Chapter 6

Restoring Biodiversity on Public Forest Lands through Disturbance and Patch Management Irrespective of Land-Use Allocation

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Critical elements of biodiversity in heterogeneous forest environments may be distributed in patches over large landscapes. The landscapes themselves are a mosaic of private and public land-use allocations designed to meet numerous public expectations that may or may not be compatible with biodiversity conservation.

Such allocations of land administratively fragment the landscape, making management and conservation efforts complex (Everett et al. 1994; Everett and Lehmkuhl 1996; Landres et al. 1998a). Further, differences in vegetation structure arising from differing standards of use result in ecologically fragmented landscapes (Wiens et al. 1985; Schonewald-Cox and Bayless 1986; Everett and Lehmkuhl 1996; Landres et al. 1998a). While objectives of specific allocations may be met, larger-scale biodiversity objectives may be jeopardized by this fragmentation of habitats (Soulé and Wilcox 1980; Harris 1984), the boundary effects of fragmented habitats (Soulé 1986; Jansen 1986; Wiens et al. 1985; Landres et al. 1998a), and the disruption of disturbance and recovery processes across large landscapes (Schonewald-Cox and Bayless 1986; Everett et al. 1996).

Differing management goals and the resulting ecosystem character of private versus public lands provide great challenges to biodiversity conservation (Noss 1983; Sprugel 1991; DellaSala et al. 1996). However, management of public lands perhaps presents greater challenges because of the wider array of social, economic, and ecological demands placed on them. On public forest lands, the U.S. Forest Service, under the mandate of the National Forest Management Act, developed management plans that allocated land use between a number of competing activities, such as timber production, livestock use, recreation, and wildlife habitat, according to a multiple-use model (Diaz and Apostol 1993; Smith et al. 1995). The law did not specifically define the mechanics of how that allocation should occur on the landscape, so land-use emphasis was defined by permanent allocation for the "best" use. The result is administrative and ecological fragmentation of landscape with similar ecological potential. For example, composition and structure of dry pine-fir forests of the inland western United States that are managed for timber production are different from landscapes managed for deer winter range (40 percent cover, 60 percent forage; Thomas 1979), and both could be significantly different from historical stand conditions that were in synchrony with disturbance regimes (Figure 6.1A, B).

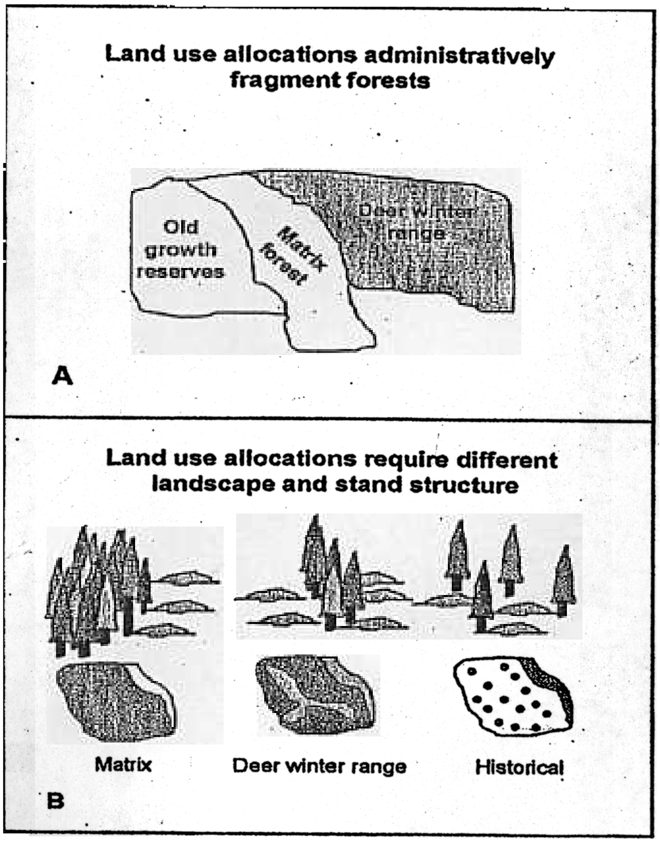

Figure 6.1. A, administrative fragmentation of landscapes by land-use allocations; B, associated stand and landscape characteristics.

Current approaches to federal land-use planning emphasize management of ecosystems for biodiversity conservation and compatible human use (Agee and Johnson 1988; Overbay 1992; Dombeck 1996), but allocations and the problems associated with them remain even where allocations, such as reserves, are primarily intended to preserve biodiversity (Schonewald-Cox and Bayless 1986; Everett and Lehmkuhl 1996; Landres et al. 1998a, b). For example, Camp (1995) found that current amounts of late-successional forest in reserves designated on federal forest land in the eastern Washington Cascades by the Northwest Forest Plan (USDA 1993) were not sustainable over the long term. She also found a similar amount of late-successional forest in adjacent allocations managed under standards that provided even less protection for late-successional forest. The relatively poor prospect of maintaining late-successional forest in the reserves was a function of the highly dynamic disturbance regimes that exist in dry forests of the eastern Washington Cascades (Agee and Edmunds 1992).

Inherent disturbance regimes, defined as the combination of natural disturbance regimes (insects, pathogens, fire, windthrow, mass wasting, indigenous people) and human-induced disturbance regimes subsequent to European settlement, have shaped forest stand and landscape structure and set limits on current management (Everett et al., in press). Goals for allocations of biodiversity conservation, ecosystem integrity, or resource production are unlikely to be achieved when anomalous ecosystem components, such as dry forest habitat for northern spotted owls (Agee and Edmunds 1992), cannot be supported under the inherent disturbance regime. Maintenance or restoration of ecosystem integrity on public lands (Quigley and Bigler Cole 1997) will require the minimum dynamic area (Pickett and Thompson 1978; White 1987) for disturbance regimes to be a primary factor in management strategies, whether those regimes are based on allocations or on the elimination of boundaries to allow a "whole-unit" approach.

Rather than adding more or different allocations and their attendant ecological and administrative problems, we need to expand and integrate biodiversity and social goals across the whole landscape and manage landscape elements in a way that accords each patch the maximum independence of its management protocol and recognizes the ecological limits to resource extraction (Ehrenfeld 1991; Haynes et al. 1996). Under a "whole-unit" ecological approach (Everett and

Lehmkuhl 1996), landscapes are viewed and managed as a unit with a consistent primary objective of ecological integrity for all areas, rather than as an assemblage of land allocations (reserves, matrix forest, riparian, and so forth) with different management standards and resulting variation in integrity. Allocation boundaries are dissolved to the extent ecologically and administratively possible, and pattern and process are managed based on the ecological potential and management opportunities, such as infrastructure, in each patch.

Until a whole-unit approach can be realized, a transitional phase would combine compatible allocations and implement an "emphasis-use" process (Everett et al. 1994; Everett and Lehmkuhl 1996) to integrate land allocations within large landscapes into more functional ecosystems. Under this approach, biodiversity goals are emphasized in similar habitats in adjacent land allocations, and continuity in disturbance regimes is restored among adjacent land allocations. This process promotes the reestablishment of inherent disturbance regimes and the minimum dynamic area required for ecosystem maintenance (Walker 1992). In the long term, the reestablishment and management for inherent disturbance effects lead to "whole-unit management" of the larger landscape.

In the following pages we describe a stepwise process to achieve whole-unit management that begins with integration of existing allocations in a transitional "emphasis-use" approach, then moves to dissolution of allocations for whole-unit management. We describe three steps in the process. Step 1 consolidates adjacent compatible allocations to reduce administrative fragmentation of the landscape. It focuses on similarities in vegetation between adjacent land-use allocations and combines land-use allocations where possible. Step 2 attempts to integrate, but not dissolve, adjacent allocations with significantly different land-use expectations and required vegetation structure. It focuses on matching within-allocation patch heterogeneity with among-allocation patch similarity to expand biodiversity goals and to restore connectivity in disturbance regimes across allocation boundaries. These first two steps work with existing allocations, including reserve systems, and could be implemented immediately.

Step 3 moves to whole-unit management by reinitiating inherent disturbance regimes and managing vegetation pattern and dynamics based on resource potential of the vegetation patch, regardless of current land-use allocation boundaries. The eventual outcome of Step 3 is whole-unit management and the dissolution of allocation boundaries within ecological units.

Step 1: Consolidate Compatible Allocations

The boundaries of land-use allocations often reflect legal mandates and ease of administration rather than precise ecological boundaries and uniformity of vegetation (Keiter 1988; Landres et al. 1998a; Brunson, in press). An allocation captures a percentage of the desired resource condition but may exclude similar areas located in adjacent allocations with different emphasized uses. Moreover, the landscape within the allocation can be heterogeneous, with patches varying in potential, thereby achieving the desired conditions. As a result, an allocation can project unrealistic expectations for the maintenance or creation of desired conditions within its own boundaries and preclude opportunities for using similar conditions in compatible adjacent allocations to meet larger-scale management goals.

Camp et al. (1996) demonstrated the limited ability to grow and maintain late-successional forests within the Swauk Late Successional Forest Reserve in the eastern Washington Cascades, a potential range of 9 to 16 percent of landscape, and showed that a similar limited amount of old forest occurred in similar adjacent, unprotected land allocations (Figure 6.2).

We suggest that the first step in integrated landscape management is to evaluate adjacent land-use allocations for similar current or potential vegetation conditions that meet the emphasized use of each, and then combine allocations where possible. An example would be combining adjacent land allocations for deer winter range and for livestock grazing to improve management on the extensive (57,000 hectares) Tyee Fire in the Entiat Watershed in eastern Washington (Everett et al. 1996; Figure 6.3A, B). Required vegetation for both uses is sufficiently similar that allocations may be combined and both uses achieved from the whole. The scenic allocation could also be integrated with adjacent allocations for increased landscape continuity. The resulting larger management areas should provide greater connectivity in vegetation conditions and common disturbances across the landscape. The capability to manage for unplanned disturbance effects should increase as we increase opportunities to provide resource conditions elsewhere in the undisturbed portions of the larger land base of the combined allocation.

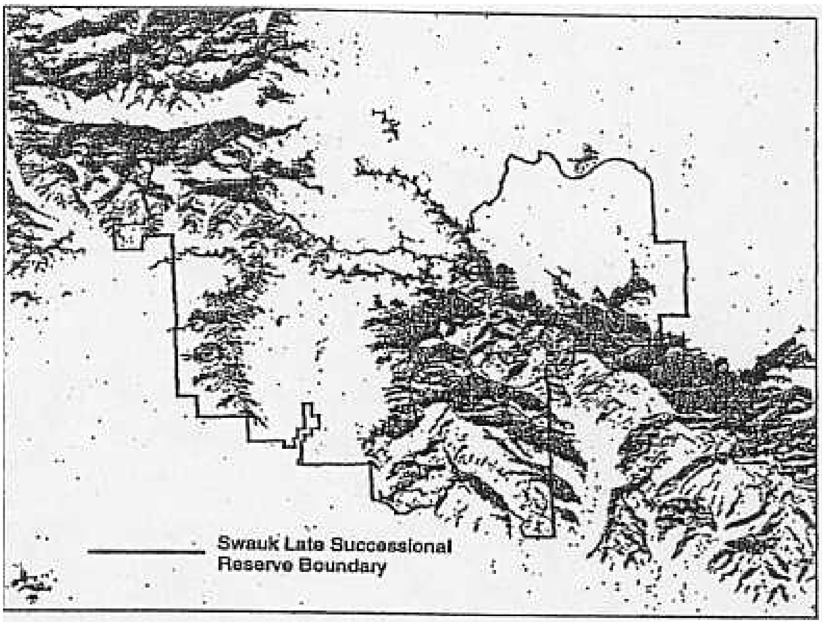

Figure 6.2. Amounts and spatial location of late-successional old-forest patches in a portion of the Swauk Late Successional Forest Reserve (Camp et al. 1996) and surrounding area.

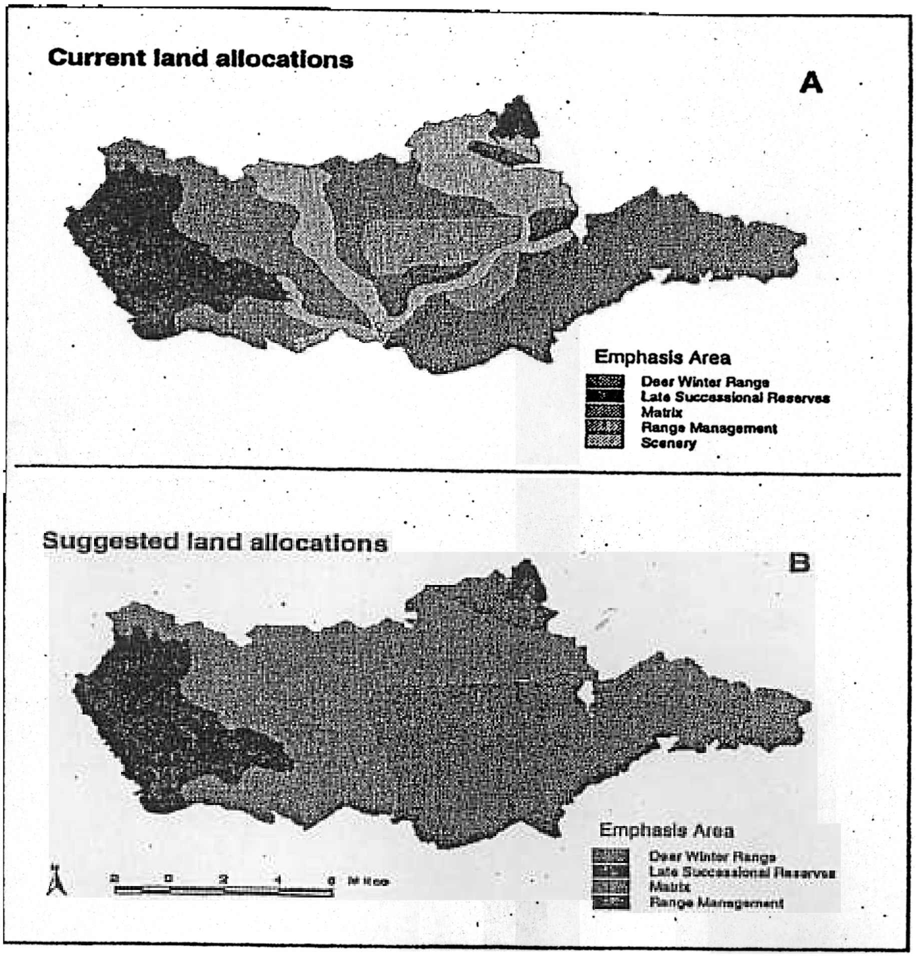

Figure 6.3. Integration of range, deer winter habitat, and scenic allocations on the Tyee burn area in eastern Washington. A, current allocations; B, suggested allocations, combining similar allocations.

Step 2: Integrate Dissimilar Allocations

An "emphasis-use" approach (Everett et al. 1994) to integrating adjacent allocations protects the emphasized use of the individual allocation but also promotes the integration of larger-scale objectives across allocations. The emphasis-use approach integrates adjacent land allocations through reciprocal conservation of emphasized conditions (for example, vegetation patterns, unique habitats) and through the reestablishment of shared disturbance regimes and their effects among allocations so as to increase their sustainability (White 1987) (Figure 6.4). If applied correctly, the approach can potentially reduce administrative fragmentation of forest landscapes by management activities and maintain the dynamic nature of the ecosystems while still allowing harvesting of forest products to meet public expectations (Everett and Lehmkuhl 1996). The strength of the emphasis-use approach lies in its ability to realistically and ecologically manage various types of existing allocations and its potential to integrate diverse allocations (including reserves) to achieve biodiversity goals in the larger landscape. Another advantage of this approach is that it does not require additional allocations and can be implemented immediately.

Extend Biodiversity Goals to Adjacent Allocations

The area required to conserve biodiversity with reserve-type allocations exceeds the amount of pristine land available or that which would likely be dedicated to biodiversity considering other competing land values (Hansen et al. 1991). Given that only 3 percent of the world's surface is in protected areas (Samson 1992), we need to capitalize on opportunities to expand biodiversity objectives to adjacent areas where desired habitats may also be present (DellaSala et al. 1996). The establishment of "late-successional reserves" (LSRs) under the Northwest Forest Plan (USDA 1993) is a partial example of overlaying an old-forest conservation emphasis on an array of existing land-use allocations to extend conservation of old forest beyond existing wilderness and roadless areas. LSRs provide a common conservation emphasis (old forest) among a collection of existing allocations to increase emphasized habitat and reduce reserve isolation. As suggested by Franklin and Forman (1987), the latter process is akin to "feathering the edges" of individual stands. The problem with the

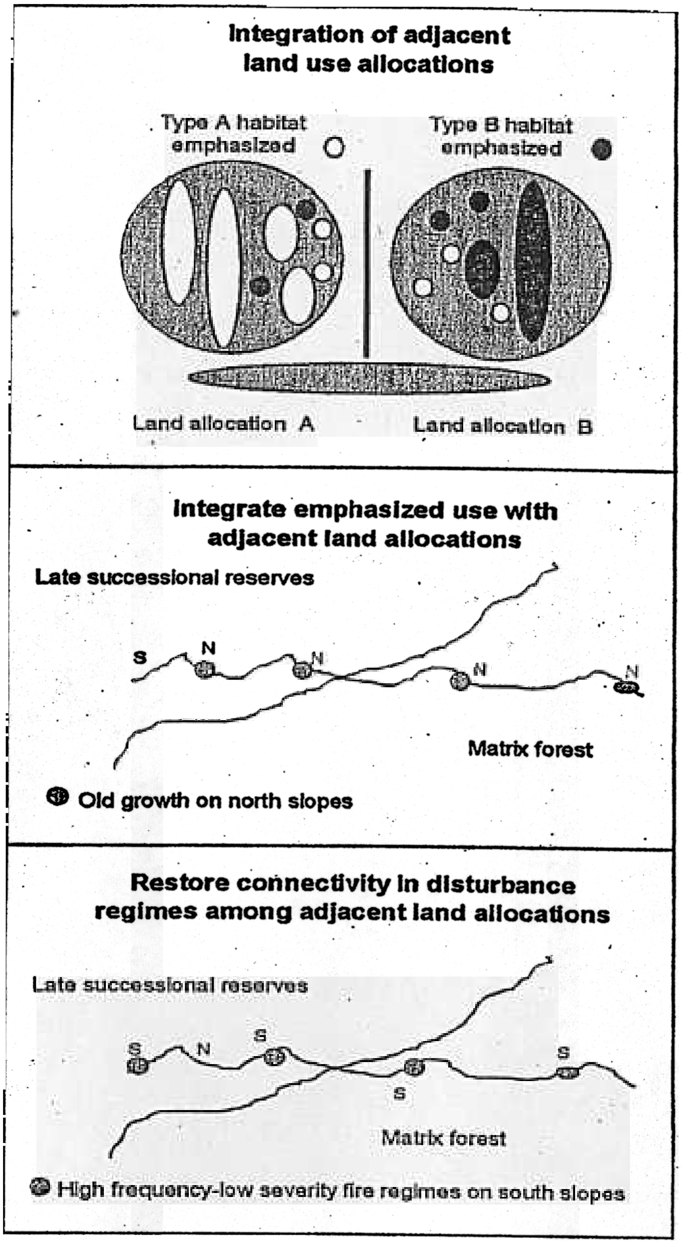

Figure 6.4. Reciprocal conservation of desired habitat across allocations and the restoration of shared disturbance regimes.

LSR solution is that the emphasis occurs in new formal allocations overlaid on old ones and is not applied to the whole landscape, so only sections of existing wilderness or roadless areas are buffered. Consequently, the LSR becomes a new allocation with boundaries and standards and their attendant ecological and administrative problems and complexities.

The emphasis-use process could be repeated at the next lower scale to integrate LSRs with adjacent allocations. For example, feathering the edges of land allocations would benefit late-successional reserves established in dry pine and fir forests on the east slope of the Cascades. Here old-forest stands occur as small patches in specific topographic positions in a matrix of other forest types (see Figure 6.2; Camp 1995; Camp et al. 1996). Because old forests occur on only a small portion of the land surface (9 to 16 percent), the conservation of old-forest habitat in adjacent land allocations would significantly increase amounts of old forest conserved, while leaving the remaining 84 to 91 percent of the adjacent land allocation dedicated to its primary emphasized use. Conserving habitat in adjacent allocations would improve continuity in forest structure, composition, and pattern across the larger landscape. This conservation of habitat in adjacent land allocations could be balanced with management in the LSR allocation to meet the emphasized uses of the adjacent allocation, provided that results are in synchrony with reserve intent, are supported by inherent disturbance regimes, and meet legal mandates.

Protect the Emphasized Use through Disturbance Management

Conserving biodiversity does not mean holding nature static, but rather "perpetuating the dynamic processes of presettlement landscapes" (Noss 1983; Hansen et al. 1991; DellaSala et al. 1996). Disturbance management is directed toward maintaining the balance of disturbance and recovery processes. Whole biotas have evolved under dominant disturbance factors such as fire, and some terrestrial and aquatic systems require a disturbance "pulse" to maintain ecosystem function (Odum 1969). Individual species may require disturbance for survival, as is the case for the rare plant species *Alopecurus aequalis* var. *sonomensis* growing in dynamic dune systems at Point Reyes, California (Fellers and Norris 1991). Disturbance affects ecosystems at many scales, and some, such as fire, work at much larger scales than the area of allocations.

To protect biodiversity, inherent disturbances both internal and external to the target allocation need to be restored and managed to reduce deleterious effects. Deleterious effects—the loss of structure, function, or species—can arise from both excessive and insufficient disturbance. Under excessive disturbance levels, disturbance reoccurs before the restoration process is complete and site degradation occurs (Turner et al. 1993). Too frequent or severe prescribed burning or timber harvest can deplete site nutrient capital, cause soil compaction, or reduce coarse woody debris and lower site potential for biomass production (Harvey et al. 1981; Grier et al. 1989). On a landscape basis, excessive disturbance of old-forest habitats has reduced amounts below historical levels (Everett et al. 1994).

Insufficient disturbance occurs when disturbance characteristic of the biophysical environment is suppressed. An example is fire suppression on the east slope of the Washington Cascades that resulted in stand development beyond that supported by the inherent disturbance regimes (Agee and Edmunds 1992; Everett et al., in press). When the system eventually corrects itself, the effects may be more severe and of greater extent than what historically occurred, with the potential for catastrophic loss in habitats (Covington et al. 1994; Everett et al. 1996) and site nutrient capital (Grier 1975).

Disturbance management needs to consider the different spatial scales and intensities of coexisting disturbance regimes. Disturbance management to conserve the limited and patchy (less than 1 hectare) habitat of Wenatchee larkspur (*Delphinium veridescens*, threatened species) in the Camas Meadows of eastern Washington is an example of managing for hierarchical disturbance effects at different spatial scales and levels of intensity. At the site level, within-patch disturbance is required to prevent tree canopy closure and loss of habitat, but disturbance needs to be moderate to maintain canopy shading at between 33 and 66 percent for maximum *Delphinium* vigor (Kuhlmann and Everett, in press). At the watershed level, excessive or insufficient disturbance that causes a significant loss or gain in tree cover could alter hydrologic processes and adversely affect *Delphinium* habitat, which is restricted to moist soils adjacent to streams, seeps, and shallow drainage bottoms. At still larger drainage basin scales, the grazing and trampling effects of an expanding elk herd that utilizes several watersheds need to be considered. Although the area of *Delphinium* habitat may be small, "the area of concern" where disturbance is managed for species viability is much larger (Figure 6.5).

Increase Disturbance Continuity

Reserves will probably remain too small to contain all required diversity (Noss and Cooperrider 1994), and it is unlikely they will capture the "minimum dynamic area" of some of the forms of disturbance required for long-term reserve maintenance (Pickett and Thompson 1978; White 1987). This suggests the need for disturbance management at larger scales than the reserve, or an "expanded coarse filter" (Noss 1987; DellaSala et al. 1996), to conserve biodiversity outside

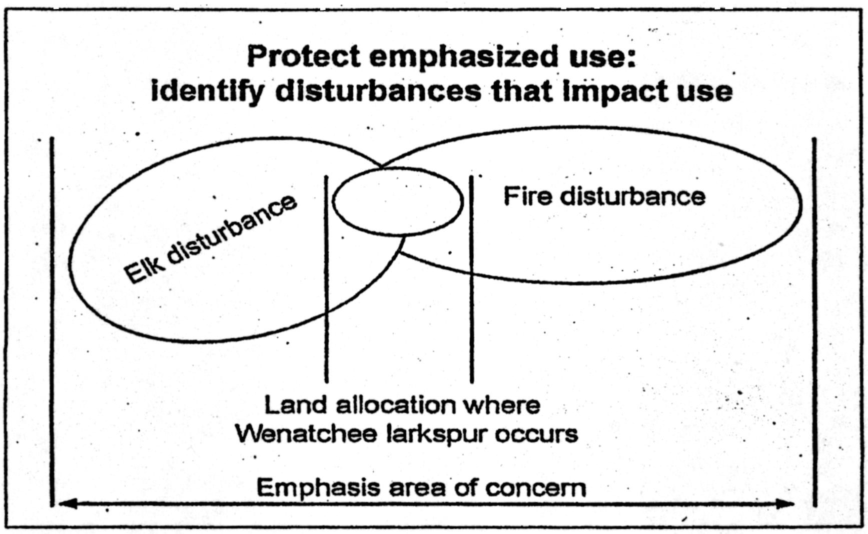

Figure 6.5. Hierarchical disturbance effects on habitat of the rare Wenatchee larkspur (*Delphinium veridescens*).

reserve boundaries. Rather than enlarging the reserve boundaries to encompass large-scale disturbance events, only the disturbance boundary (area of concern; Figure 6.5) need be expanded into the adjacent allocations. This disturbance boundary can be viewed as one of the multiple boundaries to conserve biodiversity within and outside reserve areas.

For those disturbances whose historical extent affected the area of several land allocations, a policy to enhance continuity in disturbance effects across boundaries (e.g., broad "let burn" policy) is desirable to maintain landscape integrity. In other instances, historical disturbance was patchy in nature (e.g., root rot; Hessburg et al. 1994), and individual events were confined within each allocation. Here, maintaining the patchy disturbance process within each allocation would preserve the larger landscape-level process and effects. In the LSR example, continuity in disturbance regimes could be accomplished by the reestablishment of high-frequency/low-severity fire regimes on southern slopes in both the LSR and adjacent allocations (Figure 6.4). Periodic ground fires could maintain low crown fire hazard in the reserve and adjacent allocations such that neither presents a fire hazard to the other.

Precautions

The emphasis-use concept fails when the initial land allocation is faulty—that is, when the allocation and the emphasized use are not in synchrony with inherent disturbance regimes. For example, if late-successional reserves are established in areas with a high-frequency/low-severity fire regime, we should not expect to be successful in creating and maintaining the dense, multilayered old-forest structure and composition that would occur only under a low-frequency/high-severity fire regime.

The reevaluation of land allocation, emphasized use, and the sustainability of required vegetation structure under inherent disturbance regimes of the area should be a priority for all land allocations and specifically for biodiversity reserves. If reserves that have been created are not sustainable over time, new reserve areas should be found or created to safeguard biodiversity over the long term. Reserve designations based on current vegetation characteristics may not have considered that existing vegetation is a result of altered disturbance regimes and that "spurious habitat" may not be supportable under the inherent disturbance regimes of the area over the long term (Agee and Edmunds, 1992; Everett et al. 1997). Utilization of spurious habitat may be required in the short term to maintain viability of species dependent upon habitat that has been lost elsewhere, but we suggest that other, more stable reserve areas be identified to maintain species over time.

The reevaluation of reserve areas and their modification were an integral part of the Northwest Forest Plan (USDA 1993) east of the Cascades and also of the PACFISH (USDA and USDI 1994) buffer zones for riparian areas. In both instances, the creators of these documents realized the dynamic nature of inland forests and recommended the reevaluation of initial set-asides as more scientific information became available. New information on inherent disturbance regimes and vegetation characteristics that are in synchrony with the accompanying disturbance effects will improve the land manager's ability to evaluate the need, characteristics, and sustainability of reserve or buffer areas over time.

Step 3: Move to Whole-Unit Management

> Managing regional (and smaller) landscapes as a whole is preferred when trying to further the goal of biodiversity while meeting the human need for natural resources. (DellaSala et al. 1996)

"Whole-unit management" is defined as management to achieve the array of public expectations for resource conditions and products from the whole ecological management unit rather than compartmentalizing desired resource conditions and products among the individual land-use allocations. According to Stoszek (1990), "Forest stands within the unit would be treated as parts of one interacting entity, not as isolated planning segments of conventional forestry." The goal would be to manage for fully functional and interconnected ecosystems (Noss and Cooperrider 1994) free of the ecological and administrative problems associated with boundaries.

The whole-unit concept is based on the assumption that resource conditions in dynamic forest systems are rarely consolidated in finite areas over extended lengths of time but are continually redistributed throughout the landscape in accordance with topographic, edaphic, biotic, and disturbance influences. Managing the disturbance regime is key to whole-unit management.

Disturbance Management

Reestablishment of natural disturbance processes should maintain or enhance the dynamic nature, integrity, and long-term stability of ecosystems and the conservation of biodiversity (Leopold et al. 1963; Noss 1983; Parsons et al. 1986; Urban et al. 1987; Agee and Johnson 1988; Christensen 1988; Samson 1992). Agee and Huff (1985) suggested the shepherding of natural disturbance patterns across the landscape for intelligent management of wilderness. However, realistic expectations and goals are needed in defining our abilities to conduct disturbance management and the reinitiating of inherent disturbance regimes.

Hunter (1987) recommended the use of natural disturbance as a relevant model for managing spatial heterogeneity, but in the application of large-crown fire disturbance regimes, he pointed out the need for practicality because of current social constraints (Hunter 1993). In nonequilibrium landscapes, large-scale loss of reserves or other allocations for extended periods of time would not meet public expectations. Also, the ability to reestablish large-scale disturbance regimes may no longer be possible with altered landscapes, and so the reestablishment of large-scale disturbance may have to be created through the cumulative treatment of smaller areas (Swanson and Franklin 1992). Reestablishing inherent disturbance regimes in ecosystems characterized by a dynamic equilibrium in shifting mosaic vegetation would require mimicking the frequency, severity, and extent of the dominant disturbance agents. Moreover, a great deal of flexibility would be required in disturbance management because of unplanned disturbance events in dynamic inland forest systems. However, we would be managing for change, a rare constant in natural systems (Agee and Johnson 1988), rather than nonviable, static systems.

We are rapidly increasing our ability to define disturbance regimes both in the present and past. Disturbance regimes can be identified and quantified through the study of vegetation patterns (Swanson et al. 1994), stand composition, age structure and gap dynamics (Lundquist 1995; Spies et al. 1990), and tree ring analysis for fire and insect events (Fritts and Swetnam 1989). Composite disturbance regimes are now being formulated for some areas (Wargo 1995), and disturbance profiles are used to define causal factors and results in stand dynamics (Lundquist 1995). Disturbance response surfaces are being developed to describe the probability of disturbance events based on their frequency, severity, and extent (Swanson et al. 1994; Everett et al., in press). Information on historical vegetation patch composition, size, and spatial location would provide insight into historical disturbance effects and regimes (Morgan et al. 1994) and define when disturbance and resulting patch conditions are significantly over- or underrepresented on the landscape (Haufler et al. 1996). This information could be used to define where disturbance effects are required to create desired habitat and increase disturbance continuity to maximize biodiversity goals and other public expectations.

Social and Economic Acceptance of Whole-Unit Management

Land use has been described as the intersection of three planes: ideological, social, and physical (activities) (Smith et al. 1995). The increase in land-use allocations in response to continually emerging public issues graphically demonstrates the complexity of public expectations for land use. In this context, whole-unit management is an ideological compromise between biocentric and anthropocentric resource management philosophies. Nature is allowed to take its course under the inherent disturbance regimes of the area, but the rate and direction of change providing for the maintenance of ecosystem integrity are used to encourage desired resource conditions and forest products. The process appears socially acceptable because it provides for desired human habitats and utilizes the resource base to meet multiple socioeconomic expectations. It also advances the goal that our physical effects on the landscape reflect management working with natural processes of disturbance and recovery and provide for long-term maintenance and integrity of the ecosystem. Socioeconomic gains are maximized when management activities are consistent with the functioning of ecosystems (Averill et al. 1997).

Implementing Whole-Unit Management

Whole-unit ecosystem management approaches are not new. For millennia, the Yakama Indian Nation of eastern Washington practiced an integrated land-use approach that recognized different resource potentials among vegetation patches and emphasized uses within large landscapes but allowed each piece to contribute to their social, cultural, and economic well-being (Uebelacker 1986). Their extensive knowledge of the resource base, its spatial–temporal relationships, and the freedom they had to use centers of resource convergence made this possible. Such coarse-filter approaches of conservation (Hunter 1987; Noss and Cooperrider 1994; Haufler et al. 1996) are also forms of whole-unit management.

Implementation of whole-unit types of management that deemphasizes allocations might resemble the work of the Interior Columbia Basin Ecosystem Project (Quigley et al. 1996). On this project, spatially referenced information on resource conditions and disturbance regimes were assembled and analyzed to allow land-use integration across multiple administrative and jurisdictional boundaries to achieve large-scale social, economic, and resource-based objectives. Multidisciplinary information was gathered to assess conditions and develop management alternatives at multiple scales: region, ecoregion, drainage basin, and individual watershed. A multiscale analysis of the interaction of the biophysical environment, ecological processes (particularly disturbance), past history, and management needs and opportunities was used to target management approaches on a watershed level. Under the "active management" alternative, areas with moderate-to-high ecological integrity were given a conservation emphasis. Those areas would act as sources for ecosystem services, processes, and wildlife populations. The conservation emphasis would prescribe relatively minimal management, similar to reserves. However, unlike many reserve proposals (Noss 1993; Noss and Cooperrider 1994), management standards and boundaries would be flexible to account for unpredictable disturbance events that might alter the value of the area for conservation (for example, wildfire in old-forest reserves) and for needed restoration within the area. Other areas with greater human disturbance would be managed through some level of active restoration based on their biophysical potential, need for restoration, and the opportunity for management, such as road systems and other infrastructure. Production of goods and services on federal lands would be an outcome of restoration activities, but production might remain a primary emphasis on private lands. Regardless of emphasis (conservation, restoration, production), the goal of ecosystem integrity would be the same and emphasis areas would share common goals—for example, maintenance and restoration of old forest, riparian systems, and disturbance regimes. Analysis of such an active approach (Haynes et al. 1996) showed that ecological integrity (Quigley et al. 1996) and vertebrate species viability (Lehmkuhl et al. 1997) would be similar to that of a large regional reserve network with relatively passive management.

Whole-unit management is currently being developed for 16,000 hectares of the Teanaway Project area on lands owned by the Boise Cascade Corporation in eastern Washington and in Idaho (Haufler et al. 1996). All stands have been typed and mapped to describe ecosystem characteristics and potential forest products, resource conditions, and species viability. Both this and a related project in the Idaho Southern Batholith are using an ecosystem diversity matrix of vegetation patches and knowledge of inherent disturbance regimes to define conditions needed for long-term maintenance of their forest systems. The ecosystem matrix provides information on what constitutes the adequate ecological representation of vegetation development stages on the landscape and how it can be used to integrate the company's landholdings with adjacent lands and define its role in biodiversity conservation within the larger ecological unit.

Summary and Conclusions

A practical and flexible approach for managing wildlands and natural resources will be found in the middle ground of ecosystem management that attempts to integrate diverse human values and uses while maintaining or restoring ecological integrity. A reserve model with core, buffer, and multiple-use areas may be flexible enough to integrate biological and social goals. However, boundaries have ecological and management costs, and critical elements of biodiversity may be dispersed over large landscapes and may not occur or be maintained in existing reserves. Larger and more numerous reserves might enhance conservation of biodiversity, but this option may hinder our ability to meet other ecosystem objectives. Moreover, more or larger reserves may not be a practical or ecologically sustainable solution in dynamic landscapes or those in which humans have already highly altered ecological pattern and processes. Reserve network management, which should be primarily very conservative, needs also to be flexible to restore areas of past human abuse within reserves, and areas outside reserves need to be managed to account for patterns and processes working at scales larger than individual reserves. The reserve model becomes fuzzy when boundaries need to be porous to disturbance. In point of fact, any practice is acceptable if it maintains or improves the ecological integrity of an area.

We suggest viewing the landscape as a whole unit with a consistent primary objective of ecological integrity for all areas, rather than as an assemblage of allocations (core areas, buffers, and so forth) with different levels of management and resulting integrity. Conservation or restoration of ecosystem processes, primarily inherent disturbance regimes, would be a principal objective. Problems associated with the stability of reserves in dynamic landscapes would be minimized, and conservation would not be constrained by continuing processes of disturbance and renewal that have historically maintained ecosystem integrity. As part of this strategy, reserve-like areas with a conservation emphasis might be established in areas of moderate-to-high integrity where natural processes dominate, where conservation is the primary goal, where resource extraction activities have not yet significantly altered ecosystems but would have a significant effect on them, and where the risk of losing the reserve to disturbance is small. Reserves would be a tool, not a primary objective.

Others have proposed similar models that attempt to manage ecosystems by relying less on delineating permanent land allocations with standard management prescriptions than on the potential of landscape elements to integrate ecological and social goals across the landscape. This "whole-unit" approach is not a disguised multiple-use paradigm but is a true ecosystem approach that puts ecological integrity first and recognizes the ecological limits to resource extraction. It stresses whole-landscape management by prescribing passive (conservation reserves), active, or production (commodity) management strategies based on a multiscale analysis of the interaction of the biophysical environment, ecological processes (particularly disturbance), past history, and management needs and opportunities. Areas with moderate-to-high integrity likely would have a conservation emphasis similar to a core reserve and act as source areas for ecosystem services and processes. However, the conservation emphasis would be flexible, rather than static, to account for unpredictable disturbance events. Other areas with greater human disturbance would be managed according to their potential and need for restoration. Production of goods and services on federal lands would be an outcome of restoration activities, but production might remain a primary emphasis on private lands.

There are three phases to initiating whole-unit management:

1. Consolidate adjacent compatible land-use allocations and reduce administrative fragmentation of the landscape.
2. Integrate adjacent land-use allocations with significantly different land-use expectations and required vegetation structure.
3. Move to whole-unit management by dissolving land-use allocation boundaries within ecological units, reinitiating inherent disturbance effects, and managing vegetation pattern and dynamics based on resource potential of the patch.

Step 1 identifies similarities in vegetation in order to meet the emphasized use of adjacent land-use allocations and combines land-use areas for ease of disturbance management. Step 2 focuses on matching within-allocation patch heterogeneity with among-allocation patch similarity to expand biodiversity goals and to restore connectivity in disturbance regimes across allocation boundaries. These first two steps work with existing allocations, or reserve systems, and could be implemented immediately to move toward whole-unit management. Step 3 focuses on the potential of individual patches to contribute to biodiversity or other resource conditions regardless of the land-use allocation in which they currently occur.

Recent efforts to craft a conservation strategy for federal lands in the interior Columbia River Basin considered both the conventional reserve and whole-unit approaches. Evaluation of the alternatives found a whole-unit approach to be slightly better overall in main-

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