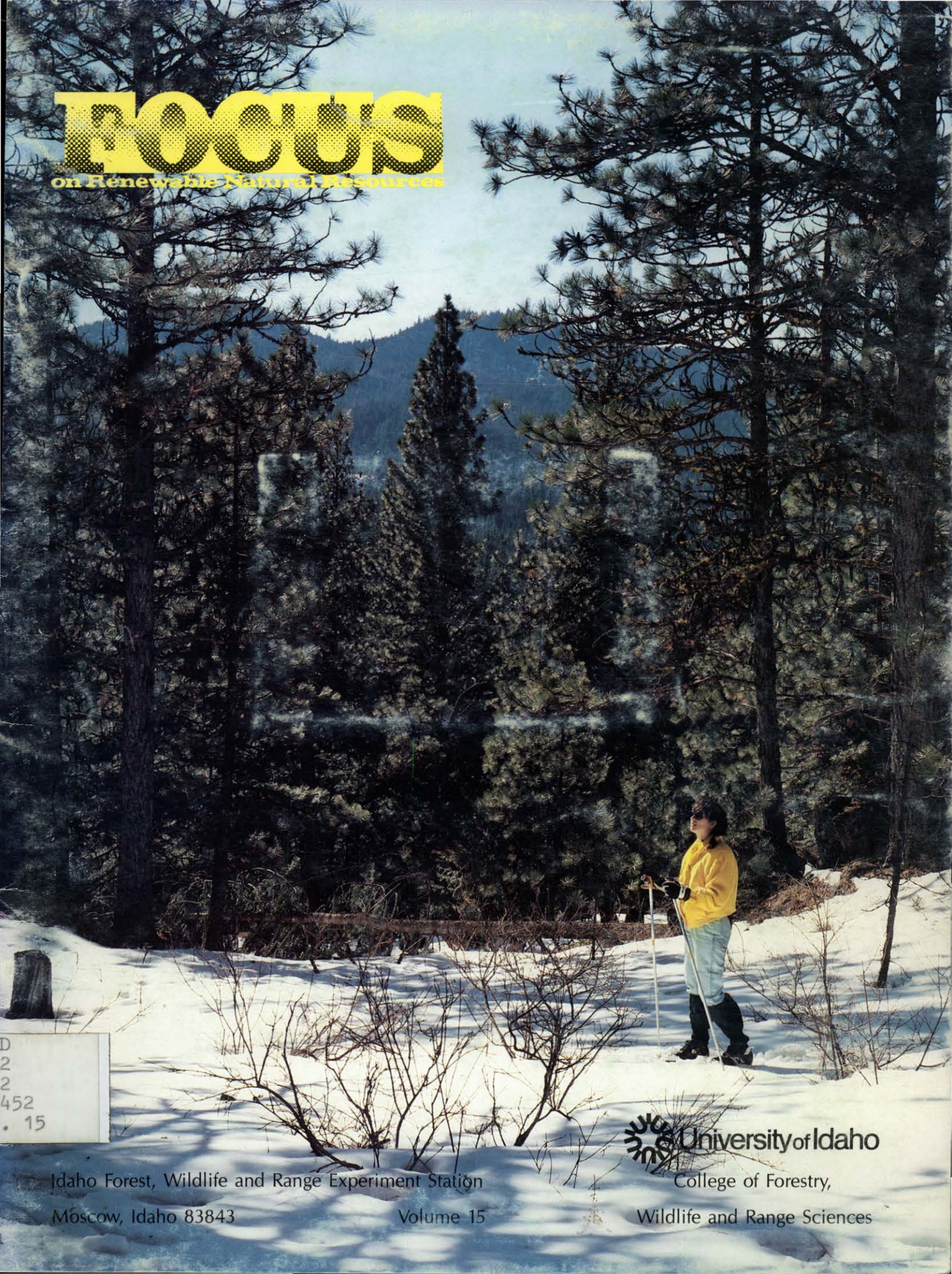
FOCUS

on Renewable Natural Resources



Idaho Forest, Wildlife and Range Experiment Station
Moscow, Idaho 83843

Volume 15

University of Idaho
College of Forestry,
Wildlife and Range Sciences

From the Associate Director

Reaching Out to Idahoans

Leon F. Neuenschwander

The twenty articles in this issue of *Focus* represent less than eight percent of the research projects now in progress through the Idaho Forest, Wildlife and Range Experiment Station, the research arm of the College of Forestry, Wildlife and Range Sciences. *Focus* is the annual report of the experiment station and its articles were selected by members of the college's five departments: Fish and Wildlife Resources, Forest Products, Forest Resources, Range Resources, and Wildland Recreation Management.

This year several FWR scientists focused their research on issues important to the Idaho economy—improving the state's wood products market, measuring the stability of resource-dependent communities, and assessing the tourism potential of small northern Idaho towns in response to a changing national economy. Others addressed issues important to maintaining the state's regional resources, like salmon, many of which are dying from bacterial kidney disease. And they have investigated issues of cultural, social, economic, and environmental importance: post-timber harvest regeneration of conifers, the disposal of wood wastes that can taint the water table, the effects of timber harvest methods that may impact future site productivity, and for this year's cover story—"adaptive" forest management effective enough to make efficient use of Idaho trees now as well as ensuring future timber productivity, wildlife habitat, and recreation.

The first step toward resolving resource problems and one way that FWR scientists learn what issues are important to the public is to go directly to Idahoans and ask them. This issue of *Focus* provides the results of five surveys. These include resident and nonresident opinions about hunting quality in Idaho, Idaho landowner attitudes toward public hunting on private lands, public reaction to the Bureau of Land Management's new riparian management plan, and foresters' attitudes toward using computers to help with land management decisions. Fulbright Scholar Edwin Krumpe surveyed Australian tourists to "capture" their decision-making processes for selecting leisure options. He will use this information to contribute to the development of Idaho tourism—possibly the state's fastest growing economic sector.

In addition, this year's *Focus* covers some of the college's "firsts." Ten students have already enrolled in the new Wood Use and Design degree option, the first undergraduate degree in North America to combine wood construction with the design disciplines of art and architecture. The degree option is just one part of a plan to strengthen the state's forest products industry through teaching, research, and outreach. Led by Thomas Gorman and colleagues in the College of Art and Architecture, the Wood Use and Design Program has secured a $221,000 grant from the Northwest Area Foundation. To help accomplish program goals, the college also acquired the fundraising assistance of former Pack River management executive Max McClintick who is working full-time to build an endowment to support the program. The new program has sponsored many continuing education events, among them—the Wood Products Academy held in June 1990 to teach in-plant personnel fundamentals for the future of the forest industry. There's more on the Wood Use and Design Program in Gorman's article, and also an article about Alton Campbell's studies on new ways to dispose of mill waste, one research focus of the program.

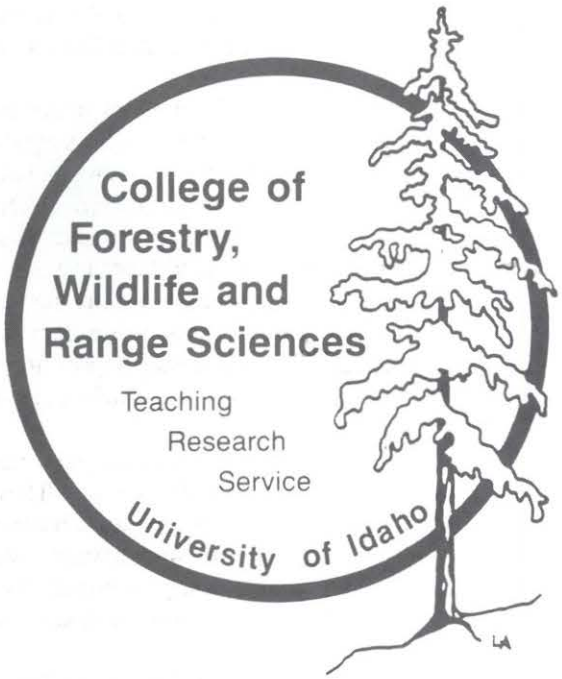
In another first, the college welcomed Jay O'Laughlin who came from Texas A&M University to head the Policy Analysis Group (PAG). Created by the Idaho legislature in 1989, the PAG conducts objective analyses of the potential impacts of natural resource policies in Idaho. A policy analysis advisory committee of representatives from natural resource agencies, industries, and interest groups helps the PAG select topics for analysis. O'Laughlin's first report, "Idaho's Educational Endowment Lands: A Matter of Sacred Trust," was so well-received that in February 1990 the Idaho legislature provided increased funding for next year, and more assignments. This issue of *Focus* introduces Jay O'Laughlin and describes the processes of the PAG, the first of its kind in the country.

I hope you enjoy this year's *Focus*.

Leon F. Neuenschwander

FOCUS

Volume 15 August 1990



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Cover: Adaptive Forestry considers all our needs—for timber, wildlife habitat, recreation, and beauty. Photo by Gerry Snyder

1989 Annual Report

Research Highlights

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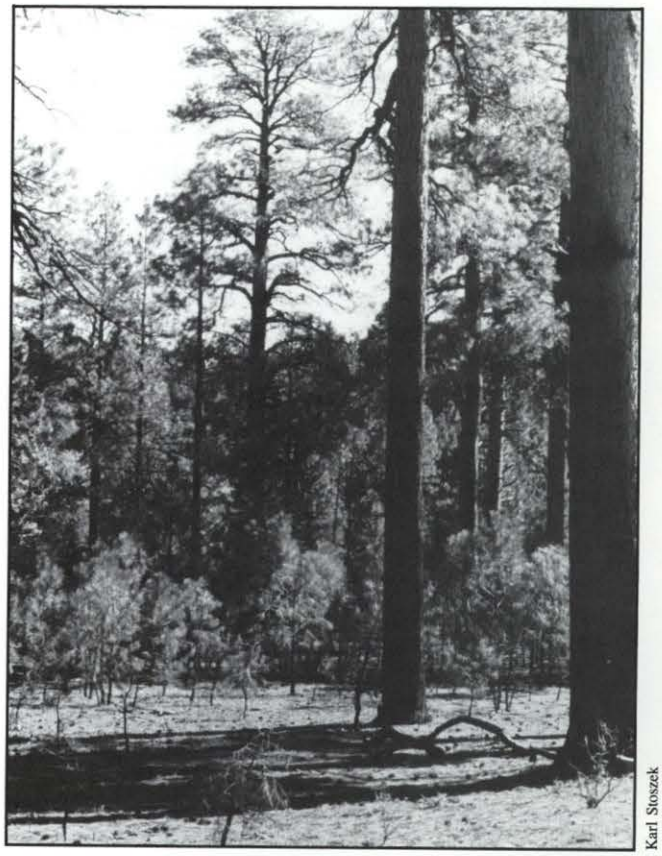
Cover Story:

Managing Change Through Adaptive Forestry

Adaptive Forestry is intended to be the University of Idaho's contribution to the development of "New Forestry." To demonstrate the Adaptive Forestry concept, a scientific and managerial team is being formed at the College of Forestry, Wildlife and Range Sciences to develop, implement, monitor, and evaluate the approach on a thousand-acre tract of land within the University of Idaho Experimental Forest.

Karl J. Stoszek



Karl Stoszek

Adaptive Forestry means sustaining all the elements of a healthy forest ecosystem—ground cover, wildlife, diverse tree species composition—even the insects, snags, and surface fires that recycle nutrients.

Forestry is at a crossroads. In the interior west of America it is confronted with serious political problems and scientific concerns. Conventional forest management plans and practices, particularly clearcut-based management and broad-range pesticide and herbicide application are under fire—the objects of litigation, legislative action, and scientific scrutiny.

At the core of the problem are competing demands for forest resources and conflicting cultural attitudes. The issues involve jobs, economic diversity, resource sustainability, and environmental quality. Growing social concern over the threats of pollution and predicted global warming are bound to further escalate environmental concerns.

Public and scientific concerns are especially important for mountain forests. How do we simultaneously maintain the productive capacity of the soil, foster production of wood, and protect watershed values, wildlife habitats, and aesthetics? What is needed to increase the resistance of forest ecosystems to acidic depositions or other pollutants? What can be done to safeguard the functional survivability of forests in the face of predicted changes in global climate?

As in any complex situation, the solution rests in pragmatism. There is a need to replace the current pillar of contemporary forest planning, the assumption that the key determinants affecting forest growth do not change—that soil fertility, air quality, precipitation, and solar radiation are constants. In fact, even without dramatic changes in the current climate, all these factors are changing under the polluting effects of the industrial era. Environmental change and uncertainty is the norm. And it is manageable if we *adapt* forestry decisions and management to incremental changes in environmental conditions and attempt to foster ecologically sustainable functioning of the forest under these conditions. This would mean focusing on holistic management of the forest as an ecosystem.

Research indicates that some conventional silvicultural practices, such as mechanical site preparation and successive harvesting of commercially desired conifer plantations, degrade soil fertility and increase the forest's vulnerability to disturbances. Furthermore, by curtailing both the early and advanced phases of forest development (the shrub and old-growth phases), intensive even-age management may reduce plant, microbial, and animal interactions that are essential to the maintenance of the system's productive stability. The haphazard scatter of clearcut units on the landscape fragments the forest, degrading aesthetic values and animal habitats. In addition, by altering atmospheric and hydrologic patterns, clearcuts may have undesirable cumulative effects on the landscape's other terrestrial and aquatic systems. Thus the integrity of forested landscapes is affected and multi-resource values diminished.

A possible answer lies in a forestry based on a landscape-oriented approach, and a continuously updated

understanding of how forest ecosystems function and of which interactions play key roles in the maintenance of the system. Such a management approach would be highly adaptive to spatial and temporal changes in forest conditions, as well as to changes induced by alterations in atmospheric chemistry and climate. Applied within the practical constraints of technical feasibility and socio-economic acceptability (which considers not only commodity values but also intangibles like the values of a livable environment), Adaptive Forestry could reconcile the escalating conflicts between utilitarian users of forest resources and those concerned with environmental quality.

Adaptive Forestry is applicable under land use policies aimed at fostering sustainable functioning of all major ecosystems on forested landscapes. Its cornerstones would be: (1) land-use objectives that are socially desirable and attainable in both socio-economic and functional-sustainability terms, that is, tailor-made to the productive and functional capacity of ecosystems on a given landscape; (2) silvicultural treatments that are process-driven, derived from considerations of both the existing forest pattern and also the perceived need for changes in the pattern to maintain or enhance the desired functions and processes of the forest; and (3) integration of the above decisions with technical, economic, and social acceptability and feasibility assessments that are realistic to an uncertain future. Facets of this type of scheme are already part of resource management planning on many public and corporate lands within the American West.

Implementing such management would require designation of landscape-based planning units. A planning unit would be relatively uniform in its productive and functional capability, in the pattern and dynamics of the forest community, in its functional interaction with neighboring units, and in environmental, technical, and socio-economic constraints. The unit's boundary would consist of readily discernible permanent landscape features. Forest stands within the unit would be treated as parts of one interacting entity, not as the isolated planning segments of conventional forestry.

Grouping planning units into categories of ecological and technical similarity would be key to developing generic management guidelines. It would enable efficient use of both simulation models appropriate to the planning task and the expertise of interdisciplinary specialist teams. Barring certain provisions, most existing silvicultural methods and practices would serve the needs of such a systems-oriented management. Harvest methods for forests on productive sites would for the most part resemble irregular shelterwood cuts, strip or patch cuts, and group selection cuts described in conventional silvicultural literature.

Consistent with the overall aims of Adaptive Forestry, silvicultural objectives would include, as a minimum, the following: (1) to maintain a continuous and adequate supply of woody residues to the forest floor through retention of coarse woody residue, snags, and snag replacement trees with desirable characteristics; (2) to protect the soil from compaction and displacement by appropriately restricting on-ground movement of compaction agents and the type, extent, and intensity of slash disposal treatments; (3) to regenerate the widest possible spectrum of tree species genetically suited to the present and anticipated environmental conditions of a given site (including natural regeneration, planting, or both); (4) to maintain (or restore if needed) ground cover of a functionally useful spectrum of woody plants and other perennials adequate to the conditions of the site and the developmental stage of the forest at the time of treatment; (5) to foster viable development of all tree species present and adapted to the environmental conditions of the site; and (6) to substitute those effects of natural disturbances that are vital to the maintenance of forest ecosystems' productive capacity and resilience to perturbations, for example substituting prescribed burning for the wild surface fires that stimulate acid neutralizing effects and nutrient recycling.

The prospective structure and species composition of forests under Adaptive Forestry would expectedly be as diverse as permitted by the environmental constraints and developmental history of forests on the landscape planning unit. Forests on harsh sites would retain the irregular unevenaged-multistoried structure, while forests on productive sites would exhibit an evenaged, yet horizontally diverse structure. The diverse pattern would augment the manager's flexibility in adapting the forest to changing conditions, while at the same time it would assist in maintaining the land's productive and functional capacity. Adaptive Forestry would not necessarily mimic nature.

Harvest levels of timber and other desired commodities would be the result of changes in the existing structure and composition made by silvicultural treatments that consider the system's maintenance needs. Outputs would reflect the existing state of the forest and its productive potential, rather than desires that are not realistic or ecologically sustainable.

Adaptive Forestry has the flexibility to respond to incremental changes in both environmental conditions and societal demands on the resource. It has the potential to reduce the damage of impending changes. It provides an opportunity for reconciling resource use conflicts, and it may be forestry's way out of the current crisis.

Karl Stoszek is professor of silviculture and forest protection in the Department of Forest Resources. As part of an Environmental Protection Agency/University of Idaho cooperative agreement, he has served since 1987 as senior forest scientist for the EPA's project on Acid Rain at the Environmental Research Laboratory in Corvallis, Oregon. This manuscript has not been reviewed by the EPA and should not be construed as representing agency policy.

Idaho Landowner Attitudes on Hunting and Hunters

Charles McKetta and Natalie Bolon

When a pheasant explodes from autumn cover, startling both pointer and master, that's quality recreation. In Idaho the pheasant is one of many types of wildlife that provide such enjoyment. Whether habitat and wildlife survive cultivation to produce a valuable recreation experience depends on a triangle of people: hunters (also bird watchers), game agencies, and landowners.

Unfortunately, to an Idaho landowner choosing between crop and game, wildlife looks like all costs and no benefits. Economists can estimate the implied values of hunting, but landowners rarely view such values as tangible incentives to preserve habitat, allow access, or produce hunting opportunity.

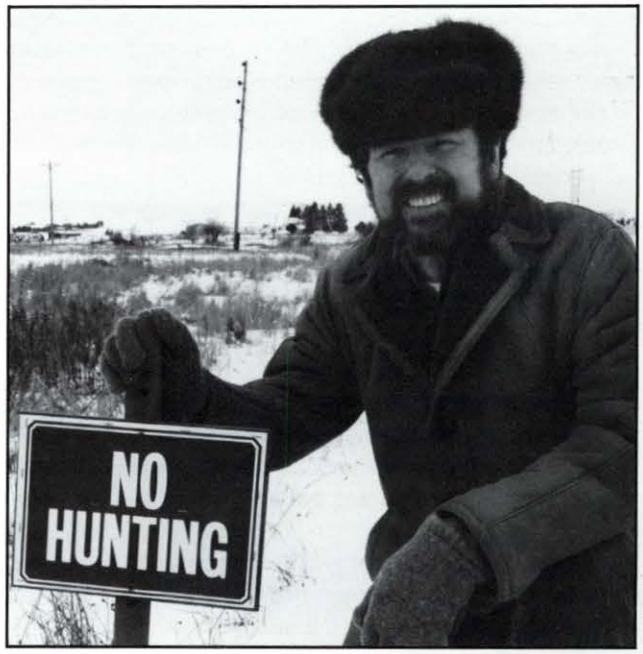
Rights to private habitat and public game conflict with each other because farmers and ranchers own game habitat and control access to it while the state owns the game itself. To add to this, trespass laws and bag limits are often differentially enforced. The specter of liability and requirements for guide licenses further limit the farmer's or rancher's potential to gain from and foster wildlife on his or her lands.

We surveyed Idaho farm and ranch landowners in 1989 to discover how much public outdoor recreation they provided. Camping, fishing, and horseback riding activities are common, but hunting is the dominant form of recreation on private rural lands. These private lands are hunted mainly for upland birds, with deer, waterfowl, and varmints running close seconds.

Farmers' and ranchers' attitudes influence their decisions to provide public recreation, particularly hunting. Landowners feel responsible for the well-being of wildlife on their lands and see their private role in wildlife management as important, even though three-quarters of Idaho's huntable lands are public. They acknowledge that hunting is an essential wildlife management tool, particularly to control damages to land by wildlife.

Access is the key. Almost half of the 814 respondents post their lands to control entry and to hold visitors accountable. However, few think that trespass law enforcement is sufficient to keep unwanted strangers off their lands. It is important to note that only six percent of these Idaho landowners adamantly want to keep *all* strangers off.

Hunting is allowed on 89 percent of private lands, though only two-thirds of the owners themselves hunt. They do not limit access to friends and family, and 80 percent permit strangers to hunt, but want them to ask for permission. Attitudes toward hunters are surprisingly positive and access policies lenient. However, landowners find that allowing hunting reduces their privacy, conflicts with their other land uses, and results in some crop and property damage.



Gerry Snyder

Charles McKetta leans on one of many signs typically encountered by hunters who cross into private lands from the three-quarters of huntable Idaho land open to the public.

Giving their permission depends on how people present themselves. Formally permitted visitors seem to respect property and landowner rights. As most Idaho farmers and ranchers allow strangers to hunt regardless of the posted status of their lands, it is clear that posting is less a land access prohibition (as it might appear to hunters) than it is a visitor filter.

Now, with no landowner incentives to manage game and provide access, public hunting on Idaho private lands is declining. Pheasant hunter numbers are half what they were in 1980. Reversing this trend will require generating incentives for landowners. Landowners would like to receive damage compensation and have liability insurance available. Although the traditional support for private wildlife management is planting supplies, landlowners rank these incentives as least preferred. Cash payments are secondary to them since most have been giving hunting access away. Less than one-half percent of owners charge fees for hunting access. Even though charging fees might increase income and justify investments in wildlife, many have not considered the option, and one-quarter do not believe that charging fees for hunting is right.

In most states bordering Idaho, hunter-landowner transactions are slowly evolving from free to fee. Landowners in these states have entered into fee hunting agreements as a low cost way to control trespass, but paid hunting remains infrequent.

Idaho fee hunting will also increase someday, but a free hunting tradition and the fact that only densely game-populated habitats are marketable means that any increase in cash sales of hunting rights could be slow, and would probably never dominate hunter-landowner interactions in this state.

Farmers' and ranchers' contributions to Idaho hunting opportunities are unsung and unrewarded. Landowners freely provide significant hunting and other recreational opportunities and could provide more. They are relatively positive about wildlife, hunting, and hunters, even if they are reluctant to invest in habitat.

Wildlife management is as much people as it is animal management, and landowners must be incorporated into the decision process. Study of game biology dominates the wildlife profession, but this survey of habitat owner behavior suggests that game management efforts must recognize another factor: that it is humans who produce outdoor recreation opportunities for other humans.

Charles McKetta is associate professor of forest resources and economist for the Idaho Forest, Wildlife and Range Experiment Station. Natalie Bolon graduates this May with a master's degree as the college's first wildlife economist. *Their survey was supported by funds and assistance from the Idaho Department of Agriculture, the State Board of Education, the USDA Idaho Agricultural Statistics Service, the National Rifle Association, and the University of Idaho.*

Gerry Snyder

Despite the bold warning, most landowners allow strangers to hunt their land, posting more to filter visitors than to prohibit access.

Policy Analysis Group: an Idaho First

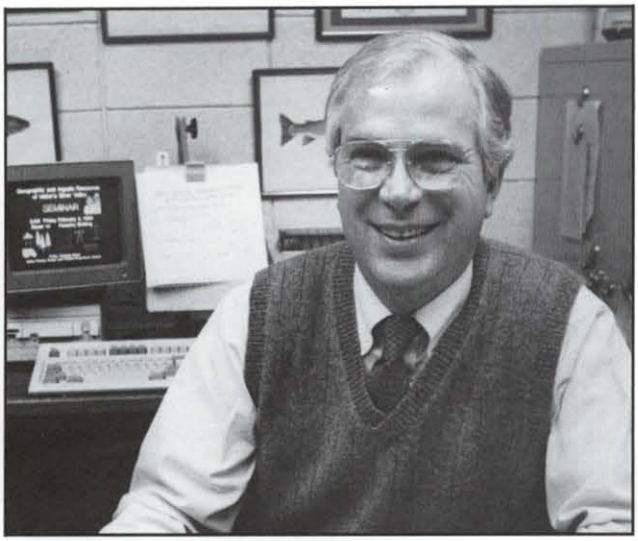
Jay O'Laughlin

The use, management, and protection of Idaho's resources involve complex and sensitive questions and issues. Because interest groups tend to interpret data and research results to support their own viewpoints, legislators, agency leaders and their advisors, and other policy makers sometimes address resource management issues emotionally or politically, often with insufficient information. To benefit as many Idahoans as possible, decision-makers need unbiased analysis of resource policy issues.

To provide them with impartial information for making natural resource management decisions, the Idaho legislature in 1989 created the Policy Analysis Group, or PAG, a unit of the Idaho Forest, Wildlife and Range Experiment Station. The purpose of the PAG is not to advocate positions or viewpoints, but to analyze pertinent facts and present its findings objectively.

When it created the PAG, the legislature gave John C. Hendee, dean of the College of Forestry, Wildlife and Range Sciences, the responsibility of appointing an advisory committee to review policy issues the PAG might consider. The members of the PAG Advisory Committee represent a cross section of resource interests and agencies, and include Stan Hamilton, director of the Idaho Department of Lands; Jerry Conley, director of the Idaho Department of Fish and Game; Jim Hawkins, director of the Idaho Department of Commerce; Roberta Moltzen, deputy supervisor of the Boise National Forest; Phil Soulen, a rancher from the Weiser-McCall area; Tom Geary, Twin Falls farmer and president of the Idaho Farm Bureau; Grangeville outfitter Harold "Frog" Stuart of the Idaho Travel Council; Bruce Bowler, attorney and environmental representative from Boise; and representing the forest products industry—Tim Mueller of Edwards Brothers in St. Maries.

Attuned to a wide variety of public, governmental, and interest group issues, members of the advisory committee help the PAG decide which issues to address, and in what order of priority. When the PAG decides to analyze an issue, the PAG director enlists a group of technical experts to develop a proposal for the analysis. These experts are usually College of Forestry, Wildlife and Range Sciences faculty specializing in the issue area, and in most cases will be involved in the analysis as well. To do the analysis, the PAG uses existing research and also performs, commissions, or subcontracts new research, seeking expertise from oth-



Gerry Snyder

A specialist in forest resource economics and policy analysis, Jay O'Laughlin supervises the interdisciplinary, interagency, and groundbreaking PAG.

er colleges within the University of Idaho, and in some cases, from other institutions. Study results go through a technical review process, and become available to decision-makers and the public as promptly as possible through a Policy Analysis Group publication series.

At this writing, the Policy Analysis Group has three studies underway: (1) public reaction to a draft of the BLM's new riparian management policy, (2) policies affecting the management of Idaho's education trust fund endowment lands, and (3) a pulp mill feasibility study and resource assessment in Idaho's Silver Valley.

At least three more issues will be analyzed during 1990: Idahoans' opinions about natural resource issues (in cooperation with Boise State University); forest management issues affecting the availability of the state's timber resource; and alternative strategies for wolf recovery in central Idaho.

Many policy centers exist in government agencies and collegiate units outside of natural resources. Some of these centers deal with natural resource issues. But to date, Idaho is the only state with a dedicated unit for natural resource policy analysis based in a natural resource institution for teaching, research, and service.

Formerly a professor at Texas A&M University, Jay O'Laughlin was hired by the college to direct the PAG. Since earning a Ph.D. in forest economics and policy from the University of Minnesota, his research interests have focused on the contribution of economics to forest resource policy analysis. Recent publications include "Forests and the Texas Economy," published by the Texas Agricultural Experiment Station, "Swedish Forestry and Forest Policy," published in the Journal of Forestry *following a brief consulting role with the Swedish Pulp and Paper Association, and* Forest Resource Policy: Processes, Participants, and Programs, *a textbook he co-authored, soon to be published by John Wiley and Sons. O'Laughlin is adjunct professor of forest products.*

First Assignment: Garnering Public Input

Kendall Johnson

Idaho relies heavily on the utility and beauty of its riparian zones—lands associated with or affected by water sources. These lake sides, stream banks, and green areas naturally draw cattle, wildlife, and people alike, but in so doing, are affected by them.

Riparian areas are especially vital in Idaho's semi-arid basins and valleys. However, previous use has damaged many of these zones, and growing public awareness has made their use and management a major resource policy issue. In response, the Bureau of Land Management (BLM) in August 1989 completed a draft policy statement to guide its management of riparian areas on public lands.

The Idaho Riparian Management Policy Draft states that major land uses that affect riparian areas include grazing, timber harvest, road construction, mining, and recreation. Policy objectives are to maintain, restore, and improve riparian areas by monitoring and studying their special needs, cooperating with landowners and public land users in doing so, and allocating BLM funds to achieve these goals.

The BLM requested that the PAG gather and analyze public comment on the draft, and the advisory committee accepted the request as the first PAG project. The program is being conducted by an interdisciplinary group of College of Forestry, Wildlife and Range Sciences faculty centered in the Department of Range Resources and under the direction of department head Kendall L. Johnson.

We began our two-pronged approach by first hearing individual concerns at a series of eight public workshops held during 1989 in Lewiston, Salmon, Idaho Falls, Pocatello, Coeur d'Alene, Caldwell, Boise, and Twin Falls.

Early main themes emerging from the workshops suggest that Idahoans are most concerned with (not in order of importance): (1) the definition, inventory, and classification of riparian areas, (2) uses and management of those areas, (3) socioeconomic factors, (4) issues relating to water quantity and quality, and (5) a need for public education on the issue.

In the second prong of our approach, we mailed surveys to 265 organizations having an interest in Idaho riparian management: state and federal agencies, county commissioners, user organizations, and interest groups.

When we have analyzed the workshop and survey data, we will report the opinions of Idahoans on the riparian issue to the BLM for their use in refining the draft Idaho Riparian Management Policy.

Drug Testing for Fish—

Controlling Bacterial Kidney Disease in Salmon

Christine M. Moffitt

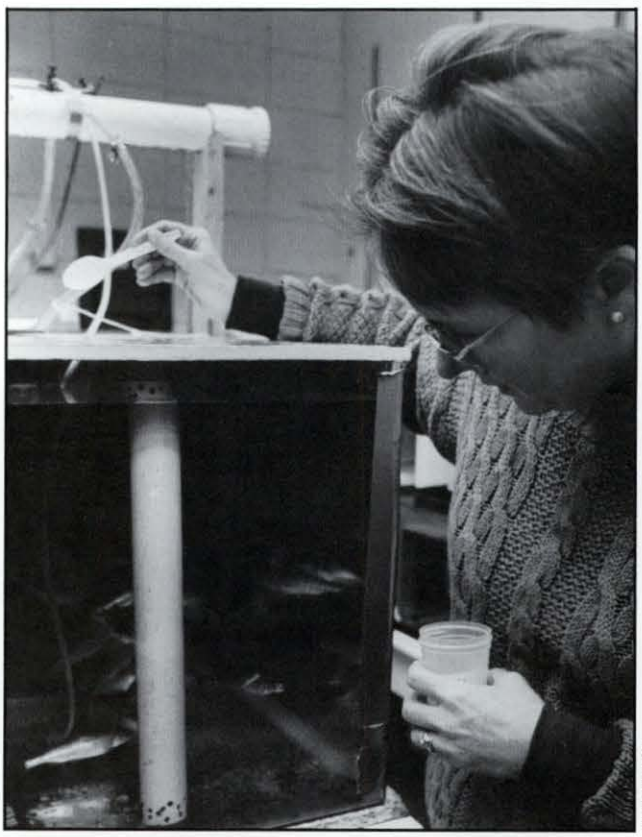
Bacterial kidney disease (BKD) is a chronic disease specific to salmonid fish. First observed in Atlantic salmon in Scotland, it is now reported in salmon and trout in both the northern and southern hemispheres, probably spread along with transplants of these species over the past century.

For Pacific salmon in the Northwest, especially chinook salmon, BKD is the number one disease problem. Losses of Pacific salmon to BKD are generally most severe after the fish reach the ocean, probably due to the greater demand which full strength sea water puts on their kidneys. These losses can exceed 60 percent in fish held in seawater net pens. Because of the difficulty of following fish at sea, we lack knowledge on exact mortality rates attributable to bacterial kidney disease at sea, but we do know that hatchery returns are very low.

As with many human and other vertebrate bacterial pathogens, the kidney disease bacterium is sensitive to antibiotics. Using a basic knowledge of drug and disease interactions, blood and tissue tests, and observation, we are studying ways to administer the antibiotic erythromycin to salmon so that we can more effectively control BKD and help these important stocks of fish in Idaho to survive.

Research has shown that erythromycin, an antibiotic commonly used to fight human disease, is particularly effective against *Renibacterium salmoninarum,* the bacteria that causes kidney disease in salmon. For years, University of Idaho scientists have explored ways to control BKD in salmon. University aquaculture specialist G.W. "Bill" Klontz and his associates were among the first to use erythromycin to treat BKD in Idaho fish, enhancing adult salmon survival by injecting them with the drug (since adult salmon do not eat in fresh water, they must be injected; erythromycin can be administered to juvenile fish in their feed).

In the early 1980s, fisheries researcher Theodore C. Bjornn and I showed that feeding a ration with erythromycin reduced BKD in juvenile salmon in some of the Idaho and nearby hatcheries. As a result of these and other studies, biologists at hatcheries throughout North America have experimentally treated both juvenile and adult salmon with erythromycin.



Gerry Snyder

Testing their palates, Moffitt feeds juvenile chinook salmon the bitter drug erythromycin in corn and wheat-based carriers to learn which they like better. They seem to prefer the wheat.

However, in order for drug treatment to be legal in public and private aquaculture facilities, the drug and dosage regime must be registered with the U.S. Food and Drug Administration after rigid testing. Recognizing the importance of erythromycin treatment to maintaining northwest stocks of salmon and as part of the Fish and Wildlife Program mandated in the Power Planning Act of 1980, the Bonneville Power Adminstration sought to have erythromycin registered. To do this, it contracted with the University of Idaho to conduct the necessary research in administering oral and injectable erythromycin to treat bacterial kidney disease in aquaculture.

We assembled a team of University of Idaho scientists, graduate students, undergraduates, and technical assistants to conduct the project. In addition, we have collaborated with Washington State University pharmacologist Bill Hayton and his graduate assistant Irv Schultz for their considerable understanding of drug metabolism, distribution, and elimination, and of the experimental procedures necessary to study these in fish.

In the spring of 1989 we began the project by transforming our 20-year-old College of Forestry, Wildlife, and

Range Sciences wet laboratory into a laboratory that could accommodate up to 60 adult salmon. Research associate Rudy Ringe hauled the salmon to the wet lab from Cowlitz Salmon Hatchery in Washington and Eagle Creek National Fish Hatchery in Oregon in a 1000-gallon refrigerated tank truck. Working with these adult salmon, we investigated the absorption and elimination of erythromycin in their blood and tissues to discover what vehicle and route of administration is best to use.

Graduate student Colleen Fagan and I are currently testing for the pattern of erythromycin absorption and elimination following oral administration to juvenile salmon. Since erythromycin tastes bitter to fish, palatability can be a problem when dealing with oral administration. We hope to maximize the amount of drug absorbed so we can minimize dosage. We are testing the palatability of diets containing a corn-based carrier for the drug and a wheat-based carrier, and have found so far that the wheat carrier may work better.

Future phases of this project will take place in the wet lab facility the university is building as part of the new University of Idaho Aquaculture Program. This facility will house 320 adult chinook salmon in 14 tanks, 12 feet in diameter and three feet deep.

Here, graduate student Becky McKivigan will help test varying quantities of drug and differing injection intervals on the adult salmon to learn what administration method and dosage best protects them from BKD. We will also be able to observe the fish for two or three months prior to spawning, periodically taking blood samples to determine the amount of bacteria and drug present. We will collect blood and tissue samples for testing at the time of spawning, as well as from the offspring, to follow how effectively these treatments influence resulting generations of fish.

Other phases of our project include testing the toxicity of doses and monitoring and predicting the amount of erythromycin the fish release back into the water following oral or injected doses.

Erythromycin is not a cure-all, but a useful stopgap for preserving critical populations of native fish. We hope our final product after this six year study will be the FDA's registration of erythromycin to treat bacterial kidney disease in this historically, culturally, and economically important fish resource for Idaho and the Northwest.

Christine Moffitt is adjunct associate professor and research scientist in the Department of Fish and Wildlife Resources. Assisting her are research associates Rudy Ringe and Gwynne Chandler, master's student Colleen Fagan, Ph.D. student Becky McKivigan, and ten undergraduate students from both the College of Forestry and the College of Letters and Science.

Christine Moffitt

Washington State University student Rudy Kucera (right) and research associate Rudy Ringe place an anesthetized and catheterized chinook salmon into a trough to test its blood following a dose of erythromycin.

North Idaho Tourism Potential—A New Gauge

Charles C. Harris, William J. McLaughlin, and Sharon E. Timko

As global and regional economies shift and change, rural communities are sometimes threatened by the loss of their traditional economic bases and, thus, of community stability. Concerns have emerged about revitalizing these communities and diversifying their economies.

At the state and local levels, the Idaho Department of Commerce's Division of Economic Development is working with small communities to advance their economic development through the Gem Community Program. We in the Department of Wildland Recreation Management have begun collaborating with the Division of Economic Development to accomplish two goals closely tied to this program: (1) to help local areas assess the potential for diversifying their economies through tourism development, and (2) to provide communities with a process for evaluating the preliminary feasibility of the development projects they desire. Funding provided by the USDA Forest Service through its State and Private Forestry Program has enabled us to work with Gem Community Program Coordinator Galen Schuler to achieve these goals in four north Idaho communities: Bonners Ferry, Priest River, the Silver Valley, and St. Maries.

To begin the assessment and evaluation process, we sent each of the four communities a copy of the *Idaho Rural Tourism Primer: A Tourism Assessment Workbook.* We developed this workbook to help community representatives identify and evaluate tourist attractions, infrastructures, and services in their communities. Community representatives completed the workbook prior to an initial community meeting we held with members of the area's economic development corporations and others interested in the town's tourism development.

One objective of the workshop was to present community leaders with a profile of their existing visitors. This profile was based on a regional analysis of data from a statewide study of travelers conducted by the Wildland Recreation Management Department in 1986 and 1987 and documented in a report titled *A Profile of Leisure Travelers in Region I.*

A second objective of the workshop was to help community representatives define the type of tourism services they felt their community was currently providing and the kind of economic role they want tourism to play in their area over the next decade. After helping them examine their present situation, we worked with them to create a broad future scenario based on the above objectives. They then generated a list of specific projects necessary to make the future scenario a reality.

Sharon Timko

A tour trolley in Wallace, Idaho: Silver Valley community members also considered developing a valley transit system, sponsoring paragliding competitions, and recreating an 1890s western brothel.

To assess the tourism potential of the towns and the attitudes of residents towards tourism development, we toured the communities and surrounding areas to experience first hand the tourism services existing there. We took photographs, assembled materials on the various attractions, and contacted tourism operators and other key community leaders of the region(s).

We used this information along with community input, the best tourism data available, and trends and projections for north Idaho, the Pacific Northwest, the nation, and the world, to develop a tourism scenario that we felt was most realistic within the community's own specified parameters, and which could be achieved in the next five years. With this information, we rated the scenario with predetermined standards for each of ten criteria to evaluate the most feasible and desirable attributes of that scenario.

We also rated each project according to the standards for each criterion, using a table which listed the evaluation criteria along the top and approximately 15 community-proposed tourism projects down the side. Projects listed included not only those the community generated, but also some that we as consultants suggested.

For an example of how the table works, we briefly examine the idea proposed by the Bonners Ferry community to develop local sightseeing flights there. According to the table, the project fits under the Dominant Type (criterion 1) as *day use,* would require a *short* Time Horizon (2), *moderate* Investment Level (3), *inside/shared* Investment Control (4), *moderate* Community Support (5), *low* Enhancement—scope of community businesses and publics that would benefit (6), *low* Diversification—extent to which the product duplicates what is already available locally, statewide, regionally, nationally, and worldwide (7), *trainable and employed* Human Resources (8), *moderate* Market Potential (9), and Project Site Availability (10) that is *available and underutilized.*

Our tourism planning team then computed the overall compatibility of each project with the achievable scenario; this "compatibility score" was based simply on the number of matches between standards assigned to each project and the standards for the achievable scenario. At a second workshop we presented recommendations consisting of the obtainable scenario and a prioritized list of projects the community might pursue to implement the scenario (the projects rated as most compatible with the scenario). Each of the four communities have taken our results, selected the projects deemed most feasible, and are now in the process of making their hopes for tourism development and community revitalization a reality.

The format of our table allows workshop participants to add and rate new projects as they emerge. If they decide to change the entire scenario or a rating for one component, the change could result in new compatibility scores.

Sharon Timko

When a changing economy threatens the stability of some small Idaho towns, one option is diversification through tourism development. The only people taken for a ride in Wallace would be community-revitalizing tourists.

Thus, we have developed a dynamic approach that allows for re-evaluation of proposed projects if the conditions and desires of the community change.

The positive responses we have received through the Gem Communities Program indicate that our process is an effective, flexible, and useful one that facilitates community involvement and decision making. It is a process we believe could be applied nationwide, and we are already working with the Rural Recreation Development Center in Colorado to modify it for use in that state. In January of 1990 we presented our work to Idaho legislators and the Idaho Travel Council, and we are in the process of publishing our method in a tourism research journal. We hope to continue our efforts of tourism development planning in other parts of Idaho, including the southeastern regions of the state.

Charles Harris is an associate professor and William McLaughlin a professor in the Department of Wildland Recreation Management. Sharon Timko, a recent graduate of the master's program in wildland recreation management, now works as a tourism planner for an Oregon planning company.

Projecting Effects of Wolf Predation

James M. Peek and David J. Vales

Wolves have not occupied the northern Rocky Mountains for over 50 years since they were eliminated to reduce livestock depredation. However, in 1987 the U.S. Fish and Wildlife Service designated for wolf population recovery portions of formerly occupied wolf range in the Central Idaho Wilderness, along with Yellowstone National Park and surrounding wilderness areas, Glacier National Park, the Bob Marshall Wilderness, and adjacent areas in northwestern Montana.

Funded by the U.S. Fish and Wildlife Service, we explored the potential effects of wolf predation on the mule deer and elk populations of the East Front from Glacier National Park down to and including the Dearborn River drainage in Montana, about 2000 square miles. While moose, bighorn sheep, mountain goats, and white-tailed deer also live in this region, mule deer and elk would likely be the major prey for wolves because of their high numbers and distribution away from human activity along the Rocky Mountain East Front.

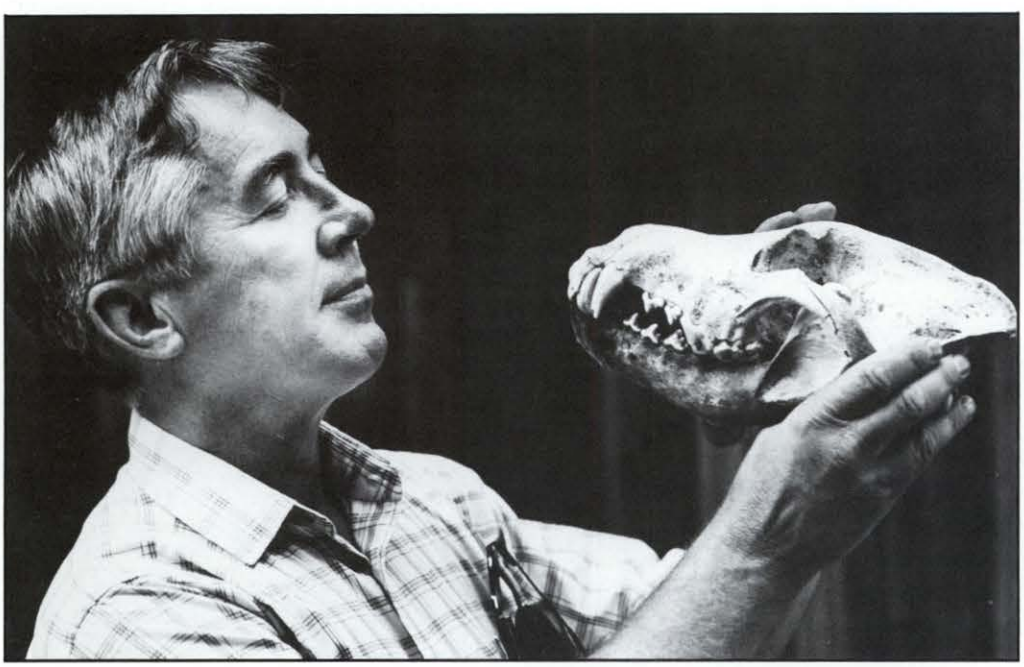
Hunter harvest has regulated elk populations along the East Front for over 20 years, and no trends in their population size or sex and age composition have been observed over that period, though their numbers can be estimated at about 4600. Mule deer populations are thought to fluctuate in this area between 6000 and 12,000 over a ten year period, and hunter harvest fluctuates accordingly. We used age distributions, cow:calf ratios (doe:fawn ratios for mule deer), and hunter harvest information from the Montana Fish, Wildlife and Parks Department to predict what elk and mule deer population trends would be for the East Front if it were inhabited by wolves.

Using nine studies including information from Minnesota, Alberta, and Manitoba, we examined wolf densities, pack sizes, and wolf:prey ratios to gain insight into the potential population level of wolves the East Front might sustain. From these studies we also figured the composition of prey in the typical wolf diet.

Wolf kill rates from 13 studies on wolf ranges in North America helped determine the potential numbers of elk and mule deer killed per wolf per year. Using information from Jasper National Park in Alberta, we estimated what the proportions of mule deer and elk to wolves would be if wolves reoccupied the East Front. We calculated that the average number of prey taken per wolf per year ranges from 12 to 28 deer and elk, with five to ten deer taken for each elk.

We designed five computer simulations, which included factors like calf production and varied ranges of kill rate, to help us predict the effects of different sizes of wolf populations on mule deer and elk populations.

Because elk are regulated by hunter harvest, the presence of wolves would inevitably reduce the number of elk available for harvest, assuming no population survival or



Shelly Gildehaus

James Peek ponders the skull of a wolf that weighed approximately 100 to 125 lbs., the size that may someday reinhabit Yellowstone.

Sam Ham

One wolf may take an average of 12 to 28 deer and elk per year, with five to ten deer taken for each elk.

reproduction rates changed and population levels remained stable. We estimated that approximately 50 wolves could be sustained on the East Front if hunter harvest of cows and calves were reduced by half; more wolves could be sustained if no antlerless hunting of elk were allowed.

For mule deer, we were able to project that populations of 50 wolves would curtail increases in deer population levels at 6000, but not at 9000. When mule deer survival rates increased 5 to 10 percent in our simulation, their populations increased at all levels. The mule deer population could probably support 30 to 45 wolves, in addition to hunter harvests of over 500 animals annually.

We found little evidence that wolf predation causes reductions in other forms of deer and elk mortality, for example hunter kills, malnutrition, or other predators. There is also scant evidence that wolf predation causes the remaining individuals to survive longer or produce more young. Therefore, the presence of wolves on the Eastern Front of the Rockies would undoubtedly require intensive monitoring of prey populations to determine their responses to wolf predation. Our results provide insight into the nature and kinds of information that will be required when wolves again occupy the northern Rocky Mountain states.

James Peek is a professor and David Vales a Ph.D. student in wildlife resources, Department of Fish and Wildlife Resources.

Stimulating Idaho's Wood Products Industry

Thomas M. Gorman

A major initiative at the College of Forestry, Wildlife and Range Sciences is underway to develop wood use and design programs to help the forest products industry in the state and the region. Jointly developed by the College of Forestry, Wildlife and Range Sciences and the College of Art and Architecture, the leading goal of these programs is to strengthen and help diversify the state's forest products industry and its timber-dependent communities by encouraging increased manufacture of value-added wood products.

To do this, we are planning and implementing a variety of programs in teaching, research, and outreach. For example, a new curriculum has been developed that prepares students for careers in wood construction and related professions. Offered through the Department of Forest Products, the new Wood Construction and Design option integrates courses in forest products, wood technology, business, and design. Eight students enrolled in the option last fall, and two will graduate next spring.

Developed by faculty of both the Department of Forest Products and the Department of Architecture, the new curriculum is the first of its kind. In spite of the importance of wood as a construction material, no other undergraduate program in North America combines wood construction with the traditional design disciplines. As a result, our program has captured the interest and encouragement of professional associations for forest products and building design. They recognize that graduates of this program should understand how wood and structurally engineered wood components function in a building system, in addition to possessing fundamental business skills. Upon graduation from the program, students will have a variety of exciting career options, including planning, design, and supervisory positions in residential and commercial construction.

We all recognize the importance of a strong wood products industry to a healthy Idaho economy. Wood manufacturing plant owners and managers have shown their commitment by making the necessary investments to remain competitive, and the labor force has also expressed its commitment. This overall effort has resulted in tremendous increases in productivity, and in a primary processing industry that is efficient, internationally competitive, and able to survive tough markets. However, despite record

levels of production in recent years, a smaller total primary processing workforce is employed now than during the boom years of the past.

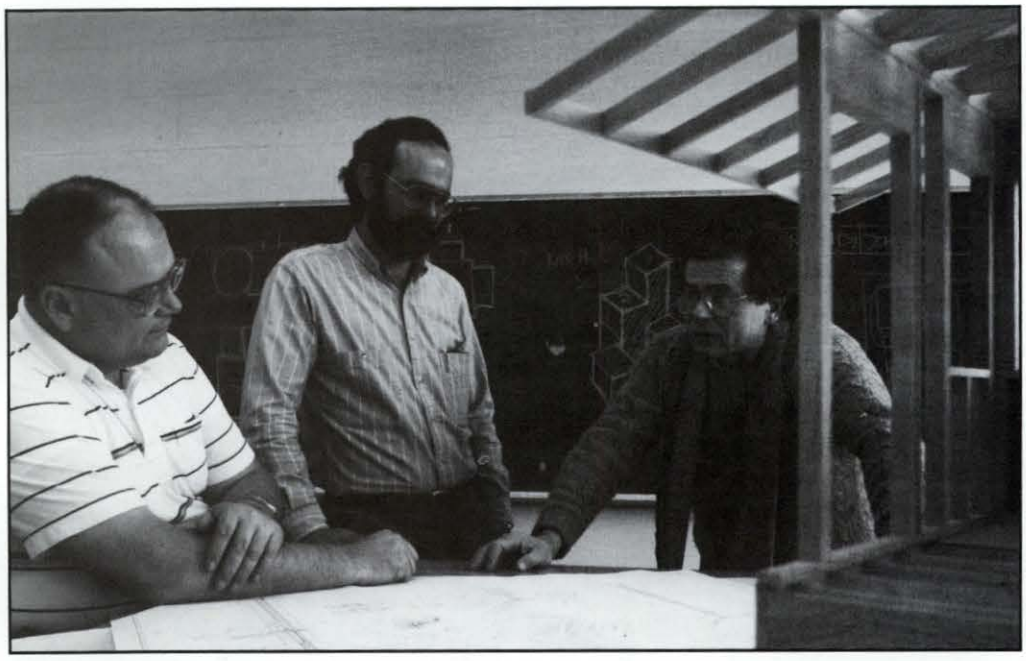
In the research branch of our plan, a three year $221,000 grant from the Northwest Area Foundation will allow forest products faculty to develop programs to increase employment and income in Idaho's wood products industry by investigating the potential of "value-added," or, secondary manufacturing. The term "value-added" here refers to additional manufacturing processes or marketing strategies that result in higher valued products. Well known examples of value-added products include windows, doors, moulding, millwork, and furniture, among others. Marketing strategies that add value to current wood products include various methods of upgrading the status of our commodity products into higher valued classifications.

We'll begin our study this summer by examining the current state of wood products technology in Idaho and assessing the possibilities for new value-added technologies, as well as new markets for the region's existing wood products. When we have assessed that information, we will use it as the basis for the outreach part of our plan—a series of technology transfer programs that will include consultation teams, conferences, workshops, short courses, and other means to communicate value-added opportunities to Idaho wood products industries.

A steering committee of university officials and representatives of the wood products industry, from small independent mills to large corporations, will guide the development of this effort as well as direct an endowment fundraising effort to continue the outreach programs after the Northwest Area Foundation grant programs are completed.

Other research efforts will focus on developing and introducing new wood technologies and products and determining their potential for use in wood construction and wood design. Besides identifying secondary products and their markets, we will look at substituting wood for other construction materials; also, we will encourage ideas for improving the aesthetics, marketability, and efficiency of present and future wood structures. Our ultimate goal in this teaching, research, and outreach plan is to integrate products and markets, to connect the manufacturer and user, and to acquaint both with the extremely broad range and uses of wood products.

Thomas Gorman is assistant professor of forest products. His colleagues in the Wood Construction and Design Program include Robert L. Govett, associate professor of forest products; William Bowler, associate professor of architecture; and Larry G. Fisher, professor of architecture.



Gerry Snyder

Primary members of the effort to stimulate the region's forest products industry through wood use and design programs (left to right): Larry Fisher from architecture, Thomas Gorman of forest products, and William Bowler from architecture.

Community Stability and Resource Dependency

Randy Guy Balice, Jo Ellen Force, and Gary Machlis

"But we must maintain community stability!" Sound familiar? Forest managers, planners, timber industry interest groups, local citizens, politicians, and many others have either made this plea or heard others do so during the forest planning activities of the past decade. The implicit assumption is that a stable flow of timber from the national forests will result in stable communities: a politically popular idea. However, though it is often assumed, this relationship—that local resource systems have a deterministic impact on community social systems—is largely untested, and the empirical data necessary for testing this causal image are remarkably sparse.

Not only are scholars interested in community stability theories and issues, but also policy and decision-makers in both public and private sectors need more information on the relationships between resource management decisions and the ensuing changes in local communities. For a community that depends essentially on one resource, changes in resource output may have dramatic effects on stability. Yet resource dependency is a general socio-economic condition for many Idaho communities.

We asked: is there a relationship between local resource production and social change, and if so, what form(s) can it take? Resource dependency and social system variables have predominantly been measured in economic terms related to production, and have included employment, bank deposits and property valuations, nonmarketable goods and services, social institutions, and occupations. In contrast, our research focuses on a wide variety of social indicators.

We suggested that changes in resource production may alter the social order primarily through their impacts upon secondary groups—altering the flow of individuals in and out of community institutions, modifying wants and needs through household economies, creating new social networks, and so forth. The key issue is social change. We hypothesized that community social change, indicated by changes in four crucial elements, is associated with changes in the production level of the local resource system. The four indicators were: community size (population, city budget, etc.), structure (number of churches in the community, number of businesses, etc.), cohesion (number of social groups, marriages, festivals, etc.), and anomie or conflict (number of suicides, arrests, divorces, police budget, etc.).

Gerry Snyder

Resource dependency is a general socio-economic condition for many Idaho communities. Above: Jo Ellen Force.

We tested the hypothesis on two communities of similar size, duration, region, and demographic characteristics, one timber-dependent and one mining-dependent. We restricted the region to rural northern Idaho, to the towns of Orofino (timber) and Wallace (mining). Both communities were settled at the about the same time, both are county seats, and both are situated in narrow, forested valleys on the Clearwater and Coeur d'Alene Rivers, respectively. For both Orofino and Wallace, over a third of the workforce was directly employed in the local production system.

We collected information covering 1920 to 1987 from city and county records, newspapers, and other sources indicating resource production levels. For Orofino these were: timber harvest volume, lumber production, value of timber cut, and number of employees in the lumber industry; for Wallace: mineral production, mineral value, and number of mining industry employees.

For both the timber-dependent and mining-dependent communities, the general hypothesis that community social change is associated with changes in local resource production was supported. This is neither a frivolous nor obvious finding. Indeed, the lengthy historical periods we dealt with, global and influential events such as World War II, and the inherent difficulty of archival data all conspire to frustrate attempts to demonstrate this relation.

More problematical however, is the original causal image—the rural community with a social order that directly responds to changes in local resource production. While our hypothesis was supported, the causal relationship is blurred by the results. For example, in Orofino, both the indicator for cohesion (marriage rate) and the indicator for conflict (arrest rate) rose with increased timber production.

Perhaps increased resource production is both a stabilizing and a destabilizing influence on community social order.

To gain insight into the form of these relationships, we are considering a reanalysis from a wider perspective, viewing local production levels largely in terms of national business cycles, interest rate influences on resource demand, relations between capital and labor, government policy toward resource extraction, or international markets for raw materials, to name a few. Hence, "resource dependent" communities like Orofino and Wallace may actually be "small towns in mass economies," their social stability a function of larger economic systems.

Another approach would be to examine a larger sample of communities representing a wider range of resource production dependencies. The results of our exploratory investigation could then be generalized, modified, or replaced. The complexity of sorting out community social order/resource production relationships is obvious, yet perhaps from such studies a new causal image would emerge. It would describe resource-dependent communities as they are—independent and resilient, yet embedded in wider systems, complex and varied. The result may be a richer view of communities dependent upon natural resource production, and a better understanding of rural life.

Randy Balice is a Ph.D. candidate in the Department of Forest Resources; Jo Ellen Force is associate professor of forest resources; Gary Machlis is professor of forest resources and sociology and a project leader of the Cooperative Park Studies Unit. *Funding for their study was provided by a McIntire-Stennis grant.*

The Atriplex Solution: Reviving Disturbed Lands

Brett Dumas and Kenneth Sanders

Shrubs within the genus *Atriplex*, often referred to as saltbushes, are important constituents of the world's arid ranges. Adapted to dry, salty environments unsuitable for most plants, they are essential to the stability of these areas because they maintain the balance of the ecosystem by providing forage and cover for animals, cycling nutrients, and controlling erosion.

Atriplex confertifolia, commonly known as shadscale, dominates thousands of acres within the salt desert shrub region of the western United States. Covering vast regions of the Great Basin, especially in Utah and Nevada, one finds shadscale in southern Idaho mostly as islands among the more common sagebrush-grass communities.

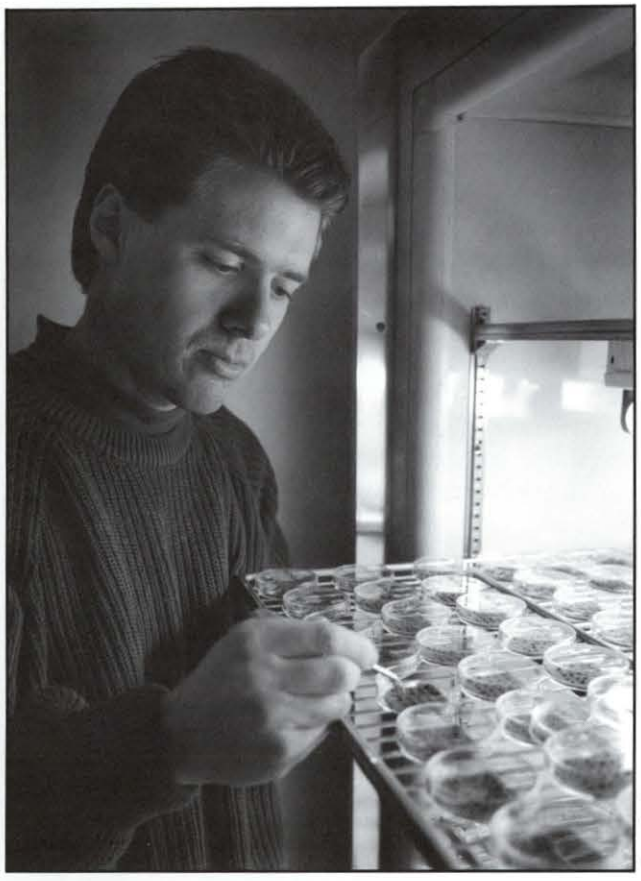
Livestock and wildlife utilize shadscale stands primarily as winter range because its branches end in spines, limiting its appeal as forage. Rodents and small game use shadscale as both forage and cover, while rabbits in particular seek out its nutritious leaves and seeds.

Because of recent emphasis on rehabilitating disturbed lands with shrubs in addition to the traditional grasses, shadscale's adaptability to harsh conditions also makes it potentially useful for revegetation purposes. Stripmine reclamation has traditionally been the focus of revegetation work, but now issues like the rehabilitation of burned and eroded areas are receiving increased attention.

Attempts to reseed shadscale have been largely unsuccessful because its complex of dormancy mechanisms—both mechanical and chemical—limits its usefulness. The bracts, two hard petal-like outer layers that envelop the seed, contain a high concentration of salts which may inhibit the absorption of water required to achieve germination. This can easily be resolved by leaching the seeds in running water for several hours.

Even more problematical however, the bracts provide a mechanical barrier to the germinating seed. The seed simply is not strong enough to break through them. In nature, the bracts break down over time, eventually enabling the seed to germinate. This type of dormancy mechanism staggers germination or delays it until the most favorable growing conditions exist. But when reseeding disturbed lands, we need a more reliable, less sporadic response in germination than would occur naturally.

Our research goal has been to facilitate a faster and more complete germination by reducing the resistance



Gerry Snyder

To understand the effect of scarification, Dumas germinates shadscale seeds in a refrigerated growth chamber where he can observe the germination process free of soil.

caused by the bracts. Most of our efforts have involved scarifying the seeds, a process wherein we "sand down" the seeds using a sandpaper-lined drum, creating fractures and holes and generally weakening the bracts which surround the seed. By scarifying we do not expect to obtain complete germination, but rather a significantly higher rate than would occur in untreated seeds. We have found that by removing the bracts entirely (a hand process), the seed germinates readily. However, this type of treatment is not practical on a large scale.

Our work has involved subjecting different seed samples to varying periods of scarification and then germinating the seeds in a growth chamber. Unlike seedings in the field or greenhouse, the growth chamber gives us the most control over conditions that might affect germination, thereby allowing us to investigate the effects of scarification exclusively.

Our growth chamber data indicates that in general, scarifying seeds improves germination rates. Although percentages of germination vary among seed sources, in all sources scarification improved germination by at least 15 percent. For example, seeds collected from the Raft River Valley had a 21 percent germination rate when unscarified, and increased to 54 percent after scarification; seeds from other sources improved similarly.

We have not been able to detect a trend in germination rate among the different periods of scarification. We had expected to see germination increase steadily with longer periods of scarification, or else increase to an optimum point and then start to decrease as over-scarification destroyed the seeds. Instead, while scarification improved germination rates, different periods of scarification produced only random increases in germination levels. Further research and analysis will attempt to resolve this problem.

Now that we have obtained positive results from the scarification process, the next step will be to take our research back to the greenhouse and the field to test the validity of our findings under more natural conditions. If successful, our research could eventually lead to greater use and success of shadscale as a tool for rehabilitating and reseeding rangelands.

Brett Dumas conducted this research as his thesis for a master's degree in range resources. Kenneth Sanders is a range extension specialist and professor of range resources.

Fill 'er Up: Stream Carrying Capacity

Cleve Steward and Theodore C. Bjornn

How many fish can a stream support? What factors are responsible for variations in fish abundance? To answer these questions, we recently completed three years of study on the distribution, abundance, and behavior of juvenile steelhead trout and chinook salmon in relation to several key habitat features: streamflow, pool morphology, cover, and water temperature. Habitat quality and quantity, along with food availability, are important factors governing the production of seaward migrating juvenile salmon and trout in Idaho's streams. Our general hypothesis was that because these juvenile fish are habitat specialists and thus sensitive to their surroundings, the physical characteristics of a stream should dictate its "carrying capacity," that is, the upper limit on the number of fish it can support.

We conducted much of our work in an artificial stream channel at the Hayden Creek Research Station in east central Idaho. In using an artificial stream, we were able to overcome some of the problems associated with the complexity and variability of free-flowing streams. We carefully controlled outside factors such as food supply to ensure that they did not interfere with our results.

Our initial experiments considered the effects of pool morphology (depth, volume, and shape) and streamflow (low, intermediate, and high discharge) on the distribution and abundance of juvenile chinook salmon during the summer. We selected pools because they are the type of stream habitat that juvenile salmon most frequently use. The 200-foot long artificial stream contained two each of six different pool types which varied in cross-sectional shape and total length. We determined the carrying capacity of the pools by introducing large numbers of fish into each, allowing them to either stay or emigrate in response to local conditions, and then counting them after a week. Throughout several week-long trials we also observed fish behavior to evaluate the effects of our treatments on their social interactions.

In a second series of experiments, we added various types and quantities of cover to the experimental pools to see if juvenile chinook numbers would rise with increases in habitat complexity. We evaluated fish response to four quantities each of rock pile, rock layer, undercut bank, and brush cover, repeating the tests during summer and winter to examine seasonal differences. We then conducted similar experiments with steelhead trout, and finally, with both chinook salmon and steelhead trout together, to learn whether interspecific (between species) competition affected habitat choice. What did we find?

Not surprisingly, both chinook salmon and steelhead trout preferred deeper pools to shallow ones, even when cover was present in both. The carrying capacity of pools correlated with pool length and volume, but not cross-

Cleve Steward

Screens separate pools equipped with different cover types during a summer test in the channel at Hayden Creek Research Station. At either side in the foreground are simulated undercut bank and brush cover habitats.

sectional shape. Only under the highest flows tested did water current velocities appear to limit the number of fish that could establish and maintain territories within the experimental pools.

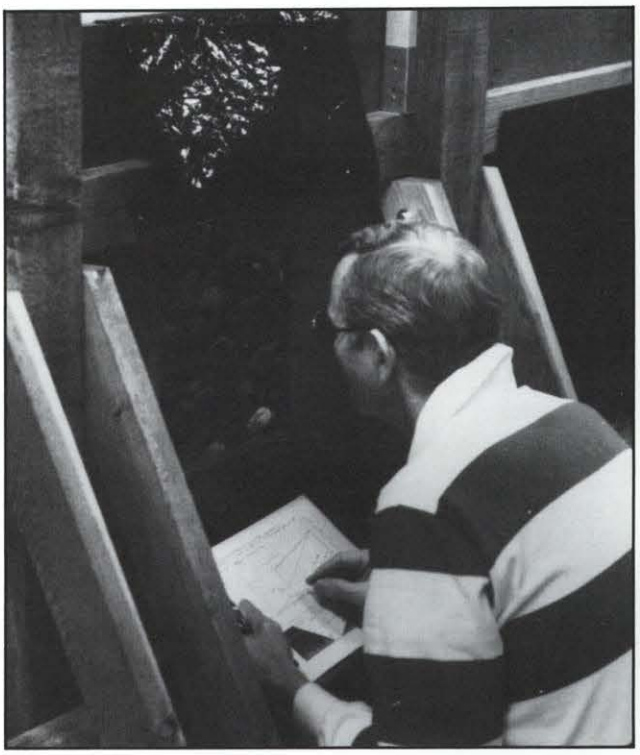
Fish abundance varied with cover type and quantity. In general, the more cover we added, the larger the size of the resident population. The effect was greater in winter than in summer, and our observations of fish behavior and distribution told us why.

In summer, juvenile salmon and trout seemed to select areas on the basis of their proximity to food-bearing currents. The addition of cover increased the hydraulic complexity of the pools, altered fish distributions, and in several instances, boosted pool carrying capacities. Yet we never observed fish to reside permanently within cover structures. We concluded that cover serves primarily as escape habitat for juvenile salmon in summer. Food acquisition and growth appear to be more important than access to cover during the summer.

In our winter trials, reductions in water temperature prompted fish to stop feeding and move into low velocity areas associated with cover. Concealed areas—rock crevices, thickly bundled brush, etc.—were chosen most frequently, presumably because they reduced the risk of predation. Population sizes, especially those measured for steelhead trout, increased with the increased availability of all cover types. Pools containing brush cover supported the highest densities of both species. These results convinced us that the habitat requirements of juvenile salmon are different in summer and winter.

Final numbers of mixed populations of salmon and trout in winter experiments rose with increased cover in much the same way as in earlier single-species trials. However, on the average, fewer steelhead trout remained than chinook salmon. We believe the disparity in abundance was size related: the trout were usually smaller than the salmon, and may have been competitively displaced by them.

We have conducted a partial field test of our laboratory results these past two years in Marsh Creek near Stanley, Idaho. Specifically, we wanted to know whether adding brush cover to pools in a cover-deficient stream would augment the seasonal abundance of free-living juvenile salmon. Our findings corroborated earlier results: strategically placed brush bundles provide little benefit during the summer growing season, but increase carrying capacity during the winter.



Cleve Steward

Looking through an observation window below water level in the experimental channel, Ted Bjornn records the position and number of juvenile salmon during a simulated cover test.

Our experiments offer more precise information than previously available concerning the relationships between channel geometry, stream hydraulics, instream cover, and habitat selection by juvenile chinook salmon and steelhead trout. We must protect and enhance the structural complexity of salmon rearing streams if they are to reach their productive potential.

Cleve Steward is a Ph.D candidate in fish resources and chair of the Chinook Committee for the Idaho chapter of the American Fisheries Society. Theodore Bjornn is professor of fishery resources and assistant leader of the Idaho Cooperative Fish and Wildlife Research Unit.

Hunting: It's Not Just for Killing Anymore

Nick Sanyal and William J. McLaughlin

Hunting, as even a casual student of natural resource management knows, has always been justified by wildlife managers as a critical tool for maintaining wildlife populations. Hunting, as many non-hunters and all anti-hunters picture it, is a larger than life diorama of bloodthirsty, beer-swilling killers showing little regard for nature. Hunting, as recreation specialists know it, is just one of many outdoor opportunities provided on public and private lands. Hunting, as land managers know it, is an activity that can be used to justify a plethora of management activities—from forest road building and clear cutting to livestock grazing, prescribed fires, and road closures. Hunting, as hunters know it—well, "only the Shadow knows," right?

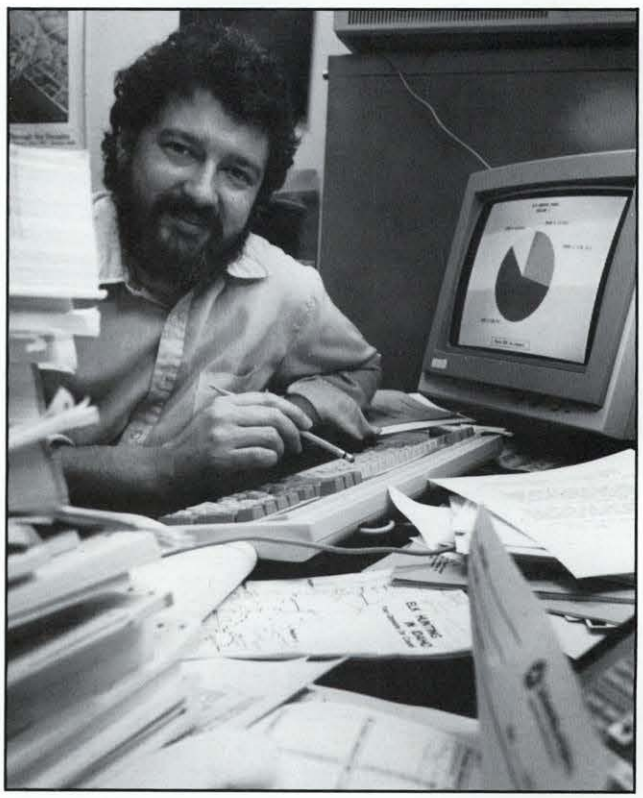
One group of people interested in the thoughts, motivations, and actions of Idaho hunters is the Idaho Department of Fish and Game. To help the department meet the challenges of managing wildlife for a diverse constituency and as part of the 1987-1988 Idaho Hunting Studies, we surveyed 8546 residents and non-residents who hunted elk or deer with a rifle, or who hunted upland game or waterfowl with a shotgun in 1987. Funded by the Idaho Department of Fish and Game, these studies were designed to assist the department in assessing the views of people who hunt in Idaho. Our year long study explored hunters' descriptions of quality Idaho hunting experiences, characteristics of preferred hunting settings, and opinions about various game management issues.

While the results are both informative and interesting, some are surprising, and serve to dispel some of the many myths that traditionally surround game management. For example, the most important reasons for hunting in Idaho were not harvest related, as one might expect, but focused on such aspects as being out in nature, viewing scenery, seeing game in natural settings, reminiscing, and escaping the usual demands of life.

Characteristics that detract from the hunting quality of at least two-thirds of the hunters included encountering other hunting groups, motorized vehicles used off roads, areas with many open roads, current logging, and areas recently burned by forest fires.

Access by foot (97.3%) and four-wheel-drive vehicles (83%) were the most common travel modes while hunting deer or elk. Over half of hunters surveyed used horses or pack animals, and almost half used two-wheel-drive vehicles at least "sometimes." Fewer than one of every five hunters used dirt bikes and ATVs; fewer than seven percent used snowmobiles, boats, aircraft, or mountain bikes.

All hunters were aware of and sympathetic to the problem of crop depredation. When given a choice of actions to address the problem, they tended to favor options that require both the landowner and the Department of Fish and Game to contribute. The most favored options were to provide materials the landowners would install to keep wildlife away, or else to have the Fish and Game Department chase the animals from the fields.



Gerry Snyder

The Idaho Hunting Studies Survey resulted in a six-volume report written for the Idaho Department of Fish and Game. Above: Nick Sanyal.

Results like these became a six-volume report which the Fish and Game Department released in January of 1990, and enabled us to make seven comprehensive wildlife management recommendations to the department from a sport hunting perspective. The recommendations included the following, which we termed "major policy implications."

One, wildlife managers formulating policy need to recognize that the department manages a diversity of hunting opportunities or "products." The potential exists to market these to definable hunter market segments. Presently, Idaho's highest quality hunting product as defined by the hunters polled is an unroaded natural setting (particularly those designated as Wilderness) with an abundance of wild-

life species (particularly unique ones), few other hunters, the opportunity to pursue animals in all age classes, and the chance to practice hunting skills with companions.

Two, managers formulating policy need to develop non-hunting opportunities or products based upon the findings of this study and national trends which suggest that increasing numbers of people are interested in wildlife for non-harvest reasons. If trend measurements prove accurate, the development of new wildlife products (wildlife viewing, photography contests, etc.) will play a critical role in the future of the department and its programs.

Three, quality hunting in Idaho is the result of "packages" of attributes that include natural setting characteristics, an uncrowded feeling, healthy animal populations of diverse age composition, regulations that recognize that people hunt in groups, perceived game abundance, the chance for trophy hunting, and the experience of harvesting an animal. Therefore, the department's effort, energy, and money need to be balanced among these to ensure that multiple attributes are considered in the management and species planning process, rather than just the number of animals available for harvest or how many licenses can be sold.

Four, hunters do not want to limit their hunting opportunities, but are willing to trade aspects like road access or to accept increased fees to ensure that a quality game population is maintained. This provides managers an opportunity to manage both from a biological and sociological perspective.

Five, management issues are often perceived differently by diverse groups such as residents and nonresidents, Idahoans from different regions of the state, and hunters who seek distinct hunting products. Therefore, it is important to monitor these opinion trends and consider them when analyzing impacts and making decisions.

Six, channels for communicating with the hunting public need to be expanded to ensure that the opinions of formal, organized groups are not over-represented in the department's managment processes. Only from one-quarter to one-third of the hunters were members of hunting, sportsmen, and/or conservation groups. To add to this, many expressed the need for additional information to better evaluate wildlife management alternatives—they are eager to learn more about wildlife management.

Seven, these studies point to the need to integrate social science expertise into the day-to-day management operations and research and planning programs of the Idaho Department of Fish and Game.

Nick Sanyal is a research associate and Ph.D candidate in the Department of Wildland Recreation Management. William McLaughlin is professor of wildland recreation management. Other researchers were Stewart Allen, visiting assistant professor; Charles Harris, associate professor; Jim Tangen-Foster, Ph.D candidate; and Joanne Tynon, Ph.D. student—all in wildland recreation management. Their report is available from the Idaho Department of Fish and Game.

Mallard Ducklings: Water, Habitat, and Survival

Jay J. Rotella and John T. Ratti

The prairie pothole region of south central Canada is the most important mallard breeding area in North America. Unfortunately, loss of wetlands and upland nesting habitat in this area has been severe and can be expected to continue. Over the past ten years North American waterfowl populations have declined to historically low levels, and management agencies are alarmed by the trend.

For decades wildlife managers have been concerned about the effects of declining habitat conditions on ducklings and their survival. Although much is known of waterfowl nesting ecology, knowledge of duckling (brood) ecology is poor. Accurate survival data and knowledge of factors influencing mortality are crucial to understanding the nature of waterfowl production and for the development of management plans.

How does habitat quality affect duckling survival? Addressing this concern requires teasing out and piecing together answers to the following questions. What constitutes quality duckling habitat? How far do ducklings have to move from nest sites to find quality wetlands (semi-permanent and permanent ponds)? Are distances moved related to survival? What do ducklings do if the type of ponds they prefer are unavailable due to drought or agricultural drainage? What percentage of ducklings survive from hatching to Autumn migration? These are some of the main questions our research addresses.

We have been studying mallard hens and their ducklings for the past three summers in the prairie pothole region of southwestern Manitoba. As many as 150 wetlands per square mile are strewn across the gently rolling terrain of this important breeding area. However, the area is also intensively farmed, and upland nesting cover and small wetlands have disappeared at an alarming rate. Past research in the prairie potholes indicates that only a small percentage of females successfully hatched their eggs each year. We have been studying the fates of those hatched eggs to determine what percentage of ducklings survive the summer and join the southward migrating flocks.

We followed a total of 69 females and their broods over the past three years. During the spring and early summer of each year, we conducted nest searches on 32 square miles in southwestern Manitoba by dragging a chain between a tractor and an ATV or by zigzagging on foot through nesting habitat. Once we located nests, we protected them from

predators by surrounding each with a three foot high fence of two inch mesh. During the week before hatching, we trapped and radio-marked a sample of the nesting females. Because mallard hens and their ducklings are capable of moving long distances unobserved, radios were critical to our work. We could identify every female because each radio transmitted at a different frequency.

Using a truck-mounted antenna system, we tracked the daily movements of each female and her brood to determine which pond(s) they used. We compared the characteristics of ponds ducklings used with nearby ponds not used to discover if they preferred certain wetland types. Periodically observing from a blind or observation tower set near the ponds, we assessed survival by comparing the number of ducklings still alive with the number of originally hatched ducklings.

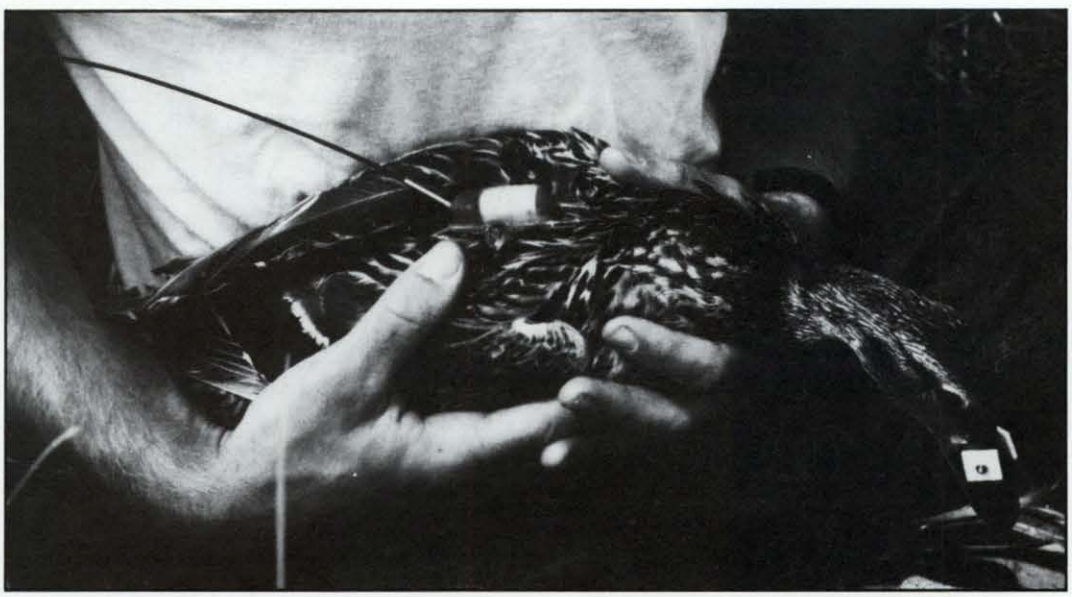
The past three years provided excellent environmental variation for achieving some of our research objectives. Water levels in ponds declined from near average conditions in 1987 to severe drought conditions in 1989. Over 80 percent of the wetlands in many portions of our study area went dry during the summer of 1989. Yet despite dry conditions, our spring 1989 nest searches found mallard nest densities similar to or higher than densities in 1987 and 1988. Thus, mallards in our study area produced ducklings even during the 1989 drought. We were able to compare duckling habitat use and survival among years with wetland habitat conditions ranging from average to very dry.

During the years of average water levels (1987 and 1988), the typical female and her ducklings used one to four ponds spaced over less than a square mile of area. Some showed a preference for small shallow ponds, a pond type very susceptible to agricultural draining and gradually disappearing from the southwestern Manitoba landscape. In 1987, 26 percent of all ducklings hatched survived to 30 days of age. Survival in 1988 was similar at 27 percent. However, these rates are lower than the 35 to 50 percent reported in studies conducted in other areas.

During the drought summer of 1989, movements from nests to ponds and from pond to pond did not appear grossly different from those of 1987 and 1988. However, broods had very few wetlands to choose from in 1989—only large permanent ponds held water during July and August. Thus, although small shallow ponds are probably preferred, large deep ponds may be critical in drought years. Survival dropped drastically during the drought of 1989: only 18 of every 100 ducklings survived to 30 days of age.

In preliminary conclusion, we can say that mallard production was severely impacted by the drought. Data from wet years indicate that managers should strive to protect small shallow wetlands, while data from the drought year reveal the importance of larger wetlands. Thus, it seems that managers should be concerned with protecting wetland complexes that include a wide range of sizes and depths. Hopefully the knowledge we gained by studying duckling ecology in a variety of habitat conditions will allow us to better preserve the species and manage its habitat.

Jay Rotella is a Ph.D candidate and John Ratti adjunct associate professor and research scientist in the Department of Fish and Wildlife Resources. *Funding for their project was provided by the Delta Waterfowl and Wetlands Research Station and Ducks Unlimited Canada. This study was the subject of Rotella's dissertation.*



John Ratti

Just captured from her nest of eggs due to hatch within a week, this female wears a radio transmitter backpack-style, and a colored nylon marker on her bill so that she can be distinguished visually.

A Forest Regeneration Mystery—The Grand Fir Mosaic

David L. Adams and Dennis E. Ferguson

Sometimes silviculturists run across a mystery—like the one that exists in up to 500,000 acres of forest land in the remote higher elevations of northern Idaho—a productive forest ecosystem with what appears at first glance to be good forest soil, but where attempts to regenerate conifers after harvest have not been very successful. Concern has recently increased because landowners and government agencies have scheduled much of this land for timber harvest over the next 40 years.

The term "Grand Fir Mosaic" has been applied to these forest areas because when they are seen from a distance or from the air, they appear as a mosaic of various sizes and shapes of openings dominated by alder, coneflower, conifers, and bracken fern, with grand fir being the prevalent tree species. The soils are deep and productive, and once established, conifers grow very well, but forest regeneration on harvested areas has generally been unsuccessful within a five-year period after harvest.

Because of planned harvests and the history of regeneration problems, the Grand Fir Mosaic has recently been the focus of much attention and research. Foresters and soil scientists from the Clearwater and Nez Perce National Forests, the USDA Forest Service Regional Office in Missoula, Montana, the Intermountain Research Station in Moscow, Idaho, and the University of Idaho formed a committee in 1984 to investigate the Grand Fir Mosaic and propose future research and management direction for these areas.

University scientists and those of the Intermountain Research Station are working cooperatively to more clearly define the Grand Fir Mosaic, understand the basic ecology of the ecosystem, determine the reasons for lack of adequate regeneration, and ultimately develop management guidelines that will lead to more successful tree regeneration. Our research group is in the second year of a three to five year project funded primarily by the USDA Forest Service, Intermountain Research Station.

The first of our three studies is an ecological study. In addition to explaining the Grand Fir Mosaic based on plant associations, we are monitoring the climate of mosaic and adjacent non-mosaic areas with four automated, remote weather stations to compare and contrast weather conditions in the areas.

Gerry Snyder

Conifer seeds in the upper half of the dish died when germinated on mosaic soil they shared with bracken fern, a common invader after timber harvest. In the lower half: seeds successfully germinated in non-mosaic soil.

Another factor possibly related to regeneration failure is "allelopathy," or, the harmful effect of one plant on another through production of chemical compounds released into the surrounding environment. Through laboratory and field tests, we are investigating the allelopathic potential of western coneflower and bracken fern, two predominant invaders after timber harvest. Preliminary results of our growth chamber experiments indicate that chemicals derived from coneflower reduce germination of conifer seeds and growth of seedlings.

Gerry Snyder

To study the effect of coneflower on conifer growth, the authors grew seedlings in soil with and without combinations of coneflower roots, and stems and leaves.

Physical and chemical soil properties may also limit regeneration. In a second study, we are analyzing soil samples collected in mosaic and non-mosaic areas to determine if there is something unique about the soils of the Grand Fir Mosaic that may help explain the lack of regeneration. For example, soil samples collected during the 1989 field season show that mosaic soils are more acidic than non-mosaic, and contain chemical elements known to decrease conifer establishment and growth.

The third major study has allowed us to investigate the separate and combined effects of pocket gophers and plant interference on the vegetation of areas where conifer regeneration would be expected. We established pocket gopher exclosures on four sites where forb and gopher densities were high. Extending three feet into the ground and five feet above ground, the fenced exclosures contain seedlings of four conifer species on weeded and unweeded halves of the exclosure. Tests conducted here are repeated in similar plots outside the exclosures. We monitor gopher and vegetation treatments inside and outside the exclosures to follow successional patterns and conifer mortality.

Initiated in 1988, these field studies will continue through at least the 1991 season. Our data should add to the understanding of this important forest ecosystem and lead to management guidelines for more successful conifer regeneration.

David Adams is professor of silviculture in the Department of Forest Resources and executive secretary of the Inland Empire Vegetation Management Working Group; Dennis Ferguson is a Ph.D. candidate in forest resources and research forester at the USFS Intermountain Research Station in Moscow, Idaho; Mark Sommer is a graduate assistant in forest resources specializing in forest soils; Robert Mahler is associate professor of soil science in the Department of Plant, Soil, and Entomological Sciences, College of Agriculture.

Capturing People's Decision-Making Processes

Edwin E. Krumpe

What do tourists in New South Wales, Australia, have in common with travelers in the state of Idaho? This is part of what I investigated for the Hunter Valley Research Foundation during 1988-1989, specifically to capture the decision-making processes people utilize for making recreation and tourism decisions. Like Idaho, Australia relies heavily on tourism. While there, I tested and refined a technique called "policy capturing" to assess how people value the different attributes of their recreational options. Never before applied to leisure choice studies, the technique was developed at the University of Colorado at Boulder, and has been used to measure how people make decisions concerning budget allocations, resource uses, personnel selection criteria, and even law enforcement policies, among others.

When people make a recreation decision, they normally consider how much of each important attribute different alternatives possess. For example, when Australians choose among beaches to visit, they consider such characteristics as the type of surf, level of crowding, extent of facility development, and whether four-wheel-drive vehicles can be expected. Different beaches obviously contain various levels of each of these attributes. But how do we know what level of each is desirable? Policy capturing reveals how people make "trade-offs" when some attributes are at desirable levels and others are not. Past research has typically relied upon questionnaires that asked people to evaluate the importance of such aspects as levels of crowding, facility development, scenery, or characteristics like distance and cost in making a recreation choice. Researchers combined these ratings with data on age, income, occupation, education, and place of residence to define various market segments, or, groups of people who showed common patterns of values in their recreation choices.

One problem with this method is that it describes only the relative importance placed on each attribute considered by itself. But in the "real world" we often must decide among imperfect options with competing amounts of the various attributes. We are often forced to make trade-offs among alternatives that are more than adequate on some attributes and not so adequate on others. For example, a particular destination may offer better scenery, nicer accommodations, or less crowding, but requires traveling farther or paying higher prices than another alternative.

Edwin Krumpe

An "undeveloped" Australian beach with big surf, no facilities, and free access to 4-wheel-drive vehicles. On the horizon: 21 miles of infrequently-used white sand beach.

Seldom is one option clearly superior on all of the attributes we value most.

What is needed is a methodology that measures how much people value each different attribute when considered in context with varying levels of other attributes. Additionally, it would be useful to know how the value they place on an attribute increases or decreases with differing amounts of that attribute present. Using the policy capturing approach, I asked approximately 200 students at two Australian universities to evaluate a series of decision alternatives called "scenarios." Each scenario consisted of a brief description of varying levels of specific attributes. For example, you might be asked how likely it is you would go to a beach with little development, calm water, moderate crowds, and no four-wheel-drive vehicles; next, a beach with fully developed facilities and conveniences (picnic areas, restrooms, stores, parking lots), very big surf, large crowds, and no four-wheel-drive vehicles; then, a beach with a developed parking lot but no other facilities, safe surf, large crowds, and unrestricted four-wheel-drive vehicles. You would indicate on the questionnaire how likely it is you would go to each of a series of these beach scenarios where each scenario contained different levels of the same attributes.

Using a computer program, I would then compare the score you gave each alternative beach with the various levels of attributes in each alternative. The advantage of this approach is that your values are captured relative to the fluctuating levels of each attribute; the score reflects how you made trade-offs when undesirable attributes were present

Edwin Krumpe

Fairly developed (with parking lot and facilities) and situated on the tip of a resort, the foreground beach is much-used by Australians, and preferred to the one shown in the picture above. Behind: two remote, undeveloped beaches reached by hikers only.

along with those you desired. Because recreation destinations seldom possess exactly the mix of attributes we ideally want, policy capturing more closely approximates the real world in which we consider and make such decisions.

As we make trade-offs among different attributes, the-more-the-better may not be the decision rule we follow. For example, in choosing a fishing stream, the-less-the-better might be the way we value seeing other fishermen, while for number of fish caught it may be the-more-the-better we like it, to a point, and then the desirability would drop off above a certain number as fish abundance began to stifle the challenge. Other characteristics we value might include size of fish, variation of species, bag limits, and so on.

Obviously, people can differ dramatically on their decision rules and successful entrepreneurs are quick to produce goods and services to fill these different market niches. This new method of capturing people's decision policies provides leisure industry planners and managers a powerful tool that can be applied to other tourism situations as well, both in Australia and in Idaho. Tourism operators could use it to learn how people value various combinations of facilities, attractions, pricing, travel times, accommodations, dining venues, and so forth for their proposed destinations. They could also use it to evaluate the mix of things to do and see in a tour package or travel route. Through my developmental work in Australia, we now have additional expertise with which to contribute to what promises to become both Idaho's and Australia's fastest growing economic sector for many years to come.

Edwin Krumpe is associate professor of wildland recreation management and principal scientist of the Wilderness Research Center. He conducted this study as a Fulbright Scholar.

A Simple, Easy Index to Assess Stream Health

David H. Bennett and Tim Fisher

The sounds of forest resource development echo throughout Idaho forests in the roar of large tractors and skidders churning the forest ground for timber harvest, or for road construction, common sounds in Idaho's forest lands. These are not new activities, but they are raising more concerns today than ever before. We have long known that poorly conducted forest practices can be highly destructive to streams within the watershed. Up to now however, standards to assess the impacts of these development activities on aquatic resources have been exclusively based on either monitoring various contaminant concentrations or determining physical habitat quality. These methods are expensive, labor intensive, and they disturb the biological communities of the streams. What is needed is a single indicator or measurement to assess overall stream health.

Scientists generally use the term "stream health" to describe the overall condition of an aquatic system, especially the aquatic organisms—the multiple fish species, amphibians, insects, and algae—that inhabit the waters. Biologists have long known that habitat quality determines the health of a stream community.

The key issue for many years has been what "indicator" group of organisms or species best provides a yardstick for the health of a stream system. In the eastern and midwestern United States, investigators have used primarily fish, aquatic insects, and the actual species composition or species diversity as indicators of stream health. None has been more commonly used than fish species composition and abundance.

We set out to identify what species most represent stream health and thus, to provide resource managers with an easy "index" to assess stream health. To do this, we examined the characteristics of fauna in over 100 small headwater streams in the Priest, Coeur d'Alene, St. Joe, Clearwater, Salmon, and Payette river drainages. We rated each site as to how much it deviated from the *optimal* condition—an unimpacted stream, either "strongly," "somewhat," or "not at all." We totalled the scores for each site to yield an index score and then grouped them into six classes of excellent, good, fair, poor, very poor, and no fish.

We collected over 5600 fish, 1900 amphibians, and 31,000 aquatic insects from 134 streams. These streams ranged in potential impacts from heavy to none. For example, road densities varied from zero to nearly 22.5 miles

per square mile; forest harvest activities ranged from zero to 99 percent; cobble embeddedness, or how much of the bottom gravels were covered by fine sediment, ranged from zero to 100 percent.

Initial results were less than promising. Our scores did not correlate with measures of land use, and it was even beginning to look like the characteristics of aquatic communities were independent of stream health! After a number of late nights and "skull sessions," we decided to look at differences in geology. About half of the streams sampled were in the Idaho Batholith, that highly erosive rock strata that has contributed massive amounts of sediment to streams and rivers throughout the state. After we separated the streams by size and according to "erosive" and "nonerosive" rock types, the relationships among our measures began to make sense. Factors affecting stream health were different among stream sizes and between the two rock types, though we do not yet know why, or which factors exactly; further research may explain why.

Charlie Holderman (left) and Tim Fisher electrofishing for fish samples in one of the 134 streams studied.

We also examined 26 different characteristics of the aquatic communities, among which we found nine to significantly represent stream health. The nine characteristics in our index were: the number of fish species present, number of salmon and trout species, number of introduced species, density of salmon and trout, lengths and weights of salmon and trout, number of amphibian species, weight of amphibians, and density of invertebrates. Based on field sampling results, we numerically rated each of the nine characteristics for the health of the streams.

Our index offers a relatively simple appraisal of stream health, one we are confident will provide land and aquatic managers a good measure for assessing the effects of forest practices on stream systems.

David Bennett is professor of fishery resources in the Department of Fish and Wildlife Resources. Tim Fisher is a recent graduate of the Department of Fish and Wildlife Resources, now a fisheries biologist with the Bonneville Power Administration. Completed in March of 1990, the project was funded by the Idaho Institute of Water Resources and a McIntire-Stennis grant.

Soil Compaction From Mechanical Fellers

Harry W. Lee, Leonard R. Johnson, and Robert Stoker

Old-time loggers may speak with remorse of how the pounding of the ax and the rhythmic ripping of the crosscut saw gave way to the humming of the chainsaw, but there was nothing they could do about it. Progress. The loss of romance in the logging industry has come about primarily due to necessity.

The forests have changed since the early days when the trees were large and seemingly in infinite supply. Second growth has replaced old growth, and now the forest products industry finds itself struggling for survival. Economic and environmental concerns have forced the industry to become more efficient, mostly through technological advances.

One of the more recent advances, slow in coming to the Inland Empire area, is mechanization of the harvesting process. One part of that process is the feller-buncher—a machine capable of cutting down trees and stacking them in a bunch. When combined with a grapple-equipped skidding machine, the feller-buncher can increase system production and lower costs over a conventional operation.

There are two basic types of feller-bunchers. One type has the saw head mounted to a swinging boom arm attached to a tracked carrier. The other, on either tracked or wheeled carrier, has the saw mounted to non-swinging arms in front of the machine. While the second machine needs to travel from the bunched area to each tree and then back in order to complete a cycle, the boom mounted machine generally stays in one place to cut and bunch a number of trees.

Land managers are concerned with the amount of soil compaction these machines may cause during their normal operation. Research has shown that soil compaction can decrease the pore space of soil, resulting in less tree root growth and development. The frame mounted feller-bunchers may cause increased soil bulk density as they travel to each tree. The boom mounted feller-bunchers do not make as many trips, but sit in one place for several minutes where the machine's vibration may create more opportunity for compaction. The purpose of our study was to examine the soil compaction effects of both types of feller-bunchers.

The main objectives of our study were: to measure changes in soil bulk density after using boom and front-mounted feller-bunchers; to correlate changes in soil bulk density with the number of machine trips over a site; to correlate changes in soil bulk density with the length of time

spent by a machine on a given site; and to distinguish between soil compaction caused by repeated machine travel over a site and compaction caused by the vibration of the machine working over a site.

We collected data through two field studies in June 1987 and June and July 1989. In 1987 we studied a TIMBCO model 2518 with a ROTO SAW felling head (boom mounted) on a site in the Colville National Forest northeast of Cusick, Washington, and in 1989 we studied a CATERPILLAR model 963, also equipped with a ROTO SAW felling head (frame mounted) in the Waha area of the Nez Perce Indian Reservation east of Lewiston, Idaho. Both machines operated in the removal of large trees where considerable residual stand remained. Rubber-tire wheeled skidders with grapples used existing trails to move (skid) the bunched trees to the landing.

To evaluate the effect of the machines, we established reference densities in undisturbed areas and then took bulk density readings perpendicular to the paths of the machines. To determine the change in bulk density caused by the machines, we sampled points five feet outside both tracks, one foot outside both tracks, in the center of each track, and between the tracks. At the Cusick site we recorded the number of trees cut and the length of time the machine spent in one place, and at the Waha site we recorded the number of passes over the area, mapping the area of disturbance at both sites. After the harvesting operation, we distinguished between the areas covered only by the feller-buncher and the areas also covered by subsequent skidding operations.

Results from the Cusick site for the (boom-mounted) TIMBCO showed that 18 percent of the gross land area was actually covered by the feller buncher. After the skidding operation, only 14 percent of the area was also covered by the skidding machine. The TIMBCO caused no measurable vibratory compaction outside the area covered by the tracks while the area between the tracks was loosened in most of the runs. The area where the tracks touched the ground showed increases in bulk density of less than 20 percent in most cases.

At the Waha site, the (frame-mounted) CAT machine covered 20 percent of the gross land area. The subsequent skidding operation covered 10 percent of the area. In about half the cases, the CAT did not compact the area outside the tracks, but did loosen the area between the tracks. With one pass, it caused up to about a 5-percent increase in bulk density in the area covered by the tracks; with three or more passes, bulk density increased less than 20 percent in most cases.

In general the results of our study indicate that first, the frame-mounted feller-buncher caused more site disturbance and compaction than the boom-mounted feller-buncher because of increased traffic over the soil during the felling and bunching operation. Second, increasing the number of passes over the ground increased the bulk density of the disturbed area. Third, it seems the length of time a machine spent in one area did not affect soil compaction. And finally, there was no significant evidence to indicate that the area was compacted by the boom-mounted machine's vibration.

Harry Lee

Snow vibrates down on the CATERPILLAR 963 as it fells a Douglas-fir at the Waha site east of Lewiston.

Study results suggest that by specifying certain corridors for machine operations to work within, we can minimize the number of impacted areas. Designating skid trails for subsequent operations would signficantly decrease the total land area that is disturbed.

Harry Lee is assistant professor of forest engineering in the Department of Forest Products; Leonard Johnson is professor of forest engineering in the Department of Forest Products and associate dean for academics and continuing education. *Their project was funded by a McIntire-Stennis grant.*

How Does Disturbance Affect Site Productivity?

Robert Stoker, Harry Lee, James A. Moore

Recently I watched a film about an old logging operation and was completely amazed at the lack of regard the loggers showed for the land. The crawler tractors used in skidding were buried in mud and operating in streams. Terms like "site impact" and "site productivity" did not exist in the logger's vocabulary when that film was made.

Today, site impact and site productivity are extremely important concepts to the forest products industry. The industry has begun to recognize that the timber supply is not infinite, and that it will have to re-evaluate its harvesting strategies: it needs to remove the most biomass with the least amount of site disturbance to minimize productivity losses in the future.

We are investigating site disturbance by evaluating nutrient levels in foliage and soil, soil bulk density, and other characteristics to determine their effects on long term stand productivity. Funded by the BPA and supported by Potlatch Corporation and the Washington Department of Natural Resources, we established four study sites near Headquarters, Idaho, and one near Springdale, Washington.

Each site contains plots of trees planted in each of four disturbance conditions: undisturbed, burned but otherwise undisturbed, heavily disturbed and skid trailed, and organic or soil accumulated. To determine chemical or physical differences in soil and foliage caused by different disturbance conditions, we took soil samples for each tree, measured total height and third year incremental growth, and collected foliage samples at each condition of each plot. We tested soil samples for nutrient solubility and concentrations, cation exchange capacity, percent of organic matter, and bulk density.

At three of the sites so far, third year height growth in the disturbed condition has been significantly less than growth in the other conditions. Our examinations of foliar samples yielded no overall trends in foliar nutrient concentrations to explain the height difference. However, we can attribute the limited growth, at least in part, to the soil's increased bulk density, decreased organic matter, lower cation exchange capacity, and depleted nitrogen pools. Deficiencies like these in the stand's soil nutrients when foliage nutrient demands are highest can ultimately decrease the volume and quality of trees in a stand.

We will continue to monitor our sites for at least five more sampling dates on an every-other-year sampling scheme. While our research is relatively new, it has generated much interest from the forest products industry because what happens to a site now, may cost money in the future.

This study is Robert Stoker's thesis for a master's degree in forest products.

Designing Forester-Friendly Computer Programs

Molly Stock, Larry Amell, and Elisabeth Kersey

Natural resource management is an increasingly technical occupation. New technologies are producing vast quantities of stored data that foresters can use to make better decisions, and computers can help them use these data more effectively. Foresters have available to them an array of computer tools to help them with specific decision-making tasks, for example PROGNOSIS for growth and yield simulation, FORPLAN for management modeling, and RIEDIT for database management. However, many specialized computer programs such as these are underutilized or not used at all. We believe this is because they have been designed with little knowledge about their users. As a result, the programs are difficult to use and rob foresters of the opportunity computers could offer them to ease their workload and increase their efficiency.

Through our research, we will learn more about the foresters for whom computer programs are being developed so that we can help design systems better suited to their specific needs and preferences. We are investigating the psychological, sociological, and physical/environmental context within which foresters are using (and *not* using) computers.

Funded by a Boise Cascade Fellowship and a University of Idaho seed grant, our research tests the hypotheses that (1) foresters have unique and identifiable attitudes about their work, as well as certain personality attributes and learning styles that affect their acceptance and use of computer decision aids, and that (2) knowledge about these attributes can be directly applied to design of improved computer software for silviculture.

Using interviews, surveys, specialized tests, and questionnaires, we have begun to identify factors that affect computer use by foresters. In 1988 and 1989, we conducted an intensive study of the tasks that silviculturists do in a stand level analysis when developing a silvicultural prescription, and evaluated both the potential for computerization of these tasks and the silviculturists' attitudes towards the tasks. Of the more than 100 stand level analysis tasks, we identified over 30 with good potential for computerization.

We asked 45 district silviculturists how willing they would be to delegate these 30 or more tasks to an assistant—human or computer. Within the overall activity of stand level analysis, there was considerable variation among the different tasks the silviculturists were willing

Gerry Snyder

Kersey (left) and Stock used over five major psychological tests to help them assess forester attitudes toward computer use in making resource management decisions.

to delegate. They indicated a desire to remain in control of some of the more complex and demanding tasks, which suggests to us that the issue of professional accountability might be another important factor in some foresters' reluctance to use computers.

Over the past year, we further explored attitudes, personality attributes, and environmental factors that affect computer use by foresters by administering a full battery of tests to silviculturists attending University of Idaho and Oregon State University continuing education short courses. Through surveys and questionnaires, we also evaluated the attitudes of SAF (Society of American Foresters) members at their 1989 national meeting in Spokane.

Some of the more promising tests we have used are the Canfield Learning Styles Inventory, the Minnesota Importance Questionnaire, the Myers-Briggs Type Indicator and the California Psychological Inventory, and the Computer Aptitude, Literacy, and Interest Profile. We are also working to identify a useful indicator of relative risk aversion because we believe that this personality attribute might be related to computer use. Based on these test results, we will design and carry out a major survey of SAF silviculturists during 1990 and 1991.

Results thus far suggest that computer use is a complex and multidimensional issue, involving social and physical/environmental factors, as well as factors related directly to software design. For example, for many silviculturists, simple lack of time to learn a program is an important reason not to use a computer. Others cited "too much red tape," lack of funds for new software, poor physical setup of the work environment, lack of space, poor office management, lack of ready access to computers, limited availability of trained support personnel, and lack of encouragement by co-workers and supervisors. Several foresters expressed frustration with the difficulty of choosing among the wide variety of software packages available to them.

Personality characteristics also influence people's interest in and success at using a computer. A need for human interaction in the work environment, a preference for doing certain types of tasks, and a particular learning style, for example, can affect an individual's willingness to work with computers on a regular basis. Our preliminary studies suggest that, on average, silviculturists can be characterized as more introspective, "thinking" types of people than many other professional groups, and that their needs for detailed and well-organized information in their work environment are very high. A possible implication is that foresters need computer programs designed with more apparent organizational structure and detail.

Computers and other advanced technologies play an integral part in modern natural resource management. Our work will help sensitize both programmers and administrators to the people for whom advanced computer technology is being developed, and will enhance communication between the builders of technology and its users. A greater awareness of the special characteristics and preferences of foresters will result in computer technology more closely adapted to their needs and, ultimately, more effective resource management.

Molly Stock is professor of forest resources and computer science, and founder and editor of the quarterly journal AI Applications in Natural Resource Management. *Larry Amell is a master's student and Elizabeth Kersey a Ph.D. student—both in forest resources.*

Converting Wood Ash to Palouse Gold

Alton G. Campbell

Solid wastes in the form of wood residues—log yard trash, bark, sawdust, and wood ash—are a major problem to the forest products industry in the Northwest and may limit the industry's growth. For example, current disposal costs of $1 to $6 per ton of solid waste could increase to $55 or $75 per ton when companies are required to use "secure" landfills with liners, and systems that prevent seepage of wastes into the water table.

Paper mills, sawmills, and cogeneration facilities burn large quantities of wood waste to dispose of residues and to produce steam and electricity, a process which generates a huge amount of wood ash. For example, the Washington Water Power 50 megawatt electrical power plant in Kettle Falls, Washington, produces approximately 100 cubic yards of wood ash per day. Currently, most wood ash is landfilled, but future environmental regulations and landfill costs will force the forest products industry to consider recycling and resource recovery.

Several states have already classified wood ash as a dangerous material because of its high alkalinity. This classification necessitates special handling and disposal procedures which have caused some major problems for ash generating facilities. As waste wood residues become a more important fuel because of the greenhouse effect and the acid rain contributions of fossil fuels, ash disposal problems will become more problematical.

To address these problems, some of us in the Forest Products Department have directed our research toward management and utilization of wood ash, especially in its application to agricultural and forest lands. This promising resource recovery approach improves soil productivity and lowers the cost of disposal.

Applying wood ash to farmland could benefit northwest agriculture by increasing pH of acidic soils while replacing minerals removed during plant growth and harvest. Many Palouse soils have become increasingly acidic over the past several decades because of the addition of nitrogen fertilizers. Acidic soils become less productive and need to be limed—applying wood ash might be a solution.

Ash application rates would depend on the types of soil and the characteristics of the ash, for example the alkaline ash would not be applied to a neutral or alkaline soil as pH changes could harm productivity. Ash would be used sparingly on sites growing plant species that require acidic soils, as in the case of hardwoods, but perhaps more liberally on soils that need to be limed, such as some of those in the Palouse.

Our work on land application of wood ash began in 1986 and includes five projects funded by Washington Water Power and the University of Idaho. To evaluate wood ash as an agricultural soil supplement and liming material, we grew wheat and poplar in a greenhouse in six different Idaho soils amended with different ash concentrations. We observed no detrimental effects to crops at ash levels equal to or lower than 20 tons per acre. In fact, the yield of the wheat and the height of the poplar cuttings increased 25 to 50 percent compared with the untreated soil. These results suggest that wood ash could be used in agricultural applications as a low-grade fertilizer and liming agent.

A second, nearly complete greenhouse project assessed the toxicity of wood ash at very high application rates. We examined the alkalinity, potassium content, and boron content of the ash as potential toxicants. The experiment provided information on bean yield in response to these potentially toxic elements and their interactive relationships. We will use these data to recommend to Idaho and Washington regulatory agencies acceptable application rates of wood ash to farmland.

Richard Folk

Dotting a field in Reardon, Washington, barrels of ash await application to 10-by-30-foot plots of farmland at 1-16 tons per acre.

A third project moves our research from the greenhouse to the field. We are treating small field plots on the Palouse with different application rates of wood ash to study the growth and yield of winter wheat when grown in ash-amended soil.

Projects four and five investigate the chemical and physical properties of wood ash and the binding of heavy metals to soil particles. The latter project will allow us to predict the rate of movement of ash components from the soil to groundwater.

Results thus far have given us hope that agricultural application of ash—a safe low-cost method of ash disposal—could be used by wood burning facilities to alleviate disposal problems and help local farmers.

Alton Campbell is associate professor of forest products. His co-researchers included Robert Mahler, associate professor of soil sciences in the Department of Plant, Soil, and Entomological Sciences, College of Agriculture; Etiegni Lazarre, a Ph.D. candidate in forest products; and Huang Honghan, a master's student in forest products.

Appendix

Experiment Station Scientists

Department of Fish and Wildlife Resources

Ables, Ernest D.
Professor
Wildlife ecology, especially animal behavior and radiotelemetry techniques

Bennett, David H.
Professor
Warmwater fishery management, fish ecology

Bizeau, Elwood G.
Professor Emeritus
Associate, Wildlife Research Institute
Birds, principally waterfowl and marsh

Bjornn, Theodore C.
Professor
Assistant Leader, Idaho Cooperative Fish and Wildlife Research Unit
Fish ecology and management

Brannon, Ernest L.
Professor
Director, Cooperative University of Idaho Aquaculture Program
Fish culture, fish behavior, salmonid life history, sturgeon life history

Congleton, James L.
Associate Professor
Assistant Leader, Idaho Cooperative Fish and Wildlife Research Unit
Fish immunology, stress physiology

Csuti, Blair A.
Adjunct Associate Professor
Research Associate
Strategies for the selection and design of nature reserves, endangered species conservation, wildlife/habitat relationships

Falter, C. Michael
Professor and Department Head
Reservoir limnology, stream ecology, lake management

Garton, Edward O.
Professor
Wildlife population biology, systems ecology, census methods, statistical analysis

Hayward, Gregory D.
Visiting Assistant Professor
Quantitative analysis, wildlife habitat, bird and small mammal response to forest management, forest owl ecology

Hornocker, Maurice G.
Professor
Director, Wildlife Research Institute
Population ecology, predator-prey interactions

Hungerford, Kenneth E.
Professor Emeritus
Wildlife management

Klontz, George W.
Professor
Diseases and rearing problems of aquatic animals, aquaculture

MacPhee, Craig
Professor Emeritus
Fish behavior, ecology, toxicology

Moffitt, Christine M.
Adjunct Associate Professor
Research Scientist
Fish ecology and management, fish health management

Nelson, Lewis, Jr.
Professor
Continuing education, wildlife communications

Peek, James M.
Professor
Big game management, habitat relationships

Ratti, John T.
Adjunct Associate Professor
Research Scientist
Avian ecology; behavioral, evolutionary, and population ecology; habitat analysis

Reese, Kerry P.
Associate Professor
Wetland ecology, avian ecology

Ringe, Rudy R.
Research Associate
Anadromous fish ecology and management

Scott, J. Michael
Professor
Leader, Idaho Cooperative Fish and Wildlife Research Unit
Ecology and management of nongame and endangered species, sampling methods for estimating bird numbers, systems approaches to conservation ecology

Setter, Ann L.
Research Associate
Fish culture, sturgeon life history, electrophoresis

Wright, R. Gerald, Jr.
Professor
Project Leader (Biology), Cooperative Park Studies Unit
Wildlife habitat management, national park wildlife management

Yeo, Jeffrey J.
Research Associate
Ungulate habitat and behavior

Department of Forest Products

Bottger, Richard F.
Adjunct Associate Professor
Director of Administrative Services
Assistant Director, Idaho Forest, Wildlife and Range Experiment Station
Business and personnel management

Campbell, Alton G.
Associate Professor
Pulp and paper science, pulp effluent treatment technology, wood chemistry

Folk, Richard L.
Research Associate/Instructor
Densified wood fuel manufacturing, resource recovery and waste management, continuing education

Gorman, Thomas M.
Assistant Professor
Wood construction and design, physical properties of wood, moisture problems in wood-frame houses

Govett, Robert L.
Associate Professor
Forest products business management, forest products marketing, forest products primary manufacturing, production feasibility

Johnson, Leonard R.
Professor
Adjunct Professor, Forest Resources
Associate Dean for Academics and Continuing Education
Systems and cost analysis of timber harvesting operations, wood energy, recovery and processing of small timber and forest residue

Lee, Harry W.
Assistant Professor
Harvesting systems, road design, site productivity, soil-water relationships

Moslemi, Ali A.
Professor and Department Head
Director, Graduate Programs
Wood particle composites, wood technology

O'Laughlin, Jay
Adjunct Professor
Director, Policy Analysis Group
Forest economics, forest policy, structural changes in wood-based industries

Steinhagen, H. Peter
Associate Professor
Drying of lumber and wood particulates, heat transfer in frozen and nonfrozen wood systems, wood energy, wood preservation

Department of Forest Resources

Adams, David L.
Professor
Executive Secretary, Inland Empire Vegetation Management Working Group
Silviculture, growth and yield

Belt, George H.
Professor
Forest hydrology and watershed management, social forestry, agroforestry

Brunsfeld, Steven J.
Instructor
Director, Forestry, Wildlife and Range Sciences Research Herbarium
Vegetation ecology, autecology, systematics, molecular biology of wood plants

Burlison, Vernon H.
Extension Forester Emeritus
Extension Professor Emeritus

Canfield, Elmer
Associate Professor Emeritus
Forest pathology

Dennis, Brian
Associate Professor
Statistical ecology, biometrics, mathematical modeling

Deters, Merrill E.
Professor Emeritus
Silviculture

Dumroese, R. Kasten
Research Associate
Forest technology and production, nursery management

Fins, Lauren
Associate Professor
Director, Inland Empire Tree Improvement Cooperative
Genetic improvement of forest trees, effects of forest management on genetic resources

Force, Jo Ellen
Associate Professor
Forest planning and policy, particularly the role of people and other social science aspects; training and international development

Hatch, Charles R.
Professor
On leave in Islamabad, Pakistan, for Winrock Consulting Agency
Forest mensuration and statistics

Heller, Robert C.
Research Professor Emeritus
Remote sensing, photographic interpretation, forest entomology surveys and evaluation

Hendee, John C.
Professor
Professor, Wildland Recreation Management
Dean, College of Forestry, Wildlife and Range Sciences
Director, Idaho Forest, Wildlife and Range Experiment Station
Human dimensions of resource management, conflict resolution, resource management policy and planning, use of natural environments for personal growth

Johnson, Frederic D.
Professor
Autecology, synecology, and phytogeography—emphasis on northern Rockies and on forest lands and woody plants, dendrology—temperate and tropical

Johnson, Leonard R.
Adjunct Professor
Professor, Forest Products
Associate Dean for Academics and Continuing Education
Systems and cost analysis of timber harvesting operations, recovery and processing of small timber and forest residue

Loewenstein, Howard
Professor Emeritus
Forest soils and tree nutrition

Lotan, James E.
Adjunct Professor
Research Scientist
Silviculture and fire management

Machlis, Gary E.
Professor
Project Leader (Sociology), Cooperative Park Studies Unit
Sociology of natural resources

Mahler, Robert
Adjunct Associate Professor
Associate Professor, Soil Sciences (Department of Plant, Soil, and Entomological Sciences, College of Agriculture)
Soil fertility, plant nutrition

Mahoney, Ronald L.
Associate Extension Professor
Extension Forester, Cooperative Extension Service
Silviculture and management of non-industrial private forests, natural resources education for youth

Marshall, John D.
Assistant Professor
Tree physiology, ecophysiology

Mattson, Kim G.
Research Assistant Professor
Forest ecology

McKetta, Charles W.
Associate Professor
Economist, Idaho Forest, Wildlife and Range Experiment Station
Timber investments, forest policy, international forestry, fire and fuel management economics, harvest scheduling, forest taxation, timber supply

Medema, E. Lee
Associate Professor
On leave in Thailand with the U.S. Agency for International Development's Forestry/Fuelwood Research and Development Project
Forest economics (investment analysis, stumpage markets, policy, impact assessments)

Mika, Peter G.
Research Associate
Biometrics, forest nutrition

Moore, James A.
Professor
Director, Intermountain Forest Tree Nutrition Cooperative
Various aspects of forest growth and yield modeling, mineral nutrition of forest trees, influence of nutritional status on primary forest productivity

Morgan, Penelope
Assistant Professor
Fire ecology and management, silviculture and forest ecology, ecological modeling

Neuenschwander, Leon F.
Professor
Adjunct Associate Professor, Range Resources
Associate Dean for Research and International Programs
Associate Director, Idaho Forest, Wildlife and Range Experiment Station
Forest and range ecology, fire management, prescribed burning, site preparation for conifer release

Osborne, Harold L.
Associate Extension Professor
Manager, University of Idaho Experimental Forest
Silviculture, log scaling and timber cruising, forest resource inventories

Partridge, Arthur D.
Professor
Insect/disease interactions, nursery problems, urban tree problems

Pym, Geneva E.
Research Technician
Quantitative and qualitative analysis

Robison, M. Henry
Visiting Assistant Professor
Regional economic modeling and forest management

Rust, Marc
Research Associate
Genetic improvement of forest trees, application of computer technology to forestry

Sanders, Kenneth D.
Adjunct Professor
Professor, Range Resources
Range Extension Specialist
Range extension, nutrition, and livestock

Schenk, John A.
Professor Emeritus
Forest entomology (insect bionomics, silviculture, and biological control)

Seale, Robert H.
Professor Emeritus
Forest economics

Stark, Ronald W.
Professor Emeritus
Population dynamics and integrated pest management of forest insects

Stiff, Carol M.
Research Scientist (until May 1990)
Plant tissue culture

Stiff, Charles T.
Assistant Professor
Growth and yield modeling and simulation, forest sampling and inventory methods, site productivity, international forestry

Stock, Molly W.
Professor
Artificial intelligence/expert systems applications in natural resource management, human-computer interactions, biosystematics and population genetics of forest insects

Stoszek, Karl J.
Professor
Forest protection, silviculture

Ulliman, Joseph J.
Professor and Department Head
Aerial photographic interpretation, remote sensing

Wenny, David L.
Associate Professor
Manager, University of Idaho Forest Research Nursery
Forest nursery technology and production, seedling physiology and quality, forest regeneration

White, Donald R.
Associate Extension Professor
Extension County Chairman, Kootenai County
Extension forestry

Department of Range Resources

Bunting, Stephen C.
Professor
Fire ecology, range ecology, range management

Ehrenreich, John H.
Professor
Agroforestry, range ecology, international forest and range management

Hironaka, Minoru
Professor
Range ecology, rangeland classification, soil/plant relationships

Johnson, Kendall L.
Professor and Department Head
Shrubland ecology and management, range extension

Kingery, James L.
Assistant Professor
Forest grazing policy and management, rangeland rehabilitation

Mosley, Jeffrey C.
Assistant Professor
Grazing management, foraging behavior, livestock/wildlife relations

Neuenschwander, Leon F.
Adjunct Professor
Professor, Forest Resources
Associate Dean for Research and International Programs
Associate Director, Idaho Forest, Wildlife and Range Experiment Station
Forest and range ecology, fire management, prescribed burning, site preparation for conifer release

Robberecht, Ronald
Associate Professor
Ecophysiology, autecology, range ecology

Sanders, Kenneth D.
Professor
Adjunct Professor, Forest Resources
Range Extension Specialist
Range extension, nutrition, and livestock

Sharp, Lee A.
Professor Emeritus
Integrated range resource management, range management planning, grazing systems

Tisdale, Edwin W.
Professor Emeritus
Vegetation classification, vegetation habitat relationships

Department of Wildland Recreation Management

Fazio, James R.
Professor and Department Head
Acting Director, Wilderness Research Center
Interpretation, communication, public relations and marketing, conservation history, wilderness use, continuing education

Ham, Sam H.
Associate Professor
Director, Natural Resources Communication Laboratory
Interpretation; tourism marketing; communication; environmental education; visitor behavior, especially as it relates to families; international park and preserve management through user education

Harris, Charles C.
Associate Professor
Consumer psychology of recreationists/tourists, demand estimation in modeling recreationist/tourist behavior, economic and psychological approaches to measuring the values and benefits derived from recreation/tourist opportunities and other amenity resources

Hendee, John C.
Professor
Professor, Forest Resources
Dean, College of Forestry, Wildlife and Range Sciences
Director, Idaho Forest, Wildlife and Range Experiment Station
Human dimensions of resource management, conflict resolution, resource management policy and planning, use of natural environments for personal growth

Krumpe, Edwin E.
Associate Professor
Principal Scientist, Wilderness Research Center
Wilderness and dispersed recreation management, recreation and tourism behavior and the decision process, interpretation and communication, administration, facilities management, research methods

Machlis, Gary E.
Adjunct Professor
Professor, Forest Resources
Project Leader (Sociology), Cooperative Park Studies Unit
Sociology of natural resources

McLaughlin, William J.
Professor
Regional resource and tourism planning, environmental and social impact assessment, perceptions of environments, public involvement and conflict management, international nature conservation and resource development, research methods

Sanyal, Nick
Research Associate
Recreation planning, recreation behavior, human dimensions of wildlife management, research methodologies

Publications and Reports

The following list contains most of the works published during 1989 by scientists of the Forest, Wildlife and Range Experiment Station. Copies of experiment station publications and reprints of some journal articles are available from the authors. Reports issued to fulfill contracts are generally not available for distribution to the public.

Department of Fish and Wildlife Resources

Barrington, M., and R.G. Wright. 1989. An inventory of plant communities and methods to monitor vegetation change at White Bird Battlefield, Nez Perce Natural Historic Site. Report for the University of Idaho Cooperative Park Studies Unit.

Bennett, D.H., J.A. Chandler, L.K. Dunsmoor, and T. Barila. 1989. Use of dredged material to enhance fish habitat in Lower Granite Reservoir, Idaho-Washington. Symposium on Effects of Dredging on Anadromous Fishes on the Pacific Coast, Seattle, Washington.

Bennett, D.H., L.K. Dunsmoor, R.L. Rohrer, and B.E. Rieman. 1989. Mortality of tournament-caught largemouth and smallmouth bass in Idaho lakes and reservoirs. California Fish and Game 75(1):20-26.

Bennett, D.H., and T.R. Fisher. 1989. Use of the Index of Biotic Integrity to assess the impact of land management activities on low order streams in northern Idaho. Report for the Idaho Water Resources Research Institute, Moscow.

Bennett, D.H., C.M. Falter, and A.G. Campbell. 1989. Pilot-scale plant cleans paper mill waste. FOCUS On Renewable Natural Resources 14: 15. Idaho Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow.

Bjornn, T.C., C.M. Moffitt, R.W. Tressler, Jr., K.P. Reese, C.M. Falter, R.E. Meyers, C.J. Cleveland, and J.H. Milligan. 1989. An evaluation of sediment and nutrient loading on fish and wildlife production at Bear Lake National Wildlife Refuge. Report to the U.S. Fish and Wildlife Service, Portland, Oregon.

Bjornn, T.C., and C.R. Steward. 1989. Concepts for a model to evaluate supplementation of natural salmon and steelhead stocks with hatchery fish. Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow.

Bloom, P.H., J.M. Scott, J.W. Carpenter, and M.R. Smith. 1989. Lead contamination of golden eagles *Aquila chrysaetos* within the range of the California condor *Gymnogyps californianus*. Pages 481-482 *in* Raptors in the Modern World, B.N. Beyberg, and R.D. Chancellor, eds. World Working Group on Birds of Prey and Owls, London, England.

Bodurtha, T.S., J.M. Peek, and J.L. Lauer. 1989. Mule deer habitat use related to succession in a bunchgrass community. Journal of Wildlife Management 53:314-319.

Brannon, E., and G.W. Klontz. 1989. The Idaho aquaculture industry. Northwest Environmental Journal 5:23-35.

Chandler, G.L., and T.C. Bjornn. 1989. Survival and growth of sub-yearling steelhead homozygous for alternate alleles at the dipeptidase locus. Transactions of the American Fisheries Society 118:86-89.

Christensen, N.L., J.K. Agee, P.F. Broussard, J. Hughes, D.H. Knight, G.W. Minshall, J.M. Peek, S.J. Pyne, F.J. Swanson, J.W. Thomas, S. Wells, S.E. Williams, and H.A. Wright. 1989. Interpreting the Yellowstone Fires. Bioscience 39(10):678-685.

Christensen, N.L., J.K. Agee, P.F. Broussard, J. Hughes, D.H. Knight, G.W. Minshall, J.M. Peek, S.J. Pyne, F.J. Swanson, J.W. Thomas, S. Wells, S.E. Williams, and H.A. Wright. 1989. Ecological consequences of the 1988 fires in the Greater Yellowstone area. Final report of the Greater Yellowstone Postfire Ecological Assessment Workshop, Mammoth, Wyoming.

Christophersen, K., T. Catterson, E.D. Ables, and R.W. Michieka. 1989. Kenya action plan. Natural Resources Management Support Project, USAID/Kenya.

Christophersen, K., T. Catterson, E.D. Ables, and R.W. Michieka. 1989. Alternatives to natural resources planning. Natural Resources Management Support Project, USAID/Kenya.

Congleton, J.L. 1989. Getting in control of deadly IHN. FOCUS On Renewable Natural Resources 14:18-19. Idaho Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow.

Day, T.A., and R.G. Wright. 1989. Positive plant association with *Erigonum ovalifolium* in primary succession on cinder cones. Vegetatio 80:37-45.

Duncan, W.F.A., M.A. Brusven, and T.C. Bjornn. 1989. Energy-flow response models for evaluation of altered riparian vegetation in three southeast Alaskan streams. Water Resources 23:965-974.

Falter, C.M., D.H. Bennett, and A.J. Campbell. 1989. Biotreatment and toxicity testing of CTMP effluent: parts 1-4. Final report submitted to RUST Engineering International, Portland, Oregon.

Garton, E.O., P.H. Hayward, and G.D. Hayward. 1989. Managing prey populations to benefit raptor populations. Pages 298-304 *in* Proceedings of the Western Raptor Management Symposium and Workshop, Washington, D.C. National Wildlife Federation.

Griffith, D.B., and J.M. Peek. 1989. Mule deer use of seral stage and habitat type in bitterbrush communities. Journal of Wildlife Management 53:636-642.

Griffith, B., J.M. Scott, J.W. Carpenter, and C. Reed. 1989. Translocation as a species conservation tool: status and strategy. Science 245:477-480.

Griswold, R.G., and T.C. Bjornn. 1989. Development of indices of yellow perch abundance in Cascade Reservoir, Idaho. Report for the Idaho Department of Fish and Game, Boise.

Hayward, G.D. 1989. Historical grizzly bear trends in Glacier National Park, Montana: a critique. Wildlife Society Bulletin 17:195-197.

Hayward, G.D., and R.E. Escano. 1989. Goshawk nest-site characteristics in western Montana and northern Idaho. Condor 91:476-479.

Hayward, P.H., and G.D. Hayward. 1989. Managing forests for an overlooked owl. FOCUS On Renewable Natural Resources 14:6-7. Idaho Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow.

Hayward, P.H., and G.D. Hayward. 1989. Lone rangers of the Rockies. Natural History Magazine (November):79-85.

Hayward, P.H. 1989. Boreal owl. *In* Rare, Sensitive and Threatened Species of the Greater Yellowstone Ecosystem, T.W. Clark, ed. The Nature Conservancy.

Hoffman, R.A., and R.G. Wright. 1989. User's manual for the National Park Natural Resource Database Search and Storage System. University of Idaho Cooperative Park Studies Unit.

Kann, J., and C.M. Falter. 1989. Periphyton as indicators of enrichment in Lake Pend Oreille. Idaho Lake and Reservoir Management 5:39-48.

Keith, R.M., and T.C. Bjornn. 1989. Streamsides and salmon in southeast Alaska. FOCUS On Renewable Natural Resources 14:10-11. Idaho Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow.

Klontz, G.W. 1989. Fish disease regulations: friend or foe? Salmonid 13(2):8-14.

Markwardt, N.M., Y.M. Gocha, and G.W. Klontz. 1989. Evaluation of four methods to establish asymptomatic carriers of *Aeromonas salmonicida* in juvenile spring chinook salmon, *Oncorhynchus tshawytscha* (Walbaum). Journal of Fish Diseases 12:311-315.

Markwardt, N.M., Y.M. Gocha, and G.W. Klontz. 1989. A new application for Coomassie Brilliant Blue Agar: detection of *Aeromonas salmonicida* in clinical samples. Diseases of Aquatic Organisms 6:231-233.

Markwardt, N.M., and G.W. Klontz. 1989. A method to eliminate the asymptomatic carrier state of *Aeromonas salmonicida* in salmonids. Journal of Fish Diseases 12:317-322.

Miller, T., C.C. Harris, and K.P. Reese. 1989. A survey of taxpayer opinions on Idaho's Nongame Wildlife and Tax Checkoff Program. Final Report to the Idaho Department of Fish and Game, Boise.

Moffitt, C.M., and T.C. Bjornn. 1989. Protection of chinook salmon smolts with oral doses of Erythromycin against acute challenges of *Renibacterium salmoninarum*. Journal of Aquatic Animal Health 1:227-232.

Moffitt, C.M., and J.L. Congleton. 1989. Natural immunity to IHN and BKD in salmon and trout. University of Idaho Aquaculture Project.

Moffitt, C.M., and J.L. Congleton. 1989. Natural immunity in salmon and trout. Report submitted to the State Board of Education.

Parker, J., J. Allen, and R.G. Wright. 1989. The Mount Rainier resource database: its structure, contents, and methods used to construct it. Final report for the University of Idaho Cooperative Park Studies Unit.

Parker, J., J. Allen, and R.G. Wright. 1989. The Whitman Mission National Historic Site resource database: its structure, contents, and methods used to construct it. Report for the University of Idaho Cooperative Park Studies Unit.

Peek, J.M. 1989. On furthering the use of habitat classifications in wildlife habitat management in the northwestern United States. Pages 234-237 *in* Proceedings—Land Classifications Based on Vegetation: Applications for Resource Management, D.E. Ferguson, P. Morgan, and F.D. Johnson, compilers. USDA Forest Service, General Technical Report. Intermountain Research Station, Ogden, Utah.

Peek, J.M. 1989. A look at wildlife education in the United States. Wildlife Society Bulletin 71:361-365.

Peek, J.M. 1989. The Yellowstone fires: an opportunity to learn. The Idaho Forester: A Magazine of Natural Resources 14:4-6. College of Forestry, Wildlife and Range Sciences, University of Idaho, Moscow.

Peek, J.M. 1989. Another look at burning shrubs in northern Idaho. Pages 152-159 *in* Proceedings—Prescribed Fire in the Intermountain Region: Forest Site Preparation and Range Improvement, D.M. Baumgartner, D.W. Breuer, B.A. Zamora, L.F. Neuenschwander, and R.H. Wakimoto, eds. Washington State University Cooperative Extension, Pullman, Washington.

Ratti, J.T., and J.J. Rotella. 1989. Test of a gray partridge density index: response to a critique. Journal of Wildlife Management 53:1133-1134.

Reese, K.P., and J.T. Ratti. 1989. Birds and edges: a reevaluation. FOCUS On Renewable Natural Resources 14:9-10. Idaho Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow.

Scott, J.M., B. Csuti, H. Anderson, and J.E. Estes. 1989. Biodiversity. Science (February): 589.

Scott, J.M., B. Csuti, J.E. Estes, and H. Anderson. 1989. Status assessment of biodiversity protection. Conservation Biology 3(1):85-87.

Scott, J.M. 1989. Preserving life on earth: a new approach. FOCUS On Renewable Natural Resources 14:1-2. Idaho Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow.

Scott, J.M., C.B. Kepler, C. van Riper III, and S.I. Fefer. 1989. Reply to L.A. Freed and R.L. Cann, 1989. Integrated conservation strategy for Hawaiian forest birds. BioScience 39(7):476-478.

Steward, C.R., and T.C. Bjornn. 1989. Supplementation of salmon and steelhead stocks with hatchery fish: a synthesis of published literature. Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow.

Stickney, R.R., C.M. Falter, and D.M. Jones. 1989. Report of evaluation of the AID cooperative agreement with Auborn University for the Agricultural Technology Development Project.

Strach, R.M., and T.C. Bjornn. 1989. Brook trout removal, stocking cutthroat trout fry, and tributary closures as means for restoring cutthroat trout in Priest Lake tributaries. Report for the Idaho Department of Fish and Game, Boise.

Department of Forest Products

Blatner, K.A., and R.L. Govett. 1989. Report on opportunities for further development of tribal forest land holding.

Campbell, A.G. 1989. Small to medium sized modular combustion systems. *In* Supplement to the Biomass Energy Project Development Guidebook, Bonneville Power Administration and the Department of Energy.

Carter, D.R., and J. O'Laughlin. 1989. Changing technology and the quantity demand for Texas pulpwood. Pages 170-181 *in* Proceedings, Southern Forest Economics Workshop, San Antonio, Texas.

Folk, R.L. 1989. Wood pellets: a look at standards and small-scale production. FOCUS On Renewable Natural Resources 14:24-25. Idaho Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow.

Gorman, T.M., and W.C. Feist. 1989. Chronicle of 65 years of wood finishing research at the Forest Products Laboratory. USDA Forest Service, Forest Products Laboratory, General Technical Report. College of Forestry, Wildlife and Range Sciences, University of Idaho, Moscow.

Gorman, T.M. 1989. Directory of Idaho Secondary Wood Products Manufacturers. Idaho Forest, Wildlife and Range Experiment Station Miscellaneous Publication No. 14.

Gorman, T.M. 1989. Research produces directory of wood products manufacturers. FOCUS On Renewable Natural Resources 14:21. Idaho Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow.

Govett, R.L. 1989. Report on small-scale forest products manufacturing opportunities for Indian tribes.

Govett, R.L., ed. 1989. Idaho Forest Products Marketing Bulletin. Department of Forest Products, College of Forestry, Wildlife and Range Sciences, University of Idaho, Moscow.

Hachmi, M., and A.A. Moslemi. 1989. The correlation between wood-cement compatibility and wood extractives. Forest Products Journal 39(6):55-58.

Jelvez, A.M., K.A. Blatner, R.L. Govett, and H.P. Steinhagen. 1989. Chile's evolving forest products industry part I: its role in international markets. Forest Products Journal 39(10):63-67.

Jelvez, A.M., K.A. Blatner, and R.L. Govett. 1989. Chile's evolving forest products industry part II: investments in the expanding forest products industry. Forest Products Journal 39(11-12):76-78.

Johnson, L.R. 1989. Recovery of wood residues in the Intermountain Region. Pages 11-31 *in* Proceedings of the International Energy Agency Task IV/Activity 3 Workshop, Auburn, Alabama. USDA Forest Service.

Johnson, L.R. 1989. Wood residue recovery, collection and processing. Chapter II *in* Biomass Energy Project Guidebook, Pacific Northwest and Alaska Bioenergy Program, Bonneville Power Administration, Portland, Oregon.

Kim, W-J., and A.G. Campbell. 1989. Chemical Variation in lodgepole pine with latitude, elevation, and diameter class. Forest Products Research Society Journal 39(3):7-12.

Lee, H.W. 1989. Decision model for timber selling. Brochure and computer program submitted to Clearwater Research Conservation and Development Council, Moscow.

Lee, H.W., and J.E. Force. 1989. A summary report—non-industrial private forest landowner survey for southern Idaho. Submitted to Clearwater Research Conservation and Development Council, Moscow.

Meimban, J.J., and R.L. Govett. 1989. Report on assessment of potential targets to use biomass resources.

Miller, D.P., A.A. Moslemi, and P.H. Short. 1989. The use of fly ash in wood-cement panels. Forest Products Journal 39(9):34-38.

Moslemi, A.A., editor and author. 1989. Fiber and particleboards bonded with inorganic binders. Forest Products Research Society, Madison, Wisconsin.

Moslemi, A.A. 1989. Wood-cement composites: coming of age. Pages 12-18 *in* Proceedings of the International Conference on Fiber and Particleboard Bonded with Inorganic Binders, Moscow.

O'Laughlin, J. 1989. Economic structure and performance of forest-based industries. Pages 83-104 *in* Forest Economics and Policy Research: Strategic Directions for the Future, P.V. Ellefson, ed. Westview Press, Boulder, Colorado.

Rule, L.C., and J. O'Laughlin. 1989. Expert opinions on the future production of five manufactured wood products in the Pacific Northwest. Western Journal of Applied Forestry 4(3):92-98.

Sim, H.C., H.P. Steinhagen, and R.L. Govett. 1989. Effect of heat conditioning time on veneer recovery from grand fir peeler blocks. Forest Products Journal 39(7-8):25-27.

Steinhagen, H.P., H.C. Sim, and R.L. Govett. 1989. Penalty of insufficient conditioning of grand fir and Douglas-fir veneer blocks. Forest Products Journal 39(3):51-52.

Steinhagen, H.P. 1989. Graphic method to estimate heat-conditioning periods of frozen and nonfrozen peeler blocks. Forest Products Journal 39(11-12):21-22.

Williams, R.A., and J. O'Laughlin. 1989. Relative magnitude of primary and secondary wood-based industries by state. Pages 160-169 *in* Proceedings, Southern Forest Economics Workshop, San Antonio, Texas.

Department of Forest Resources

Balice, R.G., J.J. Ulliman, and J.M. Scott. 1989. Aërial photos record history of habitat. FOCUS On Renewable Natural Resources 14:5-6. Idaho Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow.

Baumgartner, D.M., D.W. Breuer, B.A. Zamora, L.F. Neuenschwander, and R.H. Wakimoto, eds. 1989. Proceedings—Prescribed Fire in the Intermountain Region: Forest Site Preparation and Range Improvement. Washington State University Cooperative Extension, Pullman, Washington.

Bolon, N., and C.W. McKetta. 1989. Incorporating economics into wildlife management. The Idaho Forester: A Magazine of Natural Resources 14:23-25. College of Forestry, Wildlife and Range Sciences, University of Idaho, Moscow.

Brunsfeld, S.J., and G. Nesom. 1989. *Erigeron salmonensis*, a rare new species from Idaho. Brittonia 41:424-428.

Brunsfeld, S.J. 1989. Genetics of wildland plants. FOCUS On Renewable Natural Resources 14:17-18. Idaho Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow.

Carree, Y., and R.L. Mahoney. 1989. Windbreaks provide many benefits for you and your environment. Cooperative Extension Service Miscellaneous Note No. 124, University of Idaho, Moscow.

Dennis, B. 1989. Stochastic differential equations as insect population models. Pages 219-238 *in* Estimation and Analysis of Insect Populations, L. McDonald, B. Manly, J. Lockwood, and J. Logan, eds. Springer-Verlag, Berlin.

Dennis, B. 1989. Allee effects: population growth, critical density, and the chance of extinction. Natural Resource Modeling 3(4):481-538.

Dennis, B. 1989. Putting the beef back into our burgers. FOCUS On Renewable Natural Resources 14:12-13. Idaho Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow.

Dolsen, D.E., and G.E. Machlis. 1989. Visitor Services Project Report 21: Everglades National Park. Cooperative Park Studies Unit, University of Idaho, Moscow.

Ferguson, D.E., F.D. Johnson, and P. Morgan, compilers. 1989. Symposium Proceedings—Land Classification Based on Vegetation: Applications for Resource Decisions. USDA Forest Service, General Technical Report. Intermountain Research Station, Ogden, Utah.

Fins, L., ed. 1989. Inland Empire Tree Improvement Cooperative Newsletter. College of Forestry, Wildlife and Range Sciences, University of Idaho, Moscow.

Force, J.E., and K.L. Williams. 1989. A profile of National Forest Planning participants. Journal of Forestry 87(1):33-38.

Force, J.E. 1989. Residential wood energy use in Idaho. Forest Products Journal 39(2):25-29.

Foss, C.C., C.R. Rowe, J.R. Fazio, and R.L. Mahoney. 1989. A guide to starting and developing community forestry programs with specific reference to shade tree committees. Cooperative Extension Bulletin No. 692, University of Idaho, Moscow.

Hendee, J.C. 1989. International involvement by U.S. forestry schools and colleges. Journal of Forestry 87(11):24-27.

Hendee, J.C. 1989. Forestry, society and changing values. Renewable Resources Journal 7(4):6-8.

Hendee, J.C. 1989. Summary and 2nd look to the future. Pages 489-491 *in* Transactions of the 54th North American Wildlife Second National Research Conference, Washington, D.C.

James, R.L., R.K. Dumroese, and D.L. Wenny. 1989. *Fusarium* diseases of containerized conifer seedlings in northern Rocky Mountain nurseries: infection, symptom production and pathogenicity of associated fusaria. Phytopathology 78(12):1533.

James, R.L., R.K. Dumroese, and D.L. Wenny. 1989. *Fusarium* diseases of containerized conifer seedlings in northern Rocky Mountain nurseries: sources of inoculum and control tests. Phytopathology 78(12):1607.

James, R.L., R.K. Dumroese, and D.L. Wenny. 1989. Occurrence, characteristics, and descriptions of *Fusarium* isolates from Douglas-fir seed and seedlings. USDA Forest Service Northern Region Forest Pest Management Report 90-4.

James, R.L., R.K. Dumroese, C.J. Gilligan, and D.L. Wenny. 1989. Pathogenicity of *Fusarium* isolates from Douglas-fir seed and container-grown seedlings. Idaho Forest, Wildlife and Range Experiment Station Bulletin No. 52.

Kemp, W.P., B. Dennis, and P.L. Munholland. 1989. Modeling grasshopper phenology with diffusion processes. Pages 118-127 *in* Estimation and Analysis of Insect Populations, L. McDonald, B. Manly, J. Lockwood, and J. Logan, eds. Springer-Verlag, Berlin.

Kemp, W.P., and B. Dennis. 1989. Development of two rangeland grasshoppers at constant temperatures: development thresholds revisited. The Canadian Entomologist 121:363-371.

Machlis, G.E. 1989. Managing parks as human ecosystems. Pages 255-273 *in* Public Places and Spaces, I. Altman, and E.H. Zube, eds. Plenum Publishing Corporation, New York.

Machlis, G.E., and M.A. Littlejohn. 1989. The Visitor Services Project and beyond. Interpretation (summer):20-26.

Machlis, G.E., and D.E. Dolsen. 1989. The 1988 National Park Service Visitor Services Project mail surveys: an evaluation. Cooperative Park Studies Unit, University of Idaho, Moscow.

Machlis, G.E., D.E. Dolsen, and D.L. Madison. 1989. Visitor Services Project Report 20: Craters of the Moon National Monument. Cooperative Park Studies Unit, University of Idaho, Moscow.

Machlis, G.E., D.E. Dolsen, and M.A. Littlejohn. 1989. Visitor Services Project Report 19: Bryce Canyon National Park. Cooperative Park Studies Unit, University of Idaho, Moscow.

Machlis, G.E., and D.E. Dolsen. 1989. Visitor Services Project Report 18: Denali National Park and Preserve. Cooperative Park Studies Unit, University of Idaho, Moscow.

Machlis, G.E., and D.E. Dolsen. 1989. Visitor Services Project Report 17: Glen Canyon National Recreation Area. Cooperative Park Studies Unit, University of Idaho, Moscow.

Mahoney, R.L. 1989. Does it pay to thin? Woodland Notes (winter): 1-2.

Mahoney, R.L. 1989. Black cherry: a high value alternative crop for Idaho? Woodland Notes (spring): 2.

Mahoney, R.L. 1989. When to plant? Woodland Notes (spring): 3.

Mahoney, R.L. 1989. Woodland workshops. Woodland Notes (spring): 5.

Mahoney, R.L. 1989. The cooperative extension system. Woodland Notes (summer).

Mahoney, R.L., and T. Hawkings. 1989. Forest grazing. Woodland Notes (summer): 1-2.

Mahoney, R.L. 1989. Bustin' boards and making weird wood. Woodland Notes (fall): 2.

Mahoney, R.L, D.R. White, and C. Schneff, eds. 1989. Woodland Notes. Volume 1(1-4). University of Idaho Cooperative Extension System.

Marshall, J.D., and S.H. Cadle. 1989. Evidence of trans-cuticular uptake of nitric acid vapor by foliage of eastern white pine (*Pinus strobus* L.). Environmental Pollution 60:15-28.

Mason, A.C., and D.L. Adams. 1989. Black bear damage to thinned timber stands in northwest Montana. Western Journal of Applied Forestry 4(1):10-13.

Mattson, K.G., and W.T. Swank. 1989. Soil and detrital carbon dynamics following forest cutting in the southern Appalachians. Biology and Fertility of Soils 7:247-253.

McKetta, C.W. 1989. Idaho landowner attitudes on hunting and hunters. *In* Proceedings of the International Landowner/Sportsman Relations Conference, Boise.

McKetta, C.W. 1989. The relevance of the economic theory of information in national forest planning. Report submitted for USDA-Forest Service Forest Planning Evaluation Project.

McKetta, C.W. 1989. An evaluation of economic issues in the Tepee Butte Recovery Project EIS. Proprietary document for the Boise Cascade Corporation.

McKetta, C.W. 1989. Effects of alternative forest tax payment mechanisms on Boundary County, Idaho. Report submitted to the Boundary County commissioners.

McKetta, C.W., and E. Packee. 1989. Sustained-yield without even-flow: the legitimacy and the advantages. Proprietary document for the University of Alaska.

McKetta, C.W. 1989. Estimated revenue generation capacity of the proposed Boulder-Katka Forest. Proprietary document for the Kootenai Tribe of Idaho.

Morgan, P. 1989. Managing shrub response through site preparation. Pages 161-165 *in* Proceedings—Prescribed Fire in the Intermountain Region: Forest Site Preparation and Range Improvement, D.M. Baumgartner, D.W. Breuer, B.A. Zamora, L.F. Neuenschwander, and R.H. Wakimoto, eds. Washington State University Cooperative Extension, Pullman, Washington.

Morgan, P., and S.C. Bunting. 1989. Whitebark pine: fire ecology and management. Women in Natural Resources 11(1):52.

Morgan, P., and S.C. Bunting. 1989. Survival by fire: whitebark pine. FOCUS On Renewable Natural Resources 14:20. Idaho Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow.

Morgan, P., and B. Shiplett. 1989. Photographic series: appraising slash fire hazards in Idaho. Idaho Department of Lands, Statehouse, Boise.

Munholland, P.L., J.D. Kalbfleisch, and B. Dennis. 1989. A stochastic model for insect life history data. Pages 136-144 *in* Estimation and Analysis of Insect Populations, L. McDonald, B. Manly, J. Lockwood, and J. Logan, eds. Springer-Verlag, Berlin.

Neumann, R.P., and G.E. Machlis. 1989. Land use and threats to parks in the neotropics. Environmental Conservation 16(1):13-18.

Osborne, H.L., and D. Gordon. 1989. Map-brochure of the University of Idaho Experimental Forest. Cooperative Extension Service Publication, University of Idaho, Moscow.

Osborne, H.L., and D. Gordon. 1989. Flat Creek Driving Tour. Cooperative Extension Service Publication, University of Idaho, Moscow.

Osborne, H.L. 1989. What do I do with my slash? Northwest Woodlands 5(2):5-6.

Partridge, A. 1989. Tree evaluation. Cooperative Extension Service Bulletin, University of Idaho, Moscow.

Perez, D.N., H.E. Burkhart, and C.T. Stiff. 1989. A variable-form taper function for *Pinus oocarpa* Schiede in central Honduras. Forest Science 35(4).

Perez, D.N., O. Ferreira, and C.T. Stiff. 1989. Ecuaciones de volumen para *Pinus oocarpa* Schiede en la region central de Honduras. Nota Tecnica No. 6, ESNACIFOR/COHDEFOR—Siguatepeque, Honduras.

Real, P.L., J.A. Moore, and J.D. Newberry. 1989. Principal components analysis of tree stem profiles. Canadian Journal of Forest Research 19:1538-1542.

Roberts, D., and P. Morgan. 1989. Classifications and models of succession. Pages 49-53 *in* Proceedings—Land Classification Based on Vegetation: Applications for Resource Management, D.E. Ferguson, P. Morgan, and F.D. Johnson, compilers. USDA Forest Service, General Technical Report. Intermountain Research Station, Ogden, Utah.

Robison, M.H. 1989. Estimating the importance of wood products in regional economies. Technical Newsletter, Forest Products Marketing and Economics 3(4).

Robison, M.H., C.C. Harris, R.L. Govett, and S.A. Katzer. 1989. Economic model to aid Idaho planners. FOCUS On Renewable Natural Resources 14:2-3. Idaho Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow.

Saveland, J.M., and M.W. Stock. 1989. Knowledge engineering: lessons from teaching. AI Applications in Natural Resource Management 3(3):45-52.

Shafii, B., J.A. Moore, and J.R. Olson. 1989. Effects of nitrogen fertilization on growth of grand fir and Douglas-fir stands in northern Idaho. Western Journal of Applied Forestry 4(2):54-57.

Stiff, C.M., D.L. Wenny, R.K. Dumroese, L.W. Roberts, and C.T. Stiff. 1989. Establishment of western white pine shoots *in vitro* using needle fascicles. Canadian Journal of Forest Research 19(10):1330-1333.

Stiff, C.M. 1989. Growing test-tube trees and shrubs. FOCUS On Renewable Natural Resources 14:16-17. Idaho Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow.

Stiff, C.M., Y. Carree, and M. Mousseaux. 1989. Biotechnology research expands to sagebrush, bitterbrush and elite black cherry. The Idaho Forester: A Magazine of Natural Resources 14:22. College of Forestry, Wildlife and Range Sciences, University of Idaho, Moscow.

Stiff, C.M. 1989. Tissue culture. Woodland Notes 1(1):2-3.

Stiff, C.M., and D.L. Wenny. 1989. Tissue culture of forest plants. IMAGE Newsletter 1(1):6-7.

Stiff, C.M. 1989. The role of plant tissue culture in forest tree improvement. *In* Taking Advantage of Genetic Gain—Tree Improvement and Regeneration. Inland Empire Tree Improvement Annual Meeting and Workshop, Post Falls.

Stiff, C.M., D.L. Wenny, L.W. Roberts, J.R. Olson, and D. LeTourneau. 1989. Micropropagation of western white pine using needle fascicles. Pages 268-274 *in* Proceedings of the Tenth North American Forest Biology Workshop, J. Worrall, J. Loo-Dinkins, and D. Lester, eds. University of British Columbia, British Columbia, Canada.

Stiff, C.T., D.N. Perez, and F.D. Johnson. 1989. Site index and height growth curves for *Pinus oocarpa* in central Honduras. Turrialba 39(2).

Stiff, C.T., and H.W. Lee. 1989. Training manual for University of Idaho/Honduras Forestry Field Training Course, 2nd edition (in Spanish). University of Idaho, Moscow.

Stiff, C.T. 1989. Effects of fugitive cement kiln dust on forest productivity. Final report to the Lehigh Portland Cement Company, Portland, Oregon.

Stock, M.W. 1989. Graduate instruction in the research process. Pages 1-4 *in* Discovering New Knowledge About Trees and Forests. USDA Forest Service, General Technical Report. North Central Forest Experiment Station, St. Paul, Minnesota.

Stock, M.W., ed. 1989. AI Applications in Natural Resource Management. Volume 3.

Ulliman, J.J., and M. Dahle. 1989. Aerial photo interpreted maps of the vegetation communities along the Snake River, Jackson Hole section for 1956, 1974, and 1986. Submitted to the Army Corps of Engineers, Walla Walla, Washington.

Vander Ploeg, J.L., and J.A. Moore. 1989. Comparison and development of height growth and site index curves for Douglas-fir in the Inland Northwest. Western Journal of Applied Forestry 4(3):85-88.

Wenny, D.L. 1989. Lotus 1-2-3[r] template for nutrient calculation. Tree Planters' Notes 40(2):5-7.

Wenny, D.L., ed. 1989. Forest Nursery Research Update Number 3. Idaho Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow.

Department of Range Resources

Alcocer-Ruhling, M., R. Robberecht, and D.C. Thill. 1989. The response of *Bouteloua scorpioides* to water stress at two phenological stages. Botanical Gazette 150(4):454-461.

Barrington, M., S.C. Bunting, and G. Wright. 1989. A fire management plan for Craters of the Moon National Monument. Final Report submitted to the National Park Service, Seattle, Washington.

Bunting, S.C. 1989. Effect of fire on rangeland shrubs in the intermountain region. Pages 103-106 *in* Proceedings—Prescribed Fire in the Intermountain Region: Forest Site Preparation and Range Improvement, D.M. Baumgartner, D.W. Breuer, B.A. Zamora, L.F. Neuenschwander, and R.H. Wakimoto, eds. Washington State University Cooperative Extension, Pullman, Washington.

Dahl, B.E., J.C. Mosley, P.F. Cotter, and R.L. Dickerson. 1989. Winter forb control for increased grass yield on sandy rangeland. Journal of Range Management 42:400-403.

Fisser, H.G., K.L. Johnson, K.S. Moore, and G.E. Plumb. 1989. 51-year change in the shortgrass prairie of eastern Wyoming. Pages 29-31 *in* Proceedings of the Eleventh North American Prairie Conference, T.B. Bragg, and J. Stubbendieck, eds. Lincoln, Nebraska.

Fosberg, M.A., M. Hironaka, and K.E. Houston. 1989. The soil-habitat type relationship. Pages 277-278 *in* Proceedings—Land Classifications Based on Vegetation: Applications for Resource Management, D.E. Ferguson, P. Morgan, and F.D. Johnson, compilers. USDA Forest Service, General Technical Report. Intermountain Research Station, Ogden, Utah.

Hironaka, M. 1989. Primary successional theories. Pages 29-31 *in* Proceedings—Land Classifications Based on Vegetation: Applications for Resource Management, D.E. Ferguson, P. Morgan, and F.D. Johnson, compilers. USDA Forest Service, General Technical Report. Intermountain Research Station, Ogden, Utah.

Hironaka, M. 1989. Relationship of habitat type and range site. Pages 300-301 *in* Proceedings—Land Classifications Based on Vegetation: Applications for Resource Management, D.E. Ferguson, P. Morgan, and F.D. Johnson, compilers. USDA Forest Service, General Technical Report. Intermountain Research Station, Ogden, Utah.

Jirik, S.J., and S.C. Bunting. 1989. Grazing systems and prescribed fire can mix. FOCUS On Renewable Natural Resources 14:4. Idaho Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow.

Johnson, K.L., ed. 1989. Rangeland resources of Utah. Utah State University Cooperative Extension Service, Logan, Utah.

Johnson, K.L., P.F. McCawley, and J.E. Bowns. 1989. Status and future of Utah rangeland. Pages 74-86 *in* Rangeland Resources of Utah, K.L. Johnson, ed. Utah State University Cooperative Extension Service, Logan, Utah.

Johnson, K.L., and V.J. Anderson. 1989. Utah as a geographical entity. Pages 2-3 *in* Rangeland Resources of Utah, K.L. Johnson, ed. Utah State University Cooperative Extension Service, Logan, Utah.

Mosley, J.C., S.C. Bunting, and M. Hironaka. 1989. Quadrat and sample sizes for frequency sampling mountain meadow vegetation. Great Basin Naturalist 49:241-248.

Mosley, J.C., and B.E. Dahl. 1989. Evaluation of seven-day grazing periods for short duration grazing on tobosagrass rangeland. Applied Agricultural Research 4:229-234.

Ogden, P.R., and J.C. Mosley. 1989. Summary of the elk-livestock information workshop. University of Arizona Cooperative Extension Service Miscellaneous Publication.

Robberecht, R. 1989. Environmental photobiology. Pages 135-154 *in* The Science of Photobiology, K.C. Smith, ed. Plenum Press, New York.

Roscoe, K.C., and J.L. Kingery. 1989. Forest grazing: cattle, deer, and elk diets. FOCUS On Renewable Natural Resources 14:8. Idaho Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow.

Saveland, J., and S.C. Bunting. 1989. Fire effects in ponderosa pine forests. Pages 125-132 *in* Proceedings, Ponderosa Pine—the Species and Its Management, D.M. Baumgartner, and J.E. Lotan, eds. Washington State University Cooperative Extension, Pullman, Washington.

Department of Wildland Recreation Management

Allen, S.D. 1989. To hells and back: trouble in paradise. FOCUS On Renewable Natural Resources 14:22-23. Idaho Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow.

Bajimaya, S.S., M.E. Bean, C.G. Bush, El.L. Castillo, A. Dagamaissa, S. Hajib, Y. Hanako, W.J. McLaughlin, K.L. McCoy, J.B. Rundell, J.A. Strassman, S.E. Timko, and M.P. Vander Ploeg. 1989. Salmon River Corridor: desired actions for enhanced recreation and tourism potential. Idaho Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow.

Barborak, J.R., and S.H. Ham. 1989. Funding recommendations and logical framework for environmental awareness, protected areas and biodiversity component, Regional Environmental and Natural Resource Management Program for Central America. Final report to Tropical Research and Development, Inc., Gainesville, Florida, and U.S. Agency for International Development, Regional Office of Central American Programs, Guatemala.

Fazio, J.R., and R.J. Ratcliffe. 1989. Mailed literature as a method to reduce problems of wild river management. Journal of Park and Recreation Administration 7(4):1-9.

Fazio, J.R. 1989. Managing woodlands for wildlife. Practical Forestry 1:16-19+.

Fazio, J.R., columnist. 1989. World of Trees. *In* Arbor Day. The National Arbor Day Foundation, Lincoln, Nebraska.

Fazio, J.R., ed. 1989. Tree City USA Bulletin. The National Arbor Day Foundation, Lincoln, Nebraska.

Ham, S.H. 1989. Identifying obstacles to environmental education: analysis and implications for interpreters. Journal of Interpretation 12(2):5-18.

Ham, S.H., D.S. Sutherland, and J.R. Barborak. 1989. Role of protected areas in environmental education in central America. Journal of Interpretation 13(5):1-7.

Publications and Reports

Ham, S.H., and L. Castillo. 1989. Análisis de la situacion ambiental en las escuelas del a area rural de Honduras. Semana Cientifica 7:191-225.

Ham, S.H. 1989. Problems in transferring U.S. environmental education models to developing countries. Pages 401-407 *in* Research Proceedings, National Association of Interpretation.

Ham, S.H. 1989. Mass media training for foresters in Trinidad and Tobago. Interim report to the Organization of American States, Washington, D.C.

Ham, S.H. 1989. Mass media applications for public natural resource education in Trinidad and Tobago. Final report to the Organization of American States and the Division of Forestry, Republic of Trinidad and Tobago, West Indies.

Harris, C.C., D. Rawhouser, L. Grussing, E.E. Krumpe, and W.J. McLaughlin. 1989. Cooperative research for monitoring recreation uses on the Lower Salmon River. Journal of Park and Recreation Administration 7(1):41-57.

Harris, C.C., B.L. Driver, and W.J. McLaughlin. 1989. Assessing contingent valuation methods from a psychological perspective. Journal of Environmental Economics and Management 17(1):213-229.

Harris, C.C., ed. 1989. An approach to assessing community tourism potential: results for four north Idaho communities—1990 to 1995. Report prepared for Idaho Department of Commerce, Boise.

Harris, C.C., S.E. Timko, and W.J. McLaughlin. 1989. An assessment of tourism development potential in St. Maries, Idaho—1990 to 1995. Idaho Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow.

Harris, C.C., S.E. Timko, and W.J. McLaughlin. 1989. An assessment of tourism development potential in the Silver Valley, Idaho—1990 to 1995. Idaho Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow.

Harris, C.C., J.F. Tynon, S.E. Timko, and W.J. McLaughlin. 1989. The 1987 Idaho Leisure Travel and Recreation Study: analysis for Region IV. Final report for Division of Travel Promotion, Idaho Department of Commerce, Boise.

Harris, C.C., W.J. McLaughlin, S.E. Timko, and J.F. Tynon. 1989. The 1987 Idaho Leisure Travel and Recreation Study: analysis for Region VII. Final report for Division of Travel Promotion, Idaho Department of Commerce, Boise.

Harris, C.C., K.P. Reese, and T.A. Miller. 1989. Idaho's nongame program: the taxpayers' views. FOCUS On Renewable Natural Resources 14:13-14. Idaho Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow.

Krumpe, E.E. 1989. Predicting leisure choice behaviour. *In* Bicentennial Conference Proceedings of the Royal Australian Institute of Parks and Recreation.

McLaughlin, W.J., N. Sanyal, J. Tangen-Foster, J.F. Tynon, S. Allen, and C.C. Harris. 1989. 1987-1988 Idaho Rifle Elk Hunting Study. Volume 1: Results. Idaho state document for the Idaho Department of Fish and Game, Boise.

McLaughlin, W.J., N. Sanyal, J.F. Tynon, J. Tangen-Foster, S. Allen, and C.C. Harris. 1989. 1987-1988 Idaho Shotgun Hunting Study. Volume 1: Results. Idaho state document for the Idaho Department of Fish and Game, Boise.

McLaughlin, W.J., C.C. Harris, J.F. Tynon, and S.E. Timko. 1989. The 1987 Idaho Leisure Travel and Recreation Study: analysis for Region II. Final report for Division of Travel Promotion, Idaho Department of Commerce, Boise.

McLaughlin, W.J. 1989. An assessment of tourism development in Priest River, Idaho—1990-1995. Idaho Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow.

McLaughlin, W.J. 1989. Critical issues for the Inland Empire's recreation and tourism industry, 1989-1995. Pages 59-60 *in* What's Happening in Forestry in the Inland Northwest. Summary papers of the Annual Inland Empire Section Meeting, Society of American Foresters, Post Falls.

Rundell, J.B., W.J. McLaughlin, and C.C. Harris. 1989. Idaho Rural Tourism Primer: A Tourism Assessment Workbook. Idaho Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow.

Sanyal, N., W.J. McLaughlin, J.F. Tynon, J. Tangen-Foster, S. Allen, and C.C. Harris. 1989. 1987-1989 Idaho Rifle Deer Hunting Study. Volume 1: Results. Idaho state document for the Idaho Department of Fish and Game, Boise.

Sanyal, N., W.J. McLaughlin, J. Tangen-Foster, J.F. Tynon, S. Allen, and C.C. Harris. 1989. 1987-1988 Idaho Rifle Deer Hunting Study. Volume 2: Open-Ended Questions Appendix. Idaho Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow.

Sanyal, N., W.J. McLaughlin, J. Tangen-Foster, J.F. Tynon, S. Allen, and C.C. Harris. 1989. 1987-1988 Idaho Rifle Elk Hunting Study. Volume 2: Open-Ended Questions Appendix. Idaho Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow.

Sanyal, N., W.J. McLaughlin, J. Tangen-Foster, J.F. Tynon, S. Allen, and C.C. Harris. 1989. 1987-1988 Idaho Shotgun Hunting Study. Volume 2: Open-Ended Questions Appendix. Idaho Forest, Wildlife and Range Experiment periment Station, University of Idaho, Moscow.

Timko, S.E., C.C. Harris, J.F. Tynon, and W.J. McLaughlin. 1989. The 1987 Idaho Leisure Travel and Recreation Study: analysis for Region I. Final report for the Division of Travel Promotion, Idaho Department of Commerce, Boise.

Timko, S.E., C.C. Harris, and W.J. McLaughlin. 1989. Profile of leisure travelers in Region I. Prepared for the Division of Economic Development, Idaho Department of Commerce, Boise.

Tynon, J.F., S.E. Timko, W.J. McLaughlin, and C.C. Harris. 1989. The 1987 Idaho Leisure Travel and Recreation Study: analysis for Region III. Final report for Division of Travel Promotion, Idaho Department of Commerce, Boise.

Tynon, J.F., C.C. Harris, S.E. Timko, and W. J. McLaughlin. 1989. The 1987 Idaho Leisure Travel and Recreation Study: analysis for Region VI. Final report for Division of Travel Promotion, Idaho Department of Commerce, Boise.

Research Projects and Investigations

This listing shows the range of work in progress through the Idaho Forest, Wildlife and Range Experiment Station. For additional information, please write to the principal investigators or to the Associate Director, Idaho Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow, Idaho 83843.

Department of Fish and Wildlife Resources

Influence of cross-country skiers on elk in Yellowstone National Park. E.F. Cassirer, E.D. Ables

The role of voice in coyote society. K. Fulmer, E.D. Ables

Behavorial interactions between bighorn sheep, mule deer and elk on the winter range. H. Akenson, E.D. Ables

Ecology of elephants on Nazinga Game Ranch. B. Faso, E. Damiba, E.D. Ables

The Arabian oryx re-introduction: the development of a wild population. T. Tear, E.D. Ables

Biotreatment and toxicity reduction of CTMP effluent by the carousel process. D.H Bennett, A.G. Campbell, C.M Falter

Biotreatment and biomonitoring of CTMP pulp and paper mill effluent. D.H. Bennett

Toxicity evaluation of CTMP effluent biotreated by a pilot-scale carousel oxidation ditch system. D.H. Bennett

Pilot sampling for heavy metals in fish flesh from Killarney Lake in the Coeur d'Alene River system. D.H. Bennett

Monitoring fish and benthic community activity at disposal and reference sites in Lower Granite Reservoir, Washington. D.H. Bennett

Distribution, abundance, and life history of northern pike in the Coeur d'Alene Lake system, Idaho. D.H. Bennett

Idaho pulp/paper mill feasibility project. D.H. Bennett

Use of the Index of Biotic Integrity to assess impacts of logging practices on low order streams. D.H. Bennett

Factors limiting the abundance of largemouth bass in northern Idaho and northeastern Washington. D.H. Bennett

Survival of chinook salmon as related to stress at dams and smolt quality. T.C. Bjornn

Viability of progeny from hatchery steelhead and their effects on native stocks. T.C. Bjornn

Survival of steelhead trout embryos in relation to organic and inorganic sediments. T.C. Bjornn

Fish response to solar input, riparian vegetation, and instream cover in second-growth forest streams of southeast Alaska. T.C. Bjornn

Physical and biological factors limiting coho salmon smolt production in the Slippery Creek drainage of Alaska. T.C. Bjornn.

Development of a conceptual model to evaluate the effects of supplementation on native salmon and steelhead stocks. T.C. Bjornn

Supplementation of Idaho chinook salmon stocks with hatchery fish. T.C. Bjornn

Evaluation of upstream passage of salmon and steelhead at the lower Snake River dams and reservoirs. T.C. Bjornn

Estimation of chinook salmon fry emigration from natal spawning areas in the upper Salmon River. T.C. Bjornn

Spawning behavior and distribution of wild and hatchery chinook salmon. T.C. Bjornn

Re-evaluation of the effects of catch-and-release angling regulations on the trout stocks of the Lochsa, St. Joe, and North Fork of the Clearwater rivers. T.C. Bjornn

Infectious hematopoietic necrosis (IHN) virus in the Clearwater River and Dvorshak National Fish Hatchery. J.L. Congleton

Nonspecific resistance of rainbow trout to IHN virus. J.L. Congleton

A model for assessing the protection needs for biodiversity protection in the United States. B.A. Csuti, J.N. Scott

Scientific guidelines for the design of nature preserves. B.A. Csuti, P.R. Ehrlich, S.L. Pimm, D.D. Murphy, K. Freas

Catalog and map of the natural areas of Oregon. B.A. Csuti, R. Vanderschaaf, J. Kagan

Attached algae production in in-shore areas of Pend Oreille Lake north Idaho. C.M. Falter

Experimental biotreatment of CTMP wastes and biomonitoring on hemlock and fir furnish. C.M. Falter, D.H. Bennett, A.G. Campbell

Ecology and management of the Pend Oreille River in northeastern Washington. C.M. Falter, D.H. Bennett, K. Reese, W. McLaughlin

Littoral productivity of Pend Oreille Lake. C.M. Falter

Silver Valley pulp mill feasibility analysis. C.M. Falter, Policy Analysis Group (PAG)

Impact of wolf reintroduction on Yellowstone elk populations. E.O. Garton

Functional feeding response of coyotes to changing prey abundance. E.O. Garton, B. Kelly

Recreational impacts on wilderness wildlife. E.O. Garton

Wilderness sensitivity rating for wildlife of Nez Perce National Forest. E.O. Garton, P.H. Hayward

Population ecology of trumpeter swans and whooping cranes. E.O. Garton, P.H. Hayward

Utility of nest boxes as a monitoring tool for boreal owls and other small forest owls. G.D. Hayward

Examination of distribution, habitat use and population biology of boreal owls in the northern Rocky Mountains. G.D. Hayward

Distribution, habitat use and population biology of boreal owls in central Idaho. G.D. Hayward, P.H. Hayward, E.O. Garton

Are all old forests oldgrowth: definition of oldgrowth outside the Pacific Coastal Region. G.D. Hayward

Epidemiology of fish diseases. G.W. Klontz

Environmental diseases of salmonids. G.W. Klontz

The effects of reduced continuous versus intermittent feeding of rainbow trout. G.W. Klontz, M.H. Maskill, and H. Kaiser

FDA approved registration of erythromycin for treatment of bacterial kidney disease (BKD) in juvenile and adult chinook salmon. C.M. Moffitt

Dose titration studies in juvenile salmon. C.M. Moffitt

Energy dynamics, foraging ecology, and behavior of pre-nesting white-fronted geese on the Yukon-Kuskokwim Delta, Alaska. J.T. Ratti, D. Budesn

Ten-year analysis of gray partridge population fluctuations and associated environmental factors. J.T. Ratti, K.P. Reese, J.J. Rotella

Behavior and ecology of tundra swans. J.T. Ratti, M. Monda

Habitat use, movements, and survival of mallard broods in southwestern Manitoba: consideration of untested hypotheses. J.T. Ratti, J.J. Rotella

Analysis of edge habitats and their relationship to productivity of passerine birds. J.T. Ratti, K.P. Reese

Pesticides and pheasants: a proposal. K.P. Reese

Sage grouse response to fire on the Big Desert. K.P. Reese

Wildlife use of Conservation Reserve Program lands. K.P. Reese

Snag site characteristics and their associated use by avian species in old-growth ponderosa pine forests in Montana. K.P. Reese

Wildlife use of the Pend Oreille River Reservoir in northeast Washington. K.P. Reese

Ecology of sympatric sage and sharp-tailed grouse. K.P. Reese

Winter movement and habitat use of sage grouse. K.P. Reese

Spring movements and nesting ecology of sage grouse in southeastern Idaho. K.P. Reese

Spring movements and nesting ecology of sharp-tailed grouse in southeastern Idaho. K.P. Reese

Evaluation of methods used to estimate numbers of animals. J.M. Scott

Assessment of habitat selection by grizzly bears. J.M. Scott

Preserve design at the continental and regional level. J.M. Scott

Designing recovery strategies for endangered species. J.M. Scott, E.D. Ables

Developing resource databases for national parks in the Pacific Northwest. R.G. Wright

Developing an interaction GIS-ecosystem model for the Stehekin River drainage in North Cascades National Park. R.G. Wright

Analysis of long-term vegetation changes at Craters of the Moon National Park. R.G. Wright

Analysis of white-tailed deer impacts at Gettysburg National Military Park. R.G. Wright

Developing a model of wolf predation on ungulates on Yellowstone's northern range. R.G. Wright

Department of Forest Products

Environmental aspects of wood ash: production, disposal, and utilization. A.G. Campbell, R.L. Folk

Wood ash as a liming agent and soil amendment in a greenhouse study. A.G. Campbell, R. Mahler, R.L. Folk

Classified yard trash fines and bark as horticultural media. A.G. Campbell, R.R. Tripepi

Land application of mechanical pulp and paper sludge. A.G. Campbell

Land application of primary and secondary sludge. A.G. Campbell

Log yard trash composting. A.G. Campbell

Log yard trash management and utilization demonstration project for Idaho. A.G. Campbell

Assessment of solid wastes from the forest products industry in Idaho. A.G. Campbell, R.L. Folk

Yard trash composting demonstration project for Idaho. A.G. Campbell

Wood ash as a bulking agent and odor absorber in static pile composting. A.G. Campbell

Disposal and utilization of wood ash using land application. A.G. Campbell

Development of an HPLC method for rapid analysis of resin acids in pulp mill effluent. A.G. Campbell

Evaluation of physical and chemical properties of classified log yard waste. A.G. Campbell, R.L. Folk

Technical and economic feasibility of manufacturing densified wood fuel in small-scale equipment for local markets. R.L. Folk, R.L. Govett, H.W. Lee

Assessment of wood pellet fuel quality and characteristics for Idaho and the Intermountain West. R.L. Folk, R.L. Govett

An assessment of value-added opportunities for the Idaho wood products industry. T.M. Gorman, R.L. Govett

Roof system replacement on sports dome. T.M. Gorman, D.N. Reese

A mathematical model for moisture in attics—the effects of construction design and ventilation. T.M. Gorman, A. TenWolde

Ceiling joist-rafter connection performance and evaluation. T.M. Gorman, R. Wolfe

Harvesting, Processing and Marketing of Wood Products—Idaho Agriculture Extension. R.L. Govett.

Tribal forest products enterprise shortcourse series. R.L. Govett

Western whitewoods (grand fir and western white pine) as a source material for shakes and shingles. R.L. Govett

Marketing of christmas trees. R.L. Govett

Modeling of cost and availability of wood fuel. L.R. Johnson

Conceptual analysis of mobile log merchandising centers. L.R. Johnson

Decision model for wood residue supply. L.R. Johnson

Compaction, soil disturbance and production associated with mechanical fellers. H.W. Lee, L.R. Johnson

Plant materials study. H.W. Lee

Decision model for timber selling. H.W. Lee

Study of the nonindustrial private forest land in southern Idaho. H.W. Lee, J.E. Force

Forest biomass recovery demonstration project. H.W. Lee

Economic evaluation of the results of the Non-Industrial Private Forest Survey. H.W. Lee

Environmental impacts on site productivity from increased utilization of biomass for energy and fiber. H.W. Lee, J.A. Moore

Bolivian forestry field training course. H.W. Lee

Woodland owners utilization guide. H.W. Lee

Weir Creek Monitoring. H.W. Lee

SOFORM crosslinked (formaldehyde crosslinking catalyzed with sulfur dioxide) fibers as reinforcement for fiber-cement composites. A.A. Moslemi

The effect of particle size and other material factors on the properties of gypsum-bonded particleboards. A.A. Moslemi

Political and economic aspects of forest protection: a case study of the 1982-86 southern pine beetle epidemic in Texas. J. O'Laughlin, D.R. Carter, C. McKinney

Bureau of Land Management Riparian Policy: analysis of public comment on the draft statement. J. O'Laughlin, Policy Analysis Group (PAG)

Pulp mill feasibility in Idaho's Silver Valley. J. O'Laughlin, PAG

Idaho citizen opinions about natural resource issues. J. O'Laughlin, PAG

Idaho's timber supply and availability. J. O'Laughlin, PAG

Alternative strategies for wolf recovery in central Idaho. J. O'Laughlin, PAG

Idaho Department of Fish and Game's land acquisition program and land management capabilities. J. O'Laughlin, PAG

State agency responsibilities for water quality programs in Idaho. J. O'Laughlin, PAG

Block conditioning. H.P. Steinhagen

Hog fuel drying. H.P. Steinhagen

Development of a computerized, two-dimensional heat transfer model with phase change for logs (LOGHEAT2). H.P. Steinhagen

Drying mixtures of tropical hardwoods. H.P. Steinhagen

Department of Forest Resources

Shade effects on survival and growth of nursery and field grown western redcedar seedlings in the northern Rockies. D.L. Adams

Western redcedar animal damage and microsite effects. D.L. Adams

Seed wafer development: effects of water-retention and rodent repellent chemicals on seed germination. D.L. Adams

Response from thinning ponderosa pine plantations in northern Idaho. D.L. Adams

Erosion modeling. G. Belt

Agro-forestry for cost-benefit analysis. G. Belt

Evapotranspiration modeling. G. Belt, W. Wang, C.W. McKetta

Systematics and evolution in *Salix* sect *Longifoliae*. S.J. Brunsfeld

Genetics and ecology of bitterbrush. S.J. Brunsfeld

Implementation of grasshopper stage-development models for Integrated Pest Management. B. Dennis

Response rates and mail recreation survey results: how much is enough? D.E. Dolsen, G.E. Machlis

Survival of *Fusarium* root disease on Douglas-fir seedlings after outplanting. R.K. Dumroese, R.L. James, D.L. Wenny

Western white pine seed germination. R.K. Dumroese, D.L. Wenny

The efficacy of sodium metabisulfite for sterilizing seedling growing containers. R.K. Dumroese, R.L. James, D.L. Wenny

Using *Gliocladium* for biological control of *Fusarium* root disease in container-grown Douglas-fir seedlings. R.L. James, R.K. Dumroese, D.L. Wenny

Biological control of aphids on container-grown *Robinia* and *Caragana*. R.K. Dumroese, J.B. Johnson, D.L. Wenny

Efficacy of granular Banrot® to control *Fusarium* root disease of container-grown Douglas-fir seedlings. R.K. Dumroese, R.L. James, D.L. Wenny

Container-grown seedlings with lime-induced stunting. R.K. Dumroese, G. Thompson, D.L. Wenny

Growing more seedlings with less pesticide. R.K. Dumroese, D.L. Wenny, K.E. Quick

Genetic variation in nutrient efficiency among field-planted Douglas-fir. L. Fins

Conversion of the SORNEC Model to a loblolly pine plantation growth and yield prediction system. Development of coefficients for genetically improved trees for existing growth and yield model. L. Fins, D. Wei

Evaluation of performance of pedigreed Douglas-fir seedlings over six years and four environments. L. Fins, M. Rust, B. Wilson

Shoot growth patterns in western larch: comparison of growth in 2-year and 6-year-old trees. L. Fins, J. Zhang

Genetics and nutrition of field-planted Douglas-fir: evaluation of family differences in foliar nutrient concentrations of progeny-tested Douglas-fir. L. Fins, G.E. Rehfeldt, V. Aston

Genetic variation in height growth of nine-year-old grand fir. L. Fins, M. Rust

Genetic variation in height growth of seven-year-old western larch. L. Fins, M. Rust

Genetic variation in height growth of ten-year-old lodgepole pine. L. Fins, M. Rust

Forestry extension programs in Mali. J.E. Force

Agroforestry research planning in Senegal. J.E. Force

Development of a profile of international programs of National Association of Professional Forestry Schools and Colleges member schools. J.E. Force, S.H. Ham

Idaho Department of Lands forest landowner survey. J.E. Force, H.W. Lee

Indian faculty associates program. J.E. Force

Research Projects and Investigations

Community stability in timber-dependent communities: a longitudinal study in north Idaho. J.E. Force, G.E. Machlis

Succession in the subalpine fix/beargrass habitat type in central Idaho. M. Simpson, F.D. Johnson

Ecology of woody plants. F.D. Johnson, S.J. Brunsfeld

Pantropical trees. F.D. Johnson

Relations between strangers: a new theory of social ecology. G.E. Machlis, W.R. Burch

Delaware water gap social science research plan. G.E. Machlis

Visitor services project: an examination of visitor use patterns in national parks. G.E. Machlis

High-value hardwoods for Idaho and the Pacific Northwest. R.L. Mahoney, Y. Carree

Gas exchange responses of xylem-tapping mistletoes to variations in host physiology. J.D. Marshall

Water sources and water status of Utah juniper growing in southwestern Utah. J.D. Marshall

Groundwater dependence of perennials of southwestern Utah. J.D. Marshall

Assimilation of nitric acid vapor deposited on conifer foliage. J.D. Marshall

Maintenance respiration response of soybean and Norway spruce to ozone exposure. J.D. Marshall

Solution fluxes of organic carbon and nutrients from woody debris in regenerating clearcut forest. K.G. Mattson, W.T. Swank

Changes in forest structure in the balsam fir and spruce-fir forests of Mt. Mossilanke, New Hampshire. K.G. Mattson, G.E. Lang, W.E. Reiners

The feasibility of transactions evidence analysis for state timber sale appraisal. C.W. McKetta

The potential of ranch recreation to diversify small farm income. C.W. McKetta

Forest nutrient management in the Inland Empire. J.A. Moore

Forest fertilization and nutrient management in the Intermountain Northwest. J.A. Moore, P.G. Mika

First-year coppice of *Quercus emoryi* sarg. in the Huachuca Mountains, Arizona. J.W. Meyer, A.M. Lynch, P. Morgan

Status of whitebark pine in the northern Rocky Mountains. R.E. Keane, P. Morgan

Ecology and management of interior Douglas-fir. P. Morgan, J.E. Lotan

Ecology and management of ponderosa pine. P. Morgan, J.E. Lotan

Assessing alternative hazard fuel treatments in the wildland/development interface of Grand Teton National Park, Wyoming. H. Yamane, P. Morgan

Hazard fuel management planning in the wildland/development interface of Grand Teton National Park, Wyoming. H. Yamane, P. Morgan

Horselogging applied to the Group Selection Harvest Regeneration Method: a production and feasibility assessment. H.L. Osborne

Thinning and other intermediate stand treatments to promote stand management and provide material usable as fuelwood. H.L. Osborne

A soil survey of the University of Idaho Experimental Forest. H.L. Osborne

Herbicide potential for managing forest vegetation: chemicals suitable for site preparation and conifer release. H.L. Osborne

Farm tractor winching systems for woodlot management. H.L. Osborne

Vegetation control for ponderosa pine seedling establishment on Conservation Reserve Program lands. H.L. Osborne

Black stain root disease. A.D. Partridge

Nursery problems. A.D. Partridge

Rural economic impact assessment and intercommunity input-output analysis: the west-central Idaho highlands timber economy. M.H. Robison

Modeling a community economy in transition: The case of Riggins, Idaho. M.H. Robison, C.C. Harris

Micropropagation of bitterbrush. M.R. Mousseaux, C.M. Stiff, M. Hironaka

Volume and taper equations for commercial forest species in the Intermountain Northwest. C.T. Stiff

Recovering forest stand structure from aerial photography. C.T. Stiff

Composite estimators for predicting individual tree height. C.T. Stiff, J. Newberry, A. Samih

Simultaneous height and diameter increment models for second growth Douglas-fir in the Inland Northwest. C.T. Stiff, J.A. Moore, W. Zhang

The northern Rocky Mountain version of the Timber Resource Inventory Model (TRIM). C.T. Stiff, C.W. McKetta, R.O. Barkley

An evaluation and comparison of two distance-independent forest projection models in the Inland Northwest. C.T. Stiff, D.A. Patterson

Evaluating user group psychological profiles to enhance computer interfaces. M.W. Stock, E.A. Kersey

Factors influencing computer use by natural resource professionals. M.W. Stock, E.A. Kersey

Expert systems for silviculture. L.A. Amell, M.W. Stock

Estimating the risk of prescribed fire. M.W. Stock

Predicting the spread of wilderness fires. M.W. Stock

Psychological profiles of foresters. M.W. Stock, E.A. Kersey

Computer use by foresters. M.W. Stock, E.A. Kersey

Ecosystem dynamics under stress. K.J. Stoszek

Planning aerial photo projects: especially small format. J.J. Ulliman

Vegetation community mapping and changes along the Snake River, Idaho Border to Henrys Fork, for 1940, 1960 and 1983 photoperiods. J.J. Ulliman

A comparison of operational methods for compiling road centerlines on large scale line maps. J.J. Ulliman, J.V. Johnson

Feature matching in Triangular Irregular Network (TIN) data processing. A. Fahsi, J.J. Ulliman

Using digital elevation model data in a geographic information systems to correct for topographical influences in synthetic aperature radar data. M. El Meslouhi, J.J. Ulliman

Interactions between fungal root diseases and coniferous forest vegetation. R.G. Balice, J.J. Ulliman

Containerized seedling sowing template utilizing LOTUS 1-2-3[r]. D.L. Wenny

Root development of containerized ponderosa pine: a comparison between non-treated and chemically root-pruned seedlings. D.L. Wenny, Z. Wang

A growing regime for container-grown Douglas-fir. D.L. Wenny, R.K. Dumroese

A growing regime for container-grown spruces. D.L. Wenny, R.K. Dumroese

A growing regime for container-grown western redcedar. D.L. Wenny, R.K. Dumroese

A growing regime for container-grown Scotch and Austrian pine. D.L. Wenny, R.K. Dumroese

Responses of container-grown Douglas-fir seedlings to varying potassium and nitrogen fertilization regimes. R. Kingsbury, D.L. Wenny

Inducing long-shoot growth for vegetative propagation of western larch. J.L. Edson, D.L. Wenny, L. Fins

Propagation of western larch by stem cuttings. J.L. Edson, D.L. Wenny, L. Fins

Growth and form of western larch rooted cuttings. J.L. Edson, D.L. Wenny

Applying foliar fertilizers to container-grown ponderosa pine and Douglas-fir seedlings. M.E. Montville, D.L. Wenny

The production of cottonwood and hybrid poplar for wafer wood and firewood. D.R. White

Provenance testing for concolor fir. D.R. White

Provenance testing for Scotch pine seed sources. D.R. White

Fertilizer study for tree reproduction. D.R. White

Pelletized fertilizer test in grand fir, concolor fir, Fraser fir, and western white pine. D.R. White

Field testing bud-guides on grand fir christmas trees. D.R. White

Department of Range Resources

A study on the post fire defoliation response of bluebunch wheatgrass and bottlebrush squirreltail. S.J. Jirik, S.C. Bunting

Fire effects in whitebark pine forests. S.C. Bunting, P. Morgan

Interaction of heat and soil moisture on determining fire effects on bluebunch wheatgrass. P. Balatsos, S.C. Bunting

Fire effects on Caldenal vegetation, central Argentina. S.C. Bunting, R.M. Boo

Fire effects on soils of western juniper woodlands. S.C. Bunting, R.M. Josaitis, V.A. Miller

Hybridization of shrubs to restore southern Idaho burned rangelands. M. Hironaka

Developing native shrub cultivars for the Northern Great Basin. M. Hironaka, S.C. Bunting

Bureau of Land Management riparian policy in Idaho: analysis of public comment on the draft statement. K.L. Johnson, Policy Analysis Group (PAG)

The effect of cattle grazing on ponderosa pine regeneration. J.L. Kingery, R.T. Graham

Sheep grazing as a silvicultural tool in conifer plantations. J.L. Kingery, J.C. Mosley, H.L. Osborne

Diet nutrient quality of elk inhabiting a semi-arid environment. J.C. Mosley, D.C. Strohmeyer

Feeding stations and biting rates of cattle as indicators of diet nutrient quality. J.C. Mosley, G.B. Ruyle, R.W. Rice

Habitat use and diet selection by Chihuahuan pronghorns. J.C. Mosley, E.L. Smith, K. Bahti

Tree establishment and development patterns within a pinyon-juniper woodland. J.C. Mosley, D.W. Despain

Influence of streamside residual herbage on stream water quality. J.C. Mosley, D.E. Lucas, J.W. Walker

The influence of solar radiation and environmental variation on subarctic and arctic plant species (Fulbright Scholar Program). R. Robberecht

The effect of interspecific plant competition on the productivity of tree seedlings during the regeneration of forest stands. R. Robberecht

Short duration grazing system on crested wheatgrass. K.D. Sanders

Control of broom snakeweed on rangelands. K.D. Sanders, J.C. Mosley

Effect of fire on site preparation for natural conifer regeneration. L.F. Neuenschwander

Economics of public land grazing and multiple use. K.D. Sanders

Effects of drought on crested wheatgrass. K.D. Sanders

Reseeding arid rangelands. K.D. Sanders

Department of Wildland Recreation Management

Transference of environmental education to Costa Rican families by school children. S.H. Ham

Environmental interpretive methods: a guide for parks with big ideas and small budgets. S.H. Ham

Situational analysis for environmental education development in rural Honduras. S.H. Ham

Developing a knowledge-based system for improved amenity-resource valuation. C.C. Harris, W.J. McLaughlin

The role of resource-based tourism in development of rural communities in Idaho. C.C. Harris, M.H. Robison

Comprehensive assessment of the benefits of wildland recreation for Idaho's economy. C.C. Harris

Summary of progress in implementation of the five-year federal interagency wilderness management program. E.E. Krumpe

Increasing the predictability of leisure choice models. E.E. Krumpe

The role of information in planning and management of recreation and tourist services. E.E. Krumpe

An international perspective for understanding wilderness management. E.E. Krumpe

Linking wilderness to rural revitalization. W.J. McLaughlin, E.E. Krumpe

Fish, wildlife and recreation and tourism potential of Box Canyon Reservoir. W.J. McLaughlin, D.H. Bennett, C.M. Falter, K.P. Reese, N. Sanyal

Motivations for participating in forest land use planning. W.J. McLaughlin, J.E. Force

Lower Salmon River planning. W.J. McLaughlin

Case study of the economic development and nature conservation programs used in French regional natural parks. W.J. McLaughlin

Rural tourism planning and development. W.J. McLaughlin

Idaho rifle elk hunting survey. N. Sanyal

Idaho rifle deer hunting survey. N. Sanyal

Idaho shotgun hunting survey. N. Sanyal

Master's Theses

Budeau, David. Energy dynamics, foraging ecology, and behavior of prenesting greater white-fronted geese on the Yokon-Kuskokwim Delta, Alaska. *Major professor: J. Ratti*

Byrd, George Vernon, Jr. Seabirds in the Pribilof Islands, Alaska: Trends and monitoring methods. *Major professor: J. Scott*

Castillo Ruiz, Eugenia Lizeth. Situational analysis for environmental education in rural Honduran elementary schools. *Major professor: S. Ham*

Daa, Mohamed. Effect of fall planting time on survival and growth of container-grown Douglas-fir, western white pine and ponderosa pine seedlings in northern Idaho. *Major professor: D. Adams*

Fahsi, Ahmed. The effect of spatial resolution of digital elevation model data on map characteristics. *Major professor: J. Ulliman*

Hammoudi, Abdelaziz. Effect of planning period specifications on timber harvest scheduling using linear programming. *Major professor: D. Adams*

Head, John Dean. Container culture of ponderosa pine: The effect of shortened seasons and artificially accelerated growth. *Major professor: C. Hatch*

Hemin, Zhang. The condition of nature reserves in China. *Major professor: G. Machlis*

Hughes, Michael M. Recovery and processing of chunkwood from logging residue and whole trees in northeast Washington. *Major professor: L. Johnson*

Jirik, Steven. A study on the post-fire defoliation response of *Agropyron spicatum* and *Sitanion hystrix*. *Major professor: S. Bunting*

Johansen, Ole J. Lynx winter habitat selection in Central Troms County, Northern Norway. *Major professor: O. Garton*

Kingsbury, Ralph W. Responses of container-grown Douglas-fir seedlings to varying potassium and nitrogen fertilization regimes. *Major professor: D. Wenny*

Meinke, Paul. Effect of nitrogen fertilization on hybrid poplar growth. *Major professor: H. Loewenstein*

Miller, Tracy. A survey of taxpayer opinions about Idaho's Nongame Wildlife and Tax Checkoff Program. *Major professor: C. Harris*

Musil, David D. Movements, survival, and habitat use of sage grouse translocated into the Sawtooth Valley, Idaho. *Major professor: K. Reese*

Rohlman, Jeffrey A. Black bear ecology near Priest Lake, Idaho. *Major professor: M. Hornocker*

Roscoe, Kirsten C. Analysis of cattle, deer and elk diets on cutover areas in northern Idaho. *Major professor: J. Kingery*

Saphra, Irene. Modeling variable fuels, fire behavior, and fire effects in uneven-aged ponderosa pine stands. *Major professor: P. Morgan*

Smith Badame, Shirley A. An objective approach to determine avian management indicator species for the Wasatch National Forest, Utah. *Major professor: W. Kessler*

Tayyib, Zarnigar Amal. Implications of fuelwood use by Afghan refugees in the Northwest Frontier Province, Pakistan. *Major professor: D. Adams*

Timko, Sharon E. Sources of information used by leisure travelers: Profiling by trip and sociodemographic characteristics. *Major professor: C. Harris*

Zida, Bertrand Ouiraogo. Cost benefit analysis for fuelwood project investment in Burkina Faso: The case of Ouagadougou. *Major professor: J.E. Force*

Ph.D. Dissertations

Bertagnole, Catherine Lee. Interacting fungi and bark beetles (*Coleoptera: Scolytidae)* associated with black-stain root disease of ponderosa pine. *Major professor: A. Partridge*

Crabtree, Robert L. Sociodemography of an unexploited coyote population. *Major professor: E. Ables*

DeStefano, Stephen. Ecological relationships of lead exposure in Canada geese of the Eastern Prairie population. *Major professor: M. Hornocker*

Dobson, Janice L. Autecology of aquatic and terrestrial growth forms of *Arctophila fulva,* an arctic tundra grass of northern Alaska. *Major professor: R. Robberecht*

Hayward, Gregory D. Habitat use and population biology of boreal owls in the northern Rocky Mountains, USA. *Major professor: O. Garton*

Maganga, Samwel L.S. Bark-stripping and food habits of blue monkeys in a forest plantation on Mount Meru, Tanzania. *Major professor: R.G. Wright*

Nurkin, Baharuddin. Soil factors related to teak plantation site quality in the Madiun Forest region of eastern Java, Indonesia. *Major professor: H. Loewenstein*

Real, Pedro L. An individual tree taper system for Douglas-fir in the Inland Northwest. *Major professor: J. Moore*

Rimbey, Neil R. The economics of the Challis Experimental Stewardship Program. *Major professor: L. Sharp*

Saveland, James M. Knowledge-based systems approach to wilderness fire management. *Major professor: M. Stock*

Stiff, Carol M. In vitro propagation of western white pine using needle fascicles. *Major professor: D. Wenny*

Continuing Education and Outreach

Faculty in the College of Forestry, Wildlife and Range Sciences conduct continuing education programs for natural resource professionals and outreach programs for the public on campus, at the Clark Fork and McCall Field Campuses, and throughout Idaho and the West. The college offered the following continuing education and outreach programs during 1989. Most programs scheduled for 1990 are also listed.

More information is available from Continuing Education, College of of Forestry, Wildlife and Range Sciences, Moscow, Idaho 83843; (208) 885-6441.

Continuing Education

1989

January 23-27	Statistical Methods and Data Analysis for Wildlife and Fisheries Biologists—Moscow
February 11	Idaho Logging Safety Awareness Committee Safety Training Session—Moscow
February 13-24	Forest Regeneration and Site Preparation—Moscow
February 16	Inland Empire Tree Improvement Cooperative Annual Meeting and Workshop—Taking Advantage of Genetic Gain: Tree Improvement and Regeneration—Post Falls
March	North Central Idaho Woodland Workshop—Lewiston
March 1-2	The Sixth Annual Inland Empire Forest Engineering Conference—Moscow
March 3	Designing with Wood—Post Falls
March 6-17	Leadership and Communication Workshop—Moscow
March 6-24	Log Scaling School—Lewis and Clark State College, Lewiston
March 8-9	Coordinated Range Management Workshop—Boise
March 28	Idaho Woodland Council—Moscow
March 31-April 2	Interpersonal Communication Skills for Natural Resource Professionals—Clark Fork
April-September	South Idaho Spring Diagnostic Tours—Emmett, Boise, Twin Falls, Burley, Pocatello
April 7	Designing with Wood—Ketchum
April 7	Log Scaling Workshop—Princeton
April 7	Log Scaling and Manufacturing Workshop—Potlatch
April 17-21	Executive Leadership of Political and Social Forces in Natural Resources—Moscow
May 15-17	Northwest Wood Products Clinic—Spokane, Washington
May 15-19	Microcomputer Applications in Wildlife and Fisheries Biology—Moscow
May 22-June 30	Organization and Project Management for International Natural Resource Professionals (Pakistan Forest Service)—Moscow
May 24-25	Forestry Advisors' Workshop—Moscow
June 12-17	Annual Central Idaho Natural Resources Workshop for School Teachers—Ketchum
June 12-July 21	Land Use Planning: Integration of Natural Resource Management and Food Production (sponsored by Department of Agriculture)—Moscow
June 18-24	Annual Central Idaho Natural Resources Workshop for School Teachers—Harrison
June 20	Nursery Soils Management Workshop—Coeur d'Alene
June 22-26	Long Term Ecological Studies of Birds (Cooper Ornithological Society Symposium)—Moscow
July	Woodland Field Tour Workshops—Moscow, Bonners Ferry, Sandpoint, St. Maries, Coeur d'Alene
July 9-15	Fish and Wildlife Ecology Workshop—McCall
July 18	Indian Forest Products Development Workshop—Seattle, Washington
July 20	Indian Forest Products Development Workshop—Coeur d'Alene
August 8-10	University of Idaho Log Furniture Workshop—McCall
August/September	Urban Forest Problems Workshops—Emmett, Pocatello
August/September	Nursery Problems Workshop—Twin Falls
August/September	Idaho Tree Problems Workshop—Boise
September 1-October 27	University of Idaho/Honduras Forestry Field Training Course—Moscow
October	South Idaho Christmas Tree Workshop—Boise
October 5	Timber Bridge Design Workshop—Coeur d'Alene
October 16-20	Eighth Annual Dry Kiln Workshop—Moscow
October 23-November 10	CEFES: Continuing Education in Forest Ecology Land Silviculture—Moscow
November 28	Idaho Logging Safety Awareness Committee Workshop—Moscow
Ongoing	Project WILD Workshops (for teachers)
Ongoing	Project Learning Tree Workshops (for teachers)

1990

January	Coordinated Resource Management—Boise
February 7	Intensive Grazing Systems—Arco
February 15	Marketing Basics for Public Land Managers (in cooperation with Montana State University)—Boise
February 21	Range Monitoring Workshop—Twin Falls
February 28-March 1	The Seventh Annual Inland Empire Forest Engineering Conference—Moscow
March 5-16	Leadership and Communication Workshop—Moscow
March 13	Woodland Marketing Workshop—Lewis and Clark State College, Lewiston
March 15-16	Inland Empire Timber Improvement Cooperative Annual Meeting and Workshop—Post Falls

March 19-23	Tribal Forest Products Enterprise Shortcourse Series: Introduction to Forest Products Enterprise Business and Feasibility Studies (in cooperation with Bureau of Indian Affairs)—Moscow
April 2-May 13	Bolivian Forester Training Course—Moscow
April 5	Planning for Drought (Range Workshop)—Salmon
April 6	Planning for Drought—Challis
April 6-8	Interpersonal Communications for Students and Professionals in Natural Resources—Clark Fork
April 9-13	Executive Leadership of Political and Social Forces in Natural Resources—Moscow
April 10-12	Forest Soil Productivity and Management Symposium—Boise
April 11	Planning for Drought (Range Workshop)—Arco
April 23-27	Tribal Forest Products Enterprise Shortcourse Series: Introduction to Forest Products (in cooperation with Bureau of Indian Affairs)—Moscow
April 24	Log Scaling and Manufacturing Workshop—Kueterville
June	Log Scaling and Manufacturing Workshop—Princeton
June 4-8	Tribal Forest Products Enterprise Shortcourse Series: Forest Products Enterprise Development and Feasibility Studies (in cooperation with Bureau of Indian Affairs)—Moscow
June 7-8	Range Monitoring Workshop—Mountain City, Nevada
June 11-15	Wood Products Academy—Moscow
June 11-16	Natural Resources Conservation Workshop—Ketchum
June 11-July 20	Land Use Planning for Community Forestry and Natural Resource Development—Moscow
June 17-23	Natural Resources Conservation Workshop—Harrison
June 25-August 3	Training Program for Southeast Asia Wildlife Preserve Managers—Moscow
July	Uneven-Aged Management Workshop (in cooperation with Oregon State University)—LaGrande, Oregon
July	Wood Pellet Manufacturing Short Course (tentative)—McCall
July 9-13	Fish and Wildlife Ecology Workshop I (for teachers)—McCall
July 16-20	Fish and Wildlife Ecology Workshop II (for teachers)—McCall
August 1-September 26	University of Idaho/Honduras Forestry Field Training Course—Moscow
August 13-18	Costa Rican Environmental Educators' Course—McCall
September-December	Range Monitoring Workshops (tentative)—Salmon, Challis, Arco
October 8-12	Ninth Annual Dry Kiln Workshop—Moscow
October 14-17	2nd International Inorganic Bonded Wood and Fiber Composite Materials Conference—Moscow
October 15-26	Forest Regeneration and Site Preparation—Moscow
Ongoing	Project WILD Workshops (for teachers)
Ongoing	Project Learning Tree Workshops (for teachers)

Outreach

1989

January 14-15	Animal Tracks and Winter Ecology—Clark Fork
February 22	Fire in the Urban-Wildland Interface: Could Moscow Mountain Burn Like Yellowstone? (panel discussion)—Moscow
February 25	Beginning Fly Tying and Casting—Clark Fork
March 4	North Central Idaho Woodland Workshop for Private Landowners and Advisors—Lewiston
March 18	Panhandle Country Fishing—Clark Fork
April 1	Wetland Ecology and Water Birds—Clark Fork
April 6-17	International Week Centennial Lecture: Global Deforestation—Echoes of the Sound Nobody Hears—Moscow
May 6	Community Forestry Day—University of Idaho Experimental Forest
June 5-8	Hoofed Mammals of Grand Teton and Yellowstone National Parks—Teton Science School, Kelly, Wyoming
June 5-9	Grizzly Bear Biology, Ecology, and Management—Yellowstone National Park
June 10-11	Elk of Yellowstone: Biology and Ecology—Yellowstone National Park
June 13-16	Eagles and Hawks of Greater Yellowstone—Teton Science School, Kelly, Wyoming
June 13-17	Large Mammals of Yellowstone—Yellowstone National Park
June 17	Mushroom Identification—McCall
June 21-23	The Greater Yellowstone Ecosystem—Teton Science School, Kelly, Wyoming
June 24-25	Getting Published—Clark Fork
June 24-27	Interpreting Tracks and Sign—Teton Science School, Kelly, Wyoming
June 24-27	Field Botany: Flora of the Tetons—Teton Science School, Kelly, Wyoming
July 3-7	Illustrating from Nature—Teton Science School, Kelly, Wyoming
July 8-9	Wild Flower Identification—McCall
July 9-15	Elderhostel: Wild Country Botanizing—Clark Fork
July 14-15	Animal Behavior—Teton Science School, Kelly, Wyoming
July 15	Wild Flower Identification—McCall
July 16-21	Alpine Ecology—Teton Science School, Kelly, Wyoming

July 16-21	Elderhostel: The Wild Nature of Idaho—McCall
July 22-25	Pattern in Nature—Teton Science School, Kelly, Wyoming
July 26-28	River Channels—Teton Science School, Kelly, Wyoming
July 29	Archaeology and History of McCall—McCall
July 30	History of the Pend Oreille Country—Clark Fork
July 30-August 3	Natural Science Illustration—Teton Science School, Kelly, Wyoming
July 31-August 4	An Island Ecosystem: Conserving Biological Diversity in the Greater Yellowstone—Teton Science School, Kelly, Wyoming
August 2-4	Wildfire: Fire Ecology of the Greater Yellowstone—Teton Science School, Kelly, Wyoming
August 12-13	Wildland Photography—McCall
August 13-17	Ecology Through the Lens—Teton Science School, Kelly, Wyoming
August 14-18	Landscape Watercolor Painting—McCall
August 19-20	Outdoor and Nature Photography—Clark Fork
August 19-20	Writing Workshop: How to Get Published—McCall
August 24-25	Wildland Photography—McCall
August 26-27	Payette Lakes: The Story of Ancient Glacier Bulldozers—McCall
September 1-3	Wildlife Management Policies and Practices—Teton Science School, Kelly, Wyoming
September 9-10	History and Archaeology of Long Valley—McCall
September 18	Research Presentation: The Future of Hells Canyon—McCall
October 21	Fossil Collecting and Geologic Tour of the Lake Pend Oreille Area—Clark Fork
November 11	Herb and Herb Crafts—Clark Fork

1990

March 3	Animal Tracks and Winter Ecology—Clark Fork
March 17	North Idaho Fishing—Clark Fork
April 21	Advanced Fly Tying and Casting—Clark Fork
May 19	For Bird Lovers Only—Clark Fork
June 2	Wildflowers—Clark Fork
June 9-12	Grizzly Bear Ecology and Management—Yellowstone National Park
June 11-12	Elk of Yellowstone: Biology and Ecology—Yellowstone National Park
June 13-15	Eagles and Ospreys of the Greater Yellowstone—Teton Science School, Kelly, Wyoming
June 13-17	Behavior of Ungulates—Yellowstone National Park
June 21-24	Field Botany: Teton Flora—Teton Science School, Kelly, Wyoming
June 23-24	Getting Published—Clark Fork
June 23-26	Interpreting Animal Tracks and Sign—Teton Science School, Kelly, Wyoming
July 9-11	Rocky Mountain Wildflower Photography—McCall
July 15-20	Alpine Ecology—Teton Science School, Kelly, Wyoming
July 15-21	Elderhostel: Wild Country Botanizing—Clark Fork
July 15-21	Elderhostel: Lake Pend Oreille Geology and Ecology—Clark Fork
July 15-21	Elderhostel: Forests and Forest Management—Clark Fork
July 17	History and Archaeology of Warren's Chinese Occupation—McCall
July 21-22	Wildflower Identification—McCall
July 22-25	Pattern in Nature—Teton Science School, Kelly, Wyoming
July 22-28	Elderhostel: Plant and Animal Communities of Central Idaho—McCall
July 22-28	Elderhostel: Nature Photography—McCall
July 22-28	Elderhostel: Idaho's Wild Lands: Challenges for the Future—McCall
July 23-27	Elderhostel: The Wild Nature of Idaho—McCall
July 25-27	River Channels—Teton Science School, Kelly, Wyoming
July 30-August 3	Understanding Animal Behavior—Teton Science School, Kelly, Wyoming
July 30-August 3	Natural Science Illustration—Teton Science School, Kelly, Wyoming
August 11	History of North Idaho Railroads—Clark Fork
August 27-29	Alpine Landscape Photography—McCall
September 8	North Idaho Folklore—Clark Fork
September 17-21	Elderhostel: Celebrating Idaho's Centennial—McCall
September 22 (or 23)	Fossil Collecting and Geologic Tour of the Lake Pend Oreille Area—Clark Fork
October 4-6	Fall Colors of the High Country Photography—McCall
October 6	Wetland Ecology and Water Birds—Clark Fork
October 20	Rocks, Rocks and Minerals—Clark Fork
November 3	Astronomy—Clark Fork

Agency and Funding Support

Agency for International Development
Agriculture Research Service
AID Bureau for Science and Technology
Alaska Fish and Game Department
American Forest Institute
Bennett Lumber Company
Boise Cascade Corporation
Boise National Forest
Bonneville Power Administration
Champion Timberlands
Clearwater National Forest
Clearwater Potlatch Timber Protective Association, Inc.
Clearwater Resource Conservation and Development Council
Colorado State University
Colville Confederated Tribes
Consortium for International Development
Cooperative State Research Service
Crown Zellerbach
Curt Berklund
Diamond International Corporation
Energy/Development International
Environmental Protection Agency
Flathead National Forest
Foundation for North American Wild Sheep
Glacier National Park
Government of Honduras
Idaho Department of Commerce
Idaho Department of Fish and Game
Idaho Department of Health and Welfare
Idaho Department of Lands
Idaho Department of Parks and Recreation
Idaho Fish Food Industry
Idaho Forest Industries
Idaho National Engineering Laboratory
Idaho Nuclear Energy Commission
Idaho Power Company
Idaho Research Foundation, Inc.
Idaho Travel Council
Idaho Water Resources Board
Idaho Water Resources Research Institute
Inland Empire Paper Company
Inland Empire Tree Improvement Cooperative
Inland Northwest Growth and Yield Cooperative
International Society of Arboriculture
Lake Superior Construction, Inc.
Lake Superior Forest Products, Inc.
Mississippi State University
Montana Fish and Wildlife
Montana State University
National Aeronautics and Space Administration
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
National Wildlife Federation
North Idaho Forestry Association
Oregon State University
Pacific Northwest Power Company
Pack River Lumber Company
Payette National Forest
Potlatch Corporation
PUD #1, Pend Oreille County
Roger Guernsey
Rust International Corporation
St. Regis Paper Company
South Idaho Forestry Association
Stillinger Trust
The Wildlife Society
U.S. Army Corps of Engineers
USDA Cooperative Research
USDA Extension Service
USDA Forest Service, Intermountain Forest and Range Experiment Station
USDA Forest Service, Northeastern Forest Experiment Station
USDA Forest Service, Pacific Northwest Forest and Range Experiment Station
USDA Office of International Cooperation and Development
U.S. Department of Commerce
U.S. Department of Energy
U.S. Department of Navy/Naval Undersea Center
USDI Bureau of Indian Affairs
USDI Bureau of Land Management
USDI Bureau of Reclamation
USDI Fish and Wildlife Service
USDI National Park Service
Universidad Nacional Republica de Costa Rica
University of Alaska
University of California
University of Edinburgh
University of Idaho Experimental Forest
University of Idaho Forest Research Nursery
University of Minnesota
University of Montana
University of Washington
Washington State Department of Natural Resources
Washington State University
Washington Water Power Company
Western Forestry and Conservation Association
Weyerhaeuser Company
Wildlife Management Institute
Winrock International Institute

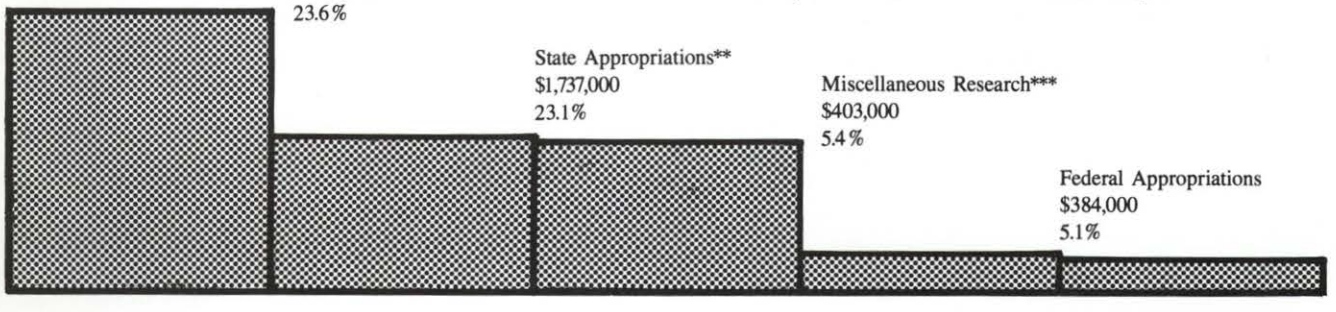
Fiscal Year 1989 Financial Picture

Research expenditures, shown by funding source, totaled $7,510,000 for the fiscal year 1988-89.

*Includes overhead allowances, external matching, outside federal unit support, and external cooperative research support

**Includes FWR Experiment Station, Wildlife, Wilderness, and Forest Utilization Research

***Includes Forest Research Nursery, Experimental Forest, Idaho Research Foundation, Taylor Ranch, and Clark Fork Field Campus



Productivity: 1986-1989

	Departments					
	Fish & Wildlife Resources	**Forest Products**	**Forest Resources**	**Range Resources**	**Wildland Recreation Management**	**Total**
1986						
Books	2	0	2	1	1	6
Chapters in Books	9	0	2	1	0	12
Refereed Publications	11	13	30	13	2	69
Other Publications	2	10	40	5	16	73
1987						
Research FTE's[1]	2.5	1.9	6.4	1.5	0.7	13
Books	0	0	2	0	1	3
Chapters in Books	0	0	2	2	2	6
Refereed Publications	34	9	30	7	4	84
Other Publications	6	9	38	11	3	67
1988						
Research FTE's	2.5	1.9	6.4	1.5	0.7	13
Books	0	0	2	0	0	2
Chapters in Books	1	0	2	0	1	4
Refereed Publications	20	6	25	4	4	59
Other Publications	27	15	56	1	17	116
1989						
Research FTE's	2.5	1.9	6.4	1.5	0.7	13
Books	0	0	2	0	0	2
Chapters in Books	6	7	11	9	3	36
Refereed Publications	18	9	23	4	7	61
Other Publications	30	11	46	5	26	118

[1] FTE = the equivalent of one full-time researcher paid by the state of Idaho

Since its inception in 1909, the College of Forestry, Wildlife and Range Sciences at the University of Idaho has become one of the oldest and most highly regarded natural resource schools in the United States. As part of the state's land grant institution, the college serves the state through teaching, research, and service. College research is administered through the Idaho Forest, Wildlife and Range Experiment Station, established by the Idaho Legislature in 1939 to conduct research on the state's renewable resources.

The experiment station has the equivalent of 13 full-time researchers funded by the state of Idaho. However, all 67 of the college's faculty members conduct research, as do most of its 173 graduate students. The faculty spend about one-third of their time on research, much of it paid for through outside grants and contracts.

During the 1989 fiscal year, income from outside grants and contracts totalled $3.1 million. State appropriations for research at the experiment station amounted to an additional $1.55 million. For every dollar appropriated by the state for experiment station research during fiscal 1989, faculty grants and contracts brought in $2.00.

Changes: 1985-1989

	1985 vs. 1989 Percent Change	**5-year Total**
Graduate Student Enrollment	+6%	—
Outside Grants & Contracts[2]	+55%	$13 .4 million
Books	—33%	16
Chapters in Books	+620%	63
Refereed Publications	+42%	316
Other Publications	+69%	444

[2] Fiscal years

From the Director

John C. Hendee

Launching a New Decade in Resource Management

As the University of Idaho begins its second century, we in the College of Forestry, Wildlife and Range Sciences share with you our pride in being one of the world's leading natural resource schools. Continuing our tradition of hands-on training and academic excellence, our five departments currently accommodate 338 undergraduate and 173 graduate students from 35 nations and 46 states.

Our college's facilities include an experimental forest which is used for classes, demonstrations, and research studies and which produces annual timber harvests of about two million board feet. Our forest research nursery produces 850,000 seedlings each year, serves as a full-scale research laboratory, and provides nursery management training for our students and the state's nursery industry. Other facilities include field campuses at Clark Fork and McCall, the Taylor Ranch Field Station in the Frank Church-River of No Return Wilderness, and the Lee A. Sharp Experimental Area for range studies located near Malta.

The 1990s promise to be an exciting decade in our college. This past year marked the arrival and orientation of a new university president who has displayed a keen interest in enhancing Idaho's natural resources—Elisabeth Zinser. President Zinser has already toured northern Idaho with our college's administrators and Guidance Council members, has met with many of our college advisors and supporters, and has personally reviewed our facilities and building requests. We are pleased to have the interest and support of our new president.

During the past year, we wrapped up the University of Idaho Centennial Campaign, the university's first-ever major fundraising effort. In our own college, we strengthened student scholarship endowments and launched a new Wood Use and Design initiative to stimulate the state's forest and design industries. You were very generous in supporting our programs; we appreciate your ongoing contributions of time, money, and advice.

The past year saw funding also for the newly created Policy Analysis Group, and a grant from the Bonneville Power Administration for development of a new aquaculture wet lab in Moscow. In response to the near elimination of our college nursery by the legislature five years ago, our two years of increased funding proposals and development of a joint research plan with Idaho's seedling industry were rewarded in 1989 with funding for a new seedling initiative, a program which will expand our capability to use tissue culture methods to propagate genetically improved trees and shrubs.

We also committed to building future initiatives focused on riparian ecosystem management; a demonstration of Adaptive Forestry—our contribution to New Forestry approaches for strengthening ecological balance in forest management; and an initiative on forest productivity—a plan to enhance long-term forest productivity and health in cooperation with an intermountain research council of public, private, and industry representatives. In 1989 we became a member of the Raptor Research Technical Assistance Center at Boise State University in cooperation with the USDI Bureau of Land Management and Fish and Wildlife Service, Idaho Fish and Game, and the Peregrine Fund. Ideally located near the Birds of Prey Natural Area, the new technical assistance center is designed to provide international leadership in raptor research.

In addition, we committed to expanding "distance education" activities that will take FWR educational programs all across Idaho. Ernest Ables will coordinate activities that include FWR-taught classes and workshops and even transmission of classes throughout the state via satellite. Finally, we resolved to work with the state's varied tourism industries to find better ways to meet their needs and help launch Idaho's tourism industry into the 21st century.

The college is beginning an exciting decade that will bring great changes to the way we manage our state's natural resources. If you would like to discuss these and other issues, please feel free to write or call me or the associate director.

John C. Hendee

University of Idaho

University of Idaho

Idaho Forest, Wildlife and Range Experiment Station
College of Forestry, Wildlife and Range Sciences
Moscow, Idaho 83843

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