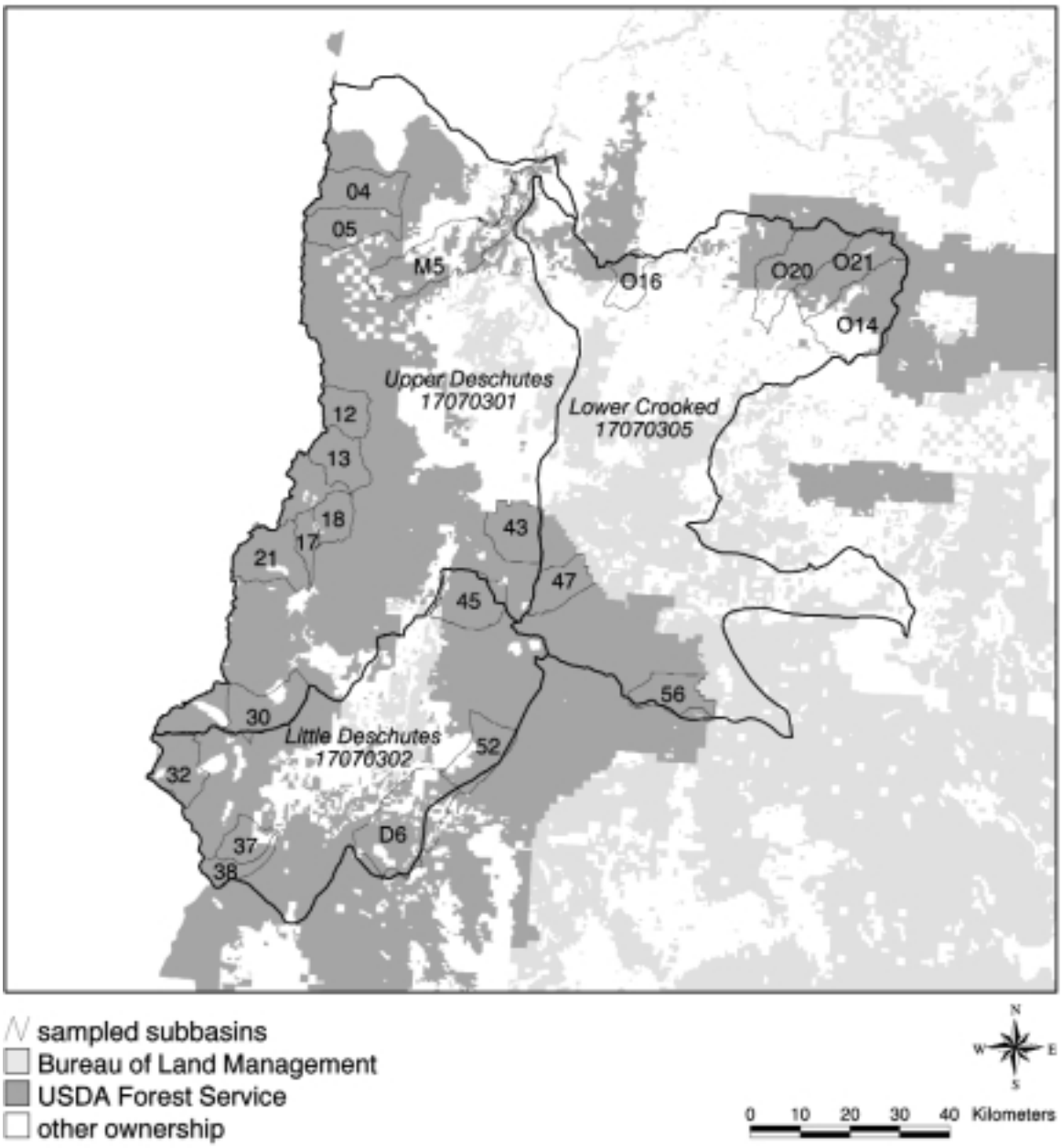

Figure 15—Subwatersheds on USDA Forest Service, Bureau of Land Management, and other ownerships sampled in the Lower Crooked, Upper Deschutes, and Little Deschutes subbasins of Oregon for the midscale ecological assessment of the interior Columbia River basin.

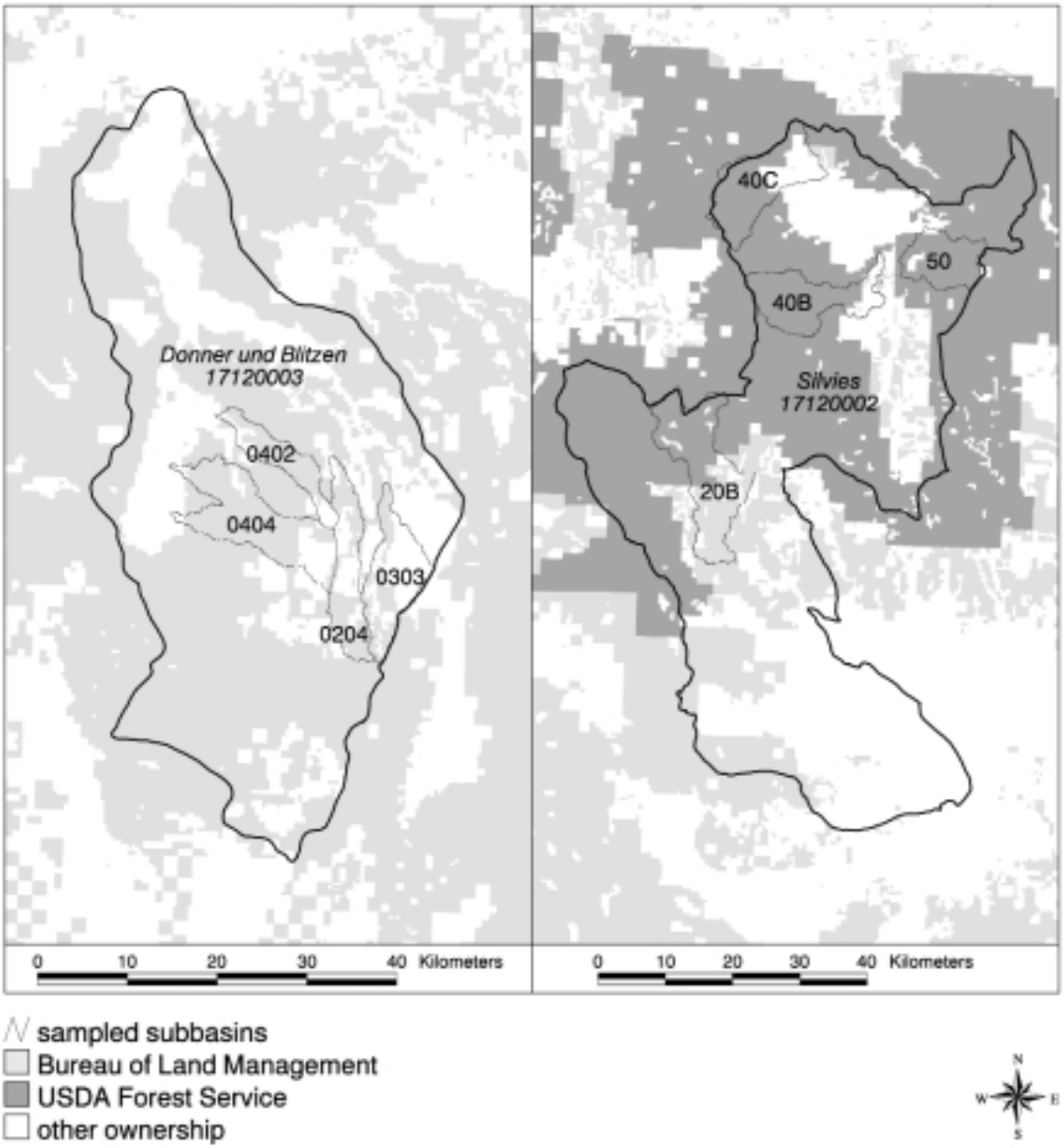

Figure 16—Subwatersheds on USDA Forest Service, Bureau of Land Management, and other ownerships sampled in the Silvies and Donner und Blitzen subbasins of Oregon for the midscale ecological assessment of the interior Columbia River basin.

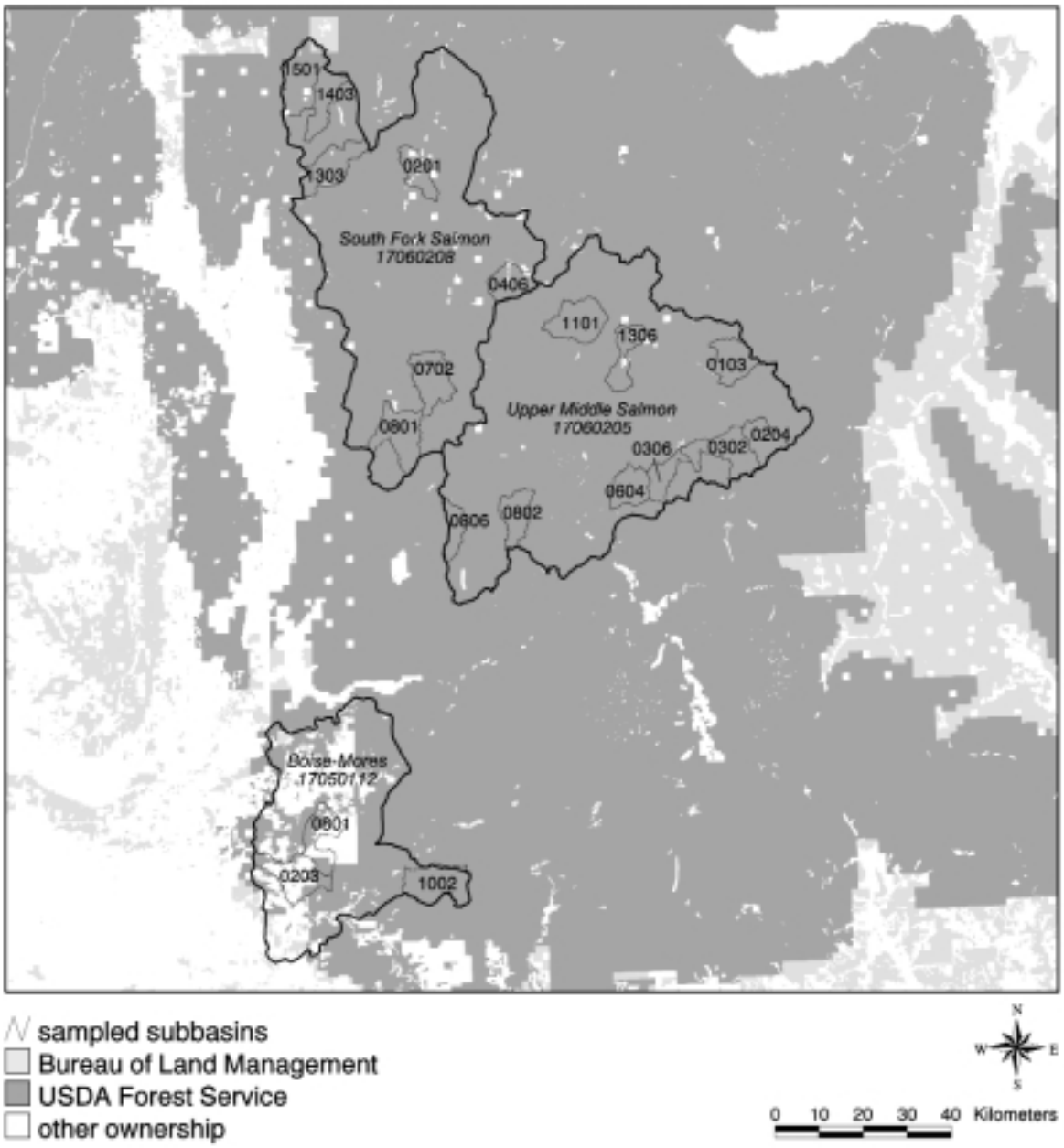

Figure 17—Subwatersheds on USDA Forest Service, Bureau of Land Management, and other ownerships sampled in the South Fork Salmon, Boise-Mores, and Upper Middle Fork Salmon subbasins of Idaho for the midscale ecological assessment of the interior Columbia River basin.

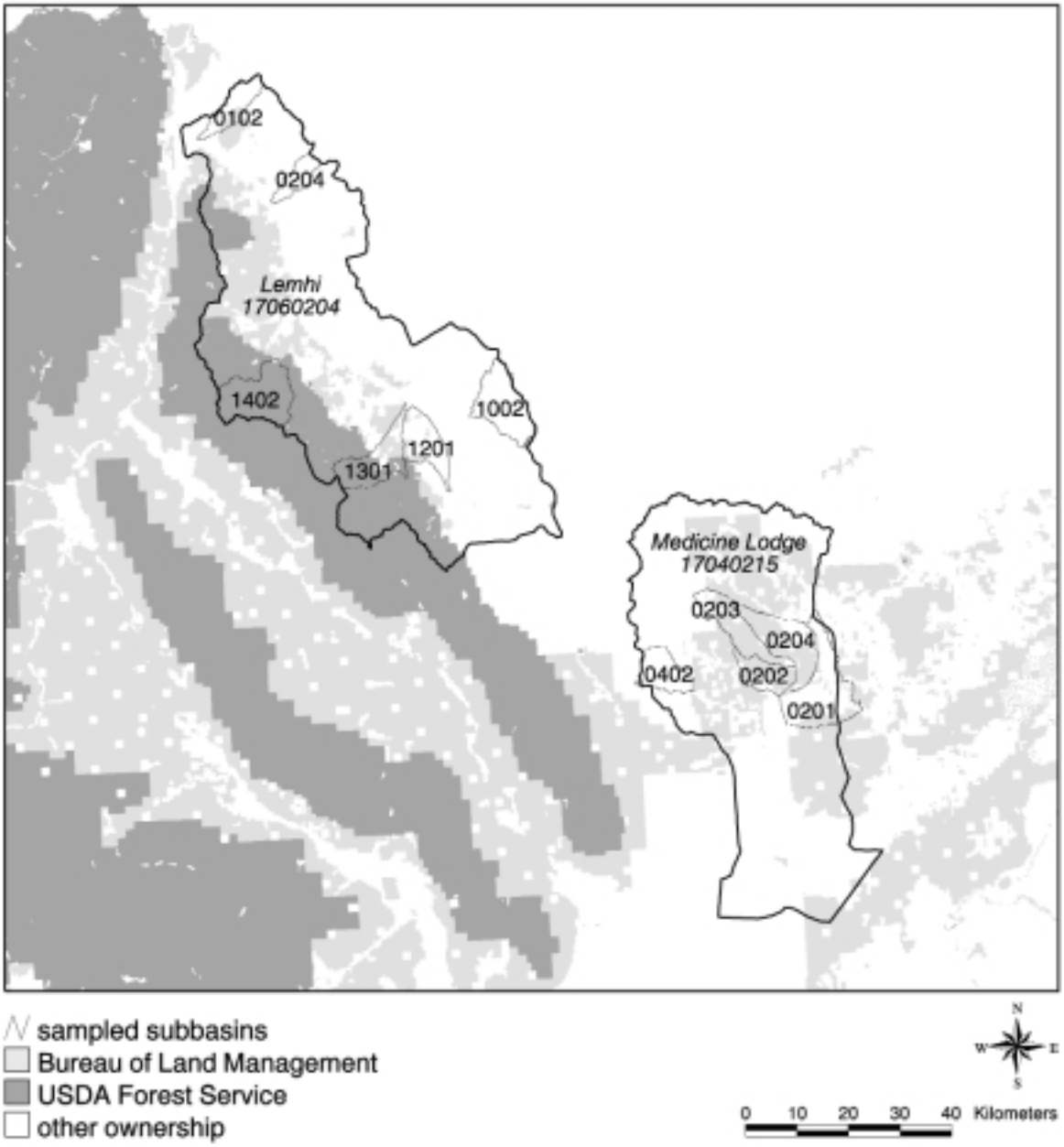

Figure 18—Subwatersheds on USDA Forest Service, Bureau of Land Management, and other ownerships sampled in the Lemhi and Medicine Lodge subbasins of Idaho for the midscale ecological assessment of the interior Columbia River basin.

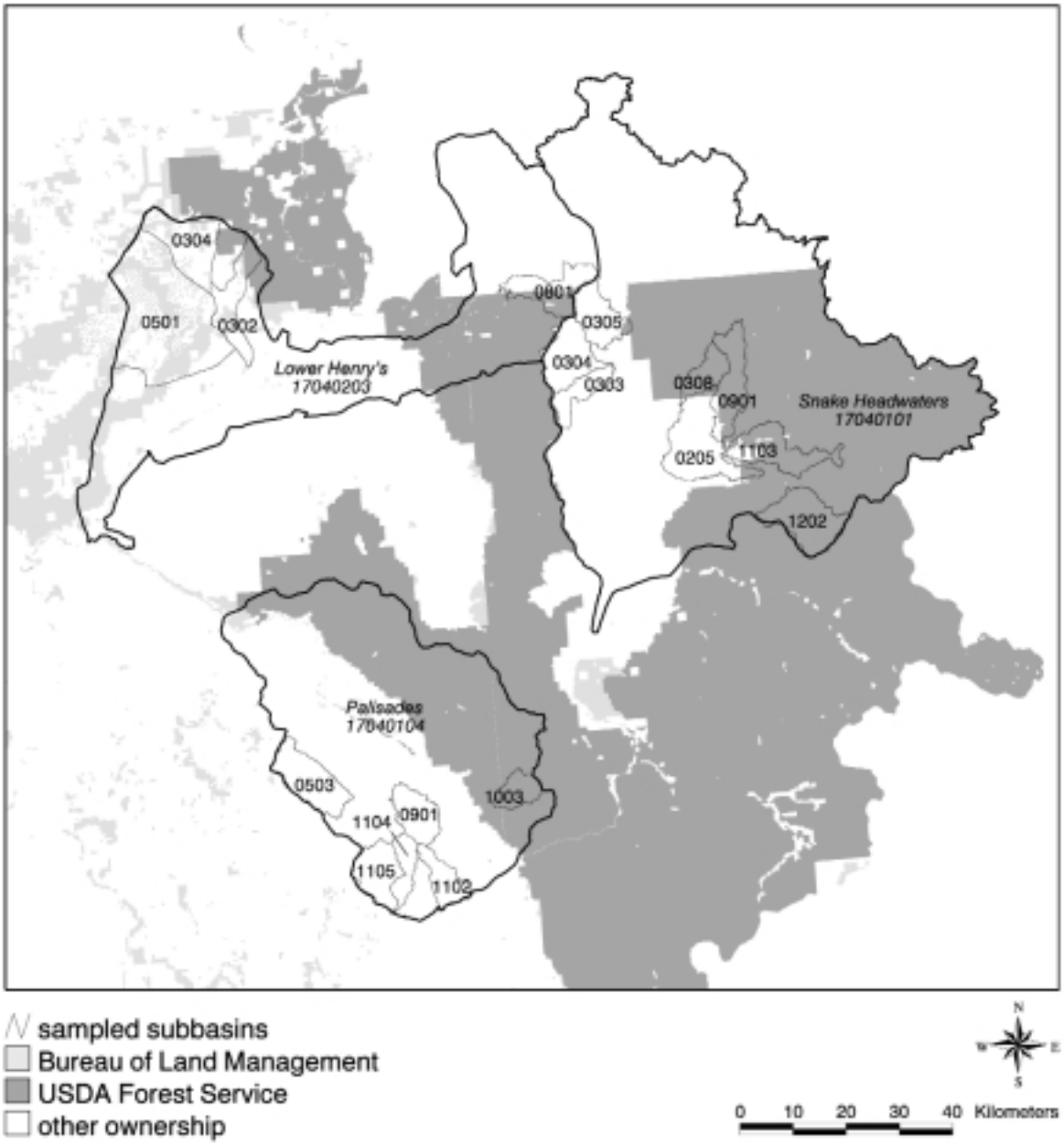

Figure 19—Subwatersheds on USDA Forest Service, Bureau of Land Management, and other ownerships sampled in the Lower Henry's, Palisades, and Snake Headwaters subbasins of Idaho and Wyoming for the midscale ecological assessment of the interior Columbia River basin.

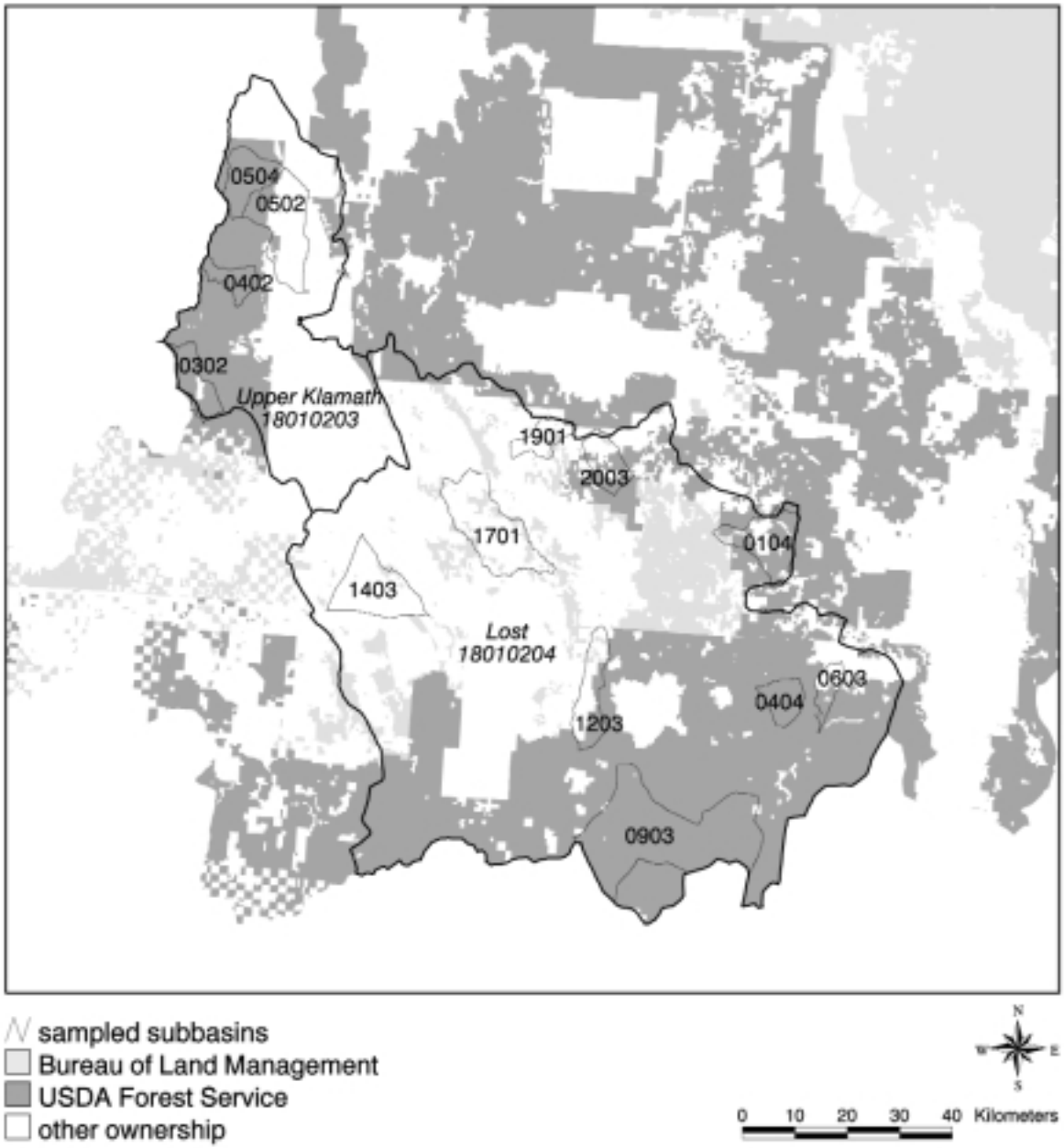

Figure 20—Subwatersheds on USDA Forest Service, Bureau of Land Management, and other ownerships sampled in the Upper Klamath Lake and Lost subbasins of Oregon and California for the midscale ecological assessment of the interior Columbia River basin.

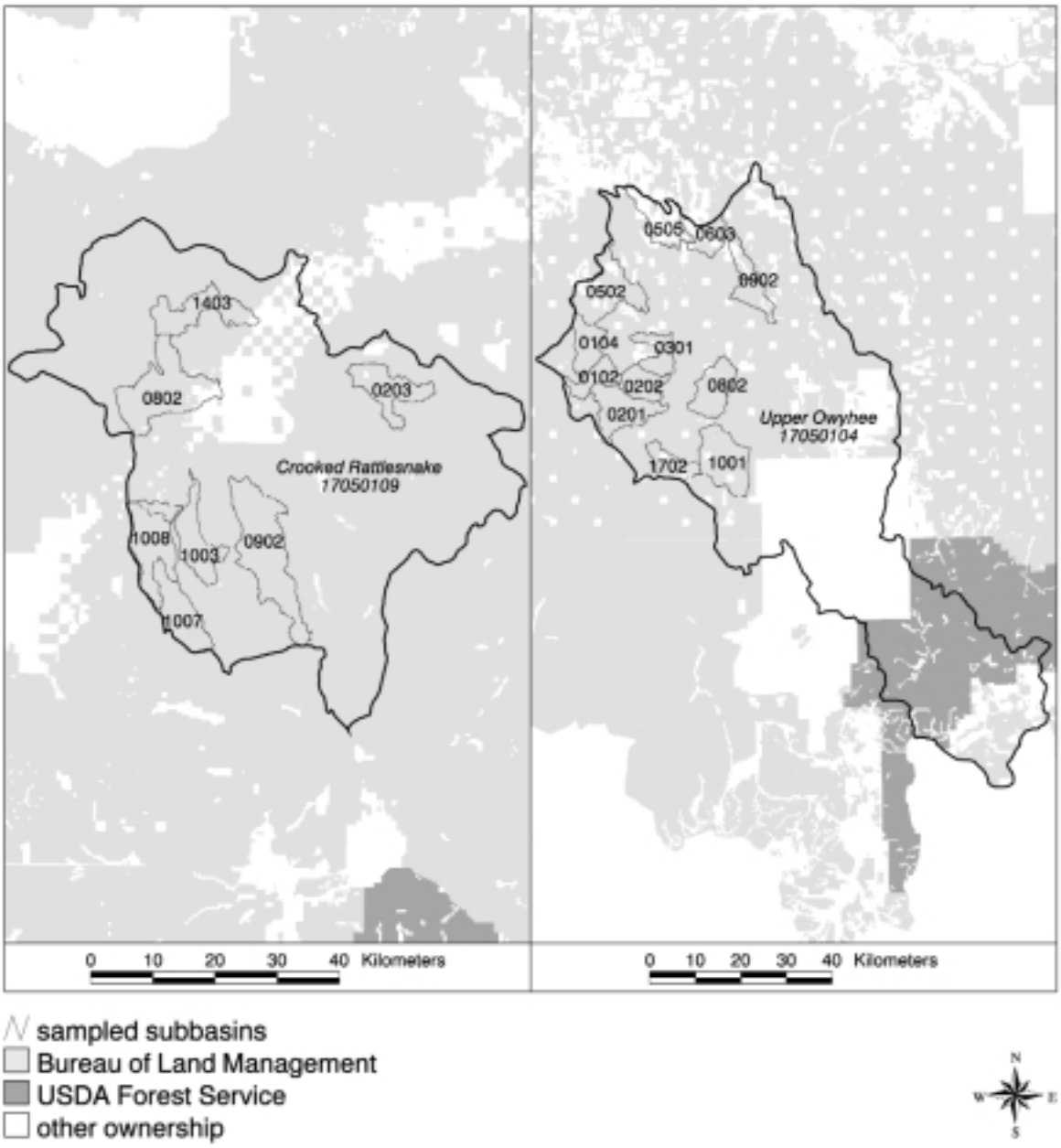

Figure 21—Subwatersheds on USDA Forest Service, Bureau of Land Management, and other ownerships sampled in the Crooked Rattlesnake and Upper Owyhee subbasins of Oregon, Idaho, and Nevada for the midscale ecological assessment of the interior Columbia River basin.

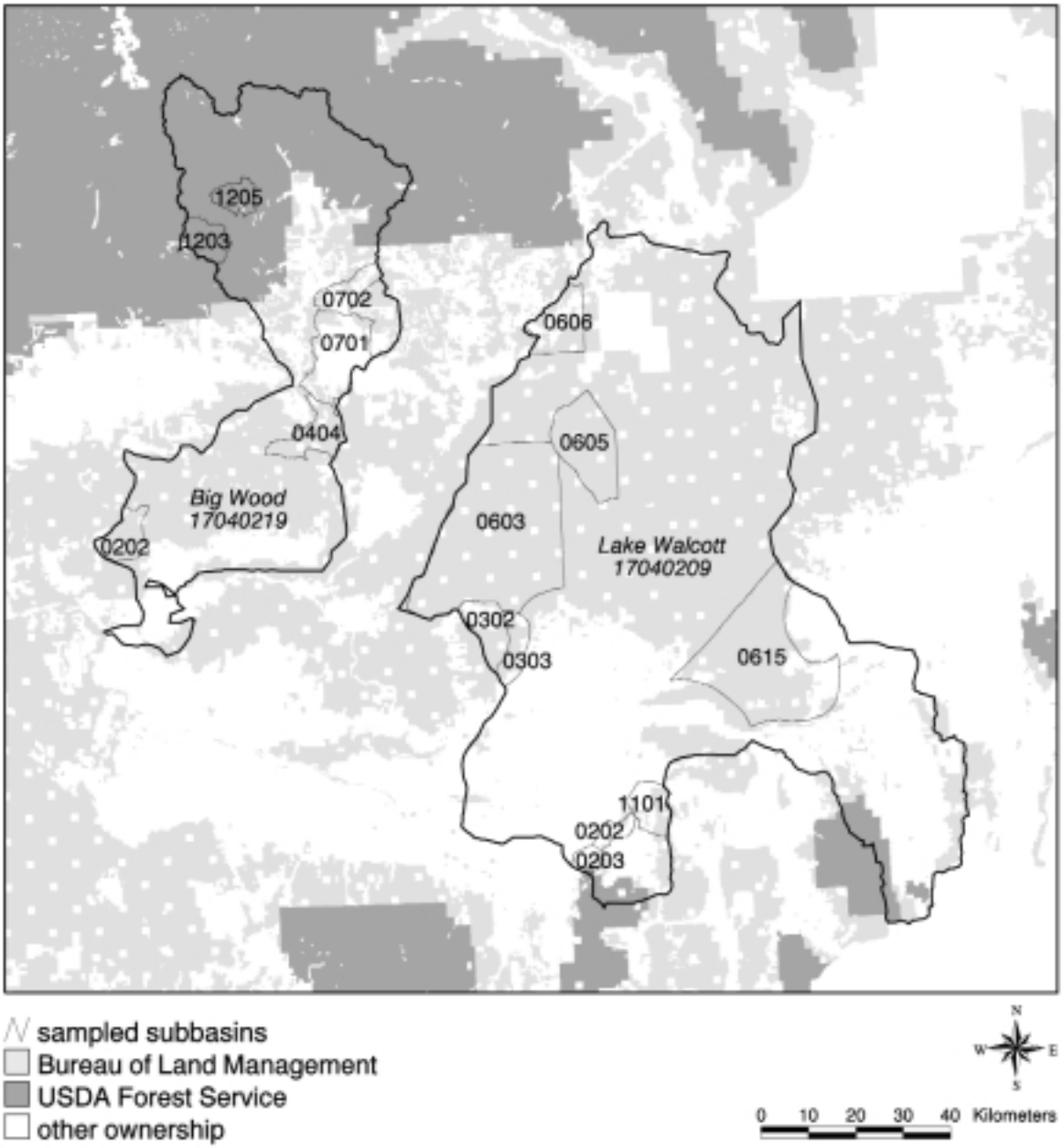

Figure 22—Subwatersheds on USDA Forest Service, Bureau of Land Management, and other ownerships sampled in the Big Wood and Lake Walcott subbasins of Idaho for the midscale ecological assessment of the interior Columbia River basin.

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				Span, current	Subbasin percentage	
			1930s	1940s	1950s	1960s		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. Photo-interpreted 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 under-burning 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 photointerpreted 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]

					Forest (by structural class[b])				
Physiognomic type	Nonforest and nonrange	Herbland	Shrubland	Woodland	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.

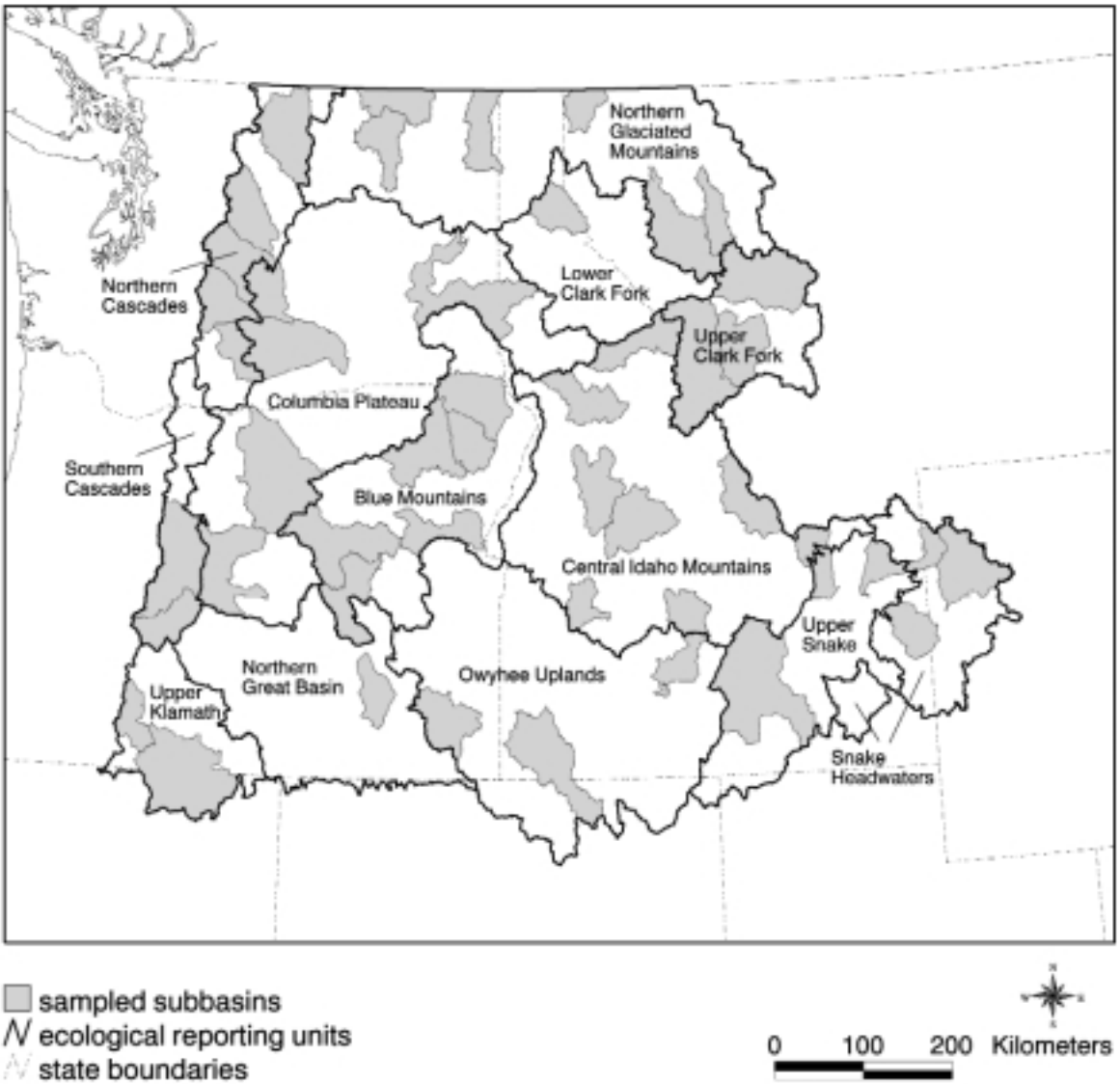


Figure 23—Ecological reporting units (ERUs) of the interior Columbia River basin broad-scale and midscale assessments. Shaded areas denote subbasins sampled within each ERU.

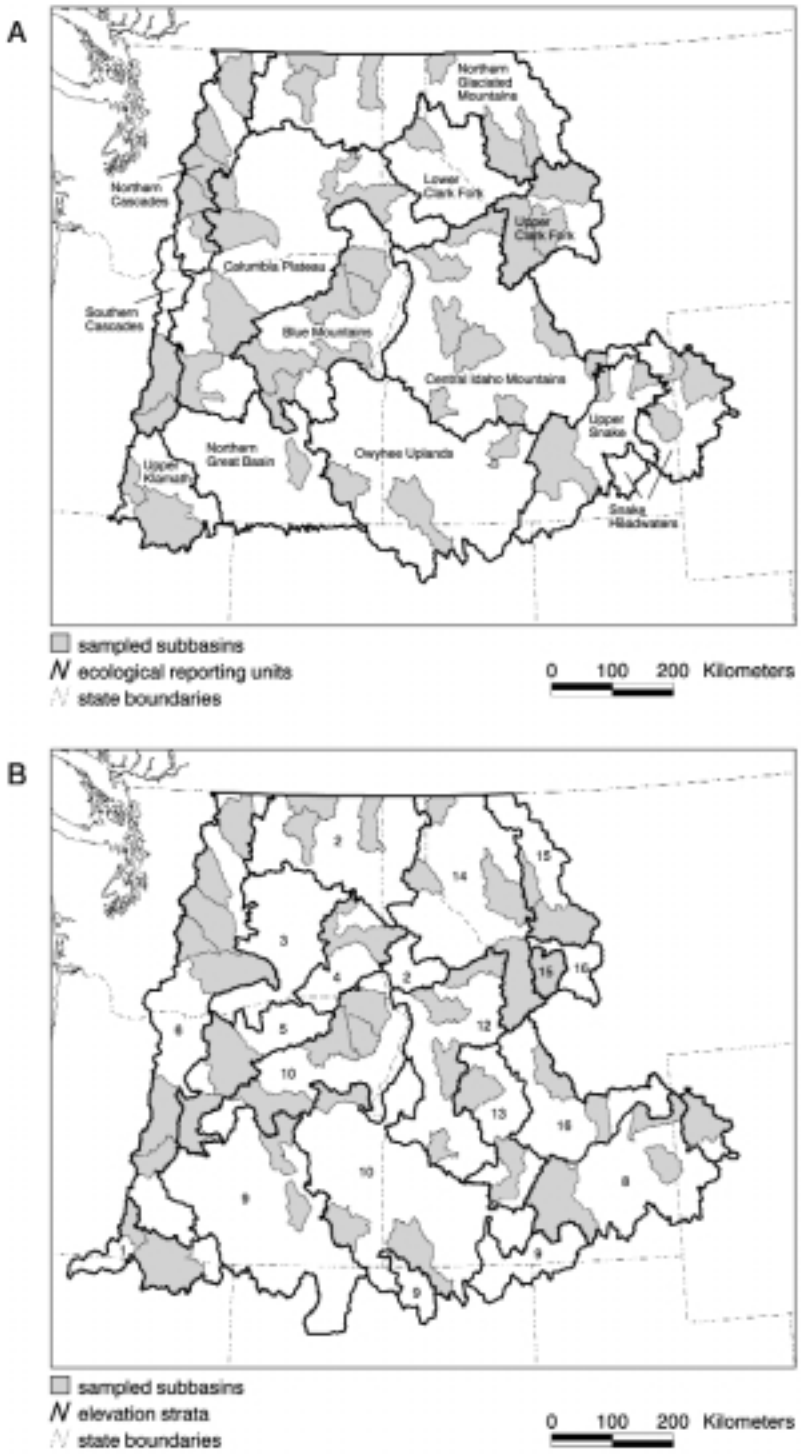


Figure 24—Composite of ecological reporting units (A) and Bailey's province-elevation strata (B) for subbasins sampled in the midscale assessment of the interior Columbia River basin. Shaded areas denote sampled subbasins.

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.

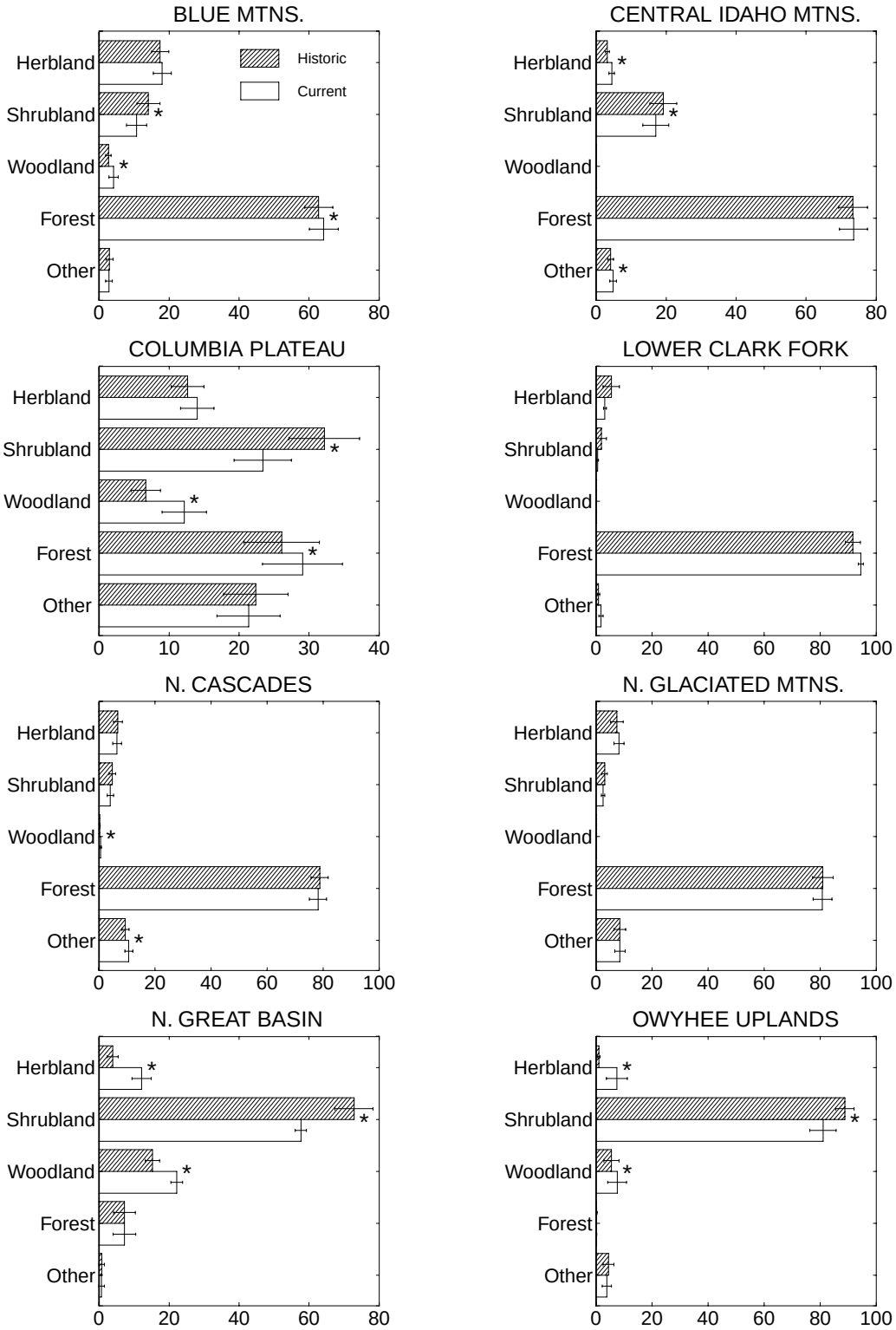
Physiognomic types—Area in the forest physiognomic type increased from an average of 62.8 to 74.2 percent of the area of the ERU, and area in woodland increased from an average of 2.7 to 4.2 percent (fig. 25 and appendix 2) Shrubland area declined from an average of 14.1 to 10.7 percent of the ERU area. 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 white-bark 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.
0 20 40 60 80
COLUMBIA PLATEAU
0 10 20 30 40
LOWER CLARK FORK
0 20 40 60 80 100
N. CASCADES
0 20 40 60 80 100
N. GLACIATED MTNS.
0 20 40 60 80 100
N. GREAT BASIN
0 20 40 60 80
OWYHEE UPLANDS
0 20 40 60 80 100

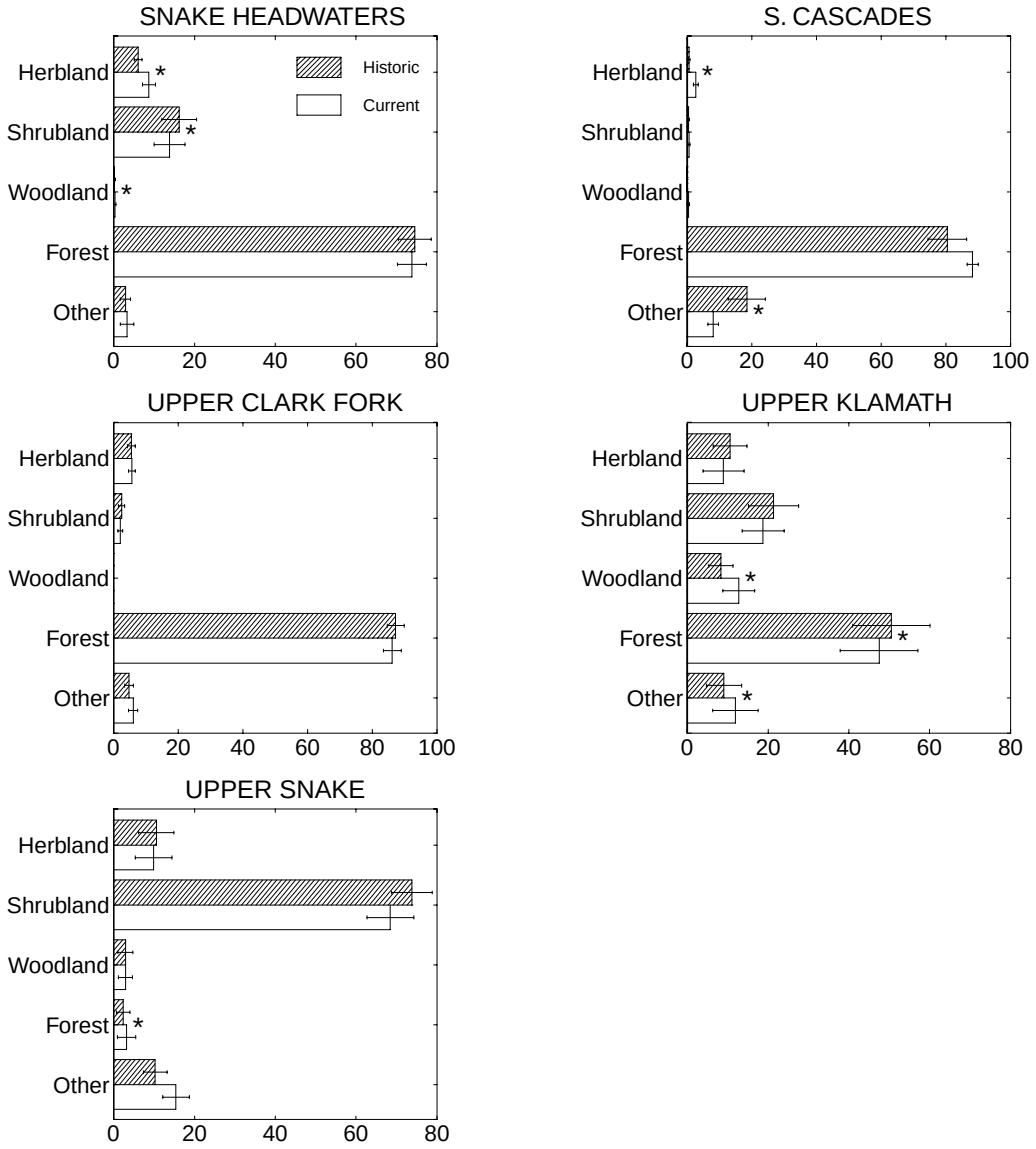
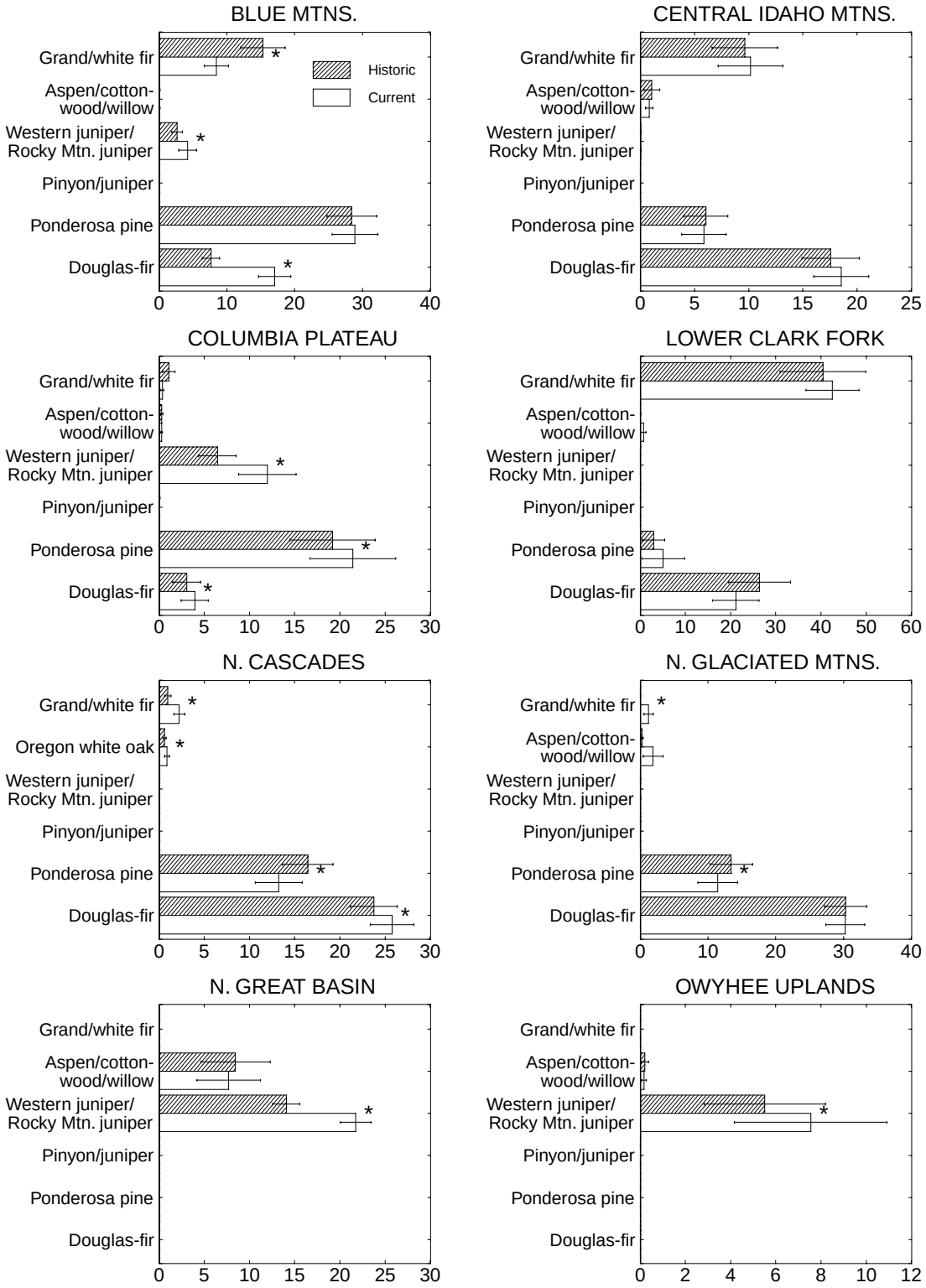


Figure 25—Historical and current distribution of physiognomic types expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) difference between historical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


BLUE MTNS.
Historic
Current
Grand/white fir
Aspen/cotton-wood/willow
Western juniper/ Rocky Mtn. juniper
Pinyon/juniper
Ponderosa pine
Douglas-fir
0 10 20 30 40
CENTRAL IDAHO MTNS.
0 5 10 15 20 25
COLUMBIA PLATEAU
0 5 10 15 20 25 30
LOWER CLARK FORK
0 10 20 30 40 50 60
N. CASCADES
Oregon white oak
0 5 10 15 20 25 30
N. GLACIATED MTNS.
0 10 20 30 40
N. GREAT BASIN
0 5 10 15 20 25 30
OWYHEE UPLANDS
0 2 4 6 8 10 12

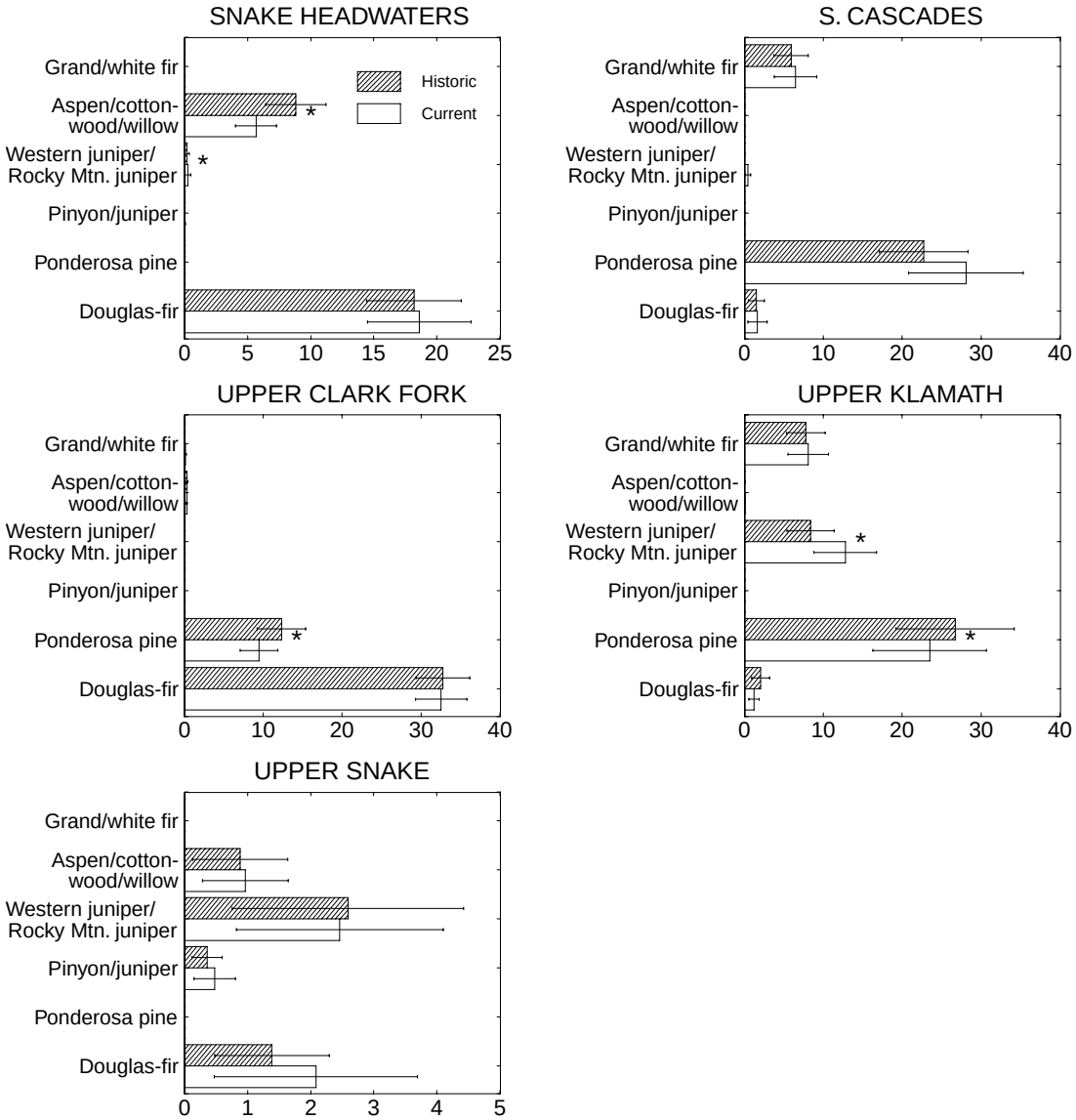
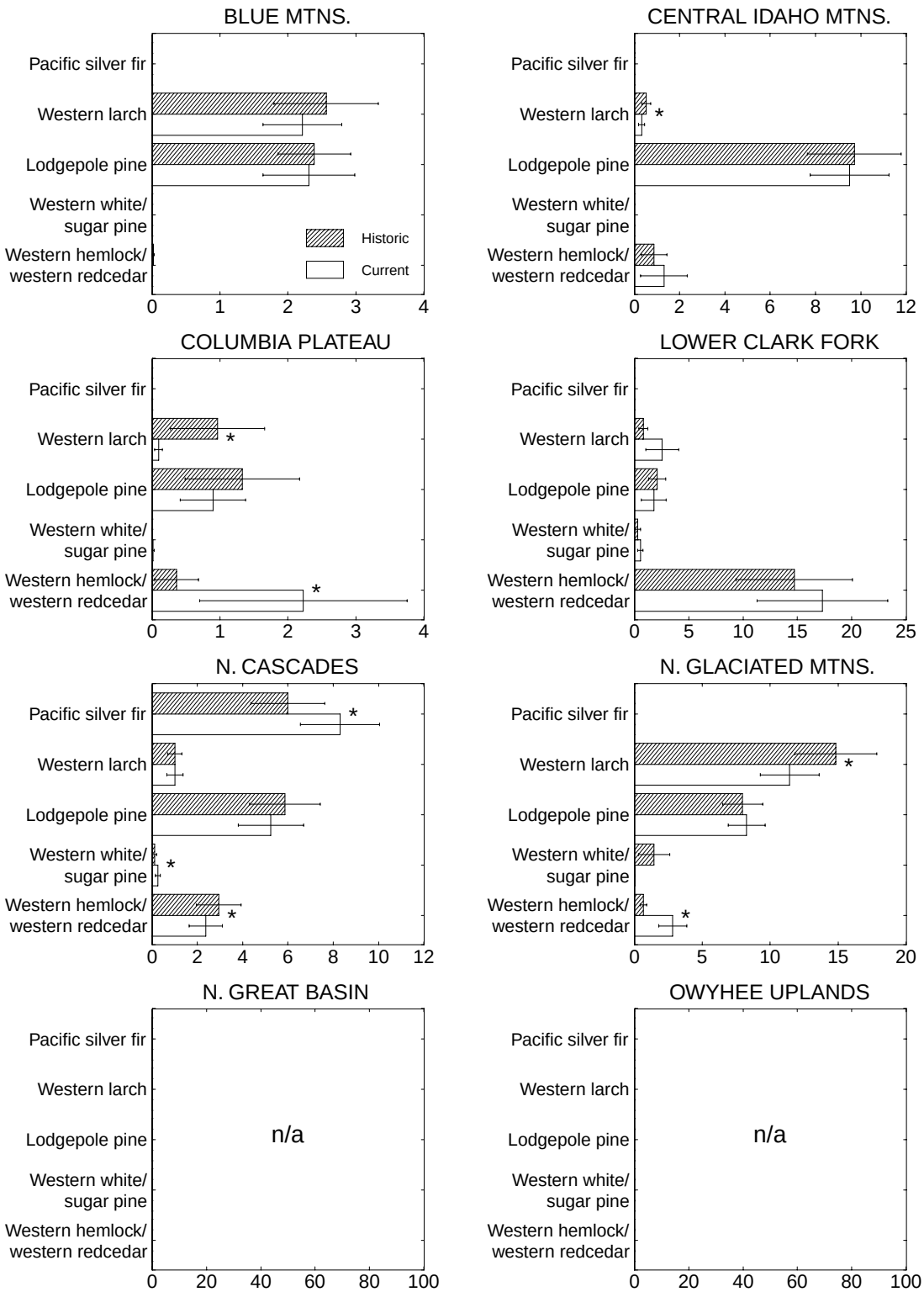


Figure 26—Historical and current distribution of forest and woodland cover types expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) difference between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

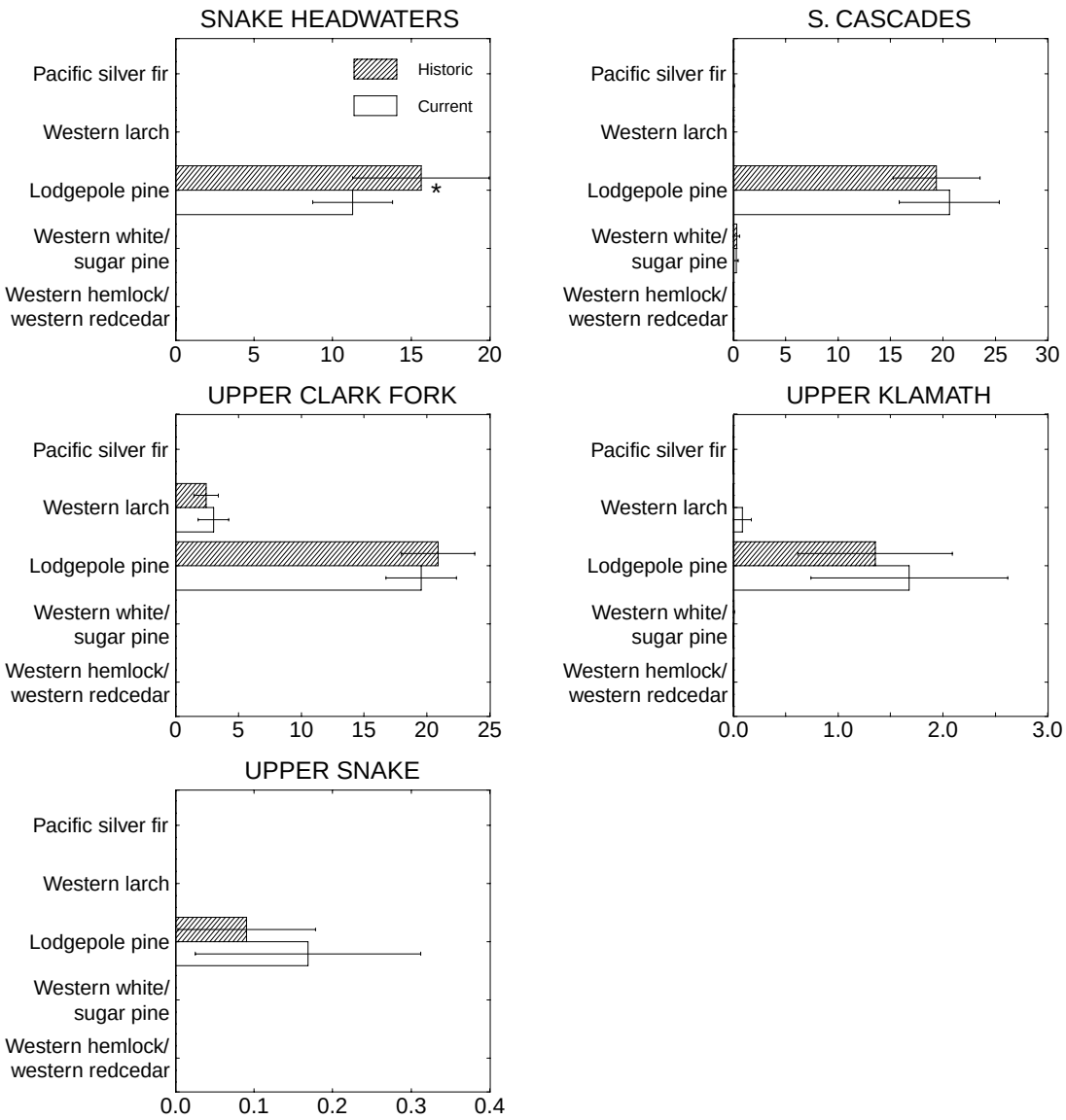
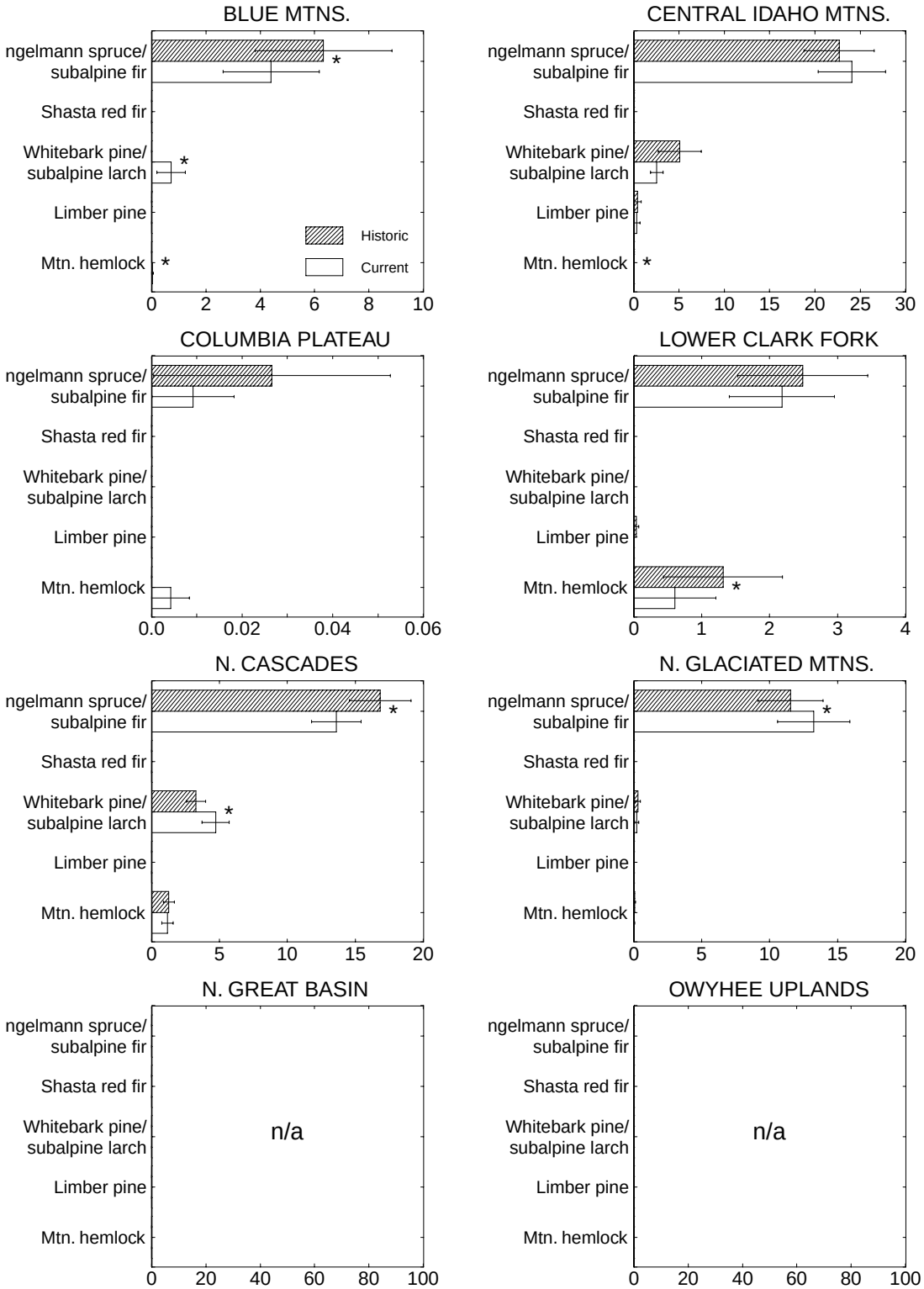


Figure 27—Historical and current distribution of forest cover types expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) difference between historical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


BLUE MTNS.
CENTRAL IDAHO MTNS.
COLUMBIA PLATEAU
LOWER CLARK FORK
N. CASCADES
N. GLACIATED MTNS.
N. GREAT BASIN
OWYHEE UPLANDS
ngelmann spruce/ subalpine fir
Shasta red fir
Whitebark pine/ subalpine larch
Limber pine
Mtn. hemlock
Historic
Current
n/a
*

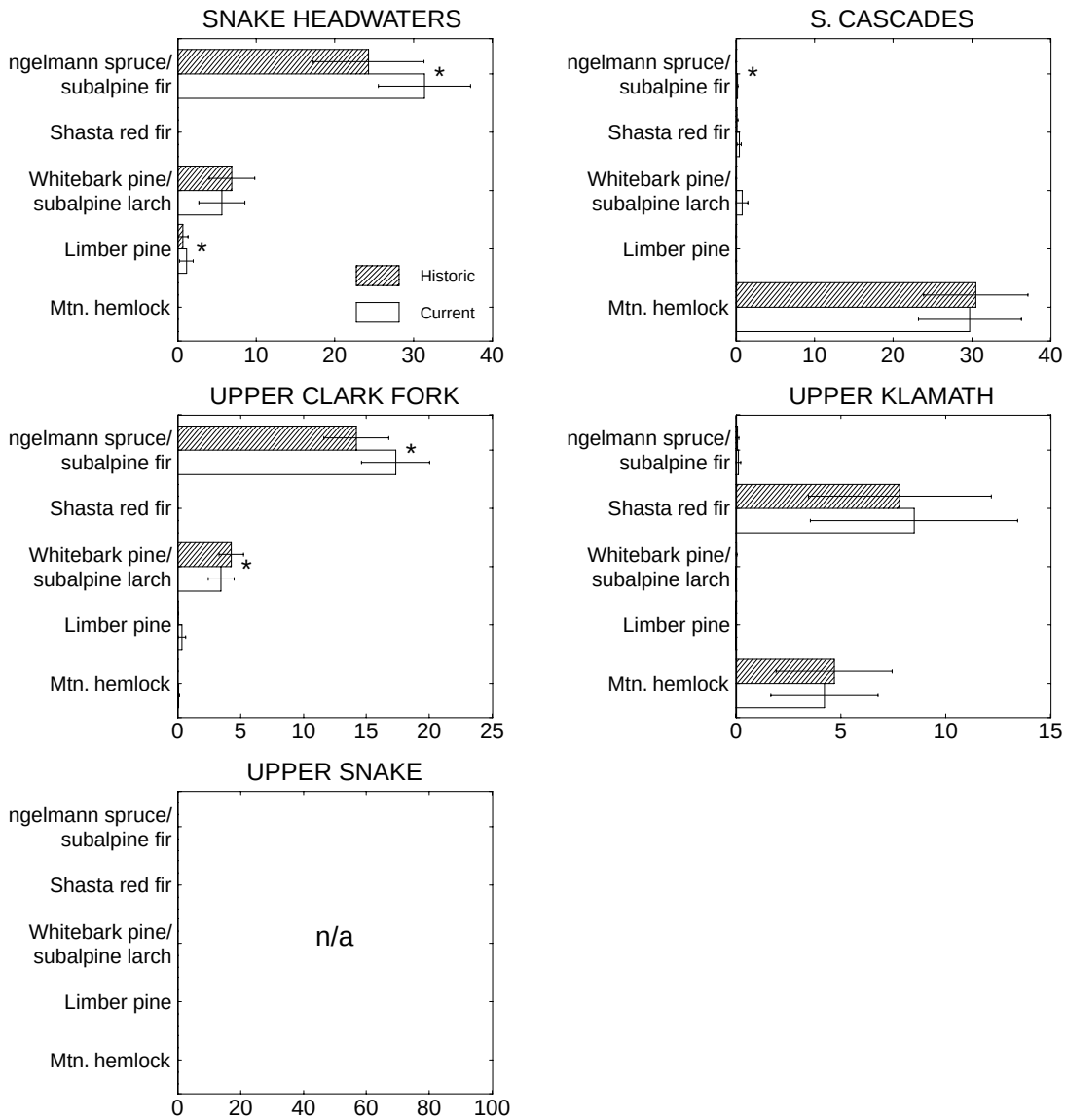


Figure 28—Historical and current distribution of forest cover types expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) difference between historical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

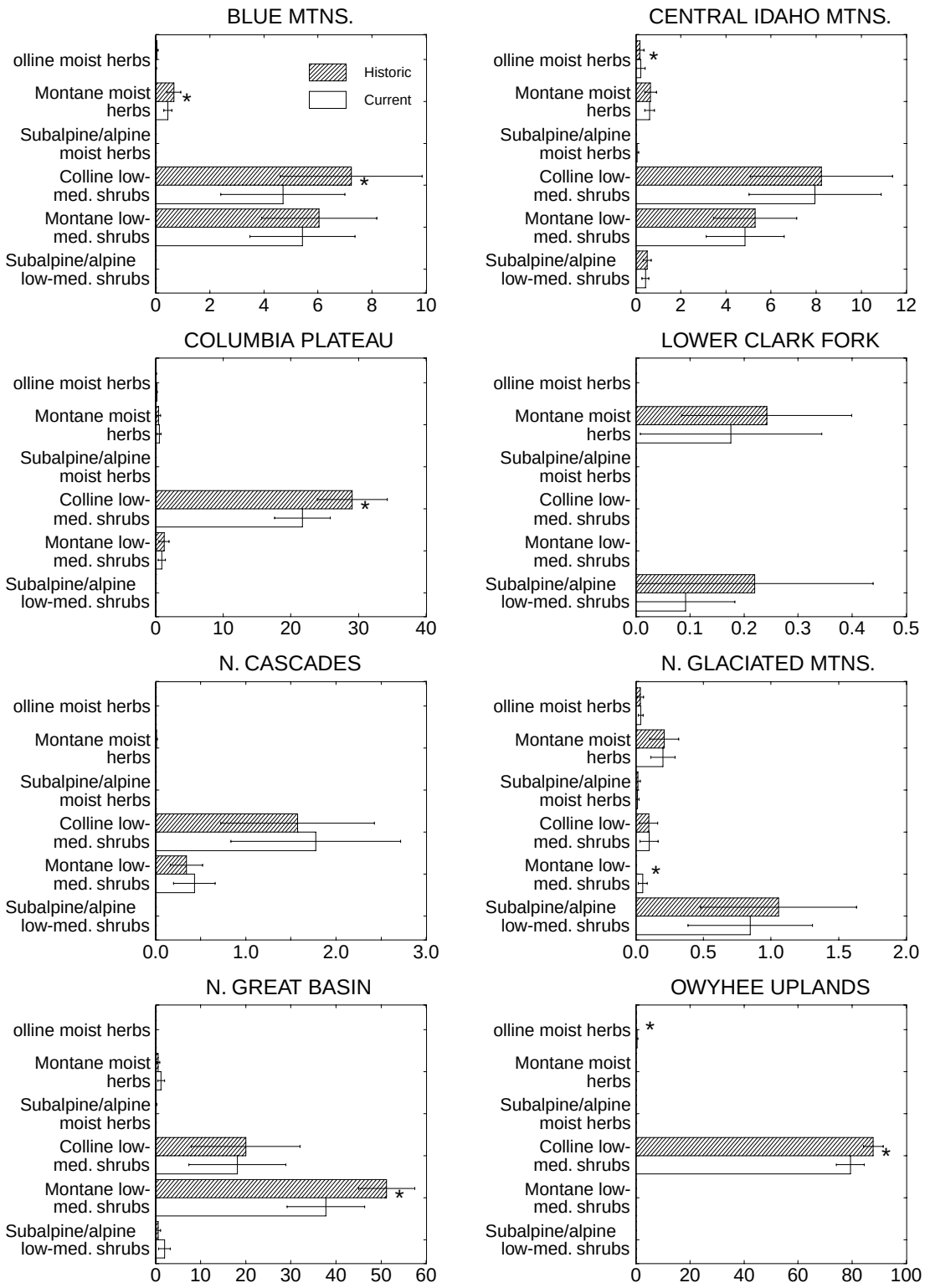
Herbland—Significant change also occurred in herbland structures: open herbland area increased from an average of 6.4 to 8.5 percent, and closed herbland area declined from an average of 3.2 to 2.5 percent of the ERU area (fig. 38 and appendix 2). Connectivity of open herblands increased with significantly 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
*

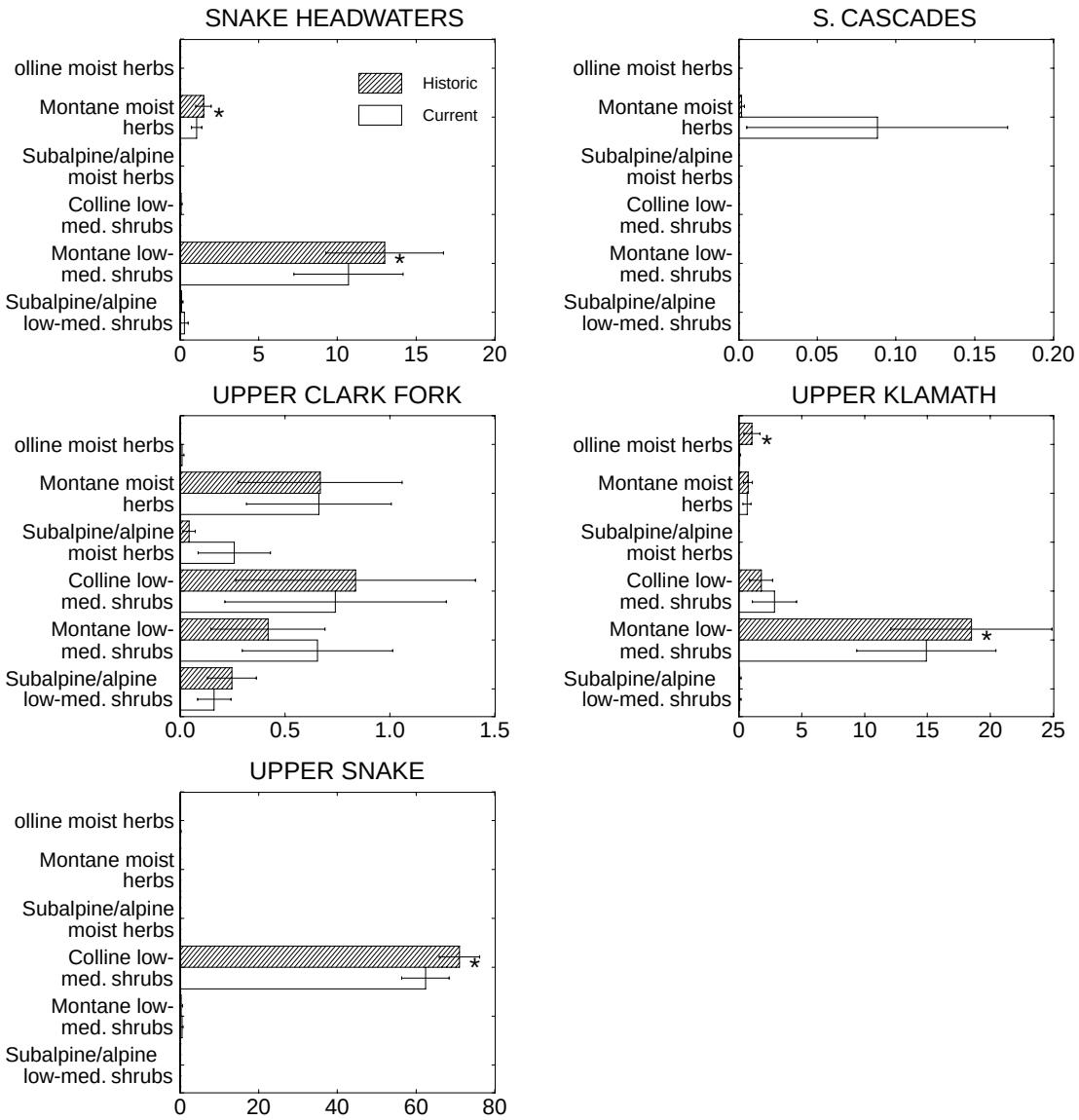
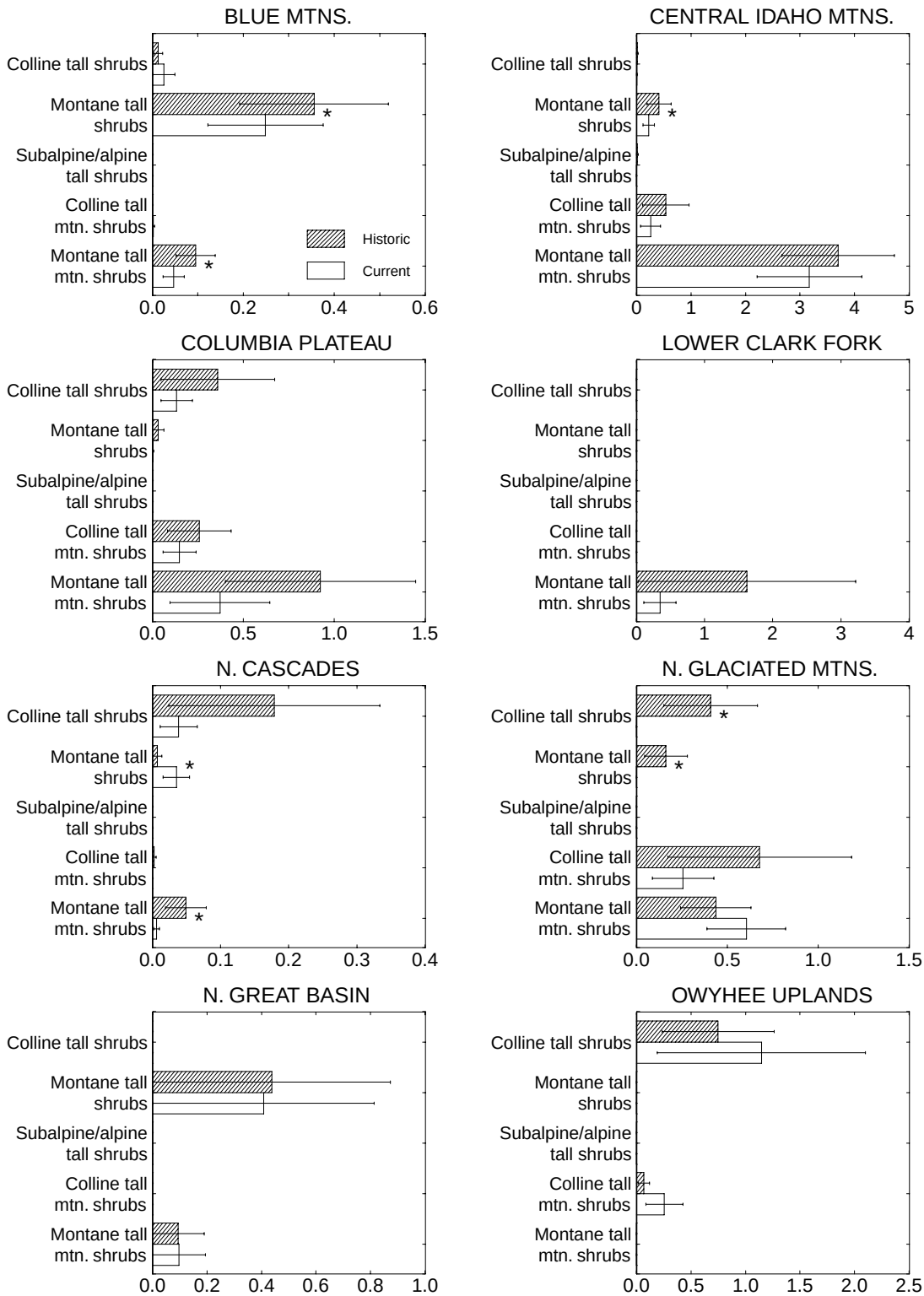


Figure 29—Historical and current distribution of herbland and shrubland cover types expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) difference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

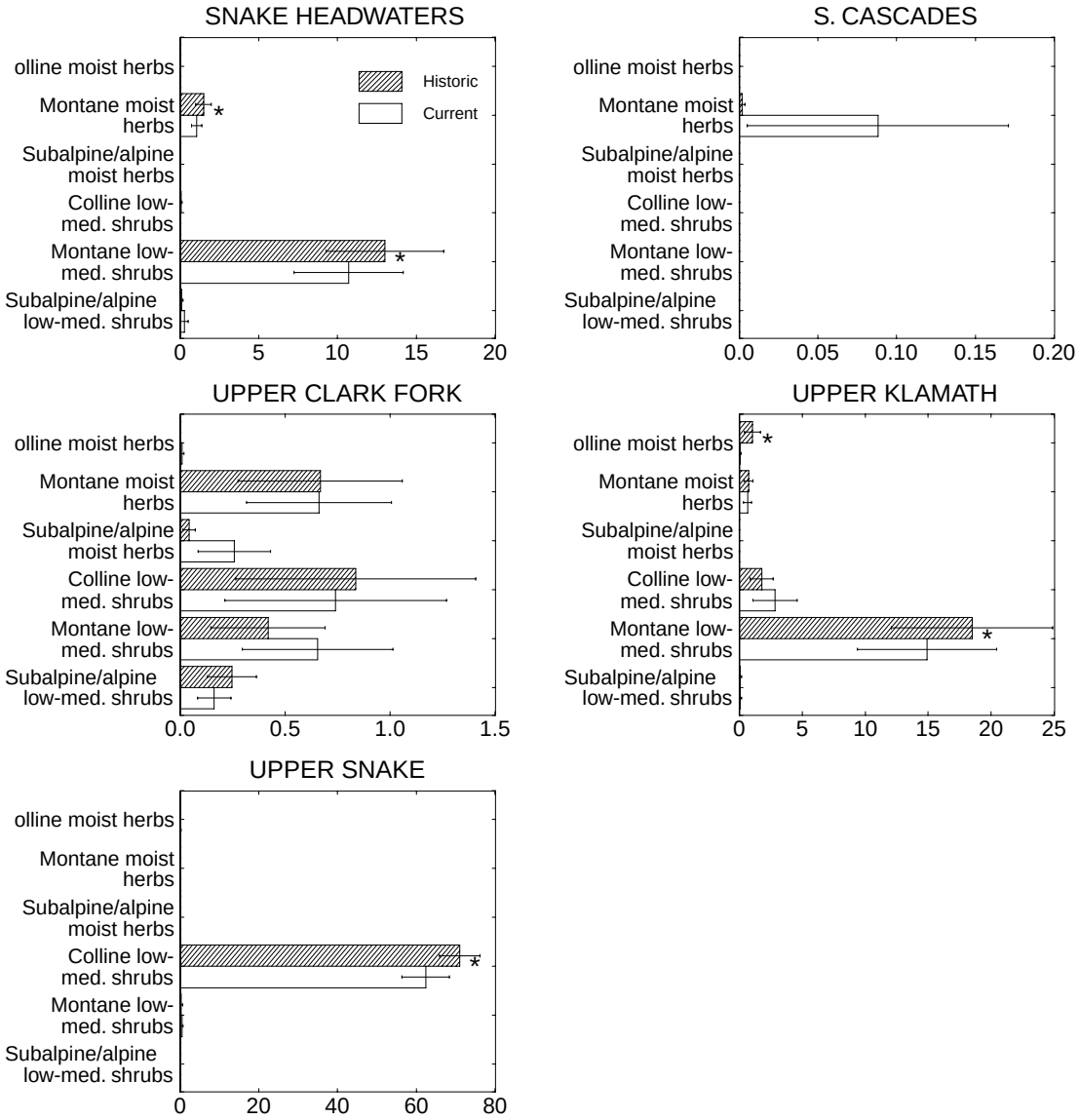
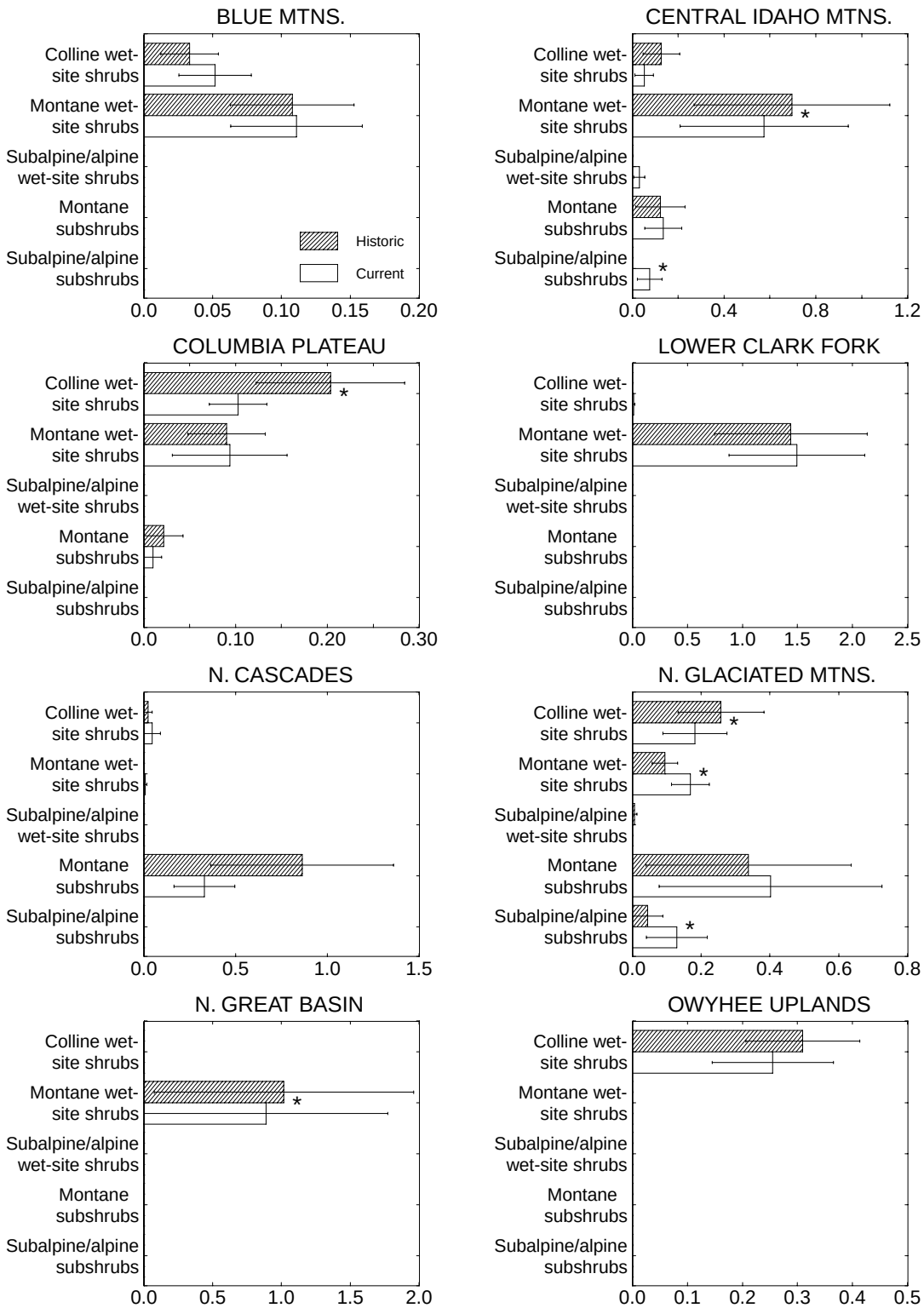


Figure 30—Historical and current distribution of herbland and shrubland cover types expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) difference 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
0.4
0.8
1.2
0.30
0.5
1.0
1.5
2.0
2.5
0.2
0.6
0.8
0.1
0.3

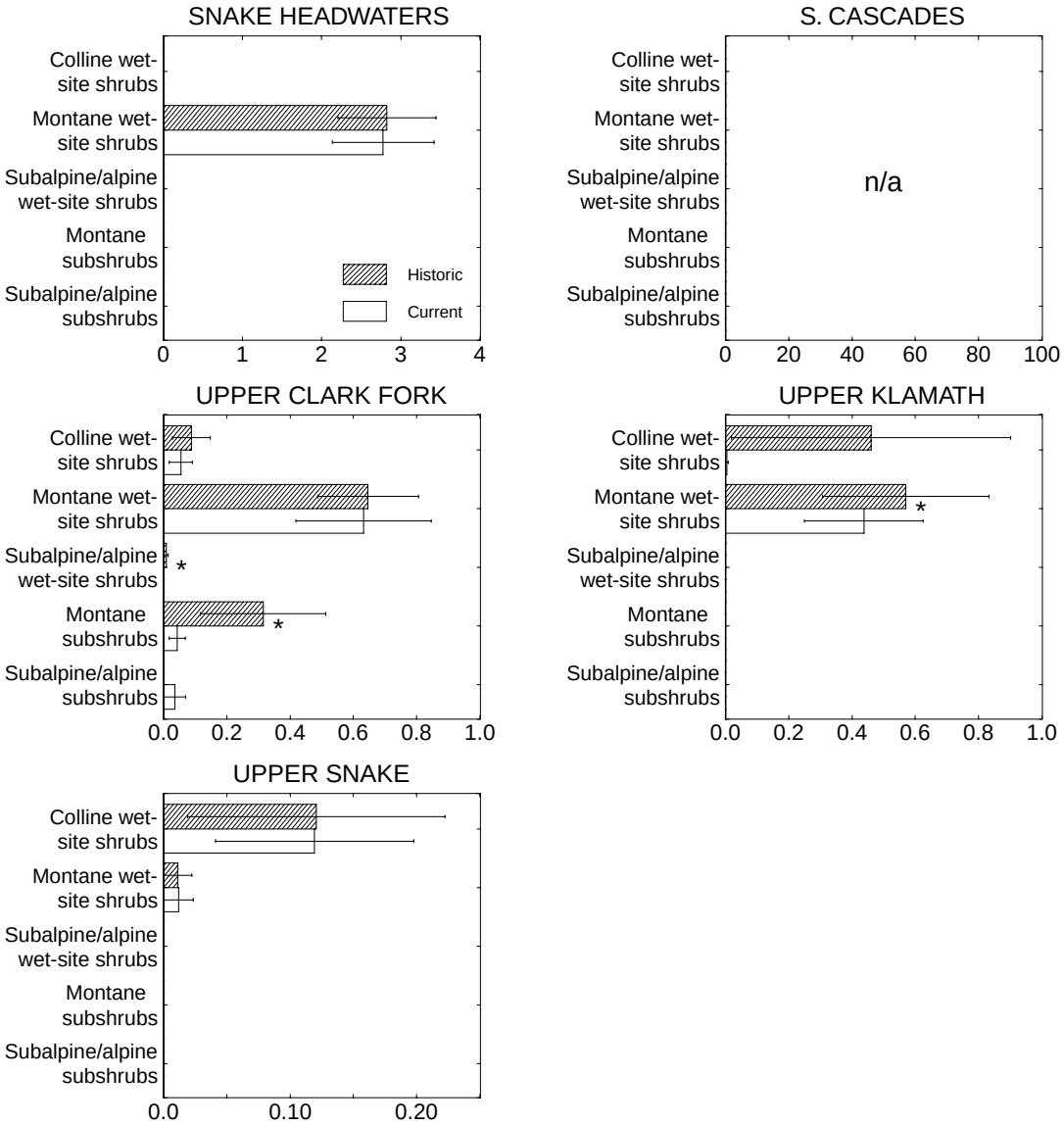
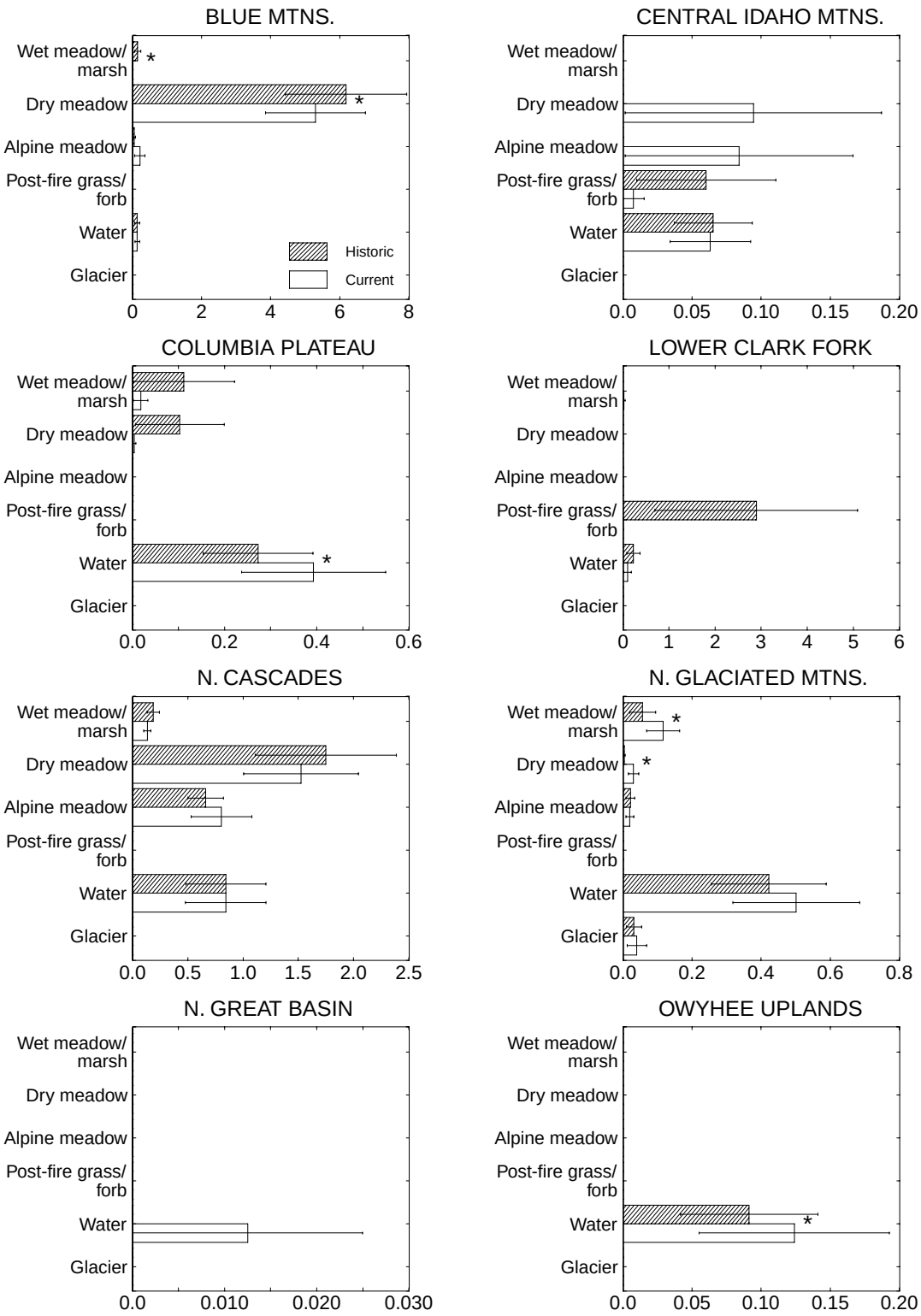


Figure 31—Historical and current distribution of shrubland cover types expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) difference between historical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

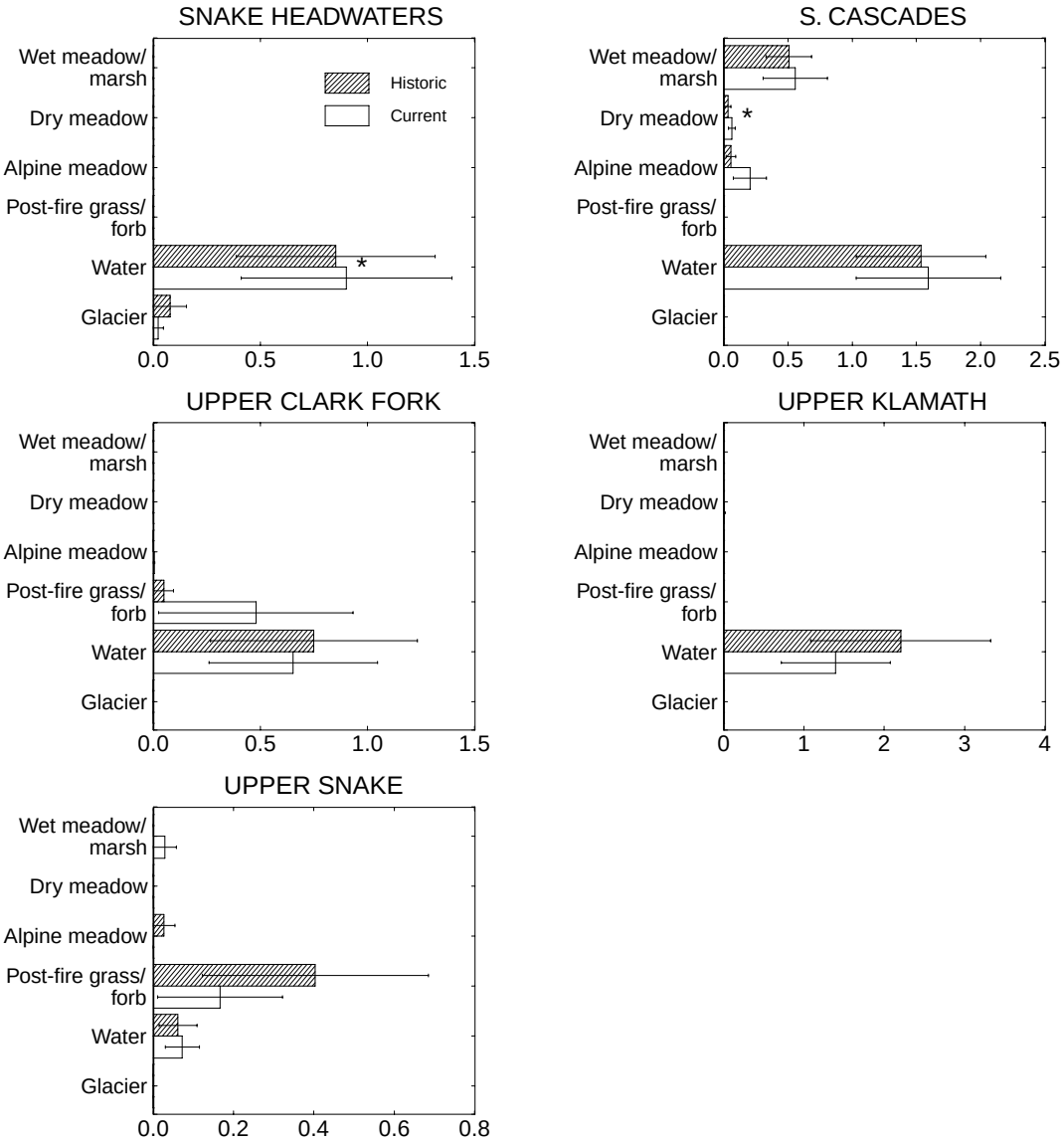
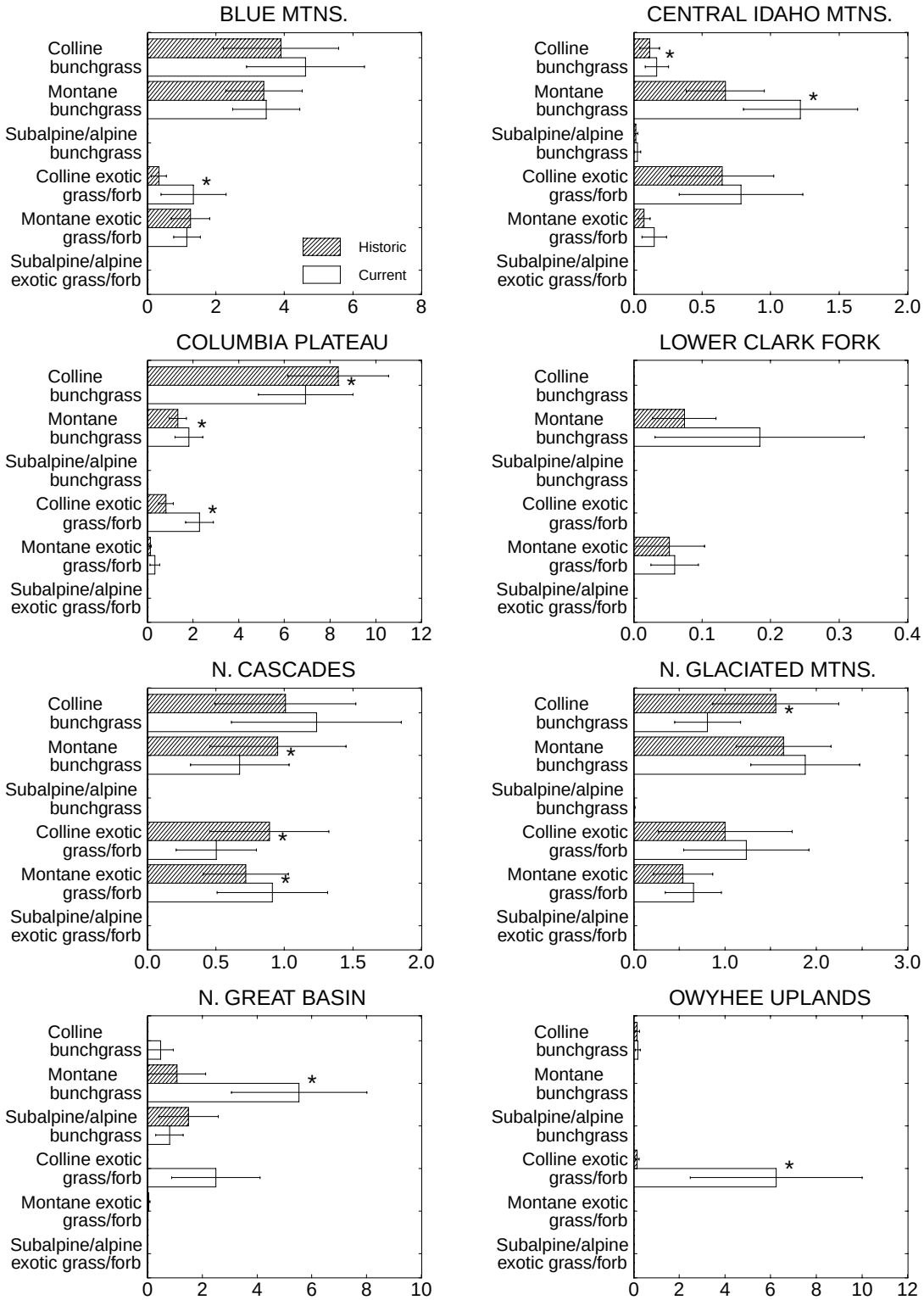


Figure 32—Historical and current distribution of herbland and nonforest-nonrange cover types expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant ($P \leq 0.2$)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

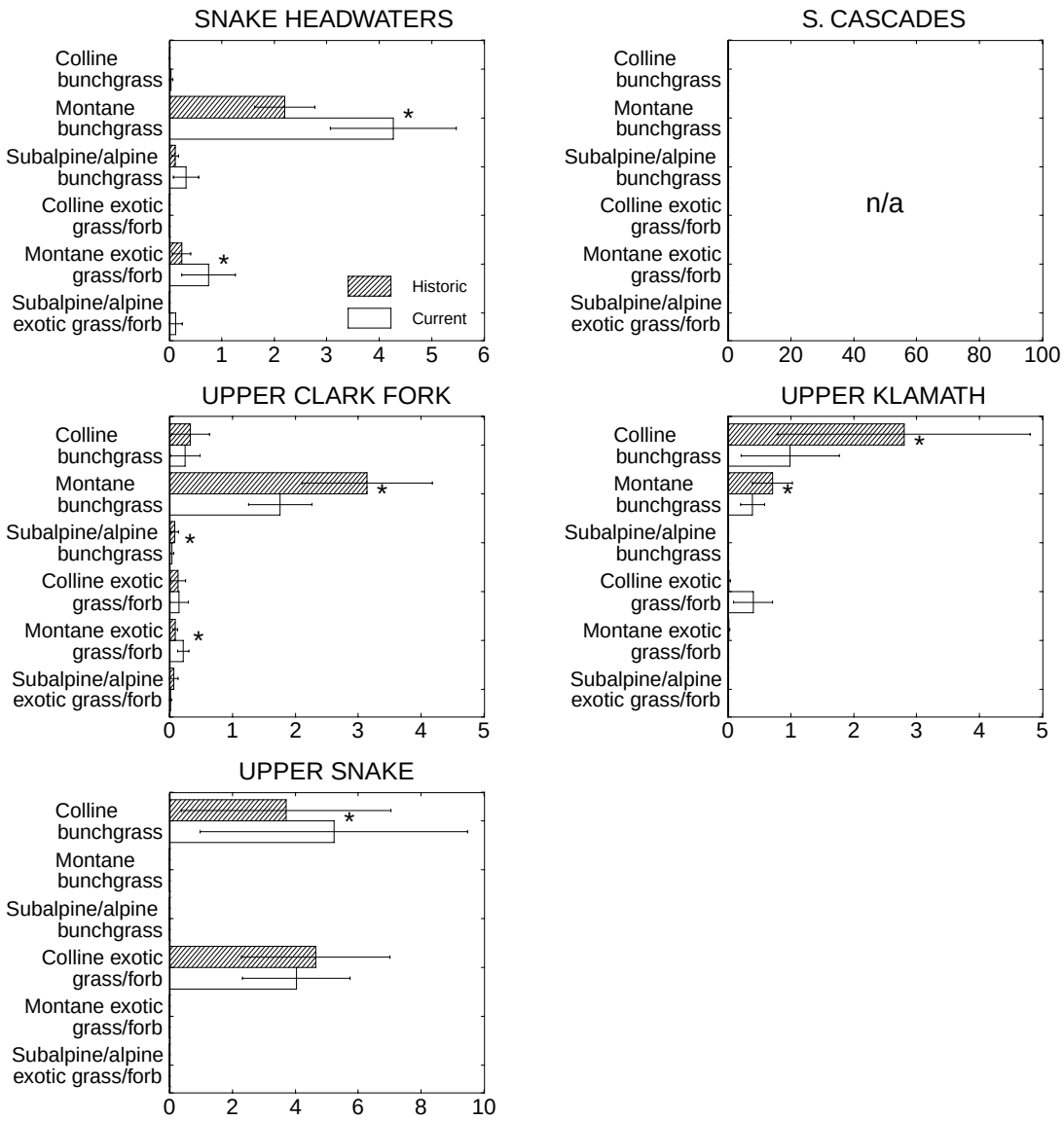
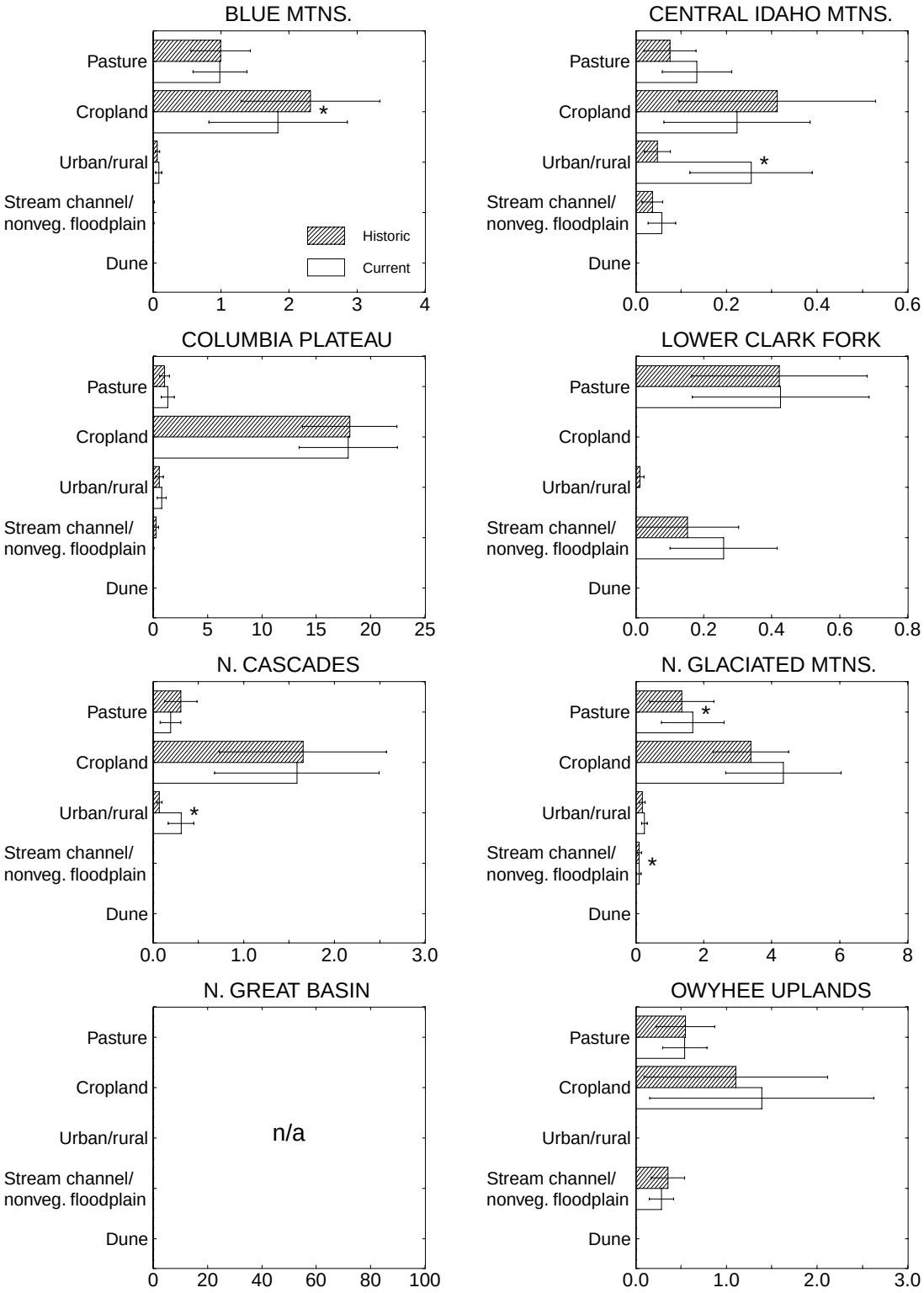


Figure 33—Historical and current distribution of herbland cover types expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) difference between historical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

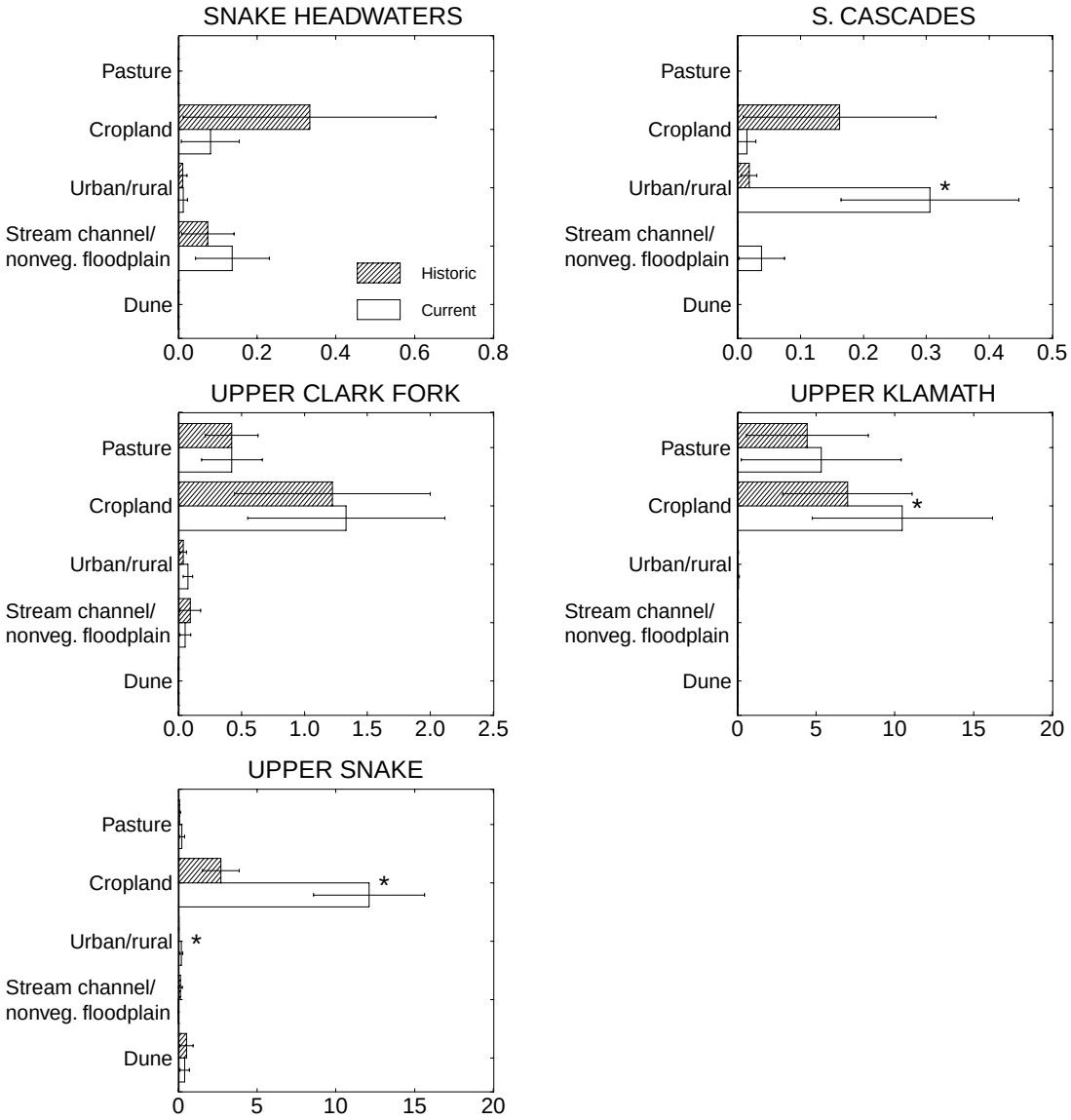
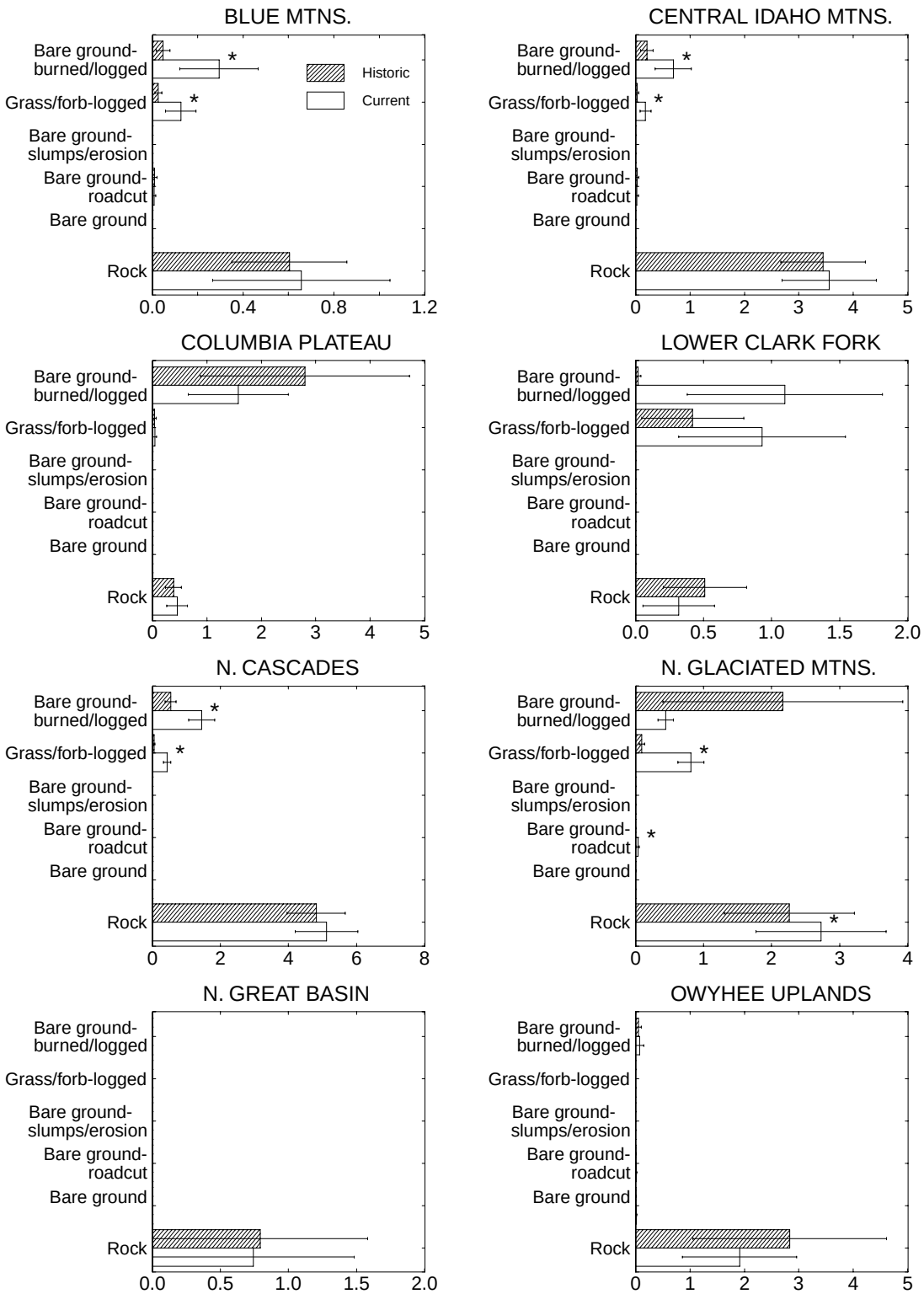


Figure 34—Historical and current distribution of anthropogenic and other nonforest-nonrange cover types expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant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

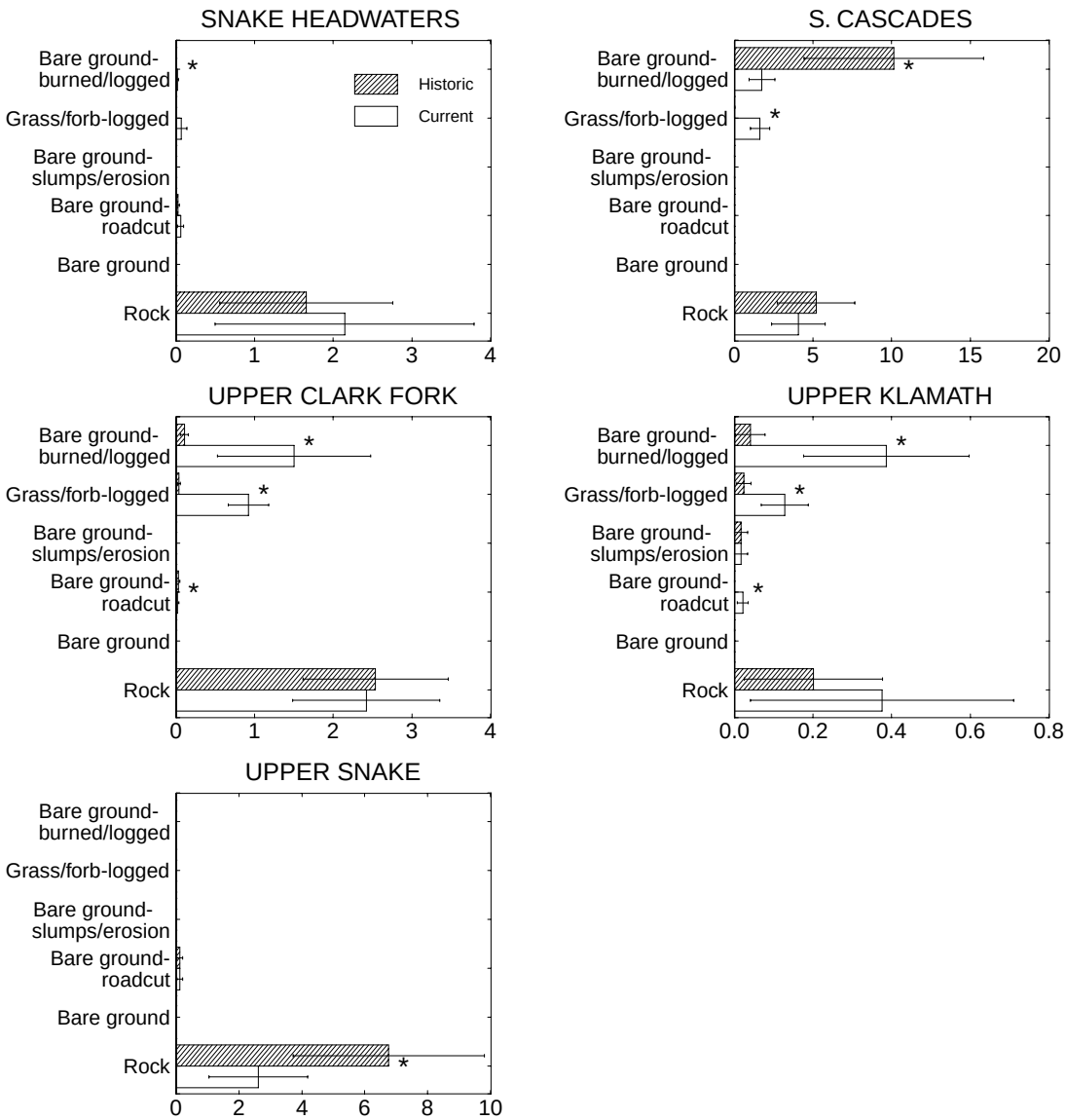
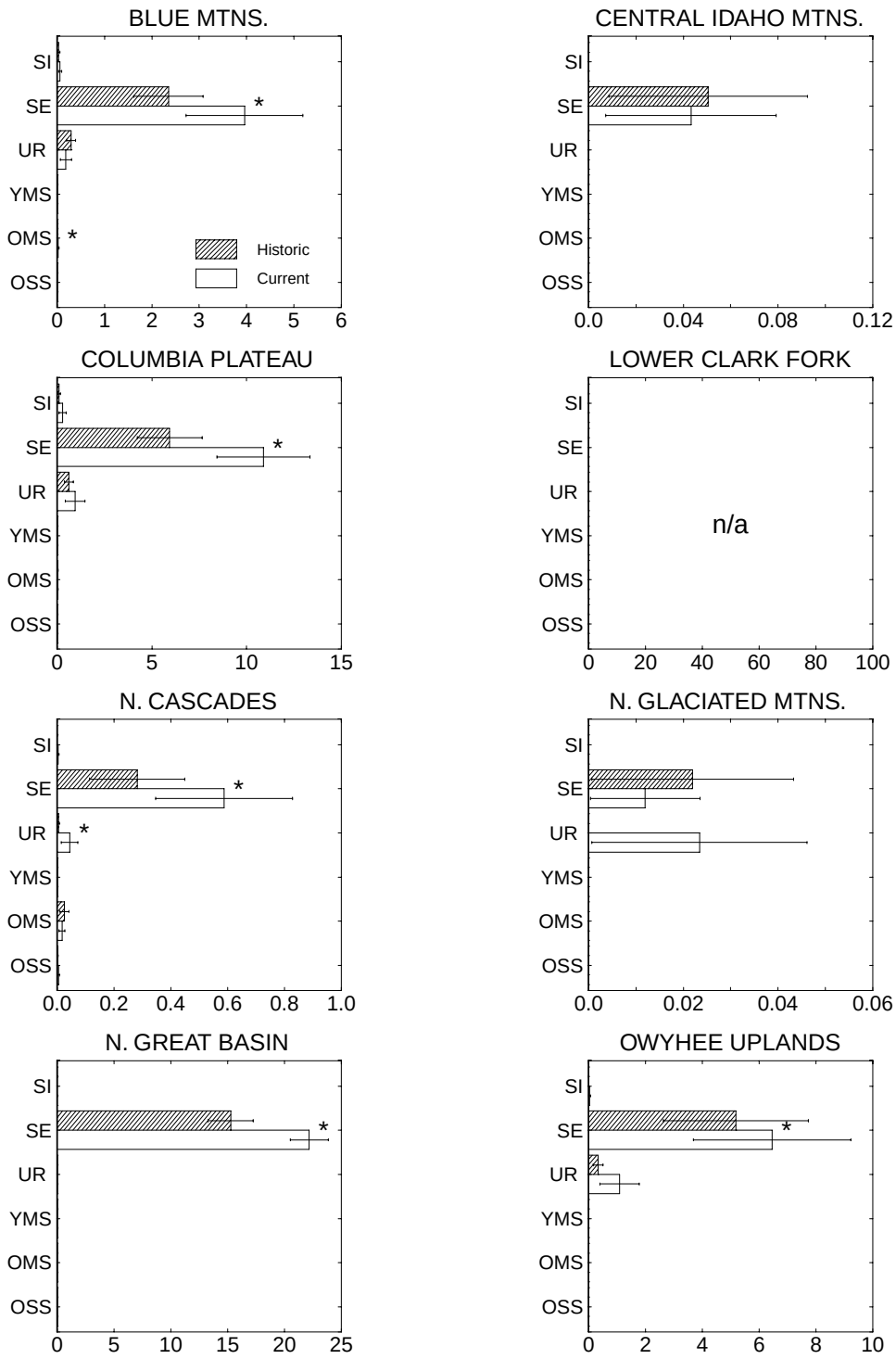


Figure 35—Historical and current distribution of anthropogenic and other nonforest-nonrange cover types expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant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

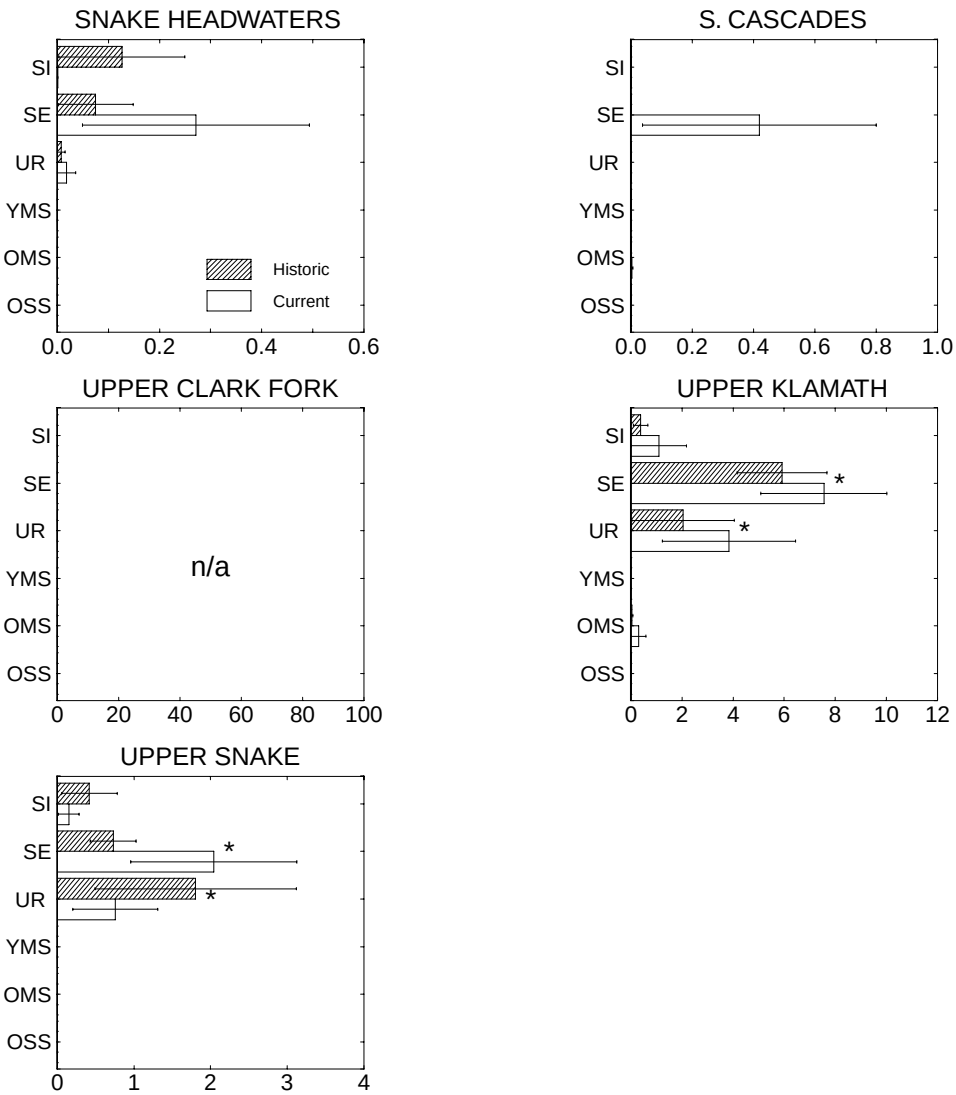
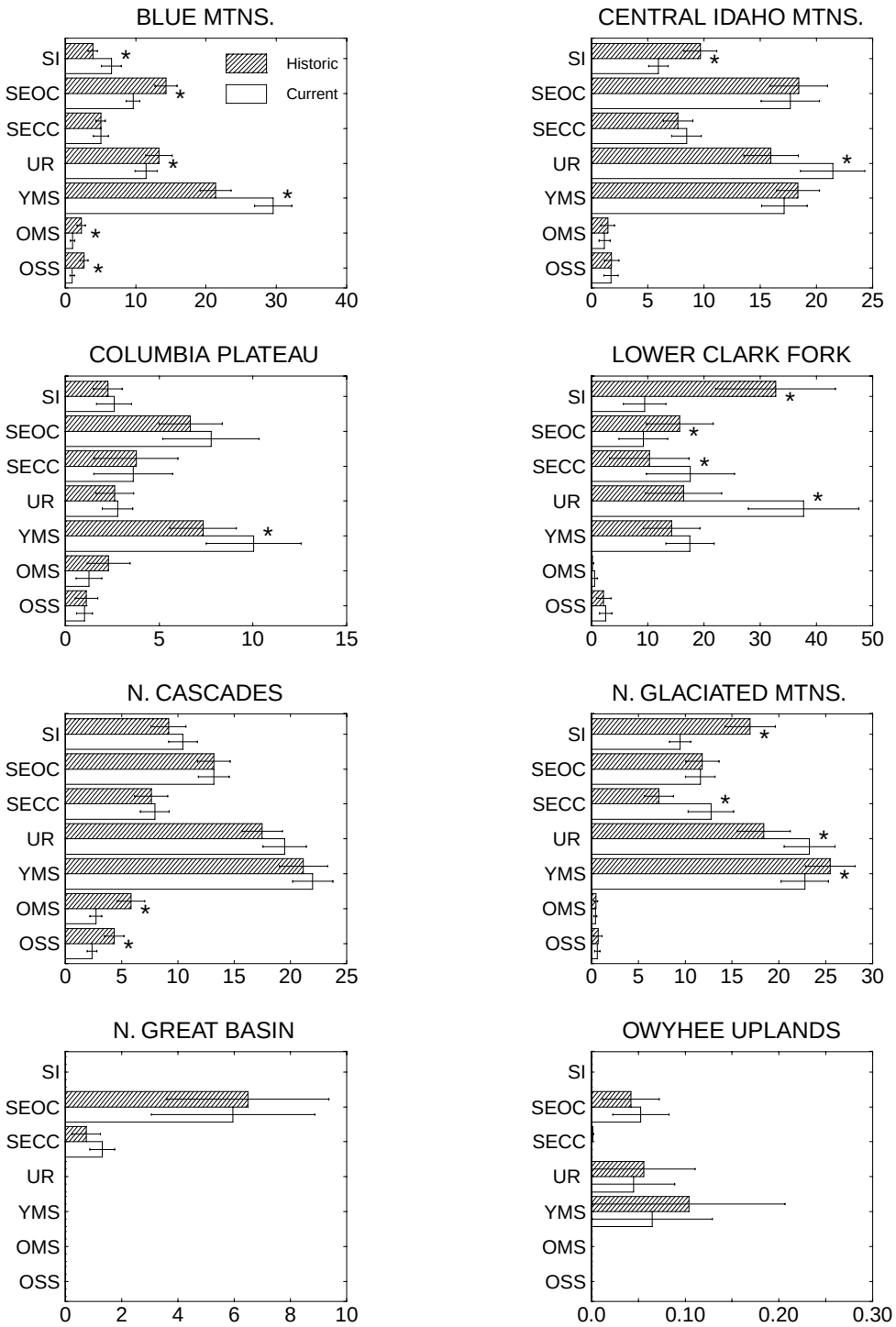


Figure 36—Historical and current distribution of forest structural classes expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) difference between historical 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

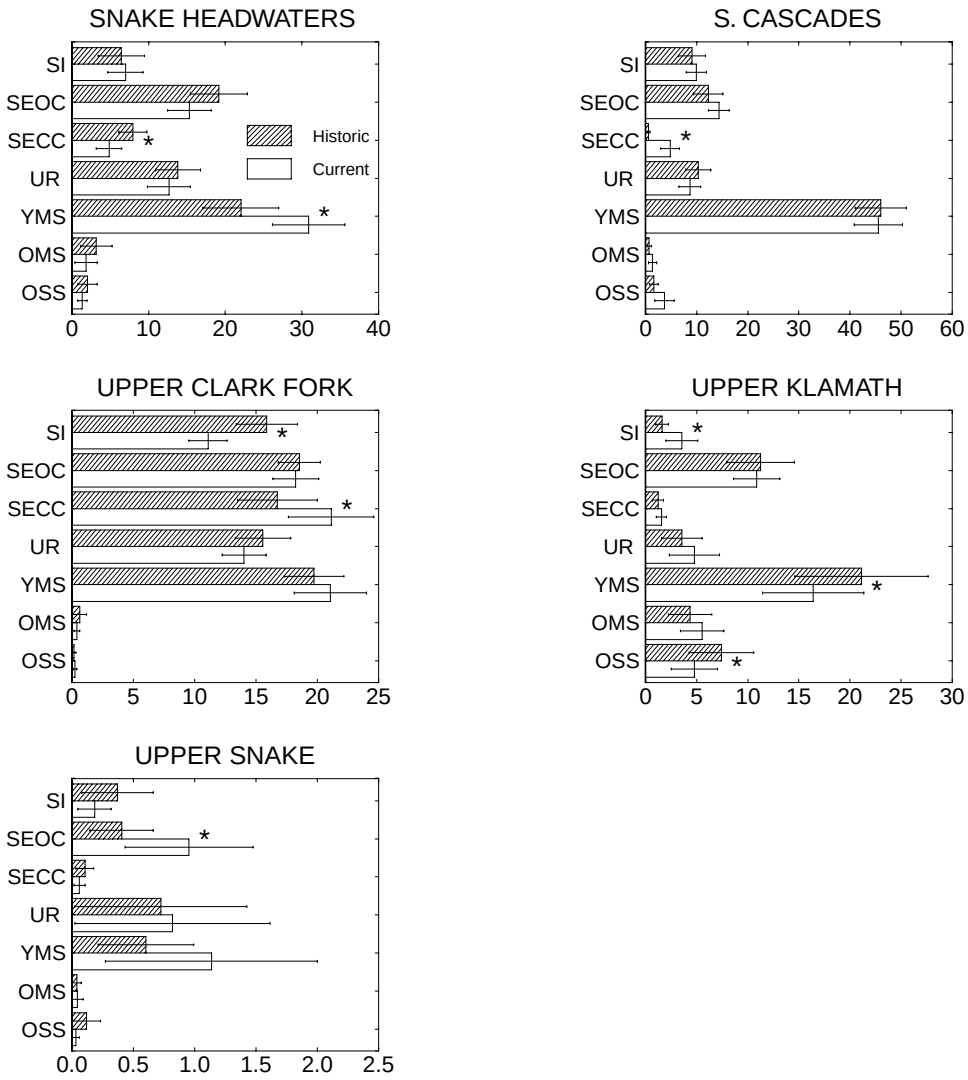
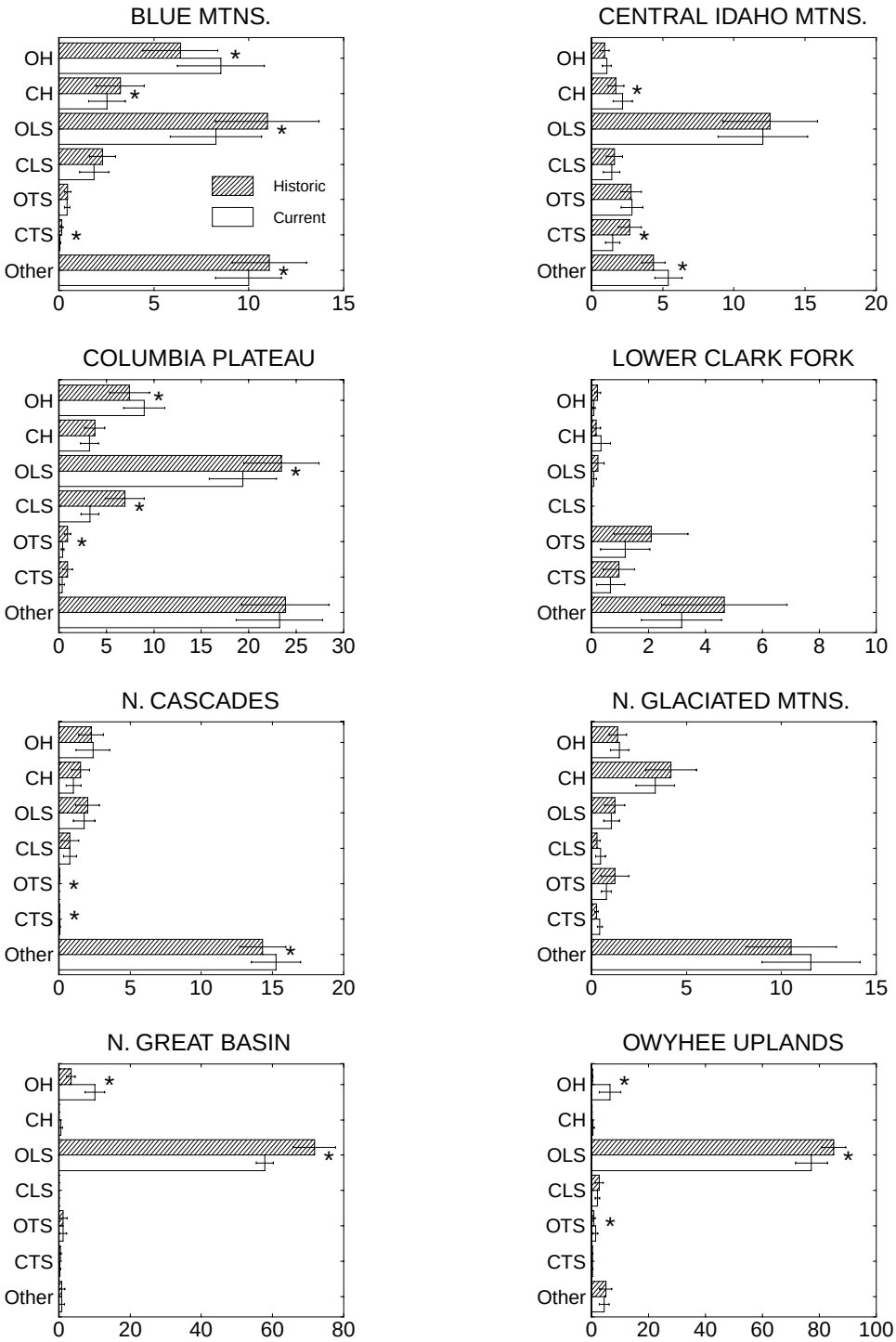


Figure 37—Historical and current distribution of woodland structural classes expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) difference between 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

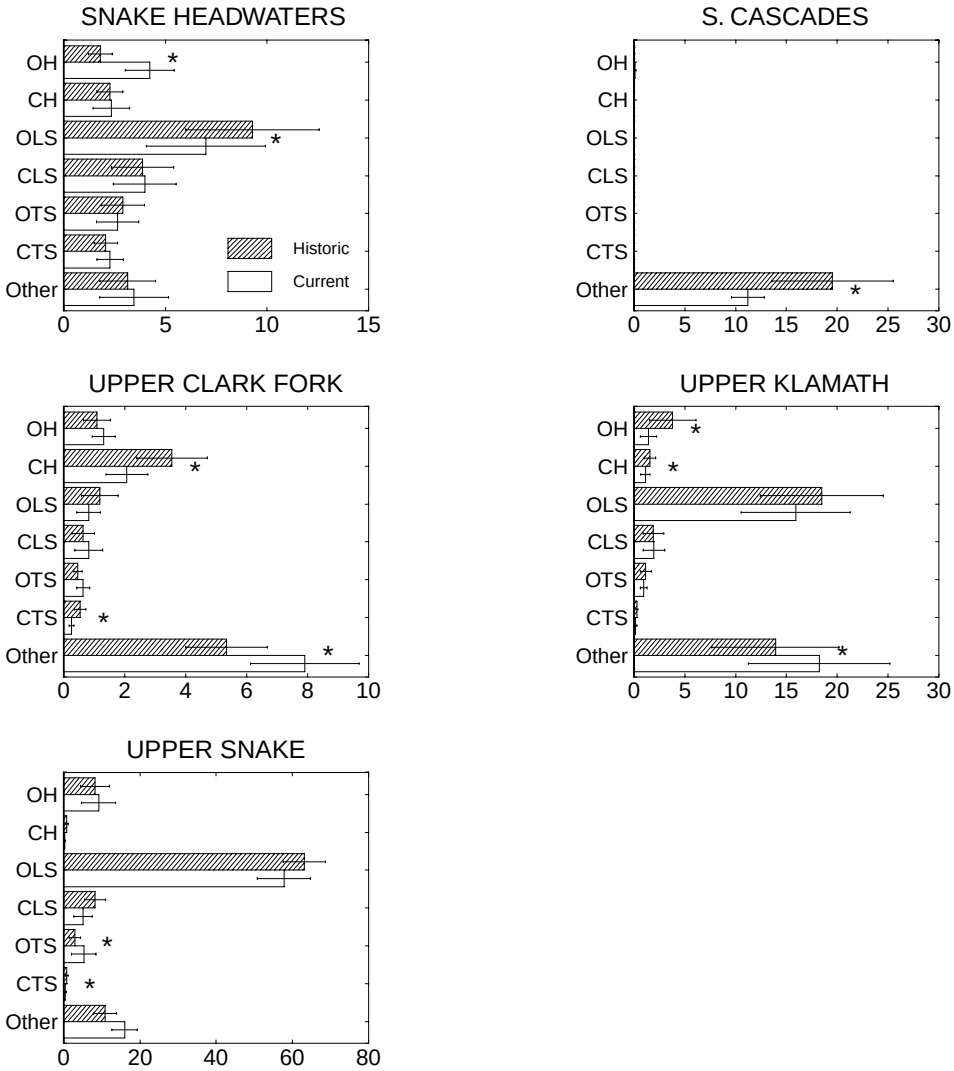


Figure 38—Historical and current distribution of herbland, shrubland, and other structural classes expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) 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 redcedar 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 redcedar 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 $P \leq 0.2$. 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 thirty-fold 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 2½-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

Landscape metrics	Ecological reporting units												
	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[ab]	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≤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 λ = 0.143, and 1 - Simpson's λ = 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 $P \leq 0.2$. 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 $P \leq 0.2$. 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 $P \leq 0.2$. 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 $P \leq 0.2$. 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

Ecological reporting unit	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)		
	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[abc]														
	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 multistory 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≤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≤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≤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≤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

Ecological reporting unit	Area														
	Forest and woodland crown cover[a b]												Nonforest-nonwoodland crown cover (< 10 percent)		
	10 to 30 percent			40 to 50 percent			60 to 80 percent			90 to 100 percent					
	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≤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≤0.2 only in the Northern Glaciated Mountains and Upper Clark Fork ERUs (table 24).

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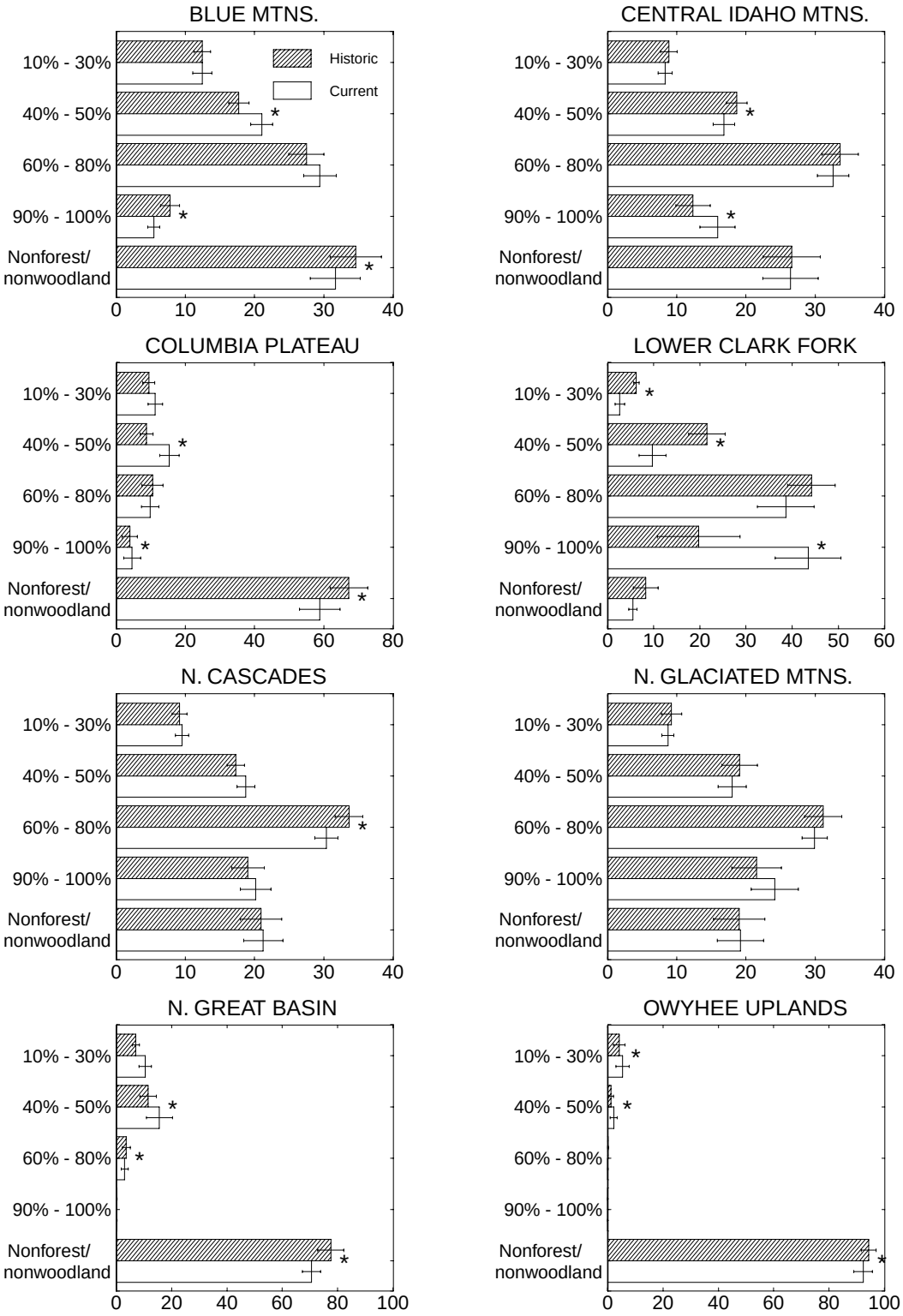
Table 23—Percentage comparison of area of forest and woodland with 1, 2, or more than 2 canopy layers for ecological reporting units in the midscale assessment of the interior Columbia River basin

	Area[a]											
	Canopy layers-forest and woodland											
	1 layer			2 layers			> 2 layers			Nonforest-nonwoodland		
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

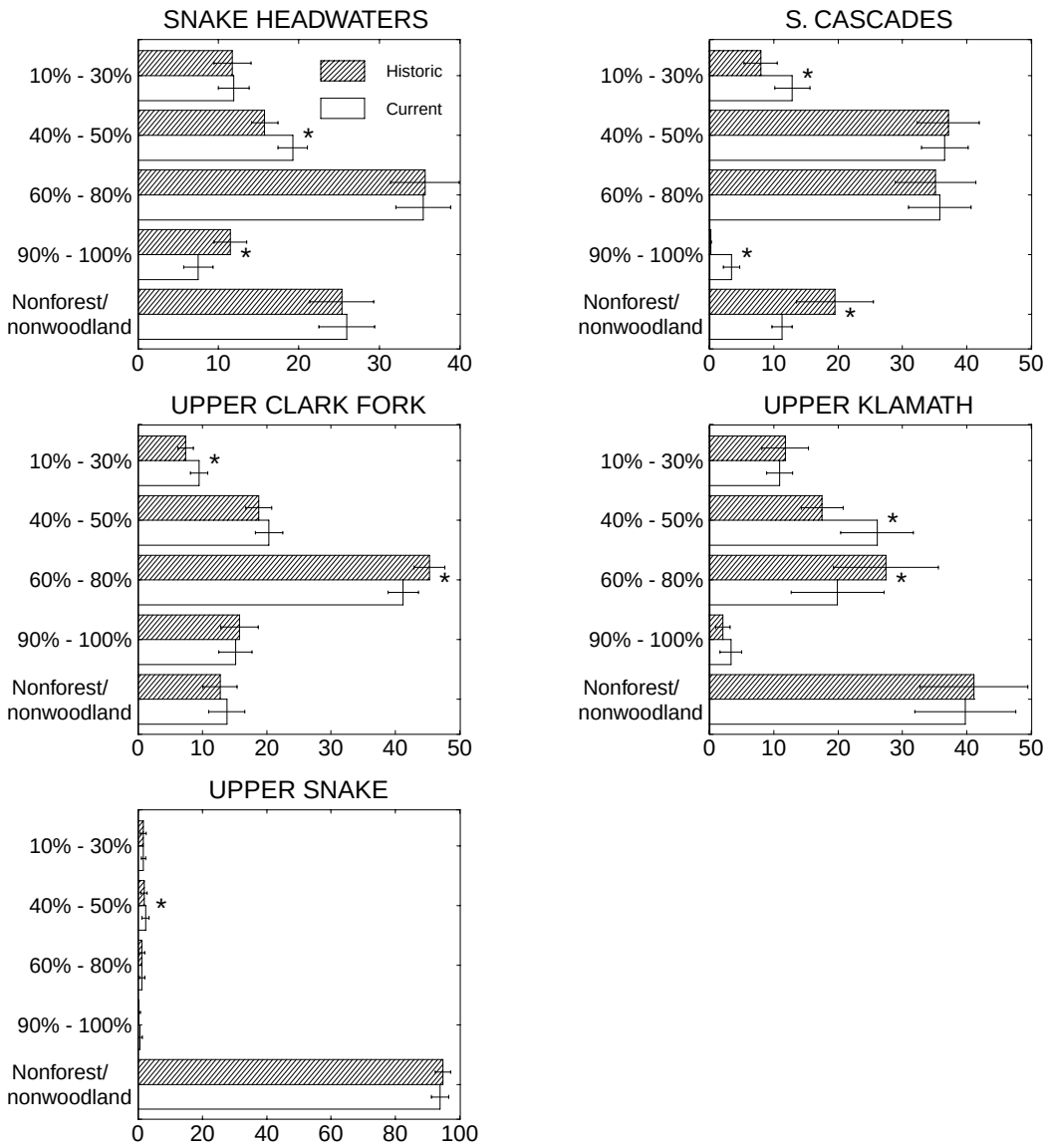
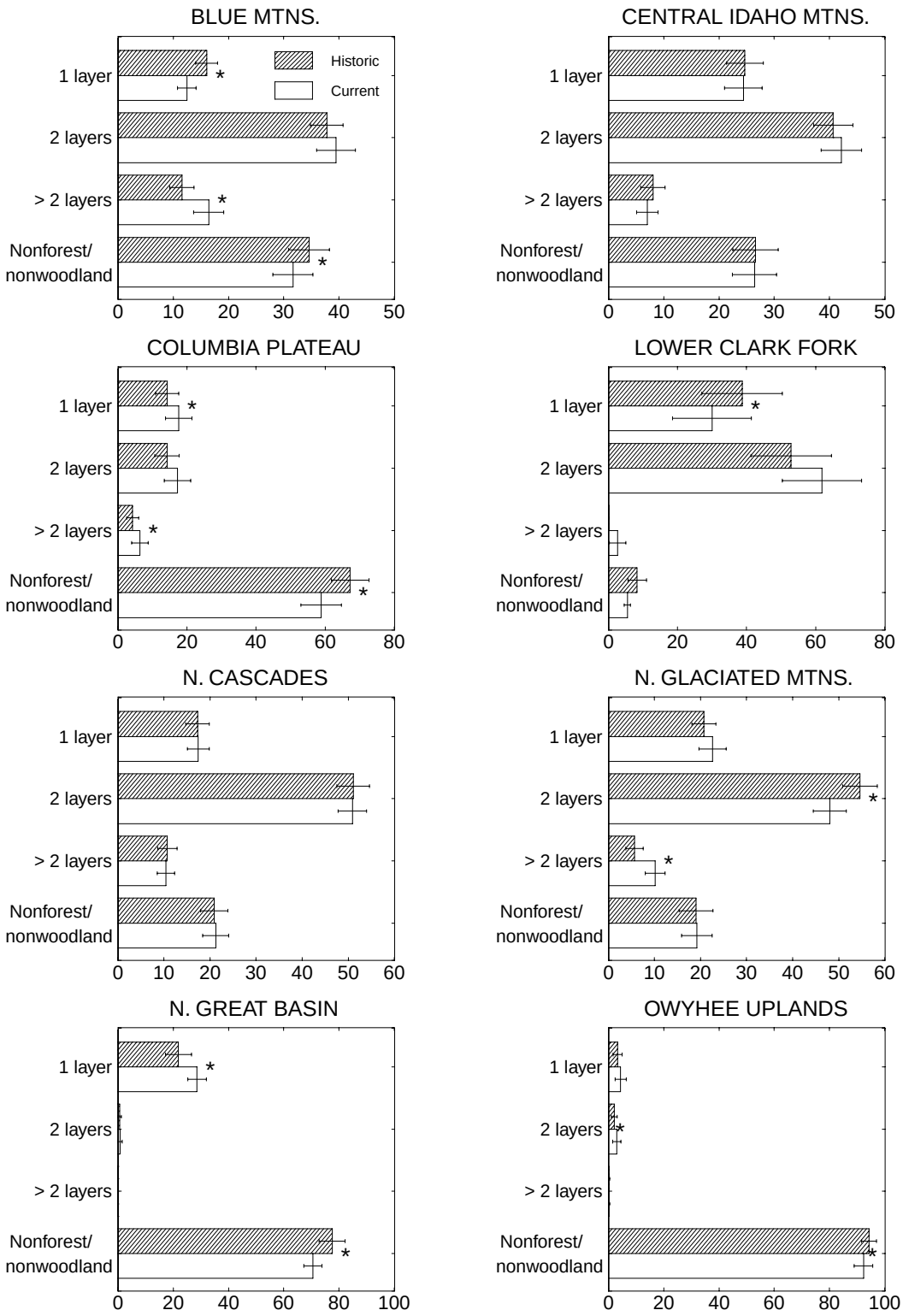


Figure 39—Historical and current distribution of forest and woodland total crown cover classes expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) 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.
1 layer
2 layers
> 2 layers
Nonforest/ nonwoodland
0 10 20 30 40 50
COLUMBIA PLATEAU
1 layer
2 layers
> 2 layers
Nonforest/ nonwoodland
0 20 40 60 80
LOWER CLARK FORK
1 layer
2 layers
> 2 layers
Nonforest/ nonwoodland
0 20 40 60 80
N. CASCADES
1 layer
2 layers
> 2 layers
Nonforest/ nonwoodland
0 10 20 30 40 50 60
N. GLACIATED MTNS.
1 layer
2 layers
> 2 layers
Nonforest/ nonwoodland
0 10 20 30 40 50 60
N. GREAT BASIN
1 layer
2 layers
> 2 layers
Nonforest/ nonwoodland
0 20 40 60 80 100
OWYHEE UPLANDS
1 layer
2 layers
> 2 layers
Nonforest/ nonwoodland
0 20 40 60 80 100

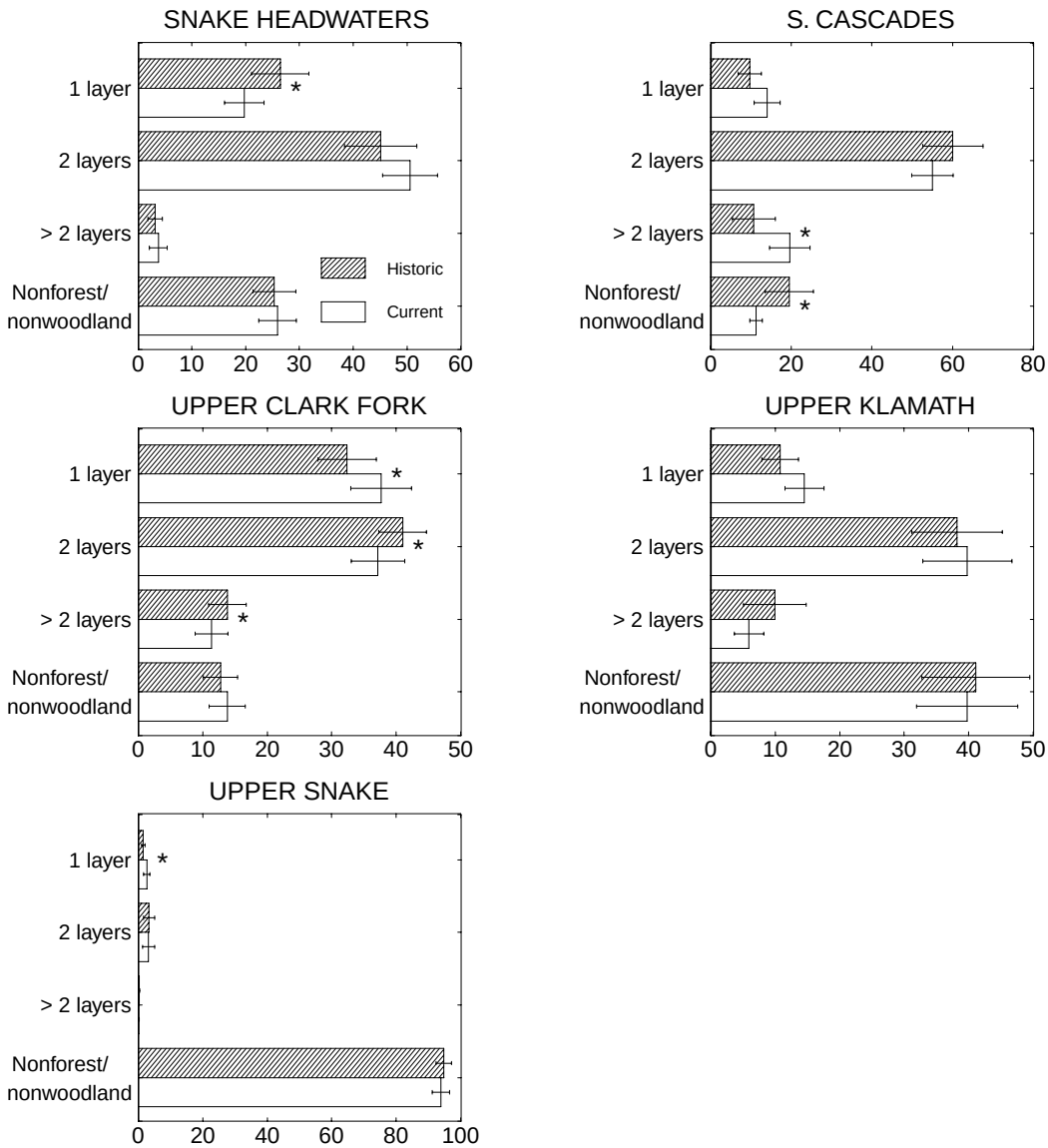


Figure 40—Historical and current distribution of forest and woodland canopy layer classes expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) difference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

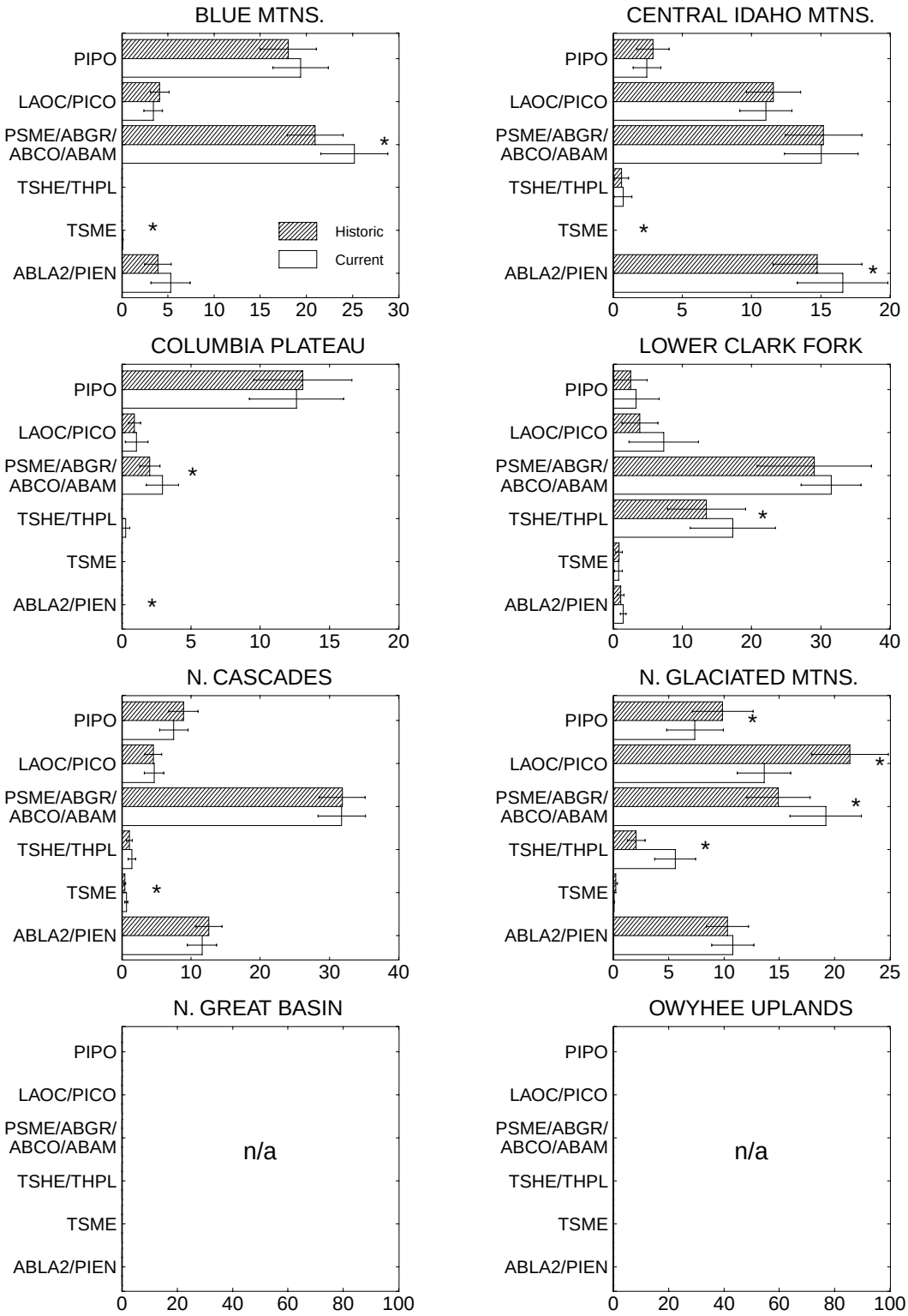
Table 24—Percentage comparison of area of forest and woodland understory species classes for ecological reporting units in the midscale assessment of the interior Columbia River basin (continued)

	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.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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

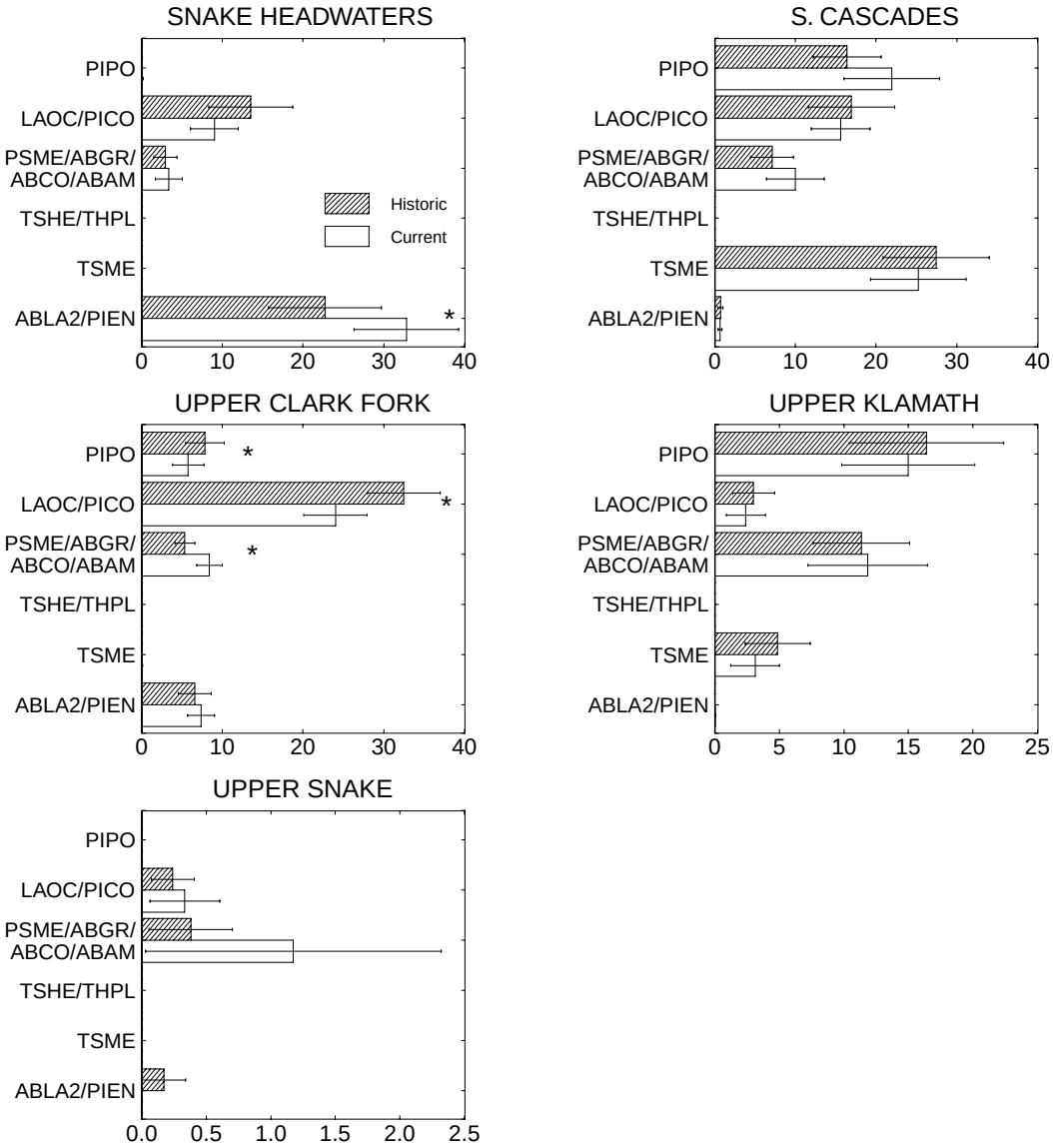
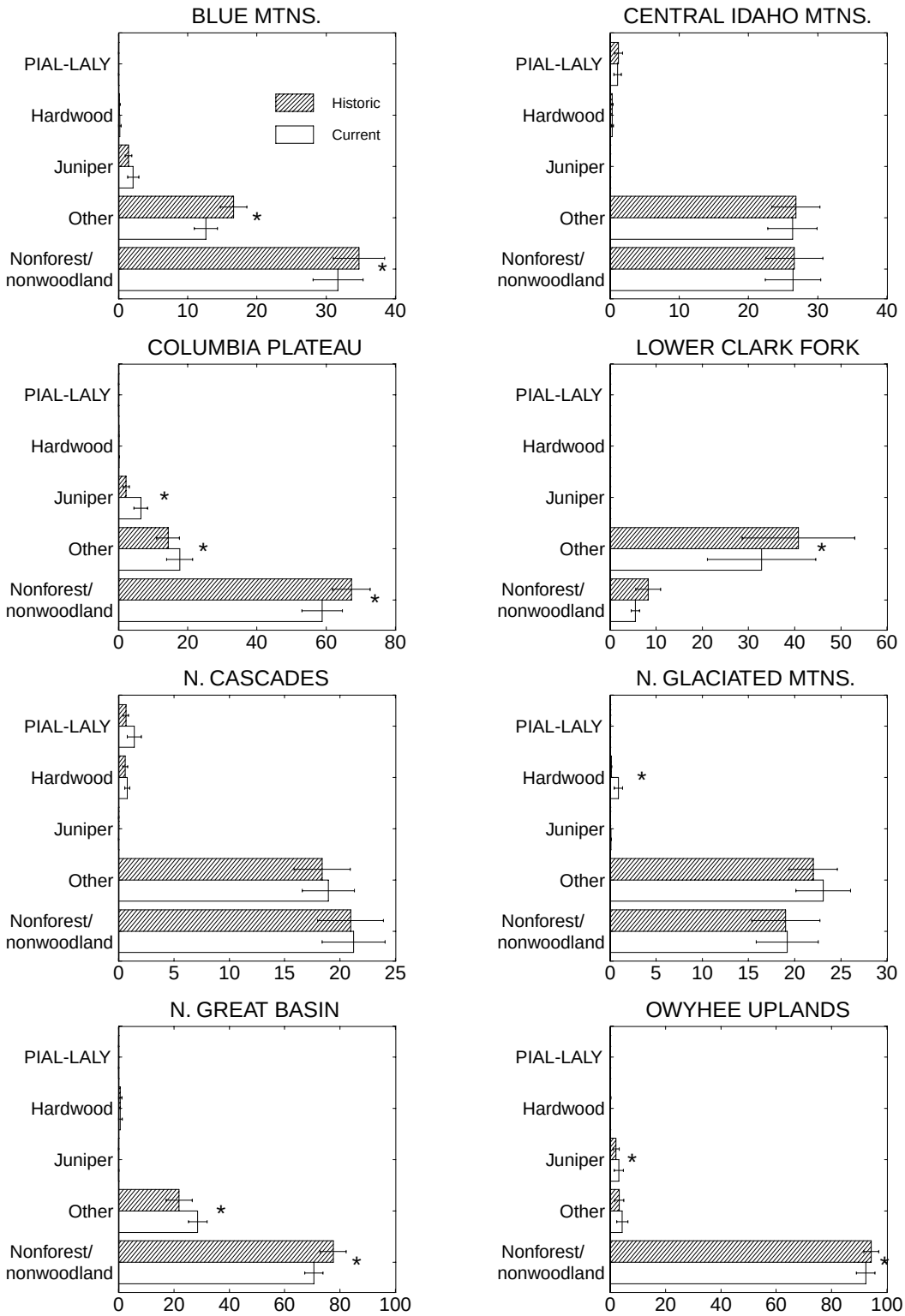


Figure 41—Historical and current distribution of forest and woodland understory species classes expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) 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
*

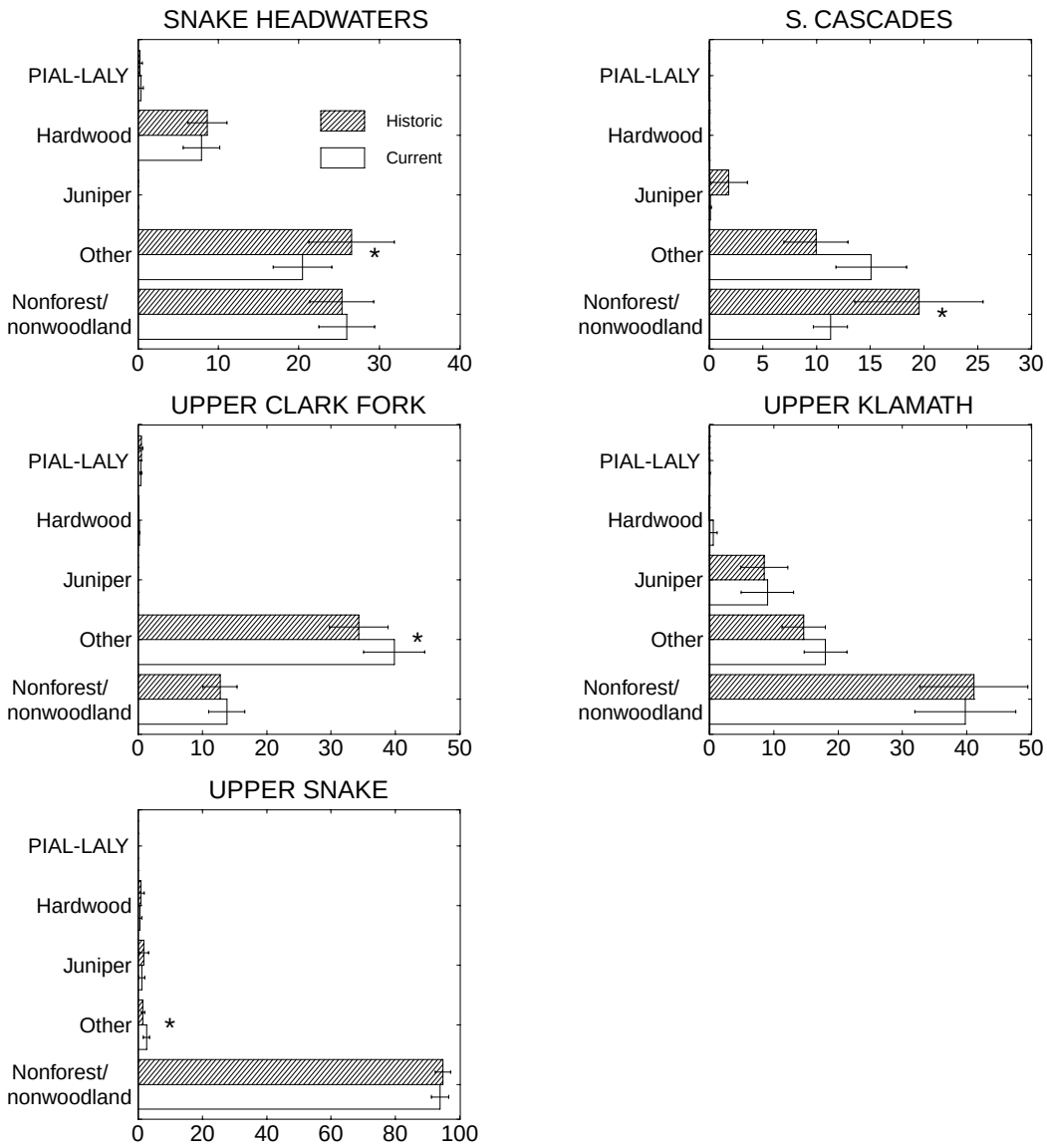


Figure 42—Historical and current distribution of forest and woodland understory species classes expressed as a percentage of total area on all ownerships in ERUs of the interior Columbia River basin. Error bars indicate the standard error of the mean estimate. Asterisks indicate a significant (P≤0.2) 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.