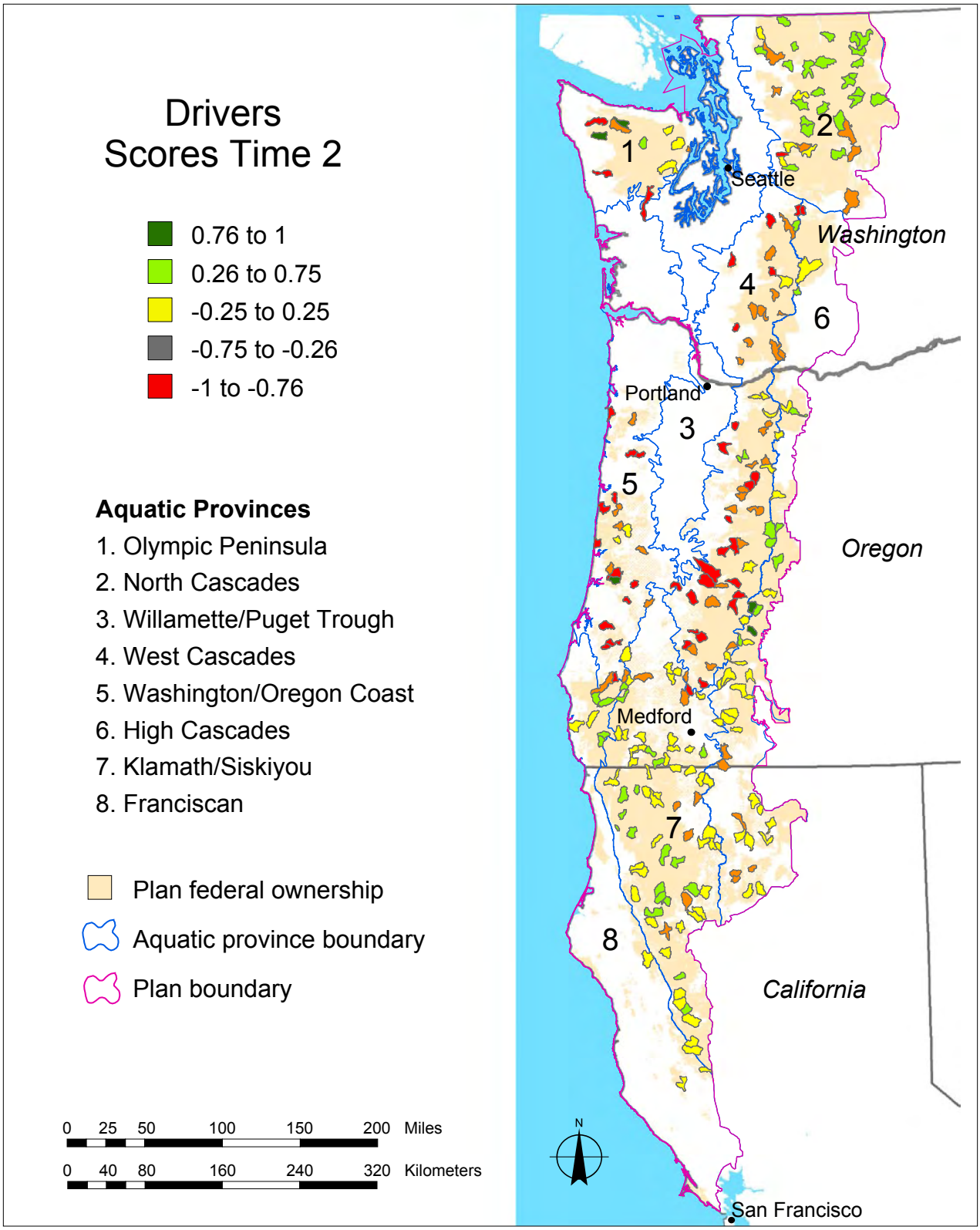
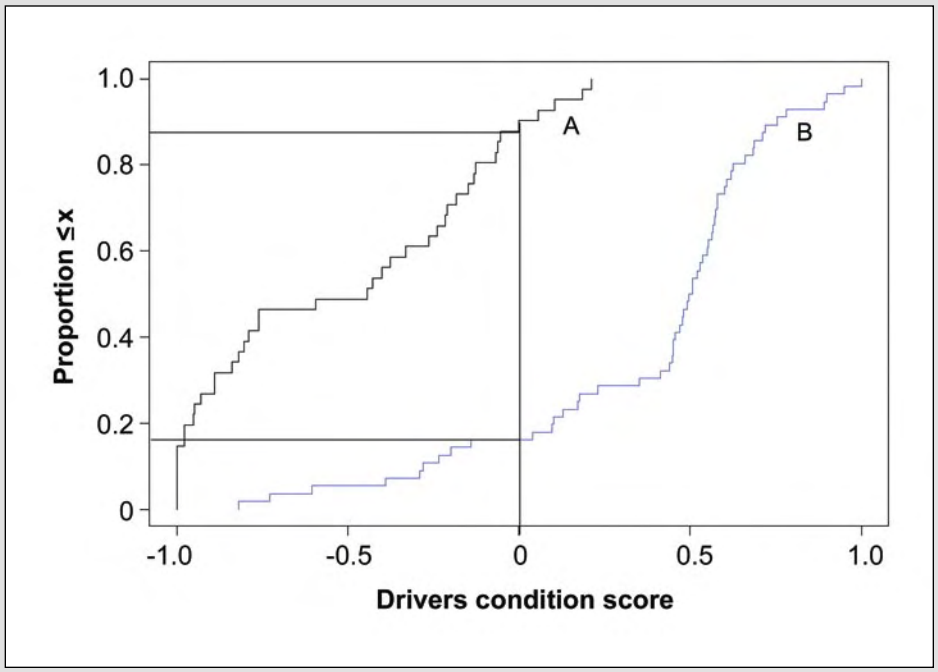


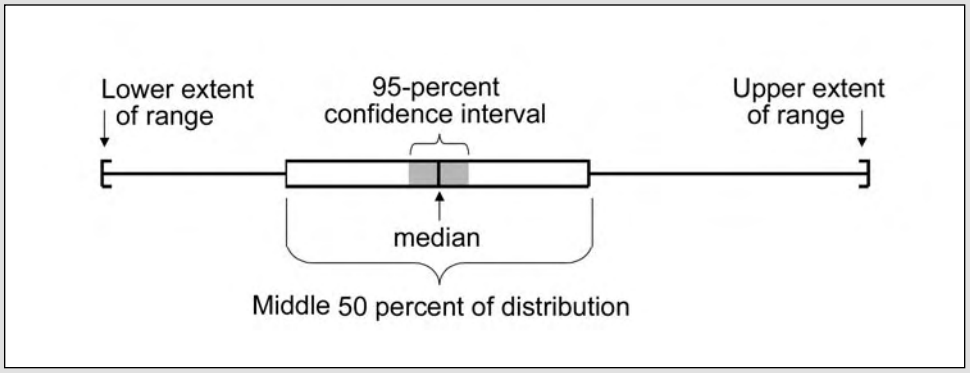
Figure 14—Time 2 drivers condition scores of 250 randomly selected watersheds in the Plan area. The drivers condition scores are the aggregate of the evaluation scores for the roads and vegetation attributes.

Distribution Functions



Cumulative distribution functions are used to describe and compare distributions, on a number of watersheds. The x-axis includes the range of the attribute of interest, which might be condition scores or acres of older forest vegetation in watersheds. The y-axis describes the proportion of units in the distribution (watersheds, in this example) with attribute values less than x. In the example below, we compare condition scores for two distributions, A and B. In this example, more than 80 percent of the watersheds in distribution A have condition scores less than 0. In distribution B, fewer than 20 percent of the watersheds have condition scores less than 0. The shape of the curves is key in interpreting cumulative distribution functions. Notice that the lower part of curve B is relatively flat, but the upper portion becomes very steep. The flat portion of the graph represents few watersheds, whereas the steep portion of the graph represents many watersheds with similar scores. Curve B shows that roughly 60 percent of the watersheds have condition scores between 0.5 and 0.7.

Box and whisker plots also describe distributions. In this example, the box represents the middle 50 percent of the distribution. The line inside the box represents the median of the distribution, and the shaded area describes the 95 percent confidence interval around the median. The whiskers on the plot represent the range of the distribution.



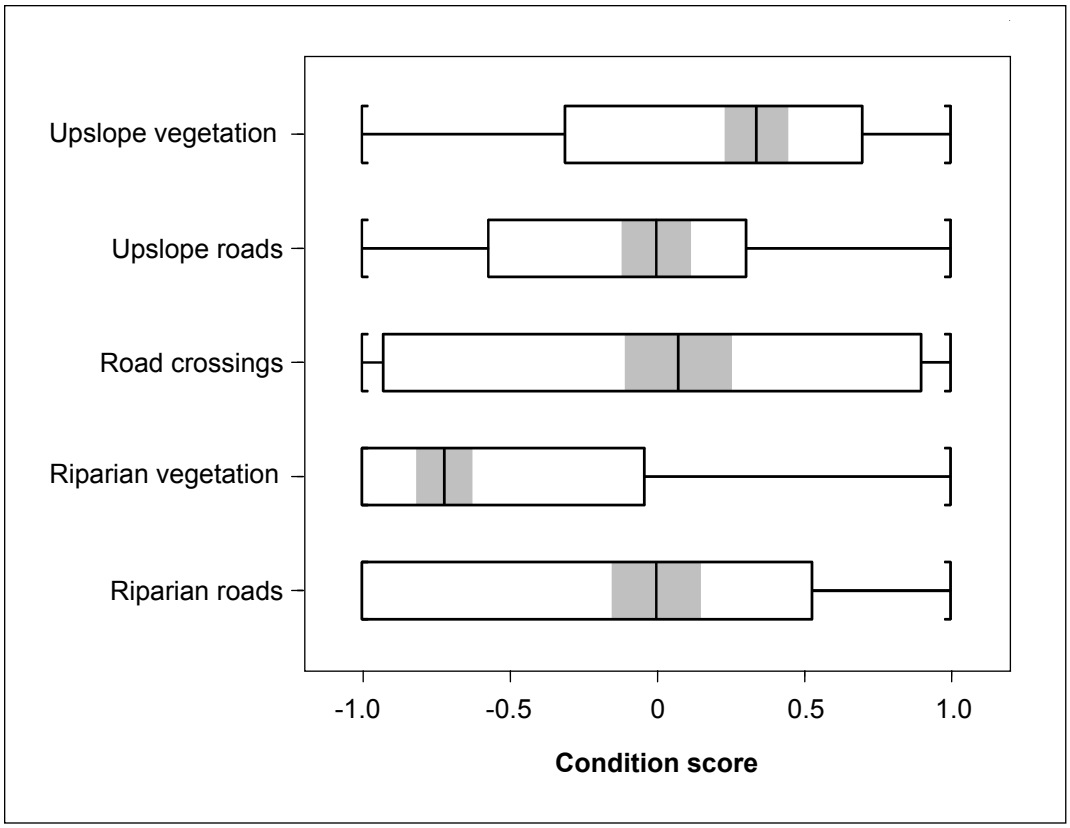


Figure 15—Distribution of time 2 condition scores for upslope and riparian roads and vegetation attributes in 250 randomly selected watersheds in the Plan area. Bars in the center of the boxes represent the median of the distribution, and shading represents the 95 percent confidence interval around the median. Boxes represent the middle 50 percent of the distribution, and the whiskers represent the range of the distribution.

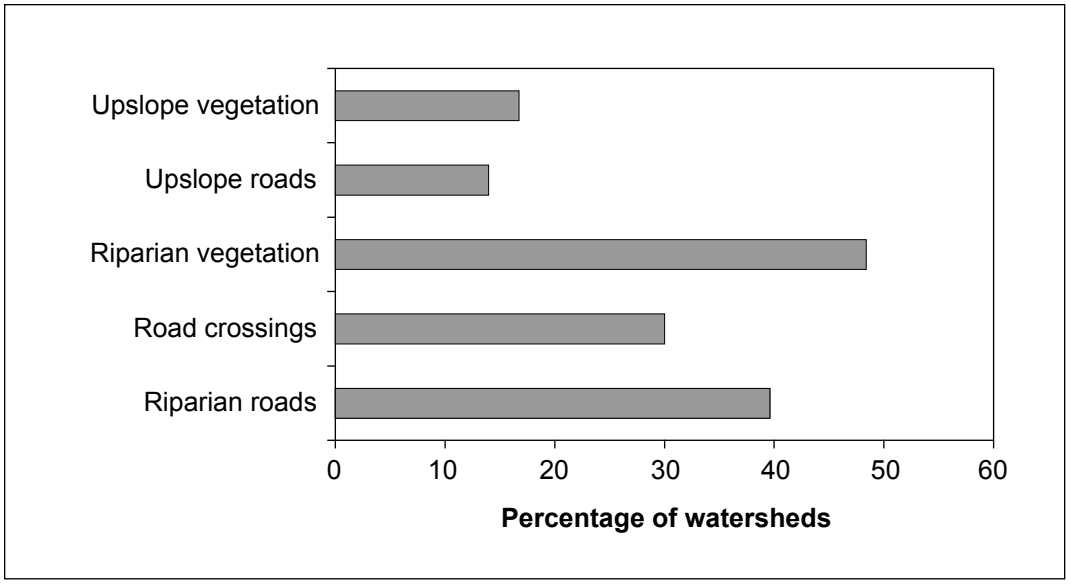


Figure 16—Percentage of watersheds with condition scores lower than -0.75 for upslope and riparian attributes. Data are based on the 250 randomly selected watersheds in the Plan area.

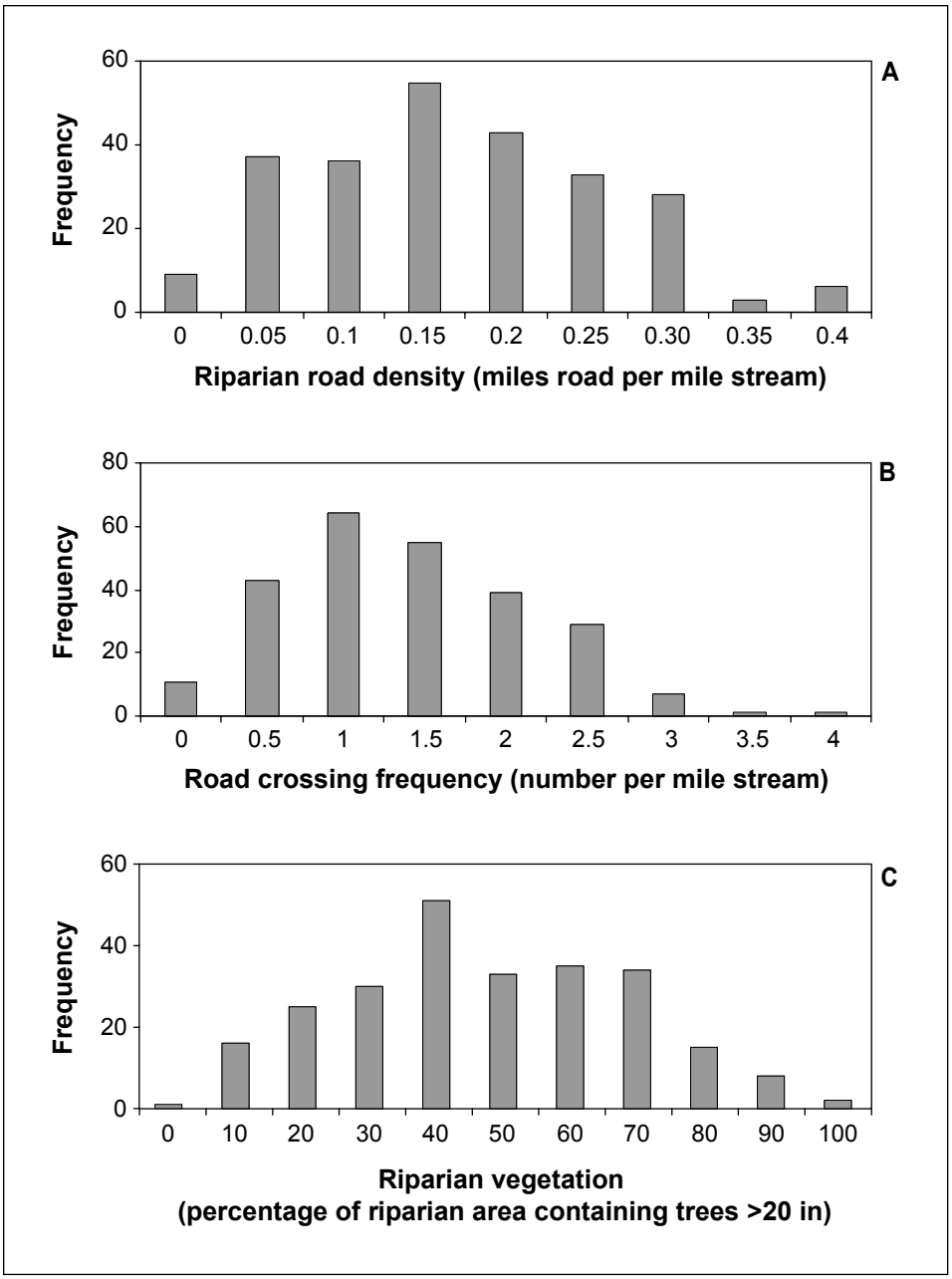


Figure 17—Frequency distribution of time 2 (A) riparian road density, (B) frequency of road-stream crossings, and (C) percentage of the riparian area with conifers >20 in diameter at breast height (d.b.h.) in the 250 randomly selected watersheds in the Northwest Forest Plan area.

reaches either had high levels of fine sediment or were scoured down to bedrock. Wood condition scores tended to be very low (fig. 19c), nearly 70 percent of the sample reaches had scores of -1, suggesting that low levels of large wood are prevalent throughout the Plan area.

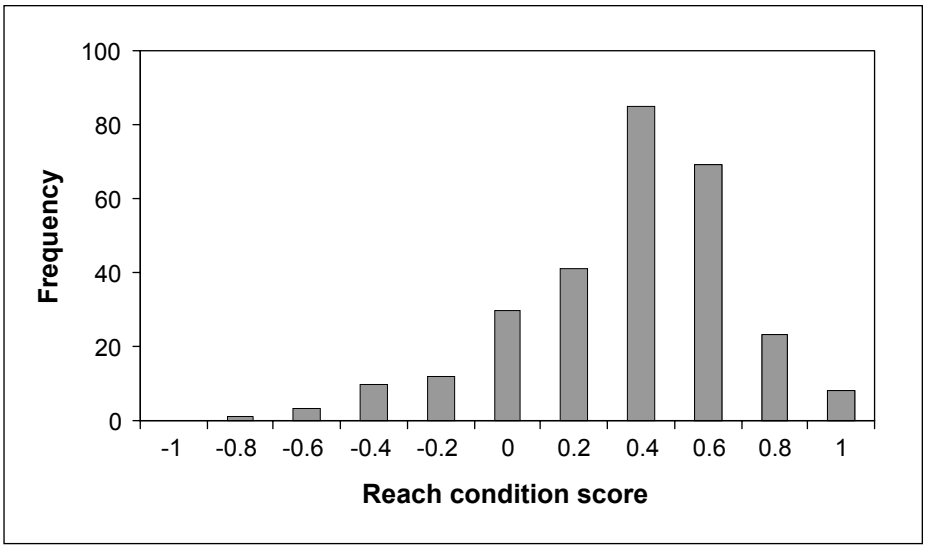


Figure 18—Frequency distribution of condition scores for 281 reaches in 55 watersheds in the Northwest Forest Plan area. Reach condition scores are aggregates of all inchannel attributes, including morphology, wood and pool frequency, and substrate.

The attributes used to evaluate substrate include D_{50} (median particle size) based on pebble measurements and the percentage of fine (<2 mm [<0.08 in]) sediments in pool tail crests. The evaluation criteria for D_{50} typically rate 60 to 100 mm (2.36 to 3.94 in) as desirable. Nearly 20 percent of the sampled reaches had D_{50} values in this range (fig. 20a). Median D_{50} scores were 200 mm (8 in). Fine sediment levels below 11 percent were considered desirable. Nearly 64 percent of the sampled reaches met this criterion (fig. 20b). Sixty percent of the sampled reaches had more than two pools per 100 m (109 yd) (fig. 21a). Wood levels tended to be very low; nearly half the sampled reaches did not contain any large wood (fig. 21b).

Changes Since the Implementation of the Plan

Because historical inchannel data are lacking, change data were presented only for roads, vegetation, and drivers (the aggregate of all roads and vegetation attributes). Unlike the watershed condition scores—which were clustered between -0.4 and 0.6—condition scores for drivers, vegetation, and roads were distributed across the range of possible scores (fig. 22). Condition scores were generally higher in time 2 than in time 1; however, the magnitude of change was very small. The drivers condition score increased in 161 of the 250 watersheds (64 percent) by an average of 0.09 (SD 0.19; table 4). This level of change represents a significantly higher percentage of watersheds than would be expected if the changes were random ($Z = 6.25$, $p < 0.01$). Of the remaining watersheds, 18 (7 percent) had drivers condition scores that were the same in time 1 and time 2, and 71 (28 percent) had scores that were lower in time 2 (table 4). The average decrease in condition scores for those 71 watersheds was 0.14 (SD 0.3). The overall net change in drivers condition score across all 250 watersheds was 0.02 (SD 0.1).

Most of the watersheds changed little during the last 10 years; however, 7 of the 250 watersheds had drivers condition scores that changed by more than 0.2 from time 1 to time 2. Wildfires that burned 31 to 55 percent of the watershed area explain the decrease in drivers score in four of the seven watersheds. The remaining three watersheds had higher condition scores in time 2. Each of these watersheds was the target of road decommissioning. A total of 16 mi of road was decommissioned in one watershed, more than half of which was in the riparian zone. A reduction in the number of road-stream crossings, which were also evaluated in the decision-support models, often accompanies decommissioning of riparian roads. In this case, 34 road-stream crossings were removed. In another watershed, just over 9 mi of road was decommissioned, of which 3 mi was in hazard areas (i.e., prone to failure) and 4.6 mi was in the riparian zone. Fifty road-stream crossings were removed. Nine miles of road was decommissioned in the last watershed, which resulted in the removal of 3 mi of road in the riparian area and 41 road-stream crossings.

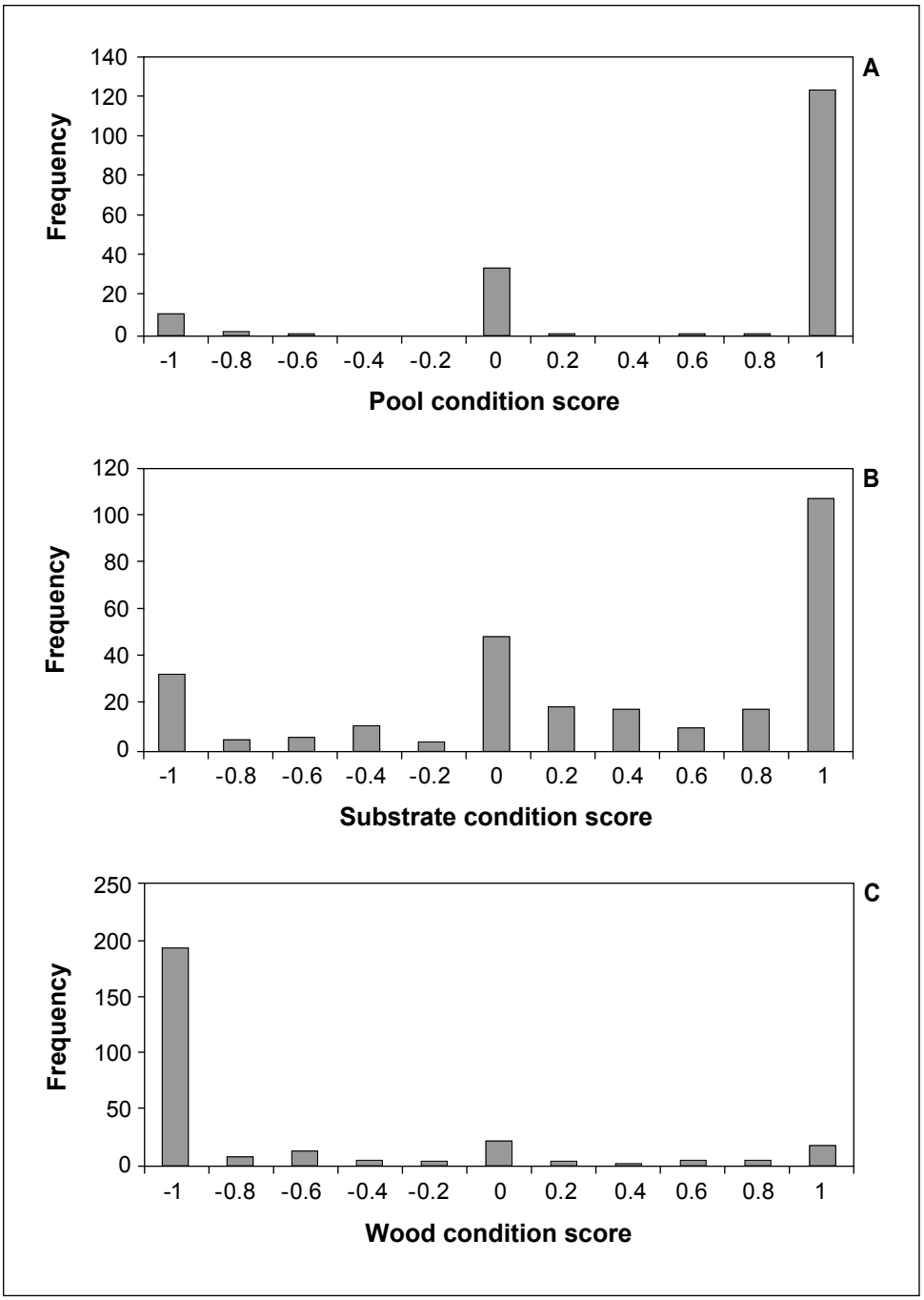


Figure 19—Frequency distribution of the time 2 inchannel attribute condition scores including (A) pools, (B) substrate, and (C) large wood. Graphs are based on 281 sample reaches in 55 watersheds in the Northwest Forest Plan area.

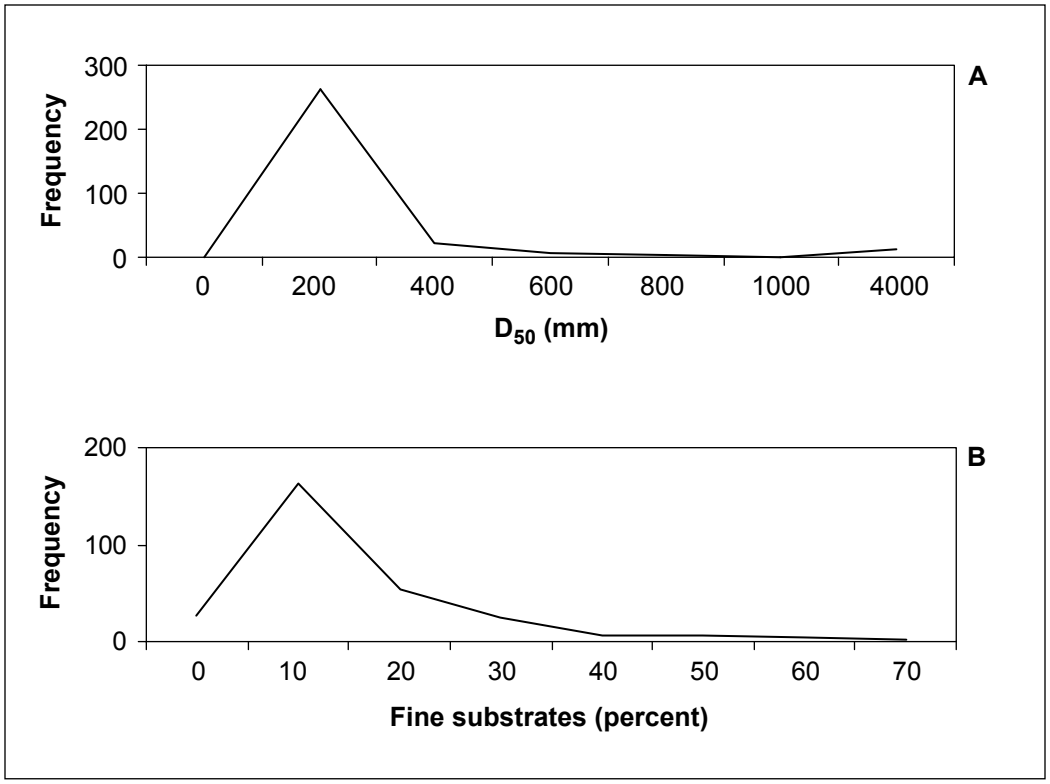


Figure 20—Frequency distribution of time 2 substrate (A) D_{50} and (B) percentage of fine sediment in pool tail crests in 281 sample reaches in 55 watersheds in the Plan area.

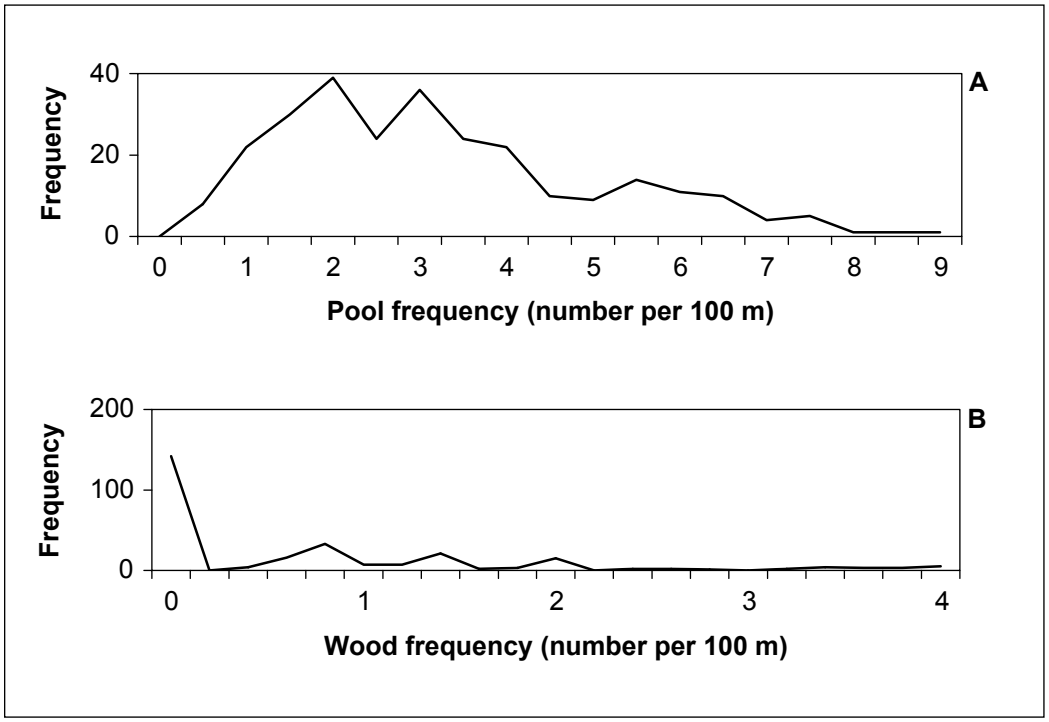


Figure 21—Frequency distribution of time 2 (A) pool frequency and (B) wood frequency in 281 sample reaches in 55 watersheds in the Northwest Forest Plan area.

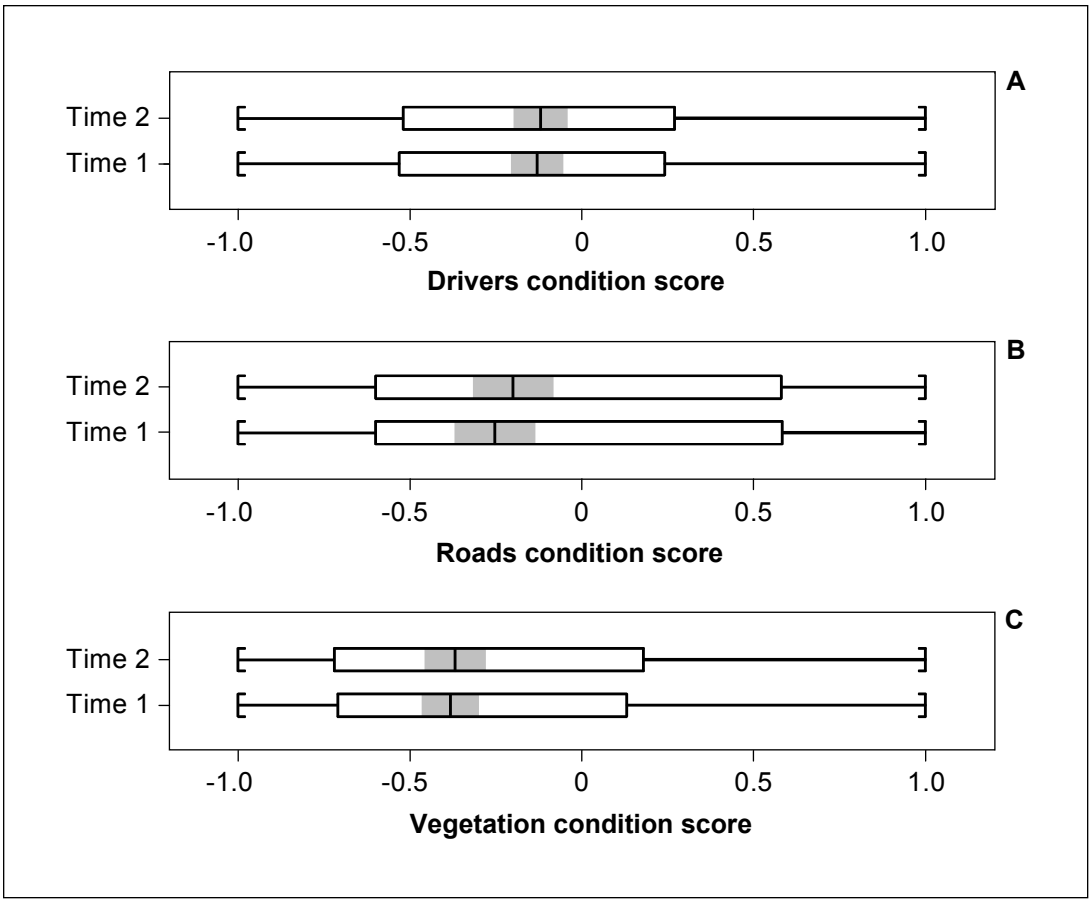


Figure 22—Distribution of evaluation scores for the drivers (the aggregate of roads and vegetation attributes), roads, and vegetation, for 250 randomly selected watersheds in the Northwest Forest Plan area. Bars in the center of the boxes represent the median of the distribution, and shading represents the 95 percent confidence interval around the median. Boxes represent the middle 50 percent of the distribution, and the whiskers represent the range of the distribution.

Roads—

In the road condition assessment, about 33 percent of the watersheds had scores that were at least 0.1 higher in time 2, and the remainder of the watersheds did not change (table 4). None of the watersheds decreased in condition by more than 0.1. The net decrease in road miles on federal lands was about 4,300 mi, out of about 91,000 mi of road that existed in 1994 (Baker et al. in press). The effort was spread out across the Plan area; consequently, the miles of roads in the 250 watersheds changed very little (fig. 23). Road building and decommissioning are the only factors that affected road condition in this assessment. We did not account for the 3,085 mi of road improvements made by federal agencies since the Plan was implemented.

Vegetation—

The small changes in the drivers scores were largely owing to higher vegetation scores in the watersheds. Vegetation condition scores were a minimum of 0.1 higher in about 55 percent of the watersheds (table 4). Assessments of vegetation depended largely on the presence of large conifers (typically greater than 20 in d.b.h.). Large trees in riparian areas were usually weighted more heavily than upslope vegetation in the decision-process models. Net tree growth and mortality from stand-replacing fire and harvest were the only factors that affected the change in vegetation in this evaluation. Two to four percent of the trees moved from a size class less than 20 in d.b.h. to greater than 20 in across the Plan area since 1994. Stand-replacing harvest in watersheds on federal

Table 4—Change in drivers, roads, and vegetation condition scores since the Northwest Forest Plan was implemented[a]

		Change[b]										
	N	-0.5	-0.4	-0.3	-0.2	-0.1	0	0.1	0.2	0.3	0.4	0.5
							Percent					
Plan	250											
Drivers		1.6	0	0	0	1.6	39.6	49.2	6.8	0.4	0.4	0
Roads		0	0	0	0	0	66.0	29.2	3.2	0.8	0	0.4
Vegetation		1.6	0	0.8	0.4	1.2	40.8	33.6	13.6	8.0	0	0
Key	88											
Drivers		2.3	0	0	0	0	23.9	61.4	10.2	1.1	1.1	0
Roads		0	0	0	0	0	58.0	34.1	4.5	2.3	0	1.1
Vegetation		2.3	0	0	0	1.1	29.5	33.0	21.6	12.5	0	0
Non-key	162											
Drivers		1.2	0	0	0	2.5	47.5	42.6	4.9	0	0	0
Roads		0	0	0	0	0	69.8	26.5	2.5	0	0	0
Vegetation		1.2	0	1.2	0.6	1.2	46.3	34.0	9.3	5.6	0	0
AMA	18											
Drivers		0	0	0	0	0	27.8	66.7	5.6	0	0	0
Roads		0	0	0	0	0	61.1	38.9	0	0	0	0
Vegetation		0	0	0	0	0	27.8	55.6	11.1	5.6	0	0
CR	62											
Drivers		0	0	0	0	3.2	37.1	51.6	3.2	1.6	0	0
Roads		0	0	0	0	0	75.8	19.4	0	1.6	0	0
Vegetation		0	0	1.6	0	1.6	30.6	38.7	12.9	11.3	0	0
LSR	63											
Drivers		6.3	0	0	0	1.6	14.3	68.3	7.9	0	1.6	0
Roads		0	0	0	0	0	52.4	41.3	4.8	0	0	1.6
Vegetation		6.3	0	1.6	0	0	20.6	39.7	22.2	9.5	0	0
Matrix	41											
Drivers		0	0	0	0	0	43.9	39.0	14.6	0	0	0
Roads		0	0	0	0	0	65.9	17.1	12.2	2.4	0	0
Vegetation		0	0	0	0	0	48.8	31.7	12.2	7.3	0	0
Nonfederal	45											
Drivers		0	0	0	0	0	66.7	31.1	2.2	0	0	0
Roads		0	0	0	0	0	64.4	35.6	0	0	0	0
Vegetation		0	0	0	0	0	73.3	20	4.4	2.2	0	0

[a] Values are the percentage of watersheds in each category. Data are provided for the entire Northwest Forest Plan area (Plan), key watersheds (Key), non-key watersheds (Non-key), adaptive management areas (AMA), congressional reserves (CR), late-successional reserves (LSR), matrix, and nonfederal lands. N is the number of watersheds in each land use allocation.

[b] Change categories reflect the magnitude and direction of change. Positive values indicate that scores were higher in time 2 than in time 1, and negative values indicate that scores were lower in time 2. Category values represent the top of the range (i.e., 0.4 includes the range from 0.31 to 0.4).

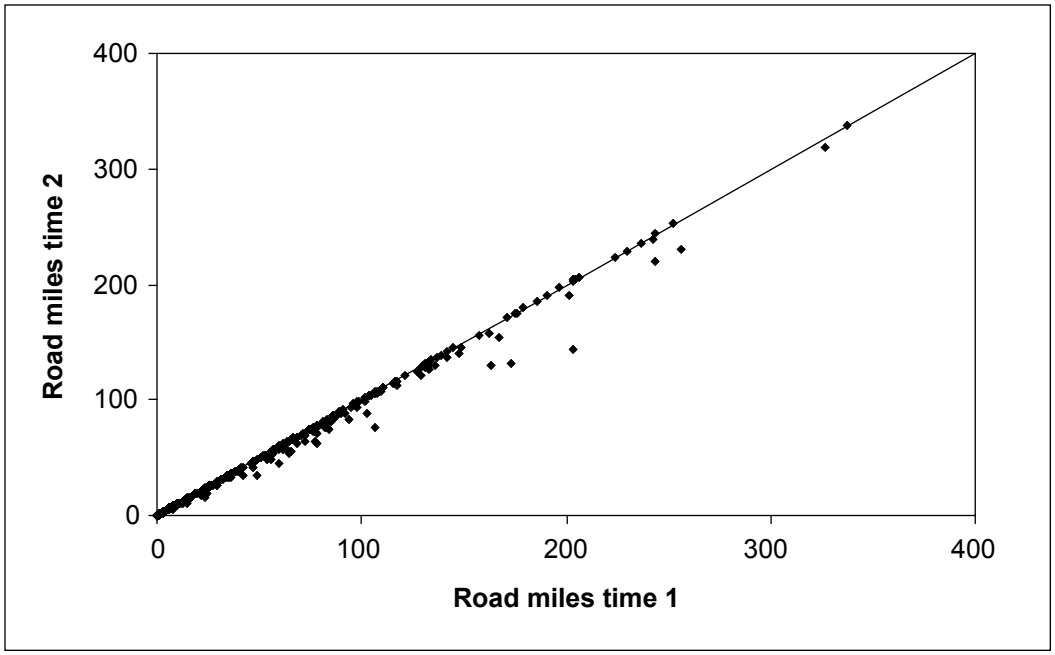


Figure 23—Total road miles in time 1 and time 2. Data points on the line indicate that the total miles of road in the watershed did not change in the last 10 years. Points below the line represent watersheds that have fewer miles of roads in time 2 than in time 1.

lands in Oregon and Washington has decreased to about 15 percent of the 1991 level (fig. 24). Historical harvest data were not available for California. Harvest on nonfederal lands has changed very little since 1972. Although the area harvested in riparian areas has decreased since the implementation of the Plan, riparian harvest as a portion of total harvest has remained fairly constant since 1972, with an average of 25 percent of total harvest in riparian areas of federal lands (range 17 to 35 percent over the time periods) and an average of 30 percent riparian harvest on nonfederal lands (range 23 to 36 percent). Riparian area was defined by using the same buffer width as used for the riparian vegetation evaluation in the decision-support model.

Change in roads and vegetation attributes were also examined relative to their location in the watershed (upslope or riparian area). Shifts in the medians of the distributions were very small for all of the upslope (fig. 25) and riparian (fig. 26) attributes. On average, twice as many roads were decommissioned in upslope areas as in riparian areas (table 5).

Key Watersheds

Key watersheds are one of the primary components of the strategy (fig. 27). They provide high-quality habitat to aquatic and riparian organisms or have the potential to do so. Key watersheds were identified by the strategy independent of the land use allocations in the Plan, thus key and non-key watershed designations do not mutually exclude the other land use allocations. Of the 250 watersheds, 88 have >50 percent of the area designated as key watershed. The remaining 162 watersheds are considered as non-key in this assessment.

Current Status

Roads—

Currently, key watersheds tend to be in better condition overall than non-key watersheds with respect to roads. The range of riparian road densities extends from 0 to about 0.4 mi of road per mile of stream for both key and non-key watersheds. However, riparian road densities generally tend to be lower in key watersheds. Nearly half of the key watersheds have riparian road densities lower than 0.1 mi

Cummins and Tenmile Watersheds, Siuslaw National Forest, Oregon

Restoring a free-flowing coastal river—
A large-scale watershed restoration effort was implemented by the USDA Forest Service, Oregon Department of Fish and Wildlife, National Audubon Society, and a partnership of landowners, environmental groups, watershed councils, and local government agencies in the northwest Oregon coastal area of Cummins Creek and Tenmile Creek during 1994 to 2002 to begin restoring ecological processes altered by the last 150 years of human activities. Restoration activities included stabilizing and decommissioning 116 mi of roads, thinning plantations along 65 mi of streams to promote faster tree growth, planting 150 ac of riparian areas, and adding nearly 300 large wood pieces into 4.5 mi of stream. Activities were focused on areas with the greatest potential to restore watershed processes.

About 75 percent of the 55,000 ac in the Cummins and Tenmile Creek area are designated as key watersheds under the Plan because of existing and potential high-quality coho salmon (*Oncorhynchus kisutch*) habitat (a species listed under the Endangered Species Act). The area's 100 mi of fish-bearing streams also provide habitat for Chinook (*O. tshawytscha*), chum (*O. keta*), steelhead (*O. mykiss*), cutthroat (*O. clarki*), Pacific lamprey (*Lampetra tridentata*), western brook lamprey (*L. richardsoni*), sculpin (*Cottus* spp.), and eulachon (*Thaleichthys pacificus*).

Progress to date—
This successful restoration effort is helping to restore ecological processes, while providing immediate improvements to the watershed. For example, road decommissioning, building, and water-barring have stabilized 53 percent of the roads (63 percent of Forest Service roads).

- The area of deep pools with complex wood cover tripled after wood additions (project and natural) in Tenmile Creek.
- Overwinter survival of coho and steelhead has significantly increased in Tenmile Creek since large wood was added (project and natural) while the no-treatment control basin remained unchanged.
- Steelhead smolt production has doubled since large wood was added (project and natural) to Tenmile Creek.

Jack Sleeper

Jack Sleeper

This valley bottom road was removed to restore valuable riparian and flood-plain processes. Riparian areas on the temperate Oregon coast are highly productive, and streamside vegetation will be quick to recover. Contact Jack Sleeper (jsleeper@fs.fed.us) for more information.

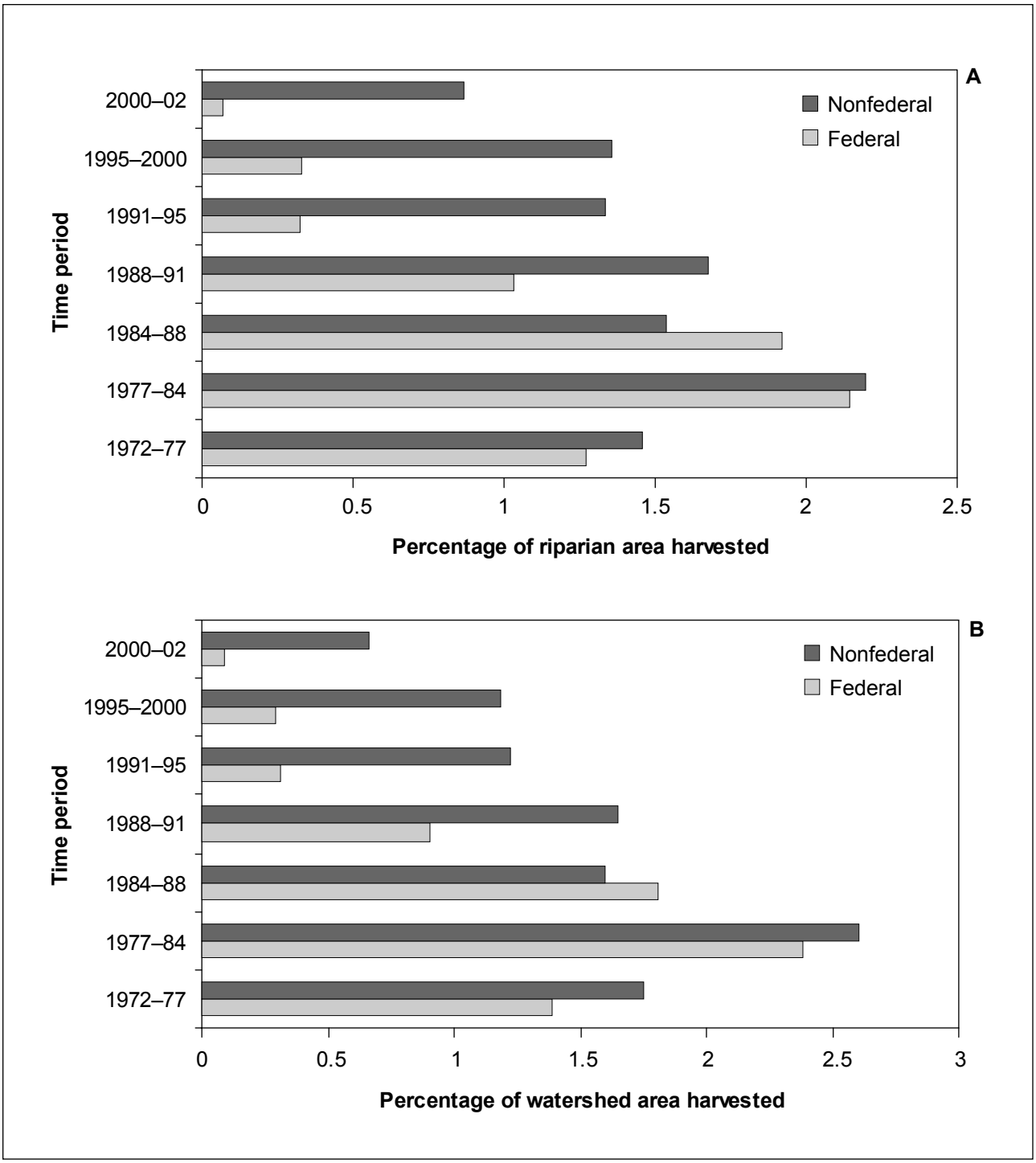


Figure 24—Percentage of (A) riparian area harvested and (B) watershed area harvested on federal and nonfederal lands in various periods ranging from 1972 to 2002. Bars represent the mean across 189 of 250 randomly selected watersheds in Oregon and Washington (the remaining 61 watersheds were not harvested during these periods). Harvest is defined as stand-replacing harvest, such as regeneration harvest.

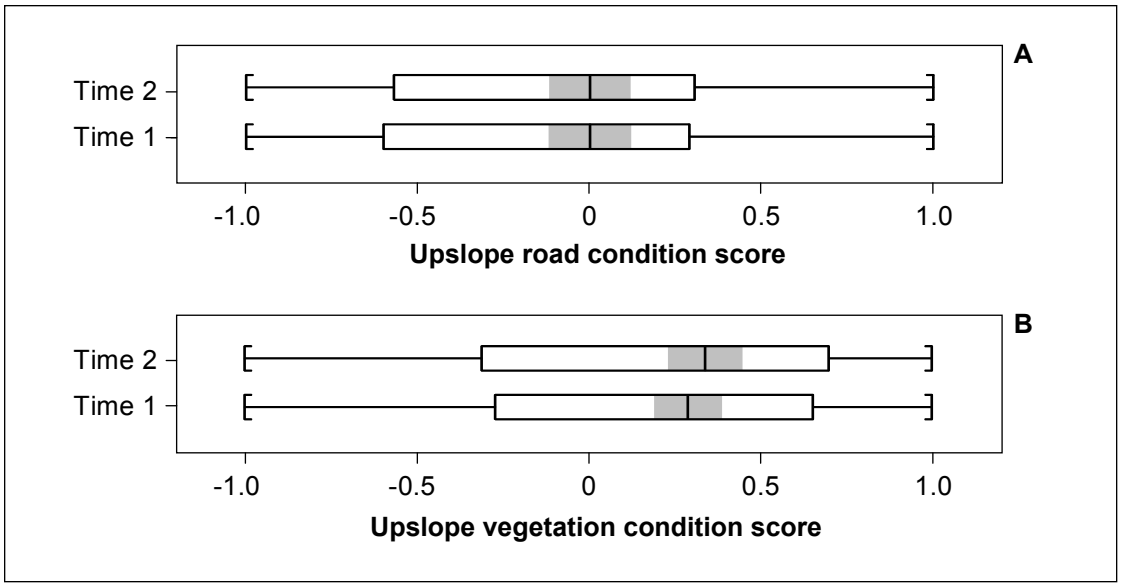


Figure 25—Distribution of time 1 and time 2 condition scores for upslope roads and upslope vegetation for 250 watersheds in the Northwest Forest Plan area. Bars in the center of the boxes represent the median of the distribution, and shading represents the 95 percent confidence interval around the median. Boxes represent the middle 50 percent of the distribution, and the whiskers represent the range of the distribution.

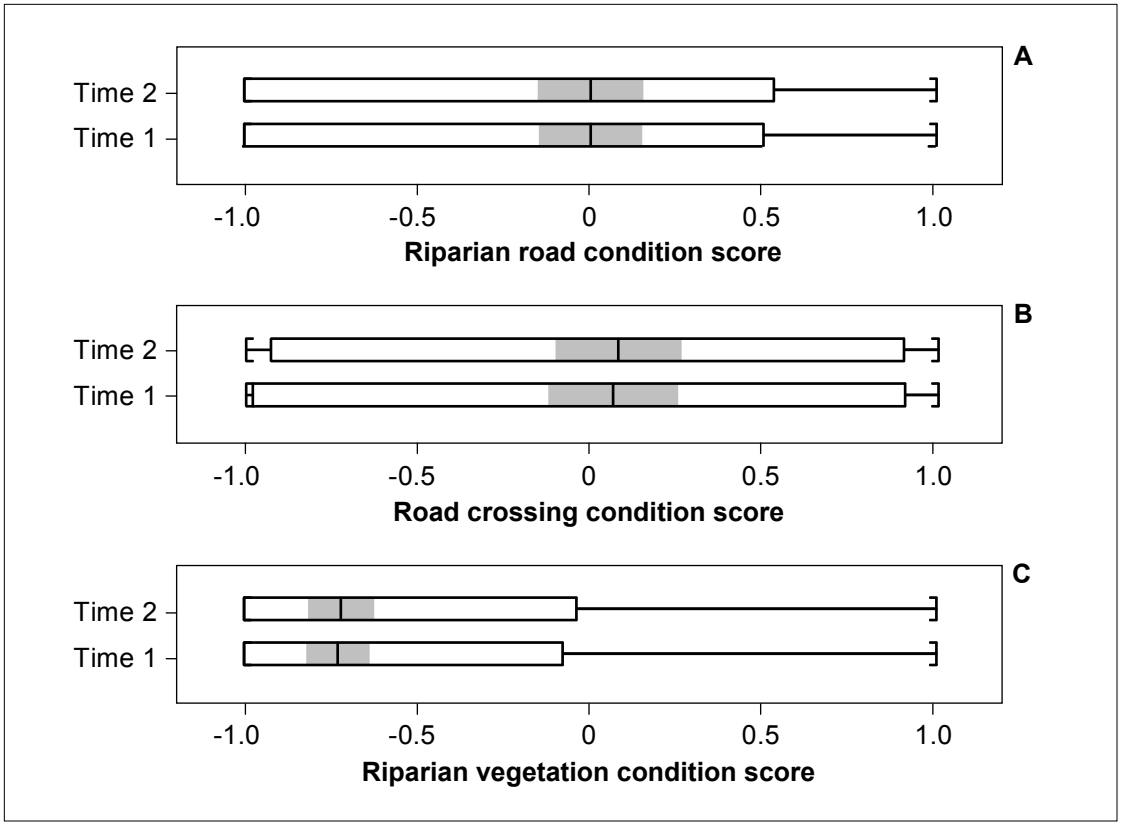


Figure 26—Distribution of time 1 and time 2 condition scores for riparian roads, road-stream crossings, and riparian vegetation for 250 watersheds in the Northwest Forest Plan area. Bars in the center of the boxes represent the median of the distribution, and shading represents the 95 percent confidence interval around the median. Boxes represent the middle 50 percent of the distribution, and the whiskers represent the range of the distribution.

Table 5—Average number of road miles decommissioned in upslope and riparian areas in the Plan area and in each land use allocation[a]

Land use allocation	Number	Riparian		Upslope		Total
		Average	SD	Average	SD	
		Miles				
All	250	0.65	1.79	1.44	4.21	2.09
Key	88	0.96	1.71	2.00	4.30	2.97
Non-key	162	0.57	1.60	0.74	1.90	1.31
AMA	18	0.93	1.93	0.97	1.75	1.90
CR	56	0.23	0.84	0.53	2.01	0.76
LSR	64	0.83	1.53	1.80	3.51	2.64
Matrix	37	0.97	1.88	1.55	4.48	2.52
Nonfederal	41	0.89	2.26	1.20	2.94	2.08

[a] Data are presented for key watersheds, non-key watersheds, and watersheds in adaptive management areas (AMA), congressional reserves (CR), late-successional reserves (LSR), matrix, and watersheds that are predominantly nonfederal.

Kimberly Baker

Figure 27—Tier 1 key watersheds, such as Upper North Fork Coquille River shown here, contribute directly to conservation of at-risk anadromous salmonids, bull trout, and resident fish species. They also have the high potential of being restored as part of a watershed restoration program (USDA and USDI 1994).

of road per mile of stream, compared to 24 percent of non-key watersheds (fig. 28). Road-stream crossings also tend to be lower in key watersheds than in non-key watersheds. Just over 60 percent of key watersheds have road crossing frequency one or less crossing per mile of stream, compared with 40 percent of non-key watersheds (fig. 28).

Vegetation—

Key and non-key watersheds are comparable in condition with respect to riparian vegetation. Just over 20 percent of the key watersheds have <30 percent of the riparian area covered by conifers greater than 20 in d.b.h., compared with 33 percent of non-key watersheds (fig. 29).

Changes Since the Implementation of the Plan

Small shifts in the drivers, roads, or vegetation score distributions were detected in both key watersheds (fig. 30) and non-key watersheds (fig. 31). In general, conditions in key watersheds improved more than those in non-key watersheds. Drivers condition scores in 74 percent of key watersheds and 48 percent of non-key increased by at least 0.1 in time 2 (table 4). Fewer than 4 percent of the watershed declined by that amount in the last 10 years.

Roads—

Key watersheds had significantly higher drivers scores than non-key watersheds in time 2 (Wald F = 4.1, df = 3, 246, $p < 0.01$). The primary difference between key and non-key watersheds was attributed to roads. Not only did key watersheds have higher road condition scores than non-key watersheds at time 1 and time 2, more than twice the miles of roads were decommissioned in key watersheds than in non-key in the last 10 years (fig. 32, table 5). Road condition scores increased by more than 0.1 in 42 percent of key watersheds and 29 percent of non-key watersheds. None of the watersheds had declining road condition scores.

Vegetation—

Vegetation condition scores increased more in key watersheds; 34 percent of key watersheds had scores that were a minimum of 0.1 higher in time 2 than in time 1, compared with 15 percent of non-key watersheds (table 4). Vegetation rates declined by more than 0.1 in less than 4 percent of key and non-key watersheds. Harvest rates were historically lower in key watersheds than in non-key watersheds (fig. 33a). This trend continued after the Plan was implemented (fig. 33b). Harvest rates in key and non-key watersheds were similar for harvest areas less than 100 ac. However, harvests that were larger than 100 ac were found more frequently in non-key watersheds than in key watersheds. Of the

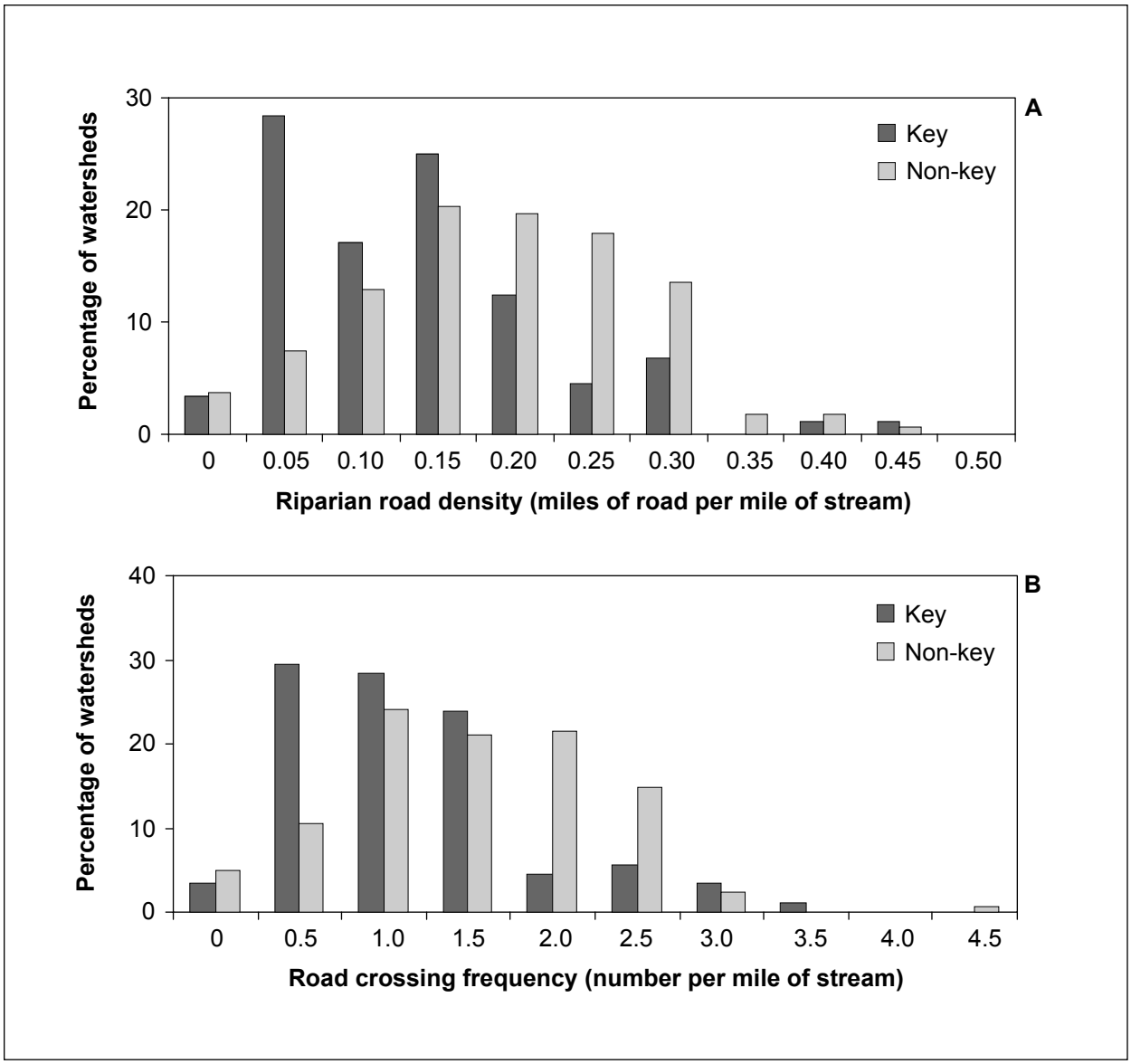


Figure 28—Frequency distribution of time 2 (A) riparian road density and (B) frequency of road crossings (b) in 88 key watersheds and 162 non-key watersheds. These watersheds represent a subset of the 250 randomly selected watersheds in the Northwest Forest Plan area.

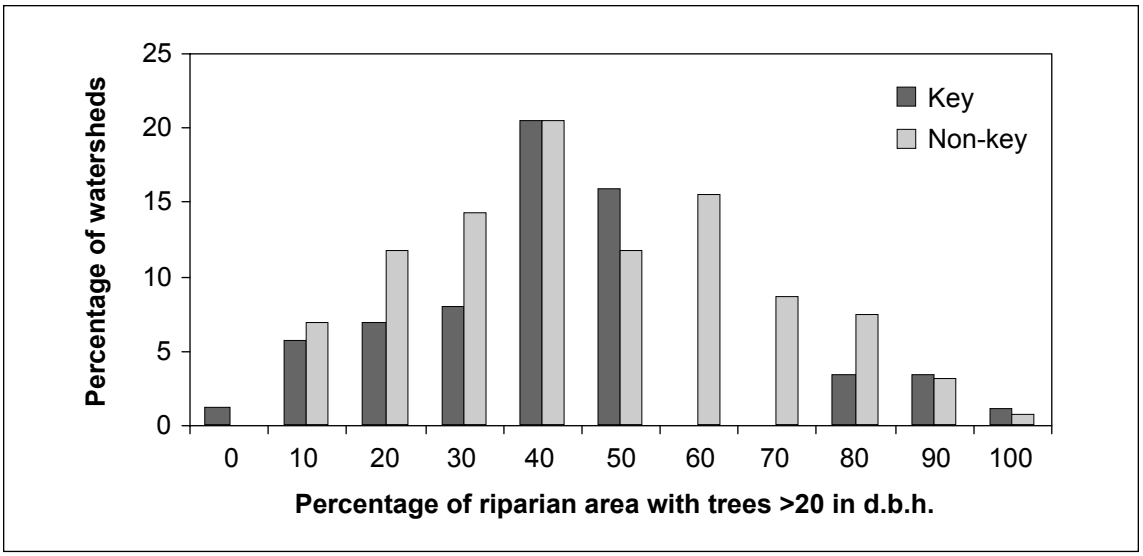


Figure 29—Frequency distribution of the percentage of riparian area with trees >20 in diameter at breast height (d.b.h.) in time 2 in 88 key watersheds and 162 non-key watersheds. These watersheds represent a subset of the 250 randomly selected watersheds in the Northwest Forest Plan area.

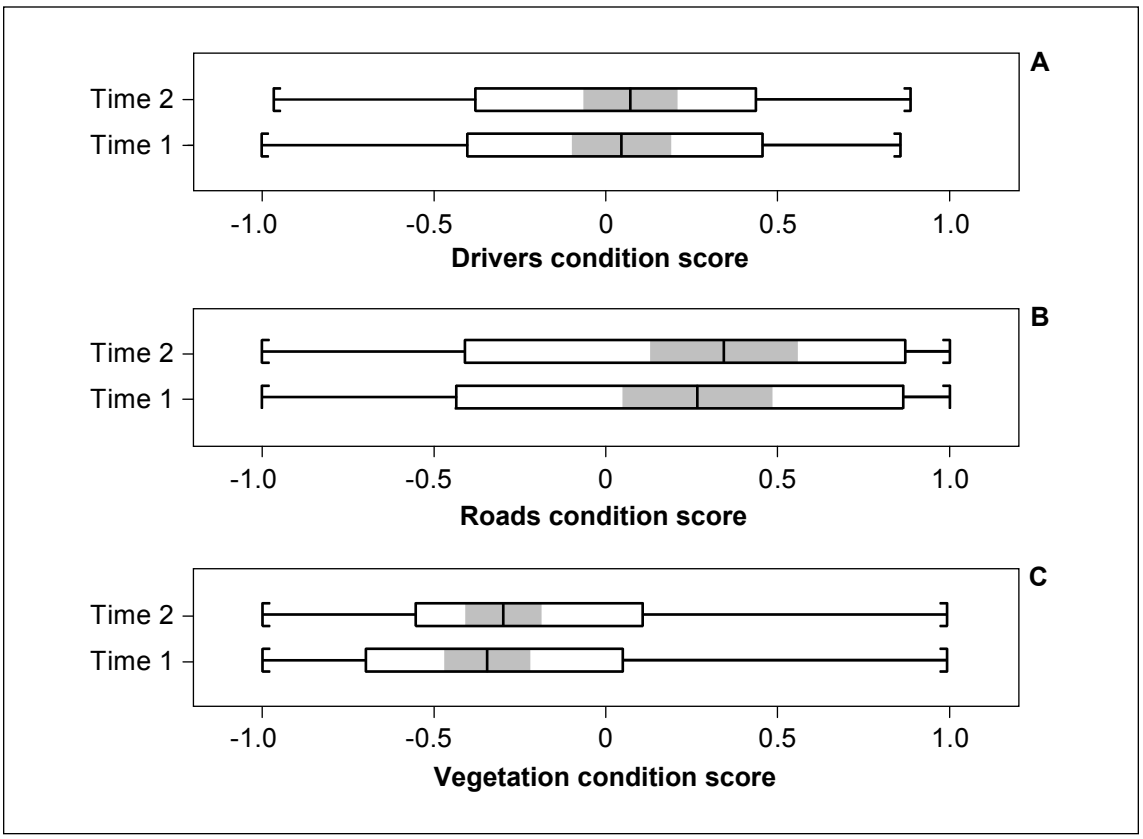


Figure 30—Distributions for (A) drivers, (B) roads, and (C) vegetation condition scores in key watersheds for time 1 and time 2. The distributions are based on 88 of the 250 randomly selected watersheds in the Northwest Forest Plan area that were designated as key watersheds in the aquatic conservation strategy. Bars in the center of the boxes represent the median of the distribution, and shading represents the 95 percent confidence interval around the median. Boxes represent the middle 50 percent of the distribution, and the whiskers represent the range of the distribution.

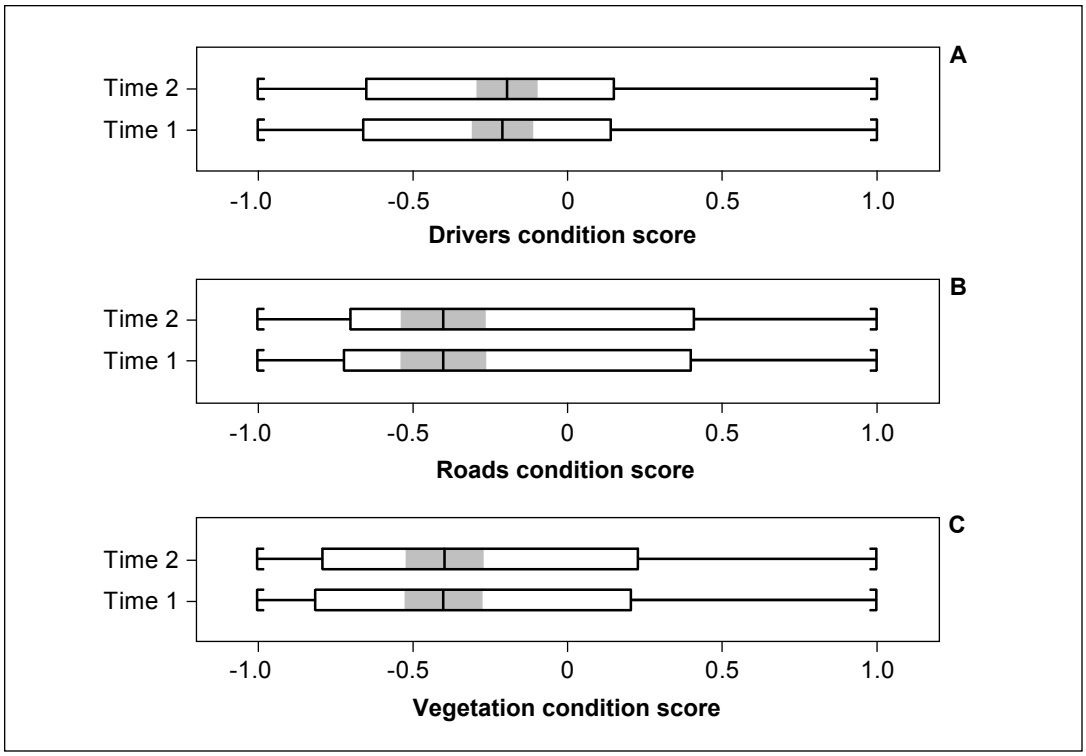


Figure 31—Distributions for (A) drivers, (B) roads, and (C) vegetation condition scores in non-key watersheds for time 1 and time 2. The distributions are based on 162 of the 250 randomly selected watersheds in the Northwest Forest Plan area that were not designated as key watersheds in the aquatic conservation strategy. Bars in the center of the boxes represent the median of the distribution, and shading represents the 95 percent confidence interval around the median. Boxes represent the middle 50 percent of the distribution, and the whiskers represent the range of the distribution.

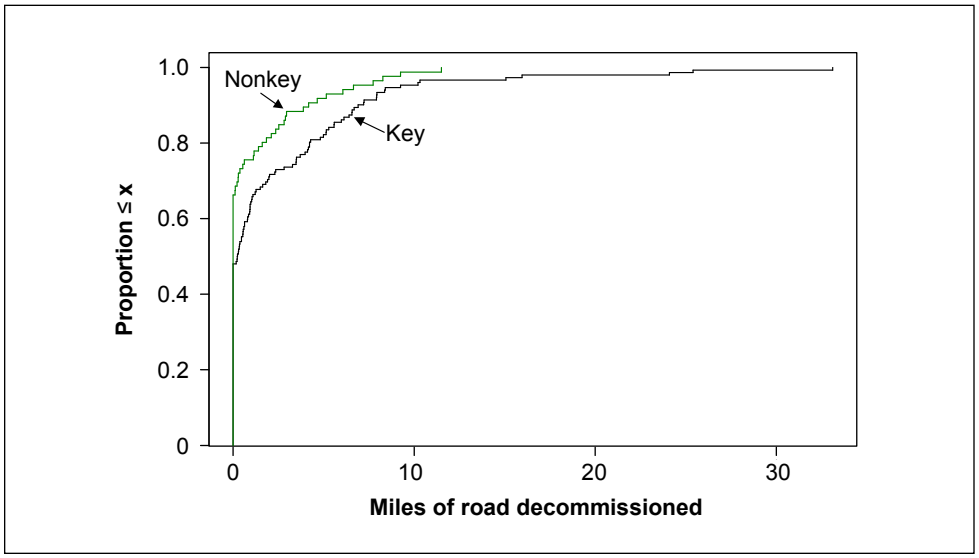


Figure 32—Cumulative frequency distribution of the miles of road decommissioned since the strategy was implemented in key and non-key watersheds. Distributions are based on 250 randomly selected watersheds in the Northwest Forest Plan area subset into key (n = 88 watersheds) and non-key watershed (n = 162 watersheds) designations. The y-axis values represent the proportion of watersheds with fewer road miles decommissioned than the x-axis value of interest.

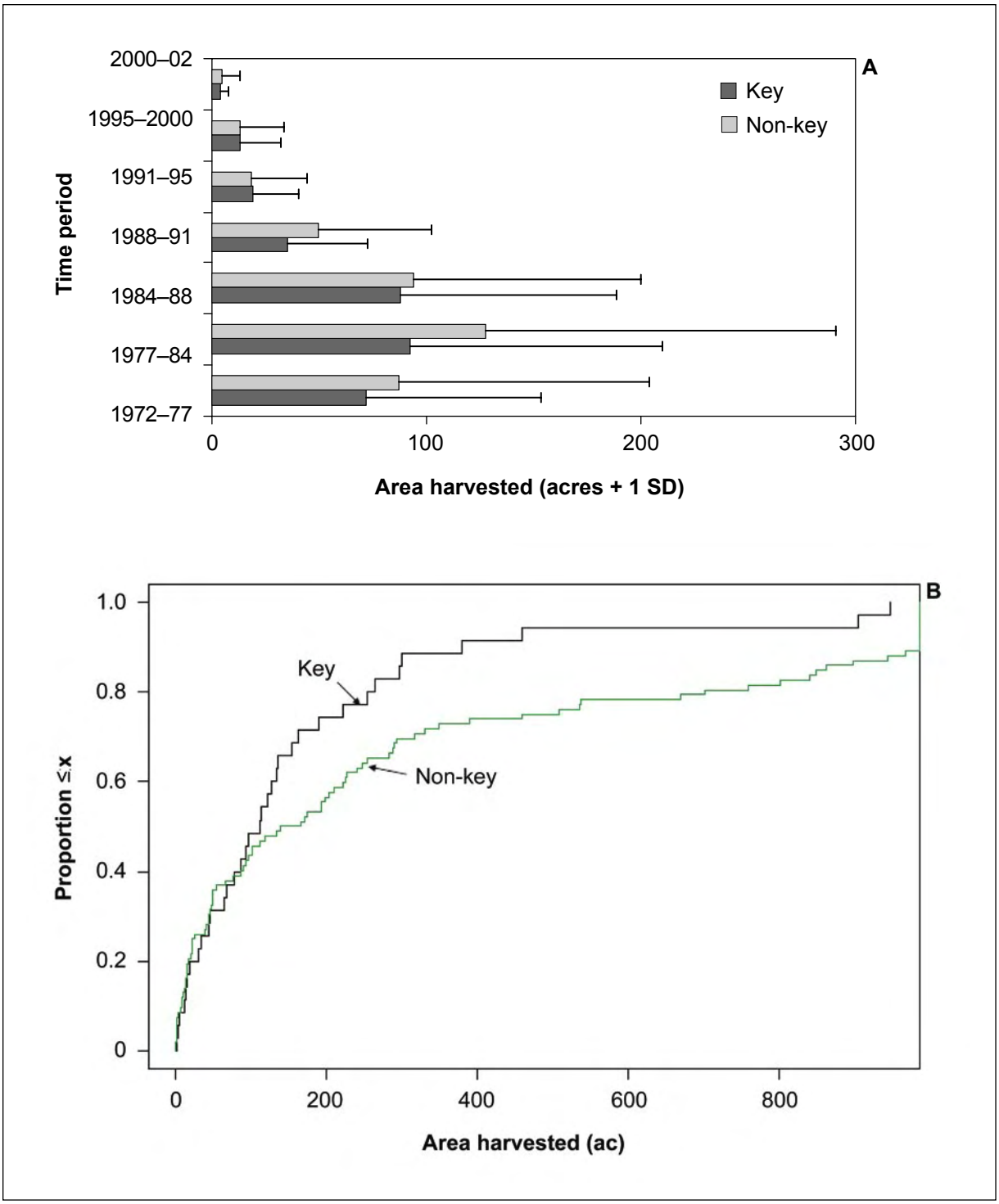
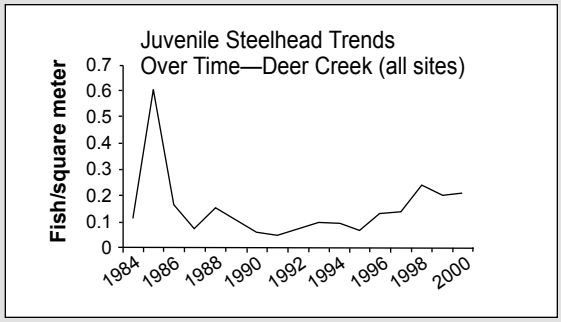


Figure 33—Average harvest in key and non-key watersheds based on 250 watersheds in the Northwest Forest Plan area. In panel A, columns represent average acres harvested during each period from 1972 to 2002. Panel B shows the cumulative distribution of acres harvested in individual watersheds since 1995. The y-axis values on the bottom panel represent the proportion of watersheds with fewer acres harvested than the x-axis value of interest.

Deer Creek, Mount Baker Snoqualmie National Forest, Washington

Road treatments help recover steelhead trout—The long-term goal of restoration efforts in Deer Creek, a tributary to the North Fork Stillaguamish River located in the North Cascades of Washington is the recovery of depressed native fish stocks, with a particular emphasis on summer-run steelhead (*Oncorhynchus mykiss*) trout. About two-thirds of the Deer Creek stream channel network is accessible by anadromous fish and has historically supported runs of steelhead trout, coho salmon (*O. kisutch*), and native char (*Salvelinus malma*). Deer Creek is a Tier 1 key watershed.

The focus of restoration efforts from 1985 to 1995 was to reduce the effects of 50 years of timber harvesting and road building throughout the watershed and to promote a return to the natural hydrologic and erosional regimes. Timber was harvested over the entire lower watershed and on one-third of the federal land in the upper watershed. One area of emphasis was to reduce the effects of coarse sediment input from roads to the downstream channel system.



Fish populations in Deer Creek have increased since 1995. The increase in juvenile fish densities is a reversal of a decade-long decline and is attributed, in part, to improvement of aquatic habitat during the past 5 years.

Progress to date—

- Coarse sediment input to the stream system was reduced by three types of road treatments completed during 1984–94: road storm-proofing, decommissioning, and road upgrading.
- Fifty-five out of sixty-eight mi of federal roads were treated. Despite five major flood events during 1984–2003, little or no major failure on treated roads was recorded.
- Bridges, larger or additional culverts, or hardened dipped crossings (concrete fords and open box culverts) were installed to replace ineffective culverts.
- Culverts were removed from inactive roads to restore the natural drainage.
- Water-bars were installed to intercept water and provide a controlled flow in a drainage ditch.
- Sidecast or settling road fill materials were removed to reduce the risk of mass wasting.

Jim Doyle

Jim Doyle

Twenty-one hardened road/channel crossing sites like these (the earliest was installed in 1985) survived four major floods. The amount and size of the bedload and woody debris deposited at the outlet of this box culvert would have plugged and overtopped a conventional circular culvert. This type of road failure was common in Deer Creek before the application of these flood-proofing structures. Contact Jim Doyle (jdoyle@fs.fed.us) for more information.

watersheds that were harvested, the average area harvested fell from just over 50 ac per watershed per year before the Plan was implemented to 6 ac per watershed per year in key watersheds and from just over 55 to 10 ac per watershed per year in non-key watersheds (table 6).

Adaptive Management Areas

Adaptive management areas were designated as testing grounds for new management approaches. Eighteen of the 250 randomly selected watersheds had greater than 50 percent of the area designated for adaptive management.

Current Status

Adaptive management areas had drivers condition scores that ranged from -1 to 0.3. Adaptive management areas appear to be in similar condition to most of the watersheds in other land use allocations identified in the Plan (fig. 34), with the exception of congressional reserves, which tend to be in better condition than watersheds in other land use allocations.

Table 6—Mean harvest rates in the 250 watersheds in acres harvested per watershed per year[a]

Land use allocation	N	1972–1995	1995–2003
		- - - - - *Acres*	- - - -
Key			
Mean	82	52.8	6.1
SD		47.2	12.9
Non-key			
Mean	152	54.6	10.6
SD		48.4	27.4
AMA			
Mean	18	62.9	5.6
SD		44.9	6.5
CR			
Mean	62	30.8	3.2
SD		31.5	7.9
LSR			
Mean	63	66.8	10.9
SD		54.5	21.9
Matrix			
Mean	41	71.3	21.1
SD		51.2	46.3
Nonfederal			
Mean	45	86.0	44.4
SD		80.3	45.3

[a] Land use allocations include key watersheds, non-key watersheds, adaptive management areas (AMA), congressional reserves (CR), late-successional reserves (LSR), matrix, and watersheds that are predominantly nonfederal.

Roads—
Riparian road densities in adaptive management areas ranged from 0.07 to 0.28 mi of road per mile of stream. Eighty-eight percent of these watersheds had riparian road densities greater than 0.1 mi of road per mile of stream (fig. 35a). Road crossing frequencies ranged from 0.6 to 2.0 crossings per mile of stream. Seventy-eight percent of the watersheds had road crossing frequencies greater than 1 crossing per mile of stream (fig. 35b). The density of roads in adaptive management areas is among the highest of those on federal lands.

Vegetation—
Riparian area with conifers >20 in d.b.h. ranged from 10 to 70 percent in adaptive management watersheds. Twenty-eight percent of the watersheds had less than 30 percent of the riparian area containing large conifers (fig. 36). Large trees were less abundant in the riparian areas of adaptive management watersheds than in other federally owned watersheds.

Changes Since the Implementation of the Plan

Small positive changes in the distribution of condition scores were detected for drivers, roads, or vegetation (fig. 37). Drivers condition scores increased by at least 0.1 in 72 percent of the watersheds in the last 10 years (table 4). None of the watersheds decreased in condition.

Roads—
Road condition scores increased by a minimum of 0.1 in nearly 40 percent of the watersheds, and the remainder did not change in condition (table 4). The miles of roads decommissioned in adaptive management areas was the lowest of any watersheds. No decommissioning occurred in nearly 70 percent of the watersheds (fig. 38). Of those watersheds that did have roads decommissioned, about 1 mi was decommissioned in riparian areas and 2 mi were decommissioned in upslope areas (table 5).

Vegetation—
Vegetation condition scores increased by a minimum of 0.1 in just over 70 percent of the watersheds in adaptive management areas. Harvest levels in adaptive management areas were low in the past 10 years, comparable with those

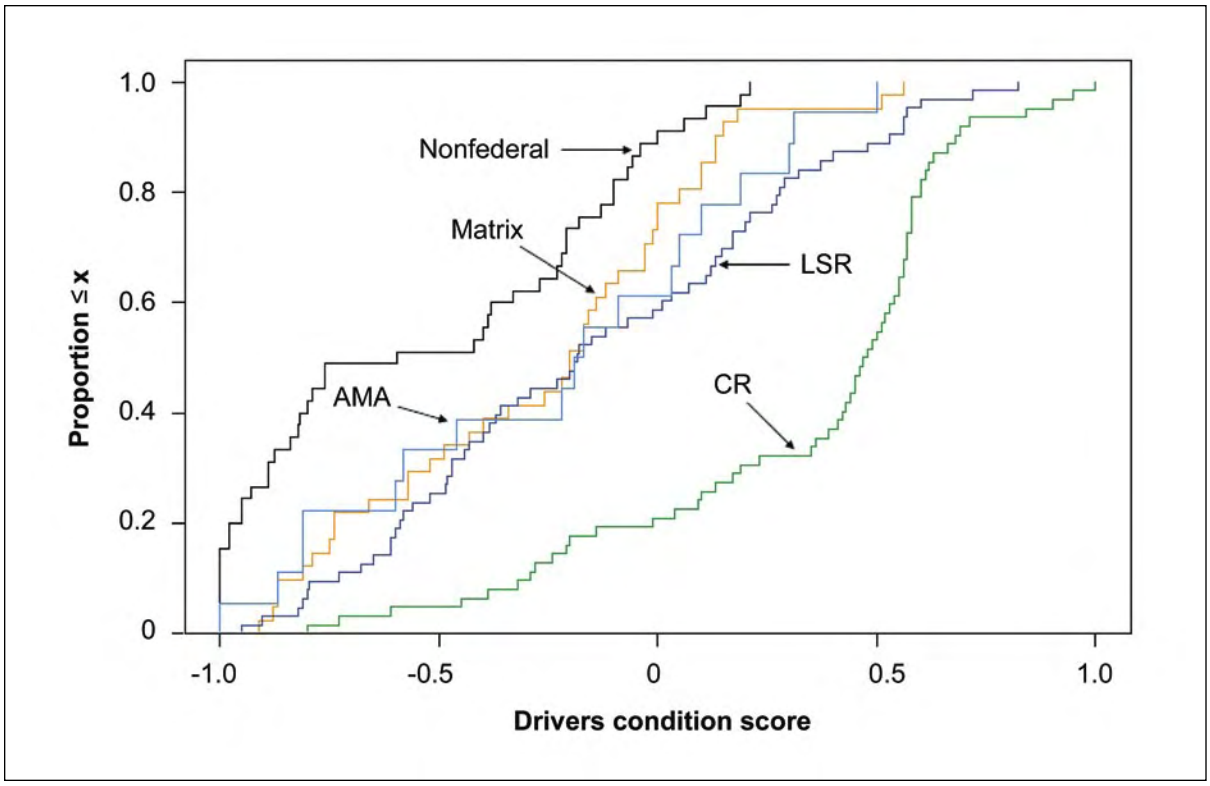


Figure 34—Cumulative distribution function for time 2 drivers condition scores for watersheds in each land use allocation, including predominantly nonfederal (n = 45 watersheds), matrix (n = 41), late-successional reserves (LSR; n = 63), congressional reserves (CR; n = 62), and adaptive management areas (AMA; n = 18). These distributions are based on subsets of 250 randomly selected watersheds in the Northwest Forest Plan area. The y-axis values represent the proportion of watersheds with condition scores less than or equal to the x-axis value of interest.

in congressional reserves (fig. 39). Mean harvest rates in adaptive management areas dropped from about 63 ac per watershed per year prior to 1995 to 5 ac per watershed per year after 1995 (table 6).

Congressional Reserves

Congressional reserves include national parks and monuments, wilderness areas, wildlife refuges, and other areas reserved by the administrative unit or act of Congress (fig. 40). These lands are generally not managed for timber production. Of the 250 randomly selected watersheds, 62 had more than 50 percent of the area designated as congressional reserve.

Current Status

Drivers condition scores range from -0.8 to 1. Condition scores in congressional reserve watersheds are generally higher than all other watersheds (fig. 34). More than 60 percent of the congressionally reserved watersheds had scores higher than 0.5.

Roads—

Road densities in congressional reserves are the lowest of any of the land use allocations. Riparian road densities in congressionally reserved watersheds ranged from 0 to 0.28 mi of road per mile of stream. Fourteen percent of these watersheds had riparian road densities greater than 0.1 mi of road per mile of stream (fig. 35a). Road crossing frequencies ranged from 0 to 2.2 crossings per mile of stream. Eight percent of the watersheds had road crossing frequencies greater than 1 crossing per mile of stream (fig. 35b).

Vegetation—

Riparian area with conifers >20 in d.b.h. ranged from 0 to 93 percent in congressionally reserved watersheds. Twelve

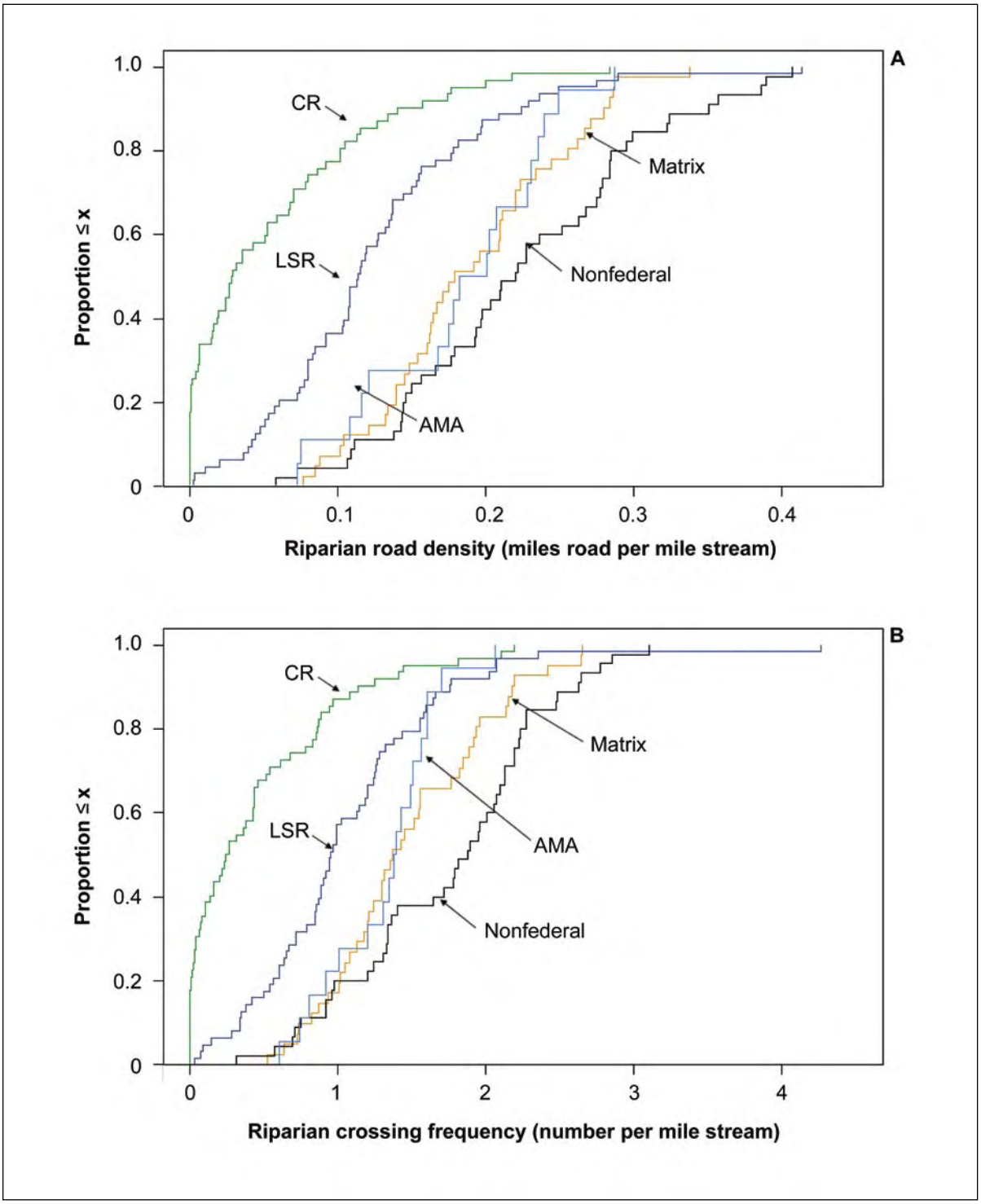


Figure 35—Cumulative distribution function for time 2 (A) riparian road density and (B) road crossing frequency for watersheds in each land use allocation, including predominantly nonfederal (n = 45 watersheds), matrix (n = 41), late-successional reserves (LSR; n = 63), congressional reserves (CR; n = 62), and adaptive management areas (AMA; n = 18). These distributions are based on subsets of 250 randomly selected watersheds in the Northwest Forest Plan area. The y-axis values represent the proportion of watersheds with density or frequency less than or equal to the x-axis value of interest.

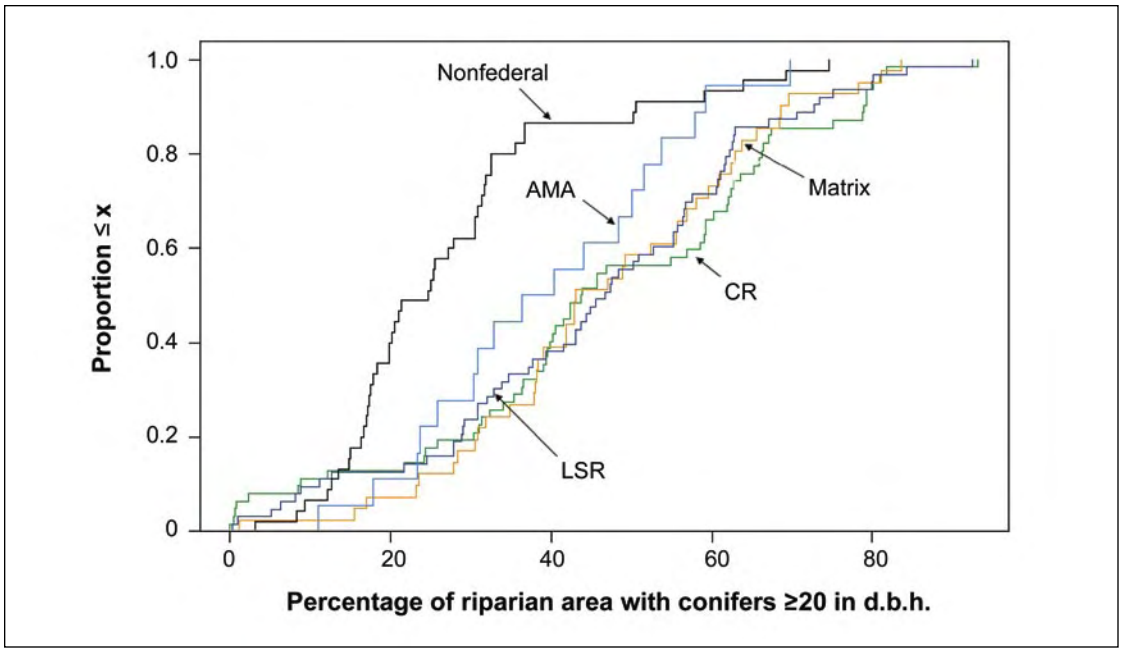


Figure 36—Cumulative distribution function of the percentage of riparian area with conifers >20 in diameter at breast height (d.b.h.) in time 2 for watersheds in each land use allocation, including predominantly non-federal (n = 45 watersheds), matrix (n = 41), late-successional reserves (LSR; n = 63), congressional reserves (CR; n = 62), and adaptive management areas (AMA; n = 18). These distributions are based on subsets of 250 randomly selected watersheds in the Northwest Forest Plan area. The y-axis values represent the proportion of watersheds with the percentage of riparian area less than or equal to the x-axis value of interest.

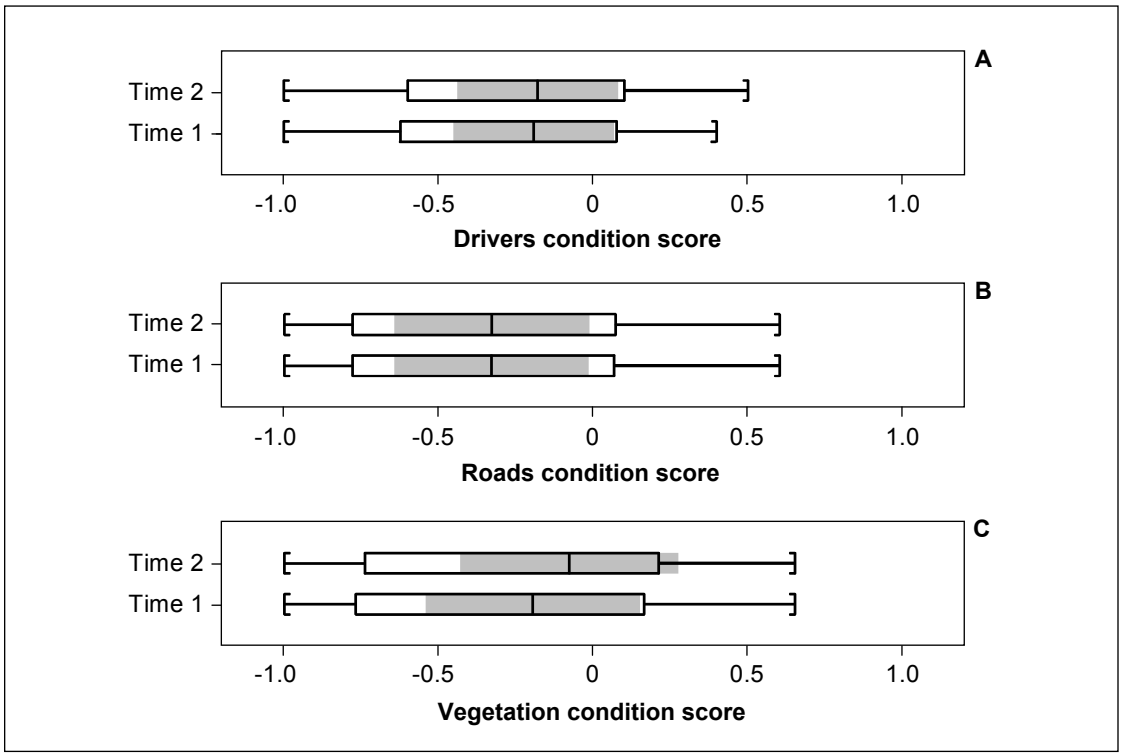


Figure 37—Distribution of (A) drivers, (B) roads, and (C) vegetation condition scores in adaptive management watersheds for time 1 and time 2. The distributions are based on 18 of the 250 randomly selected watersheds in the Northwest Forest Plan area designated as adaptive management areas. Bars in the center of the boxes represent the median of the distribution, and shading represents the 95 percent confidence interval around the median. Boxes represent the middle 50 percent of the distribution, and the whiskers represent the range of the distribution.

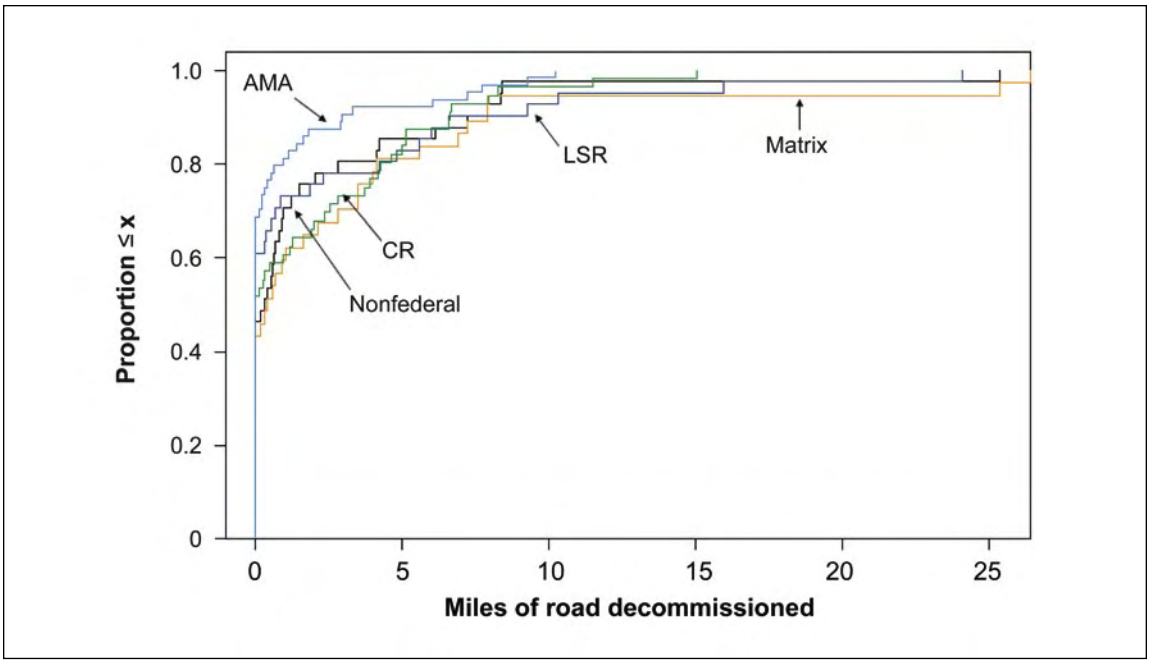


Figure 38—Cumulative frequency distribution of miles of road decommissioned in 250 watersheds by predominant land use allocation, including predominantly nonfederal (n = 45 watersheds), matrix (n = 41), late-successional reserves (LSR; n = 63), congressional reserves (CR; n = 62), and adaptive management areas (AMA; n = 18). These distributions are based on subsets of 250 randomly selected watersheds in the Northwest Forest Plan area. The y-axis values represent the proportion of watersheds with fewer miles of road decommissioned than the x-axis value of interest.

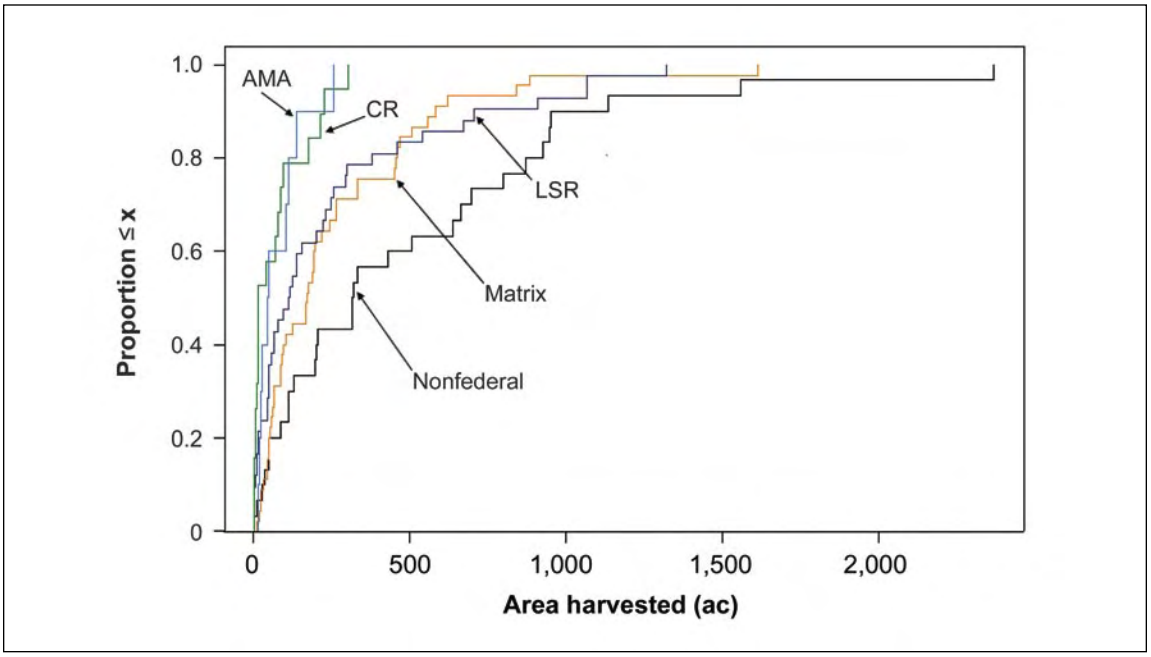


Figure 39—Cumulative frequency distribution of acres harvested in the 250 watersheds by the predominant land use allocation, including predominantly nonfederal (n = 45 watersheds), matrix (n = 41), late-successional reserves (LSR; n = 63), congressional reserves (CR; n = 62), and adaptive management areas (AMA; n = 18). These distributions are based on subsets of 250 randomly selected watersheds in the Northwest Forest Plan area. The y-axis values represent the proportion of watersheds with fewer acres harvested than the x-axis value of interest.

Eric Moberly

Figure 40—Congressional reserves, such as the Glacier Peak Wilderness in the Mount Baker-Snoqualmie National Forest, Washington, often contain upper headwater streams that serve as sources for high-quality water.

percent of the watersheds had less than 30 percent of the riparian area containing large conifers (fig. 36). Abundance of large trees in the riparian areas of congressionally reserved watersheds was comparable to the abundance in other federally owned watersheds (fig. 36).

Changes Since the Implementation of the Plan

A small positive shift in the condition of watersheds was detected in the distribution of drivers condition scores in congressionally reserved watersheds (fig. 41). Fifty-six percent of the watersheds had higher drivers condition scores in time 2, about 3 percent decreased in condition, and the remainder stayed the same.

Roads—
Road condition scores increased by a minimum of 0.1 in about 20 percent of the watersheds, and the remainder did not change in condition (table 4). The average number of road miles decommissioned in congressional reserves was the lowest of any watersheds (table 5), consistent with the low road densities in congressionally reserved watersheds. Less than 0.25 mi of road was decommissioned in riparian areas and 0.5 mi in upslope areas (table 5).

Vegetation—
Vegetation condition scores increased by at least 0.1 in about 63 percent of the watersheds (table 4). Vegetation scores decreased by at least 0.1 in about 3 percent of the watersheds, and stayed the same in the remainder. Harvest rates were very low in these watersheds (fig. 39).

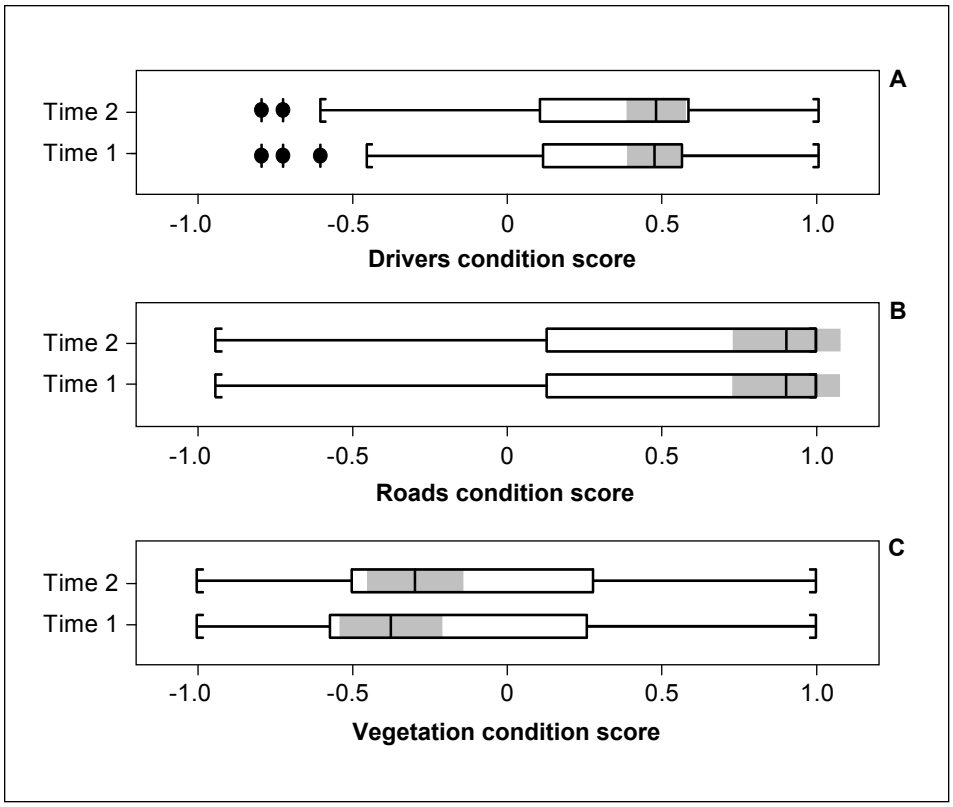


Figure 41—Distribution of (A) drivers, (B) roads, and (C) vegetation scores in congressional reserve watersheds for time 1 and time 2. The distributions are based on 62 of the 250 randomly selected watersheds in the Northwest Forest Plan area designated as congressional reserves. Bars in the center of the boxes represent the median of the distribution, and shading represents the 95 percent confidence interval around the median. Boxes represent the middle 50 percent of the distribution, and the whiskers represent the 95th quantiles. Dots represent outliers.

Karnowsky Creek, Siuslaw National Forest, Oregon

Stream Restoration Project—
Karnowsky Creek flows into the Siuslaw River Estuary, just 9 mi from the Pacific Ocean on the central Oregon coast. In the late 1800s, this valley was home to pioneers who cleared trees from the valley floor, farmed and tended livestock, hunted wildlife, and harvested huge cedar trees to build homes and barns.

The 1,800-ac Karnowsky Creek subwatershed is now managed primarily by the Siuslaw National Forest (upper 85 percent) and by three private industrial timber companies (lower 15 percent). A partnership of Forest Service, Siuslaw Soil and Water Conservation District, and the Siuslaw Watershed Council worked together to restore the channel, wetland, and estuarine processes that once made Karnowsky Creek a productive stream for aquatic resources in the Siuslaw basin.

Johan Hogervorst

Johan Hogervorst

A new channel was built and old drainage ditches were plugged to divert water into the new channel.

Progress to date—
The project is extending chum salmon (*Oncorhynchus keta*) habitat as tidal influence is allowed back into the bottom half mile of the project area. Further upstream, Oregon coast coho salmon (*O. kisutch*) (listed as threatened under the Endangered Species Act) will rear in slower moving waters of the new channel, adjacent ponds, and connected flood plain during both summer and winter. Steeper sections of stream channel in the main valley and in three tributary valleys are being restored to provide needed spawning gravels in late fall and early winter for returning adult coho salmon.

Johan Hogervorst

Johan Hogervorst

One hundred-fifty-five whole conifer trees were flown in by helicopter and placed in the flood plain and new channel to increase habitat complexity for aquatic-dependent species and to improve flood-plain interaction during high flow events. Contact Paul Burns (pnburns@fs.fed.us) for more information.

Mean harvest areas declined from 30 ac per watershed per year to 3 ac per watershed per year. These harvest rates are the lowest of any on federal land.

Late-Successional Reserves

Late-successional reserves contain largely old-growth forest and were designated to provide habitat for old-growth-dependent species such as the northern spotted owl (*Strix occidentalis caurina*) (fig. 42). Of the 250 randomly selected watersheds, 63 had more than 50 percent of the area designated as late-successional reserve.

Current Status

Drivers condition scores spanned the full possible range of scores. The drivers condition scores in late-successional reserve watersheds was generally higher than the scores of other federally owned watersheds, with the exception of congressional reserves. About half of the late-successional reserve watersheds had drivers condition scores greater than 0.

Roads—
Riparian road densities in late-successional reserve watersheds ranged from 0.01 to 0.41 mi of road per mile of stream. Sixty-three percent of these watersheds had riparian road densities greater than 0.1 mi of road per mile of stream (fig. 35a). Road crossing frequencies ranged from 0.02 to 4.26 crossings per mile of stream. Forty-three percent of the watersheds had road crossing frequencies greater than one crossing per mile of stream (fig. 35b).

Vegetation—
Riparian area with conifers >20 in d.b.h. ranged from 0.4 to 92 percent in late-successional reserve watersheds. Twenty-four percent of the watersheds had less than 30 percent of the riparian area containing large conifers (fig. 36). Abundance of large trees in the riparian zone was consistent with the abundance in other federally owned watersheds.

Changes Since the Implementation of the Plan

The change in the distribution of the drivers conditions in late-successional reserves was perhaps the most interesting. The entire distribution shifted slightly toward the right, which reflects an overall increase in scores, and the center 50 percent of the distribution became more narrow in range. The median of the distribution was slightly lower in time 2 than it was in time 1 (fig. 43). The seven watersheds that changed by more than 0.3 were all located in late-successional reserves. The positive changes in these watersheds can be attributed to management, specifically road decommissioning, in the watersheds. All of the watersheds that declined in condition were recently burned by wildfires.

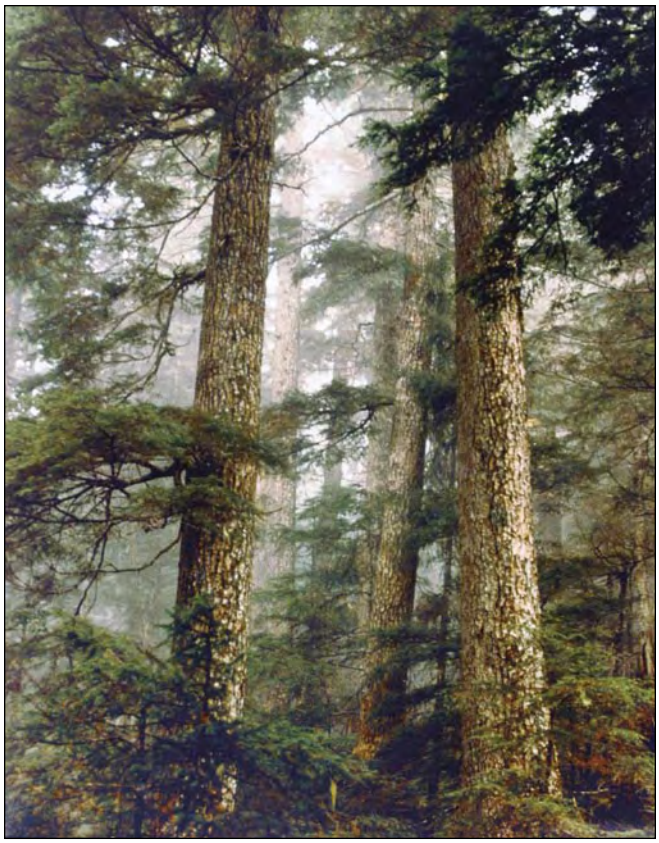

Jon Martin

Figure 42—Late-successional reserves are intended to provide forest habitat for old-growth-dependent species, such as the northern spotted owl.

Roads—
Road condition scores increased in 47 percent of the watersheds and stayed the same in the remainder of the watersheds. Road decommission was conducted in about 40 percent of the watersheds (fig. 38), at an average rate of 2.6 mi of road per watershed (table 5). These average rates were the highest of any on federal land.

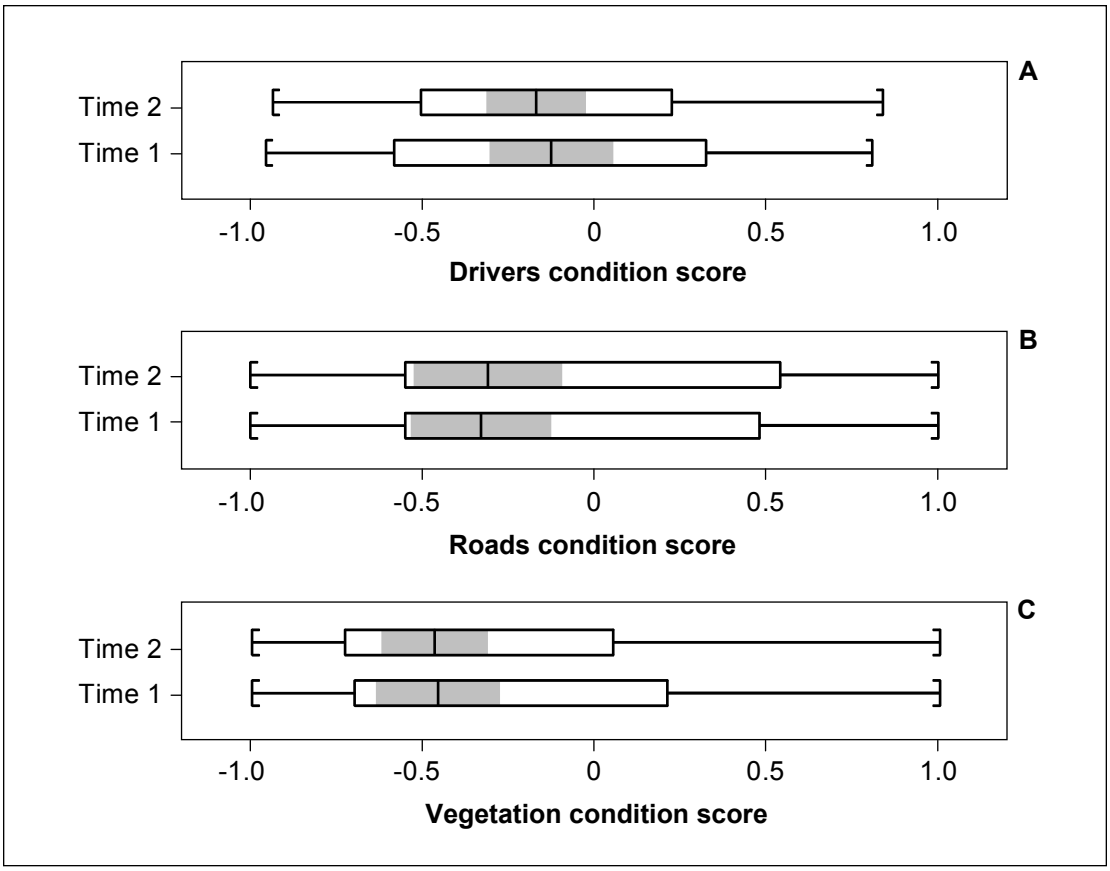


Figure 43—Distribution of (A) drivers, (B) roads, and (C) vegetation condition scores in late-successional reserve watersheds for time 1 and time 2. The distributions are based on 63 of the 250 randomly selected watersheds in the Northwest Forest Plan area that were designated as late-successional reserves. Bars in the center of the boxes represent the median of the distribution, and shading represents the 95 percent confidence interval around the median. Boxes represent the middle 50 percent of the distribution, and the whiskers represent the range of the distribution.

Vegetation—

Vegetation condition scores increased in just over 70 percent of the watersheds, decreased in 8 percent, and stayed the same in the remainder of the watersheds (table 4). The decline in vegetation in the watersheds that had lower condition scores in time 2 was attributed to wildfires that burned 30 to 55 percent of the watershed area. Harvest area was fairly high in late-successional reserves, comparable to those on matrix lands (fig. 39). We recognize that harvest objectives in late-successional reserves differ from those on matrix lands; this analysis considers only the harvest itself, not its objectives. Mean annual harvest rates declined in late-successional reserves from about 67 to 11 ac per watershed per year after the Plan was implemented (table 6).

Al Doelker

Figure 44—Matrix lands are expected to produce most of the timber production from federal lands within the Northwest Forest Plan area.

Matrix

The matrix land use allocation includes all lands not included in one of the other allocations (fig. 44). Riparian reserves are included in this land use allocation because the reserves have not been mapped and we were not able to separate them. Matrix areas were expected to have most of the silvicultural activities, including stand-replacing harvest. Forty-one of the 250 randomly selected watersheds had greater than 50 percent of the area designated as matrix.

Current Status

Drivers condition scores ranged from -0.9 to 0.5 on matrix lands. Matrix lands generally had low condition scores compared with other federally managed lands; about 60 percent of the watersheds had scores less than 0 (fig. 34).

Roads—

Riparian road densities in matrix watersheds ranged from 0.07 to 0.33 mi of road per mile of stream. Ninety-three percent of these watersheds had riparian road densities greater than 0.1 mi of road per mile of stream (fig. 35a). Road crossing frequencies ranged from 0.5 to 2.6 crossings per mile of stream. Eighty-three percent of the watersheds had road crossing frequencies greater than one crossing per mile of stream (fig. 35b).

Vegetation—

Riparian area with conifers >20 in d.b.h. ranged from 1.2 to 83 percent in matrix watersheds. Seventeen percent of the watersheds had less than 30 percent of the riparian area containing large conifers (fig. 36).

Mill Creek, Klamath National Forest, California

Fish passage—

The Mill Creek Ford on the Klamath National Forest was rehabilitated to remove a barrier that restricted passage to 5 mi of stream for fish and other aquatic species. This crossing is on a road very popular for sight seeing, hunting, hiking, bicycling, and as an equestrian route to local neighborhoods around Happy Camp, California. The road also provides administrative access into the area for fire suppression and resource protection.

Allan Olson

Old: The old concrete box culvert (left) blocked natural flow at the inlet and always created a buildup of debris. The outlet had eroded the streambed down about 2 ft below the concrete bottom. The narrow 5-ft restriction of the old culvert increased the water velocity to the point that fish and other aquatic species were unable to travel upstream.

Allan Olson

New: The new 20-ft, open-bottomed arch culvert (right) provides coho, steelhead, resident rainbow, Pacific lamprey, and Pacific giant salamanders (*Dicamptodon tenebrosus*) with unrestricted access to 5 mi of upstream habitat. Contact Jack West (jwest@fs.fed.us) for more information.

Changes Since the Implementation of the Plan

Just over half of the watersheds in matrix lands had higher drivers condition scores in time 2 than they did in time 1 (table 4). This change resulted in a small positive shift in the distribution of drivers condition scores on matrix lands (fig. 45). None of the watersheds had lower condition scores in time 2 than they did in time 1.

Roads—

Roads condition scores increased in 32 percent of the watersheds in the last 10 years (table 4). Decommissioning was conducted in about 40 percent of the watersheds in matrix lands (fig. 38). Average decommissioning rates within these watersheds was about 2.5 mi (table 5).

Vegetation—

Vegetation condition scores increased in just over half of the matrix watersheds in the last 10 years (table 4). The number of acres harvested was the highest in matrix lands when compared with the other federal land use allocations (fig. 39), as would be expected under the Plan. Mean harvest rates were 21 ac per watershed per year, down from over 70 ac per year prior to implementation of the Plan (table 6).

Nonfederal Lands

Lands that are not federally owned are not subject to the management guidelines included in the Plan. However, because ownership is mixed in many of the watersheds, it is important to note the contribution federal lands are making to the condition of watersheds as a whole. Forty-five of the 250 randomly selected watersheds had more than 50 percent of the area not federally owned.

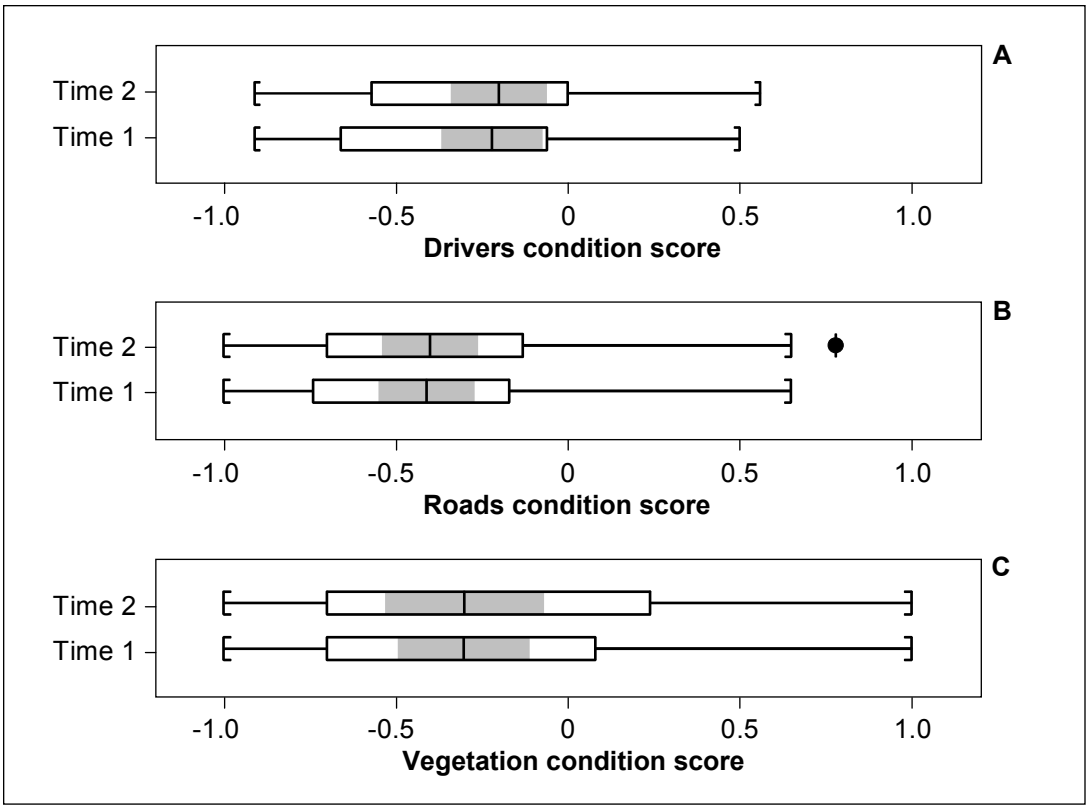


Figure 45—Distribution of (A) drivers, (B) roads, and (C) vegetation condition scores in matrix watersheds for time 1 and time 2. The distributions are based on 41 of the 250 randomly selected watersheds in the Northwest Forest Plan area that were designated as matrix. Bars in the center of the boxes represent the median of the distribution, and shading represents the 95 percent confidence interval around the median. Boxes represent the middle 50 percent of the distribution, and the whiskers represent the 95th quantiles. Dots represent outliers.

Current Status

Drivers condition scores in watersheds that are predominantly nonfederal ranged from -1 to 0.2. Only 5 of the 45 watersheds had drivers condition scores higher than 0 (fig. 34). Overall, nonfederal watersheds had the lowest condition scores of the land use allocations.

Roads—

Watersheds that contained more than 50 percent nonfederal lands had the highest road densities of the watersheds. Riparian road densities in nonfederal watersheds ranged from 0.05 to 0.41 mi of road per mile of stream. Ninety-six percent of these watersheds had riparian road densities greater than 0.1 mi of road per mile of stream (fig. 35a). Road crossing frequencies ranged from 0.3 to 3.1 crossings per mile of stream. Eighty percent of the watersheds had road crossing frequencies greater than 1 crossing per mile of stream (fig. 35b).

Vegetation—

Riparian area with conifers >20 in d.b.h. ranged from 3 to 74 percent in nonfederal watersheds. Sixty-two percent of the watersheds had less than 30 percent of the riparian area containing large conifers (fig. 36).

Changes Since the Implementation of the Plan

One-third of the predominantly nonfederal watersheds had higher drivers condition scores in time 2 than in time 1 (table 4). Drivers condition scores did not change in the remainder of the watersheds. The distribution of drivers condition scores moved slightly toward higher scores (fig. 46).

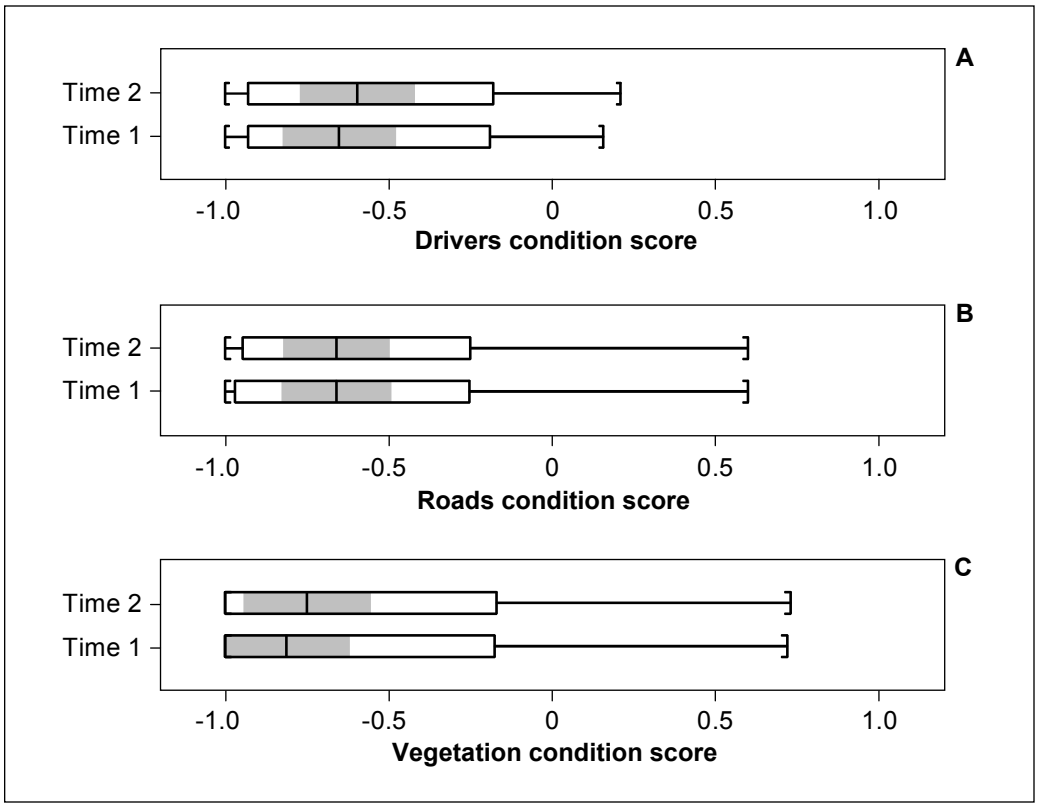


Figure 46—Distribution of (A) drivers, (B) roads, and (C) vegetation condition scores in watersheds that were predominantly nonfederal for time 1 and time 2. The distributions are based on 45 of the 250 randomly selected watersheds in the Northwest Forest Plan area. Bars in the center of the boxes represent the median of the distribution, and shading represents the 95 percent confidence interval around the median. Boxes represent the middle 50 percent of the distribution, and the whiskers represent the range of the distribution.

Roads—
Road condition increased in 36 percent of the watersheds by at least 0.1 (table 4). The number of road miles decommissioned averaged about 2, which was consistent with the average across the Plan area (fig. 38, table 5).

Vegetation—
Vegetation condition scores increased in 27 percent of the watersheds; and stayed the same in the remainder (table 4). More acres of timber were harvested on nonfederal watersheds than in any of the other land use categories (fig. 39).

In general, watersheds that are predominantly nonfederal have the lowest condition scores of all of the watersheds, notably worse than predominantly federal watersheds (fig. 34). The percentage of federal land appears to have little effect on drivers condition scores for the present period (fig. 47). Although the relationship is statistically significant ($t = 8.97$, $df = 248$, $p < 0.01$), the percentage of federal ownership explains only 25 percent of the variance in drivers condition score. When land use allocation is added to the analysis as a covariate, federal ownership explains 37 percent of the variance in drivers condition scores. These results suggest that drivers condition scores are influenced by factors other than the management applied to the watershed.

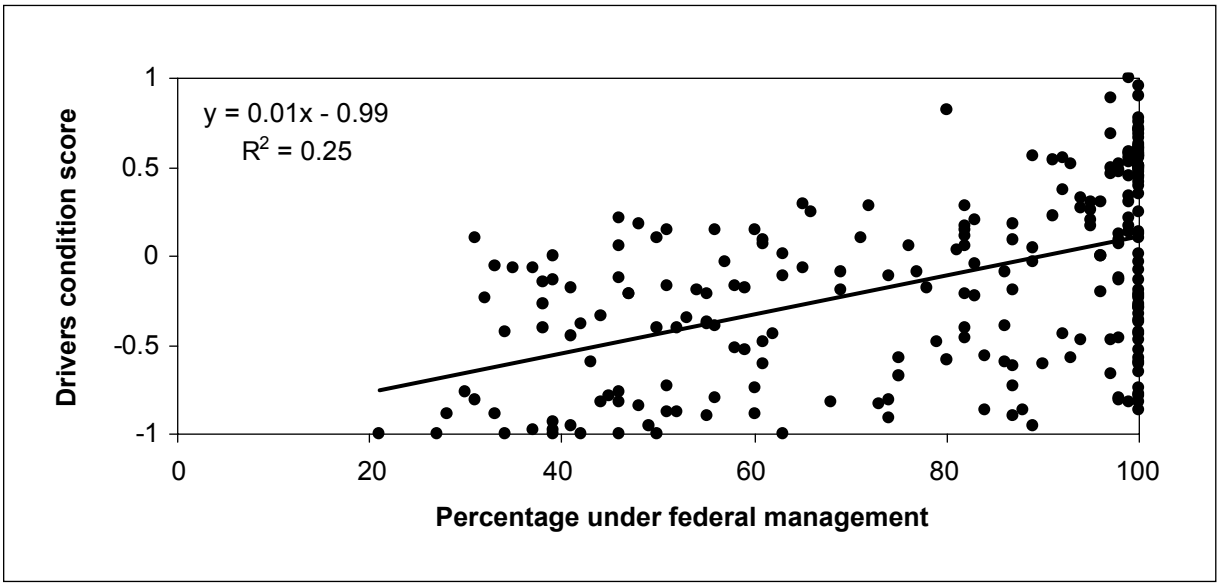


Figure 47—Relation between percentage of the watershed under federal management and the time 2 drivers condition scores based on 250 randomly selected watersheds in the Northwest Forest Plan area.

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