BULLETIN OF THE
ECOLOGICAL SOCIETY OF AMERICA

VOLUME 79, NO. 4
OCTOBER 1998

Focus on Field Stations

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H. J. ANDREWS EXPERIMENTAL FOREST

Introduction

Established in 1948, the H. J. Andrews Experimental Forest has become a world center for research and education on the ecology and management of forests and streams. Selected because of the magnificent old-growth (450-plus years) Douglas-fir forests that occupied about two-thirds of the area, over half of the Forest remains in old growth today. It is the centerpiece of a natural laboratory with large tracts of pristine landscape juxtaposed with areas of intensive forest management, a perfect setting for studies ranging from population dynamics of soil microbiota to effects of land use pattern on regional carbon budgets.

The Andrews Forest is administered cooperatively by Oregon State University, the USDA Forest Service's Pacific Northwest Research Station, and the Willamette National Forest, and is open to all research that does not conflict with existing programs or detract from the quality of the site. Experimental manipulations, including logging, are permitted in specific areas, as are nondestructive long-term studies requiring large undisturbed areas. Large manipulations are broadly advertised to the scientific community with the intent of maximizing collaborative research. With its history of experiments and extensive data sets, the Andrews Forest is committed to fostering and sustaining long-term interdisciplinary research programs.

Location and environment

The Andrews Forest is about 80 km (50 miles) east of Eugene, Oregon on the west slope of the Cascade Range (Fig 1.) at 44°15' N, 122°10' W. It lies in the Blue River Ranger District of Willamette National Forest and occupies the entire 6,400-ha (15,800-acre) drainage basin of Lookout Creek, a headwater tributary of the McKenzie River (Fig. 1). Elevation ranges from

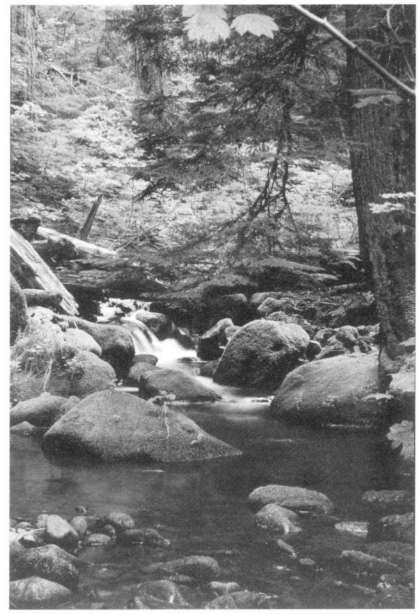

Fig. 2. A high-gradient stream in old-growth forest typical of many tributaries in the Cascade Mountains. Photograph by Al Levno.

about 410 m (1350 feet) to about 1630 m (5340 feet). Broadly representative of rugged, mountainous landscapes of the Pacific Northwest, it features excellent examples of the region's west-slope conifer forests and steep, fast-flowing streams (Fig. 2).

Lower elevations of the Forest are made up of Oligocene–lower Miocene volcanic rocks composed of mudflow, ash flow, and stream deposits. In higher areas, bedrock is composed of andesite lava flows of Miocene age and of younger High Cascade rocks. Stream erosion, landslides, and glaciation have created a deeply dissected and locally steep landscape. Soils developed from these parent materials are mainly Inceptisols with local areas of Alfisols and Spodosols.

The Forest's maritime climate has wet, mild winters and dry, cool summers. At the primary meteorological station near the Forest headquarters at 426 m (1400 feet) elevation, mean monthly temperature ranges from a low of about 1°C (34°F) in January to about 18°C (64°F) in July (Fig. 3). Precipitation is concentrated from No-

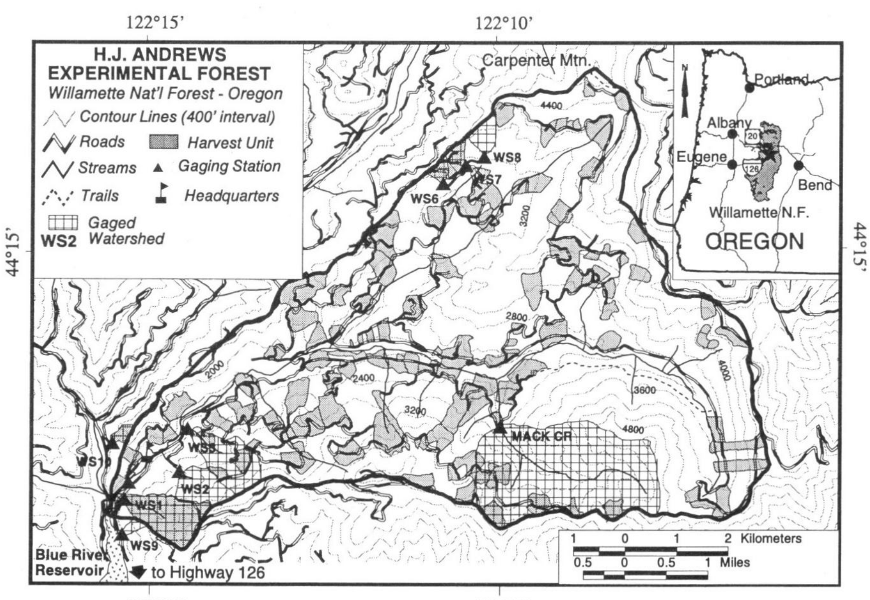

Fig. 1. Map of H. J. Andrews Experimental Forest with locator insert. The Forest occupies the entire 6400-ha watershed of Lookout Creek, and a U.S. Geological Survey gauging station is located near the outlet.

vember through March and increases with elevation, averaging about 220 cm (87 inches) per year at lower elevations to over 360 cm (140 inches) at upper elevations. Summers can be very dry, with little measurable precipitation from mid-June to September. Rain predominates at low elevations and snow is common at high elevations, creating deep snowpacks that often last until late spring. Highest streamflows generally occur from November through February, when heavy, warm rainstorms combine with snowmelt.

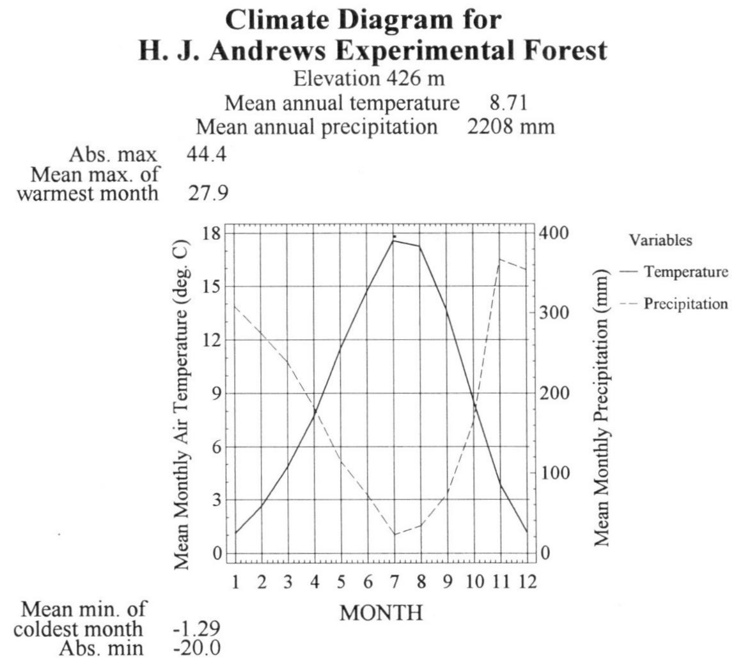

Fig. 3. Climate diagram for the Andrews Forest showing the seasonal temperature and precipitation patterns. Data are from the primary meteorological station at the Headquarters site.

Biota

Before timber cutting began in 1950, about 65% of the Forest was virgin old-growth forest, with towering, 400-plus year old Douglas-firs (*Pseudotsuga menziesii*). The rest of the Forest was largely in natural stands that became established after wildfires in the mid-1800s. Roughly one-third of the Forest has been logged, primarily by clear-cutting, and another 3–5% is in roads (Fig. 1). Many of the logged areas have been planted and/or thinned to provide young stands varying in composition and density.

The lower-elevation forests are dominated by Douglas-fir, western hemlock (*Tsuga heterophylla*), and western red cedar (*Thuja plicata*). Upper-elevation forests contain noble fir (*Abies procera*), Pacific silver fir (*Abies amabilis*), Douglas-fir, and mountain hemlock (*Tsuga mertensiana*). Wildfire was the primary disturbance agent in the natural forest. Windthrow, landslides, root rot infections, and lateral stream channel erosion were secondary disturbance agents.

The large area and mountainous topography create many habitats that support a diverse flora and fauna. About 500 vascular plant, 85 nesting bird, 50 mammal, 20 reptile and amphibian, and 8 fish species are found on the Forest, as are over 150 mosses and hepatics, over 100 lichen, and well over 3700 invertebrate species. Notable terrestrial vertebrates include Harlequin Duck (*Histrionicus histrionicus*), Northern Spotted Owl (*Strix occidentalis*), Pileated Woodpecker (*Dryocopus pileatus*), Osprey (*Pandion haliaetus*), beaver (*Castor canadensis*), otter (*Lutra canadensis*), black bear (*Ursus americanus*), bobcat (*Lynx rufus*), mountain lion (*Felis concolor*), coyote (*Canis latrans*), black-tailed deer (*Odocoileus hemionus columbianus*), and Roosevelt elk (*Cervus canadensis columbianus*). The cool, wet climate keeps the number of reptile and amphibian species low, although some amphibians such as the Pacific giant salamander (*Dicamptodon tenebrosus*) and tailed frog (*Ascaphus truei*) are abundant. Species lists are available through the Internet (see *Further information*).

The clear, fast-flowing streams contain cutthroat (*Oncorhynchus clarkii*) and rainbow trout (*Oncorhynchus mykiss*), Pacific giant salamanders, and other vertebrate species, as well as a great variety of invertebrate species. The streamside vegetation, dominated by herb- and shrub-rich mixed hardwood/conifer forests, strongly influences stream ecosystems by shading and contributing large woody debris and litter to streams.

Research

The Andrews Forest has a rich and diverse research history, with the major themes changing through time (Fig. 4). Research in the 1950s centered on efficient forest regeneration, road engineering, and logging methods for old-growth forests. In the 1960s, research focused on effects of logging on hydrology, sediment loads, and nutrient losses from small watersheds. During the NSF-funded International Biological Program (IBP) of the 1970s, basic ecological studies examined how forest and stream ecosystems function in old-growth and managed forests. These basic ecological studies have continued under the auspices of NSF's Long-Term Ecological Research Program (LTER), which began in the 1980s, as did the earliest research on ecosystem management. With LTER as the core program, research at the Andrews Forest during the 1990s has been characterized by the development of landscape-scale studies and testing of ecosystem management methods.

From a small cadre of Forest Service scientists working in isolation in the 1950s and 1960s, the program has grown to a multifaceted, interdisciplinary program involving scientists and graduate students from around the nation and the world. A listing of active scientists and graduate students

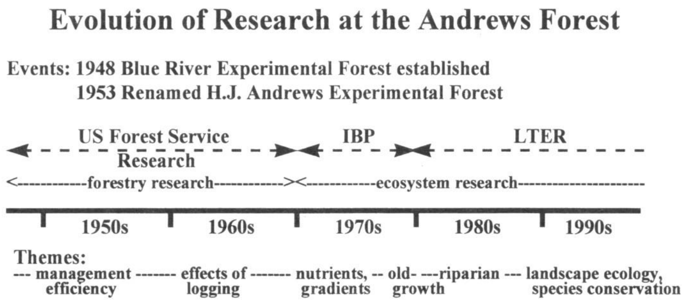

Fig. 4. Time line of selected research programs and themes at the Forest. The shifts of dominant funding from U.S. Forest Service to the National Science Foundation-sponsored International Biological Program (IBP) and the Long-Term Ecological Research Program (LTER) are presented as well as the approximate timing of major research themes.

would be too lengthy for this article, and the reader is referred to the Andrews Forest web site for that information (see *Further information*).

The current research program is quite diverse, with well over 100 research projects in any given year. The following are selected examples of recent and current studies.

Long-Term Ecological Research

The LTER Program is the centerpiece of Andrews Forest research, providing a framework for many ancillary projects. The central question of the Andrews LTER is, "How do forest management, natural disturbances, and climate changes affect key ecosystem properties, such as biodiversity, carbon dynamics, and hydrology?" It has several components that address basic studies of climate, hydrology, disturbance/landscape dynamics, vegetation succession, biological diversity, carbon and nutrient dynamics, and forest–stream interactions. The components provide information for four synthesis areas that examine effects of species on ecosystem function, processes affecting the rate of early succession, influence of vegetation succession on streamflow, and effects of landscape pattern on carbon stores, hydrology, and biological diversity.

Hydrology

Long-term hydrology records begin in the early 1950s, and are being revisited to examine interactions of disturbance and vegetation succession to downstream responses. New statistical approaches have related increases in peak flows to road development that functionally extends the stream network, and to the pattern of logging that alters evapotranspiration and snow accumulation and melt (Jones and Grant 1996). Hydrology, geomorphology, and ecological models are being combined to evaluate alternative management and climate scenarios, and to advance our understanding of the mechanisms that generate streamflow and the possible range of trajectories that watersheds can follow in response to disturbances.

Landscape dynamics

Contrasting disturbance regimes of natural and human origins affect the landscape of the Andrews Forest. Studies of landscape patterns of disturbance have examined wildfire, valley-floor geomorphic processes, logging and other land use changes, and insect outbreaks, as well as the overall processes that produce these landscape patterns. The studies have revealed major differences between wildfire and logging in frequency, severity, size distribution, and spatial pattern, and have been instrumental in shifting management of federal lands from a system of dispersed clear-cut patches to one more closely reflecting landscape dynamics driven by wildfire, and geomorphic and other natural disturbances (Cissel et al. 1994). Studies have also revealed interactions among past disturbance patterns on the character of landscapes, particularly regarding the effects of past landscape fragmentation on future landscape patterns (Wallin et al. 1994).

Biological diversity

Studies of biodiversity have revealed a large variation in species richness among taxonomic groups. Although a few tree species dominate biomass, about 500 vascular plant species are known to occur on the Andrews Forest. Chronosequence studies in natural forests indicate a generally increasing diversity of vascular plant species and soil arthropods through succession to old growth, but most species are not restricted to particular stages of stand development. Much of the biodiversity effort has focused on the strikingly rich arthropod fauna, representing over 85% of all species currently known to occur on the Andrews Forest (Parsons et al. 1991). Studies of canopy arthropod community structure along a successional chronosequence found that old-growth forests have the highest arthropod biodiversity. Species diversity and abundance of several taxa, especially predators and detritivores, are significantly lower in young plantations than in older forests. The lower abundance of predators may partially explain why defoliation is often higher in younger stands.

Forest–stream interactions

A conceptual model of forest–stream interactions has been derived from experimental studies of the mechanisms of aquatic response to natural disturbances and land use (Gregory et al. 1991). Studies of wood inputs to streams from adjacent forests have contributed to our basic understanding of this important terrestrial–aquatic linkage, and helped to direct management on millions of acres of public forests. Long-term population studies of trout and salamanders have revealed patterns of interannual variation that provide a quantitative foundation for interpreting regional declines in salmonids and amphibians. Long-term studies have also created an opportunity for measuring responses to episodic disturbances, such as landslides and debris flows. A new area of research couples analysis of riparian landscape patterns using remote sensing and modeling to examine large-basin response to land use change. This research considers the network properties of stream ecosystems to complement past emphasis on longitudinal gradients.

Carbon dynamics

A major effort has been made to examine carbon dynamics of Pacific Northwest forests by integrating data on forest production, decomposition, and stand condition. Preliminary analysis indicated that a substantial quantity of carbon was released by past timber harvest in the region (Harmon et al. 1990). Subsequent analyses, which coupled an ecosystem carbon model to remotely sensed data on forest age and disturbance history, confirmed the earlier finding and indicated that carbon flux varied greatly with location, wood use standards at the time of harvest, and stage of succession after harvest (Cohen et al. 1996).

Education and outreach

These programs are varied, including field trips, workshops, short courses, formal classroom teaching, many types of publications, videotapes, public outreach presentations, campfire talks, consultations with managers and policy makers, and providing information to media representatives. About 15 classes from universities and colleges schedule annual field trips to the Forest. It is also heavily used by graduate students for about 40 thesis projects per year. Over 80 undergraduate students from more than 55 institutions have worked and studied here as part of our summer Research Experience for Undergraduates program. The completion of a new education building provides additional opportunities for year-round graduate and undergraduate education, including traditional summer courses found at field stations.

Articles about the Andrews Forest have appeared in the *New York Times, Science, Discover,* and *Wilderness,* as well as regional and national newspapers. The articles cover a broad range of topics from natural history stories of general interest, to new scientific findings, the science behind policy changes, the weighing of alternative conservation strategies, and conflict resolution.

We also have an active program of international collaboration and education that over the past five years has included participants from Sweden, Turkey, Japan, Israel, Taiwan, China, Russia, Germany, and France.

Cascade Center for Ecosystem Management

The Cascade Center for Ecosystem Management was established in 1992, and is an education and outreach partnership involving Oregon State University, the USDA Forest Service's Pacific Northwest Research Station, and the Willamette National Forest. The Cascade Center's mission is to develop new information about forest and stream ecosystems of the Pacific Northwest, develop and test management applications, and publicly discuss findings and their implications. Outreach to the public and land managers is the major role of the Cascade Center, and an extremely important component of the education program of the Andrews Forest.

Relevance

The last decade has seen great turmoil and rapid change in land management policy and practice in the Pacific Northwest. Collectively, research and education programs of the Andrews Forest have had a tremendous impact by providing crucial input to policy makers during this transition (e.g., FEMAT 1993). Andrews scientists were involved, and remain so, because Andrews-based science provides data that are directly relevant to contentious issues in the political forefront (e.g., old growth, long-term productivity, Northern Spotted Owl, watershed effects of forestry). This information comes directly from highly credible, peer-reviewed, basic science sponsored by NSF. A change of this magnitude is a long-term, cumulative process requiring a high level of understanding among policy makers. This is an excellent example of how long-term science has been, and will continue to be, an important contributor to society's efforts to learn how to manage ecosystems on a sustainable basis.

The Andrews research program has been both scientifically productive and socially relevant, and it is our intent that this continue. We believe strongly that field stations such as Andrews Forest are at their best when they do four things well: (1) develop a strong site-based research program; (2) foster regional studies to provide a larger context for research results; (3) actively engage in research and education networks with other field stations; and (4) interact with managers and policy makers to ensure good communication of relevant science and understanding of issues.

Facilities

The main facilities are located at a low-elevation site near the western boundary (Fig. 1) and are open year-round, with the highest use between May and October. Housing at the Headquarters consists of 11 relatively new apartments in two quadruplexes and a triplex (nine four-bedroom, two-bath units with kitchen and dining/living rooms, and two two-bedroom/one-bath units with kitchen and dining/living room), providing an overnight capacity of 80–85, depending on configuration. Most bedrooms have one set of bunk beds.

People within a project are normally assigned an apartment together, and it is common for several smaller projects to share an apartment. Where possible, special needs are accommodated, e.g., researchers who work at night being assigned an apartment all their own.

Fig. 5. Facilities include laboratories, offices, and classrooms in a connected pair of buildings (left) and overnight housing in apartments (right). Photographs by Al Levno and Art McKee, respectively.

Fig. 6. Terrestrial–aquatic interactions are a major theme of research at the Forest. A small, hand-lined blimp with camera is being used to record channel changes and disturbance to riparian vegetation caused by a large flood. Photograph by Pam Druliner.

Long-term users are expected to bring their own bedding, but linen/towel service is available for short-term visitors attending courses and workshops.

Laboratories, offices, and classrooms are in two adjoining buildings of about 465 m^2 each (Fig. 5). Classroom facilities consist of a laboratory classroom for 32 students, a lecture hall that can be configured for 100-plus people, and a library/conference room for 15–20 people. There are two small chemical laboratories with hoods (21 m^2 each), a soils laboratory (28 m^2), an herbarium/veg laboratory (28 m^2), a small vert laboratory (21 m^2), and a computer room (37 m^2). There are eight offices of various sizes and numbers of desks. All laboratories, offices, and classrooms are connected by computer via a local area network.

Currently, a small cafeteria with a capacity of 32 is used for short courses and workshops. Funding has just been obtained to replace this with a larger (capacity of 85), more modern facility, which should be operational by the summer of 2000.

In addition to Headquarters facilities, four small cabins located at remote, high-elevation sites around the Andrews are intended to function primarily as emergency shelters during winter, but are available to researchers whose studies require them to be located near a field site around the clock.

There is a hydrology/meteorology network of nine gauging stations and four meteorological stations. Streamflow, air and soil temperature profiles, windspeed and direction, precipitation, relative humidity, and total shortwave radiation are continuously monitored and the data are downloaded daily via telemetry to the Headquarters office. Current weather conditions and recent hydrology of selected gauges are available through the Andrews web site, or at <http://fredb2.fsl.orst.edu>.

Although summer access is excellent, with a good road and trail system, winter access can be difficult due to heavy snowpacks. Snowcats and snowmobiles are available to researchers for the cost of operation.

Housing, laboratory space/benches, desks, and classrooms are scheduled and assigned on a first-come, first-served basis, with some weighting for long-term users of the site. For information on the current fee schedule, contact the Site Manager.

Databases and information management

Information management needs for the H. J. Andrews Forest have been the primary driving force for the creation and maintenance of the Forest Science Data Bank (FSDB), a 20-plus year effort to store and maintain scientific data in a readily retrievable and usable form. Investigators using the Andrews Forest are expected to cooperate with the FSDB data manager before initiation of any study, and to contribute their data and metadata to the FSDB. Protocols that ensure security and proprietary ownership have been developed.

The Andrews Forest metadata system conforms substantially to the standards established by LTER data managers (http://lternet.edu). It consists of a set of central catalogs and sets of study-specific tables. The central catalogs store information about databases, table structures, and data files. Dedicated server subdirectories house individual study databases, including both data and metadata tables. The metadata tables help users to understand and access databases. All metadata are stored in Foxpro DBMS and are easily made accessible as column-formatted ASCII files. Access is possible through the Andrews Forest web site.

Research and education opportunities

Those interested in using the Andrews Forest for research or education purposes are encouraged to contact the Director or Site Manager (see *Further information*). Research projects require prior approval. A brief prospectus describing the project, methods, and criteria for site selection must be submitted to the Director. The prospectus is reviewed at a monthly committee meeting where opportunities for collaborative research are discussed. The turnaround time is quick, and rejections are extremely rare. A serious attempt is made to accommodate all who apply. Graduate students with limited funding should not be discouraged from submitting a prospectus. Assistance is often possible. Telephone calls are encouraged to discuss options.

The new laboratory classroom and lecture hall provide a wonderful base for field-oriented classes. A schedule of classes is under development, and we encourage instructors to contact the Director if they would like to develop a class. The peak research season of the Andrews runs from mid-June to late August. To minimize potential conflicts, educators from institutions on early-semester systems should consider using the site in May and early June. Those on late-start systems should consider September. Brief field trips are wel-

Fig. 7. Field trips are an important part of the education program at the Forest. During the 1990s, over 2000 people per year have participated in field trips. Photograph by Aaron McKee.

come virtually any time, including weekends and traditional breaks.

Undergraduates can participate in four ways: as students taking formal classes, as participants in a Research Experiences for Undergraduates (REU) program, as employees/interns on projects, or as volunteers. Inquiries about classes or employment can be addressed to the Director, and will be forwarded to the most appropriate people and projects. If seeking employment, send a resume and a cover letter explaining interests and time of availability, and include a couple of references. E-mail is by far the most expeditious method.

Further information

Please visit the Andrews Forest web site <www.fsl.orst.edu/lterhome.html> to learn more about the site, research projects, education programs, publications, people, facilities, data sets, and other matters. Questions about use of facilities can be addressed to the Site Manager, Bonnie West (541-822-6300; fax: 541-822-6329; e-mail: AEFhq@FSL.ORST.EDU). Questions about research or educational use can be addressed to the Director, Arthur McKee (541-750-7350; fax: 541-750-7329; e-mail: mckee@FSL.ORST.EDU), or to the Forest Service Officer in Charge, Fred Swanson (541-750-7355; fax: 541-750-7329; e-mail: swansonf@FSL.ORST.EDU).

Literature cited

Cissel, J. H., F. J. Swanson, W. A. McKee, and A. L. Burditt. 1994. Using the past to plan the future in the Pacific Northwest. Journal of Forestry **92**:30–31, 46.

Cohen, W. B., M. E. Harmon, D. O. Wallin, and M. Fiorella. 1996. Two recent decades of carbon flux from forests of the Pacific Northwest, USA. BioScience **46**:836–844.

FEMAT (Forest Ecosystem Management Assessment Team; J.W. Thomas, Team Leader). 1993. Forest ecosystem management: an ecological, economic, and social assessment. U.S. Government Printing Office, Washington, D.C., USA.

Gregory, S. V., F. J. Swanson, W. A. McKee, and K. W. Cummins. 1991. An ecosystem perspective of riparian zones. BioScience **41**:540–551.

Harmon, M. E., W. K. Ferrell, and J. F. Franklin. 1990. Effects on carbon storage of conversion of old-growth forests to young forests. Science **247**:699–702.

Jones, J. A., and G. E. Grant. 1996. Long-term stormflow responses to clearcutting and roads in small and large basins, western Cascades, Oregon. Water Resources Research **32**:959–974.

Parsons, G. L., G. Cassis, A. R. Moldenke, J. D. Lattin, N. H. Anderson, J. C. Miller, P. Hammond, and T. D. Schowalter. 1991. Invertebrates of the H.J. Andrews Experimental Forest, western Cascade Mountains, Oregon. V. An annotated list of the insects and other arthropods. U.S. Forest Service Pacific Northwest Research Station General Technical Report **PNW-GTR-290**.

Wallin, D. O., F. J. Swanson, and B. Marks. 1994. Landscape pattern response to changes in pattern generation rules: land-use legacies in forestry. Ecological Applications **4**:569–580.

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