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Combining Silviculture and Landscape Architecture to Enhance the Roadside View

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Abstract

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On a high-quality site in the mixed conifer forest of northern California, understory and overstory vegetation along a 3-mile paved county road were manipulated to enhance the view for the traveler. Traditional silvicultural cutting methods and landscape architectural techniques were blended to give contrast and variability to the vegetation along both sides of the highway. Understory vegetation (hardwoods, shrubs, forbs, graminoids, ferns, conifer seedlings); saplings (hardwoods, conifers, shrubs); and trees (California white fir, sugar pine, coast Douglas-fir, incense-cedar, California black oak, ponderosa pine, and Pacific dogwood) were sampled before logging, after logging, after brush disposal, and 6 years later in 10 distinct visual segments along the road and in a control (untreated area). Measurements included density, foliar cover, height, basal area, and basal area growth. Plant diversity also was quantified. Major findings were that although the hardwoods and shrubs obscured about 25 percent of the view 6 years after brush disposal, the view is still vastly improved over what it was before. And with careful logging and other vegetation management, the roadside stand can yield both pleasing scenery and timber.

Retrieval Terms: landscape management, mixed conifer forest, northern California, plant community dynamics, stand growth, view enhancement

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Contents

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Introduction

Millions of people annually travel America's highways for business and pleasure. Some travelers stare straight ahead engrossed in inner thoughts, but others look forward to the trip. To them, getting there is half the fun. For many, a changing sequence of pleasing views makes the difference between an ordinary trip and a special one. But creating a pleasing view often requires skill and hard work, and manipulating the trees and understory vegetation can be expensive. To what end? Does Mother Nature fill new views with vegetation? If so, how long does it take (*fig. 1*)? Is the vegetation that comes back the same as that which was present before?

Pleasing scenery has long been recognized as a major "yield" from forest land. The National Environmental Policy Act of 1969 and later the Forest and Rangeland Renewable Resource Planning Act of 1974 and the National Forest Management Act of 1976 assured productive and esthetically pleasing forests. And ecosystem management, which is now the operational paradigm for managing forest land,

A

B

Figure l—A typical sprout clump of shrub tanoak about 20 feet from the highway (A) after shrub disposal in August 1979, and (B) 3 years later in September 1982. The clump is 8 feet in diameter with stems 5.5 feet tall.

involves a major social (human) component. Amenity and spiritual values are part of this component. If the scenery along the road is pleasing to the traveler, then traveling across the landscape also is enjoyable. Not only does enhancement of the roadside zone fulfil the social component of ecosystem management, it also addresses two key provisions that are increasingly being recognized as needed. These are to manage larger areas for longer periods of time. Kimmins (1971) recognized this in his "roadside ecosystem." A longer time frame is important, because it suggests that the high cost of initially creating a scenic roadside landscape can be amortized over many acres of land for many years.

A major challenge facing landscape architects in the roadside zone, and indeed in the forest in general, is that society wants pleasing scenery, but does not recognize that it must be created and maintained—and paid for. Placing a monetary value on such amenity values as pleasing scenery or spiritual enlightenment is difficult. Brown (1987) noted that information about monetary value and other outputs for scenic beauty are not available.

Removing trees and shrubs in a too-dense stand means that more site resources should be available for those trees that remain. If they grow faster, revenues from this additional growth can be used to offset the cost of understory manipulation. Consequently, in this study, a specific goal addressed stand growth: how many trees of what species and size class remained after logging, and how did they respond to harvesting and the removal of understory vegetation?

An additional goal was to put the cost/view-enhancement/roadside logging operation in perspective. Understandably, forest management in the roadside zone has been nonexistent or "gentle" and often limited to cutting hazardous trees and thinning some trees around curves for safety. Worse yet, an unmanaged strip next to the road sometimes is left to hide unsightly human impacts beyond it. Manipulating vegetation in the roadside zone is easily seen and open to public scrutiny and criticism. Consequently, the roadside stand on federal land often is viewed by the timber industry as being "locked up." Local sawmills cannot count on trees from the roadside zone. In this paper, we suggest that the roadside zone can be logged and logged well, with pleasing scenery and wood products being dual yields from the land. Furthermore, some excess trees have been removed, and the remaining trees should be more healthy and less susceptible to future damage. And because fuels and fuel ladders have been reduced, future view-maintenance operations such as prescribed burning are now feasible. After presenting some ecological, social, and environmental considerations on highway right-of-ways, Young (1973) asked: "Why not a [managed] forest 50 feet wide and 150 miles long?"

This paper describes a study that combined traditional silvicultural cutting methods and landscape architectural techniques to enhance the roadside view on the Plumas National Forest in northern California.

Location and Study Design

Located on the USDA Forest Service's Plumas National Forest in northern California, the county road that runs through the study area is a gateway to rugged country that offers many wildland recreation opportunities. Our study involved both sides of 3 miles of road which was paved, two-lane, and curving, with numerous dips and rises. A prudent driving speed would average about 35 miles per hour. Potential views ranged from 100 to 500 feet of visual penetration and encompassed 176 acres. Within this travel influence zone, 10 landscape control units were located, each identifying a distinct visual reach (*fig. 2*). They denoted a range of highway segments of 0.1 to 0.6 mile and units of 5 to 35 acres.

The treatment in each landscape control unit involved using classical silvicultural cutting methods to accomplish landscape architecture goals. Each treatment took advantage of the vegetation that was there and either left it unaltered or modified it to be unique (*fig. 3*). Treated vegetation also had to blend

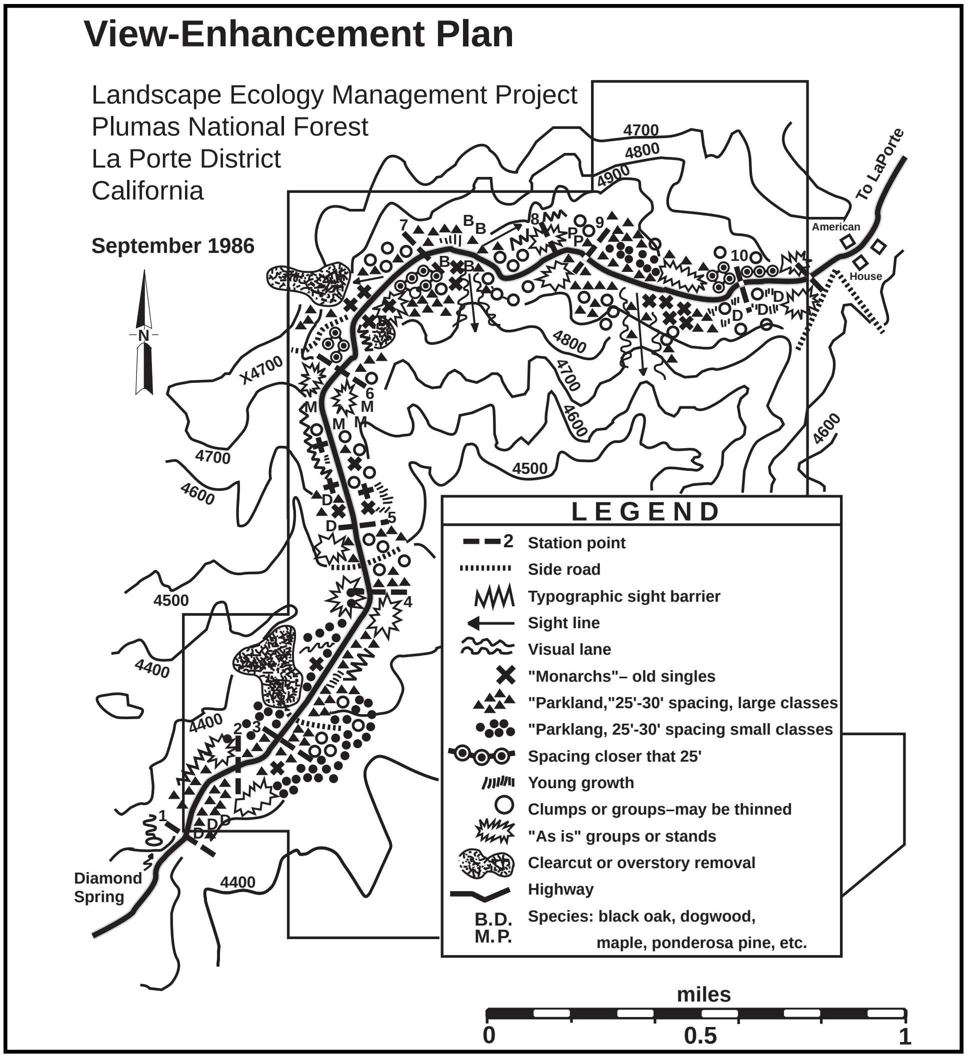


Figure 2—Schematic of prescriptions and landscape control areas (numbers 1 to 10) for improving the view of the traveler, Plumas National Forest, California.

Figure 3—The widely spaced young trees give the traveler not only a view of the contrasting older trees, but also the comfort of forest renewal.

into adjacent units and fit the character of the highway. Logging and cutting of understory vegetation were the means for accomplishing the view-enhancement prescriptions. National Forest foresters and crews were in charge of these operations. Single-tree selection, group selection, shelterwood, and clearcutting were employed (U.S. Department of Agriculture 1977). In places, a single large tree or group of trees was featured; in others, areas were modified to give a parklike appearance of open-spaced trees (*fig. 4*) or to form a stand composed of widely separated groups of trees. In still others, the stand was opened up to provide safety around curves (*fig. 5*) or held dense to provide contrast to forthcoming views. In

Figure 4—This parklike stand features large, tall trees and suggests a healthy forest.

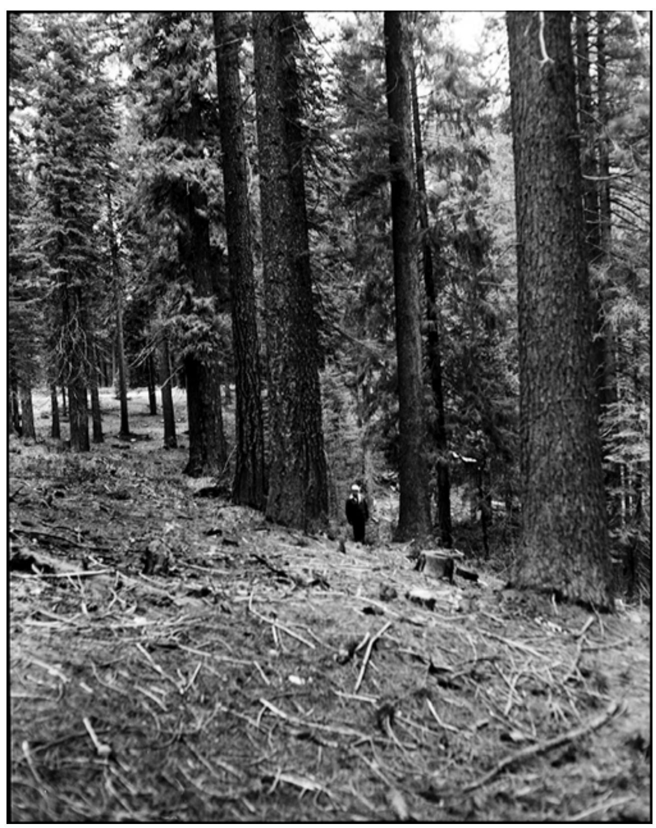


Figure 5—Not only do travelers see a clean foreground and large trees, they also get a glimpse of oncoming traffic in the curve (left center of the photo).

many places, visual lanes that extended the view were created (*fig. 6*). Distinct assemblages of vegetation that provided contrast and variability also were favored. Colorful hardwoods, which give accent to spring and contrast and beauty to fall, were retained alone or with conifers (*fig. 7*). In one unit, dogwoods in the lower stratum were featured to provide contrast with overstory conifers.

Typical of timber stands in the mixed conifer forest cover type of the Sierra Nevada (Tappeiner 1980), overstory species (taxonomy from Little 1979), in decreasing order of abundance, were California white fir (*Abies concolor* var. *lowiana*) [Gord.] Lemm.), sugar pine (*Pinus lambertiana* Dougl.), incense-cedar

Figure 6—This large sugar pine can now be fully seen by cutting a visual lane from the road to its base.

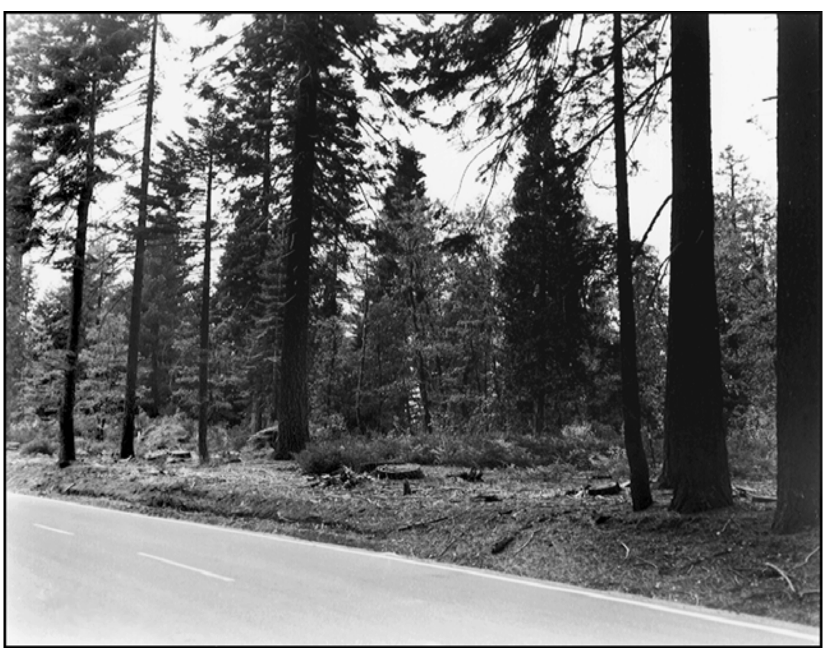


Figure 7—Heavy cutting in the foreground has freed the hardwoods in the background and provided a pleasing color contrast, especially in the spring and fall.

(*Libocedrus decurrens* Torr.), coast Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco var. *menziesii*), California black oak (*Quercus kelloggii* Newb.), and ponderosa pine (*Pinus ponderosa* Dougl. ex Laws. var. *ponderosa*). Most of these species and Pacific dogwood (*Cornus nuttallii* Audubon) also occupy the middle stand stratum, whereas white fir, incense-cedar, and woody shrubs (taxonomy from Hickman 1993) such as shrub tanoak (*Lithocarpus densiflorus* [Hook. & Arn.] Rehder var. *echinoides* [R.Br. Campst.] Abrams), golden chinkapin (*Castanopsis chrysophylla* [Hook.] Hjelmq. var. *minor* [Benth.] Munz), California hazel (*Corylus cornuta* var. *californica* [A. DC.] Sharp), and Sierra coffeeberry (*Rhamnus rubra* E. Greene), plus numerous herbaceous species, reside in the understory.

Deep soil, plentiful rainfall, and moderate temperatures combined to make this a high-quality site for growing several species of trees (Biging and Wensel 1984). As observed in road cuts, the soil is at least 5 feet deep, of loam-clayloam texture, and moderately well drained. Precipitation averages about 80 inches per year, with more than 100 inches annually being fairly common. The average annual temperature is about 50°F with the frost-free season averaging 150 days. The elevation ranges from 4,475 to 4,975 feet.

Because of this favorable environment, the forested stands consist of many plant species, several size classes, and high densities. The trees and shrubs tend to grow to the edge of the highway and create a monotonous view (*fig. 8*) that lacks contrast and variability—the keys to a pleasing visual experience (Litton 1975, U.S. Department of Agriculture 1995).

Local residents and visiting recreationists had a stake in the study, and needed to be informed of study goals, the amount of cutting, and the overall look of the forest after harvesting and slash disposal. Before cutting commenced, the public was invited to a widely advertised "town meeting" that resulted in general approval, but one expression for no cutting. Although an on-the-ground tour of the area with the no-cut people was held, the question of cutting was never fully resolved. From then on, liaison with the public was generally with individuals and groups who expressed interest in the area and study. After the work was completed, comments received by the Forest Service were

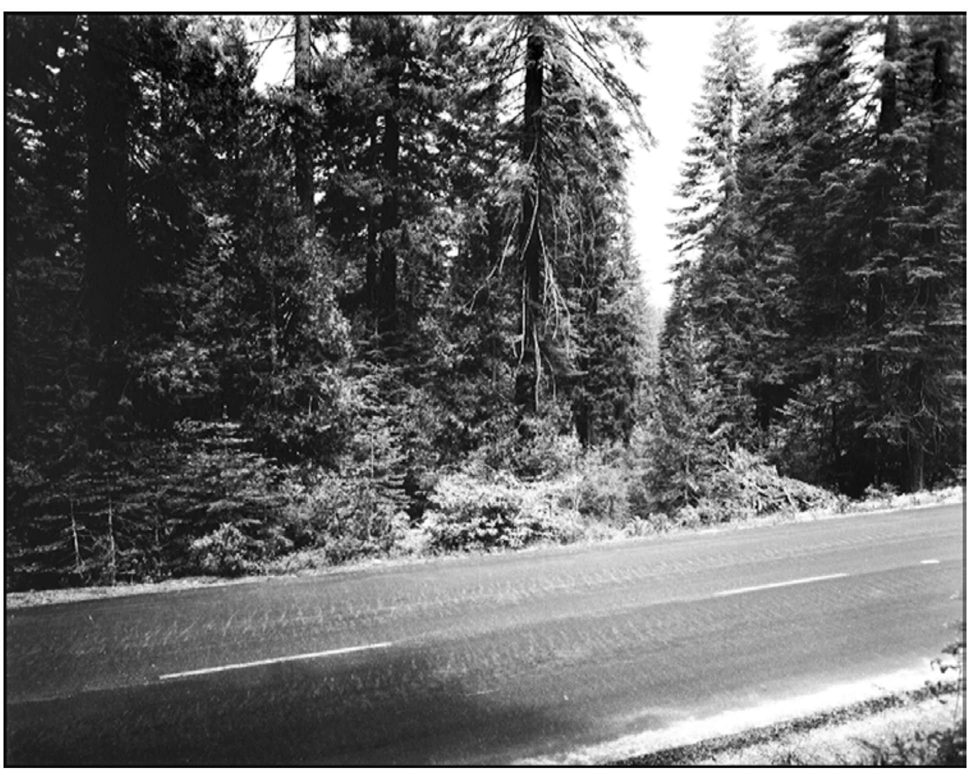


Figure 8—This stand, typical of so many in the forests of northern California, crowds the highway and severely limits the view.

overwhelmingly favorable. National Forest foresters commented on the increased number of photos of study segments being taken by the public.

Logging of conifer trees larger than 12 inches in breast-height diameter began in May 1976 and was completed in fall 1977. About 5 million board feet of timber and 160 cords of fuelwood were harvested with a value of about $450,000. The number of trees (defined as having a diameter of 3.5 inches or larger) in each landscape control area ranged from 80 to 280 per acre and basal areas from 150 to more than 400 ft^2 per acre after logging. Brush disposal, which consisted of cutting and piling smaller trees and shrubs for eventual burning, was completed in July 1980.

Sampling and Analysis

Vegetation in this study was divided into two major parts: plant community dynamics (understory and saplings) and stand dynamics (trees).

In the understory portion of the study, the vegetation, which was defined as being less than 4.5 feet tall, included shorter conifers, hardwoods, and shrubs; forbs, graminoids (grasses and sedges), and bracken fern. Saplings were defined as being more than 4.5 feet tall and less than 3.5 inches in diameter, and included several species of conifers, hardwoods, and shrubs. Saplings were measured on 0.25-acre plots, randomly located in each unit. Because of vegetational differences, one large unit was represented by four 0.25-acre plots. Understory vegetation was measured on five circular milacre subplots randomly located in each plot. A randomly selected untreated control provided comparison to the view-enhancement areas. For understory vegetation, density, foliar cover (the sum of shadows that would be cast by leaves and stems of individual species expressed as a percentage of the land surface [Daubenmire 1968]), and average dominant height (average of three tallest stems measured from mean groundline to bud) were measured. These parameters were recorded for each species and then combined into vegetation classes such as hardwoods, shrubs, and forbs. For saplings, density and stem height and diameter were quantified. All plant species were recorded at the beginning and end of the study and at various other times.

After extensive reconnaissance, we determined that it was the shrubs and hardwoods that blocked most of the potential view, at least in the critical foreground. We then calculated the combined shrub and hardwood volume (foliar cover times height) for each plot and ranked all plots by this measure. Because other foresters and landscape architects could have differing amounts of view-blocking plant volume in their areas, we then combined plots into "high-," "medium-," and "low-volume" categories after brush disposal in fall 1980. These designations are referred to in text and tables as "shrub volume" categories, although hardwoods were included. Based on our calculated values, high volume ranged from 5,100 to 37,240 ft^3 per acre, medium from 872 to 3,080 ft^3 per acre, and low from 0 to 120 ft^3 per acre. Number of plots by category was high, 4; medium, 5; and low, 4.

In the stand dynamics portion of the study, all trees larger than 3.5 inches in diameter were tagged and measured on the same 0.25-acre plots in each landscape control area where the saplings were located. And as before, an uncut control provided comparison to the view-enhancement areas.

Because other foresters and land managers could have differing amounts and kinds of trees in their roadside areas, we combined plots into "high," "medium," and "low" categories on the basis of before-logging basal area. Based on our calculated values, high basal area ranged from 392 to 460 ft^2 per acre; medium from 316 to 380, and low from 279 to 307 ft^2 per acre. Number of plots by category was high, 5; medium, 5; and low, 4.

Plant Community Dynamics

Understory Vegetation

Before logging, the understory vegetation consisted of 9 shrubs, 10 forbs, 1 graminoid (grasses and sedges), bracken fern, 3 hardwoods, and 5 conifers for a total of 29 species. By the end of the study in 1986, the total number of species had increased to 36 plus one species of grass that had been seeded in the skid roads for erosion control. New species were those that took advantage of the soil bared in logging. No naturally seeded alien species were detected at any time. Ten species occupied the control from the beginning to end of the study. All were adapted to an environment of deep shade and a thick layer of organic matter on the forest floor.

Hardwoods, shrubs, forbs, ferns, and conifers were well represented in all three shrub-volume categories in the before-logging (1976) plant community (*table 1*). Forbs, and specifically western star flower (*Trientalis latifolia* Hook.), were particularly abundant. Graminoids were generally absent. After logging (1977), all classes of vegetation generally increased. Graminoids in the high- and low-shrub-volume categories increased dramatically from almost none to more than 10,000 plants per acre. Overall, plant density increased 41 percent after logging.

After brush disposal (1980), most classes of vegetation decreased in density, particularly in the high- and low-shrub-volume categories (*table 2*). Shrubs in the high-shrub-volume category and forbs and graminoids in the medium category, which gained 63, 38, and 3600 percent, respectively, were notable exceptions. These increases were large enough to outweigh the decreases, and total plant density increased 2 percent after brush disposal.

Table 1—Average density of understory vegetation before and after logging, Plumas National Forest, California, 1976-1977

Shrub volume	Vegetation class	Before logging		After logging	
		Mean	SE	Mean	SE
		number/acre			
High	Hardwoods	1,386	694	2,650	1,284
	Shrubs	4,688	1,518	6,300	2,044
	Forbs	25,238	6,761	24,600	3,627
	Graminoids	0	-	10,500	4,113
	Ferns	1,150	456	2,050	929
	Conifer seedlings	1,362	440	2,500	1,377
	Total	**33,824**		**48,600**	
Medium	Hardwoods	310	236	440	204
	Shrubs	4,960	1,884	7,480	2,473
	Forbs	11,580	3,344	17,080	8,102
	Graminoids	0	-	40	40
	Ferns	3,380	2,444	5,360	3,330
	Conifer seedlings	880	508	960	331
	Total	**21,110**		**31,360**	
Low	Hardwoods	150	79	760	371
	Shrubs	1,520	320	3,120	700
	Forbs	11,610	3,913	16,040	5,033
	Graminoids	10	10	12,000	8,000
	Ferns	590	287	2,400	1,911
	Conifer seedlings	800	165	920	196
	Total	**14,680**		**35,240**	

Six years after brush disposal (1986), the density of almost all classes of vegetation had increased, in many instances from two to ten times (*table 2*). Forbs in the high-shrub-volume category, graminoids in the medium category, and forbs and bracken fern in the low category increased the most. The largest increases, which occurred in all three shrub-volume categories, were in conifer seedlings. They apparently had benefitted from the disturbed ground and increased resources brought about by logging and brush disposal. The only large decrease was for graminoids in the low-shrub-volume category. Total plant density increased 44 percent during the 6-year period. Foliar cover, which provides a conservative estimate of horizontal development, ranged from 0 to 6 percent among vegetation classes just after brush disposal and from 0 to 17 percent after 6 years (*table 3*). These low values reflect the shady environment and understory status of the vegetation. Mean height of understory vegetation also generally increased after brush disposal. At the end of the study in 1986, hardwood height ranged from 2.0 to 5.0 feet among shrub-volume categories, shrubs from 0.5 to 1.7 feet, and graminoids from 0.7 to 3.2 feet tall (*table 4*). Hardwood and shrub height increased the most with hardwoods gaining 35, 267, and 233 percent in high-, medium-, and low-shrub-volume categories, respectively. Shrub height increased 88 percent in the high-shrub-volume category and 70 percent in the medium category. Decreases in average height occurred in forbs and conifer seedlings and were attributed to the lower height of the many new plants noted in *table 2*.

The height values in *table 4* do not fully show the effect of the vegetation on the view. Each vegetation class is an average, and the hardwoods and shrubs, as examples, include both tall and short species. It is not the species of

Table 2—Average density of understory vegetation after brush disposal and 6 years later, Plumas National Forest, California, 1980 and 1986

Shrub volume category	**Vegetation class**	**After brush disposal**		**After 6 years**	
		Mean	**SE**	**Mean**	**SE**
		number/acre			
High	Hardwoods	1,850	479	2,550	472
	Shrubs	10,300	6,773	9,400	5,679
	Forbs	23,450	8,779	55,950	22,288
	Graminoids	7,550	4,761	8,050	5,024
	Ferns	1,850	532	2,100	881
	Conifer seedlings	1,550	690	8,350	2,274
	Total	**46,550**		**86,400**	
Medium	Hardwoods	760	621	1,160	717
	Shrubs	5,213	2,331	6,080	2,170
	Forbs	23,560	11,398	33,160	13,119
	Graminoids	1,480	995	3,041	2,150
	Ferns	3,440	3,095	4,200	2,631
	Conifer seedlings	920	377	3,480	1,253
	Total	**35,373**		**51,121**	
Low	Hardwoods	160	75	120	49
	Shrubs	1,240	325	1,640	382
	Forbs	11,800	6,859	21,000	10,500
	Graminoids	4,400	4,400	1,400	1,205
	Ferns	1,080	981	2,480	2,480
	Conifer seedlings	320	185	4,240	1,963
	Total	**19,000**		**30,880**	

Table 3—Average foliar cover of understory vegetation after brush disposal and 6 years later, Plumas National Forest, California, 1980 and 1986

Shrub volume category	Vegetation class	After brush disposal Mean	After brush disposal SE	After 6 years Mean	After 6 years SE
		----- pct -----			
High	Hardwoods	6	3	17	5
	Shrubs	3	2	7	3
	Forbs	1	<1	4	2
	Graminoids	1	<1	2	1
	Ferns	<1	<1	1	<1
	Conifer seedlings	<1	<1	1	1
	Total	**12**		**32**	
Medium	Hardwoods	<1	<1	7	3
	Shrubs	3	1	9	3
	Forbs	2	1	4	2
	Graminoids	<1	<1	<1	<1
	Ferns	1	1	3	2
	Conifer seedlings	<1	<1	1	1
	Total	**8**		**25**	
Low	Hardwoods	0	-	0	-
	Shrubs	<1	<1	1	<1
	Forbs	1	1	4	3
	Graminoids	1	1	<1	<1
	Ferns	<1	<1	2	2
	Conifer seedlings	0	-	0	-
	Total	**3**		**8**	

Table 4—Average height of understory vegetation after brush disposal and 6 years later, Plumas National Forest, California, 1980 and 1986

Shrub volume category	Vegetation class	After brush disposal Mean	After brush disposal SE	After 6 years Mean	After 6 years SE
		----- ft -----			
High	Hardwoods	3.7	1.2	5.0	1.5
	Shrubs	0.8	0.2	1.5	0.4
	Forbs	0.3	0.1	0.3	0.1
	Graminoids	1.6	0.5	2.0	0.6
	Ferns	0.7	0.1	1.0	0.1
	Conifer seedlings	0.9	0.4	0.7	0.5
Medium	Hardwoods	0.9	0.2	3.3	2.3
	Shrubs	1.0	0.2	1.7	0.2
	Forbs	0.3	<0.1	0.4	0.1
	Graminoids	1.5	1.2	3.2	0.2
	Ferns	0.9	0.1	1.1	0.2
	Conifer seedlings	1.1	0.4	0.7	0.2
Low	Hardwoods	0.6	0.1	2.0	1.1
	Shrubs	0.5	0.1	0.5	0.2
	Forbs	0.6	0.2	0.3	0.1
	Graminoids	0.4	0.4	0.7	0.1
	Ferns	0.3	0.1	0.9	0.9
	Conifer seedlings	0.3	0.1	0.3	<0.1

average height that travelers see as they speed by, but the tallest species. For the three shrub-volume categories, the range in height (feet) for tallest hardwoods and shrubs was:

Shrub-volume category	Hardwoods	Shrubs
High	5.2 - 11.0	2.7 - 4.7
Medium	1.7 - 7.0	2.0 - 4.4
Low	1.6 - 3.9	0.7 - 2.2

After the vegetation in all the shrub-volume categories was totalled and averaged, it provided a contrast to the uncut control. In general, all classes of vegetation were well represented in the view-enhancement plots, but less so in the control (*table 5*). The control was characterized by large numbers of shrubs and forbs, plus a few ferns and conifer seedlings. Altogether, there were 53,973 plants per acre in the view-enhancement plots and 77,800 plants per acre in the control. Much of the density was by the ubiquitous western star flower. Foliar cover followed a similar trend in both treated plots and control. In the treated plots, almost all vegetation classes supported some cover; in the control only shrubs and forbs provided cover. Average height of vegetation in treated plots and control showed no specific trend: ferns and conifer seedlings were taller in treated plots; shrubs and forbs were taller in the control. The tallest shrubs in the control averaged 3.3 feet.

Table 5—Density, foliar cover, and height of understory vegetation 6 years after brush disposal for treated plots and control, Plumas National Forest, California, 1986

Variable	Vegetation class	Treated plots	Control	Treated plots	Control
		---------- Means ---------		----- Standard errors ----	
Density		---------- *number/acre* ----------			
	Hardwoods	1,186	0	379	-
	Shrubs	5,443	16,000	1,847	1,000
	Forbs	35,329	60,200	8,883	5,271
	Graminoids	3,886	0	1,703	-
	Ferns	2,986	1,400	1,246	120
	Conifer seedlings	5,143	200	1,123	0
	Total	**53,973**	**77,800**		
Foliar cover		---------- *pct* ----------			
	Hardwoods	8	0	3	-
	Shrubs	6	28	2	3
	Forbs	4	9	1	1
	Graminoids	<1	0	<1	-
	Ferns	2	0	1	-
	Conifer seedlings	<1	0	<1	-
	Total	**21**	**37**		
Height		---------- *ft* ----------			
	Hardwoods	3.6	0	0.9	-
	Shrubs	1.3	2.5	0.1	0.6
	Forbs	0.4	0.5	<0.1	<0.1
	Graminoids	1.8	0	0.4	-
	Ferns	1.0	0.7	0.1	<0.1
	Conifer seedlings	0.6	0.1	0.2	<0.1

Saplings

Most saplings in this study were characterized as being shade tolerant, small, and extremely slow growing. The conifers tended to have sparse, flat sprays of needles; the hardwoods, dense masses of leaves. The conifers tended to be scattered; the hardwoods and shrubs, more clumpy. Where scattered, the saplings posed no immediate threat to the view, but where clumpy they limited the view for the highway passers-by.

After logging, conifer, hardwood, and shrub saplings in the high-shrub-volume category decreased from 123 to 109 per acre; in the medium category decreased from 170 to 129 per acre; and in the low category increased from 35 to 52 per acre. Six years after brush disposal, the conifers showed only minor changes among shrub-volume categories (*table 6*). But the hardwoods exploded. In the high-shrub-volume category, hardwoods increased from 30 to 661 per acre and, in the medium category, from 9 to 259 per acre. Change in the low-shrub-volume category was minor. Overall, the conifer, hardwood, and shrub saplings increased 10-fold between 1980 and 1986 in the high-shrub-volume category and 5-fold in the medium category.

Table 6—Mean density (standard error) of conifer, hardwood, and shrub saplings after brush disposal and 6 years later, by shrub volume category and control, Plumas National Forest, California, 1980 and 1986

Shrub volume category	Conifers		Hardwoods		Shrubs		Total	
	1980	1986	1980	1986	1980	1986	1980	1986
	number/acre							
High	45 (27)	55 (35)	30 (19)	661 (87)	0 -	39 (14)	75 (28)	755 (121)
Medium	50 (36)	58 (43)	9 (6)	259 (95)	5 (5)	3 (2)	64 (42)	320 (252)
Low	27 (23)	24 (18)	0 -	12 (12)	0 -	0 -	27 (23)	36 (18)
Control	**184**	**168**	**0**	**0**	**24**	**32**	**208**	**200**

Stand Dynamics

Effect of Cutting

Communication between the Plumas National Forest sale administrator, logger, and researcher was critical to accomplishing view-enhancement and research goals. In this study, meetings, phone calls, and on-the-ground communication resulted in "one of the best logging jobs ever seen," according to National Forest timber sale administrators. Several special view-enhancement provisions that hid skid roads and minimized skinned-up trees were carried out successfully. Plainly, the logger wanted this area to look good and to be proud of the outcome.

Before logging, the forest stand was composed mostly of California white fir and incense-cedar, with sugar pine a distant third (*table 7*). After logging and brush disposal, only minor changes occurred in the composition of the stand. Sugar pine and white fir each increased 3 percent, and incense-cedar decreased 7 percent. When portrayed by diameter classes, the stand typically was made up of many small trees and a decreasing number of progressively larger trees (*table 8*). Cutting was heaviest in the smallest classes and lightest in the largest classes. When density was averaged over all before-logging basal-area categories, trees in the 3.5-

to 12-inch diameter class lost 13 percent of their number, and those in the 12.1- to 20-inch class lost 1 percent. Conversely, trees in the 20- to 40-inch diameter range gained 13 percent, and those above 40 inches in diameter gained 1 percent.

Basal areas showed generally similar trends. Before logging, white fir, with more than 226 ft^2 per acre, had more than twice as much basal area as any other species (*table 9*). Sugar pine and incense-cedar ranked second and third with almost 82 ft^2 and more than 78 ft^2 per acre, respectively. After logging and brush disposal, white fir continued to dominate in this respect. When averaged over all before-logging basal-area categories, the species that gained the most basal area per acre was sugar pine (5 percent), and the species that lost the most was incense-cedar (4 percent). White fir also lost 1 percent of its basal area because of cutting. When arrayed by diameter classes, more than 50 percent of the basal area in the stand was in the 20- to 40-inch class (*table 10*). This was true before logging and continued after brush disposal, at least in the high and low before-logging basal-area categories. Overall, basal area per acre decreased 11 percent in the two smallest diameter classes and increased an equal amount in the two largest classes. The largest increase was in the 20- to 40-inch class.

Table 7—Average tree density by species and before-logging basal-area category (high, medium, low) before logging (BL), after logging (AL), and after brush disposal (ABD), Plumas National Forest, California, 1976-1980

Species	**High**			**Medium**			**Low**		
	BL	**AL**	**ABD**	**BL**	**AL**	**ABD**	**BL**	**AL**	**ABD**
	number/acre								
Douglas-fir	15	13	10	4	4	3	2	1	1
Ponderosa pine	1	0	0	7	6	4	2	3	2
Sugar pine	20	14	13	30	24	18	18	15	15
White fir	118	87	72	167	119	84	163	92	65
Incense-cedar	76	48	20	39	23	10	36	24	16
California black oak	3	1	1	4	4	3	10	8	8
Pacific dogwood	13	10	0	1	1	0	0	0	0
Total	**246**	**173**	**116**	**252**	**181**	**122**	**231**	**143**	**107**

Table 8—Average number of trees by diameter class before logging (BL), after logging (AL), and after brush disposal (ABD) for high, medium, and low before-logging basal-area categories, Plumas National Forest, California, 1976-1980

Diameter class	**High**			**Medium**			**Low**		
	BL	**AL**	**ABD**	**BL**	**AL**	**ABD**	**BL**	**AL**	**ABD**
inches	*number/acre*								
3.5-12	120	87	30	152	117	65	141	96	57
12.1-20	59	28	26	56	33	27	55	22	24
20.1-40	63	54	57	38	27	26	33	23	24
40+	4	4	3	6	4	4	2	2	2
Total	**246**	**173**	**116**	**252**	**181**	**122**	**231**	**143**	**107**

Table 9—Average tree basal area (standard error) by species before logging (BL), after logging (AL), and after brush disposal (ABD) for high, medium, and low before-logging basal-area categories. Plumas National Forest, California, 1976-1980

Species	High			Medium			Low		
	BL	AL	ABD	BL	AL	ABD	BL	AL	ABD
	ft²/acre								
Douglas-fir	27.02 (2.83)	19.95 (3.20)	20.93 (3.30)	17.61 (.14)	18.10 (.18)	19.53 (0)	4.78 (0)	0.92 (0)	1.04 (0)
Ponderosa pine	1.74 (0)	0.00 (0)	0.00 (0)	20.41 (.56)	7.42 (.63)	7.36 (.58)	11.39 (5.37)	11.68 (5.50)	11.82 (5.38)
Sugar pine	81.88 (4.48)	68.82 (4.30)	73.61 (3.87)	115.28 (12.19)	103.80 (12.76)	95.89 (12.40)	74.10 (5.88)	65.70 (5.83)	70.38 (6.20)
White fir	226.35 (8.37)	191.82 (6.71)	190.75 (7.08)	166.22 (6.95)	105.70 (6.18)	103.36 (6.48)	165.27 (7.11)	98.81 (5.78)	102.34 (6.32)
Incense-cedar	78.37 (4.00)	40.08 (3.04)	36.01 (3.36)	17.39 (1.13)	9.41 (.82)	5.92 (.78)	19.20 (1.45)	7.89 (1.03)	6.73 (1.01)
California black oak	2.56 (.07)	1.93 (0)	2.52 (0)	1.67 (.17)	1.39 (.17)	1.18 (.20)	9.81 (.78)	7.80 (.65)	8.26 (.63)
Pacific dogwood	1.81 (.19)	1.33 (.17)	0.00 (0)	0.06 (0)	0.08 (0)	0.00 (0)	0.00 (0)	0.00 (0)	0.00 (0)
Total	**419.73**	**323.93**	**323.82**	**338.64**	**245.90**	**233.24**	**284.55**	**192.80**	**200.57**

Table 10—Average tree basal area (standard error) by diameter class before logging (BL), after logging (AL), and after brush disposal (ABD) for high, medium, and low before-logging basal-area categories, Plumas National Forest, California, 1976-1980

Diameter class	High			Medium			Low		
	BL	AL	ABD	BL	AL	ABD	BL	AL	ABD
inches	ft²/acre								
3.5-12	36.29 (2.02)	24.35 (1.70)	10.69 (1.08)	41.80 (2.02)	33.35 (1.73)	23.05 (1.47)	41.32 (2.47)	29.52 (2.06)	22.81 (1.83)
12.1-20	80.05 (2.71)	35.97 (1.86)	33.38 (1.59)	74.13 (2.65)	44.63 (1.87)	38.67 (1.68)	70.80 (2.64)	27.97 (1.89)	30.70 (2.00)
20.1-40	259.65 (8.75)	226.71 (8.44)	247.47 (9.03)	142.27 (8.23)	107.94 (8.64)	109.45 (8.42)	152.04 (9.99)	114.79 (9.44)	125.26 (9.91)
40+	43.74 (5.13)	36.90 (2.34)	32.28 (1.46)	80.44 (11.04)	59.98 (11.00)	62.07 (11.03)	20.39 (1.61)	20.52 (1.47)	21.80 (1.80)
Total	**419.73**	**323.93**	**323.82**	**338.64**	**245.90**	**233.24**	**284.55**	**192.80**	**200.57**

Stand Growth

Basal-area growth for the 1980-1986 period tended to be highest where the largest number of bigger trees was present. Thus white fir and sugar pine contributed most to stand growth in the 20- to 40-inch diameter class (*table 11*). When totalled for all species and diameter classes, and presented as a percent of the after-brush-disposal totals in tables 3 and 4, basal-area growth per acre for each before-logging basal-area category was:

Category	Total after-brush-disposal basal area	Six-year basal-area growth	Increase
	------ *ft²/acre* ------		*pct*
High	323.82	21.63	7
Medium	233.24	21.21	9
Low	200.57	19.22	10

Comparable 6-year basal-area growth in the control was 4 percent.

Consequently, view-enhancement cutting did improve overall stand growth slightly, but not consistently for all species in all age classes. A given species would grow better in treated plots versus the control in one diameter class and not as well in the next (*table 12*). White fir is an example. Its growth averaged 0.16 ft^2 per tree in the 12.1- to 20.0-inch diameter class in treated plots and 0.65 ft^2 per acre in the control. In the 20.1- to 40-inch class, trees in the view-enhancement plots averaged 0.31 ft^2 per acre and those in the control averaged 0.25 ft^2 per acre.

Table 11—Six-year basal area growth by species and diameter class for high, medium, and low before-logging basal-area categories, Plumas National Forest, California, 1980-1986

Species	Before logging basal-area catagory	Basal area growth when breast-height diameter class (inches) was: 3.5–12		12.1–20		20.1–40		40+	
		M[1]	SE	M	SE	M	SE	M	SE
		------ *ft²/acre* ------							
Douglas-fir	**High**	0.16	0.06	0.42	0.33	3.21	0.74	0.00	0.00
	Medium	0.07	0.00	0.29	0.00	0.00	0.00	0.55	0.00
	Low	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00
Ponderosa pine	**High**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Medium	0.00	0.00	0.24	0.13	0.65	0.06	0.00	0.00
	Low	0.00	0.00	0.00	0.00	0.24	0.00	0.30	0.00
Sugar pine	**High**	0.00	0.00	0.00	0.00	4.75	0.60	0.11	0.00
	Medium	0.10	0.03	0.65	0.08	4.85	0.56	2.01	0.55
	Low	0.06	0.03	0.74	0.01	3.93	0.38	1.54	0.41
White fir	**High**	0.52	0.08	1.50	0.43	7.47	0.77	0.71	0.33
	Medium	1.98	0.27	3.91	0.43	5.23	0.67	0.00	0.00
	Low	2.25	0.29	4.12	0.48	4.15	0.38	0.00	0.00
Incense-cedar	**High**	0.16	0.10	1.29	0.30	1.33	0.22	0.00	0.00
	Medium	0.19	0.06	0.42	0.07	0.00	0.00	0.00	0.00
	Low	0.76	0.22	0.41	0.18	0.00	0.00	0.00	0.00
California black oak	**High**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Medium	0.07	0.01	0.00	0.00	0.00	0.00	0.00	0.00
	Low	0.23	0.10	0.25	0.11	0.00	0.00	0.00	0.00

[1]M and SE are mean and standard error, respectively.

Table 12—Average 6-year basal-area growth (standard error) by species and diameter class for view-enhancement plots and control, Plumas National Forest, California, 1980-1986

Species	Basal area growth when breast-height diameter class (inches) was: 3.5–12		12.1–20		20.1–40		40+	
	Cut	Control	Cut	Control	Cut	Control	Cut	Control
	ft²/tree							
Douglas-fir	0.05 (0.02)	0.06 (0.04)	0.27 (0.08)	0.09 (0.00)	0.62 (0.18)	0.00 (0.00)	0.50 (0.00)	0.00 (0.00)
Ponderosa pine	0.00 (0.00)	0.00 (0.00)	0.15 (0.04)	0.00 (0.00)	0.34 (0.03)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Sugar pine	0.29 (0.06)	0.00 (0.00)	0.20 (0.03)	0.00 (0.00)	0.45 (0.06)	0.28 (0.03)	0.39 (0.12)	0.68 (0.14)
White fir	0.45 (0.01)	0.02 (0.00)	0.16 (0.02)	0.65 (0.03)	0.31 (0.04)	0.25 (0.07)	0.32 (0.11)	0.56 (0.00)
Incense-cedar	0.05 (0.02)	0.00 (0.00)	0.12 (0.04)	0.07 (0.00)	0.31 (0.12)	0.30 (0.13)	0.00 (0.00)	0.00 (0.00)
California black oak	0.60 (0.02)	0.01 (0.00)	0.05 (0.02)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)

Ingrowth of trees to the 3.5- to 12-inch diameter class and tree mortality were negligible and virtually in balance during the study. Ingrowth to study plots from 1980 through 1986 totalled 13 trees; 9 white firs and 4 incense-cedars. Ingrowth occurred in only 4 of the 14 plots. One white fir became ingrowth in the control. Mortality during the study amounted to 14 trees in 7 plots with almost 80 percent being white fir. Diameters ranged from 4 to 32 inches. Because suppression was the main cause of death, most trees grew very little before they died. Two California black oaks died in the control, also from suppression.

Discussion and Conclusions

Enhancing the view by manipulating roadside vegetation is nothing new, but doing it with a team made up of a research silviculturist, research landscape architect, and National Forest foresters and crews is. Several other aspects of this study also were unique. Denoting the actual cost of creating the view (McDonald and Litton 1987) seldom is done. And even more seldomly are species diversity and density quantified, let alone evaluated for growth and development after several years. The time that vegetative regrowth closes the view is mentioned as being important (Noyes 1969), but details are scant. Rare also are studies that document the effect of roadside cutting in terms of longer-term (6-year) tree and stand growth, ingrowth of new trees, and mortality of the old.

In this 1976-1986 study, we began by removing some of the dense vegetation along the highway. We did this by heavy cutting in places, light cutting in certain areas, and no cutting in specific locales. We removed many merchantable trees in a typical timber sale, and we removed many smaller trees and cut shrubs in a not-so-typical brush disposal operation that was intensive in places. It also was expensive, costing $462 per acre or $27,126 per mile for the 3 miles of highway in the study (McDonald and Litton 1987).

In terms of plant diversity, the view-enhancement cutting had no major effect. The number of natural plant species increased slightly, and no alien species became established.

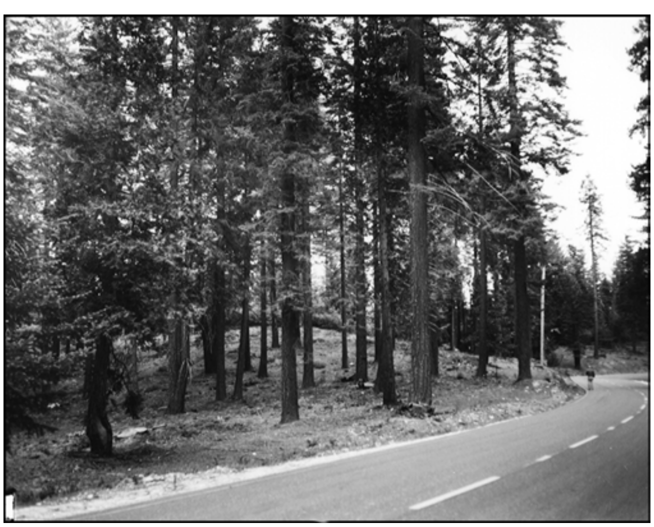
In the understory, where initial shrub and hardwood volumes had been high, the density of shrubs and hardwoods returned to their previously high levels (*fig. 9*). Not only was density high, but so was height growth. In the high shrub volume category the density of the understory vegetation was more than 86,000 understory plants and 755 saplings per acre. The tallest hardwoods ranged from 5 to 11 feet, and the tallest shrubs from 2.7 to 4.7 feet. In these areas, the view has closed. Where initially medium amounts of vegetation had been present after shrub disposal, a medium amount of vegetation returned. Here the density of the understory vegetation was more than 51,000 plants per acre, with the tallest hardwoods ranging from 1.7 to 7 feet and the tallest shrubs from 2 to more than 4 feet. In these areas, the view has closed in places. In still other places, it may close later, and in still others it will probably not close at all. Even in those areas that had a low amount of initial shrub volume, the plant community doubled in density, and height increased, but not to the point that it affected the view. The shrub component was not a factor in these areas either.

In the overstory, almost 53 percent of the trees and 27 percent of tree basal area were removed in logging and brush disposal. In spite of this reduction, no species gained or lost more than 7 percent of stand density or more than 5 percent of total stand basal area. Concomitantly, no diameter class gained or lost more than 13 percent of trees or 11 percent of basal area. Overall, white fir and sugar pine were the most abundant species when the study began, and they were the most abundant after it ended. The 20- to 40-inch diameter class had the most basal area when the study began and also when it ended. Net changes were a slight increase in sugar pine density and basal area at the expense of incense-cedar, and a slight gain in these values in the 20- to 40-inch diameter class at the expense of the 3.5- to 20-inch class. Six-year basal-area growth of residual trees ranged from 7 to 10 percent for the high, medium, and low before-logging basal-area categories and 4 percent in the control.

Plenty of trees of all species and age classes remain in the roadside stand (*fig. 10*). At the end of the study about 115 trees per acre, which supported an average basal area of 253 ft^2 per acre, were present. And at least for the study period, ingrowth was in balance with mortality. Species composition was similar to that before logging, and tree growth did not differ between view-enhancement plots and control. The traveler probably knew that some vegetation had been manipulated, but the overall stand was the same after cutting as it was before. The Forest Service's landscape management objective of "partial retention" (retaining the major impression of the original landscape) was achieved.

Figure 9—(A) After brush disposal in 1980, this high-shrub-volume area resembled a parklike stand. (B) After two growing seasons, sprouting shrubs and hardwoods were rapidly covering the ground.

A



B

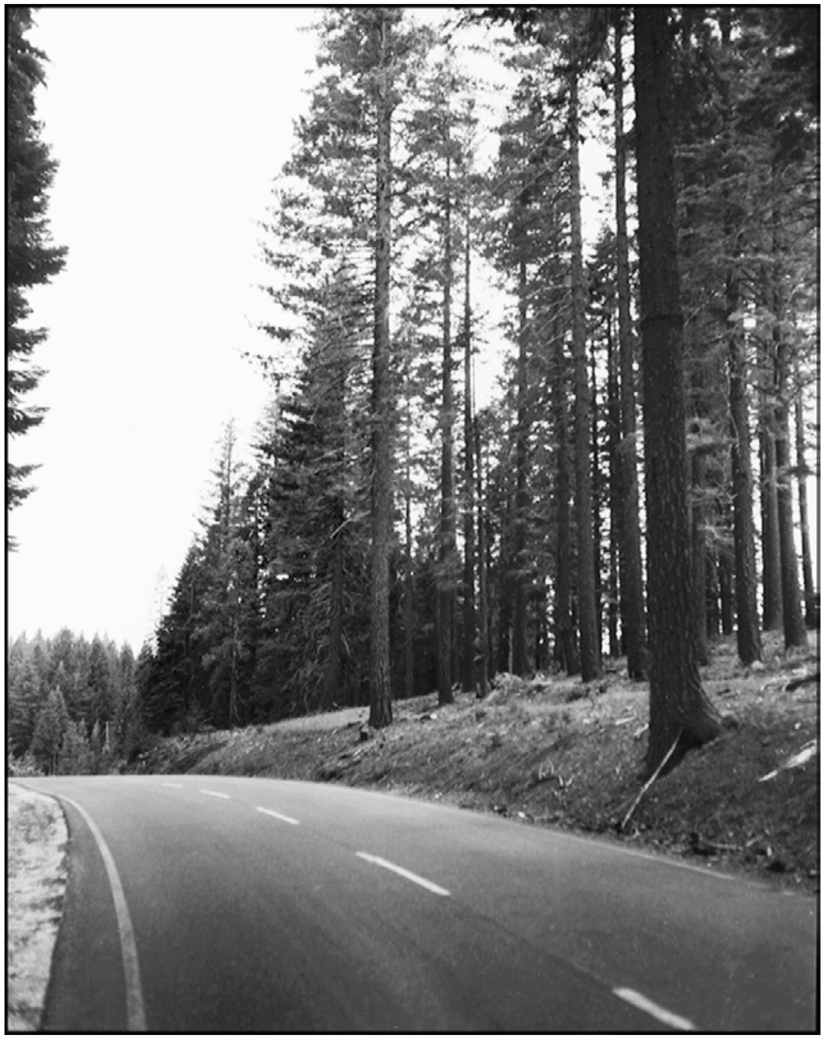


Figure 10—Even with heavy cutting in places, many trees remain in the roadside zone.

The primary goal in this view-enhancement study was to break up the dense stand along the highway through which the traveler had to pass. This meant manipulating the vegetation in a special way to bring contrast and variation to the view of the traveler. We did this by creating pleasing “features” at specific locations along the way, and also by blending the features and other prescriptions together so that the unity of the entire view was maintained. The manipulation of vegetation was a success if the traveler enjoyed one small view or felt good after driving through the entire study area. Consequently, the fact that the vegetation grew back in certain areas and obscured about 25 percent of the view that had been laboriously and expensively created does not mean that the entire view was ruined in 6 years. In some instances a feature view has been lost and in other instances a longer view is not as wide or as sharp. But, many pleasing features are present, and the overall contrast and variability of the view remain.

Roadside cutting complements ecosystem management both in an obvious manner and perhaps in a manner not given much thought. Ecosystem management obviously concerns humans, and enhancing visual resources through forest management allows the forest to both be functional and fulfill a basic human need. A fundamental precept of ecosystem management is sustainability—continuance for posterity of the plants and animals that belong in a specific area or habitat. Sustainability of the view is a corollary to ecosystem management that has merit. The traveler who enjoys a pleasing view perceives a healthy forest and one that will be present (sustained) for future generations.

On the plus side of the balance sheet in this study, some timber was harvested from the roadside zone, and income was received from it. Stand growth increased slightly, and future mortality probably will be less, at least in the near term. Most important, the overall view has been enhanced, even though part of it was obscured in a few years. And because the heavy cutting of trees and shrubs has reduced the amount of fuels and fuel ladders along the highway, the rate of spread of wildfire has been reduced. Crews now have more time to extinguish a flare-up that starts in the fire-prone roadside zone (Wilson 1979).

On the minus side of the balance sheet was the high initial cost. Although daunting, some mitigating factors need to be considered. First of all, the current emphasis on ecosystem management creates the long timeframe needed to amortize vegetation manipulation costs. And because additional silvicultural manipulations will need to be applied to maintain the view, they too can be amortized over time. These manipulations should be less expensive and involve only "touch-up" operations such as thinning, application of herbicides to dense resprouting shrubs, and broadcast burning. Broadcast burning is now feasible, whereas before, the dense fuels and fuel ladders made it too risky.

Is the improved scenery worth the cost? Because the view cannot be improved until trees are removed, the question really becomes "Are harvested trees and an improved view worth the cost?" We believe that the combined yield of timber (*fig. 11*) and improved recreational experience shift the balance—the pluses outweigh the minuses. The roadside zone need not be off limits to such management activity as a careful timber harvest. Magill (1992) presented an interesting suggestion regarding managed landscapes and view acceptance. His extensive survey noted that most respondents were urbanites that are "immersed in some kind of management every day." Thus they likely "would accept management and perceive it favorably." Why not a managed forest 50 feet wide and 150 miles long?

Figure 11—With careful management, the roadside zone can yield both pleasing scenery and wood products.

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United States
Department
of Agriculture

Forest Service

**Pacific Southwest
Research Station**

Research Paper
PSW-RP-235

Combining Silviculture and Landscape Architecture to Enhance the Roadside View

In Brief

McDonald, Philip M.; Litton, R. Burton, Jr. 1998. **Combining silviculture and landscape architecture to enhance the roadside view**. Res. Paper PSW-RP-235. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 22 p.

Retrieval Terms: landscape management, mixed conifer forest, northern California, plant community dynamics, stand growth, view enhancement

All too often, the forest roadside zone is a hands-off zone for timber harvest. Activities there are easily seen and subject to the traveler's scrutiny and positive or negative response. But this zone contains trees that are a valuable commodity, and scenery that is a valuable amenity. The two need not conflict. The zone also contains numerous shrubs and small trees that grow to the edge of the highway and limit the variability and contrast needed for a pleasing visual experience. In addition, the dense stand is a fire waiting to happen in the sense of being a large amount of fuel near a source of ignition (a burning cigarette from a passing motorist) with a fuel ladder straight to the top of tree crowns. And if the highway twists and turns, dense stands of trees impede visibility of oncoming traffic. Plainly, the typical forested roadside stand in northern and central California could use some forest management. But how to extract trees, remove view-blocking shrubs and smaller trees, provide pleasing scenery, and not lose the inherent character of the forest landscape? A critical question involves cost. Society has stated many times that it wants an enhanced esthetic quality to the forest (and roadside zone), but the question of how to cover the cost of making it attractive and maintaining that attractiveness is seldom addressed.

We quantified the initial cost in a previous paper (McDonald and Litton 1987). Enhancing the view and initiating forest management in the roadside zone with very careful logging and shrub removal techniques cost \$81,379. When allocated to the 176 acres in the travel influence zone, the cost was \$462 per acre or \$27,126 per mile for work on both sides of the 3-mile roadway in the study. About 5 million board feet of timber and 160 cords of fuelwood were harvested with a value of about \$450,000.

Research questions also abounded. How much of what species of vegetation came back after cutting? Was the species makeup the same? What happened to the remaining trees: did they die, did they grow? Answering these and other questions was the purpose of this study.

We began with a team made up of a research silviculturist, a research landscape architect, and National Forest foresters and crews. We also solicited input from the public before the study began. And we talked to the logger about the potential to unlock the roadside zone for timber yield. We got "one of the best logging jobs ever seen" according to several knowledgeable timber sale specialists.

We also gained some knowledge about plant community and stand dynamics. In terms of plant diversity, the harvesting and shrub removal operations had no major effect. Total number of plant species increased slightly, and no alien species were found. In the understory, the density and foliar cover of hardwoods, shrubs, forbs, graminoids, ferns, and conifer seedlings more than doubled between the before-logging and 6-years-after-brush-disposal plant communities. Density in the highest shrub-volume category after 6 years was 86,400 plants per acre; in the medium category, 51,121 per acre; and in the low category, 30,880 plants per acre. A major contributor to density was a ubiquitous forb. Corresponding heights of view-blocking hardwoods ranged from 3.9 to 11 feet. By the end of the study, we judged that about 25 percent of the view that we created had been compromised by vegetative regrowth.

In the overstory, many trees remained in the roadside zone—115 per acre; and much basal area also was present—253 square feet per acre. Almost 53 percent of the trees and 27 percent of tree basal area were removed in logging and brush disposal. In spite of this reduction, no species gained or lost more than 7 percent of stand density or more than 5 percent of total stand basal area. And no diameter class gained or lost more than 13 percent of trees or 11 percent of basal area. Ingrowth of new trees greater than 3.5 inches in diameter at breast height was in balance with mortality. Six-year basal-area growth of residual trees ranged from 7 to 10 percent for the high, medium, and low before-logging basal-area categories and 4 percent in the control (untreated area).

Overall, the removal of merchantable trees and unmerchantable trees and shrubs was best characterized as "gentle." The traveler could tell that some vegetation had been removed, but the overall impression of the landscape was retained. Most important, the view was much improved over that before logging and brush disposal in spite of vegetative regrowth in places. And the forest roadside zone yielded some timber and became less prone to wildfire.