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Forestry Research West

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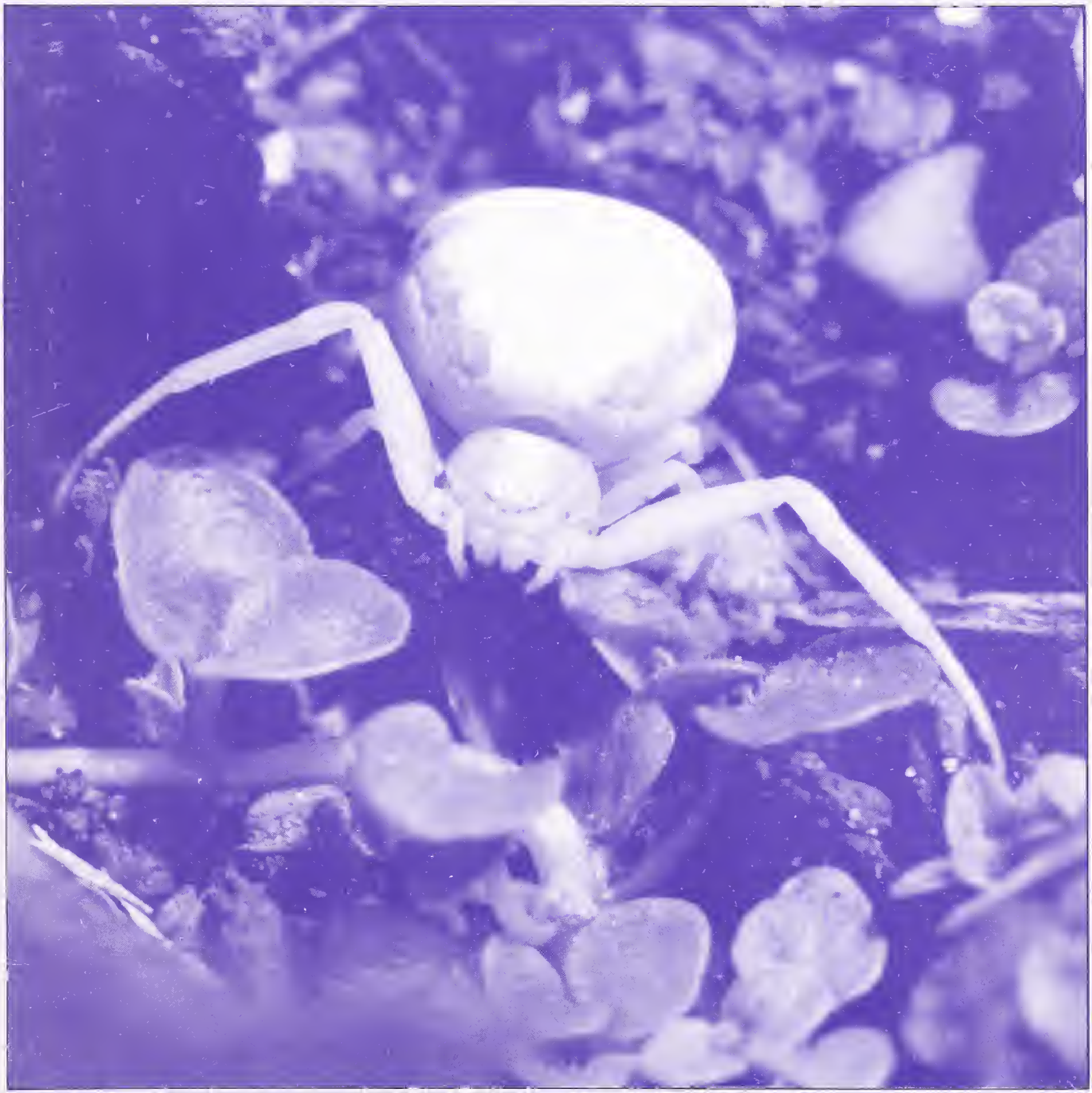

A report for land managers on recent developments in forestry research at the four western Experiment Stations of the Forest Service, U.S. Department of Agriculture.

Forestry Research West

In This Issue

Cover

Ecosystem management is a relatively new term and concept for managing our Nation's public lands. The philosophy considers all life forms simultaneously. While considering species like this crab spider, for example, soil productivity, biological diversity and sustainability of resource use are also factored in. Scientists at the Pacific Northwest Station are studying new ways to implement ecosystem management, particularly as it relates to wildlife. Details begin on page 15.

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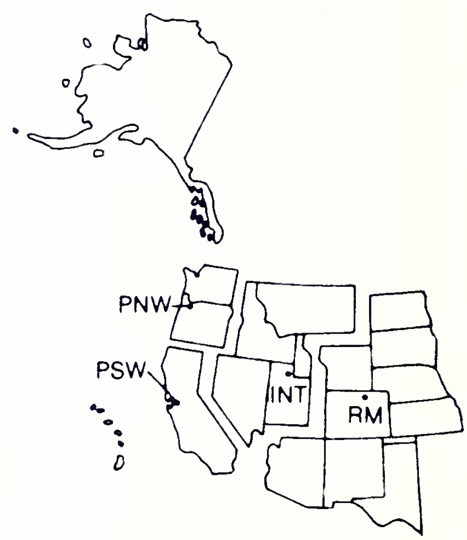

Restoring ecological processes

by David Stalling
and D.W. Tippets
Intermountain Station

Scientists studying ecosystem processes in the Bitterroot National Forest discovered that the landscape-shaping role of natural fire differs dramatically with elevation. While some assumed that the stand-replacing fires the world witnessed on television in Yellowstone during 1988 were typical for high-elevation lodgepole pine, these researchers discovered that fire behavior on the Park's high plateaus wasn't historically typical for areas with a greater range of topographic relief. In just one drainage in the Bitterroot National Forest they discovered the role of fire is very complex and can't be categorized into simply light understory versus stand replacing fires.

Scientists are working with forest and district people to restore the natural process of fire to the ecosystem in one of the Nation's leading ecosystem management demonstration areas. The research helps managers understand and restore the complexity of the ecosystem process that shaped the diverse mosaic of vegetation in this one watershed.

Fire Chemist Lynn Weger shows the instruments that are encased on the top of a portable tower that scientists used during a prescribed fire in the Lick Creek area to monitor the "greenhouse gases" emitted by the fire.

Research Foresters Clint Carlson (left) and Steve Arno (right) show a group of journalists a cross section of a ponderosa pine from the Lick Creek Ecosystem Management Demonstration Area in the Bitterroot National Forest. The large fire scar from the base of the pine reveals a 300-year history of frequent light surface fires that maintained the seral community of open, parklike timber. By assembling fire scar data and other information into a several century-long fire history, scientists now better understand how natural fire has been one of the ecosystem's landscape-shaping natural processes.

Prior to the 1900's, the lower elevation forests in the Lick Creek area, northwest of Darby, MT, consisted of open park-like ponderosa pine with a grassy understory containing scattered shrubs and occasional patches of ponderosa pine or Douglas-fir saplings. The old-growth ponderosa pine forests were maintained by low-intensity, slow-burning wildfires that occurred every 3 to 30 years — either caused by lightning or ignited by Native Americans who wanted to maintain health habitat for the game they hunted. The fires killed most of the tree regeneration but caused little damage to overstory trees.

Today those forests have changed. Logging and fire suppression since the early 1900's have allowed thickets of young ponderosa pine and shade-tolerant species such as Douglas-fir and grand fir to replace the old-growth ponderosa pine forests. The absence of fire has affected nutrient cycling, allowed fuels to increase, and created stands of dense, stagnant trees susceptible to insects, disease, and large, intense stand-replacing fires.

Return to fire-dependent species

An effort is under way, however, to return the Lick Creek area forests to a complex of early seral fire-dependent species, such as ponderosa pine and larch that were common during presettlement times. Scientists are confident that large ponderosa pine and larch can be maintained on the landscape with a sustained flow of forest products harvested from the same stands. At the same time, fire can be restored to the ecosystem at an interval that will optimize browse production in the understory.

The Intermountain Research Station (INT), the Bitterroot National Forest, and the University of Montana are cooperating in the ecosystem restoration and research in the Lick Creek Analysis Area.

The group, which won the Chief's 1992 New Perspectives Team Award, consists of Clint Carlson, a research forester with INT's Subalpine Silviculture Research Work Unit; Stephen Arno and Michael Harrington, research foresters with INT's Fire Effects Research Work Unit; Russell Graham, a research forester with INT's Silviculture and Genetics Research Work Unit; Carl Fiedler of the University of Montana; Robert Benson of Systems for Environmental Management (SEM) in Missoula, MT; and Tom Wagner, Darby District Ranger.

Photographic history

The Lick Creek area offers a unique opportunity to study vegetative changes caused by fire suppression. For much of forested North America, there is little reliable information on changes in vegetation over long periods. In the Lick Creek area, however, foresters have photographically recorded vegetation since 1909.

Lick Creek attracted attention in 1906 when it was the site of the first large National Forest timber sale in the ponderosa pine type — a total of 37.6 million board feet was cut. There is evidence that Gifford Pinchot, the first Chief of the Forest Service, provided direction for the sale. The logging removed much of the old-growth pine, and silvicultural practices were aimed at perpetuating pine and reducing the fir component. A variety of silvicultural practices were attempted over the years, including partial cutting, release cuts, pruning, and cone stimulation. The resulting series of photos allows scientists and managers to visually interpret changes in the ecosystem.

By studying the available photographs and fire history in the ponderosa pine zone, scientists have determined what lower Lick Creek was like prior to logging and fire suppression and the changes that have since occurred. The logging operations and subsequent lack of low-intensity fires have dramatically changed the patterns of plant succession.

The thorough fire history research in the lower elevations resulted in the publication of *Seventy Years of Vegetative Change in a Managed Ponderosa Pine Forest in Western Montana — Implications for Resource Management,* General Technical Report INT-130. It is no longer available from the Intermountain Station but can be ordered by contacting the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

The photo series in GTR INT-130 reveals that, because of the absence of fire and the opening of the stand through logging, the Lick Creek area has changed from an open, park-like stand of ponderosa pine to a more dense stand consisting of some large ponderosa pine, thick patches of Douglas-fir, shrubs, and small ponderosa pines. There is more death, decay, and downfall than existed prior to the 1900's, and a resulting increase in fuels. The continuing fuel buildup is accompanied by a deterioration in forest health and wildlife forage.

Electronic Engineer Ron Babbit recovers fire-monitoring equipment after an experimental prescribed fire in the Lick Creek study area.

Silviculture and fire

Retention shelterwood and single-tree selection systems, in conjunction with prescribed fire, are being experimentally and operationally applied to restore healthy seral forests.

The higher elevations in the subalpine lodgepole pine type survived the early day heavy harvesting that occurred in the lower drainage where the more highly valued ponderosa pine and larch grow. There are few photos that show stand conditions during the period that is so well documented in lower elevations.

Scientists Stephen Arno, Elizabeth Reinhardt, and Joe Scott developed a sampling procedure that reveals a comparatively detailed fire history at the higher elevations. Using the procedure, they learned that severe stand-replacing fires, such as some that the media showed in Yellowstone, were the exception rather than the norm in this area's lodgepole pine type.

From their research they produced *Forest Structure and Landscape Patterns in the Subalpine Lodgepole Pine Type: A Procedure for Quantifying Past and Present Conditions,* General Technical Report INT-294, available from the Intermountain Station. The report provides managers with a methodology that they can use to learn the history of the natural disturbances that shaped their landscape and then apply that knowledge to restore those kinds of processes to the ecosystem.

"Fire burned in a real crazy quilt pattern," Arno said, describing how hundreds of years of natural fire shaped the subalpine part of the landscape.

Although scientists and managers are aggressively using prescribed fire in the lower elevations to try to restore the forest conditions to more closely approach those existing before the 1900's, the fires must be accompanied by pretreatments such as thinning. Accumulated fuels produced by past fire suppression have created the potential for unusually severe fire behavior in some areas: high-intensity, stand-replacing fires that would not emulate historic low-intensity surface fires. Fires burning with current fuel conditions pose a threat to nearby homes and developments.

A cooperating researcher, Range Science Professor Don Bedunah of the University of Montana, records data on willows prior to a prescribed fire in the Lick Creek ecosystem management study area. Willow is one of the big game winter browse plants that scientists believe can be maintained in the understory of the ponderosa pine forest through restoring natural fire as an ecosystem process.

Research in the lower elevations includes determining the effects of different timber harvesting treatments and fire regimes on tree growth, nutrient cycling, and understory development in second-growth ponderosa pine stands; determining the effects of uneven-aged management and fire on growth and development of residual ponderosa pine and understory; studying nutrient cycling in multi-aged ponderosa pine/Douglas-fir stands; determining esthetic evaluations on the "new perspectives" management and research at Lick Creek; and determining wildlife use in the treated and untreated study units.

INT has made proposals to extend the intensive ecosystem research that is ongoing in lower Lick Creek all the way through the subalpine zone to the whitebark pine forests near the upper edge of timberline. Only through looking at ecosystem processes and functions from the Bitterroot Valley to the top of the watershed can scientists provide managers with the insight into ecological systems that they need to keep wildlands healthy and sustainable.

If successful, scientists and managers hope to restore the Lick Creek area back to ecologically sustainable patterns that more closely emulate presettlement conditions: a diverse, healthy forest that can provide sustainable levels of goods and services including wildlife and fish, recreation, and timber.

Silvicultural effects on birds in the Rockies

by Deborah Finch
and Rick Fletcher
Rocky Mountain Station

Blue Grosbeak

The declining populations of North American landbirds that migrate to the neotropics has attracted widespread attention from resource specialists. Documented declines in populations of eastern neotropical migrants, as well as habitat fragmentation on breeding grounds and habitat loss on wintering grounds have led researchers and resource managers to increase efforts to understand and effectively manage for the long-term conservation of these bird populations. Despite this attention, little is known on the population ecology of neotropical migrants inhabiting the western United States. One of the most important unknowns is the effects of silvicultural treatments on these birds in the Rocky Mountains.

To a manager in need of such information, it is clear that too few studies have been conducted. It is difficult to ascertain the effects of silvicultural practices except in very general terms. Moreover, there are no quantitative data on the range of habitats occupied by landbird species, no data on cumulative landscape effects, few data for other than the breeding season, and no data on reproductive or survival success in relation to treatments. Bottom line — despite timber harvesting in the Rocky Mountains, and despite Forest Service mandates to maintain populations of all vertebrate species, there are relatively few studies on the effects of silvicultural practices on songbird populations. "However," says Deborah Finch, Project Leader and Research Wildlife Biologist with the Rocky Mountain Station, "this situation is changing now that current silvicultural treatments are beginning to be guided by the agency's 'total ecosystem management' philosophy, including the objective to maintain populations of nongame species."

Finch is an editor of a new book that reviews existing literature and provides specific management guidelines that address the needs of nongame species, particularly neotropical migratory landbirds (the over 150 species that breed in temperate North America and winter in Mexico, the Caribbean and Central and South America). A section of the book deals with the relationships between land use practices and population responses of migrants.

To review the effects of timber harvesting on landbird and raptor communities within the Rocky Mountains, a team of scientists that included Finch from the Rocky Mountain Research Station and Sallie Hejl from Intermountain Station, along with Richard Hutto from the University of Montana and Charles Preston from the Denver Museum of Natural History perused a wide variety of federal publications, ornithological and ecological journals, and unpublished reports for studies reporting on before-and-after effects of forest cutting on birds.

Information was classified into six vegetative cover types: 1) ponderosa pine, 2) mixed-conifer, 3) lodgepole pine, 4) spruce-fir, 5) Cascadian forest, and 6) aspen. Harvest methods were also categorized. For each study, the scientists scored each bird species as one that either declined, was unaffected, or increased in abundance as a result of harvesting activity. The overall effect on each species was then evaluated by calculating the average score over all studies.

Differences between cut and uncut forests

In general, a large majority of species appear to be less abundant in treated, as compared to unlogged, areas (Table 1). For instance, Brown Creeper abundance differed consistently between harvested and unharvested treatments; creepers were always less abundant in clearcuts or partially logged forests than in uncut areas. Twelve other species were also always less abundant in recent clearcuts than uncut forests, but were not always so in partially cut forests. All permanent resident species were less abundant in recently clearcut forests than in uncut forests, but only about 60 percent of the migrants were less abundant. In addition, 94 percent of the residents were less abundant in partially logged forests, while about 40 percent of the migrants were less abundant. Ten species were consistently more abundant in one of the three age categories of clearcuts or in partially cut forests.

Red-eyed Vireo (Photo by Mike Hopiak, for the Cornell Laboratory of Ornithology).

There is no question that clearcuts have negative effects on many forest-dependent species, and positive effects on many species that frequent open forests or open habitats in general. This result alone raises two important management issues. First, different species within various behavioral guilds respond differently to a given silvicultural treatment (for example, the Hammond's Flycatcher is negatively affected by clearcutting, while Olive-sided Flycatchers are not, or the migratory Ruby-crowned Kinglet declines, while the migratory Mountain Bluebird does not). Result — managing for groups of species that prefer one set of forest conditions, for example, species that inhabit the edges of forest clearings, may be to the detriment of those species that require a different forest environment, for example specialists that prefer forest interiors. Land managers have traditionally used fire and clearcuts to increase species diversity by increasing the variety of forest habitats. "Unfortunately" says Finch, "the gain in terms of increased species diversity may not outweigh the costs of losing sensitive forest specialists, especially when the new species added are often species that are already common. At larger scales, such losses can accumulate, resulting in reduced regional biological diversity." In terms of managing for maintenance of bird populations, there is no substitute for understanding habitat needs of each species,

Species[a]	NTMB[b] status	Clearcuts 0-10 yrs	Clearcuts 10-20 yrs	Clearcuts 20-40 yrs	Partially Cut
Red-breasted Nuthatch	P	-1.00 (8)	-1.00 (4)	-1.00 (3)	-0.70 (10)
Brown Creeper	B	-1.00 (8)	-1.00 (5)	-1.00 (3)	-1.00 (12)
Golden-crowned Kinglet	P	-1.00 (8)	-	-	-0.60 (10)
Ruby-crowned Kinglet	B	-1.00 (8)	-1.00 (4)	-1.00 (3)	-0.40 (10)
Mountain Chickadee	P	-1.00 (7)	-1.00 (5)	0.00 (3)	-0.77 (13)
Winter Wren	P	-1.00 (6)	-	-	-0.20 (5)
Varied Thrush	P	-1.00 (6)	-	-	-0.75 (4)
Townsend's Warbler	A	-1.00 (6)	-	-	-0.40 (5)
Black-capped Chickadee	P	-1.00 (5)	-	-	-0.67 (3)
Swainson's Thrush	A	-1.00 (5)	-	-	-0.50 (6)
Three-toed Woodpecker	P	-1.00 (4)	-1.00 (3)	-	-0.50 (6)
Solitary Vireo	A	-1.00 (4)	0.00 (4)	-	0.33 (9)
Evening Grosbeak	P	-1.00 (3)	-	-	-
Hammond's Flycatcher	A	-	-1.00 (3)	-	-
White-breasted Nuthatch	P	-	-1.00 (3)	-	-0.14 (7)
Pygmy Nuthatch	P	-	-	-	-1.00 (5)
Cooper's Hawk	B	-	-	-	-0.67 (3)
Violet-green Swallow	A	-	-	-	-0.60 (5)
Gray Jay	P	-0.75 (8)	-1.00 (3)	0.00 (3)	-0.25 (4)
Warbling Vireo	A	-0.75 (4)	1.00 (3)	-	0.33 (9)
Western Tanager	A	-0.75 (4)	-1.00 (4)	-	0.09 (11)
Orange-crowned Warbler	A	-0.67 (3)	-	-	-0.50 (4)
Yellow-rumped Warbler	B	-0.67 (9)	-0.67 (6)	0.67 (3)	-0.46 (13)
Hairy Woodpecker	P	-0.62 (8)	-0.67 (6)	-0.33 (3)	-0.25 (12)
Common Nighthawk	A	-	-0.67 (3)	-	-0.50 (4)
Red Crossbill	P	-	-0.25 (4)	-	-0.33 (3)
Red-naped Sapsucker	B	-0.60 (5)	-0.25 (4)	0.67 (3)	0.17 (6)
Clark's Nutcracker	P	-0.60 (5)	-	-	0.33 (3)
Hermit Thrush	B	-0.60 (5)	-1.00 (3)	-	-0.80 (10)
Black-headed Grosbeak	A	-0.60 (5)	0.20 (5)		0.22 (9)
Steller's Jay	P	-0.50 (4)	0.00 (4)	-	-0.29 (7)
Common Raven	P	-0.43 (7)	-0.33 (3)	-	-0.17 (6)
Pine Siskin	B	-0.38 (8)	-0.17 (6)	0.00 (3)	-0.08 (12)
Northern Flicker	B	-0.37 (8)	0.33 (6)	0.33 (3)	-0.17 (12)
Pine Grosbeak	P	-0.33 (3)	-	-	-1.00 (3)
Cassin's Finch	B	-0.33 (3)	-0.50 (4)	1.00 (3)	0.60 (5)
Western Wood-Pewee	A	-0.20 (5)	-	-	-0.50 (4)
Fox Sparrow	B	-0.20 (5)	-	-	-
MacGillivray's Warbler	A	-0.17 (6)	1.00 (3)	-	0.17 (6)
American Robin	B	-0.10 (10)	0.33 (6)	0.33 (3)	0.15 (13)
Rufous Hummingbird	A	0.00 (5)	1.00 (3)	-	0.33 (3)
House Wren	A	0.00 (3)	-0.25 (4)	-	0.86 (7)
Wilson's Warbler	A	0.00 (5)	-	-	-
Williamson's Sapsucker	B	-	-	-	0.00 (5)
Cordilleran Flycatcher	A	-	-	-	0.00 (6)
Western Bluebird	B	-	-	-	0.20 (5)
Chipping Sparrow	A	0.13 (8)	0.50 (6)	-	0.60 (10)
Olive-sided Flycatcher	A	0.20 (10)	0.00 (3)	-	0.67 (9)
Red-tailed Hawk	B	0.33 (3)	0.33 (3)	-	0.33 (3)
Tree Swallow	B	0.33 (3)	-	-	-
White-crowned Sparrow	B	0.40 (5)	-	-	-
Dark-eyed Junco	B	0.60 (10)	0.67 (6)	0.67 (3)	0.38 (13)
Northern Goshawk	B	0.67 (3)	-0.75 (4)	-	-
Mourning Dove	B	0.67 (3)	0.33 (3)	-	0.67 (3)
Townsend's Solitaire	B	0.80 (5)	0.00 (5)	0.00 (3)	-0.25 (8)
Mountain Bluebird	B	1.00 (7)	0.80 (5)	-	0.67 (6)
Lincoln's Sparrow	A	-	0.67 (3)	-	-
American Kestrel	B	-	1.00 (3)	-	-
Broad-tailed Hummingbird	A	-	1.00 (3)	-	0.25 (4)
Calliope Hummingbird	A	-	-	-	1.00 (3)
Rock Wren	B	-	-	-	1.00 (3)

[a] Only those results from sample sizes greater than three are included in the table.
[b] Neotropical migrant (NTMB) status, as designated in the Partners in Flight Newsletter (1992, Vol. 2, No. 1, p. 30): A = long-distance migrant species, those that breed in North America and spend their nonbreeding period primarily south of the United States, B = short-distance migrant species, those that breed and winter extensively in North America, P = permanent resident species that primarily have overlapping breeding and nonbreeding areas.

Table 1.—Indices of the tendency for a bird species to be more or less abundant in clearcut or partially cut forest than in uncut forest. A given study was scored according to whether the species increased (+1), decreased (-1), or was unaffected by cutting (0). Values are averages of these scores over all studies in which the species was recorded. Species are listed in order from -1.00. Sample sizes are in parentheses.

and for monitoring populations of as many of them as possible. A species-by-species management approach is needed, but it must be accomplished largely through development of land-based management plans coupled with species-by-species monitoring efforts.

Secondly, "effects of timber harvesting" is complicated. This is because "effect" can be measured as either a short-term or a long-term consequence of harvesting activity. The literature deals exclusively with short-term consequences, but managers' legal mandates require a long-term, broad-scale perspective that allows only land use patterns that will not cause the widespread or complete disappearance of natural populations, patterns and processes. A timber harvesting practice that might cause a relatively great amount of short-term change from pre-harvest conditions may actually be integral to a long term strategy for maintaining populations of all wildlife species. Rather than simply asking what the short-term effect of a given harvest method is, Hutto and authors believe the question should be, "what is the best long-term strategy for achieving natural patterns and processes over the long term, and how should we manage for those species that fall through the cracks, even after our strategy mimics nature as well as any can?"

Effects of forest fires

Fire is the single-most important factor influencing the development of landscape patterns in the northern Rockies, and landbird communities associated with standing dead "forests" that characterize early post-fire habitats are unique and distinctly different from clearcuts. The distinctness is largely due to the relative abundance of species that are nearly restricted in their habitat distribution within the Rocky Mountains to early post-fire conditions, and to species not restricted to, but relatively abundant in, early post-fire habitats. "These associations deserve greater attention by land managers because frequent, low intensity understory fires do not satisfy the needs of fire-dependent bird species. Such species rely on the presence of large, high-intensity crown fires that characterize the historical fire regime of many conifer forest types in the northern Rockies," says Hejl.

Management recommendations

Assuming that an important management goal is to maintain natural populations, patterns and processes over broad landscapes, the scientists recommend several management guidelines.

The first is to manage for desired landscape patterns. Harvest-by-harvest decisions should not be made in the absence of a clear picture of trends and conditions over a broad landscape. It is recommended that managers develop a clear picture of the landscape (including the proportions and juxtaposition of cover types) that they are trying to create and maintain so that decisions on single harvests are made in the context of a desired landscape picture, and in light of the processes and patterns that would normally produce that landscape. The scientists recommend managing timber harvesting activities to either 1) have negligible impact in the present, and not affect the probability that natural processes occur in the treatment area in the future, or 2) have moderate to extreme impact on the land and biological community, but in a manner that is close to what some natural process would have been expected to do in the same place at about the same time. The first option means cutting in a manner such that the same species and processes (e.g. fire) persist on the management unit. The second option means understanding that management activities should never be viewed as substitutes for natural processes because human activities differ in important ways from natural disturbance.

Some critics would claim that a changing world makes it difficult to know what the existing landscape patterns "ought to be", and that past environments may be inappropriate models for desired future conditions, but the researchers agree it is presumptuous to assume that they know what "ought to be", but they also agree that such an approach is workable.

Botanists have provided a good deal of information about what landscapes looked like before mechanized land-use became the norm, and it would be well worth putting that information to use. Managing at the landscape level will require improved inter-agency coordination, and knowledge of the conditions of private lands in the same region. In short, management decisions will have to be made in the context of broader bio-regional planning efforts.

Managing for the maintenance of natural disturbance regimes

Because the adaptive histories of most species in natural ecosystems are linked to natural periodic disturbance, it is highly unlikely that the maintenance of biodiversity will be possible without allowing natural disturbances to occur as they have historically. This means a huge public education effort so that 1) fires, blowdowns, insect outbreaks and the like are properly viewed as natural

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events, and 2) efforts to maintain these processes are understood and encouraged by both natural resource managers and the public. Researchers also caution about extrapolating results from other areas. Everything from habitat use to food requirements changes markedly from one place to another. Thus, decisions should rely heavily on information about the natural history and ecology of the local area for management decisions.

Move toward multi-species management

Some species are benefitted and some hurt through any silvicultural method. Managers will have to deal increasingly with this fact as they generate information for the larger numbers of species that will be part of newer multi-species management schemes.

However, managing for some species and against others is not a conflict when viewed from the perspective of a large landscape and a long time period. There should always be enough variety in the constantly shifting mosaic of successional stages such that all native species are being managed simultaneously over a broader landscape. "Defining the pieces of the puzzle necessary to maintain populations of all vertebrates requires knowledge of the habitat needs of a larger number of species than wildlife biologists have traditionally considered, especially nongame species," says Finch. Research suggests managing for single species only when they become species of special concern, threatened, or endangered, and only for as long as it takes for the species to recover.

Monitoring landscape patterns and species populations

"Even though these scientists recommend managing for landscape patterns, this does not remove the need for a multi-species monitoring program," says Hejl. "One could be maintaining a 'proper' landscape, but still witness population declines of bird species because of improper management elsewhere, or because of the decline of habitat elements that cannot be monitored at the landscape level. Ecosystem management is not a move away from monitoring single species, it is a move away from managing the land for the benefit of relatively few species."

A final note — Hutto and authors also recommend that a GIS be used to monitor how successfully the landscape is matching the suspected "natural" pattern of cover types, including their sizes, proportions and juxtapositions. "For bird monitoring," they say, "use as many species as possible to monitor how successfully we are managing for the maintenance of all wildlife species. Landbirds are a powerful tool here because a large number of species can be monitored as easily as one. Moreover, the range of conditions that landbirds occupy is so varied that the monitoring of these species might be expected to provide a good indication of how well we are managing for the variety of species that are not monitored through other methods."

Further details on this research and related studies on neotropical migratory birds are available in the new publication titled *Status and Management of Neotropical Migratory Birds,* General Technical Report RM-229. It is available from the Rocky Mountain Station.

Other available publications include: "Bird Use of Riparian Habitats in North-Central Arizona During Fall Migration — Results and Recommendations," in *Riparian Management: Common Threads and Shared Interests: A Western Regional Conference on River Management Strategies,* General Technical Report RM-226; *Population Ecology, Habitat Requirements and Conservation of Neotropical Migratory Birds,* General Technical Report RM-205; and *Integrating Neotropical Migratory Birds into Forest Service Plans for Ecosystem Management,* a reprint. All can be ordered from the Rocky Mountain Station.

Finally, a unique inter-agency, neotropical migratory bird conservation program titled "Partners in Flight" has been formed. It is a coordinated cooperative program of monitoring, research, management and education, involving North and Latin America. For more information on this effort, contact Deborah Finch, Research Wildlife Biologist, Forestry Sciences Laboratory, 2205 Columbia S.E., Albuquerque, NM 87106, (505) 766-2384.

Predicting young conifer stand dynamics

by J. Louise Mastrantonio for Pacific Southwest Station

The evolution of growth and yield information in the United States has resulted in a transition from the traditional presentation of yield tables to computer-based stand simulators. At the Pacific Southwest Research Station's Redding Silviculture Laboratory, work is underway to take another step in this evolutionary process. A model called CONIFERS is under development that will employ the power of object-oriented programming to predict the dynamics of forest ecosystems in early successional stages in northern California and southern Oregon.

Little known and understood outside the ranks of professional forestry, growth and yield prediction systems are nevertheless the building blocks of modern forest management. With them, foresters can predict tree growth and wood volume production. Such systems have traditionally been used to develop annual timber harvest levels (allowable cuts), plan for sustained yield, and as an aid in evaluating the economic benefits of various cultural practices: density management, control of competing vegetation, and fertilization. Without them, timber harvest predictions would be little more than an educated guess.

Much of the contemporary work in growth and yield in this country is based upon the foundation built in the 1920's and 1930's by researchers such as Donald Bruce, Richard McArdle, Walter Meyer, Duncan Dunning and L.H. Reineke. Early work in this field featured normal yield tables. Such tables have allowed forest managers to estimate future yields of fully stocked (usually single species) stands, as a function of site index and stand age.

In the late 1960's, growth and yield research moved forward with the development of computer-based simulation systems. One of the most notable examples of this development was the release of the Prognosis model for the intermountain region. The Prognosis model allowed users to make predictions for mixed species stands, and produce much more detailed output than could be obtained from traditional yield tables.

Currently, there are four computer growth models available for use in northern California and southwest Oregon.

- Prognosis, several different variants have been developed for this region,
- CACTOS (California Conifer Timber Output Simulator), developed in the mid 1980's at the University of California, Berkeley. CACTOS is used in predicting growth and yield of established mixed conifer stands in Northern California.
- ORGANON, a model developed by David Hann of the Forest Resources Department of Oregon State University. ORGANON was developed for established (age 20 and greater) mixed conifer stands in southwest Oregon.
- SYSTUM-1, a prototype young stand model developed at the Pacific Southwest Research Station.

These models all run on personal computers (Prognosis was originally developed for main-frame computers but has recently been adapted for the PC). With the exception of SYSTUM-1, these models are used to predict growth and yield of established stands in which shrubs are not influencing tree growth. While these simulators work well for many stands, they share a significant shortcoming. They are not well suited to young stands, particularly young plantations, growing with a significant component of non-tree vegetation.

SYSTUM-1 is a model built for predicting the growth of young plantations. The SYSTUM-1 project was one of the first to attempt to address the problems of predicting the growth of young stands of trees and shrubs. Two problems revealed by the SYSTUM-1 project were the difficulties of predicting the growth of non-tree vegetation and the limited utility of the traditional approaches to forestry software development and interface design.

Conifers

CONIFERS (California and OregoN Interactive Forest Ecosystem Response Simulator) is a model being developed by Martin Ritchie of the Pacific Southwest Research Station in Redding, California. This model continues the work on young stands started with the SYSTUM-1 modeling project. There are, however, a number of substantial differences between the two. The primary differences are in the way non-tree vegetation is simulated and in the structuring of the software itself.

The idea behind CONIFERS is to simulate young stand growth. "You input a list of sample trees from a plantation and the simulator attempts to predict how that stand will develop over time," according to Ritchie.

In CONIFERS, the tree (or plant) is the basic modeling unit and height growth is the primary driving variable. In addition to height growth, the model also predicts changes in crown size, tree diameter and probability of mortality.

CONIFERS requires three types of data as input:

1. Plant-level data — a sample list of trees (and, optionally, shrubs) from the target stand. These must be from a statistically valid sample of plots within the stand being studied. The primary required observations include a plot identifier, species code, height and expansion factor. Other variables in the standard file are current annual height increment, crown width, crown ratio, diameter at breast height, and diameter at 10 centimeters.

2. Plot level data includes optional information on percent cover and height, slope and aspect, elevation and universal transverse mercator projection.

3. Stand-level data include site index and stand age.

Tree- and plant-level information may be input in one of five formats: CACTOS, ORGANON, SYSTUM-1, comprehensive CONIFERS file, or the US Forest Service Region-5 field data recorder file.

In addition to simulating a number of different thinning regimes, CONIFERS is capable of simulating treatment of competing vegetation. In northern California and southwest Oregon, young mixed-conifer stands are often significantly impacted by non-tree vegetation. Often the competition is provided by brush such as ceanothus and manzanita. Thus, the effect of competing vegetation on tree growth is an important factor in predicting stand dynamics.

Ritchie is attempting to develop a more robust methodology for predicting growth of non-tree vegetation. He notes, "We are developing individual plant-based predictors of growth for competing vegetation in an attempt to overcome some of the problems encountered with the SYSTUM-1 model. This is something that has not been done before, to my knowledge."

One other unique aspect of this simulator is the application of object-oriented programming in simulator development. The end result of this work is a group of reusable objects in the form of a class-library. The program is being written in the C++ language by programmer Jeff Hamann. Ritchie hopes this will allow for much faster development of software for forestry applications. "We have been reinventing the wheel with respect to software development, and this new direction will provide a general forest stand analysis application class-library. We have already used this class-library in a number of other applications which have nothing to do with simulating growth and yield. It is a very powerful tool," he says.

Ritchie describes CONIFERS as an "interactive system that is more user-friendly than earlier growth and yield simulators." It enables managers to analyze the pros and cons of various management alternatives; that is, to test various management schemes before they are applied on the ground. The model has the appearance and feel of many contemporary commercial software products, with drag and drop menus, mouse support and context-sensitive help.

The CONIFERS simulator also provides flexible, user defined output variables that are established "on the fly." This is important because forest management goals often change over time, and resource managers must constantly respond to meet new needs and challenges presented by society. This flexible output may take the form of a user-designed table, a spreadsheet output file for graphical analysis, or a plot summary file including spatial data when available.

New developments are just around the corner for this effort. "We want to get away from focusing on classic plantation forestry and take better advantage of the capabilities of modern computer systems," Ritchie says. Wood volume production is by no means the only application of such simulators. Another application of models like CONIFERS is in evaluating wildlife habitat. Models can be designed to estimate stand characteristics that can be related to habitat suitability. Examples include snag retention, and more specific descriptors of stand structure and non-tree vegetation. By including flexible, on-the-fly, user-defined output, it is hoped that the model will allow users to address a variety of issues. For example, the spatial arrangement of some stand parameter may be analyzed by means of a plot summary file. This will allow the user to evaluate such things as the spatial distribution of regeneration in an area.

The model has not been released to cooperators, but a first release may be ready soon. The model is being beta-tested at this point. Currently, context-sensitive help is being refined for the simulator, so that all needed documentation will be available on screen.

Cooperators

CONIFERS is a cooperative effort of the Pacific Southwest Research Station and the California Forest Research Association (CFRA). The CFRA is a forestry research support group that includes public and private forest resource management concerns. The work was done by scientists at the Silviculture Laboratory of the Forest Service's Pacific Southwest Research Station at Redding, California, under the auspices of the CFRA's Small Tree Growth Modeling Project. The CFRA is comprised of private and public forest resource managers.

For those interested in the CONIFERS model, Ritchie will be developing a user's guide for the program. For further information about other models mentioned in this article, contact the Pacific Southwest Research Station and request the following:

User's Guide for SYSTUM-1 (Version 2.0): A Simulator of Growth Trends in Young Stands Under Management in California and Oregon, General Technical Report PSW-147, by M.W. Ritchie and R.F. Powers. This publication is now in press and will be available later in 1994.

Predicting Height Increment of Young-Growth Red Fir in California and Southern Oregon, Research Paper PSW-214, by K.L. Dolph.

Managing ecosystems for the future

by Sherri Richardson
Pacific Northwest Station

The Pacific Northwest is blazing the trail in the arena of ecosystem management. The protection of the northern spotted owl heralded in a new era of land management. Half way around the world, in Russia, Pacific Northwest Research Wildlife Ecologist Bruce Marcot journeyed to work on a land management plan for a watershed surrounding a river whose boundaries are shared by Russia and China. It is believed to be the first joint management plan between the two countries. What does it all mean? Are we really entering a new era of land management? According to Marcot we are.

"At stake is the sustenance of the health and fabric of entire ecosystems," says Marcot. "We can no longer simply manage for a single species. A new era of wildlife management is emerging. The interest in conserving a particular species is now being integrated within a broader tapestry of concerns on how to ensure our continued use and protection of natural resources."

Marcot asserts that in the past, several approaches were taken in national forest planning to preserve species. They were focused on featured species, threatened or endangered species, sensitive species, and management indicator species.

Traditional forest management considered the need for fish and wildlife management, as well as the impacts on forest ecosystem health, only after objectives for commodity extraction (such as timber harvesting) were specified.

In the report, "The Lay Person's Guide to Managing for Featured, Threatened, Endangered, and Sensitive Species and Unique Habitats for Ecosystem Sustainability," Marcot and his colleagues explain how and why ecosystem management fits into species management planning. Coauthors PNW Wildlife Biologist Michael Wisdom, Oregon State University Fisheries Biologist Hiram Li, and Oregon State University Fisheries graduate student Gonzalo Castillo collaborated with Marcot to produce a reference that can be used by land managers and others who need to understand the implications of the trend.

Traditional approach to wildlife management evolves

"The traditional approach to wildlife management," explained Marcot, "has focused largely on maintaining a single species rather than an ecological community and ecosystem." This approach also has taken several forms and targeted the following species in a different format in each instance.

- featured
- threatened or endangered
- sensitive
- management indicator

When managing for featured species, a species is chosen for management focus. The species is usually rare or valued by society for hunting or sustenance. Guidelines are then developed by the Forest Service under the assumption that applying the same guidelines will conserve other species as well.

"With featured nongame species," explains Marcot, "the aim is to conserve habitats to help ensure viable populations over time. Whereas for featured game, the species is meant to ensure a sustainable, harvestable surplus."

Another example of the single-species approach is management guidelines and recovery plans for threatened or endangered species, such as the Snake River sockeye salmon and the bald eagle.

"As other species become threatened or endangered," says Marcot, "recovery plans are developed. The combination of the individual plans are then assumed to provide for the collective needs of all threatened and endangered species in an area. But each species is treated individually."

The Forest Service also identifies sensitive species as those not yet listed as threatened or endangered by the Fish and Wildlife Service, but that are nonetheless scarce, declining, or in need of specific management. The guidelines for sensitive species are prepared and implemented as part of National Forest Land and Resource Management Plans.

Although not listed as threatened, rare species like the northern goshawk have required development of new management guidelines and revamping of planning strategies.

"Management indicator species are identified by the Forest Service as planning aids," says Marcot. "One type of management indicator species is the ecological indicator species whose population trends are intended to represent those of other species in similar kinds of habitats." The regulatory document supporting this mandate is found in the regulations implementing the National Forest Management Act of 1976. A variety of indicator species have been identified in each forest plan and may include various threatened, sensitive, game, and other categories of species.

Single-species management sometimes has resulted in conflicting approaches to national forest management. Often for each new species identified as featured, threatened, endangered, sensitive, or indicator, new management guidelines have to be developed and implemented.

When this happens, land management allocations on National Forests must be realigned. This in turn often impacts the expected production of forest commodities or the conservation of forest conditions for other species. An example is management of old-growth forests in western Washington and Oregon. "In this case," explains, Marcot, "the concern for the Federally listed northern spotted owl and marbled murrelet causes repeated revisions of National Forest Land and Resource Management Plans and Regional Guide management standards."

Ecosystem management is the way of the future

The issue now is a concern for entire ecosystems rather than for the safety of a single species and interests in single commodities, including timber and featured game species. Concern for the ecosystem includes old-growth forests, riparian (streamside) vegetation, and the ecological communities of all plant, fish, and wildlife species associated with them.

Marcot cited two examples of ecosystem management now occurring in eastern Washington and Oregon: The need to manage simultaneously for elk as well as all other forest-associated wildlife species that might need very different habitats and conditions to thrive; and another example is sustainably conserving communities of native fish species, and maintaining or restoring the types of aquatic ecosystems they need to survive.

Species-specific management still valid

"The new focus on ecosystems does not invalidate the need to continue species-specific management of fish and wildlife," explained Marcot. "Single-species approaches are still authentic, legitimate, and necessary components of forest planning."

The real change in the paradigm of forest management is in the need to integrate such species approaches into broader concerns for the fate and wise use of ecosystem and ecological communities in which the species reside.

What are the ultimate management goals?

The Forest Service now must operate under the system of ecosystem management. Marcot states that the success of fulfilling this mandate rides on three goals:

- Maintenance or restoration of a full range of natural biological diversity. This includes maintaining the variety of life and its processes.
- Maintenance of long-term site productivity. This includes the conservation of soil and its biological processes needed for perpetuating healthy and productive forests.
- Maintenance of sustainable uses of natural resources. This includes harvesting of timber, fish and game, and other forest products, and maintaining amenities such as recreational, traditional, and aesthetic aspects of forest use.

One challenge in ecosystem management is knowing when to intervene — such as restoring ecological conditions to healthy conditions or procuring commodities from forest products such as this blowdown of timber on the Olympic Peninsula in Washington — and when to let the system self-adjust.

"To meet these goals, management objectives for individual fish and wildlife species should be identified at several scales of time and space," says Marcot, "and incorporated into all forest management objectives simultaneously."

In the past, considerations for fish and wildlife management were only considered after commodity needs were met (such as timber harvesting). The new ecological approach is that all aspects of ecosystem health and resource management should be considered in synchrony to craft management objectives at the beginning of any planning effort.

Some of the basic elements that must be included in such a forest ecosystem management plan are:

- commodity production
- fish and wildlife species management
- conservation and restoration of entire species communities and ecosystems
- long-term efforts from fire, major outbreaks of insect pests, and other disturbance events

"Only with such a proactive and integrated approach can forest planning be made more efficient to avoid conflicts among management objectives and to ensure long-term diversity, productivity, and sustainability of entire forest ecosystems," says Marcot.

New from research

Considerations for elk in revising forest plans

"Elk vulnerability is the framework issue," biologists Alan Christensen, Jack Lyon, and James Unsworth state in their overview of the new information that National Forest personnel should consider when updating the parts of land management plans that deal with providing elk habitat.

This general technical report is written for the Northern Region of the Forest Service where Christensen is the Wildlife Program Leader and Elk Initiative coordinator. Lyon is Project Leader for the Intermountain Station's Northern Rockies Forest Wildlife Habitat Research Work Unit in Missoula, and Unsworth is Principal Wildlife Research Biologist for the Idaho Department of Fish and Game in Nampa. Although prepared specifically for the Northern Rockies, the report contains information that big game managers elsewhere will find useful.

The biologists carefully define fundamental concepts to prevent their misapplication in forest plans. They explain the differences between the appropriate use of the concepts of habitat effectiveness and elk vulnerability. They thoroughly discuss road density and other factors in habitat effectiveness, and make recommendations for conducting elk vulnerability analyses.

The authors remain aware of the differences between State responsibility in managing the animals and National Forest responsibility in managing habitat. They provide a conceptual framework for state and forest biologists to work together in updating forest plans with consideration for the things that have been learned since the first round of forest planning occurred.

Request *Elk Management in the Northern Region: Considerations in Forest Plan Updates or Revisions*, General Technical Report INT-303, from the Intermountain Research Station.

Sites for retrospective studies: opportunities for research in western Washington and Oregon

Sites were identified on publicly managed and privately owned lands in western Oregon and Washington where research or demonstration of new forestry practices could be conducted by using a retrospective approach. One hundred and seventy-six stands were selected for this catalog to represent examples of the future condition that could be expected from new forestry practices.

Information from these stands will serve to guide current management in developing alternative forestry practices. The stand types cataloged are characteristic of a range of structural conditions desirable for specific objectives that could be achieved with alternative forestry practices. Baseline information on overstory and understory composition and structure, amounts of coarse woody debris, disturbance history, past management activities, and landscape context of each stand was compiled in a database and is available to the forest research and management community. Information will aid researchers from many disciplines and managers by providing data about stand conditions and locations.

Request *Sites for Retrospective Studies: Opportunities for Research in Western Washington and Oregon*, General Technical Report, PNW-312, from the Pacific Northwest Research Station.

The aspen family tree

Quaking aspen (*Populus tremuloides* Michx.) has been documented as one of the largest clonal organisms on the planet; it reproduces asexually from root suckers following the removal of overstory stems.

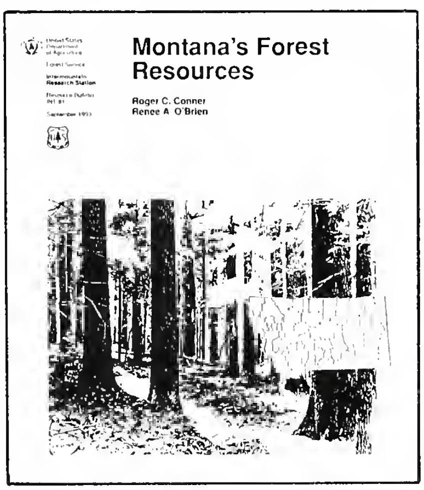
A study was conducted to determine the extent of clonal dynamics on regenerated aspen after clearcutting; the idea was to study living root connections between individual stems, how vegetative regeneration affects the spatial arrangement of stems within the stand, and how growth and competition differs between dense and sparsely populated stems.

The study showed that young aspen remain connected to their parent stem through age 14, but become increasingly independent of these root connections over time. The density of stems and root nodes decreased exponentially, with most mortality occurring by age three. Growth was shown to be determined by crown position of the individual stems, and stem density was found to be non-uniform, in either sparse or densely populated stands.

For more information, request *Initial Growth, Development, and Clonal Dynamics of Regenerated Aspen in the Rocky Mountains,* Research Paper RM-312, from the Rocky Mountain Station.

Montana's forest resources

Research Forester Roger Conner and Range Scientist Renee O'Brien, with the Interior West Resource Inventory, Monitoring, and Evaluation Program, based in Ogden, UT, have reported on the status of Montana's private forest land.



They compare some information about forests and harvesting inside the national forests to the land outside of the national forest boundary. However, their comparative analysis is limited because inventory methods differ widely from one national forest to another. Authorized by the Renewable Resources Research Act of 1978, the resource inventory crews collect data on private land with a standard methodology that allows a more valid comparison of private forest land between counties.

In one interesting comparison made in their analysis, Conner and O'Brien describe by county the ratio of timber harvesting to timber growth. Their report shows readers where forests are being harvested at a rate that probably can't be sustained. In contrast, the report shows that, on the average, growth exceeded harvesting on Montana's private lands at the time of the inventory.

Request *Montana's Forest Resources,* Resource Bulletin INT-81, from the Intermountain Research Station.

Earthworms in southern California?

You may remember a previous "FRW" feature article on the surprising discovery of how rapidly soils can form under certain vegetation types (see Dec. 1990 issue). In a related study of soils associated with chaparral ecosystems in southern California, researchers unexpectedly found earthworms and evidence of significant earthworm impact on soil development.

Because earthworms may be an important part of some wildland ecosystems, the researchers decided to conduct a survey. They collected and identified 20 different species at varied sites with many soil types.

The report outlines earthworm biology and ecology and documents survey results. In this somewhat limited survey, earthworms seem to prefer certain types of plant communities. The report encourages continuing research on earthworms and their relationship to soils, plants, and fire in southern California.

Request *Native and Introduced Earthworms from Selected Chaparral, Woodland, and Riparian Zones in Southern California*, General Technical Report PSW-142, from the Pacific Southwest Research Station.

Rangelands of Colorado

Recently published research results provide an overview of the rangeland areas in Colorado. As with many western states, Colorado consists primarily of rangeland; fully 72% of its acreage is grazed. Fifty-five percent of this is under private ownership, while the rest is owned by municipal, State, and federal agencies.

The article details the physiographic regions of Colorado, and also describes the species composition of wildlife and vegetation communities, and the historical and present land-use of the plains, mountains and western plateaus. To order a reprint of this article, request *The Rangelands of Colorado*, a reprint, from the Rocky Mountain Station.

The export premium: why some logs are worth more abroad

Throughout a century of log exports from the Pacific Northwest, export logs have been associated with higher prices than logs sold in the domestic market. Conventional wisdom currently maintains this perception that any export log is worth more than its domestic counterpart. The export-domestic difference, or export premium, seems to belie reason. Why would foreign buyers be willing to pay more than U.S. customers for the same log? In reality, do they? If they do, why do offshore purchasers not shift to inland logs, so that the premium would dwindle? Discussed here are circumstances that do and do not foster a continuing export premium.

Request *The Export Premium: Why Some Logs are Worth More Abroad*, Research Paper PNW-462, available from the Pacific Northwest Research Station.

Packstock in wilderness: use, impacts, monitoring and management

Range Professor Mitchel McClaran of the University of Arizona in Tucson and Research Biologist David Cole of the Aldo Leopold Wilderness Research Institute in Missoula have summarized the current state of knowledge about packstock in wilderness.

Professor McClaren explains the basic principles of how livestock can impact soil and plant communities through defoliation, trampling, compacting soil, and concentrating animal waste. His quick explanation of range science may be particularly valuable for seasonal wilderness rangers who deal with packstock on a daily basis in their jobs, but have no formal education or training in range ecology.

The report quickly deepens from basic range science to a more complex discussion of the technical aspects of monitoring the ecological influences of packstock in wilderness environments. The authors point out that the lack of scientific information about packstock impacts is the greatest handicap facing wilderness managers charged with keeping the wilderness "untrammeled," while simultaneously providing recreation for packstock users.

Much of what is known about grazing influences comes from the study of "production livestock," such as cattle and sheep, rather than packstock, such as mules or llamas. They point out that the extreme behavior differences between production livestock and packstock put limitations on application of much of the existing research. For example, the difference between a packhorse on the end of a picket chain and a cow roaming in fenced pasture puts severe limitations on extrapolating research from the more typical pasture scenario.

McClaran and Cole go into detail making recommendations about the fundamentals of a monitoring program; what, where, when, and how much monitoring is needed. Then they explain how to apply the new knowledge gained through monitoring to achieve wilderness goals.

The authors conclude with an analysis of management techniques and an identification of research needs.

Request *Packstock in Wilderness: Use, Monitoring, and Management,* General Technical Report INT-301, from the Intermountain Research Station.

Demonstration forests in California: a directory

Demonstration forests show resource management activities and offer an alternative way to publicize research results, transfer technology, educate, and share information. These forests offer the general public, forest landowners, foresters, educators, politicians, and media representatives a vivid picture of differing management and silvicultural treatments and practices in a variety of forest types common to California. This new directory includes descriptions of 39 of these units, each of which is managed by one of a variety of state and federal agencies, universities, industries, and cities. Because of the diverse ecosystems represented by these units, they may also offer a rich variety of opportunities for researchers looking for new study sites. For a copy, contact Pacific Southwest Research Station and ask for *Demonstration Forests in California: a Directory.*

To order any of the publications listed in this issue of *Forestry Research West*, use the order cards below. All cards require postage. Please remember to use your Zip Code on the return address.

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3) *Population Ecology, Habitat Requirements and Conservation of Neotropical Migratory Birds*, General Technical Report RM-205.
4) *Integrating Neotropical Migratory Birds into Forest Service Plans for Ecosystem Management*, a reprint.
5) *Initial Growth, Development and Clonal Dynamics of Regenerated Aspen in the Rocky Mountains*, Research Paper RM-312.
6) *The Rangelands of Colorado*, a reprint.
7) *Technology Change and the Economics of Silvicultural Investment*, General Technical Report RM-232.

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3) *Elk Management in the Northern Region: Considerations in Forest Plan Updates or Revisions*, General Technical Report INT-303.
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2) *Predicting Height Increment of Young-Growth Red Fir in California and Southern Oregon*, Research Paper PSW-214.
3) *Native and Introduced Earthworms from Selected Chaparral, Woodland and Riparian Zones in Southern California*, General Technical Report PSW-142.
4) *Incidence and Effects of Endemic Populations of Forest Pests in Young Mixed-Conifer Forests of the Sierra Nevada*, Research Paper PSW-212.
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Scientists lay foundation for conserving the bull trout

Intermountain Station Fisheries Biologists Bruce Rieman and Jack McIntyre summarized the most important knowledge about bull trout and analyzed that knowledge using the latest principles of conservation biology and metapopulation dynamics. In General Technical Report INT-302 they provide resource managers with the technical and scientific foundation to complete a conservation assessment.

The decline and disappearance of bull trout populations in the West has raised concerns about the survival of the species. Many biologists believe that the bull trout is especially sensitive to changes in its habitat. The American Fisheries Society and others have asked the U.S. Fish and Wildlife Service to review the status of the species and consider listing it as endangered under the Endangered Species Act.

In their report, the scientists outline concepts needed to develop a conservation strategy that minimizes the risk of extinction. They have also alerted land managers about situations that they must be especially concerned about.

Request *Demographic and Habitat Requirements for Conservation of Bull Trout,* General Technical Report INT-302, from the Intermountain Research Station.

Forest pests are always present

Forest pest managers know that pest epidemics can reduce tree growth and increase tree mortality. However, until recently they could not measure the impacts of endemic pest levels on trees and forest stands under non-outbreak conditions.

Using a Pest Damage Inventory (PDI) system, researchers rated the severity of pest- and human-caused injuries to forest trees in young, mixed-conifer stands at mid-elevations on the Sierra Nevada's west slope. Approximately 3,200 mature trees under 80 years old were studied. The 877 trees felled for stem analysis became the main focus of data analyses.

Because the study was limited to young-growth mixed conifer stands largely composed of trees under 80 years old, the low mortality rate (averaging 3.16%) and relatively minor effect on tree growth are not surprising. The data did indicate potential problems for older mixed-conifer stands, and they indicated white fir as the species most affected by pest- and human-caused injuries.

To learn more, request *Incidence and Effects of Endemic Populations of Forest Pests in Young Mixed-Conifer Forests of the Sierra Nevada,* Research Paper PSW-212, from the Pacific Southwest Research Station.

Low-cost silviculture pays off

Given the right kind of market, some low-cost reforestation options have been found to be economically superior to intensive options for two timber types in the Pacific Northwest: loblolly pine and Douglas-fir. The expected present values (EPV) of low-cost options, which result in a mixed species stand are higher when a market exists for both pine and hardwood thinnings. For Douglas-fir/red alder stands, the low-cost option was found superior when pre-commercial thinning of the alder is an option. Furthermore, the results of the study suggest that the low cost options may satisfy environmental objectives, which are often hard to attain with intensive silvicultural practices. For more information on this study, request *Technology Change and the Economics of Silvicultural Investment,* General Technical Report RM-232, from the Rocky Mountain Station.

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