CHAPTER 6

Late Successional Old-Growth Forest Conditions

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❄ CRITICAL FINDINGS

Status of Current Late Successional Forests Late successional old-growth forests of middle elevations (west-side mixed conifer, red fir, white fir, east-side mixed conifer, and east-side pine types) at present constitute 7%–30% of the forest cover, depending on forest type. On average, national forests have about 25% the amount of the national parks, which is an approximate benchmark for pre-contact forest conditions. East-side pine forests have been especially altered.

Forest Simplification The primary impact of 150 years of forestry on middle-elevation conifer forests has been to simplify structure (including large trees, snags, woody debris of large diameter, canopies of multiple heights and closures, and complex spatial mosaics of vegetation), and presumably function, of these forests.

Distribution of Late Successional Forests Four Sierran national parks, Lassen Volcanic, Yosemite, Sequoia, and Kings Canyon, provide most of the remaining large contiguous areas of late successional forests in middle-elevation conifer types.

Historic Conditions of Federal Lands Much of the best of the accessible pine forest was cut before the national forests were created. Many national forest lands were created from the leavings: cutover lands, steep canyon walls, high montane forests, and relatively inaccessible timberlands.

Continuous Forest Cover Despite 150 years of Euro-American timber harvest activity in the Sierra Nevada, clear-cut blocks larger than 5–10 acres are at present uncommon in the conifer forests of the Sierra Nevada, and tree cover is relatively continuous.

Forest Mortality Over the past decade, as they have many times in the past, Sierra Nevada conifer forests have experienced widespread, locally severe mortality caused principally by bark beetles infesting trees stressed by drought, overdense stands, and pathogens.

ASSESSMENT

The forests of the Sierra Nevada are complex in composition, structure, and function, reflecting wide variations in environmental conditions on both local and regional scales, and varied histories of natural and human disturbance. This complexity makes an assessment of forest conditions challenging. The term *old growth* has, in common parlance, suggested ancient forests undisturbed and unaltered through time. In reality, all forests are dynamic, although the rate and spatial distribution of change varies widely from region to region. Under ideal conditions, Sierran trees may live from several centuries (common) to several thousand years (uncommon), depending on species. Changes in climate over the past 10,000 years (after the end of the Pleistocene) have resulted in a continuously changing mix of species aggregations. Fire, drought, insect attacks, wind, avalanches, and other disturbances—often in combination—have typically modified and not infrequently destroyed entire stands of trees. As seedling trees are added and other trees in a stand grow, mature, and eventually die, both the appearance and the ecological function of the stand and the forest of which it is a part evolve until they reach a condition we refer to as late successional.

Old growth is incorporated within the broader category of late successional forest conditions in the following analysis. Contribution to late successional forest function refers to the ability of a stand or landscape to provide habitat for species that prefer or require late successional forest conditions and to carry out ecological functions of the types and at levels characteristic of late successional forest ecosystems, such as regulation of hydrologic regimes. Thus *old growth* and *late successional* are used as interchangeable terms here. Some of the ecological functions peculiar to the late successional stage can operate at the scale of an individual stand; others require much larger landscapes of intact forest.

SNEP used ten principal forest types for late successional analysis in the Sierra Nevada (table 6.1). Of these, our assessment of late successional old-growth (LSOG) forests has been directed principally toward the conifer forest types growing at middle elevations, the commercially important west-side mixed conifer, white fir, red fir, east-side mixed conifer, and east-side pine forests (plate 6.1). These are forest types in which structural complexity continues to increase with stand age for at least several centuries, and for which the ecological differences between late successional and earlier successional stages are distinctive and relatively well understood.

Conifer forests within the middle-elevation forested zones of the Sierra Nevada that are not disturbed by logging, clearing, or severe fire tend to develop complex structures over time. That is, most often the trees reflect a variety of sizes and conditions and, especially in the case of mixed conifer types, variety of species as well. There are large standing dead trees and down logs present, not as a by-product of timber harvest but through the natural processes of senescence and decay. Patches dominated by large, mature, and old trees are interspersed with openings and younger stands (or even single trees), forming a fine-scale mosaic resulting in both complexity from ground to tree canopy (vertical complexity) and spatial (horizontal) complexity (figure 6.1). The forest floor itself becomes more complex through the accumulation of organic

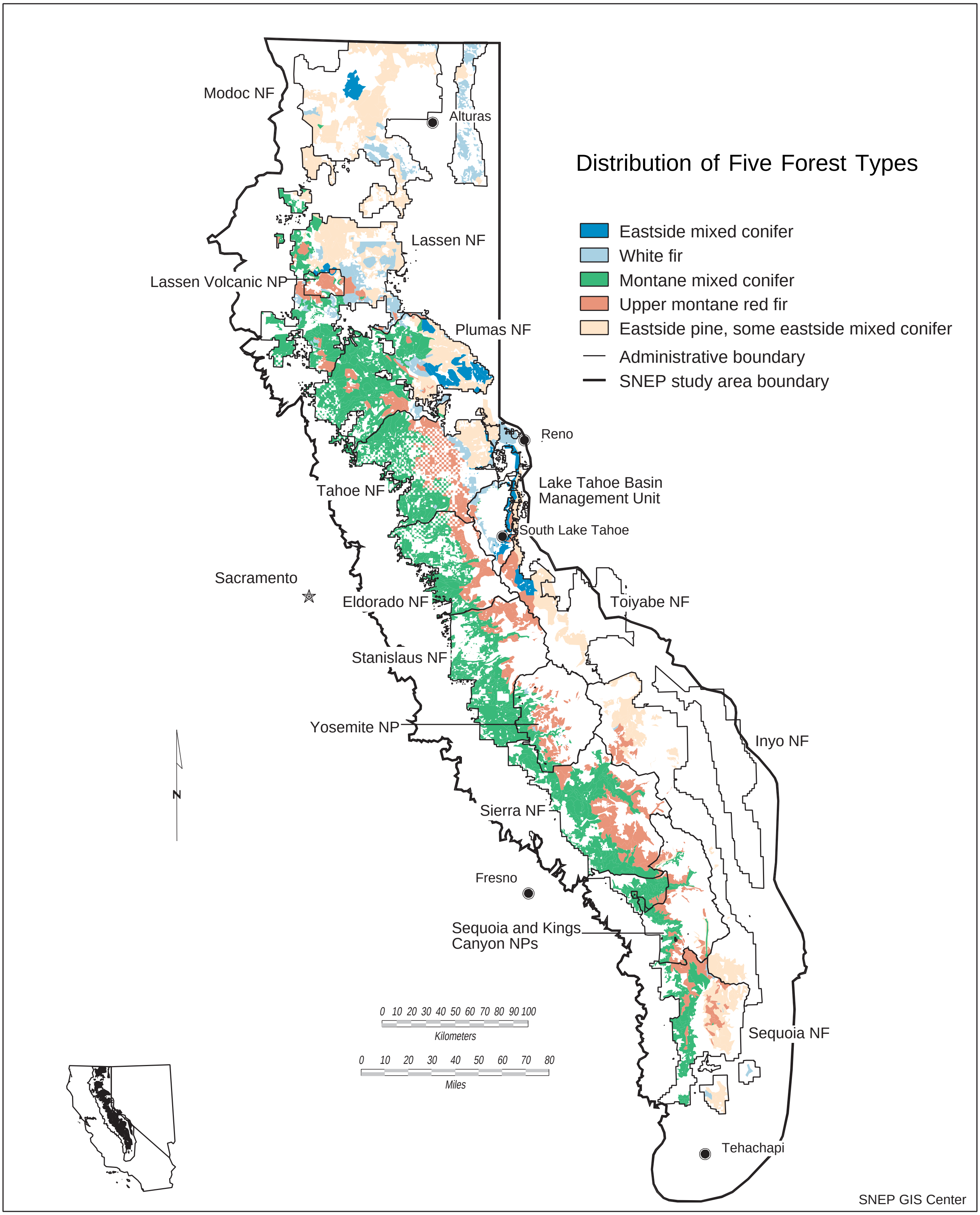

PLATE 6.1

Distribution of five forest types in the Sierra Nevada that were assessed for successional status. (From volume II, chapter 21.)

TABLE 6.1

Characteristics of the major forest type groups of the Sierra Nevada. (From volume II, chapter 21.)

Forest Type	Dominant Trees: Northern Sierra	Dominant Trees: Southern Sierra	Landscape Patterns	Primary Disturbances	Presettlement Fire Regime: Northern Sierra	Presettlement Fire Regime: Southern Sierra
Foothill pine and oak	Foothill pine, ponderosa pine, blue oak, live oak, Douglas fir	Foothill pine, ponderosa pine, blue oak, live oak	Mostly open structure, limited patches of dense forest, frequent natural openings (chaparral and outcrops)	Fire, insects, pathogens, drought	Low-severity regime: frequent, low-intensity fires	Same
West-side mixed conifer	Douglas fir, ponderosa pine, sugar pine, white fir, incense cedar, black oak, tan oak	Ponderosa pine, sugar pine, incense cedar, black oak, giant sequoia, Jeffrey pine	Primarily continuous forest with few extensive natural openings (e.g., outcrops)	Fire, insects, pathogens, drought	Low- to moderate-severity regimes: areas > 50 inches annual precipitation likely mixture of low- and moderate-intensity fires in complex mosaic with sufficient variability in interval to perpetuate Douglas fir; areas < 50 inches annual precipitation likely more dominantly low-intensity fires; infrequent large-scale high-severity fires	Low-severity regime: dominantly low-intensity fires
White fir	White fir	Same	Same as west-side mixed conifer	Insects, pathogens, fire, drought	Moderate-severity regime: frequent but variable extent or frequency, variable intensity with small patches of moderate to high intensity	Same?
Red fir	Red fir, lodgepole pine, western white pine	Same	Fine- to moderate-scale high patch diversity of natural openings (meadows, outcrops) and open or closed forest; large, extensive patches limited	Insects, pathogens, fire, drought, wind, avalanche	Moderate-severity regime (same as white fir)	Moderate-severity regime (same as white fir)
Jeffrey pine (upper montane)	Jeffrey pine	Same	Generally extensive uniform patches of very open forest or woodland interspersed with small pockets of denser forest	Insects, pathogens, fire, drought	Low-severity regime: low intensity and/or small extent of fires due to discontinuous fuels	Low-severity regime
Subalpine	Lodgepole pine, mountain hemlock, western white pine, whitebark pine	Lodgepole pine, mountain hemlock, western white pine, whitebark pine, foxtail pine, limber pine, western juniper	Highly variable patterns but generally diverse patch mosaic with large meadows, small patches of dense forest embedded in a large matrix of open forest or scattered trees and rock outcrop	Avalanche, wind	Low-severity regime: low intensity and/or small extent of fires due to discontinuous fuels and infrequent ignitions (due to precipitation associated with lightning)	

continued

TABLE 6.1 (continued)

Forest Type	Dominant Trees: Northern Sierra	Dominant Trees: Southern Sierra	Landscape Patterns	Primary Disturbances	Presettlement Fire Regime: Northern Sierra	Presettlement Fire Regime: Southern Sierra
East-side mixed conifer and white fir	White fir, ponderosa pine, Jeffrey pine (some Douglas fir, sugar pine, incense cedar)	White fir, Jeffrey pine	Variable patterns, most often occur in a coarse-scale mosaic with east-side pine related to aspect	Fire, insects, pathogens, drought	Low- to moderate-severity regime: dominantly frequent low-intensity fires but with variable intervals, enabling recruitment of Douglas fir and white fir to large sizes; greater proportion of moderate-intensity fires than in east-side pine due to greater productivity and fuel accumulations from variable intervals	Same
East-side pine	Ponderosa pine, Jeffrey pine, lodgepole pine	Jeffrey pine, lodgepole pine	Large, continuous patches of open forest that are often interspersed with large meadows, grasslands/shrublands	Fire, insects, pathogens, drought	Low-severity regime: dominantly frequent, low-severity fires	Same
Piñon and juniper	Western juniper	Utah and western juniper, piñon pine	Large, continuous savannas and woodlands	Fire, grazing, woodcutting	Low-severity regime: frequent low-intensity fires	Same
Riparian hardwood	Black cottonwood, aspen	Water birch, black cottonwood, aspen	Streamside strips	Flood, debris flow	Low-severity regime: infrequent fire	Same

FIGURE 6.1

Schematic cross section of typical west-side mixed conifer forest illustrating the structural complexity and spatial patterning characteristic of high-quality late successional stands ranked 4 and 5. (From volume II, chapter 21. Drawing by Robert VanPelt.)

matter and associated organisms. These late successional forests provide habitats for animals and plants that are not available in areas of extensive young forests, as well as regulating snowmelt, modifying biochemical processes, and moderating temperatures below their canopies.

Forests and woodlands composed of other tree species, such as foothill pine woodlands and oak woodlands and forests, riparian hardwood forests, piñon-juniper woodlands, and the several types of subalpine woodlands (e.g., whitebark pine) and forests (e.g., lodgepole pine) represent 40% of the Sierra Nevada's tree-dominated vegetation. These types also undergo structural succession that results in trees that are often very old and very large. They produce ecologically and aesthetically important structural elements, such as large snags and logs, but they generally do not develop the canopy cover, tree density, structural complexity, or patch dynamics over the substantial areas associated with middle-elevation late successional conifer forests. Our understanding of differences in ecology between early and late successional stages of these types is only partial, and although SNEP classified structural complexity in these forests, interpretations about successional status are not discussed here.

The structural complexity of natural stands reflects local environmental conditions, such as microclimate, soil depth and chemistry, water table, and disturbance patterns. Particularly at higher elevations, rock outcrops, thin soils, wetlands, and frost pockets further enrich the forest mosaic while constraining the size of the trees themselves (figure 6.2). Prior to the mid-1800s, the most significant disturbances at lower and middle elevations were apparently frequent, usually light to moderately severe fire, which thinned stands, created (usually) small openings, and generated as well as consumed snags and logs. Drought, insects, and disease killed individual trees or aggregations, providing another source of dead woody debris. Large, severe, forest-destroying fire events resulting from the interaction of drought, insect outbreaks, and extreme weather undoubtedly occurred in the Sierra Nevada, but their importance in constructing its successional landscape is a matter of conjecture.

In contrast, human activities have altered the structure of many forests in the Sierra Nevada directly and indirectly. Timber harvest has removed trees, snags, and logs, especially of larger diameters, simplifying forest structure. Denser and less diverse stands have been purposely created following harvest to accelerate timber production. The period of aboriginal occupation likely was one of increased fire frequency, with consequent lower fire intensities. Modern fire suppression has led to the invasion of shade-tolerant trees into existing older stands, producing greater vertical and horizontal continuity in canopies and largely excluding shrubs and herbs. This dense in-growth lacks the structural and ecological diversity of naturally disturbed forests and is vulnerable to high-intensity, stand-destroying fire.

Most of the timber harvest for the last half-century in the Sierra Nevada (on private and public lands) has been selective (partial) cutting rather than clear-cutting, although early logging (1850–1920) was often by clear-cutting of large areas. As a consequence, harvested forest stands often contain substantially more structural complexity, and more elements of a natural late successional stand, than would have been the case following clear-cutting. The potential contribution of these managed stands toward late successional ecological

FIGURE 6.2

An example of an area of higher elevation forest with low structural complexity. Exposed granitic outcrops dominate the site. (Photo by Jerry F. Franklin.)

functions of the Sierra depends greatly upon their size and on the forest matrix in which they occur, but they are an important legacy in the Sierra and are considered along with the contribution of unharvested stands.

Approach to Late Successional Analysis

In recent years late successional stands in the Sierra were mapped, largely using remote sensing imagery from satellite and ground sampling and subsequent computer-assisted classification. SNEP used a novel approach to identify and map remaining late successional forests on Sierran public lands. New approaches were necessary because of the size of the range itself and the complex spatial distribution of late successional elements on the landscape. In middle-elevation conifer forests, late successional forest structures, especially elements of structural complexity, provide readily observed surrogates for ecological functions (e.g., nutrient cycling, decomposition) and for species that depend upon late successional forest but that are difficult to observe directly.

Major elements of the SNEP analysis were (1) adoption of structural complexity as the measure and surrogate for level of late successional function; (2) creation of a six-point ranking scale for structural complexity; and (3) identification, mapping, and characterization of landscape-level units ("polygons" of 1,000 acres or larger) to serve as the basic units of analysis (see volume II, chapter 21, for detail on methods). SNEP mapped conditions on public lands, including national forests, national park lands, and national resources lands (BLM) of the Sierra.

An experimental pilot mapping effort was applied to the Eldorado National Forest to test and refine procedures. This pilot effort led to rules and standards for structural complexity to ensure consistency in mapping over the range. Subsequently, mapping and characterization were carried out by a large team of resource specialists assembled from the federal and state land units of the Sierra, directed by members of SNEP. These specialists were used because of their familiarity with on-the-ground conditions. A wide variety of source materials, including aerial photographs, satellite imagery, and maps showing forest conditions and habitat suitability as well as personal knowledge of forest conditions, was used by the specialists to delineate landscape polygons and characterize the patches within them.

The polygons, generally of several thousand acres each (although significantly smaller in the national parks), were delineated on maps based upon overall forest type and characteristics of structural complexity. More than 2,800 such polygons were mapped on the public lands of the Sierra Nevada. For each polygon, mappers described and ranked several large, relatively homogeneous units called "patches" using late successional structural features, including numbers of large trees, numbers of large snags and logs, degree of canopy closure, and history of human disturbances. The ranks of these patches were then aggregated to provide an overall rank for the larger polygon in which they occur. Thus the landscape polygons were usually mixes of forest and nonforest vegetation of varying composition and structure.

The six-point scale for ranking structural complexity and contribution to late successional forest function in the Sierra Nevada ranged from 0 (low complexity, no contribution) to 5 (very high complexity and contribution). Examples of areas that received low ratings were structurally simple forests, such as young plantations, areas recently burned and salvaged, and landscapes that were largely nonforested, such as rock outcrops. Ranking of 2 included maturing even-aged forests lacking large-diameter trees, snags, and logs. Ranking of 3 included areas that had been selectively logged or burned but retained significant numbers of large trees and snags or where second-growth forests were approaching maturity. Old-growth mixed conifer forests with open, parklike structures often produced by frequent low-intensity fire were typically given a ranking of 4. Forests with the highest levels of structural complexity, including many large trees, were typical of areas given a ranking of 5. For example, many national park areas outside zones where aggressive fire suppression has occurred were ranked 5.

High-quality late successional polygons included patches with structural rankings of 4 and 5 intermixed with many 3-ranked stands, thus they often contained a mix of variously ranked patches. Some low-ranked polygons also contained small patches of superlative (rank 4 or 5) old growth. Stands with the highest level of structural development (rank 5) are not necessarily those stemming from natural conditions; they may reflect past fire suppression and excess numbers of smaller trees at the expense of more open understories and horizontal complexity. Many of the more open stands (rank 4) with large-diameter trees, small gaps, and open understories of low shrubs or herbs contribute more useful late successional habitat than some of those ranked 5 and are less vulnerable to stand-destroying fire.

The initial mapping was followed by extensive field checking, revisions, review by knowledgeable individuals outside SNEP, and final revision. An independent statistical analysis of the mapping project, based on a small number of field plots, was conducted to test the validity of the classification procedure (reported in volume II, chapter 22). The fact that patches were not specifically delineated on the maps (such an effort would have been impossibly laborious) made assessment of the polygon rankings difficult, as these ranks were composites of the patch values. Moreover, for reasons of past inventory practices, polygons on the national parks were generally smaller, about the size of national forest patches. These differences may have biased comparisons between national parks and national forests, because polygons tended to be ranked lower if late successional patches were comparatively smaller and fragmented, a problem in larger polygons. Although limited in scope, the validation study found less reliable discrimination of the middle-ranked polygons (2 and 3), than those with low (0–1) or high (4–5) rankings. Also, the degree of past human influence on polygons was a strong component of the rankings; a polygon that had experienced significant past human-caused disturbance tended to be ranked lower than an otherwise similar polygon without such influences. SNEP also compared maps produced by this LSOG process with those produced using remote sensing by the Sierra Biodiversity Institute. We found substantial disparity in the mapped locations of late successional forests, but overall quantities were similar for most forest types.

Final maps showing landscape polygons at the scale of half an inch to one mile, GIS data layers, and characterizations of the patch conditions found within the polygons are available for individual national forests and parks. Only a sample is included here.

Status of Late Successional Middle-Elevation Forests

Only a small proportion of the middle-elevation conifer landscapes are at present high-quality late successional forest (plate 6.2; table 6.2): Nineteen percent of the mapped polygons were ranked as structural classes 4 and 5. Substantially more areas were rated as structural class 3 (29% of the total); these latter polygons represent a variety of conditions, including forests that have been selectively logged, productive lands that have regrown following earlier logging, and naturally fragmented landscapes in which high-quality stands are interspersed with nonforested areas. About half of the 3-rated polygons have a substantial proportion of their area (more than 25%) in patches ranked 4 and 5. Landscapes in which high-quality late successional patches are large, or are adjoined to patches of rank 3, function far more effectively as late successional landscapes (for example, by meeting the requirements of animals requiring large areas for support) than small or comparatively isolated high-ranked patches surrounded by large areas of low-ranked forest.

As expected, national parks provide the major concentrations of middle-elevation late successional conifer forests, especially at the landscape level, and, proportionally, they have about four times as much forest with high LSOG rankings as adjacent national forests (table 6.3). Within the parks, late successional forests of ranks 4 and 5 constituted 55% of the area in five forest types in Yosemite, Sequoia, Kings Canyon, and

TABLE 6.2

Proportion of polygons by major forest type group and late successional forest ranking for federal lands in the Sierra Nevada. (From volume II, chapter 21.)

		Percentage by Rank					
Forest Type	**Total Acres Classified**	**0**	**1**	**2**	**3**	**4**	**5**
West-side mixed conifer	3,344,960	4	12	33	31	15	5
White fir (west-side)	217,583	3	16	34	33	7	7
Red fir	1,476,390	0	9	28	34	17	13
East-side pine	2,776,024	9	24	45	14	5	2
East-side mixed conifer	711,982	4	22	39	26	9	0
All forest types	**8,526,939**	**4**	**14**	**34**	**29**	**13**	**6**

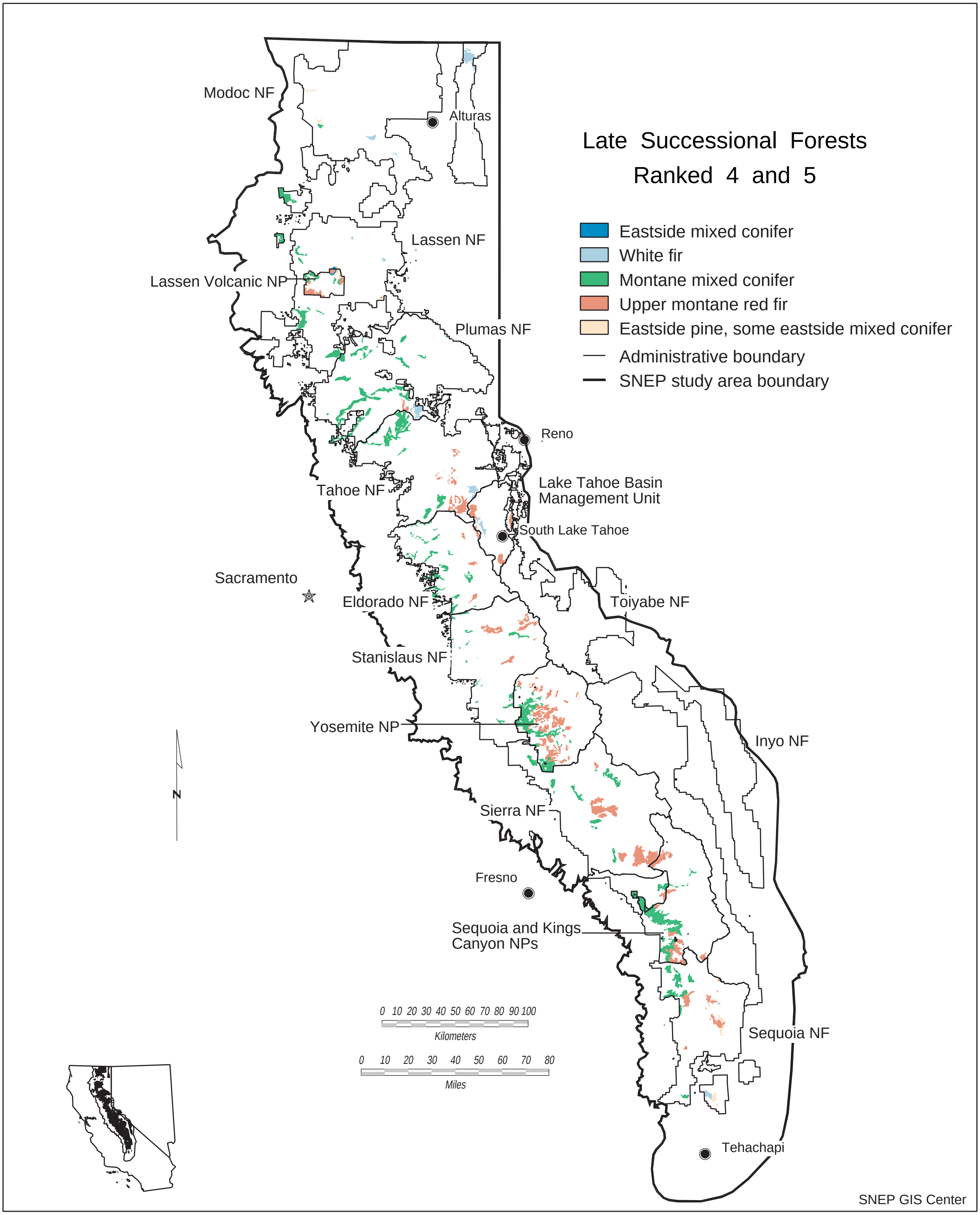

PLATE 6.2

High quality (ranks 4 and 5) late successional middle-elevation conifer forests of the Sierra Nevada ranked by SNEP. (From volume II, chapter 21.)

Lassen Volcanic National Parks (table 6.3). Despite reflecting increased forest density and fuel loadings due to fire suppression, forests in the national parks provide an instructive reference point for estimating pre-contact levels of high-quality late successional forests, as only minor areas have been subject to significant timber harvest. Fire suppression throughout most of the twentieth century is gradually giving way to prescribed management fire (controlled burns) and prescribed natural fire (lightning ignitions permitted to burn under constrained conditions), although many more forest stands in the national parks still carry excessive tree densities and unnatural fuel levels than have been restored to proximate pre-contact conditions, and extreme fire events continue to be suppressed. Although current conditions reduce the value of the national parks as indices of natural forest conditions, parks remain the best available benchmarks. The proportion of polygons (82%) with rankings of 3, 4, and 5 in the national parks is the best available indicator of conditions that prevailed in the Sierra Nevada before Euro-American settlement and is nearly twice the proportion on the national forest lands (42%).

The most commercially valuable forest types, such as the west-side mixed conifer and east-side pine forests, are proportionally the most deficient in high-quality late successional forest. These types have had the longest and most intense histories of timber harvest. Forests with high structural rankings are rarest in east-side pine: only 7% were ranked as structural class 4 and 5 (table 6.2). The west-side mixed conifer type has a greater proportion of high-ranked polygons: overall 20% are ranked 4 and 5, and red fir, with 30%, has the greatest proportion. One reason for this difference is the substantial representation of west-side mixed conifer protected within national parks.

Despite nearly 150 years of significant activity by Euro-Americans, there is still a high level of continuity in forest landscapes. The forest cover of the Sierra is relatively continuous, and most forested stands have sufficient structural complexity to provide for at least low levels of late successional forest functions. Fragmentation of forests through patch clear-cutting practices has been much less common in the Sierra than on federal forest lands in the Northwest. Though forest continuity is high, forest structure has been greatly simplified relative to pre-contact conditions; key structural features of late successional forests, such as large diameter trees, decadent trees, snags, and logs, are generally at low levels in the commercial forests of the Sierra Nevada. These forests thus do not provide the level of wildlife habitat and other ecological functions characteristic of high-quality late successional forests. In many areas, excessive stocking renders forests subject to severe wildfire and stand destruction rather than the stand-thinning fires more typical of natural Sierran conditions. Low levels of structural diversity are partially the legacy of acquired cutover lands and selective-removal timber harvest on the national forests.

TABLE 6.3

Proportion (%) of polygons ranked 4 or 5 (highest contribution of late successional function) and proportion ranked 3, 4, or 5 (mature forest with late successional potential plus 4- and 5-ranked polygons) for five middle-elevation conifer forest types in national parks and adjacent national forests and for all (Sierran) national forests, national parks, and federal lands combined. (From volume II, chapter 21.)

	Rank	
Administrative Unit	**3+4+5**	**4+5**
Lassen National Forest	42	9
Lassen Volcanic National Park	96	79
Stanislaus and Sierra National Forests	49	15
Yosemite National Park	76	48
Sequoia National Forest	51	24
Sequoia and Kings Canyon National Parks	82	56
All national forests	***42***	***13***
All national parks	***82***	***55***
All federal lands	***47***	***19***

Over the past decade, Sierra Nevada conifer forests have experienced widespread, locally severe levels of mortality caused principally by bark beetles infesting trees stressed by drought, overdense stands, and pathogens. Pine and fir forests in the Tahoe Basin and along the eastern slopes of the Sierra have been especially affected, although heavy losses to true fir have occurred in central western forests; 12%–15% of the forest inventory was lost in a recent 8-year period on the Eldorado National Forest. Along the western boundary of the southern Sierra, air pollution stress may have contributed to extensive mortality. Although fire suppression and forestry practices leading to unhealthy tree densities are implicated in the current die-off, U.S. Forest Service records dating to the beginning of the century reveal that periodic insect outbreaks, often associated with droughts, have led to high levels of tree mortality over large areas. These outbreaks are usually specific to a particular species of tree, depending on the insect.

Somewhat less than half the high-ranked late successional forest on national forest lands is unreserved and potentially available for timber harvest. A fair proportion of west-side mixed conifer polygons ranked as classes 4 and 5 may remain in the "suitable" land class in national forest plans, depending on the outcome of the California spotted owl environmental impact statement, and thus be available for timber harvest. Conversely, there is very little west-side mixed conifer or east-side pine forest with high LSOG rankings found within congressionally reserved areas, such as designated wilderness, as most wilderness occurs at higher elevations than these types. Recent Forest Service directives specify increased retention of large trees and other late successional forest components in those areas available for timber harvest.

Many (but not all) high-ranked national forest polygons in the northern and central Sierra are associated with steep, relatively inaccessible river canyons on the western slope, such as portions of the American, Feather, Yuba, and Cosumnes

❄ *Logging in the Sierra Nevada*

The logging of the Sierra Nevada took place in several stages. The gold rush created an immediate demand for mining timbers and lumber for construction of towns. Large sugar pines were cut down for shakes. This was a time of small sawmills that moved frequently as timber nearby was exhausted. Logging and lumber transport was by ox team and horses. As the placers gave out, this form of logging continued at a slower pace until the Central Pacific Railroad was built across the Sierra in 1865–68. The railroad ushered in industrial logging with its own construction followed by logging of the Tahoe-Truckee Basin, from which huge amounts of timber and wood were removed for the Comstock Mines. The construction of the railroad up and down the Central Valley offered an opportunity for industrial logging of the Sierra. The industry expanded, using new methods developed in the Tahoe Basin, such as V flumes, chutes, and inclines, and later donkey engines and logging railroads. Expansion was aided by land disposal laws that favored development of large timber holdings. In 1890 and 1891 national parks were created and the forest reserves were authorized, yet millions of acres of Sierra timberlands were still being disposed of through 1905. In a 1902 U.S. Geological Report for the Northern Sierra, John Leiberg estimated that 44% of the areas he examined at the turn of the century had been logged. He noted “a large proportion of the remaining forest (30%) is on places inaccessible and will never be available for use.” The U.S. Forest Service, created in 1905, began making timber sales soon after, but they were not a major factor in wood supply until World War II. The period after 1900 was the heyday of the logging railroad and high-speed cable yarder. This form of logging flourished until the mid-1920s, when tractor-truck logging began to increase. Markets continued to be mainly in California, where the major uses of lumber were for fruit packing boxes and for home building caused by rapid population growth. After a slowdown during the 1930s, logging in the Sierra picked up rapidly during World War II. Acquistions of private forestland by the Forest Service beginning in the depression years added hundreds of thousands of acres of cutover, partially cut, and understocked lands to the national forests. But it was the postwar population and building booms in California that caused the rapid expansion of logging in the Sierra. As a result of higher prices and great demand many private ownerships, small and large, were cutover and the national forests rose in the timber market. Production from national forests in California rose to a peak of 2 billion board feet by the late 1970s, about half from the Sierra Nevada forests. Since that time logging has steadily declined as public lands were set aside for wilderness, wildlife habitat, watershed protection, and other uses. Logging on private lands has also been impacted, first by a more comprehensive forest practices act in 1973, and later by sharp declines in national forest timber available for logging. Because of high prices resulting from short supplies of timber, much of the timber on small ownerships was cut during the late 1980s and early 1990s.

river drainages. Rather than occurring only in remote locations in the Sierra Nevada, many polygons ranked 4 and 5 are found along the western edges of the national forests. Because such areas are at the interface of rural and urban environments, they may be subject to higher fire risks, and protecting them in the future poses a major management challenge.

Summary of Late Successional Status

The current extent of structurally complex, late successional middle-elevation conifer forests in the Sierra Nevada is probably far below levels that existed prior to western settlement. The widespread occurrence of such forests can be inferred from historical accounts, the pre-contact fire regime, and current conditions in the national parks. Late successional forests (ranks 4 and 5) now occupy 19% of all federal lands comprising these middle-elevation forests, with 13% of those on the national forests versus 55% on the national parks. The amount of late successional forest on the national parks is an approximate benchmark for pre-contact conditions. Including polygons ranked 3 or higher, the proportion of late successional forest is 47% on all federal lands, 42% on national forests, and 82% in national parks. The lower values on the national forests reflect more than a century of harvest activity. Although densities have increased and composition has shifted toward shade-tolerant species in middle-elevation park forests as a result of fire suppression, it is nonetheless reasonable to infer that most Sierran forests of these types in pre-contact times maintained moderate to high structural complexity and high horizontal diversity through frequent low- or moderate-intensity fire. The collective inference is that stands with moderate (rank 3) to high levels (ranks 4 and 5) of late-successional-related structural complexity once occupied the majority of what are now middle-elevation commercial forest lands in the Sierra. The still-considerable area with polygons ranked 3 on the national forests offers significant promise for a future increase in late successional forest, should that be a policy goal.

Severe tree mortality resulting from insect damage to a dense stand of lodgepole pine, Lassen National Forest, 1907. (Photo courtesy of the U.S. Forest Service.)

MANAGEMENT STRATEGIES

Of the six strategies SNEP analyzed to counter the major declines in late successional forests that were found during the SNEP assessments, three are presented here. Each assumes that existing high-quality late successional forests must be retained and expanded to support the full range of organisms and functions into the future. In concept the strategies illustrate contrasting opportunities in a continuum of landscape designs to achieve similar goals. Although the strategies target different forest types or areas, the designs they use, as well as other combinations suggested by them, could apply to other forest types in the Sierra. Here, as elsewhere in SNEP, we emphasize that actual solutions will depend on analysis of local conditions; the key when going to the ground is to adapt a Sierra-wide framework to local needs. We suggest here the framework of thinking as well as a range of options possible for maintaining and enhancing late successional forest representation at the Sierra-wide scale.

The first two strategies (areas of late successional emphasis and distributed forest conditions) emphasize landscape designs based on existing ecological conditions encountered in different forest types (west-side versus east-side forests). They represent primarily ecological solutions, with less consideration of other factors. The third approach (integrated case study) combines a strategy with a case study. It illustrates how modification of ecological designs might occur when one applies these strategies at a local level. Other factors (than ecological) must be contended with, and several of these are integrated in the case study. A "best fit" of the rangewide pattern for late successional forests is found for local conditions on the Eldorado National Forest.

Goals of Late Successional Forest Strategies

The forest condition strategies have the following goals:

- Maintain existing high-quality late successional forest stands in middle-elevation forests.
- Expand late successional representation by actively managing forest stands that have potential to contribute structure and function.
- Restore fire as an important process in maintaining and protecting late successional habitat.
- Restore structural complexity in "matrix" lands (forested areas not targeted for primary late successional representation).
- Distribute late successional representation across latitudinal and elevational ranges of the targeted forest types.

A recurring question in the development of forest condition strategies is whether provision of large blocks of contiguous late successional forest (several thousands of acres) is critical or whether necessary conditions can be provided with smaller blocks (less than a few hundred acres). Although there are ecological and practical arguments for both, it is clear that large areas of late successional forest were the aboriginal condition. These areas were complex, fine-scale mosaics of varied stand structures, including areas of high and low density, and patches with young and mixed-age trees. Thus, large blocks of late successional forest include many seral stages and structurally diverse patches. Because aboriginal late successional forests tended to be so varied, the ecological value of large, continuous undisturbed areas or "reserves" is less clear than in areas where homogeneous landscape is a natural condition. In the Sierra there is little scientific consensus on this issue, although it is clearer that disruption by roads, mechanical entry, harvest, or grazing reduces the habitat quality and function for some species.

Strong consensus exists, however, on the importance of a late successional strategy that is widely distributed throughout the latitudinal and elevational range of the forest types and incorporates representative cross-section habitat conditions, including different productivity classes, plant associations, slopes, and soils. It is critical to provide not only representation across the range of environments but also connectivity among late successional blocks. Thus, for any strategy, the matrix lands are extremely important parts of a rangewide network. Retaining and promoting late successional structure to some target amount in these forested areas is essential, in that many organisms will use this mosaic for habitat, either independently or as extension from primary late successional blocks. Further, fungi and other detritivores provide important ecosystem functions that will support productivity of soils, animals, and plant communities in the matrix.

Strategy 1. Areas of Late Successional Emphasis

The SNEP team developed one forest condition strategy, "areas of late successional emphasis" (ALSEs), in considerable detail, advancing new simulation models, developing multiple alternatives based on different starting points, and evaluating implications from various runs. These are described in detail in technical reports found in volumes II and III and the addendum to the SNEP final report. Only a brief summary is presented here. This strategy has been developed primarily for west-slope forests, specifically mixed conifer and red fir / white fir types, although in principle the design could apply to several other Sierran forest types. The strategy is targeted for public forest lands, but it could be adopted on private lands where conditions and goals permit.

This strategy stratifies forestland into two landscape categories: areas of late successional emphasis and matrix lands. Achievement of goals at the rangewide scale depends on an integrated network of ALSEs and managed matrix lands across the latitudinal and elevational distribution of the forest type. Different management applies, or is allowed, in ALSEs and matrix lands.

Possible Solutions

Areas of late successional emphasis are areas with a management emphasis on maintenance of structurally diverse forests that provide high levels of late successional function, including habitat for species requiring or preferring such conditions. ALSEs would be large landscape units, typically in the range of 20,000–60,000 acres (multi-polygons), distributed across the range of the forest types. Existing high-ranked polygons (4s and 5s) would be used as starting points for identifying ALSEs, with adjacent or intermixed polygons potential areas for enhancing late successional characteristics. It should be recalled that these areas would not be homogeneous continuous stands of old trees. Patches of lower-ranked stands are included in many 4 and 5 polygons; what is more important, as described earlier, the "natural" late successional condition of Sierran middle-elevation forests is defined by great spatial variability (patches of deep forest interspersed with treefall gaps, areas where fires burned at different intensities resulting in different densities, etc.).

The size of ALSEs and their distribution are based on several criteria. Large size (multi-polygon) is promoted for ecological reasons: large blocks are assumed to provide preferred habitat over small areas for some plants and animals. Large areas also allow better opportunity to protect against loss from catastrophic fire (fuel breaks, fuel reduction) than small areas; if, however, fire should be uncontainable within ALSEs, they are unlikely to be entirely consumed. ALSEs are distributed across the elevational and latitudinal range of the forest types in the western Sierra. Gaps in ALSE distribution at the rangewide scale would occur where large blocks of high-ranking stands do not at present exist to form the base of an ALSE network, or where intermixed land-ownership patterns and conflicting land-use objectives preclude development of large areas.

Management of ALSEs would emphasize treatments to maintain, enhance, and protect high-quality late successional conditions . Active management within ALSEs is anticipated in at least some areas, with prescribed fire being the primary tool. Mechanical fuel treatment (timber harvest) could be allowed if limited in intensity and extent so as to maintain conditions as near natural as possible.

Fire protection within and adjacent to ALSEs would be priority ranked for treatment depending on fire risk severity. Adjacent areas would be subject to active management, with treatments including fuels breaks and other fuel protection zones, timber harvests, and prescribed burning.

SNEP developed several ALSE configurations. One solution is illustrated in plate 6.3. If the ALSEs depicted here were actually grown out as indicated, they would about double the present amount of late successional forest. The exact areal extent of high-quality late successional forest ultimately needed to achieve the objectives cannot be determined from existing information. However, the design and approximate overall abundance of late successional forests are most important. Extent and location of ALSEs illustrated here provide one solution. Local conditions will present real constraints and opportunities. However, the current total acreage is far below levels that existed in the pre-contact landscape, outside what is believed to be the natural range of variability if the rough benchmark of the national parks can be used, and may be inadequately distributed to support plant and biodiversity needs or to be protected against catastrophic loss.

ALSEs as described would not be adequate to sustain

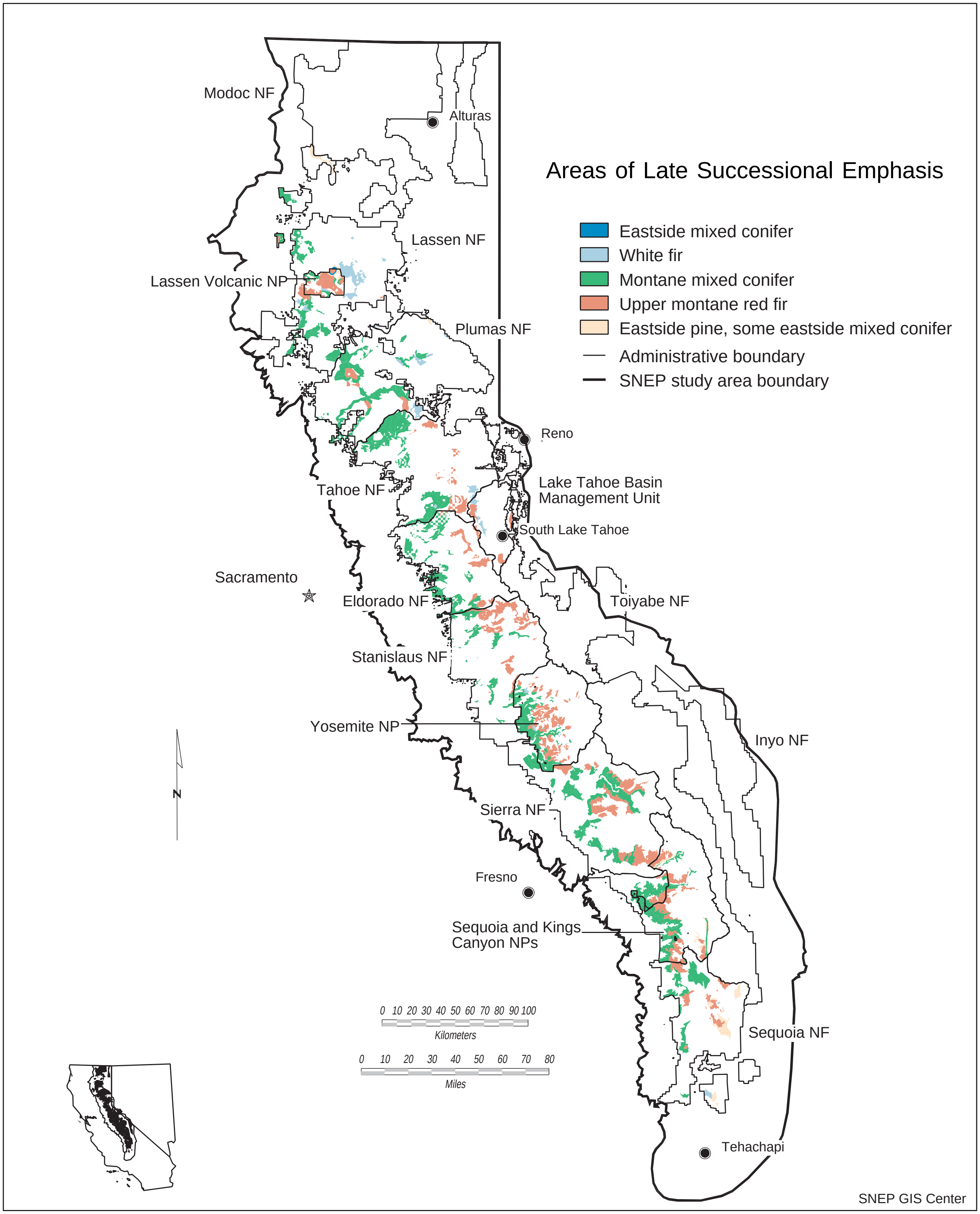

PLATE 6.3

Network of areas of late successional emphasis (ALSEs) in middle-elevation conifer forests developed by SNEP as one landscape design for maintaining late successional forests. (From volume II, chapter 21.)

amounts or distribution of late successional forest near pre-contact levels; contribution of other forest lands is essential to a rangewide network. *Matrix lands* are forested areas outside of ALSEs and fuel protection zones, and they would typically have primary management objectives other than attaining late successional representation. These may be multiple-use forest lands: timber, recreation, firewood cutting, and so on. Although matrix lands have other primary objectives (e.g., wood production), restoration of late successional forest conditions in structurally simplified stands to the structural standards of rank 3 will be critical to achieving adequate amounts of late successional forest at the rangewide scale. Forests have undergone significant structural simplification as a result of timber harvest and other human-caused disturbance. Higher levels of structural complexity are needed in the matrix to maintain biodiversity and forest functions in managed stands that are more characteristic of natural forests. Some of these processes and species—such as the array of fungi that form mycorrhizae with trees—are of direct importance in maintaining the long-term productivity of these sites. Greater structural diversity may also be important to improve the degree of connection—which affects movement of organisms and materials—across the managed landscape.

Silvicultural harvest systems that provide for retention and long-term maintenance of important structures—including large-diameter trees and their derivatives (large snags and logs)—are one effective strategy for providing a structurally complex managed-forest matrix. Partial cutting, including retention of selected forest structures at time of harvest, is a promising approach to maintaining a structurally diverse forest matrix. Structural goals, such as numbers and distribution of large-diameter trees, would vary according to management objectives. Large-diameter trees and their derivatives, large snags and logs, are of particular importance because they fulfill many important ecosystem functions, including provision of wildlife habitat. Silvicultural prescriptions should also incorporate compositional objectives, such as maintenance and restoration of sugar pine populations and representation of other species.

Two general silvicultural prescriptions have been proposed for the Sierra Nevada that can be used to maintain structural complexity in the matrix. Group selection, which involves harvest of small forest areas, is one approach; keeping harvested patches very small and retaining some structural features within areas selected for harvest would assist in maintaining late successional forest functions and organisms. Silvicultural prescriptions that maintain or restore specific structures—such as large-diameter trees—are a second approach. The interim California spotted owl (CASPO) guidelines are one step in demonstrating the feasibility of such approaches. Multiple-entry prescriptions that will systematically provide replacements for the large-diameter tree population are also essential elements of such a strategy.

Implications

The strength of the ALSE strategy developed here is that it clearly delineates a spatially explicit rangewide strategy for retaining late successional forest conditions across the environmental diversity of the targeted forest types. For plants and animals that favor large areas of undisturbed late successional habitat (including the patch diversity inherent to this condition), the ALSE strategy by intent provides this. Large blocks of land such as ALSEs provide efficiency in delineating and systematically managing late successional forests. Large management units more effectively lend themselves both to effective presuppression activities to prevent catastrophic fires and to effective application of managed fire. Blocks of large enough size are developed such that even catastrophic fire would be unlikely to decimate entire ALSE areas. Roads may expand in some areas, primarily matrix, due to the need for fire protection activities or other forest uses. Economic considerations are recognized in the ALSE strategy; potential economic impact is designed to be minimized.

Strategy 2. Distributed Forest Conditions

Whereas in the ALSE strategy goals are met through a network of large ALSEs and matrix forest lands, the distributed forest conditions (DFC) strategy distributes small to medium-sized patches of early to late successional forests continuously over the landscape in a mosaic approximating pre-contact forest patterns.

Historic conditions in many of the fire-adapted forests of the eastern Sierra Nevada were characterized by relatively continuous forest cover at the landscape scale and extreme patchiness at the local scale. Several SNEP assessments draw attention to the importance of patchiness, patch size, and patch variability for maintaining aspects of health and sustainability. An important criterion is patch size and mixture relative to mobility of forest inhabitants. For instance, many large and small mammals, amphibians, and birds use patches of different size and structure for sustenance and reproduction and rely on continuously distributed patchiness rather than large blocks of uniform forest conditions. Forest patchiness is likely to be a critical element in sustaining metapopulation structure typical of many Sierran plant and animal species. Vascular and nonvascular plants, genetic diversity within species, and insects and fungi use, or are adapted to, this landscape pattern. Juxtaposition of openings and old forest patches, size of patch, patch attributes, and distribution of different patch types within the landscape are important elements for sustaining these populations or attributes. Further, many Sierran taxa are likely to be adapted to regular disturbances within some part of their habitat. An assumption is made in several assessments that many Sierran organisms evolved under selection pressure from fire.

❈ *Implementing SNEP Forest Strategies*

Implementation of the strategies summarized in this report and detailed in volume II would require considerable further planning by local managers. Some of the management aspects involve

Fuel reduction: Reduction of fuels that have accumulated from fire prevention and suppression policies and from timber harvest is called for to reduce the potential for widespread, intense, destructive fire. Programs of prescribed burning (figure 6.3) and thinning, including logging and mechanical removal of fuels, will be needed to reduce fuels. The spatial retention of large snags and down logs desirable for late successional functions will at times conflict with the need to eliminate these fuels throughout defensible fuel space zones.

Density management: There are many acres of young stands that were regenerated after timber harvest and wildfires (of 300,000 acres of plantations on national forests in the Sierra Nevada; about half are fire related and half harvest related). These stands are often very dense, and consequently susceptible to damage by insects and fire (figures 6.4 and 6.5). They are often quite vigorous and have the potential for producing substantial yields of wood. Thinning and reducing the density of these stands would increase the tree growth and vigor, reduce susceptibility to insects and fire, increase understory tree and shrub diversity, provide some opportunity to manage tree species composition, and produce commercial yields of wood. Density management in the stands shown in figures 6.4 and 6.5, and 6.6 will enable them to become like the stands shown in figure 6.7.

Riparian areas and ALSEs: Areas selected as ALSEs and riparian areas (described in chapter 8) will contain

FIGURE 6.4

Dense, young stands of ponderosa pine, established after a fire. (Photo by John C. Tappeiner.)

FIGURE 6.3

A mixed conifer stand immediately after burning for fuel reduction. The stand was “salvaged” before burning to reduce fuel loading. This ensured a light burn and safer conditions for workers. (Photo by John C. Tappeiner.)

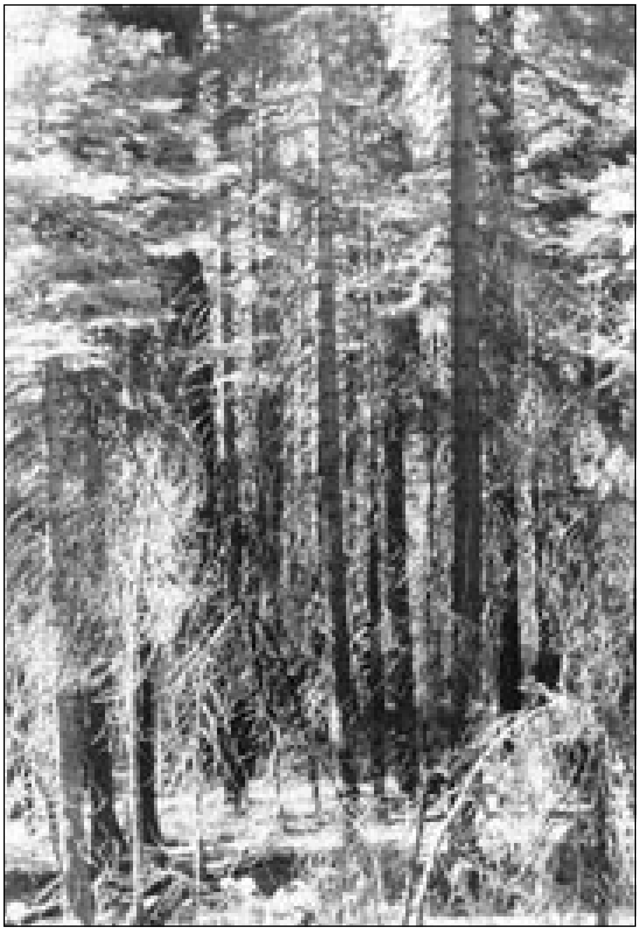

FIGURE 6.5

Mixed conifers regenerated after logging. The stand is quite dense and therefore susceptible to insects and fire. (Photo by John C. Tappeiner.)

FIGURE 6.6

Mixed conifer stands with older (120+ years) sugar pine and ponderosa pine and younger fir and cedar. The trees could be thinned to promote growth of the larger pines, reduce the potential for mortality and fuel accumulation, and produce commercial wood. Underburning could follow thinning. (Photo by John C. Tappeiner.)

FIGURE 6.7

A stand that has been thinned and could be underburned to reduce fuels. (Photo by John C. Tappeiner.)

many stand types, including stands of large old trees and often some hardwood mix; stands designated late successional (rank 4 or 5); young, dense stands regenerated after fire or timber harvest; and stands in which there has been salvage and partial cutting for timber production. Some of these stands have high concentrations of fuels that could be removed to reduce the threat of intense, destructive fire in ALSEs and riparian areas. Many are very dense and are not likely to provide large trees or diverse structures and contribute to the riparian and ALSE functions without density management (figures 6.8 and 6.9).

Management complexity and resource managers: Managing forest stands in riparian areas and ALSEs must

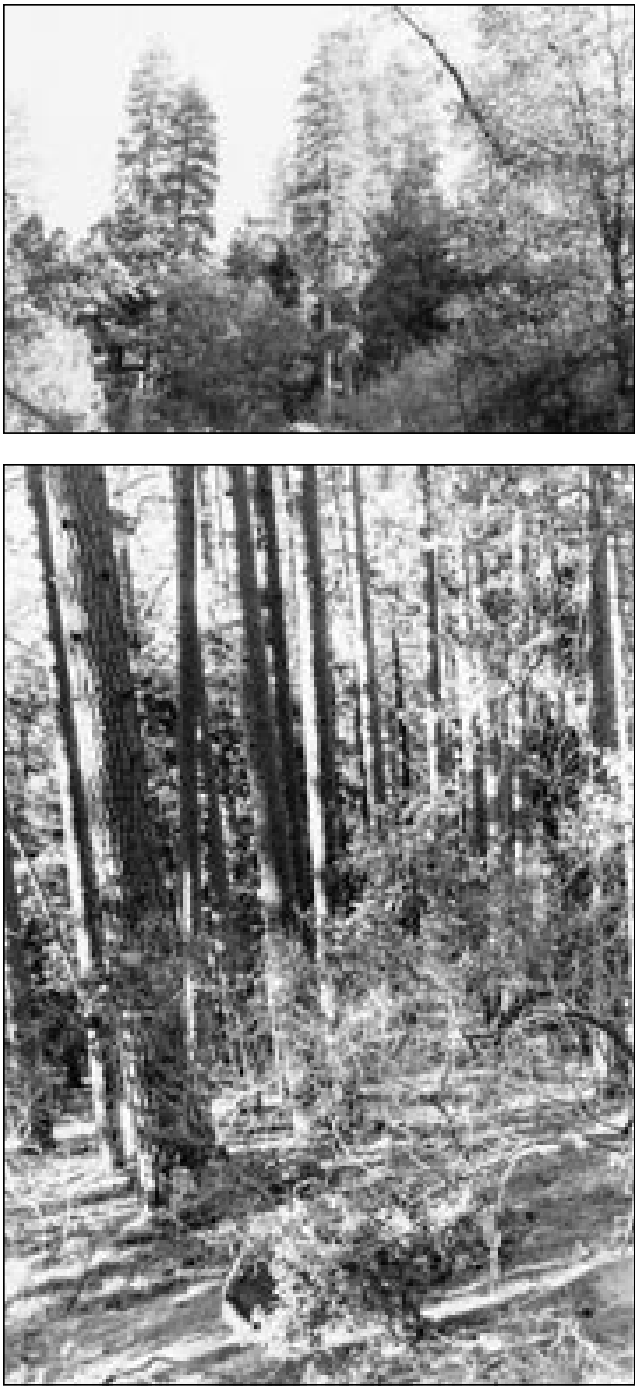

FIGURE 6.8

A group of large ponderosa pine and hardwoods (top) that are susceptible to fire because of dense fuel from shrubs and smaller conifers. An adjoining stand (bottom) of younger ponderosa pine that could be thinned to enhance tree growth and reduce insect susceptibility. The two stands could become one area of large ponderosa pine. Fuel reduction could be done in both stands. (Photos by John C. Tappeiner.)

FIGURE 6.9

High fuels (top) and dense, young stands (bottom) in a riparian area. Careful fuel removal, thinning, and prescribed burning in areas such as these may occasionally be needed to accomplish overall objectives of SNEP alternatives. (Photos by John C. Tappeiner.)

be approached cautiously and is likely to be controversial even if the purpose is to contribute to the function of these areas. For example, removing fuels in riparian areas (figure 6.9) may be needed to enhance their function in the future (figure 6.10). Managers will have to design, implement, and evaluate management strategies to ensure protection and function of these areas. Prescriptions will have to be developed case by case to address local variability in stand conditions, fire potential, wildlife habitat, and operational considerations.

SNEP has not provided prescriptions for accomplishing the objectives envisioned for the various strategies. Its philosophy has been that objectives can best be met by using local expertise to adapt to local conditions.

FIGURE 6.10

An older mixed conifer "ideal" stand in a riparian area: low density, low fuel accumulation. (Photo by John C. Tappeiner.)

Extensive harvest for over 100 years, fire suppression for upwards of 80 years, and grazing for nearly 150 years have greatly altered conditions for east-side conifer types from those indicated as important to organisms. On a regional basis, east-side pine has lost more late successional attributes in the last century than any other forest type analyzed. Small-scale patchiness characteristic of historic pine forests has been pervasively lost or reduced, extensive presence of old trees is gone, forest-floor characteristics and shrub layers have been simplified and altered, complexity of stands as a result of regular fire has been altered, and other ecological functions of fire (e.g., seed and spore germination, induction of sprouting, nutrient cycling, natural selection) have been disrupted.

Possible Solutions

The objective of the DFC strategy is to meet overall forest goals by creating a forest landscape on the east side of the Sierra Nevada (primarily east-side pine) with the following attributes:

- Small patches of different seral ages distributed in an irregular mosaic across the forest.
- Structural diversity within patches appropriate to expected levels for seral stage.
- Fire reintroduced.

Specific desired conditions would vary with local conditions, including specific plant communities, species mixes, environmental variability, total forest extent, topography, environmental and human site history, local biodiversity, and social uses and desires.

For planning and management, the scale would be the CALWATER planning watershed units (a subdivision within the river basins used by SNEP and delineated by the California Department of Water Resources), which are about 5,000 acres. Actual boundaries would flexibly be adapted to local conditions: for example, where forest polygons extend across watershed boundaries, the planning unit might also extend beyond the watershed, accommodating the local forest pattern. Forest patches within the planning watersheds would be about 2–20 acres, uneven aged and multilayered, although in some cases, small (less than 2 acres) even-aged patches could occur. Density of trees within patches and mix of patch types within a watershed would vary with local conditions. Old trees would be maintained in all patches. Snags and downed logs and debris would be retained in locally appropriate amounts. Decadence from biotic and abiotic factors would be maintained in old stands, generally those older than 200 years.

As in the ALSE strategy, forest landscapes are divided into cores and matrix, which are managed differently. Within each planning watershed (or its equivalent), about 30% of the watershed (about 1,500 acres) would be core forests, where emphasis would be to maintain natural processes and develop natural forest spatial and vertical structure, meaning to favor the dominance of nonhuman ecological processes and structures. Areas within planning watersheds that are currently minimally disturbed, especially late successional stands and roadless areas, would be favored for core forests. Core forest acres would not need to be contiguous, but areas of more than 100 acres would be best for ecological and management efficiency. Managed fire would be encouraged in core areas, with the goal of reducing risk of severe fire to a point where managed fire or prescribed natural fire could burn eventually with minimal risk. Mechanical treatment of fuels, including removal by harvest, would not be prohibited but, to the degree practicable, would be limited in intensity and extent within core forests to maintain natural conditions.

Additional biodiversity values would be given high priority in core areas, including restoration and maintenance of native plant diversity and maintenance of genetic diversity. Wildlife habitat requirements would be considered in local evaluations; decisions about patchiness and forest structure would be developed primarily relative to inferences of historic habitat, not developed from a single-perspective goal of increased animal abundances. Grazing would not be allowed in core areas.

The remaining 70%–80% of the watershed, the matrix, would be available for more intensive uses. Local conditions would dictate the number, size, distribution, content, and spatial pattern of patches in the matrix. The constraining terms for management would be achievement of the overall goals for forest strategies and the specific objectives for this scenario, especially maintenance or development of a fine-scale mosaic of seral patches (small size, distribution, juxtaposition), maintenance or development of appropriate complex structure within patches, and reintroduction of fire. For example, timber harvest, livestock grazing, or developed recreation could be allowed subject to local evaluation. In many stands, maintenance of open stands and vigorous tree growth would be encouraged in the first 100 years.

Fuels treatment would be given high priority throughout the watershed units, both core and matrix areas. With local exceptions (to protect especially highly valued late successional stands or biodiversity areas), fuels treatment would not be concentrated geographically. That is, fuels treatment would not necessarily be designed to protect core areas generally but would follow reasonable strategies aimed to eventually address fire regimes in the whole watershed. Managed fire would be used to combine objectives of restoring ecological function, reducing fuels, thinning and sanitizing stands, preparing for reforestation, and maintaining fine-scale patchiness.

Maps are not presented for this strategy, because SNEP did not map successional status at the scale of small patches.

Implications

By intent, this DFC strategy distributes seral diversity across the landscape, benefiting those organisms and ecological functions that use a pattern of patchiness. Existing small patches of late successional forest would be maintained where they occur, and late successional forest stands would be evenly distributed over the landscape. Risk of loss of late successional forest is distributed differently than in ALSE strategies, in which areas are concentrated: individual core areas could be expended, because of replication. Fire-protection efforts can be scattered across the landscape rather than concentrated. Although patches are small and inventories would be needed at that scale, forest managers are more accustomed to working at the scale of stands.

This strategy would not rely on excessive coordination at the rangewide or regional scale. Coordination among landowners of units less than 5,000 acres would be necessary, but only minimal coordination would be necessary for areas larger than that. The strategy is flexible to local adaptation and would integrate relatively easily with other solutions that are less flexible, for instance, a Sierra-wide biodiversity management areas network (chapter 5).

Despite these positive benefits, several difficulties for implementation would arise from this strategy. First, managing at the scale implied by this scenario would be administratively challenging and costly. Many administrative and on-the-ground difficulties would arise from planning, tracking, and coordinating activities in patch sizes of 2–20 acres and watershed units of 5,000 acres. Ways of managing at a higher level (clusters of patches) may exist, and GIS / GPS technology would assist the process; however, new institutional capacities and staff organization would have to be developed.

Further, excluding livestock grazing from core areas but not matrix forests may prove prohibitively expensive and nearly impossible to enforce, especially if the units of the core forest in each watershed were not contiguous (i.e., fencing difficulties). On the other hand, if grazing could be eliminated from entire select watersheds or the entire forest, this problem could be managed.

Because this strategy gives little direction for where fuel reduction and managed fires should be conducted, the average rate of reintroduction of fire per watershed would probably be very low.

Success in adaptation and use of this strategy could be evaluated by monitoring

- number of watersheds treated (general strategy mapped, planned, treatments begun)
- average number of acres per watershed treated
- average number of acres per watershed managed for (and currently in) late successional seral patch status
- average number of acres managed for other seral stages
- average number of acres designated and managed as core forest per watershed
- distribution of late successional patches in the landscape; adjacency to diverse seral patches, pattern of patch mixture
- individual tree measures, such as size increase, structural complexity changes, number of snags and downed logs, forest health trends
- average acres per watershed burned, by intensity class
- plant diversity status landscape wide
- wildlife habitat ratios per watershed and actual animal use
- average riparian protection width managed per watershed
- average timber harvest amount per watershed, as a ratio of core to matrix
- average number of acres of livestock grazing per watershed as a ratio of core to matrix
- average number of miles of roads built or eliminated per watershed
- cost and administrative feasibility and efficiency
- social acceptability

Strategy 3. Integrated Case Study

A final forest-condition case study integrates seven of the SNEP strategies and illustrates how late successional goals could be integrated with other objectives in an application to the Eldorado National Forest. This case study illustrates some of the modifications and novel solutions that are possible when implementing regionwide strategies in practice locally.

Goals

This strategy/case study integrates goals for the following attributes:

1. Late successional forests
   - Provide a well-distributed network of late successional forests sufficient to sustain the organisms and functions associated with such ecosystems.
   - Include the full range of representative native vegetation in the selection of late successional areas.
   - Include aquatic areas as feasible in late successional area selections.
2. Vegetation
   - Restore and maintain Sierran plant communities with representation of all plant community types, emphasizing native biodiversity.
   - Recognize the need for regional representation in plant community maintenance throughout the Sierra Nevada.
   - Restore a species mix more representative of natural conditions and reduce influence of exotic species wherever feasible.
   - Maintain vegetation units on a large enough scale to promote genetic resilience and provide functional wildlife habitat.
   - Restore and maintain forest health to provide resistance to large-scale insect depredations and high resiliency to meet periodic droughts and wildfires.
3. Wildlife habitat
   - Restore and protect riparian corridors of vegetation.
   - Plan forest extractive uses to attain a dynamic flow of plant communities of different ages distributed across the landscape without unnaturally large openings or extensive areas of young forest.
   - Recognize unique habitat needs for certain wildlife species.
4. Watershed and aquatic areas
   - Maintain soil profiles intact.
   - Reduce sedimentation to minimal levels, as near the low range of natural levels as practicable.
   - Provide increased protection for both large and small aquatic systems, attaining high-quality habitat for both vertebrates and invertebrates.
   - Identify and take corrective action to eliminate contamination by toxic materials.
5. Fire protection
   - Reduce substantially the area and size of high-severity wildfires, giving priority to the fire safety of communities, forests at extreme risk, and watersheds with high erosion potential.

- Restore fire to something near its historic natural role, recognizing this may be possible for only a portion of the Sierra Nevada.
- Reduce the fire severity potential for areas of late succession emphasis (ALSEs).

6. Community well-being
   - Provide a continuing flow of forest resources to meet human needs.
   - Incorporate private landowners, residents, and interested parties into collaborative planning for both public and private lands.
   - Use forest management activities to build local socioeconomic status.

7. Private land contributions to ecosystem sustainability
   - Recognize that private land uses are a critical part of ecosystem sustainability in most parts of the Sierra Nevada and that mutually acceptable goals must be formulated.
   - Institutionalize collaborative planning wherever possible when it is clear that significant ecosystem functions are dependent upon intermixed ownerships.

Possible Solutions

This strategy incorporates a wide range of strategies to bring an integrated approach for systemwide benefits. Implementation of fire strategies is largely financed through commercial sales. Private land uses are important in the long-term sustainability of ecosystems of the entire range. Every major stream within the Eldorado National Forest has private lands somewhere along its length. Collaborative planning is essential to set effective goals and attain successful results. Core ALSEs include the best of late successional conifer and hardwood forests joined with areas exceeding 40% slope added to a 300-foot zone along major streams. Areas of concentrated public use (e.g., recreation centers, main roads, communities) are placed in the matrix, recognizing the need to provide for public safety (e.g., snag removal, fuel reduction).

Specific attention is paid to the following problems addressed in assessments:

- Structural characteristics, distribution, and spatial relation of forest habitat have been fractured or threatened through development and are at risk to large wildfire burns of high intensity.
- Fire hazard is unacceptably high for many areas that include forest communities, sensitive watersheds, and much of the mixed conifer type.
- The area of high-quality, structurally complex, late succession forests is quite limited in the mixed conifer type, well below the range of natural variability.
- Areas of steep slopes or highly erodible soils continue to yield unacceptable sediment loads, whenever disturbed, adversely affecting downstream values.
- Aquatic invertebrates and vertebrates are in continuing decline due, in part, to habitat loss, introduction of exotics, and modified stream flows.
- Forest yields of commercial products have been completely disrupted in the last five years while major forest plan adjustments are made.
- Population growth rates along the western forest edge and in the oak woodlands are putting enormous stress on public land management and dependent wildlife and are potentially threatening the continuity of large blocks of undeveloped or lightly developed land areas with major representations of native vegetation.
- Fire protection for the last half century has provided for the development of continuous dense forest stands, which are in need of thinning to accelerate growth, reduce fire hazard, provide more midsuccession forest habitat, and yield usable wood.

The Eldorado strategy / case study integrates fire protection, late succession emphasis, watershed and aquatic area protection and restoration, reintroduction of fire as an element of ecological importance, linkage of late succession vegetation of all species with riparian habitat, spatial distribution of various seral stages for desired wildlife habitat, recognition of the critical contribution of private lands in maintenance of the ecosystem, adoption of an adaptive management approach so that activities may move ahead without long delays, and involvement of local communities in restoring and maintaining ecosystem elements as well as resource utilization. The case study illustrates how solutions will play out differently in the various parts of the Sierra Nevada due to local conditions, opportunities, management objectives, and ecosystem conditions.

Late Successional Forest Strategy. The core areas for late succession management are derived by

- Setting goals of area representation (e.g., 20%–25% of mixed conifer forest in late successional condition).
- Using the late successional areas ranked 4 and 5 as bases for developing "watershed ALSEs," adding areas formed by the overlapping of slopes > 40% and high soil erodibility (K factor >0.28).
- Extending the area now formed to include a 300-foot strip along perennial streams. Mixed conifer ALSEs are joined with hardwood forest, chaparral, red fir, and subalpine to form, where possible, connected late successional vegetation. Wilderness, wild and scenic rivers, and other existing

forest plan allocations retaining old-growth representation (e.g., spotted owl habitat areas) are included. The core areas are adjusted so that boundaries do not fall in the midpoint of steep slopes, are not intermixed with private lands, and do not include prominent ridgetops where fuel breaks must be constructed.

- Attempting to get some late successional representation for vegetation types occurring in each of the super planning watersheds of the California Department of Water and Resources (average about 14,000 acres).
- Accelerating the development of old-growth forest characteristics in ALSEs through thinning, favoring underrepresented tree species to attain natural species distribution. ALSE polygon boundaries are modified in some cases in order to attain practicable management boundaries.

Matrix Lands. Matrix management is prescribed to provide a full range of seral stages spatially arranged to avoid large, contiguous areas of a seral stage; protection is provided to both large and small aquatic systems, recognizing various levels of influence zones around streams.

Hardwoods are provided through silvicultural prescriptions in the conifer areas, by riparian protection along streams, and management of the oak woodland using best management practices. Rotation age is lengthened to 175–225 years for conifers. Within planning watersheds the goal is to attain and maintain more than 25% of the area in mature forest. Silvicultural prescriptions vary and include individual tree selection as well as small group harvests of 0.5 to less than 3 acres. Commercial yields are produced through silvicultural prescriptions to attain biodiversity objectives, reduce fuel hazards, and thin stands to accelerate growth and encourage stand health. Stand-terminating wildfires of substantial size (more than 1,000 acres) will require a review of both ALSE and matrix alignment. The special management areas (e.g., spotted owl habitat areas, undeveloped recreation areas) included at present in the Eldorado National Forest plan are placed in either ALSE core or matrix lands, depending on the most appropriate local fit.

Aquatic and Riparian Protection. All areas are provided increasing protection for both small and large aquatic habitats. Old-growth trees are left surrounding meadows and springs as well as along streams. Livestock grazing is eliminated from riparian areas in unstable or deteriorating condition. Watersheds with current high quality of aquatic biodiversity are maintained; those needing improvement are identified for appropriate restoration. Management direction incorporates the concepts of three zones of riparian influences; community, energy, and land-use zones associated with aquatic life.

Terrestrial Plant Representation. The biodiversity management area (BMA) selection approach developed in chapter 5 is used through a review of the ALSE design and a search for opportunities to incorporate BMA selections of local plant community types. Areas where both public and private lands are required to meet objectives are identified and favorable collaborative planning or exchange opportunities offered. BMAs require active, adaptive management with the management goal for renewable resources to sustain many if not most elements of native biodiversity. BMA selection may include either lands in the ALSE or in the matrix. For BMA matrix selections, special management provisions would be prescribed depending upon how well the present condition of the selected area matches the desired native biodiversity.

Fire Hazard Reduction. A fuel break system is incorporated that has two objectives. The first is to provide a separation between forest and developed communities that will minimize the threat of catastrophic fire to either area. The second is to break up the existing unacceptable fuel loads and thereby provide a safer place from which to apply managed fire and suppress wildfire. Prescriptions for fuel breaks will vary with the type of stand and its location. Treatments could include thinning young stands and then using prescribed fire to reduce fuels from slash, forest litter, and understory shrubs. Small patches of shrubs should be retained. Salvage of dead wood and removal of snags completes the fuel break until maintenance is required. Hazard reduction work is targeted for areas of high priority based on values at risk, likelihood of loss, or ecological benefits that justify costs. As practicable, fire is reintroduced as part of the management process to provide the natural effects of periodic low- and moderate-intensity fires.

Plate 6.4 depicts one solution possible for a portion of the Eldorado National Forest when these goals are integrated.

Implications

Implementation of an integrated strategy such as is suggested here implies the following:

- Silvicultural prescriptions must include development of structurally complex forest stands for various forest types. Opening sizes can be tailored to encourage successful reproduction and growth of both shade-tolerant and shade-intolerant species.
- Increased use of fire to reduce fuel hazard and for ecosystem health will bring substantial risk of escape fires and will probably be curtailed by air-quality regulations. Large-scale use of fire will require public education and further proof of air-quality benefit gained through prescribed fire as compared with wildfire.
- Fuel hazard reduction can be funded largely through resource extraction collections rather than through increased appropriations.
- Ecosystem restoration and maintenance will require more capital reinvestment in the system. All benefiting resource

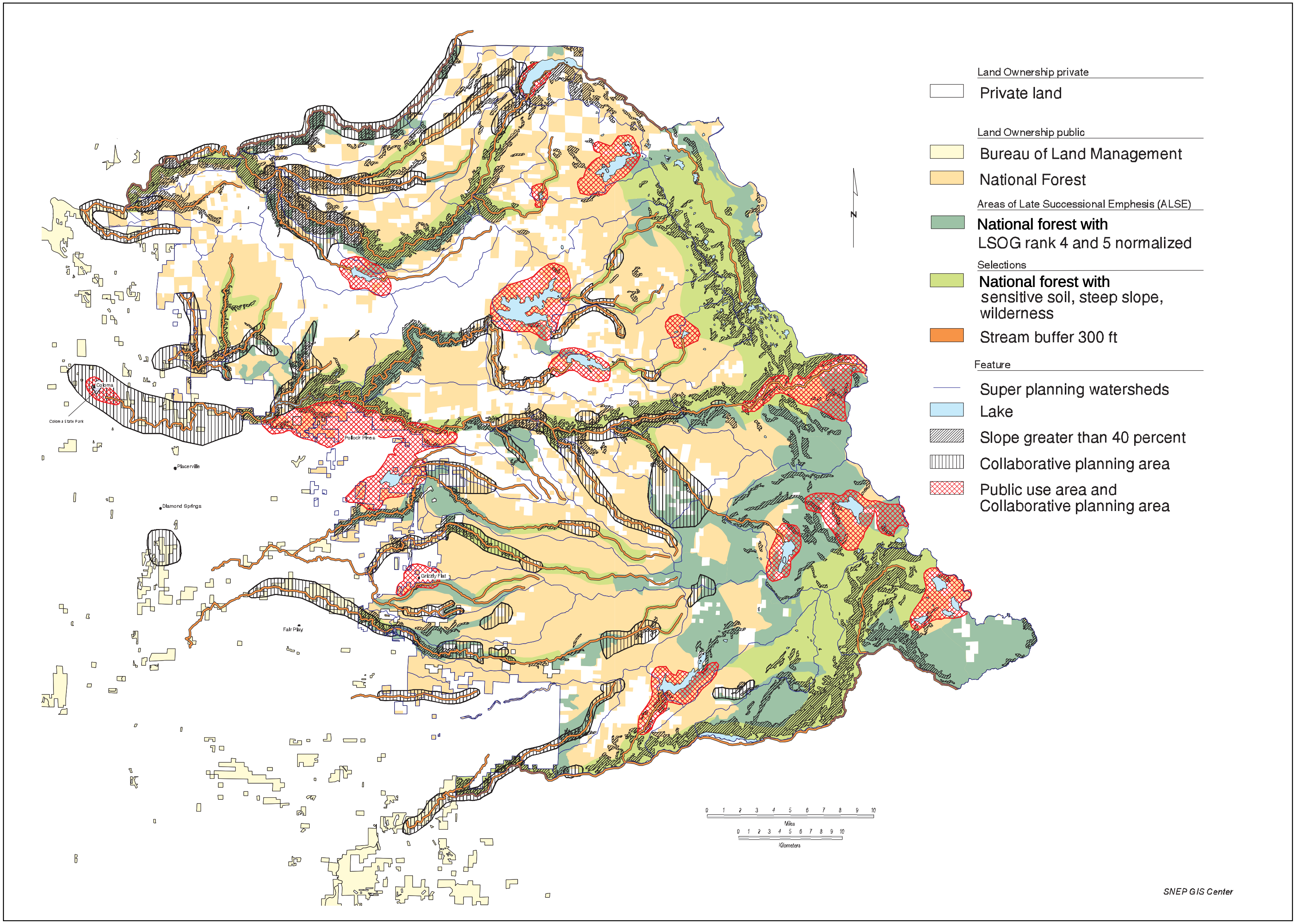

PLATE 6.4

One alternative suggested by the Integrated Watershed Strategy/Case Study for the Eldorado National Forest.

users must reinvest substantially in the maintenance of the system.

- Private and public landowners must be willing to join in collaborative planning and management toward mutually acceptable goals.
- Adaptive management will require the availability of research personnel to work periodically, but regularly, with land managers.
- Knowledge gaps must be identified and vigorously researched before major problems arise.
- Off-site air pollutants that drift into the Sierra Nevada largely from sources in the Central Valley and the Bay Area are not considered in the strategy.

The success of such a strategy / case study would be evaluated using the following criteria:

- Proposed activities are evaluated in context with landscape-scale strategies that reflect the goals for the larger area within the project objectives.
- Progress has been made in reducing the fuel hazards in selected areas, as measured by before and after fuel load; arrangement, continuity, and loss of desired structural components; and the distribution and area of attained desirable fuel profiles.
- Late successional forest areas including the existing concentrations of high-quality late successional forest are well distributed in the various watersheds. The network includes major riparian vegetation associations and areas of greatest soil sensitivity.
- A target level is established for plant community representation within major watersheds.
- Best management practices (BMPs) incorporate provisions for small and large aquatic zones, incorporating the concepts of riparian, community, and energy zones.
- Wildlife species associated with specific seral stages are supported adequately by the planned or established vegetation structure and distribution.
- Collaborative goal-setting and planning efforts are under way with private landowners and local communities.
- Local residents are involved in the various activities, including restoration, maintenance, and resource utilization.
- Baseline references have been established for key ecosystem features so that progress can be measured. A core of late succession forests (ALSE), well distributed in the super planning watersheds, is established. Matrix spatial vegetation targets are established and attainment is under way.
- Stream sedimentation levels are acceptable. There is progress in improving and maintaining local socioeconomic status.
- Resource use and output levels are meeting human needs and are consistent with ecosystem sustainability.
- Sufficient reinvestment resources are available for maintenance and some restoration progress.

Conclusions from Forest Conditions Strategies

None of the three strategies presented here or the six developed elsewhere is perfect in addressing all important design elements. In the samples presented in this chapter, it becomes clear that decision making about goals is a local and collaborative public process, although science can help understand how forested ecosystems work, defend scientific bases for setting management targets, and evaluate progress toward goals. Exact values about acres, boundaries, or locations that would guide restoration—that is, whether to use data from historical sources to guide restoration targets, ecological goals of maintaining biodiversity, or practical goals such as fire protection—are not determinable. This is partly because information is scanty, because some aspects of ecosystems are unknowable, and because in practice restoration targets are determined by local conditions. When pieces are considered collectively for a region or watershed, modifications and compromises result. What is most needed now is a collective will for collaborative goal-setting, integrated with scientific counsel and monitoring.

The best way to ensure that late successional forest conditions are available and maintained in the Sierra Nevada is to have this goal stated and explicitly addressed as part of any management strategy. It is highly unlikely that such forests will be present in the Sierran landscapes in the desired quantities if they are expected to be a by-product of other management objectives. A point of consensus is that an effective late successional strategy would start by retaining the best high-quality stands (ranks 4 and 5 and equivalents on other forest types) as core areas in any design.

How do the directions indicated in the present strategies compare with current practices? From federal policy (e.g., the new CalOwl plan) to revised state forest practices, although explicit goals for rangewide networks of late successional forests are not stated, the tendency is toward increased representation of late successional structures in Sierran landscapes, although not necessarily representation of full late successional ecosystems. The public has clearly indicated an interest in the continued existence of late successional forests both for their intrinsic interest and as habitat for associated species and processes. A pressing need is for development of a defensible rangewide strategy that explicitly recognizes the objective of maintaining late successional forests and is flexible enough to allow local adaptation and cross-ownership implementation.

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