting unit	Trend[a] Area	Trend[a] Con.[b]	Area H[c]	Area C	Area MD[d]	Patch density H	Patch density C	Patch density MD[d]	Mean patch size H	Mean patch size C	Mean patch size MD[d]
			Percent			*No./10 000 ha*			*Hectares*		
Cover types-herbland—											
Alpine	nc	nc	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.3	0.3
Colline bunchgrass	nc	nc	0.3	0.3	-0.1	0.5	0.6	0.1	3.1	1.7	-1.4
Montane bunchgrass	-	-	3.1	1.8	-1.4*	8.4	7.3	-1.2*	23.9	13.6	-10.2*
Subalpine-alpine bunchgrass	nc	nc	0.1	0.0	0.0*	0.4	0.2	-0.2*	1.3	1.2	-0.1
Colline exotic grasses-forbs	nc	nc	0.1	0.2	0.0	0.2	0.2	0.0	3.5	3.6	0.1
Montane exotic grasses-forbs	+	-	0.1	0.2	0.1*	0.4	1.2	0.8*	5.3	3.9	-1.4
Subalpine-alpine exotic grasses-forbs	nc	nc	0.1	0.0	-0.1	0.2	0.1	-0.2	1.0	0.8	-0.2
Colline moist-site	nc	nc	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.6	0.6
Montane moist-site	nc	+	0.7	0.7	0.0	1.8	2.3	0.5*	9.6	11.1	1.5
Subalpine-alpine moist-site	nc	+	0.0	0.3	0.2	0.1	0.6	0.4*	2.6	7.1	4.5
Postfire-grasses	nc	nc	0.0	0.5	0.4	0.2	0.8	0.7	1.0	1.9	0.9
Postlogging-grasses-forbs	+	-	0.0	0.9	0.9*	0.3	40.5	40.2*	1.9	0.4	-1.5*
Cover types-agricultural-rural-urban—											
Cropland	nc	nc	1.2	1.3	0.1	0.8	0.8	0.0	31.1	32.4	1.3
Pasture	nc	nc	0.4	0.4	0.0	0.7	0.8	0.1	12.3	7.8	-4.5
Urban-rural	nc	+	0.0	0.1	0.0	0.3	0.6	0.3*	1.2	2.0	0.8
Cover types-other—											
Bare ground-road	nc	nc	0.0	0.0	0.0*	0.1	0.1	0.0	2.7	1.9	-0.8*
Rock	nc	nc	2.5	2.4	-0.1	5.0	5.3	0.3	20.0	13.9	-6.1*
Postlogging-bare ground-burned	+	+	0.1	1.5	1.4*	0.5	2.3	1.8*	3.1	15.9	12.8*
Postlogging-bare ground-slumps-erosion	nc	nc	0.0	0.0	0.0	0.2	0.0	-0.2	0.6	0.0	-0.6
Stream channel-nonvegetated flood plain	nc	nc	0.1	0.1	0.0	0.2	0.4	0.2	2.2	3.1	0.9
Water	nc	+	0.8	0.7	-0.1	1.5	1.8	0.3*	23.6	26.9	3.3
Structural classes-forest—											
Stand initiation	-	-	15.9	11.1	-4.8*	21.1	23.5	2.5	69.8	50.8	-18.9*
Stem exclusion, open canopy	nc	-	18.5	18.2	-0.3	27.5	35.3	7.8*	78.2	56.3	-21.9*
Stem exclusion, closed canopy	+	+	16.7	21.1	4.4*	14.9	16.3	1.4	157.9	402.9	245.0*
Understory reinitiation	nc	-	15.6	14.0	-1.5	16.3	19.8	3.4*	97.6	68.6	-29.0*
Young, multistory	nc	nc	19.7	21.1	1.3	21.9	21.0	-0.9	90.5	100.6	10.1
Old, multistory	nc	nc	0.6	0.4	-0.2	0.6	1.2	0.5	3.1	7.3	4.2
Old, single story	nc	+	0.2	0.3	0.1	0.5	1.0	0.5	1.1	4.5	3.3*
Structural classes-shrubland—											
Open low-medium	nc	nc	1.2	0.8	-0.4	1.7	1.4	-0.3	12.7	24.3	11.6
Closed low-medium	nc	nc	0.6	0.8	0.2	1.3	1.5	0.2	5.0	8.4	3.4
Open tall	nc	+	0.5	0.6	0.2	2.0	2.7	0.7*	13.1	17.0	3.9
Closed tall	-	nc	0.5	0.3	-0.3*	1.7	1.5	-0.2	14.9	8.7	-6.2

Table 32—(continued)

Ecological reporting unit	Trend[a] Area	Trend[a] Con.[b]	Area H[c]	Area C	Area MD[d]	Patch density H	Patch density C	Patch density MD[d]	Mean patch size H	Mean patch size C	Mean patch size MD[d]
			Percent			*No./10 000 ha*			*Hectares*		
Structural classes-herbland—											
Open	nc	nc	1.1	1.3	0.2	3.7	4.8	1.1*	15.5	15.8	0.3
Closed	-	-	3.5	2.1	-1.5*	8.3	7.6	-0.8	25.9	15.3	-10.6*
Structural classes-other[e]—											
Nonforest-nonrange	+	+	5.3	7.9	2.6*	8.7	14.6	5.9*	53.6	57.3	3.7
Upper Klamath ERU:											
Physiognomic types—											
Forest	-	-	50.5	47.5	-3.1*	7.8	5.9	-1.9*	1840.7	1711.3	-129.4
Woodland	+	+	8.4	12.8	4.4*	10.6	9.0	-1.6*	58.0	189.2	131.2*
Shrubland	nc	nc	21.4	18.8	-2.6	20.5	18.1	-2.4	275.8	116.8	-159.0
Herbland	nc	nc	10.6	9.0	-1.6	7.4	8.4	0.9	297.3	202.9	-94.5
Other[e]	+	+	9.1	12.0	2.9*	3.9	6.9	3.0*	160.2	338.7	178.4*
Cover types-forest and woodland—											
Grand fir-white fir	nc	nc	7.8	8.1	0.3	5.1	3.9	-1.2	152.1	261.3	109.1
Engelmann spruce-subalpine fir	nc	nc	0.1	0.1	0.0	0.1	0.2	0.1	4.2	4.1	-0.1
Shasta red fir	nc	nc	7.8	8.5	0.7	1.5	1.5	0.0	124.1	117.3	-6.9
Aspen-cottonwood-willow	nc	nc	0.0	0.1	0.0	0.1	0.0	-0.1	2.3	6.8	4.5
Juniper	+	+	8.4	12.8	4.4*	10.6	8.9	-1.7*	58.0	189.2	131.2*
Western larch	nc	nc	0.0	0.1	0.1	0.0	0.2	0.2	0.0	3.1	3.1
Whitebark pine-subalpine larch	nc	nc	0.0	0.0	0.0	0.1	0.1	0.0	1.8	1.4	-0.4
Lodgepole pine	nc	nc	1.4	1.7	0.3	2.7	2.4	-0.3	15.0	19.6	4.6
Sugar pine-western white pine	nc	nc	0.0	0.0	0.0	0.1	0.0	-0.1	0.5	0.0	-0.5
Ponderosa pine	-	nc	26.7	23.5	-3.2*	8.2	8.7	0.5	387.3	256.7	-130.6
Douglas-fir	nc	-	2.1	1.2	-0.8	2.3	2.6	0.4	31.9	10.3	-21.6*
Mountain hemlock	nc	-	4.7	4.2	-0.5	1.1	1.0	-0.1	308.0	242.9	-65.1*
Cover types-shrubland—											
Colline low-medium	nc	-	1.8	2.9	1.1	4.7	139.0	134.3*	13.4	1.4	-12.0*
Montane low-medium	-	nc	18.5	14.9	-3.6*	15.0	13.6	-1.4	273.9	106.7	-167.2
Subalpine-alpine low-medium	nc	nc	0.1	0.1	0.0	0.2	0.1	-0.1	3.7	7.3	3.6
Colline mahogany species	nc	nc	0.0	0.1	0.1	0.2	0.2	0.0	2.6	5.0	2.4
Montane mahogany species	nc	nc	0.1	0.1	0.0	0.2	0.1	-0.1	18.0	9.3	-8.8
Colline tall	nc	nc	0.0	0.0	0.0	0.3	0.1	-0.1	2.1	1.5	-0.6
Montane tall	nc	nc	0.3	0.4	0.2	1.1	1.0	-0.1	8.9	7.0	-1.9
Colline wet-site	nc	nc	0.5	0.0	-0.5	0.6	0.0	-0.6	5.7	0.7	-5.0
Montane wet-site	-	-	0.6	0.4	-0.1*	1.5	0.8	-0.7*	35.8	29.5	-6.3
Cover types-herbland—											
Dry meadow	nc	nc	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.5	0.5
Colline bunchgrass	-	nc	2.8	1.0	-1.8*	2.4	0.8	-1.6	32.1	24.1	-8.0
Montane bunchgrass	-	-	0.7	0.4	-0.3*	1.5	1.1	-0.4	26.3	9.1	-17.2*
Colline exotic grasses-forbs	nc	+	0.0	0.4	0.4	0.1	0.4	0.3*	1.5	18.8	17.3

Table 32—(continued)

Ecological reporting unit	Trend[a] Area	Trend[a] Con.[b]	Area H[c]	Area C	Area MD[d]	Patch density H	Patch density C	Patch density MD[d]	Mean patch size H	Mean patch size C	Mean patch size MD[d]
			Percent			*No./10 000 ha*			*Hectares*		
Montane exotic grasses-forbs	nc	nc	0.0	0.0	0.0	0.1	0.0	-0.1	1.2	0.0	-1.2*
Colline moist-site	-	-	1.1	0.1	-1.0*	0.4	0.2	-0.2	49.2	3.2	-46.0*
Montane moist-site	nc	-	0.8	0.7	-0.1	1.9	2.9	1.1*	14.7	12.2	-2.5
Postlogging-grasses-forbs	+	-	0.0	0.1	0.1*	0.1	7.4	7.2*	1.9	0.1	-1.9*
Cover types-agricultural-rural-urban—											
Cropland	+	+	7.0	10.5	3.5*	2.4	2.4	0.0	187.0	384.8	197.7*
Pasture	nc	+	4.4	5.3	0.9	0.3	0.0	-0.3*	702.3	898.1	195.8
Urban-rural	nc	+	0.0	0.1	0.1	0.4	0.5	0.1	1.2	3.8	2.5*
Cover types-other—											
Bare ground-road	nc	nc	0.0	0.0	0.0*	0.0	0.0	0.0	0.0	3.8	3.8*
Rock	nc	+	0.2	0.4	0.2	0.9	0.9	0.0	2.7	5.4	2.7*
Postlogging-bare ground-burned	+	+	0.0	0.4	0.4*	0.1	2.9	2.8*	4.2	5.7	1.5
Postlogging-bare ground-slumps-erosion	nc	nc	0.0	0.0	0.0	0.0	0.2	0.2	0.0	1.1	1.1
Water	nc	nc	2.2	1.4	-0.8	1.1	1.3	0.2	256.9	77.2	-179.7
Structural classes-forest—											
Stand initiation	nc	+	1.9	3.6	1.6	4.4	3.6	-0.7	31.2	62.1	30.9*
Stem exclusion, open canopy	nc	nc	11.3	10.9	-0.4	16.9	18.3	1.4	92.0	77.6	-14.4
Stem exclusion, closed canopy	nc	-	1.2	1.6	0.3	2.1	3.7	1.6*	23.7	22.1	-1.5
Understory reinitiation	+	+	5.6	8.1	2.5	6.9	10.5	3.6*	42.9	292.3	249.4
Young, multistory	-	nc	21.1	16.4	-4.7*	10.2	11.7	1.5	401.1	163.9	-237.2
Old, multistory	nc	-	4.3	5.5	1.2	3.5	6.6	3.1*	46.1	34.1	-11.9
Old, single story	-	-	7.4	4.8	-2.6*	3.9	7.1	3.3*	69.6	22.7	-47.0*
Structural classes-woodland—											
Stand initiation	+	nc	0.4	1.1	0.7	1.2	0.9	-0.3	7.1	8.5	1.5
Stem exclusion	+	nc	5.9	7.6	1.6*	8.2	7.1	-1.1	55.8	131.6	75.7
Understory reinitiation	+	+	2.0	3.8	1.8*	2.8	3.4	0.6*	5.3	330.1	324.9
Old multistory	nc	nc	0.0	0.3	0.3	0.3	0.6	0.4	0.9	3.2	2.3
Structural classes-shrubland—											
Open low-medium	nc	nc	18.5	15.9	-2.6	18.9	16.7	-2.2	269.6	99.3	-170.4
Closed low-medium	nc	+	1.9	2.0	0.1	3.6	1.4	-2.2*	24.8	73.1	48.3*
Open tall	nc	+	1.1	0.9	-0.2	3.2	1.9	-1.4*	32.5	48.3	15.8
Closed tall	nc	-	0.3	0.2	-0.1	1.3	0.6	-0.6*	9.2	4.3	-4.9*
Structural classes-herbland—											
Open	-	-	3.8	1.4	-2.4*	3.3	2.2	-1.1	101.6	35.8	-65.8
Closed	-	nc	1.6	1.1	-0.4*	2.7	3.3	0.6	28.9	24.2	-4.7
Structural classes-other[e]—											
Nonforest-nonrange	+	+	13.9	18.2	4.3*	4.5	9.1	4.6*	340.8	630.1	289.2*

Table 32—(continued)

Ecological reporting unit	Trend[a] Area	Trend[a] Con.[b]	Area H[c]	Area C	Area MD[d]	Patch density H	Patch density C	Patch density MD[d]	Mean patch size H	Mean patch size C	Mean patch size MD[d]
			Percent			*No./10 000 ha*			*Hectares*		
Upper Snake ERU:											
Physiognomic types—											
Forest	+	+	2.4	3.2	0.9*	2.7	2.1	-0.6	26.6	42.5	15.9*
Woodland	nc	nc	3.0	2.9	0.0	6.7	6.6	-0.1	13.5	20.7	7.2
Shrubland	-	nc	73.8	68.5	-5.3	7.6	7.6	0.0	3784.1	4304.2	520.1
Herbland	nc	nc	10.6	9.9	-0.7	7.1	7.6	0.5	345.8	497.1	151.3
Other[e]	+	nc	10.3	15.4	5.1	5.5	5.5	0.0	427.4	428.3	0.9
Cover types-forest and woodland—											
Engelmann spruce-subalpine fir	nc	nc	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.8	0.8
Aspen-cottonwood-willow	nc	+	0.9	1.0	0.1	2.3	2.5	0.2	5.5	7.0	1.5*
Juniper	nc	nc	2.6	2.5	-0.1	6.3	6.1	-0.2	12.4	19.2	6.9
Lodgepole pine	nc	nc	0.1	0.2	0.1	0.7	0.3	-0.4	1.3	13.3	12.0
Pinyon pine-juniper	nc	nc	0.4	0.5	0.1	0.7	0.7	0.0	8.3	10.2	1.9
Douglas-fir	nc	+	1.4	2.1	0.7	2.7	1.3	-1.4*	13.0	39.8	26.9
Cover types-shrubland—											
Colline low-medium	-	-	71.0	62.3	-8.6*	7.3	5679.9	5672.5*	3639.5	56.8	-3582.7*
Montane low-medium	nc	nc	0.3	0.5	0.2	0.7	1.2	0.5	2.8	5.5	2.7
Colline mahogany species	nc	nc	0.4	0.0	-0.4	0.5	0.0	-0.5	6.1	0.0	-6.1
Montane mahogany species	nc	nc	0.1	0.1	0.0	0.7	0.5	-0.3	0.6	0.8	0.2
Colline tall	nc	+	3.4	5.1	1.6	5.8	3.6	-2.2*	29.9	50.9	20.9*
Montane tall	nc	nc	0.1	0.4	0.3	0.3	1.6	1.3	4.5	4.7	0.1*
Colline wet-site	nc	nc	0.1	0.1	0.0	1.0	0.7	-0.3	1.7	4.9	3.1
Montane wet-site	nc	nc	0.0	0.0	0.0	0.3	0.3	0.0	0.3	0.3	0.0
Cover types-herbland—											
Alpine	nc	nc	0.0	0.0	0.0	0.1	0.0	-0.1	1.2	0.0	-1.2
Colline bunchgrass	+	nc	3.7	5.2	1.5*	1.1	1.9	0.8	344.4	488.2	143.8
Colline exotic grasses-forbs	nc	+	4.6	4.0	-0.6	5.3	5.4	0.1	29.3	75.4	46.2*
Colline moist-site	nc	nc	0.1	0.2	0.0	0.5	0.5	0.0	11.1	12.2	1.1
Wet meadow	nc	nc	0.0	0.0	0.0	0.0	0.2	0.2	0.0	0.9	0.9
Postfire-grasses-forbs	nc	nc	0.4	0.2	-0.2	0.5	0.2	-0.3	15.8	11.0	-4.7
Cover types-agricultural-rural-urban—											
Cropland	+	+	2.7	12.1	9.4*	3.3	4.2	0.9	52.1	229.4	177.3*
Pasture	nc	nc	0.1	0.2	0.2	0.1	0.2	0.1	9.4	13.3	3.9
Urban-rural	+	+	0.0	0.2	0.2*	0.6	1.7	1.1*	1.1	3.8	2.7*
Cover types-other—											
Bare ground-road	nc	nc	0.1	0.1	0.0	0.2	0.2	0.0	9.3	10.2	0.9
Rock	-	nc	6.8	2.6	-4.1*	0.5	0.7	0.2	1884.0	182.3	-1701.7
Sand	nc	nc	0.5	0.4	-0.1	0.6	0.5	-0.1	13.4	10.6	-2.8
Stream channel-nonvegetated flood plain	nc	nc	0.1	0.0	-0.1	0.4	0.0	-0.4	2.1	0.6	-1.5
Water	nc	nc	0.1	0.1	0.0	0.4	0.2	-0.2	3.4	5.5	2.1

Table 32—(continued)

Ecological reporting unit	Trend[a] Area	Con.[b]	Area H[c]	C	MD[d]	Patch density H	C	MD[d]	Mean patch size H	C	MD[d]
			------- *Percent* -------			*No. /10 000 ha*			------- *Hectares* -------		
Structural classes-forest—											
Stand initiation	-	+	0.8	0.3	-0.5*	4.9	1.7	-3.3*	3.7	6.4	2.7
Stem exclusion, open canopy	+	+	0.4	1.0	0.6*	3.0	3.3	0.3	6.9	11.9	5.1*
Stem exclusion, closed canopy	nc	nc	0.1	0.1	0.0	0.9	0.5	-0.4	1.6	1.5	-0.1
Understory reinitiation	nc	nc	2.5	1.6	-1.0	5.7	3.5	-2.1	11.6	13.7	2.0
Young, multistory	nc	+	0.6	1.1	0.5	2.7	1.2	-1.5*	7.5	22.6	15.1
Old, multistory	nc	nc	0.0	0.0	0.0	0.1	0.1	0.0	1.7	2.0	0.3
Old, single story	nc	nc	0.1	0.0	-0.1	0.3	0.1	-0.1	2.9	1.3	-1.7
Structural classes-woodland—											
Stand initiation	nc	nc	0.4	0.2	-0.3	2.8	0.9	-1.9	1.7	1.9	0.2
Stem exclusion	+	+	0.7	2.0	1.3*	4.0	6.2	2.2*	8.7	17.9	9.3*
Understory reinitiation	-	-	1.8	0.8	-1.1*	4.4	2.9	-1.5	7.9	4.4	-3.5*
Structural classes-shrubland—											
Open low-medium	-	nc	63.1	57.8	-5.3	9.7	8.5	-1.2	2352.3	2323.8	-28.5
Closed low-medium	-	+	8.2	5.0	-3.2	11.1	2.9	-8.2*	73.9	217.3	143.4
Open tall	+	+	3.0	5.2	2.3*	5.3	4.3	-1.1	35.6	54.5	18.9*
Closed tall	-	-	0.7	0.4	-0.4*	4.0	2.1	-1.9*	13.3	2.5	-10.8
Structural classes-herbland—											
Open	nc	nc	8.1	9.1	1.0	5.4	6.2	0.8	371.1	480.2	109.2
Closed	nc	nc	0.7	0.3	-0.4	2.0	1.1	-0.9	24.9	17.6	-7.3
Structural classes-other[e]—											
Nonforest-nonrange	+	nc	10.8	16.0	5.1	5.9	5.8	-0.1	395.0	433.3	38.3

[a] Choices for either field are (+) increase; (-) decrease; (nc) no ecologically significant change.

[b] Con. = connectivity change among patches in a patch type.

[c] H = historical ; C = current; MD = mean difference of pairwise comparisons of historical and current subwatersheds.

[d] * = statistically significant difference at $P \leq 0.2$; all values rounded to 1 decimal place.

[e] "Other" includes anthropogenic cover types and other nonforest and nonrangeland (nonshrubland, nonherbland, nonwoodland) types.

Appendix 3

Table 33—Historical and current percentage of area, patch density, and mean patch size for insect and pathogen disturbance vulnerability classes of sampled subwatersheds of the ERUs of the mid-scale ecological assessment of the interior Columbia River basin

	Trend[a]		Area			Patch density			Mean patch size		
Ecological reporting unit	Area	Con.[b]	H[c]	C	MD[d]	H	C	MD[d]	H	C	MD[d]
			------- *Percent* -------			*No. /10 000 ha*			------- *Hectares* -------		
Blue Mountains ERU:											
Western spruce budworm—											
Low	nc	-	47.2	46.3	-0.9	27.7	35.3	7.6*	475.0	465.9	-9.1
Moderate	nc	-	14.6	14.8	0.2	29.1	35.0	5.9*	60.8	53.6	-7.2
High	nc	-	38.2	38.9	0.7	12.4	14.7	2.2*	568.4	516.4	-52.0
Douglas-fir beetle											
Low	-	-	75.0	69.8	-5.2*	16.2	19.5	3.3*	1332.0	1241.5	-90.5
Moderate	nc	+	19.8	22.4	2.6	17.7	22.8	5.0*	145.3	199.2	53.9
High	+	+	5.2	7.8	2.5*	4.5	8.9	4.4*	65.3	76.1	10.8
Western pine beetle (type 1)—											
Low	nc	+	78.8	81.0	2.3	12.4	13.2	0.8	2098.7	3572.1	1473.5*
Moderate	-	-	18.8	16.5	-2.3*	11.3	15.2	3.9*	304.5	128.5	-176.0
High	nc	nc	2.5	2.5	0.0	4.2	3.8	-0.4	31.3	23.0	-8.3
Western pine beetle (type 2)—											
Low	nc	nc	51.6	54.2	2.6	26.7	27.6	0.9	589.7	680.2	90.5
Moderate	-	-	30.6	26.0	-4.5*	20.6	26.7	6.0*	259.7	141.8	-118.0*
High	nc	+	17.8	19.7	1.9	10.5	13.7	3.1*	166.9	254.5	87.6*
Mountain pine beetle (type 1)—											
Low	nc	-	49.1	49.4	0.3	29.9	34.3	4.4*	661.0	447.3	-213.7*
Moderate	nc	nc	44.3	45.5	1.3	13.6	14.6	1.1	445.1	508.1	63.1
High	-	nc	6.7	5.1	-1.5*	9.1	10.6	1.6	55.0	46.1	-8.9
Mountain pine beetle (type 2)—											
Low	nc	nc	51.6	54.2	2.6	26.7	27.6	0.9	589.7	680.2	90.5
Moderate	-	-	30.6	26.0	-4.5*	20.6	26.7	6.0*	259.7	141.8	-118.0*
High	nc	+	17.8	19.7	1.9	10.5	13.7	3.1*	166.9	254.5	87.6*
Fir engraver—											
Low	+	-	65.0	70.4	5.3*	20.4	21.6	1.2	1907.4	1409.0	-498.4*
Moderate	+	+	10.3	14.6	4.3*	18.4	22.6	4.2*	65.3	81.4	16.1*
High	-	-	24.6	15.0	-9.7*	9.0	12.4	3.4*	428.3	142.2	-286.1*
Spruce beetle—											
Low	+	nc	63.3	66.0	2.7*	28.1	29.0	0.9	1466.6	1452.4	-14.2
Moderate	nc	nc	34.1	33.3	-0.8	16.7	15.2	-1.5	385.6	350.0	-35.6
High	-	nc	2.6	0.7	-2.0*	1.9	0.9	-1.0*	25.2	19.2	-6.0
Douglas-fir dwarf mistletoe—											
Low	-	-	65.5	57.4	-8.0*	20.8	29.0	8.2*	1016.1	903.9	-112.1
Moderate	nc	-	24.4	26.0	1.6	17.6	23.1	5.5*	199.6	185.0	-14.6
High	+	+	10.1	16.5	6.4*	9.3	19.6	10.3*	87.5	125.7	38.3*

Table 33—(continued)

Ecological reporting unit	Trend[a] Area	Trend[a] Con.[b]	Area H[c]	Area C	Area MD[d]	Patch density H	Patch density C	Patch density MD[d]	Mean patch size H	Mean patch size C	Mean patch size MD[d]
			Percent			*No. /10 000 ha*			*Hectares*		
Western dwarf mistletoe—											
Low	nc	nc	70.9	71.1	0.2	13.7	14.0	0.4	1741.6	2037.2	295.6
Moderate	nc	+	18.7	20.9	2.1	16.4	22.9	6.5*	161.0	171.3	10.2
High	-	-	10.4	8.1	-2.3*	9.6	12.7	3.0*	83.8	59.8	-24.0
Western larch dwarf mistletoe—											
Low	+	nc	95.9	96.5	0.6*	5.2	4.9	-0.3	3638.2	4384.5	746.4
Moderate	nc	nc	2.9	2.7	-0.2	4.4	6.9	2.6*	26.5	30.1	3.5
High	nc	-	1.3	0.8	-0.4	1.8	3.6	1.7*	16.0	9.8	-6.1*
Lodgepole pine dwarf mistletoe—											
Low	+	+	93.9	95.1	1.2*	6.3	5.5	-0.8*	3203.1	4194.6	991.6*
Moderate	-	nc	4.5	3.3	-1.2*	6.1	7.4	1.2	42.3	43.3	1.0
High	nc	nc	1.5	1.6	0.0	2.9	4.0	1.0	21.5	21.8	0.3
Armillaria root disease—											
Low	nc	-	39.6	39.1	-0.5	27.3	34.2	7.0*	414.9	393.6	-21.2
Moderate	nc	-	19.6	19.9	0.2	28.7	35.2	6.6*	97.6	81.2	-16.4
High	nc	nc	40.7	41.0	0.3	13.0	13.6	0.7	485.0	616.2	131.2
Laminated root rot—											
Low	nc	nc	50.6	50.1	-0.6	27.3	34.0	6.7*	523.7	545.4	21.7
Moderate	-	nc	14.9	13.0	-1.9*	22.2	26.0	3.8*	84.5	90.5	6.0
High	nc	+	34.5	37.0	2.5	12.6	13.9	1.3	376.7	572.4	195.6*
S-group annosum root disease—											
Low	nc	nc	65.5	68.3	2.8	20.6	23.8	3.2*	2140.7	2092.4	-48.3
Moderate	+	+	10.2	14.8	4.7*	17.8	21.7	3.8*	54.0	84.1	30.0*
High	-	-	24.3	16.9	-7.5*	11.0	15.0	4.0*	238.3	114.7	-123.6*
P-group annosum root disease—											
Low	nc	nc	72.7	72.1	-0.6	13.4	13.2	-0.2	1759.3	1993.3	234.1
Moderate	nc	nc	15.7	17.5	1.8	17.2	26.3	9.1*	87.5	91.8	4.4
High	nc	-	11.6	10.4	-1.1	9.5	11.3	1.8	110.7	75.2	-35.5*
Tomentosus root and butt rot—											
Low	nc	nc	93.3	94.1	0.8	7.3	6.3	-1.0*	3335.0	3812.5	477.6
Moderate	+	nc	2.3	3.4	1.1*	3.7	4.9	1.3	18.4	23.5	5.2
High	-	nc	4.4	2.5	-1.9*	2.6	3.0	0.4	33.4	37.2	3.7
Schweinitzii root and butt rot—											
Low	nc	nc	38.1	37.3	-0.9	26.9	32.0	5.1*	376.6	389.0	12.4
Moderate	-	-	15.1	10.6	-4.5*	25.0	27.8	2.7*	63.3	41.5	-21.8*
High	+	+	46.7	52.1	5.4*	12.7	10.5	-2.2*	807.1	956.2	149.1
Rust-red stringy rot—											
Low	nc	nc	71.8	72.7	0.9	21.4	21.7	0.3	1656.8	1728.1	71.3
Moderate	nc	nc	27.0	26.5	-0.5	15.2	14.3	-1.0	233.3	215.2	-18.1
High	nc	nc	1.1	0.8	-0.4	1.7	2.4	0.7*	21.4	13.1	-8.3

Table 33—(continued)

Ecological reporting unit	Trend[a] Area	Trend[a] Con.[b]	Area H[c]	Area C	Area MD[d]	Patch density H	Patch density C	Patch density MD[d]	Mean patch size H	Mean patch size C	Mean patch size MD[d]
			Percent			*No. /10 000 ha*			*Hectares*		
Central Idaho Mountains ERU:											
Western spruce budworm—											
Low	nc	+	31.7	32.0	0.3	26.6	33.7	7.1*	461.0	474.4	13.3
Moderate	-	-	18.9	16.9	-2.0*	29.9	36.7	6.8*	73.9	51.9	-22.1*
High	nc	nc	49.4	51.1	1.7	13.4	14.0	0.7	869.7	911.9	42.2
Douglas-fir beetle—											
Low	nc	-	74.0	72.9	-1.1	14.7	15.5	0.8	2322.0	1776.8	-545.2*
Moderate	nc	nc	21.6	22.1	0.6	15.7	17.4	1.7	164.1	141.1	-23.0
High	nc	nc	4.4	5.0	0.6	8.1	8.6	0.5	44.4	60.6	16.2
Western pine beetle (type 1)—											
Low	nc	nc	94.7	95.2	0.4	7.2	8.4	1.2*	2679.7	2738.8	59.1
Moderate	-	-	4.3	3.5	-0.8*	3.7	4.3	0.6	34.3	20.1	-14.2*
High	nc	-	1.0	1.3	0.3	1.6	2.8	1.2*	9.3	8.7	-0.6
Western pine beetle (type 2)—											
Low	-	-	57.1	54.6	-2.6*	23.0	30.7	7.7*	888.3	850.7	-37.6
Moderate	+	nc	39.6	42.1	2.5*	22.4	22.7	0.3	395.2	463.0	67.8
High	nc	nc	3.3	3.3	0.0	3.0	3.6	0.6	28.7	23.8	-4.8
Mountain pine beetle (type 1)—											
Low	-	-	43.8	41.8	-2.0*	23.9	29.3	5.4*	1173.9	857.3	-316.6*
Moderate	nc	-	35.1	36.0	0.9	24.8	27.2	2.4	452.6	184.5	-268.1*
High	nc	nc	21.0	22.1	1.1	16.4	17.3	0.9	165.4	130.6	-34.8
Mountain pine beetle (type 2)—											
Low	-	-	57.1	54.6	-2.6*	23.0	30.7	7.7*	888.3	850.7	-37.6
Moderate	+	nc	39.6	42.1	2.5*	22.4	22.7	0.3	395.2	463.0	67.8
High	nc	nc	3.3	3.3	0.0	3.0	3.6	0.6	28.7	23.8	-4.8
Fir engraver—											
Low	nc	+	57.1	56.9	-0.2	20.5	26.9	6.4*	1079.7	1220.7	141.1
Moderate	-	-	21.6	16.9	-4.7*	30.3	32.3	2.1	97.2	55.9	-41.3*
High	+	+	21.3	26.2	4.9*	17.3	16.7	-0.6	156.7	254.6	97.9*
Spruce beetle—											
Low	-	-	65.8	63.1	-2.8*	17.4	23.9	6.5*	1831.2	1491.0	-340.2*
Moderate	+	nc	31.1	33.4	2.3*	19.9	19.8	-0.1	225.7	241.5	15.9
High	nc	nc	3.1	3.6	0.4	4.6	6.3	1.7*	59.4	37.2	-22.2
Douglas-fir dwarf mistletoe—											
Low	+	nc	67.4	69.6	2.2*	15.4	16.2	0.8	2343.7	1896.8	-446.9*
Moderate	-	nc	21.9	19.9	-2.0*	20.4	22.8	2.4	137.8	97.4	-40.4
High	nc	nc	10.7	10.5	-0.2	11.0	14.6	3.6*	95.4	75.0	-20.3
Western dwarf mistletoe—											
Low	nc	nc	93.8	93.9	0.1	6.7	8.3	1.5*	3121.7	2991.7	-130.0
Moderate	nc	nc	3.9	4.4	0.4	5.1	5.3	0.1	24.1	23.5	-0.6
High	-	-	2.2	1.8	-0.5*	2.8	2.8	0.0	17.2	11.4	-5.7*

Table 33—(continued)

Ecological reporting unit	Trend[a] Area	Trend[a] Con.[b]	Area H[c]	Area C	Area MD[d]	Patch density H	Patch density C	Patch density MD[d]	Mean patch size H	Mean patch size C	Mean patch size MD[d]
			------- *Percent* -------			*No./10 000 ha*			------- *Hectares* -------		
Western larch dwarf mistletoe—											
Low	+	+	97.4	98.7	1.3*	5.1	4.5	-0.7*	3389.1	4079.1	689.9*
Moderate	-	nc	2.1	1.1	-0.9*	3.7	3.0	-0.6	15.9	13.2	-2.7
High	nc	nc	0.5	0.1	-0.4	0.7	0.5	-0.1	5.5	3.1	-2.5
Lodgepole pine dwarf mistletoe—											
Low	+	nc	70.1	71.7	1.7*	13.6	14.3	0.7	2035.5	2086.5	51.0
Moderate	-	-	16.3	13.1	-3.1*	22.0	21.9	-0.2	68.0	50.7	-17.3*
High	nc	nc	13.7	15.1	1.5	16.4	16.1	-0.3	71.1	76.2	5.0
Armillaria root disease—											
Low	nc	-	31.6	30.7	-0.9	27.8	37.0	9.1*	541.7	425.5	-116.2
Moderate	nc	-	30.8	30.1	-0.7	31.8	33.9	2.1	166.8	128.2	-38.6*
High	nc	nc	37.6	39.2	1.6	17.5	18.6	1.0	361.6	418.2	56.6
Laminated root rot—											
Low	nc	-	43.6	43.7	0.1	23.8	32.0	8.2*	737.0	545.4	-191.6*
Moderate	nc	nc	27.0	28.5	1.4	26.8	28.2	1.4	196.3	227.6	31.3
High	nc	-	29.3	27.8	-1.5	14.5	19.3	4.8*	321.5	253.2	-68.3*
S-group annosum root disease—											
Low	nc	-	38.8	38.7	-0.2	28.7	36.3	7.5*	592.8	467.3	-125.6
Moderate	-	-	25.0	22.4	-2.5*	35.2	36.9	1.7	89.1	61.4	-27.7*
High	+	nc	36.2	38.9	2.7*	17.9	19.3	1.4	378.4	377.5	-0.9
P-group annosum root disease—											
Low	nc	nc	94.4	94.3	0.0	6.6	8.0	1.5*	2993.0	3088.2	95.2
Moderate	nc	nc	3.5	3.9	0.4	4.6	5.3	0.7	21.6	20.9	-0.6
High	-	-	2.1	1.7	-0.4*	2.7	2.8	0.1	15.0	12.4	-2.7*
Tomentosus root and butt rot—											
Low	nc	+	79.3	77.7	-1.6	11.1	11.8	0.7	2363.1	2375.5	12.4
Moderate	nc	-	11.4	11.3	-0.1	16.6	19.9	3.3*	55.4	43.1	-12.3*
High	+	+	9.3	11.0	1.7*	12.4	15.0	2.6*	61.5	69.9	8.4
Schweinitzii root and butt rot—											
Low	nc	-	30.2	29.9	-0.3	22.4	30.4	8.0*	591.0	462.4	-128.6
Moderate	nc	+	12.7	13.9	1.2	25.3	28.5	3.2*	50.9	53.2	2.2
High	nc	nc	57.1	56.2	-0.9	10.2	11.0	0.9	1254.1	1527.6	273.5
White pine blister rust (type 1)—											
Low	nc	nc	62.1	61.9	-0.1	8.9	10.0	1.2*	2912.8	2712.5	-200.3
Moderate	nc	nc	37.9	38.0	0.1	8.0	8.5	0.6	1154.9	1103.2	-51.7
High	nc	nc	0.0	0.1	0.0	0.2	0.4	0.2	1.4	0.5	-0.9
White pine blister rust (type 2)—											
Low	nc	-	84.1	84.1	0.0	4.4	5.9	1.5*	4812.1	4353.2	-458.9*
Moderate	nc	nc	15.2	15.3	0.1	11.5	12.1	0.5	151.5	128.7	-22.8
High	nc	nc	0.7	0.6	0.0	2.2	2.2	0.0	6.7	7.7	1.0

Table 33—(continued)

Ecological reporting unit	Trend[a] Area	Con.[b]	Area H[c]	C	MD[d]	Patch density H	C	MD[d]	Mean patch size H	C	MD[d]
			------- Percent -------			No./10 000 ha			------- Hectares -------		
Rust-red stringy rot—											
Low	-	-	80.4	77.6	-2.8*	7.9	12.3	4.4*	3042.7	2607.3	-435.4*
Moderate	+	nc	19.5	22.2	2.6*	18.9	19.5	0.6	125.7	178.6	52.9
High	nc	nc	0.1	0.3	0.2	0.2	0.5	0.3*	1.3	2.5	1.2
Columbia Plateau ERU:											
Western spruce budworm—											
Low	-	nc	83.7	82.3	-1.3*	9.9	12.4	2.4	3311.6	3089.5	-222.1
Moderate	nc	nc	7.0	5.7	-1.3	8.7	7.4	-1.3	66.4	43.3	-23.2
High	+	nc	9.3	12.0	2.7*	3.6	4.2	0.6	132.7	172.9	40.2
Douglas-fir beetle—											
Low	-	nc	90.0	88.0	-2.0*	10.4	10.1	-0.3	2690.2	2432.6	-257.6
Moderate	+	nc	7.1	9.4	2.3*	5.3	6.2	0.9	58.7	81.6	22.9
High	nc	nc	2.9	2.6	-0.3	2.2	2.0	-0.2	31.5	36.8	5.4
Western pine beetle (type 1)—											
Low	nc	nc	83.7	82.5	-1.2	11.9	10.6	-1.3	2651.5	2838.7	187.2
Moderate	+	+	11.8	14.6	2.9*	6.5	6.3	-0.2	105.2	171.5	66.3*
High	nc	-	4.6	2.9	-1.6	3.9	3.1	-0.8	50.8	26.6	-24.1*
Western pine beetle (type 2)—											
Low	-	nc	75.3	71.1	-4.2*	10.6	12.7	2.1	4404.0	3719.9	-684.1
Moderate	+	nc	9.8	11.8	2.0*	10.3	9.2	-1.1	81.3	301.2	219.9
High	+	nc	14.9	17.1	2.2*	4.6	4.0	-0.6	199.1	245.8	46.7
Mountain pine beetle (type 1)—											
Low	-	-	87.5	85.9	-1.7*	6.6	10.6	3.9*	4032.8	3505.1	-527.6
Moderate	nc	nc	10.7	11.7	1.1	6.5	6.3	-0.1	124.6	102.2	-22.4
High	nc	nc	1.8	2.4	0.6	1.4	2.6	1.1	32.2	36.2	4.1
Mountain pine beetle (type 2)—											
Low	-	nc	75.3	71.1	-4.2*	10.6	12.7	2.1	4404.0	3719.9	-684.1
Moderate	+	nc	9.8	11.8	2.0*	10.3	9.2	-1.1	81.3	301.2	219.9
High	+	nc	14.9	17.1	2.2*	4.6	4.0	-0.6	199.1	245.8	46.7
Fir engraver—											
Low	nc	+	92.9	94.8	1.9	6.1	7.1	1.0*	3089.7	3281.7	192.0
Moderate	nc	-	2.6	2.3	-0.3	3.9	4.4	0.5	27.9	20.2	-7.6*
High	+	nc	1.8	2.9	1.0*	1.6	2.7	1.1	47.2	26.8	-20.4
Douglas-fir dwarf mistletoe—											
Low	-	nc	87.5	85.5	-2.0*	10.7	10.9	0.2	2491.6	2397.0	-94.7
Moderate	+	nc	5.6	8.1	2.5*	8.9	7.3	-1.6	38.7	41.8	3.1
High	nc	nc	6.9	6.4	-0.6	3.9	3.9	0.0	70.1	65.7	-4.4
Western dwarf mistletoe—											
Low	-	nc	80.7	77.8	-2.9*	10.4	10.3	-0.1	3217.1	3203.4	-13.7
Moderate	+	+	8.5	14.3	5.9*	11.1	7.4	-3.7*	40.9	163.8	122.9*
High	nc	nc	10.8	7.8	-3.0	5.3	5.5	0.2	108.9	65.5	-43.4

Table 33—(continued)

Ecological reporting unit	Trend[a] Area	Con.[b]	Area H[c]	C	MD[d]	Patch density H	C	MD[d]	Mean patch size H	C	MD[d]
			------- Percent -------			No./10 000 ha			------- Hectares -------		
Western larch dwarf mistletoe—											
Low	+	nc	98.7	99.4	0.8*	5.9	6.1	0.2	4148.8	3954.7	-194.1
Moderate	-	nc	1.3	0.5	-0.8*	0.7	1.0	0.3	23.2	4.8	-18.4
High	nc	nc	0.0	0.1	0.0	0.1	0.2	0.2	2.0	3.2	1.1
Lodgepole pine dwarf mistletoe—											
Low	nc	+	98.3	98.1	-0.3	6.8	7.1	0.3	3689.6	4175.1	485.5*
Moderate	nc	nc	1.4	1.6	0.1	1.0	1.0	-0.1	89.6	31.2	-58.4
High	nc	+	0.2	0.4	0.1	0.4	0.3	-0.1	3.7	15.3	11.6*
Armillaria root disease—											
Low	nc	nc	77.2	76.2	-1.0	11.1	12.8	1.7	2568.0	2725.7	157.7
Moderate	nc	-	13.7	13.3	-0.5	10.8	10.8	0.0	349.2	78.5	-270.8*
High	nc	nc	9.1	10.5	1.4	4.0	5.0	1.0	117.8	117.8	0.0
Laminated root rot—											
Low	-	nc	84.7	82.1	-2.6*	10.7	11.3	0.6	3055.8	3239.5	183.7
Moderate	+	nc	4.9	8.3	3.4*	9.0	7.5	-1.5	37.3	55.4	18.1
High	nc	nc	10.4	9.7	-0.8	4.1	4.8	0.7	114.4	98.4	-16.0
S-group annosum root disease—											
Low	-	+	94.4	92.3	-2.1*	6.4	9.2	2.8*	3504.4	3588.7	84.4
Moderate	-	-	4.8	2.3	-2.5*	2.8	3.6	0.7	72.1	20.7	-51.4*
High	+	+	0.8	5.4	4.6*	1.3	2.2	0.9*	15.6	132.1	116.5*
P-group annosum root disease—											
Low	nc	nc	80.6	78.8	-1.8	11.4	10.2	-1.2	3116.6	3219.4	102.9
Moderate	+	nc	7.7	10.0	2.4*	10.6	9.1	-1.5*	53.2	61.7	8.5
High	nc	nc	11.8	11.2	-0.6	5.0	5.0	0.0	139.1	137.3	-1.8
Schweinitzii root and butt rot—											
Low	-	nc	75.1	72.6	-2.5*	11.1	13.3	2.2	2891.4	2727.1	-164.2
Moderate	+	nc	7.8	12.0	4.3*	10.4	9.6	-0.9	106.3	82.4	-23.8
High	nc	nc	17.2	15.4	-1.8	5.7	6.7	0.9	209.8	184.5	-25.4
White pine blister rust (type 1)—											
Low	+	nc	95.7	97.1	1.5*	4.1	4.7	0.6	8057.2	7847.6	-209.6
Moderate	nc	nc	2.9	2.8	-0.1	0.4	1.0	0.5	60.6	24.5	-36.1
High	-	nc	1.4	0.1	-1.4*	0.2	0.2	0.0	45.6	4.3	-41.3
Rust-red stringy rot—											
Low	-	-	98.2	95.2	-2.9*	6.0	7.7	1.6*	4276.8	3221.8	-1055.0*
Moderate	+	nc	1.8	4.7	2.9*	1.7	3.2	1.5*	30.0	36.3	6.4
High	nc	+	0.0	0.1	0.0*	0.1	0.2	0.1*	0.8	3.5	2.7*
Lower Clark Fork ERU:											
Western spruce budworm—											
Low	nc	-	20.2	15.7	-4.5	27.4	38.2	10.8	93.5	45.8	-47.7*
Moderate	nc	nc	23.0	19.3	-3.6	38.6	37.2	-1.4	59.6	54.9	-4.8
High	nc	nc	56.8	65.0	8.2	20.8	15.0	-5.8	511.6	563.2	51.6

Table 33—(continued)

Ecological reporting unit	Trend[a]		Area			Patch density			Mean patch size		
	Area	Con.[b]	H[c]	C	MD[d]	H	C	MD[d]	H	C	MD[d]
			------- *Percent* -------			*No./10 000 ha*			------- *Hectares* -------		
Douglas-fir beetle—											
Low	-	-	91.6	65.3	-26.4*	2.4	12.4	10.0*	4905.7	1580.2	-3325.5*
Moderate	+	+	8.1	28.8	20.7*	13.0	18.8	5.8	56.4	173.9	117.5*
High	nc	nc	0.2	5.9	5.7	0.2	4.2	4.0	19.0	49.2	30.2
Western pine beetle (type 1)—											
Low	nc	nc	99.9	96.5	-3.3	5.8	5.6	-0.2	3334.5	3339.5	5.0
Moderate	nc	nc	0.2	2.9	2.7	0.2	3.6	3.4	14.1	19.5	5.4
High	nc	nc	0.0	0.6	0.6	0.0	0.4	0.4	0.0	36.0	36.0
Western pine beetle (type 2)—											
Low	-	-	28.7	15.3	-13.4*	30.8	47.4	16.6	155.7	37.6	-118.1*
Moderate	+	+	69.8	80.9	11.1*	17.0	5.0	-12.0*	652.6	2399.2	1746.7*
High	nc	nc	1.5	3.8	2.3	2.4	3.6	1.2	26.3	35.6	9.3
Mountain pine beetle (type 1)—											
Low	-	-	30.0	17.3	-12.6*	28.8	49.4	20.6*	150.1	36.4	-113.7*
Moderate	nc	+	66.1	69.8	3.7	15.2	7.8	-7.4*	726.3	1898.4	1172.1
High	+	nc	4.0	12.9	8.9*	10.6	15.8	5.2	40.1	60.8	20.7
Mountain pine beetle (type 2)—											
Low	-	-	28.7	15.3	-13.4*	30.8	47.4	16.6	155.7	37.6	-118.1*
Moderate	+	+	69.8	80.9	11.1*	17.0	5.0	-12.0*	652.6	2399.2	1746.7*
High	nc	nc	1.5	3.8	2.3	2.4	3.6	1.2	26.3	35.6	9.3
Fir engraver—											
Low	nc	-	56.9	48.8	-8.1	16.2	28.6	12.4*	1435.3	198.3	-1237.0
Moderate	nc	nc	14.8	14.2	-0.6	27.2	33.6	6.4	54.0	49.3	-4.7
High	nc	nc	28.3	37.0	8.7	22.6	25.4	2.8	129.7	171.8	42.1
Spruce beetle—											
Low	nc	nc	87.8	85.7	-2.1	4.6	3.4	-1.2	4346.8	4712.6	365.8
Moderate	nc	nc	12.1	13.8	1.7	17.6	23.0	5.4	81.2	61.6	-19.6
High	nc	nc	0.1	0.5	0.4	0.6	1.4	0.8	11.0	16.8	5.8
Douglas-fir dwarf mistletoe—											
Low	nc	nc	56.5	58.0	1.5	12.2	14.6	2.4	642.1	624.4	-17.7
Moderate	nc	+	37.5	34.1	-3.4	32.4	22.8	-9.6*	127.9	208.2	80.3
High	nc	nc	6.0	7.9	1.9	13.0	15.4	2.4	44.7	52.0	7.3
Western dwarf mistletoe—											
Low	nc	nc	97.8	94.9	-2.9	4.8	4.6	-0.2	3437.3	4609.8	1172.5
Moderate	nc	+	2.2	4.3	2.1	3.4	5.2	1.8*	27.1	37.2	10.1
High	nc	nc	0.0	0.9	0.9	0.0	0.4	0.4	0.0	53.7	53.7
Western larch dwarf mistletoe—											
Low	nc	nc	95.7	94.9	-0.8	3.8	2.6	-1.2	3290.7	5281.9	1991.2
Moderate	nc	+	4.1	4.9	0.8	6.8	7.0	0.2	32.2	54.8	22.6*
High	nc	nc	0.2	0.2	0.0	0.6	0.8	0.2	6.7	11.6	4.9

Table 33—(continued)

Ecological reporting unit	Trend[a] Area	Trend[a] Con.[b]	Area H[c]	Area C	Area MD[d]	Patch density H	Patch density C	Patch density MD[d]	Mean patch size H	Mean patch size C	Mean patch size MD[d]
			Percent			*No./10 000 ha*			*Hectares*		
Lodgepole pine dwarf mistletoe—											
Low	nc	-	95.5	90.0	-5.5	2.2	3.8	1.6*	6118.5	2691.1	-3427.4*
Moderate	nc	nc	4.3	7.5	3.2	8.8	13.2	4.4	39.5	42.1	2.6
High	nc	+	0.2	2.6	2.3	1.2	3.4	2.2	9.1	31.2	22.1*
Armillaria root disease—											
Low	nc	nc	9.9	6.9	-3.0	21.2	34.8	13.6	61.7	25.7	-36.0
Moderate	nc	nc	35.1	28.0	-7.1	34.4	32.0	-2.4	124.0	88.8	-35.2
High	nc	nc	55.0	65.1	10.1	18.2	14.8	-3.4	684.7	548.2	-136.4
Laminated root rot—											
Low	nc	nc	11.2	11.0	-0.2	23.6	38.2	14.6	79.4	35.5	-43.9
Moderate	nc	nc	29.4	27.0	-2.4	33.0	33.8	0.8	99.2	83.9	-15.2
High	nc	nc	59.4	62.0	2.6	17.0	16.2	-0.8	515.9	479.0	-36.9
S-group annosum root disease—											
Low	nc	nc	11.0	10.0	-1.0	23.0	36.6	13.6	71.5	35.2	-36.3
Moderate	nc	nc	17.6	12.9	-4.7	32.0	23.0	-9.0*	62.7	65.6	2.9
High	nc	nc	71.4	77.0	5.7	12.0	8.0	-4.0	3051.7	2622.5	-429.2
P-group annosum root disease—											
Low	nc	nc	98.1	96.7	-1.4	5.8	4.8	-1.0	1896.2	3420.4	1524.3
Moderate	nc	nc	1.9	3.0	1.1	2.6	3.8	1.2	15.0	22.3	7.3
High	nc	nc	0.0	0.2	0.2	0.0	0.8	0.8	0.0	9.8	9.8
Tomentosus root and butt rot—											
Low	nc	nc	97.7	97.4	-0.3	3.8	2.0	-1.8	5265.8	6322.7	1056.9
Moderate	nc	nc	1.3	1.1	-0.2	4.6	4.6	0.0	17.5	21.5	4.1
High	nc	+	1.0	1.5	0.5	2.8	2.6	-0.2	28.3	42.6	14.3*
Schweinitzii root and butt rot—											
Low	nc	nc	8.4	6.1	-2.3	21.0	33.2	12.2	56.5	25.3	-31.2
Moderate	+	+	35.4	41.6	6.2*	25.0	17.8	-7.2*	204.2	479.6	275.4
High	nc	nc	56.2	52.3	-4.0	17.8	17.0	-0.8	436.8	1437.1	1000.2
White pine blister rust (type 1)—											
Low	nc	-	27.4	29.9	2.5	25.4	18.0	-7.4*	216.4	204.1	-12.3
Moderate	nc	nc	71.8	66.4	-5.4	7.2	8.8	1.6	1466.1	1814.6	348.5
High	nc	+	0.8	3.7	2.9	3.2	6.6	3.4*	29.8	54.1	24.2
Rust-red stringy rot—											
Low	nc	nc	47.9	46.2	-1.7	22.0	34.4	12.4	644.3	1073.8	429.5
Moderate	nc	+	51.2	52.1	0.9	18.6	14.2	-4.4*	400.9	1053.3	652.3*
High	nc	nc	1.0	1.7	0.7	2.6	4.2	1.6	16.2	30.8	14.6
Northern Cascades ERU:											
Western spruce budworm—											
Low	nc	+	30.7	31.8	1.1	21.1	29.0	7.9*	373.3	497.0	123.8
Moderate	nc	nc	17.8	17.8	0.0	20.3	27.0	6.7*	107.6	104.2	-3.4
High	nc	nc	51.5	50.4	-1.1	10.4	10.9	0.5	972.3	929.1	-43.2

Table 33—(continued)

Ecological reporting unit	Trend[a] Area	Trend[a] Con.[b]	Area H[c]	Area C	Area MD[d]	Patch density H	Patch density C	Patch density MD[d]	Mean patch size H	Mean patch size C	Mean patch size MD[d]
			Percent			*No./10 000 ha*			*Hectares*		
Douglas-fir beetle—											
Low	+	+	65.1	68.4	3.3*	11.7	16.9	5.2*	1599.1	1614.2	15.1
Moderate	nc	-	26.2	24.2	-2.0	11.8	15.2	3.4*	376.5	274.8	-101.7*
High	nc	-	8.7	7.4	-1.3	6.2	8.2	2.0*	149.9	89.2	-60.8*
Western pine beetle (type 1)—											
Low	+	nc	84.5	89.3	4.8*	7.3	6.9	-0.3	3112.8	3373.0	260.2
Moderate	-	-	11.8	8.9	-2.9*	7.2	7.5	0.3	153.9	89.4	-64.6*
High	-	-	3.7	1.8	-1.9*	2.8	2.4	-0.4	74.5	42.8	-31.7*
Western pine beetle (type 2)—											
Low	+	+	46.6	49.9	3.3*	16.8	23.0	6.1*	765.4	801.8	36.4
Moderate	nc	-	43.6	41.9	-1.7	13.5	17.4	3.9*	631.7	369.6	-262.1*
High	-	-	9.8	8.2	-1.6*	4.8	5.2	0.4	227.4	96.8	-130.6*
Mountain pine beetle (type 1)—											
Low	nc	+	48.5	48.8	0.3	16.9	23.1	6.1*	740.3	753.0	12.6
Moderate	nc	nc	46.2	44.4	-1.8	13.9	15.3	1.4	522.6	553.7	31.1
High	nc	+	5.3	6.8	1.5	4.8	6.6	1.7*	91.6	163.2	71.7
Mountain pine beetle (type 2)—											
Low	+	+	46.6	49.9	3.3*	16.8	23.0	6.1*	765.4	801.8	36.4
Moderate	nc	-	43.6	41.9	-1.7	13.5	17.4	3.9*	631.7	369.6	-262.1*
High	-	-	9.8	8.2	-1.6*	4.8	5.2	0.4	227.4	96.8	-130.6*
Fir engraver—											
Low	nc	-	57.0	57.8	0.8	16.1	21.0	5.0*	1569.1	1302.1	-267.0
Moderate	-	-	22.6	20.7	-1.9*	19.0	24.2	5.1*	149.3	126.7	-22.6
High	nc	nc	20.4	21.5	1.1	12.6	13.2	0.6	236.3	207.3	-29.0
Spruce beetle—											
Low	+	+	56.8	60.7	3.8*	15.5	19.1	3.6*	1023.9	1037.4	13.5
Moderate	-	-	37.2	34.0	-3.2*	13.8	16.6	2.8*	375.5	330.3	-45.2
High	nc	nc	6.0	5.3	-0.7	3.8	4.1	0.3	105.3	93.3	-12.0
Douglas-fir dwarf mistletoe—											
Low	nc	-	58.1	59.1	1.0	12.3	18.9	6.6*	1400.9	1250.2	-150.7
Moderate	nc	-	23.4	23.1	-0.3	14.1	18.1	4.0*	212.4	183.8	-28.6
High	nc	nc	18.6	17.9	-0.7	9.5	11.2	1.7*	222.1	196.2	-25.9
Western dwarf mistletoe—											
Low	+	nc	81.5	85.3	3.9*	7.6	7.7	0.1	2992.8	2971.5	-21.3
Moderate	-	-	13.0	10.8	-2.2*	7.1	9.2	2.1*	156.3	90.4	-65.8*
High	-	-	5.6	3.9	-1.7*	4.1	4.1	0.0	87.0	42.5	-44.6*
Western larch dwarf mistletoe—											
Low	nc	nc	98.5	98.4	0.0	3.7	4.1	0.5	5414.5	5393.3	-21.1
Moderate	nc	nc	1.0	1.1	0.1	1.8	2.2	0.4	29.5	23.9	-5.6
High	nc	nc	0.5	0.4	-0.1	0.6	0.5	-0.1	20.6	10.6	-10.0

Table 33—(continued)

Ecological reporting unit	Trend[a]		Area			Patch density			Mean patch size		
	Area	Con.[b]	H[c]	C	MD[d]	H	C	MD[d]	H	C	MD[d]
			Percent			*No./10 000 ha*			*Hectares*		
Lodgepole pine dwarf mistletoe—											
Low	nc	nc	90.8	91.8	1.0	4.7	3.9	-0.8*	4662.7	5303.4	640.8
Moderate	-	nc	6.5	5.1	-1.4*	4.3	4.4	0.1	104.1	114.2	10.2
High	nc	nc	2.7	3.1	0.4	2.2	2.5	0.4*	65.3	68.0	2.7
Armillaria root disease—											
Low	nc	nc	27.6	28.8	1.2	19.3	28.8	9.4*	353.2	330.6	-22.5
Moderate	+	nc	23.7	25.9	2.2*	20.4	26.2	5.7*	142.5	145.7	3.2
High	-	-	48.6	45.2	-3.4*	10.7	12.4	1.7*	681.2	563.9	-117.3*
Laminated root rot—											
Low	nc	+	35.8	35.7	-0.1	19.3	28.4	9.0*	575.7	625.7	49.9
Moderate	+	+	22.5	25.0	2.6*	16.8	21.3	4.5*	203.6	344.0	140.4
High	-	-	41.7	39.2	-2.5*	8.5	10.4	1.9*	837.9	541.1	-296.8*
S-group annosum root disease—											
Low	nc	-	47.6	46.4	-1.2	19.1	27.2	8.1*	1187.8	743.0	-444.8
Moderate	nc	nc	22.7	21.4	-1.4	17.7	19.1	1.4	144.0	147.0	3.0
High	+	+	29.6	32.2	2.6*	13.2	14.9	1.7*	335.3	360.5	25.3
P-group annosum root disease—											
Low	+	nc	82.0	85.1	3.1*	7.6	7.5	-0.1	2928.6	3196.4	267.8
Moderate	-	-	10.6	9.0	-1.6*	7.5	9.9	2.4*	99.6	52.7	-46.9*
High	-	-	7.5	5.9	-1.5*	4.6	4.8	0.2	114.1	74.9	-39.2*
Tomentosus root and butt rot—											
Low	nc	+	79.8	80.9	1.2	7.2	6.7	-0.6	2608.8	3563.5	954.6*
Moderate	nc	nc	8.9	9.2	0.3	11.3	11.6	0.3	74.1	72.3	-1.7
High	-	nc	11.4	9.9	-1.5*	8.4	9.5	1.1*	141.3	120.5	-20.8
Schweinitzii root and butt rot—											
Low	+	nc	26.0	27.4	1.4*	18.0	26.9	8.9*	358.4	387.1	28.7
Moderate	+	nc	12.9	15.4	2.6*	17.9	22.5	4.6*	76.8	83.4	6.6
High	-	-	61.2	57.2	-4.0*	5.9	7.6	1.7*	1855.9	1266.6	-589.4*
White pine blister rust (type 1)—											
Low	nc	nc	61.2	61.0	-0.2	8.4	9.0	0.7*	3103.1	3097.6	-5.5
Moderate	nc	nc	38.7	38.8	0.1	5.5	5.5	0.0	1053.2	1157.0	103.8
High	+	+	0.1	0.2	0.1*	0.3	0.4	0.1	2.2	6.7	4.5*
White pine blister rust (type 2)—											
Low	-	nc	93.2	92.7	-0.5*	1.8	1.7	-0.1	7479.3	7874.9	395.6
Moderate	nc	-	6.4	6.4	0.0	7.4	8.6	1.2*	77.1	59.5	-17.6*
High	+	+	0.4	0.9	0.5*	0.8	1.1	0.3*	11.5	24.5	13.0*
Rust-red stringy rot—											
Low	nc	-	64.5	64.8	0.3	14.7	19.0	4.2*	1504.8	1258.1	-246.8
Moderate	nc	-	34.9	34.1	-0.9	11.5	14.1	2.6*	399.7	364.1	-35.7
High	+	nc	0.6	1.1	0.6*	0.9	1.9	1.0*	21.0	25.1	4.1

Table 33—(continued)

Ecological reporting unit	Trend[a] Area	Trend[a] Con.[b]	Area H[c]	Area C	Area MD[d]	Patch density H	Patch density C	Patch density MD[d]	Mean patch size H	Mean patch size C	Mean patch size MD[d]
			------- Percent -------			No./10 000 ha			------- Hectares -------		
Northern Glaciated Mountains ERU:											
Western spruce budworm—											
Low	nc	-	29.8	28.2	-1.7	24.2	41.3	17.1*	405.0	334.2	-70.8
Moderate	nc	-	25.7	23.9	-1.7	23.3	38.3	15.0*	144.5	74.7	-69.7*
High	+	-	44.5	47.9	3.4*	12.2	16.5	4.3*	806.8	742.4	-64.4
Douglas-fir beetle—											
Low	nc	-	66.3	65.5	-0.7	15.7	26.0	10.3*	1363.3	834.5	-528.9*
Moderate	nc	-	30.2	29.5	-0.7	13.8	21.9	8.0*	359.2	281.3	-77.9*
High	nc	nc	3.6	5.0	1.4	4.9	9.3	4.4*	43.6	44.2	0.6
Western pine beetle (type 1)—											
Low	nc	nc	91.6	91.3	-0.3	7.9	10.0	2.1	3684.8	3900.6	215.8
Moderate	nc	nc	7.2	7.8	0.6	7.1	7.1	0.0	70.7	83.5	12.8
High	nc	nc	1.2	0.9	-0.3	1.7	2.9	1.2	13.5	8.8	-4.7
Western pine beetle (type 2)—											
Low	nc	-	45.6	45.9	0.3	25.1	39.4	14.3*	919.2	438.0	-481.2*
Moderate	nc	-	46.5	46.8	0.4	15.6	20.8	5.2*	704.3	578.3	-126.0
High	nc	nc	7.9	7.3	-0.6	6.0	7.0	1.0	81.1	110.5	29.4
Mountain pine beetle (type 1)—											
Low	nc	-	39.6	38.3	-1.3	21.9	37.2	15.3*	733.5	570.7	-162.9
Moderate	nc	-	45.1	42.8	-2.3	13.5	22.0	8.5*	561.7	367.9	-193.9*
High	+	+	15.4	18.9	3.6*	9.3	15.8	6.4*	186.6	201.1	14.5
Mountain pine beetle (type 2)—											
Low	nc	-	45.6	45.9	0.3	25.1	39.4	14.3*	919.2	438.0	-481.2*
Moderate	nc	-	46.5	46.8	0.4	15.6	20.8	5.2*	704.3	578.3	-126.0
High	nc	nc	7.9	7.3	-0.6	6.0	7.0	1.0	81.1	110.5	29.4
Fir engraver—											
Low	-	-	76.0	70.5	-5.5*	10.6	18.4	7.9*	2305.4	1307.7	-997.7*
Moderate	+	-	17.2	21.1	3.9*	14.4	22.8	8.5*	151.3	117.4	-33.9*
High	nc	-	6.8	8.4	1.6	4.3	12.0	7.7*	135.2	90.6	-44.7
Spruce beetle—											
Low	nc	-	60.7	60.2	-0.5	16.1	29.2	13.1*	1379.3	726.4	-653.0*
Moderate	nc	-	36.2	35.2	-1.0	13.3	19.3	6.0*	381.4	307.8	-73.6*
High	+	+	3.0	4.5	1.5*	2.6	4.7	2.1*	46.6	79.9	33.3*
Douglas-fir dwarf mistletoe—											
Low	nc	-	57.3	56.4	-1.0	17.1	28.2	11.1*	921.0	710.4	-210.6*
Moderate	nc	-	29.6	29.3	-0.3	18.2	27.4	9.2*	293.1	197.3	-95.8*
High	nc	-	13.1	14.3	1.2	9.4	15.8	6.4*	219.5	129.9	-89.6
Western dwarf mistletoe—											
Low	nc	nc	86.3	86.8	0.5	8.2	12.2	4.0*	3766.2	3466.3	-299.9
Moderate	nc	nc	9.9	10.7	0.8	9.2	10.5	1.3	96.3	123.6	27.4
High	-	-	3.8	2.5	-1.2*	4.1	5.3	1.2	57.1	16.0	-41.2*

Table 33—(continued)

Ecological reporting unit	Trend[a] Area	Trend[a] Con.[b]	Area H[c]	Area C	Area MD[d]	Patch density H	Patch density C	Patch density MD[d]	Mean patch size H	Mean patch size C	Mean patch size MD[d]
			------- *Percent* -------			*No./10 000 ha*			------- *Hectares* -------		
Western larch dwarf mistletoe—											
Low	+	+	73.8	81.3	7.5*	11.4	13.0	1.6	1923.9	2306.4	382.5*
Moderate	-	-	19.4	14.6	-4.8*	11.3	16.0	4.7*	195.2	92.2	-103.0*
High	-	-	6.9	4.2	-2.7*	7.8	7.0	-0.7	57.6	38.5	-19.1*
Lodgepole pine dwarf mistletoe—											
Low	+	nc	73.8	77.2	3.4*	9.8	13.2	3.5*	2245.8	2011.0	-234.8
Moderate	-	-	16.9	13.6	-3.3*	11.1	17.0	5.8*	156.0	91.0	-65.0*
High	nc	-	9.3	9.1	-0.1	6.1	9.9	3.8*	130.2	83.3	-46.9*
Armillaria root disease—											
Low	nc	+	24.1	23.8	-0.3	26.2	41.2	15.0*	289.3	315.9	26.5
Moderate	-	-	38.6	35.5	-3.1*	20.7	31.2	10.5*	324.0	199.1	-124.9*
High	+	-	37.3	40.7	3.4*	14.1	20.8	6.6*	511.9	461.9	-50.1
Laminated root rot—											
Low	-	-	40.2	35.9	-4.3*	23.9	40.8	16.9*	443.4	357.2	-86.2
Moderate	nc	-	32.0	33.1	1.1	19.0	26.6	7.6*	353.0	281.3	-71.7
High	nc	+	27.8	31.0	3.2	15.0	20.4	5.4*	364.3	537.3	172.9
S-group annosum root disease—											
Low	-	-	54.1	47.1	-6.9*	18.4	32.2	13.8*	776.2	531.0	-245.2*
Moderate	nc	-	25.9	26.1	0.2	17.2	31.0	13.8*	254.8	109.6	-145.2*
High	+	+	20.0	26.8	6.8*	9.3	20.5	11.2*	317.8	312.8	-5.0
P-group annosum root disease—											
Low	nc	nc	87.8	87.8	0.0	7.5	10.5	3.0*	4000.9	4282.0	281.1
Moderate	nc	nc	9.1	8.2	-0.9	8.5	11.1	2.6	105.9	103.7	-2.2
High	nc	nc	3.1	4.0	0.8	3.6	5.4	1.9	40.0	23.7	-16.4
Tomentosus root and butt rot—											
Low	nc	nc	85.1	83.4	-1.7	7.0	8.1	1.0*	2409.5	2265.9	-143.5
Moderate	nc	nc	7.8	7.5	-0.2	7.5	14.5	7.0*	98.0	87.4	-10.6
High	+	+	7.1	9.0	1.9*	5.9	10.8	4.9*	89.6	84.7	-4.9
Schweinitzii root and butt rot—											
Low	nc	+	20.0	20.1	0.1	20.1	34.0	14.0*	288.8	313.8	25.0
Moderate	nc	-	13.2	14.1	1.0	15.8	27.2	11.4*	93.7	70.6	-23.1*
High	nc	-	66.9	65.8	-1.1	5.9	8.0	2.2*	2614.0	1998.3	-615.7*
White pine blister rust (type 1)—											
Low	+	+	62.9	63.7	0.9*	7.8	9.8	2.0*	2451.0	2208.7	-242.3
Moderate	nc	-	35.3	35.9	0.6	8.0	9.7	1.7*	1277.6	1055.8	-221.8
High	-	-	1.9	0.3	-1.5*	1.1	0.6	-0.5	26.3	4.2	-22.1*
White pine blister rust (type 2)—											
Low	nc	+	87.7	87.5	-0.3	3.6	4.2	0.6*	4868.2	4894.0	25.8
Moderate	nc	-	12.3	12.5	0.2	6.4	9.0	2.6*	213.6	188.7	-24.9
High	nc	nc	0.0	0.0	0.0	0.0	0.0	0.0	0.3	2.0	1.7

Table 33—(continued)

Ecological reporting unit	Trend[a] Area	Trend[a] Con.[b]	Area H[c]	Area C	Area MD[d]	Patch density H	Patch density C	Patch density MD[d]	Mean patch size H	Mean patch size C	Mean patch size MD[d]
			Percent			No./10 000 ha			Hectares		
Rust-red stringy rot—											
Low	-	-	87.3	81.7	-5.6*	5.7	11.1	5.4*	3925.2	2290.7	-1634.5*
Moderate	+	nc	12.7	18.1	5.4*	9.8	20.0	10.2*	142.9	122.5	-20.4
High	+	+	0.0	0.2	0.2*	0.0	0.6	0.6*	1.1	5.9	4.8*
Snake Headwaters ERU:											
Western spruce budworm—											
Low	nc	nc	30.4	29.6	-0.8	29.4	35.4	5.9*	126.3	102.8	-23.5
Moderate	-	-	24.7	18.6	-6.0*	35.5	42.1	6.6*	79.5	60.6	-18.9*
High	+	+	45.0	51.8	6.8*	24.3	24.8	0.6	333.1	455.5	122.4*
Douglas-fir beetle—											
Low	-	-	82.0	78.3	-3.7*	12.6	15.3	2.7*	1751.3	1041.0	-710.3*
Moderate	nc	nc	15.9	17.9	2.0	16.5	22.0	5.5*	112.3	114.0	1.7
High	+	+	2.1	3.9	1.7*	5.1	7.1	2.0*	17.5	31.6	14.0*
Mountain pine beetle (type 1)—											
Low	nc	nc	48.6	48.4	-0.2	20.1	26.4	6.3*	451.2	358.1	-93.0
Moderate	+	+	16.8	22.3	5.6*	37.8	39.8	2.0	51.5	88.6	37.1*
High	-	nc	34.6	29.2	-5.4*	19.0	18.0	-1.0	238.3	216.4	-21.9
Fir engraver—											
Low	nc	nc	54.1	55.8	1.7	17.4	21.9	4.4	648.0	1392.0	744.0
Moderate	nc	nc	26.6	28.1	1.5	32.0	35.6	3.6	98.9	126.1	27.1
High	nc	-	19.3	16.1	-3.2	10.8	18.1	7.4*	211.3	131.9	-79.4*
Spruce beetle—											
Low	+	nc	52.4	57.1	4.7*	17.4	21.1	3.6	1325.1	958.3	-366.8
Moderate	-	-	39.2	35.3	-4.0*	21.9	23.1	1.3	276.5	207.9	-68.6*
High	-	nc	8.3	7.6	-0.7*	7.7	6.9	-0.8	63.3	60.2	-3.1
Douglas-fir dwarf mistletoe—											
Low	-	nc	79.3	71.8	-7.4*	13.6	13.7	0.1	835.8	1283.0	447.2
Moderate	nc	nc	16.6	21.8	5.1	20.6	20.4	-0.2	107.6	586.4	478.8
High	+	+	4.1	6.4	2.3*	9.0	10.6	1.6	19.2	49.6	30.4*
Lodgepole pine dwarf mistletoe—											
Low	+	nc	62.3	67.7	5.4*	15.1	15.6	0.5	1571.7	1585.0	13.3
Moderate	+	+	7.0	11.5	4.5*	20.6	19.6	-0.9	37.6	74.1	36.5*
High	-	-	30.8	20.9	-9.9*	15.9	15.4	-0.5	274.3	186.6	-87.8*
Armillaria root disease—											
Low	nc	nc	32.1	30.3	-1.8	28.1	33.8	5.6	145.1	116.4	-28.7
Moderate	-	-	47.4	38.1	-9.3*	30.2	36.1	5.9*	270.6	170.3	-100.3*
High	+	+	20.4	31.5	11.1*	24.7	26.4	1.8	106.6	205.4	98.8*
Laminated root rot—											
Low	nc	-	56.3	53.7	-2.6	19.6	24.6	5.0*	407.9	328.3	-79.6
Moderate	nc	nc	32.8	33.4	0.6	27.4	30.1	2.7	272.4	211.6	-60.8
High	+	+	10.9	12.8	2.0*	17.2	18.2	1.0	71.4	100.8	29.5*

Table 33—(continued)

Ecological reporting unit	Trend[a] Area	Con.[b]	Area H[c]	C	MD[d]	Patch density H	C	MD[d]	Mean patch size H	C	MD[d]
			------- Percent -------			*No./10 000 ha*			*------- Hectares -------*		
S-group annosum root disease—											
Low	-	-	39.7	33.1	-6.6*	26.1	35.5	9.4*	220.3	118.7	-101.6*
Moderate	nc	nc	38.3	36.2	-2.1	31.9	34.9	3.0	190.6	149.8	-40.8
High	+	+	22.0	30.6	8.6*	23.3	26.6	3.3	141.1	204.0	62.9*
Tomentosus root and butt rot—											
Low	-	-	72.4	64.6	-7.7*	9.4	15.0	5.6*	1678.3	1311.6	-366.7
Moderate	+	+	14.3	20.3	6.0*	16.3	23.5	7.2*	90.9	119.7	28.8
High	nc	nc	13.3	15.1	1.7	8.7	9.9	1.3	194.4	137.8	-56.6
Schweinitzii root and butt rot—											
Low	nc	nc	37.9	35.8	-2.1	25.6	31.0	5.4	193.8	183.7	-10.1
Moderate	nc	+	12.2	15.6	3.3	34.9	37.8	2.9	45.3	65.9	20.6*
High	nc	nc	49.9	48.6	-1.3	22.4	22.4	0.0	442.2	351.7	-90.5
White pine blister rust (type 2)—											
Low	nc	-	52.5	52.3	-0.2	10.0	12.1	2.1*	1521.8	968.8	-553.0*
Moderate	+	nc	43.5	45.7	2.2*	17.5	16.8	-0.7	695.7	601.8	-93.9
High	nc	nc	4.0	2.0	-2.0	1.4	1.3	-0.1	59.4	16.0	-43.4
Southern Cascades ERU:											
Western spruce budworm—											
Low	nc	-	79.9	77.6	-2.4	7.3	20.4	13.2*	3892.6	3845.0	-47.6
Moderate	nc	-	10.0	10.1	0.2	5.6	15.1	9.6*	133.3	54.4	-78.9*
High	+	-	10.1	12.3	2.2*	4.1	6.0	1.9*	252.1	204.3	-47.8
Douglas-fir beetle—											
Low	nc	nc	96.2	96.9	0.7	4.8	5.9	1.1	7208.7	6289.7	-919.0
Moderate	nc	nc	2.1	3.0	1.0	1.4	2.1	0.6	56.9	75.9	19.0
High	-	nc	1.8	0.1	-1.7*	0.3	0.1	-0.1	186.8	9.1	-177.8
Western pine beetle (type 1)—											
Low	nc	nc	83.0	78.7	-4.3	4.6	8.4	3.8*	4860.6	3697.3	-1163.3
Moderate	nc	nc	11.8	16.2	4.5	4.8	6.8	2.1	235.0	355.9	120.9
High	nc	nc	5.2	5.1	-0.2	1.9	1.8	-0.1	134.8	189.7	54.8
Western pine beetle (type 2)—											
Low	nc	-	51.6	42.4	-9.1	12.3	30.8	18.6*	1581.7	219.0	-1362.7*
Moderate	nc	nc	27.9	33.2	5.3	10.1	14.2	4.1*	346.4	453.3	106.8
High	nc	nc	20.5	24.4	3.8	3.6	5.8	2.1*	1125.9	1294.7	168.9
Mountain pine beetle (type 1)—											
Low	nc	-	36.1	35.6	-0.5	17.9	43.3	25.4*	2281.2	680.8	-1600.4*
Moderate	+	-	34.9	39.5	4.6*	10.3	17.7	7.4*	469.1	428.6	-40.5
High	-	nc	29.0	24.9	-4.1	4.2	5.9	1.8	765.6	634.6	-131.0
Mountain pine beetle (type 2)—											
Low	nc	-	51.6	42.4	-9.1	12.3	30.8	18.6*	1581.7	219.0	-1362.7*
Moderate	nc	nc	27.9	33.2	5.3	10.1	14.2	4.1*	346.4	453.3	106.8
High	nc	nc	20.5	24.4	3.8	3.6	5.8	2.1*	1125.9	1294.7	168.9

Table 33—(continued)

Ecological reporting unit	Trend[a] Area	Con.[b]	Area H[c]	C	MD[d]	Patch density H	C	MD[d]	Mean patch size H	C	MD[d]
			------- *Percent* -------			*No./10 000 ha*			------- *Hectares* -------		
Fir engraver—											
Low	nc	-	86.1	85.0	-1.1	5.2	13.2	8.0*	6081.3	3561.2	-2520.0*
Moderate	nc	-	5.0	4.8	-0.1	3.0	7.9	4.9*	114.4	39.0	-75.4*
High	nc	nc	9.0	10.2	1.2	3.3	4.8	1.4*	166.3	207.9	41.7
Spruce beetle—											
Low	+	nc	91.6	93.1	1.5*	3.6	7.5	3.9*	6605.5	7422.3	816.8
Moderate	-	-	8.4	6.8	-1.6*	3.6	6.1	2.6*	152.7	68.4	-84.4*
High	nc	nc	0.1	0.1	0.1	0.4	0.3	-0.1	1.7	9.9	8.1
Douglas-fir dwarf mistletoe—											
Low	-	-	95.4	93.1	-2.4*	4.0	8.1	4.1	6743.6	4501.3	-2242.3*
Moderate	+	+	2.3	6.4	4.1*	2.6	4.5	1.9*	31.9	74.0	42.1*
High	-	-	2.3	0.5	-1.7*	0.5	0.4	-0.1	95.1	24.1	-71.0*
Western dwarf mistletoe—											
Low	nc	-	74.6	70.9	-3.8	3.9	8.3	4.3*	4673.0	2356.8	-2316.2*
Moderate	nc	nc	12.4	11.3	-1.2	6.4	11.9	5.5*	525.4	106.3	-419.1
High	nc	nc	12.9	17.9	5.0	2.9	5.1	2.1*	545.1	442.3	-102.9
Lodgepole pine dwarf mistletoe—											
Low	nc	+	76.9	74.4	-2.6	8.5	17.6	9.1*	2440.9	2892.8	451.9
Moderate	nc	-	12.9	13.7	0.8	7.4	14.8	7.4*	186.0	105.9	-80.1*
High	nc	nc	10.2	11.9	1.7	4.2	6.5	2.3*	164.8	115.6	-49.2
Armillaria root disease—											
Low	nc	-	32.8	34.5	1.6	18.9	49.6	30.7*	1231.4	523.4	-708.0
Moderate	nc	nc	56.3	52.7	-3.6	4.7	11.2	6.5*	1769.7	1114.4	-655.2
High	+	nc	10.9	12.8	1.9*	3.5	6.1	2.6*	230.0	171.4	-58.6
Laminated root rot—											
Low	nc	-	52.6	51.7	-0.9	13.6	31.7	18.1*	3220.0	2721.4	-498.6
Moderate	-	-	16.3	12.8	-3.4*	12.9	18.6	5.8*	109.0	63.1	-45.9*
High	+	nc	31.1	35.4	4.3*	4.6	5.2	0.6	754.9	945.3	190.4
S-group annosum root disease—											
Low	nc	-	56.3	56.4	0.1	13.3	26.0	12.8*	2713.4	2028.1	-685.4
Moderate	nc	-	6.6	5.3	-1.3	6.5	9.3	2.8*	83.9	40.6	-43.3*
High	nc	nc	37.1	38.3	1.2	4.7	5.9	1.3	1151.5	884.2	-267.3
P-group annosum root disease—											
Low	nc	-	75.2	69.4	-5.8	3.8	8.9	5.1*	4690.1	2318.5	-2371.6*
Moderate	nc	-	11.0	7.2	-3.8	6.1	13.8	7.6*	494.1	66.6	-427.5*
High	+	+	13.8	23.4	9.6*	3.6	5.8	2.2*	541.6	816.2	274.6
Tomentosus root and butt rot—											
Low	nc	nc	99.1	99.1	0.0	4.1	2.7	-1.4*	5427.1	6002.6	575.5
Moderate	nc	nc	0.1	0.1	0.1	0.3	0.7	0.4	3.5	4.8	1.2
High	nc	nc	0.8	0.8	0.0	1.6	2.4	0.8	27.1	18.2	-8.9

Table 33—(continued)

Ecological reporting unit	Trend[a]		Area			Patch density			Mean patch size		
	Area	Con.[b]	H[c]	C	MD[d]	H	C	MD[d]	H	C	MD[d]
			------- *Percent* -------			*No./10 000 ha*			------- *Hectares* -------		
Schweinitzii root and butt rot—											
Low	-	-	27.8	20.8	-7.0*	16.5	48.2	31.7*	1111.6	63.0	-1048.5*
Moderate	nc	nc	46.6	49.9	3.3	8.3	19.1	10.9*	836.3	530.3	-306.1
High	nc	nc	25.6	29.4	3.8	6.1	7.9	1.8*	775.3	574.2	-201.1
White pine blister rust (type 1)—											
Low	-	-	61.4	59.0	-2.3*	6.1	9.3	3.2*	5072.1	4551.8	-520.3
Moderate	+	+	38.5	40.7	2.2*	5.1	7.9	2.8*	1626.8	2098.8	472.0
High	nc	nc	0.2	0.3	0.1	0.3	0.8	0.5*	3.8	3.8	0.0
Rust-red stringy rot—											
Low	nc	-	59.2	57.0	-2.2	14.6	27.8	13.3*	4149.6	1796.8	-2352.8*
Moderate	nc	nc	39.7	41.4	1.7	4.6	5.9	1.4*	1486.4	915.3	-571.1
High	nc	nc	1.1	1.7	0.5	0.6	2.5	1.9*	34.5	41.1	6.7
Upper Clark Fork ERU:											
Western spruce budworm—											
Low	nc	-	20.4	21.5	1.1	19.3	25.2	5.9*	149.5	102.1	-47.4*
Moderate	nc	-	20.5	22.6	2.1	28.9	34.8	5.8*	86.0	72.9	-13.1
High	nc	nc	59.1	55.9	-3.2	11.4	11.2	-0.2	1318.4	982.5	-335.9
Douglas-fir beetle—											
Low	nc	+	61.6	62.6	1.0	14.3	21.7	7.4*	1472.4	1552.4	80.1
Moderate	nc	nc	30.4	32.6	2.2	13.5	14.9	1.5	446.1	275.1	-170.9
High	-	-	8.0	4.8	-3.2*	5.4	10.0	4.5*	114.6	44.4	-70.1*
Western pine beetle (type 1)—											
Low	+	-	90.6	93.4	2.8*	5.3	6.5	1.2*	4022.3	3727.7	-294.5
Moderate	nc	-	6.5	6.2	-0.4	6.4	6.5	0.1	85.8	54.7	-31.1*
High	-	nc	2.9	0.5	-2.4*	1.1	1.2	0.1	20.7	8.7	-12.1
Western pine beetle (type 2)—											
Low	nc	-	39.1	39.0	-0.1	22.8	32.6	9.8*	341.9	334.5	-7.4
Moderate	nc	nc	51.0	52.9	1.9	16.8	15.3	-1.5	889.2	835.0	-54.2
High	-	nc	9.9	8.1	-1.7*	6.0	5.3	-0.6	102.5	91.9	-10.6
Mountain pine beetle (type 1)—											
Low	nc	-	32.2	33.1	1.0	20.6	26.2	5.6*	338.7	195.0	-143.7
Moderate	nc	-	31.7	29.3	-2.4	26.3	32.3	6.0*	175.0	100.1	-74.9*
High	nc	nc	36.1	37.6	1.5	14.9	13.3	-1.7	549.1	551.1	2.1
Mountain pine beetle (type 2)—											
Low	nc	-	39.1	39.0	-0.1	22.8	32.6	9.8*	341.9	334.5	-7.4
Moderate	nc	nc	51.0	52.9	1.9	16.8	15.3	-1.5	889.2	835.0	-54.2
High	-	nc	9.9	8.1	-1.7*	6.0	5.3	-0.6	102.5	91.9	-10.6
Fir engraver—											
Low	nc	-	62.7	63.4	0.7	13.6	17.2	3.6*	1341.0	818.3	-522.8*
Moderate	nc	-	29.5	26.9	-2.6	23.0	28.3	5.3*	192.5	105.5	-87.0*
High	+	+	7.8	9.7	1.9*	6.4	8.7	2.3*	88.0	111.0	23.0

Table 33—(continued)

Ecological reporting unit	Trend[a] Area	Trend[a] Con.[b]	Area H[c]	Area C	Area MD[d]	Patch density H	Patch density C	Patch density MD[d]	Mean patch size H	Mean patch size C	Mean patch size MD[d]
			Percent			*No./10 000 ha*			*Hectares*		
Spruce beetle—											
Low	nc	-	64.0	65.1	1.1	13.1	16.6	3.5*	1313.2	1001.4	-311.8*
Moderate	nc	nc	29.2	29.3	0.2	20.8	21.9	1.1	200.9	160.1	-40.8
High	nc	nc	6.9	5.6	-1.3	4.3	5.9	1.6*	80.5	60.8	-19.7
Douglas-fir dwarf mistletoe—											
Low	nc	+	54.5	56.6	2.1	17.4	22.0	4.6*	747.1	1077.5	330.4*
Moderate	nc	nc	29.4	30.2	0.9	17.1	18.3	1.2	211.4	179.3	-32.1
High	-	-	16.2	13.2	-3.0*	12.3	15.4	3.1*	154.0	75.1	-78.9*
Western dwarf mistletoe—											
Low	+	+	87.4	89.4	2.0*	6.3	6.6	0.3	3389.7	4244.5	854.8*
Moderate	nc	nc	7.6	8.3	0.7	7.9	6.9	-1.0	76.4	85.3	8.9
High	-	-	5.0	2.3	-2.7*	3.2	4.2	1.1	50.2	20.4	-29.8*
Western larch dwarf mistletoe—											
Low	+	nc	87.0	89.1	2.1*	7.7	7.7	0.1	3067.0	2913.6	-153.3
Moderate	nc	-	10.2	9.7	-0.6	4.9	8.0	3.1*	83.3	70.7	-12.6
High	-	-	2.8	1.3	-1.6*	3.3	3.7	0.3	18.8	8.4	-10.4*
Lodgepole pine dwarf mistletoe—											
Low	+	+	45.2	50.4	5.2*	17.8	20.9	3.1*	530.6	628.8	98.2
Moderate	-	-	32.1	27.0	-5.1*	18.6	21.9	3.3*	500.8	146.6	-354.2*
High	nc	nc	22.6	22.5	-0.1	17.2	15.5	-1.7	199.5	190.8	-8.7
Armillaria root disease—											
Low	nc	-	19.3	20.6	1.3	20.4	28.3	7.9*	138.0	96.6	-41.4*
Moderate	nc	-	46.5	47.6	1.1	21.3	26.7	5.3*	589.4	391.8	-197.7*
High	nc	nc	34.2	31.8	-2.4	19.8	18.0	-1.8	337.1	234.1	-103.0
Laminated root rot—											
Low	+	-	40.9	44.3	3.4*	20.7	25.1	4.4*	558.9	541.8	-17.0
Moderate	nc	-	37.5	34.9	-2.6	20.9	25.8	4.9*	321.1	166.0	-155.1*
High	nc	nc	21.6	20.8	-0.8	18.5	18.3	-0.2	196.5	108.4	-88.1
S-group annosum root disease—											
Low	+	nc	30.0	33.8	3.8*	25.8	31.0	5.3*	161.4	161.8	0.4
Moderate	-	-	37.8	31.6	-6.2*	24.8	31.4	6.6*	365.0	197.7	-167.3*
High	nc	nc	32.2	34.6	2.3	18.9	17.3	-1.6	338.9	365.3	26.4
P-group annosum root disease—											
Low	+	nc	88.6	90.3	1.7*	6.2	6.2	0.0	3660.5	4077.6	417.1
Moderate	nc	nc	5.9	5.6	-0.3	8.3	7.3	-1.0	53.2	53.8	0.7
High	-	-	5.4	4.0	-1.4*	3.3	4.5	1.2*	51.8	39.4	-12.4
Tomentosus root and butt rot—											
Low	nc	nc	84.3	84.0	-0.3	7.0	7.8	0.9	3198.7	2900.6	-298.1
Moderate	nc	-	5.8	5.7	-0.1	10.4	12.6	2.2*	38.4	31.3	-7.1*
High	nc	nc	9.9	10.3	0.4	9.9	12.8	2.9*	89.1	73.1	-16.0

Table 33—(continued)

Ecological reporting unit	Trend[a] Area	Trend[a] Con.[b]	Area H[c]	Area C	Area MD[d]	Patch density H	Patch density C	Patch density MD[d]	Mean patch size H	Mean patch size C	Mean patch size MD[d]
			Percent			*No./10 000 ha*			*Hectares*		
Schweinitzii root and butt rot—											
Low	nc	-	18.0	18.6	0.6	16.9	22.9	6.0*	142.2	114.0	-28.2*
Moderate	nc	nc	21.4	22.4	1.1	26.3	31.2	4.9*	87.3	83.5	-3.7
High	nc	nc	60.6	59.0	-1.6	10.8	9.8	-1.0	1291.3	1249.4	-41.9
White pine blister rust (type 1)—											
Low	nc	-	80.0	79.8	-0.2	6.1	5.6	-0.5	3460.9	2650.9	-810.0*
Moderate	+	nc	17.5	18.2	0.8*	14.1	15.1	1.1	146.2	142.6	-3.5
High	nc	nc	2.5	1.4	-1.1	0.1	1.0	0.9	72.4	5.9	-66.5
White pine blister rust (type 2)—											
Low	nc	nc	63.0	62.6	-0.4	10.3	12.1	1.8	1147.9	1089.9	-58.0
Moderate	nc	-	34.1	34.6	0.5	15.3	18.0	2.8*	348.6	240.4	-108.2*
High	nc	nc	2.9	2.4	-0.6	3.0	2.6	-0.5	26.2	20.9	-5.4
Rust-red stringy rot—											
Low	-	nc	94.5	91.0	-3.5*	4.3	5.3	1.0	4918.9	4863.7	-55.2
Moderate	+	+	4.3	6.7	2.4*	7.7	12.5	4.9*	41.3	51.5	10.2*
High	nc	nc	1.2	2.3	1.1	0.8	2.3	1.5*	5.8	7.0	1.2
Upper Klamath ERU:											
Western spruce budworm—											
Low	nc	nc	78.7	78.2	-0.5	6.0	10.1	4.1*	3265.3	4022.6	757.3
Moderate	nc	nc	6.7	5.9	-0.8	8.1	11.9	3.7*	66.5	68.5	2.0
High	nc	nc	14.6	15.9	1.3	3.7	3.7	0.0	459.4	599.7	140.3
Douglas-fir beetle											
Low	nc	nc	94.2	93.2	-1.0	5.6	8.4	2.8	4785.6	4839.6	54.0
Moderate	nc	nc	5.7	6.8	1.0	1.6	2.3	0.6	185.0	135.5	-49.5
High	nc	nc	0.0	0.0	0.0	0.3	0.1	-0.2	0.8	1.2	0.4
Western pine beetle (type 1)—											
Low	+	+	72.1	75.9	3.9*	15.5	14.5	-1.0	3507.6	4916.7	1409.1*
Moderate	nc	-	22.3	19.6	-2.7	9.6	6.5	-3.1*	426.4	347.5	-78.8
High	nc	-	5.7	4.5	-1.2	3.5	4.9	1.4*	67.6	51.1	-16.5
Western pine beetle (type 2)—											
Low	nc	nc	61.7	59.9	-1.8	20.9	20.8	-0.1	1745.6	1380.0	-365.6
Moderate	nc	+	19.0	18.8	-0.2	20.6	10.2	-10.4*	172.1	259.8	87.8*
High	nc	nc	19.3	21.3	2.0	6.3	5.8	-0.5	322.7	273.1	-49.6
Mountain pine beetle (type 1)—											
Low	nc	nc	76.0	75.1	-0.8	10.1	11.9	1.7	5837.0	4452.9	-1384.1
Moderate	nc	nc	19.3	20.6	1.3	8.3	8.1	-0.1	242.7	305.7	62.9
High	nc	nc	4.7	4.3	-0.4	2.5	2.9	0.4	71.5	54.1	-17.4
Mountain pine beetle (type 2)—											
Low	nc	nc	61.7	59.9	-1.8	20.9	20.8	-0.1	1745.6	1380.0	-365.6
Moderate	nc	+	19.0	18.8	-0.2	20.6	10.2	-10.4*	172.1	259.8	87.8*
High	nc	nc	19.3	21.3	2.0	6.3	5.8	-0.5	322.7	273.1	-49.6

Table 33—(continued)

Ecological reporting unit	Trend[a] Area	Trend[a] Con.[b]	Area H[c]	Area C	Area MD[d]	Patch density H	Patch density C	Patch density MD[d]	Mean patch size H	Mean patch size C	Mean patch size MD[d]
			Percent			*No./10 000 ha*			*Hectares*		
Fir engraver—											
Low	nc	+	80.8	79.8	-1.1	6.1	9.9	3.9*	4330.2	4419.0	88.8
Moderate	nc	nc	2.1	2.2	0.1	5.2	5.9	0.6	25.9	48.7	22.8
High	+	+	17.1	18.0	1.0*	3.7	2.0	-1.7*	586.7	700.1	113.5
Douglas-fir dwarf mistletoe—											
Low	nc	nc	94.1	93.3	-0.8	5.3	7.1	1.8*	4520.0	4504.8	-15.2
Moderate	nc	nc	5.1	6.5	1.4	2.8	2.4	-0.4*	149.2	102.4	-46.8
High	nc	nc	0.8	0.2	-0.6	0.4	0.5	0.1	65.2	8.2	-57.0
Western dwarf mistletoe—											
Low	+	+	69.5	73.4	3.9*	17.4	14.4	-2.9*	2186.7	3866.1	1679.4*
Moderate	nc	-	12.7	11.1	-1.6	14.5	11.6	-2.9*	228.6	124.5	-104.1
High	nc	nc	17.8	15.5	-2.3	6.9	5.3	-1.6	196.7	215.1	18.4
Lodgepole pine dwarf mistletoe—											
Low	nc	nc	95.2	96.4	1.2	5.9	5.2	-0.7	3982.3	4218.8	236.5
Moderate	nc	nc	4.4	3.3	-1.1	3.3	3.2	-0.1	59.3	29.3	-30.0*
High	nc	nc	0.4	0.3	-0.1	0.7	0.9	0.1	7.7	6.0	-1.6
Armillaria root disease—											
Low	+	+	60.6	67.6	7.0*	15.9	13.9	-2.0	4661.8	5950.4	1288.6*
Moderate	-	-	26.2	18.9	-7.4*	11.1	14.9	3.7*	251.1	130.7	-120.4*
High	nc	nc	13.2	13.6	0.4	4.9	3.7	-1.2	474.5	355.1	-119.4
Laminated root rot—											
Low	nc	nc	73.9	73.7	-0.2	6.7	10.3	3.6*	3041.5	4142.1	1100.6
Moderate	nc	nc	7.6	8.6	1.0	5.4	9.4	4.1*	83.1	95.0	11.9
High	nc	nc	18.5	17.7	-0.7	4.9	2.9	-2.1*	668.8	808.5	139.7
S-group annosum root disease—											
Low	nc	nc	75.4	75.6	0.2	6.0	10.1	4.1*	4058.0	4518.7	460.7
Moderate	nc	nc	1.9	1.1	-0.7	5.2	2.9	-2.3*	20.9	30.5	9.6
High	nc	nc	22.8	23.3	0.5	4.1	2.4	-1.8*	1008.2	1243.0	234.9
P-group annosum root disease—											
Low	+	+	69.6	73.3	3.7*	17.4	14.6	-2.7*	2526.0	3855.7	1329.7*
Moderate	-	-	11.4	7.0	-4.5*	14.7	11.6	-3.1*	221.7	91.5	-130.2
High	nc	nc	19.0	19.8	0.8	5.8	5.4	-0.4	263.3	214.9	-48.4
Schweinitzii root and butt rot—											
Low	nc	+	52.4	54.1	1.7	17.4	19.2	1.9	1551.8	2746.9	1195.2*
Moderate	+	nc	21.2	28.0	6.9*	13.1	13.9	0.8	256.5	253.2	-3.3
High	-	nc	26.4	17.9	-8.6*	6.4	6.6	0.3	615.8	234.6	-381.2
White pine blister rust (type 1)—											
Low	nc	nc	93.6	93.6	0.0	2.8	2.6	-0.2	9352.5	9385.8	33.3
Moderate	nc	nc	6.4	6.4	0.0	1.3	1.1	-0.2	297.2	343.8	46.6
High	nc	nc	0.0	0.0	0.0	0.1	0.0	-0.1	0.2	0.0	-0.2

Table 33—(continued)

Ecological reporting unit	Trend[a] Area	Con.[b]	Area H[c]	C	MD[d]	Patch density H	C	MD[d]	Mean patch size H	C	MD[d]
			------- *Percent* -------			*No./10 000 ha*			------- *Hectares* -------		
Rust-red stringy rot—											
Low	nc	-	76.5	76.4	-0.1	7.8	11.2	3.4*	3923.1	3783.2	-139.8
Moderate	nc	+	18.7	19.5	0.8	6.0	4.0	-2.0*	301.6	334.6	33.0
High	nc	nc	4.8	4.1	-0.7	1.5	3.9	2.4*	66.6	26.8	-39.9*
Upper Snake ERU:											
Western spruce budworm—											
Low	-	nc	97.8	97.6	-0.2*	3.0	3.3	0.3	8642.0	8582.3	-59.7
Moderate	-	-	0.5	0.3	-0.3*	3.1	2.3	-0.8	8.3	3.1	-5.2*
High	+	+	1.6	2.1	0.5*	1.1	0.5	-0.6*	32.4	95.4	62.9*
Douglas-fir beetle—											
Low	-	nc	98.3	97.8	-0.5*	3.9	4.0	0.1	8180.8	7893.6	-287.1
Moderate	nc	nc	1.2	1.2	0.0	1.8	1.5	-0.3	9.5	48.9	39.4
High	nc	nc	0.5	1.0	0.5	1.9	1.4	-0.5	3.6	8.6	5.0
Mountain pine beetle (type 1)—											
Low	nc	nc	97.9	97.7	-0.2	3.8	3.3	-0.5	8536.7	10757.0	2220.3
Moderate	nc	nc	1.5	2.0	0.4	3.1	3.3	0.2	12.9	20.9	8.0
High	nc	nc	0.6	0.3	-0.2	1.2	0.5	-0.7	9.2	22.5	13.4
Douglas-fir dwarf mistletoe—											
Low	nc	nc	98.2	97.8	-0.5	3.7	3.8	0.1	8282.1	7903.6	-378.5
Moderate	nc	+	1.2	0.7	-0.5	2.7	1.9	-0.9*	9.7	23.3	13.6
High	nc	+	0.6	1.5	0.9	1.8	1.1	-0.7*	5.3	18.8	13.5
Lodgepole pine dwarf mistletoe—											
Low	nc	nc	99.6	99.6	0.1	3.8	3.8	0.0	10037.3	9835.6	-201.7
Moderate	nc	nc	0.1	0.0	-0.1	0.8	0.1	-0.7	1.7	4.3	2.6
High	nc	nc	0.3	0.3	0.0	0.6	0.3	-0.3	6.7	22.3	15.7
Armillaria root disease—											
Low	nc	nc	98.2	97.7	-0.5	3.2	3.7	0.5	10132.5	9762.1	-370.4
Moderate	nc	+	0.9	0.7	-0.2	3.0	2.1	-0.9*	6.7	20.0	13.2
High	nc	+	1.0	1.6	0.6	2.1	1.1	-1.1*	9.2	20.9	11.7
Laminated root rot—											
Low	nc	nc	98.2	97.7	-0.5	3.5	3.9	0.4	8290.6	7903.1	-387.6
Moderate	nc	+	0.9	0.7	-0.2	3.2	2.1	-1.1*	5.9	42.9	37.0
High	nc	nc	1.0	1.6	0.6	2.1	1.1	-1.0	9.2	21.0	11.8
S-group annosum root disease—											
Low	nc	nc	98.2	97.7	-0.5	3.5	3.9	0.4	8290.6	7903.1	-387.6
Moderate	nc	nc	0.8	0.6	-0.2	2.8	2.1	-0.7	5.4	22.6	17.2
High	nc	+	1.0	1.7	0.6	2.3	0.9	-1.4*	10.2	31.7	21.4

Table 33—(continued)

	Trend[a]		Area			Patch density			Mean patch size		
Ecological reporting unit	Area	Con.[b]	H[c]	C	MD[d]	H	C	MD[d]	H	C	MD[d]
			------- *Percent* -------			*No./10 000 ha*			------- *Hectares* -------		
Schweinitzii root and butt rot—											
Low	nc	nc	98.2	97.7	-0.5	3.2	3.7	0.5	10132.5	9762.1	-370.4
Moderate	nc	nc	0.3	0.2	-0.1	2.7	1.5	-1.2*	1.8	2.1	0.2
High	+	+	1.5	2.1	0.6*	1.4	0.7	-0.7*	20.4	57.8	37.4*

[a] Choices for either field are (+) increase; (-) decrease; (nc) no ecologically significant change.

[b] Con. = connectivity change among patches in a patch type

[c] H = historical; C = current; MD = mean difference of pairwise comparisons of historical and current subwatersheds.

[d] * = statistically significant difference at $P \leq 0.2$; all values rounded to 1 decimal place.