FOCUS
on Renewable Natural Resources

Idaho Forest, Wildlife and Range Experiment Station
Moscow, Idaho 83843
Volume 14

University of Idaho
College of Forestry,
Wildlife and Range Sciences

From the Assistant Director

Leon F. Neuenschwander

Programs with a future

When a college makes progress on more than 280 research projects in one year, it's tough to choose the few that will be featured in *Focus*, our annual report. This year we selected 17, drawn from all five of our departments: fish and wildlife resources, forest products, forest resources, range resources, and wildland recreation management. To sense our full scope, turn to the appendix for a list of all the college's research projects.

During 1988, five major research programs that promise long-term continuity were either expanded or begun. They pertain to water pollution, national park management, range restoration, preservation of biodiversity, and cold-water aquaculture.

One, a new biotreatment laboratory, moved into our basement complete with 400-gallon "bioreactors" to process paper mill waste. This laboratory, combined with upstairs chemistry and biological monitoring laboratories, has the ability to both cleanse organic industrial wastes and measure waste water quality and toxicity.

So far the laboratory has helped two pulp and paper mills to improve their proposed treatment systems. In the future, and as waste water regulations continue to toughen, we hope to help many industries solve their water pollution problems. There's more on the biotreatment laboratory on page 15.

The past year also brought the expansion of the college's Cooperative Park Studies Unit with the National Park Service. Unit Leader Gary Machlis, an associate professor of forest resources, has spent the past seven years developing and field testing an inexpensive and reliable method for surveying national park visitors in order to improve visitor services. In 1988, the National Park Service chose Machlis's technique to be applied at parks nationwide. The decision brought two full-time federal employees to the college to learn the technique and, during 1989, use it in seven parks.

In our range department, an appropriation from the United States Congress last year made it possible for Professor Minoru Hironaka to begin a long-term search for shrubs that will help restore southern Idaho's burned-over rangelands. Dr. Hironaka's goal is to produce shrubs that can sprout following fire, survive harsh growing conditions, and feed livestock and wildlife. None having all these qualities are known to exist, so Hironaka's strategy is to create them through hybridization. Hironaka is currently working with the college's tissue culturist to produce a steady supply of plants for his experiments.

During 1988 the college also gained the computer, software, and support equipment to use geographic information systems (GIS). GIS were developed for assembling and analyzing diverse data for specific geographic locations. J. Michael Scott, leader of the Idaho Cooperative Fish and Wildlife Research Unit, is using the GIS to learn how well biological diversity is currently protected in Idaho. He reports on his new conservation tool in this issue of *Focus*. We are hopeful that there will soon be funding to apply his approach to saving biodiversity nationwide.

Finally, the aquaculture program made great headway. Most important, we hired the program's first full-time leader. Dr. Ernest Brannon came to Idaho from the University of Washington, where he has supervised salmon aquaculture for the past 16 years. Dr. Brannon is now building an Idaho program of graduate studies, research, and extension to industry.

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

Leon F. Neuenschwander

FOCUS

Volume 14 May, 1989

College of Forestry, Wildlife and Range Sciences
Teaching
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Idaho Forest, Wildlife and Range Experiment Station

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Cover: These western white pine and Idaho hybrid poplar began life as stem cuttings and needle fascicles, respectively. Photographer Gerry Snyder made this picture of them and their grower, tissue culturist Carol Stiff. We have more on tissue culture and biotechnology at the college beginning on page 16.

1988 Annual Report

Research Highlights

Appendix

Preserving life on earth: a new approach

by J. Michael Scott

While the list of endangered, threatened, and sensitive species in North America is already depressingly long, it continues to grow. Today, as we reflect back over the 15 years since the passage of the federal Endangered Species Act, we see a chronicling of species loss at a level unforeseen by those responsible for the act.

Currently the U.S. Fish and Wildlife Service lists over 1,000 species as endangered or threatened. An additional 3,000 or so are identified as either Category One or Two species. In Category One are plants and animals for which sufficient information exists to propose listing, and in Category Two are those believed to be threatened or endangered but for which more data are required to meet the legal requirements for listing. There are predictions that before the end of this century the number of extinctions worldwide may reach 5,000 per year.

Thus, there should be little wonder over the frustration that resource professionals and concerned citizens feel when attempting to deal with endangered species issues. As the situation continues to worsen, frustrations and confrontations increase to the point where a sense of hopelessness prevails.

It is of great concern that even game species that are abundant today could be reduced to non-harvestable numbers or even endangerment in 100 years. These reductions will result largely from the predictable but avoidable loss of wildlife habitat through future patterns of land use and management. Thus, a greater challenge than recovering individual endangered species is ensuring the integrity of existing natural communities and ecosystems, thereby minimizing the number of species that become endangered.

In terms of protecting biodiversity, the bottom line is not whether we are able to recover the handful of species that are currently on the endangered species list, but what the overall richness of our flora and fauna will be in 100 years. Clearly, only a small fraction of Earth's biological diversity can be kept in cryogenic arks or in "protective custody." If biological diversity is to be saved, our focus must turn toward saving functioning ecosystems.

We do have a choice. We can continue focusing our efforts on the critically endangered through a single-species approach and have individual recovery efforts diluted each time a new plant or animal is added to the list. Or, we can proceed in a more positive direction by shifting *some* of our focus on individual endangered species to a more land-

Brad Griffith

J. Michael Scott cradles an endangered Hawaiian goose. Costly captive breeding has helped this species to make a limited comeback in the wild. Scott is working on a new tool to keep other species from ever becoming endangered.

based ecosystem approach aimed at conserving overall biological diversity.

We at the Idaho Cooperative Fish and Wildlife Research Unit are now testing one such land-based approach in Idaho. Cooperating in the study are The Nature Conservancy and the Idaho Departments of Fish and Game and Water Resources.

Idaho is blessed with a rich and diverse flora and fauna. Since the last Ice Age, there have been no species lost. As a result, we have the opportunity to protect the state's full range of biological diversity.

Our research uses a new method, called gap analysis, to assess the adequacy of existing Idaho preserves for protecting the state's biological diversity. Gap analysis depends on state-of-the-art computers and a computer-mapping tool, Geographic Information Systems (GIS). Using digitized maps of the state's vertebrate and vegetation type distributions, the GIS locates areas of "species richness."

By comparing the locations of species rich areas with the locations of existing preserves, the GIS can show where biological diversity already is well protected and where additional preserves will do the most good. For the purposes of the study, "preserves" are places where plants and animals are afforded some protection, places such as national parks, national wildlife refuges, and private preserves.

Questions addressed in the analysis would include the following: 1) Are existing preserves located in areas of high species richness? 2) Are threatened, endangered, or other species of special interest represented in protected areas? 3) What is the ownership status of species-rich areas? 4) What proportion of threatened, endangered, or sensitive species are protected in existing preserves? 5) How will changes in land use affect the number of species not found in protected areas? 6) What vegetation types are not found in protected areas? 7) What species occur in protected areas? 8) What species do not occur in protected areas? 9) Which species are represented in the largest number of protected areas? 10) Which species are represented in the smallest number of protected areas? 11) What set or sets of unprotected areas should be given protection to include a viable population of each species in at least one preserve? 12) Do adequate landscape corridors exist between areas of high species richness to provide for dispersal and interbreeding of populations?

Once the gap analysis for Idaho has been completed, then the process could be extended to regions and eventually continents. We already have begun a gap analysis of Oregon. Data obtained during the mapping and ground-truthing process could be incorporated into existing data banks such as The Nature Conservancy's Heritage Program.

In the final analysis, the success of efforts to retain biological diversity will be judged on the number of species surviving in the year 2100, not on whether we save the California condor or black-footed ferret in the next decade. Focusing on the protection of species-rich areas offers the most efficient and cost-effective way to retain maximum biological diversity in the minimum area.

We need to act now to identify species-rich areas so that we can initiate management actions that will reduce the number of species made critically endangered in the next century and beyond. Given the inevitability of further habitat loss, this strategy may be the only way to resolve conflicts between development and the preservation of genetic and species diversity.

J. Michael Scott, professor of wildlife resources and an employee of the U.S. Fish and Wildlife Service, is leader of the Idaho Cooperative Fish and Wildlife Research Unit at the College of Forestry, Wildlife and Range Sciences. His co-investigators include Hal Anderson, Tony Morse, and Michael Ciscell of the Idaho Department of Water Resources, Steve Caicco and Craig Groves of the Idaho Department of Fish and Game, and Joseph Ulliman and Blair Csuti of the College of Forestry, Wildlife and Range Sciences. *Funding and support for this project have been provided by the National Fish and Wildlife Foundation, the Idaho Departments of Fish and Game and Water Resources, the U.S. Fish and Wildlife Service, and the Idaho Chapter of The Nature Conservancy.*

Economic model to aid Idaho planners

by M. Henry Robison, Charles C. Harris, Robert L. Govett, and Scott A. Katzer

Idaho faces important land use and economic development questions. The U.S. Forest Service is forecasting a timber shortage in Idaho, especially southwest Idaho. How should the state and local communities plan and respond? And what is tourism's role in the Idaho economy, both locally and statewide, and how can it be enhanced? Another question is how to increase the value added to Idaho timber through wood products manufacturing. Making the best decisions will require the best information.

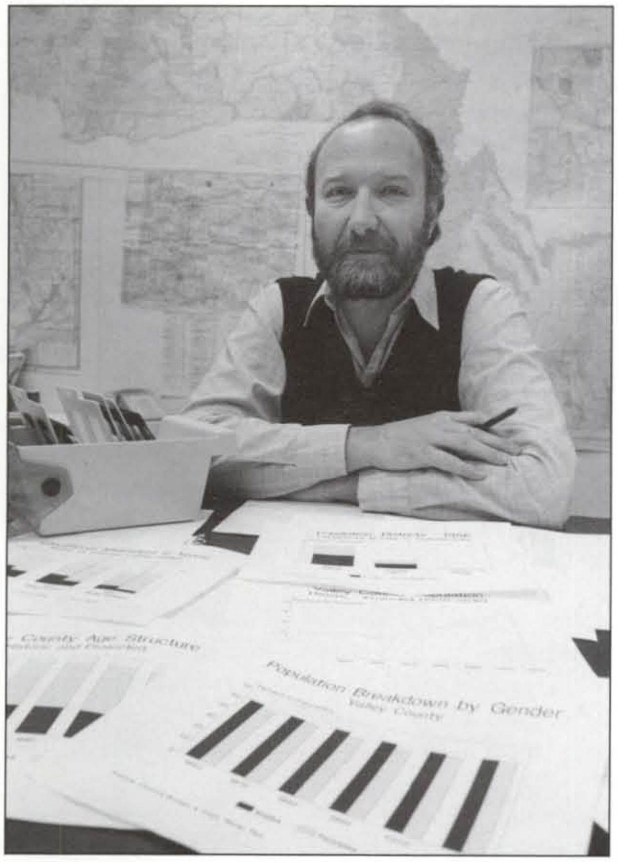
To provide Idaho decision makers with the best information, we are developing the Idaho Economic Modeling System (IDAEMS), a computerized economic and policy simulation model for Idaho. IDAEMS has two important functions: to describe Idaho's present economy and to simulate the economic effects of alternative policy actions.

IDAEMS models the entire state economy, capturing its sources of income, linkages among its industries, and particular trade relationships with neighboring state and regional economies. IDAEMS also models smaller-area and community economies, capturing their sources of income, fiscal structures, and dependence on particular industries and on other parts of the state economy.

Many decisions affecting Idaho's communities are made by the federal government, the U.S. Forest Service, for example. Forest Service land management planning includes an analysis of local economic impacts. However, as with medical advice, a second opinion never hurts. A shortcoming of Forest Service economic modeling is that it looks at broad, multicounty areas only. With its small-area and individual community focus, IDAEMS overcomes this shortcoming.

Explaining Idaho's total income in terms of "outside income" is a descriptive task of IDAEMS. Idaho doesn't coin its own money. Its source is the sale of goods to nonresidents—outside income. Idaho's total income results from outside income recirculating within the state through linked business and consumer spending.

The export of timber and other wood products is a longstanding source of Idaho income. Preliminary runs of IDAEMS indicate that in Idaho's 10 northern counties roughly 10 percent of all outside income comes from the export of wood products. Adding income linked through business and employee spending raises to nearly 30 per-



Gerry Snyder

M. Henry Robison uses demographic information as he models the present and possible future economies of Idaho's communities and the state at large.

cent the portion of northern Idaho income linked to timber.

The northern Idaho economy is simply an aggregation of individual community economies, and IDAEMS models these as well. Consider the economy of Sandpoint, site of Schweitzer Mountain Resort and other tourist attractions. The casual visitor might view Sandpoint as another tourist town, not unlike Jackson Hole, Wyoming, or Ketchum, Idaho. But IDAEMS indicates that the Sandpoint economy is driven by more than tourism. Sandpoint is the dominant trading center for Bonner County, in which nearly one-fifth of all northern Idaho wood products are manufactured. IDAEMS indicates a Sandpoint economy about equally dependent on tourism and wood products for income.

In its policy simulation role, IDAEMS is aiding in the college's timber value-added research. This research aims at identifying wood-using processes and products for which Idaho has some resource or economic advantage. IDAEMS indicates the value now added to Idaho timber from harvest through manufacture, the value that could be added by new processes and industries, and the overall economic impact of alternative strategies to boost value-added manufacturing. IDAEMS also indicates the manner in which new industry might attract other support industry.

IDAEMS's usefulness is not confined to timber issues. Suppose a large development, a ski resort or new manufacturing plant, is proposed for a small community. IDAEMS can predict its impact on community revenues and on expenditures for community infrastructure such as schools, roads, hospitals, police protection, and so on. If the community floats a bond to finance the expanded services, IDAEMS can estimate how long it will take to repay. And what if development plans prove overly optimistic? Will the associated community indebtedness bankrupt the community? These are policy questions IDAEMS can address.

IDAEMS is now being further developed for use in the college's tourism and leisure travel research program. Idaho is rich in scenic beauty and recreation opportunities. But is Idaho making the most of these resources to attract outside income? Idaho is one of the few western states with no national park. In what ways would a national park enhance, and in what ways would it diminish, local and state-wide economic opportunities?

Information gathered in the college's recently completed state-wide survey of Idaho leisure travelers is being incorporated into IDAEMS. Through that survey, we have learned where Idaho's leisure visitors come from, where they are going, and how much they spend in Idaho. Using this information, IDAEMS provides a portrait of the overall role of tourism and leisure travel in the state economy and a vehicle for designing policies to enhance Idaho's tourism industry.

In the area of economic development planning there are no simple answers. IDAEMS is not a magical black box. But it will provide decision makers, from the governor to city council members, with a picture of Idaho's state-wide and community economies and a tool for assessing the important policy action impacts.

M. Henry Robison is visiting assistant professor of forest resources; Charles Harris is assistant professor of wildland recreation management; Robert Govett is associate professor of forest products; and Scott Katzer is a master's candidate in the Department of Forest Resources. *Funding for IDAEMS has come from the USDA Forest Service and a McIntire-Stennis federal grant.*

Grazing systems and prescribed fire can mix

by Steven J. Jirik and Stephen C. Bunting

We have recently completed research on the post-fire grazing response of two common native perennial grass species found on most sagebrush grasslands of the Intermountain West. Our results suggest that contrary to current thinking, prescribed fire can be successfully incorporated into rest rotation grazing systems.

Prescribed burning is an important tool for increasing the forage production and habitat diversity of sagebrush grass ranges for livestock, big game, and other wildlife. Prescribed burns are usually conducted on productive sites and in the fall when perennial grasses are dormant. The spring and summer before burning, the site is usually protected from livestock grazing to allow accumulation of the fine fuels that will carry the fire into the sagebrush canopy. After burning, the site is traditionally rested for at least one more year to allow perennial grass vigor to recover.

This two-year rest period disrupts the three pasture rest rotation system, which is the most common system in the Intermountain West. In that system, each of three pastures is rested for just one year per three-year cycle. The two-year rest forces overuse of remaining, unburned pastures. As a result, managers choose not to use prescribed burning on many areas where it is needed.

Surprisingly, however, little work has been done to determine the post-fire nonuse period required to restore perennial grass vigor. If burned areas could be deferred from grazing for just the first season after burning and then grazed after seed set without adversely affecting the plants, prescribed fire could be applied to rangelands with minor alterations to the rest rotation grazing system.

Stephen Bunting

Steven Jirik clips botttlebrush squirreltail in a study aimed at learning how cattle grazing affects range grasses following fire.

Last summer, we conducted research to learn how two common forage species, bluebunch wheatgrass (*Agropyron spicatum*) and bottlebrush squirreltail (*Sitanion hysrix*), respond to simulated grazing following fire. We located study sites on two areas that had been burned the previous year. The first site was located near Craters of the Moon National Monument, Idaho, the second north of Emmett, Idaho.

On each site, we randomly assigned individual plants to one of three defoliation groups. Group one plants were clipped to within two centimeters of the ground in early June, simulating early grazing. Group two plants were clipped during seed set in late July, simulating deferred grazing. The third group was not clipped, representing no use.

Before clipping, we recorded the basal area and number of grass stems on each plant as indicators of vigor. We remeasured plants the following year and clipped and weighed grass foliage from each plant to determine whether differences in herbage production occurred among the three treatments.

Our results showed no significant differences in bluebunch wheatgrass or squirreltail herbage production, number of grass stems, or basal area between the deferred and rested treatments on either site. However, these measures were reduced by the early defoliation treatment. Following early defoliation, herbage production of bluebunch wheatgrass was reduced by 32 percent on the Emmett site and by 67 percent on the Craters of the Moon site. Herbage production of squirreltail was reduced by 38 percent and 12 percent, respectively.

Mortality among early-defoliated squirreltail plants on the Emmett site was 26 percent compared with 2 percent for both the deferred and rested treatments. At the Craters of the Moon site, squirreltail mortality was zero.

Mortality among early-defoliated bluebunch wheatgrass plants on the Craters of the Moon site was 7 percent compared with zero mortality for the deferred and rested treatments. Mortality among bluebunch wheatgrass at Emmett was zero.

Thus, it appears that bluebunch wheatgrass and squirreltail can readily withstand grazing during late summer and fall of the first year following fire without suffering loss of vigor. However, these grasses are susceptible to high mortality or loss of vigor when grazed during the spring and early summer following fire.

Steven Jirik is a master's candidate in the Department of Range Resources. Stephen Bunting is professor of range resources. *Their study was funded by the Bureau of Land Management.*

Aerial photos record history of habitat

by Randy G. Balice, Joseph J. Ulliman, and J. Michael Scott

The U.S. Fish and Wildlife Service is charged with mitigating impacts to wildlife habitat from human development and natural disturbances. This requires that it monitor natural fluctuations in habitat availability as well as gains and losses of habitat resulting from major man-caused and natural events.

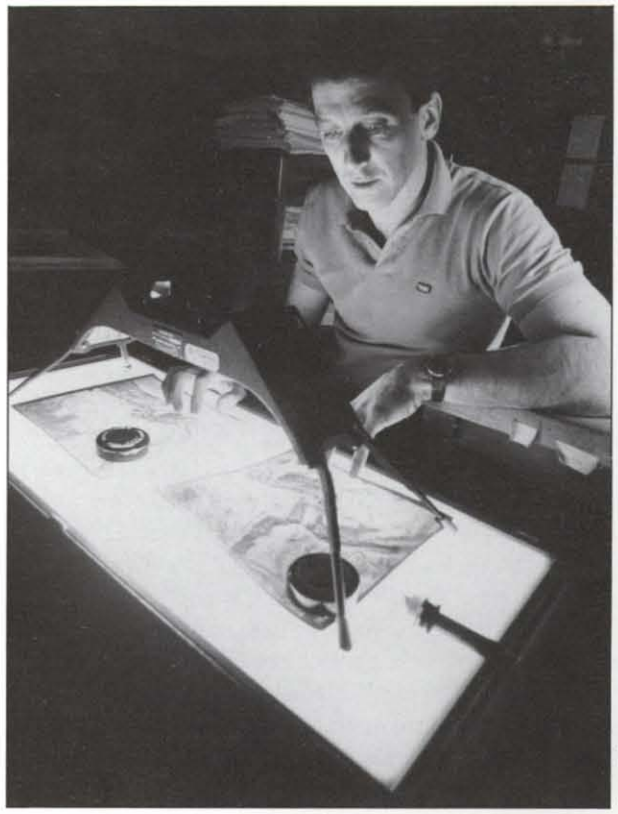
For much of the past year, we have been using historical sequences of aerial photographs to help the Boise Field Office of the U.S. Fish and Wildlife Service map and measure changes to wildlife habitat along the Snake River. Our study area is a 70-mile stretch of the river, including riparian and upland habitats, beginning at the Idaho-Wyoming state line and continuing downriver to Heise, Idaho.

This particular stretch allows us to study both natural changes in habitat and changes caused by man. Downriver from Swan Valley, postfire changes have proceeded largely unhindered by man. In contrast, the river corridor above Palisades has been inundated behind Palisades Reservoir, and riparian and upland habitats have been almost totally replaced by aquatic habitat.

The use of temporal sequences of aerial photography to map and measure changes in terrestrial vegetation is not new. In fact, it is listed as a standard technique in some authoritative aerial photointerpretation monographs. Nevertheless, practical examples of this technique in the professional literature are rare. Given the general availability of historical aerial photography and given our success with interpreting temporally spaced aerial photographs, we wonder why this method is not used more often.

Temporally spaced aerial photography has much in its favor for interpretation of changes in wildlife habitat in particular. First, medium-scale, color or black and white photographs are already frequently used to interpret vegetation detail that has wildlife habitat management value. Moreover, an aerial photograph is a permanent and exact record of this detail for every resolvable unit of land. In contrast, ground photographs record only the detail within the angle of view that the photographer deems important. Written historical records cover only a limited area and provide incomplete detail.

Resource aerial photographs have been regularly obtained for much of the United States since the 1930s. Although 50 years is much too brief a period to document complete sequences of vegetation change, it is sufficient to record partial successional sequences as well as changes attributable to disturbance.



Scott Spiker

Randy Balice uses a stereoscope and aerial photographs to get a birds-eye view of the Snake River in southern Idaho. Using a historical series of photos, he watches the river and its surroundings change with time.

For our study, we selected aerial photographs from three equally spaced time periods: 1940-1944, before the building of Palisades Dam; 1960; and 1979-1983. Our 1940s photographs came from the National Archives. The later photographs came from the USDA Agricultural Stabilization and Conservation Service, the EROS Data Center of the U.S. Geological Survey, and the Bureau of Land Management. The most recent photographs are in natural color, the others in black and white.

Next, working in consultation with wildlife biologists, we developed a vegetation classification scheme designed to maximize its usefulness in wildlife habitat evaluations. We strove to maintain the general utility of the classification by drawing heavily from existing habitat type and community type classifications as well as from the National Wetlands Classification.

Using the classification scheme, we interpreted the photography for each time period, transferred the detail to topographic maps, and measured the total acreage of each type with a digitizer. At this point, we have documented several results that we had predicted based on information in the scientific literature.

For instance, because of fire suppression policies during much of the twentieth century, we expected post-fire succession to proceed unhindered. Indeed, we found that following fire, juniper invaded sagebrush and seral aspen succeeded to Douglas-fir. Moreover, aspen communities that did not harbor Douglas-fir understories matured as closed-canopied communities, invaded sagebrush grasslands, or degraded into open-canopied, senile stands. We may be able to add to knowledge about succession by estimating the rates of change for these community types.

On the other hand, some of our preliminary results were unanticipated. Most of these relate to the interactions between riparian vegetation and the riverine life cycle. Before the completion of Palisades Dam in 1958, flooding was frequent, and sand-gravel bars, grasslands, and sandbar willow communities were common. We found that annual floods destroyed cottonwood stands, but also created new habitats for cottonwood invasion. Thus, the annual floods ensured that young, vigorous stands would proliferate. But with flood control, red-stem ceanothus and narrow-leaf cottonwood communities became more prominent. There is concern that many of the cottonwoods are now becoming overmature. If the cottonwood stands senesce, the populations of bald eagles that nest in them may also decline.

In the future, we plan to develop a photointerpretation key for our classification system, document methods for obtaining and handling historical aerial photographs, and investigate the usefulness of a geographic information system for manipulating and analyzing photointerpreted data.

Randy Balice

The study area includes a segment of the Snake River below Palisades Dam. This view is typical.

Randy Balice is a graduate student in the Department of Forest Resources; Joseph Ulliman is professor of forest resources; and J. Michael Scott is professor of wildlife resources and leader of the Idaho Cooperative Fish and Wildlife Research Unit.

Managing forests for an overlooked owl

by Patricia H. Hayward and Gregory D. Hayward

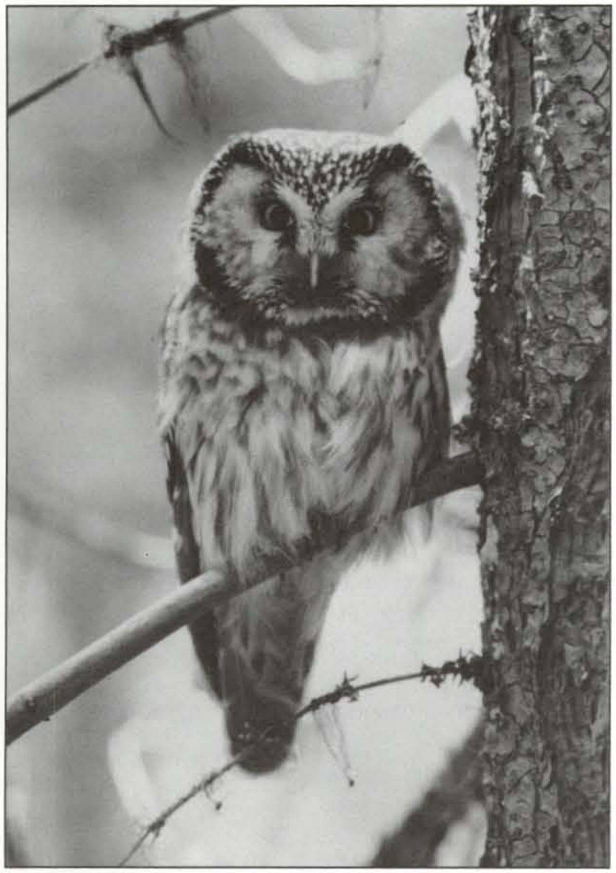
On the evening of February 20, 1980, our first in the remote Chamberlain Basin of the Frank Church–River of No Return Wilderness, we heard an unfamiliar owl call floating through the pines in the still, cold air. As biologists working for the University of Idaho, we were beginning a study of the basin's forest owls but could not identify this call. Back in the cabin, we listened to numerous tape-recorded owl songs, searching for the owner of the call. It soon became obvious that a boreal owl had been calling, yet our field guides showed the southern limit of its distribution 400 miles to the north.

As we have discovered in our search since, these owls aren't rare visitors, as formerly thought. Instead, they are easily overlooked residents in central Idaho's high mountain forests. In fact, our work has revealed boreals to be the most abundant subalpine owl species in the state, occurring in many spruce-fir forests from the Canadian border to the southeast corner of Idaho.

What habitats do these previously unnoticed residents need for nesting, foraging, and roosting? How would forest management practices affect their welfare? Our search for answers brought us back to the River of No Return Wilderness of central Idaho. Chamberlain Basin offered an ideal setting to study the habitat choices of these owls—a place where our results would not be confounded by the changing habitat on managed forest.

From 1984 to 1987 we radio-tagged 23 boreal owls at Chamberlain. Much of what we discovered about boreal owls surprised us. These pigeon-sized, 5-ounce owls used home ranges averaging 3,800 acres, almost ten times the size reported for other small forest owls. The boreals' home ranges approached those of spotted owls, an owl four to five times larger. And unlike the majority of owls, which use habitual roosts, the boreal owls moved long distances each night, roosting in stands 1 to 6 miles apart on consecutive days. We and our assistants, Lynn Flaccus, Tony Wright, and Dawn Zebley, skied and walked 16,000 miles during four years trying to keep up with the boreals.

In summer, we found the easily heat-stressed boreal owls in older, high elevation spruce-fir forest. In addition to providing cool roost sites, these productive high elevation sites supported abundant prey populations. Red-backed voles, which comprise 30-50 percent of the owls' diet, are two to 10 times more abundant in mature and older spruce-



Until 1980, no one knew that boreal owls live and breed in Idaho. But as Gregory and Patricia Hayward have learned since, they are the most abundant subalpine owl in the state.

fir forests than in the lodgepole pine, Douglas-fir, and mixed conifer forests below. In addition, the open structure of mature spruce-fir forests complements the owls' hunting strategy and flight patterns.

On the other hand, the abandoned pileated woodpecker cavities that boreals use for nesting are most abundant in isolated aspen stands or old ponderosa snags at lower elevations. As a result, boreal males, who during nesting must provide up to 12 voles and mice a night for their mates and young, become involved in some amazing long-distance commuting. The birds may travel 10 to 30 miles a night finding food for their families.

As with most predators, prey is the key to much of the owl's behavior, and many of our observations of the owls were at least partially explained by changes in prey abundance. In winter, when mice and voles stay below the snow surface and are more difficult for the owls to find, owls moved greater distances. In poor prey years, boreal owls bred less often and raised fewer young. The magnitude of breeding fluctuations in an undisturbed wilderness population surprised us. During the four years of our study, calling rates, an index to breeding effort, varied by a factor of 15.

To complement what we learned from owls in the wilderness, we have shifted our focus to managed forest. Cooperating Forest Service biologists who looked for boreal owls outside wilderness located 76 percent of the owls on sites classified as mature or old growth. Most striking, half the sites were marked for cutting, suggesting that foresters and owls select the same forest types.

Unfortunately, almost all national forest plans for Idaho and Montana propose clearcutting in commercial spruce-fir. While boreal owls can certainly tolerate some clearcutting, our results, though preliminary, suggest that extensive even-aged management of spruce-fir forests will harm the owls in several ways. First, the prey base may be reduced. Second, the open, patchy structure of mature forest that the owls need for foraging will be eliminated. Third, the already rare nesting cavities will be lost.

Boreal owl foraging and roosting habitat can be maintained, however, through uneven-aged management of high elevation spruce-fir forest. Single-tree or group selection harvest would permit economic gains associated with timber harvest while maintaining the open forest structure the owls need for hunting, the microclimate they need for roosting, and the moist forest required by their prey, the red-backed vole. In addition, uneven-aged management protects watersheds, aesthetics, and soils in subalpine forests.

A strong snag management program, in addition to uneven-aged management, will provide nesting sites for boreal owls and other forest wildlife. Even in mature to old growth spruce-fir, adequate nesting cavities are rare, so snag management will be critical in managed forests. We envision a program that maintains usable snags (large snags with surrounding forest structure). Because the owls and other wildlife will not readily use snags when the surrounding forest is entirely removed, maintaining a couple snags in the middle of clearcuts will not suffice.

Since we discovered the boreal owl in Idaho less than a decade ago, our knowledge of its ecology has grown rapidly. Although our understanding of these small forest owls began in wilderness, the value of our study comes in the application of the results to management of commercial forest. Because of increasing demands for the timber in spruce-fir forests, the boreal's survival depends on how well we integrate timber management and habitat management in these sensitive, slow-growing ecosystems.

Principal investigator Edward O. Garton is professor of wildlife resources. Gregory and Patricia Hayward are research associates in the Department of Fish and Wildlife Resources. Their work has been funded by the U.S. Forest Service, Idaho Department of Fish and Game, University of Idaho Wilderness Research Center, North American Bluebird Society, Max McGraw Wildlife Foundation, Duracell Corporation, and TDK Electronics.

Forest grazing: cattle, deer, and elk diets

by Kirsten C. Roscoe and James L. Kingery

Northern Idaho's rangelands are part of a constantly changing mosaic of timberlands interspersed with meadows and clearcuts. They occur wherever the timber overstory has been disturbed and an increase in herbaceous vegetation underneath has appeared. These rangelands are considered transitory, providing a grassland setting appropriate for grazing by livestock and big game for only 20 to 40 years.

The transitory rangelands are also sites for growing healthy new trees. All too often, however, grazing and tree regeneration are not compatible. Young tree seedlings can be easily damaged by trampling or browsing.

Many would say the solution is simple: eliminate all livestock. But grazing on transitory ranges provides a supplemental income from forest lands while the timber resource is renewed. In forest lands where timber renewal is the primary use, but livestock grazing is an important secondary use, managers need a better understanding of how to integrate the two.

We know that cattle are attracted to clearcuts and other transitory range areas because of their abundant grasses. Deer and elk are attracted by the increased production of both grasses and shrubs. What managers need to know more specifically is what forage species most attract these animals. For instance, is it the snowberry or the wild rose that most attracts white-tailed deer? Is it the bluegrass or the timothy that most attracts cattle? An area dominated by the preferred plant species will most likely get more use.

Preferred plant species also occur during different stages of succession. If we can find a relationship between a particular successional stage and an animal's diet, then we may be able to say, for example, "This clearcut has a lot of this preferred plant present, so we can expect very heavy use. This other clearcut is in a different stage of succession and has much less of the preferred plant, so animal use will be lighter. Therefore, a new plantation should be more successful today in the second clearcut, later on in the first clearcut."

Similarly, if we can determine which stage of succession provides the important components of animals' diets, managers can use the knowledge to try to maintain that stage and satisfy the animals without attracting them to areas where plantations may be at risk.

We are attempting to determine the diets of cattle, white-tailed deer, and elk grazing transitory ranges in northern Idaho and to relate the animals' diets, and any seasonal changes in their diets, to the successional stages of two habitat types: western redcedar/queen cup beadlily (*Thuja plicata/Clintonia uniflora*) and grand fir/queen cup beadlily (*Abies grandis/Clintonia uniflora*). Our two study sites, one for each habitat type, are located on national forests in northern Idaho.

Each site is divided into five sub-units representing different successional stages—a meadow area, a 3- to 7-year-old stand, an 8- to 15-year old stand, a stand 15 years or older, and a closed-canopy stand. The 3- to 7-year-old stands are clearcuts containing 2- to 3-year-old plantations.

We ran line and plot transects in each stand to determine vegetation compositions. We determined cattle, deer, and elk diets by identifying undigested plant epidermal fragments in feces, collected throughout the two study sites in early summer, mid-summer, and early fall for two years.

Using an analysis of covariance, we will compare vegetation composition in each stand with the compositions of animals' diets to determine if there are similarities in the amounts and species of plants present. Stands whose vegetation compositions more closely match the compositions of animals' diets probably contribute more to the diet than stands with less similar vegetation. We will also compare diets across seasons and years.

The results should help determine if the clearcuts provide more of an animal's diet at a particular time of the year or during a particular stage of their successional development. For instance, big game may be more attracted to a clearcut after it is 4 to 5 years old. If true, young seedlings may be more successful if planted the first or second year after harvest.

Our observations thus far indicate that cattle graze the clearcuts throughout the grazing season, generally May to October. Elk, on the other hand, seem to prefer these areas in early summer, generally before the cattle are turned onto the range. Both the cattle and elk prefer grasses and forbs. Deer use the clearcuts least and appear to be attracted to the young shrubs. This means that plantations with young seedlings could experience trampling from cattle or elk and could be browsed by both deer and elk if not protected when their buds are new and green.

Electric fences around plantations may be required for short periods when seedlings are vulnerable and wildlife may be tempted to feed on young buds, particularly in spring. Compromises with livestock owners may also be needed to adjust season of use or animal numbers to reduce incidence of trampling by livestock until the seedlings become established.

James L. Kingery is assistant professor of range resources. Kirsten C. Roscoe is a graduate assistant and master's degree candidate in the Department of Range Resources. Their work is conducted cooperatively with the USDA Forest Service Intermountain Forest and Range Experiment Station.

Birds and edges: a reevaluation

by Kerry P. Reese and John T. Ratti

An "edge" is best defined as the site where two or more plant communities or successional stages within a community meet. Examples include a forest-clearcut boundary, the transition from alpine meadow into spruce-fir forest, and an agricultural field-riparian zone border. Many species of wildlife use edge habitats because of their variety of plant species and of structures that provide cover and foraging, perching, and nesting sites.

For decades wildlife managers have used this knowledge to manipulate habitat for many bird and mammal species; for example, making small clearcuts to enhance growth of big game forage also creates edges that improve nesting sites for woodland passerine (song) birds. However, until recently, no research was conducted to determine the nesting success of birds in man-made edge habitats.

A study by J. Edward Gates and Leslie W. Gysel published in 1978 in the journal *Ecology* reported that man-made (artificial) edge habitats in forests may not always help wildlife. They found that predation on bird nests at artificial edges was high, but declined away from the edge.

Artificial edges, largely created through silvicultural and agricultural practices, tend to be abrupt and sharply defined. Natural edges, due to changes in soil, moisture, or elevational gradients, tend to be much wider and less sharply defined. Gates and Gysel found that although many bird species were attracted to the narrow, abrupt artificial edges for nesting, so were foraging predators, which easily located the birds' nests.

Gates and Gysel termed this phenomenon the "ecological trap hypothesis," that birds are attracted to the vegetative diversity at artificial edge habitats, but experience greater predation at these edges. If fledging success of birds using man-made edge habitat is reduced below that at natural edge habitats, says the hypothesis, then abrupt, artificial edges may act as "population sinks" providing no benefit to the birds.

Our objective was to examine several questions related to the ecological trap hypothesis and to predation near edge zones at forest clearcuts. Two questions we asked were (1) does nest predation vary with distance from the edge? and (2) does nest predation vary with edge structure (abrupt versus gradual edge)?

Gerry Snyder

John Ratti (left) and Kerry Reese, two wildlife biologists who specialize in birds, used craft-store nests and quail eggs to study nest predation at forest-clearcut edges. They've found that edges may not always benefit the birds.

We compared predation rates on a total of 759 artificial nests containing quail eggs in two 6-year-old clearcuts and in the mature (55- to 60-year-old) mixed conifer plots which they adjoined. One forest-clearcut edge was "abrupt," formed by a 44-acre clearcut; the other was a 70-meter-wide "feathered edge" formed by partial timber removal (shelterwood cut) along one side of a 27-acre clearcut. We placed nests along each of six 240-meter lines perpendicular to, and bisecting, the edges. Nests extended 140 meters into both the forest plots and the clearcuts.

Our results indicated that predation at the abrupt edge was twice that in the feathered edge (27 percent versus 12 percent). We suspect the reason is that the feathered edge, which provided more complex vegetation structure similar to natural edges, may have reduced predator efficiency.

The hypothesis of Gates and Gysel stated that nest predation rates would decline as distance from the edge increased, that is, as nests were removed from the concentrated zone of predator activity. However, we found no relationship between distance from edge and predation. These contradictory results may indicate that an important aspect of the hypothesis is predation on young birds in the nest rather than on eggs. Predators may detect nests through the activity of adult birds and/or food begging by young. Also, the predator species in the area may be the key factor determining distribution of predation around edge habitats. Studies in which major predators concentrate foraging near edge zones are most likely to reveal predation consistent with the hypothesis.

Our results may have important applications in habitat preservation and wildlife habitat management. They suggest that a management practice that creates edges can have mixed results. Although increased bird abundance can be expected along a narrow, man-made edge, increased predation on nests may counteract the increase. Wildlife managers may believe they are providing good-quality edge habitat for nesting birds, but unknowingly reduce abundance of desired species through increased losses to predation.

Our results also suggest that edge width and structure are important influences on wildlife use of edge habitats. In particular, artificial edges (man-made) will provide better nesting habitat if they mimic natural edges. However, no research has yet compared wildlife use of natural and artificial edges to develop prescriptions for the design of silviculturally or agriculturally derived edges.

We have demonstrated the value of a 70-meter-wide shelterwood cut in reducing predation on artificial nests at a forest-clearcut edge. We hope to continue our research by comparing predation rates in artificial edges to those in natural edges and expanding our work on shelterwood cuts at borders of clearcuts. We have submitted a proposal to the National Science Foundation for funding. Additional research is also needed to evaluate other silvicultural practices, such as edge undulations or selective leaving of individual plants or clusters of plants, that might influence predator activity or predator success at edges.

Kerry P. Reese is assistant professor and John T. Ratti is adjunct associate professor, both in the Department of Fish and Wildlife Resources. *Research was supported by a grant from McIntire-Stennis.*

Streamsides and salmon in Southeast Alaska

by Robert M. Keith and Theodore C. Bjornn

Amazingly, the harder it rains the worse the bugs become. The no-see-ums and white socks dodge rain drops as they make for shelter under the bills of their victims' baseball caps. A loud smack signals the end of one of the many biting insects that visit our bodies daily.

This was an all too familiar scene during the summer field season of 1988, on Prince of Wales Island in Southeast Alaska. We were there to evaluate the role of riparian (streamside) vegetation as a factor affecting the productivity of algae, aquatic insects, and ultimately fish in small streams flowing through 10- to 30-year-old second-growth forests formed by clearcuts.

Clearcut logging of old growth spruce and hemlock has been underway in Southeast Alaska since the 1950s. Today, a growing number of clearcuts have small streams flowing through them. These streams provide spawning and nursery grounds for several species of migratory fish, including coho salmon, steelhead trout, cutthroat trout, and Dolly Varden char, whose progeny spend up to three years in the streams before migrating to the ocean.

Clearcutting causes dramatic changes in the stream's immediate surroundings, many of which can be expected to affect fish production. Within a few years of clearcutting, the riparian zone grows thick with red alder, producing a dense canopy of leaves and branches that completely shades the stream in summer and limits primary production. The alder persists for 20-30 years or longer until conifer species regain dominance.

Jody White

Brush cutting has opened up a stretch of stream in Southeast Alaska.

Outside their trailers in Southeast Alaska, graduate students Rob Keith (left) and Nick Hetrick take advantage of a break in the rain to go outdoors for repairing aquatic insect nets and minnow traps.

The first objective of our study focuses on determining whether removing the second growth canopy will affect the streams' capacity to support fish. We would expect an increase in sunlight to increase fish production through a chain reaction in which an increase in sunlight results in an increase in algae (which need sunlight to grow), aquatic insects (some of which graze algae), and fish (which eat aquatic insects). Also, there is evidence that terrestrial insects (both aquatic and true terrestrial forms) are more active in open canopy areas. If true, increased activity could lead to increased availability of insects as food for the fish, and thus an increase in the number of fish supported by open canopy sections. We also hope to determine the relative importance of the canopy as overhead cover.

Besides limiting sunlight, the alder is also less effective than the old conifers in contributing woody material that forms long-lasting pools and shelter for the fish. In this mountainous region of medium- to high-gradient streams, pools and runs are important habitat, providing the only places where the fish can survive. Our second objective is to determine whether additions of instream cover (woody debris) affect the abundance of fish.

If fish numbers can be increased through canopy or instream cover manipulations, there should eventually result larger runs of spawning salmon for sport anglers and commercial fishermen.

To accomplish our objectives, we selected three streams and divided each into six sections. Each section was composed of four pools. The sections varied in length from 25 to 100 meters.

We cut down the alder canopy in alternating sections, creating open- and closed-canopy sections. This pattern allows us to study potential differences in solar input, stream temperature regime, leaf litter input, primary production, aquatic and terrestrial insect community, and fish community between the sections. To study fish use of instream cover, we first removed instream cover from all the pools, then added bundles of alder branches to half of them.

From May to August, 1988, we sampled each stream on an approximately 30-day cycle. During each sampling session, we collected benthic algae scrapings, aquatic insects with Hess and drift nets, leaf litter, and aerial insects with sticky traps and water traps. We also measured solar input (with solarimeters), and numbers, lengths, and weights of fish in each of the pools. In addition, we mapped each pool in detail. Temperature recorders placed along each stream measured changes in water temperature every two hours throughout the summer. We will continue sampling next summer.

Our preliminary results indicate that abundance of young coho salmon was unaffected by opening the canopy or by adding brush bundles to the pools. The fish appeared more interested in using all available space for obtaining food than in seeking the security provided by a closed canopy or instream cover. On the other hand, there were obvious increases in primary production in the sections with open canopies. We have not completed the analysis of invertebrate abundance.

In recent years, management of riparian zone vegetation and woody debris in streams has varied widely. The importance of stream shading and in-stream cover for fish varies with stream location and size, season of year, and perhaps with species of fish. Our study will help managers decide how best to manage the small nursery streams in Southeast Alaska. For example, managers will be able to use our findings to decide the effectiveness of modifying the alder canopy or instream cover to increase fish production.

Robert Keith is a graduate student in the Department of Fish and Wildlife Resources. Theodore C. Bjornn is professor of fishery resources and assistant leader, Idaho Cooperative Fish and Wildlife Research Unit. Their colleagues include Merlyn Brusven, of the University of Idaho; William Meehan, of the U.S. Forest Service, and Nicholas Hetrick, a graduate student in the Department of Plant, Soil, and Entomological Sciences. Their study is being conducted cooperatively with the U.S. Forest Service Pacific Northwest Research Station at Juneau, Alaska.

Putting the beef back into our burgers

by Brian Dennis

Question: What grazing animal consumes 25 percent of rangeland production in the western United States?

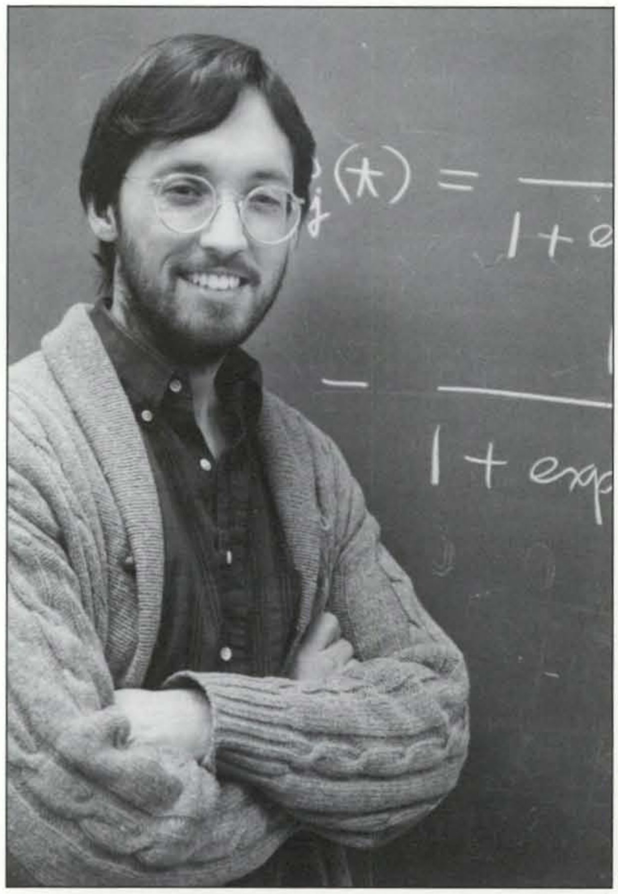
Hint: In the summer, take a stick and stir up any square yard of Montana grassland. You may see hundreds of them. Grasshoppers, that is. Hundreds of tiny, perfectly designed grass consumption machines with chewing mouthparts, high mobility, tolerance of high temperatures, and a propensity to multiply like, well, grasshoppers. If only hopper burgers tasted as good as beef burgers!

Grasshoppers remain public enemy number one to our livestock industry. And though much research is being devoted to enhancing grasshoppers' natural killers such as parasites and viruses, the most effective control method remains spray, spray, and spray again.

The goal of integrated pest management (IPM) is to reduce the amounts of toxic pesticides in the environment while suppressing the population levels of the pests. For grasshoppers, one key to IPM appears to be precise timing of control measures.

A grasshopper hatches from an egg in spring and progresses through various development stages, called instars, until becoming a breeding adult in mid- to late summer. The adults then breed, lay eggs in the ground, and die, and the life cycle begins anew.

The instars look like miniature adults, with each stage larger—and hungrier—than the last. But like runners in a marathon passing mile markers, the individual grasshoppers in a field develop at varying rates, entering and leaving stages at different times of the season.

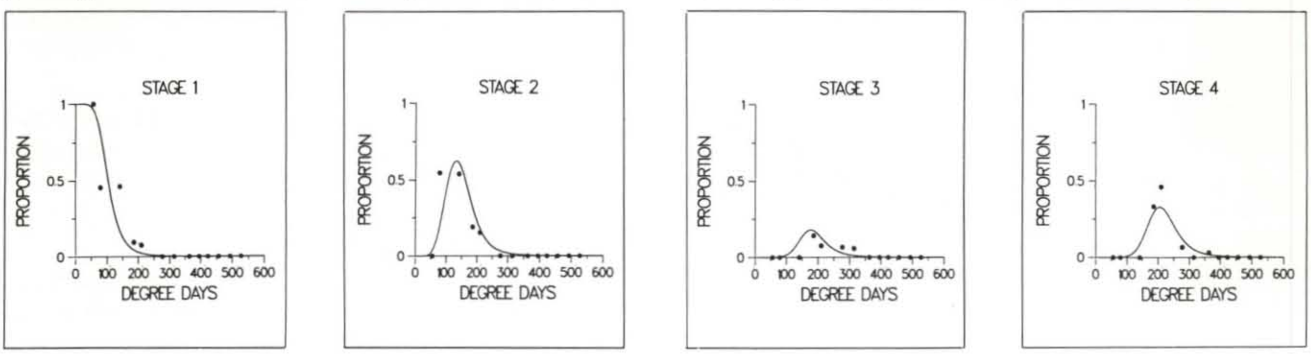


Gerry Snyder

Brian Dennis lends his mathematical talents to the fight against rangeland grasshoppers. His model of grasshopper life stages should help managers to use pesticides more sparingly and effectively.

The IPM connection is this: Different chemicals (Malathion and Carbaryl, for instance) are more effective if applied when the bulk of the grasshoppers are in certain instars. The best spraying times vary from species to species (there are dozens of kinds of grasshoppers) and from chemical to chemical. If we could forecast precisely when the grasshoppers will be entering or leaving a development

Predictions of the Dennis-Kemp mathematical model (solid curves) come close to matching dots representing the actual proportion of grasshoppers in various development stages over time (measured in degree days). (Data from Roundup, Montana, area.)



stage (like predicting when the largest number of runners will be between mile markers 8 and 9), we could hit them just once with an appropriate chemical, rather than spray over and over throughout the season. But how can we predict the vagaries of grasshopper lives?

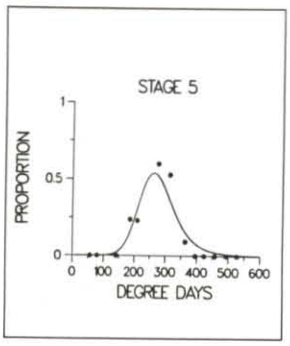
The problem is not unique to grasshoppers; controlling many other insect pests requires life stage forecasts. In 1984, William Kemp, then a graduate student in forest entomology at the University of Idaho, posed this problem to me with respect to the western spruce budworm. Our meeting began a rewarding research collaboration that continues to expand into new problems in pest control. Dr. Kemp is now a USDA scientist at the Rangeland Insect Laboratory at Bozeman, Montana, where he is one of the key researchers involved in the all-out range war against grasshoppers.

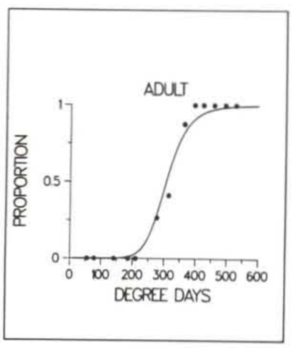
We have developed a mathematical model for predicting the progression of insects in a population through their development stages. Time in this model is measured in "degree days," a time scale that moves faster on hot days. (Insects develop quickly when it is hot and slowly when it is cool.) Though the model is in its own "early development stage," we are extremely encouraged by how well it seems to match grasshopper field data.

During the past two summers, the Rangeland Insect Laboratory has issued trial weekly grasshopper forecasts for 12 sites in Montana based on the model. Distributed through a state-wide agricultural print and broadcast network, the forecasts reach extension agents, ranchers, public agencies, and others.

During the 1989-1990 academic year, I will spend a sabbatical at Montana State University where Dr. Kemp and I will continue our work on this and other quantitative problems in IPM. With these efforts, we hope to help put the beef back in our burgers, instead of watching it hop away between our shoes.

Brian Dennis is associate professor of forest resources/mathematics and statistics. *Funding for this work is from the USDA Agricultural Research Service.*





Idaho's nongame program: the taxpayers' views

by Charles C. Harris, Kerry P. Reese, and Tracy A. Miller

In 1981, the Idaho Department of Fish and Game established its Nongame Wildlife and Endangered Species Program to take the lead in managing the 90 percent of Idaho's animal species that are not hunted, fished, or trapped. As in many states, funds for this program are derived almost entirely from voluntary donations made through a "tax-checkoff" opportunity on the state's income tax form.

In 1987, six percent of Idaho's taxpayers used the income-tax checkoff to donate $70,000. Donations in Idaho and throughout the United States have been declining, however, raising concerns about the future of this fundraising method.

How aware of the program are Idaho taxpayers, and what are their opinions concerning the priorities and projects on which the program should focus? Who donates to the program using the income-tax checkoff, and why don't more people donate? Managers in the Idaho Department of Fish and Game wanted answers to these and other questions to help guide their future management of nongame animals and the nongame program.

Working at the department's request, we initiated a survey of Idaho taxpayers in 1987. Our objective was to determine if donors are different from nondonors in terms of their demographic characteristics, their knowledge and opinions about the program and the checkoff, the ways in which they learn about the program, and their support for the program's projects. We also wanted to learn what alternative sources of program funding would be acceptable to Idaho's taxpayers.

We mailed questionnaires to two randomly selected samples of Idaho taxpayers: one sample of 1,000 persons whom the Idaho Department of Revenue and Taxation identified as donors to the program and a second sample of 1,000 persons identified as nondonors. We used standard survey research methods, resulting in a return of 67 percent of the deliverable questionnaires. A bias check (a separate survey of those not responding) suggested that the answers we obtained from survey respondents were representative of those of all Idaho taxpayers.

We found that donors tended to be younger and more highly educated than nondonors, with higher incomes and homes in Idaho's larger cities and towns. Those least likely

Idaho Department of Fish and Game

Since its inception in 1981, the Idaho Nongame Wildlife and Endangered Species Program has depended for operating expenses on voluntary donations made through the Idaho income tax checkoff.

to donate were older than 65, from small towns, with at most a high school education, and annual incomes less than $20,000—most likely retirees on fixed incomes. At least a third of the donors fished and at least 22 percent of them hunted.

A major finding was that awareness of the program and of the tax checkoff are primary influences on donation behavior: 83 percent of the donors had heard of the program, but only 54 percent of the nondonors. Even fewer nondonors—47 percent—had heard of the tax checkoff. This difference suggests that nondonors are either not being exposed effectively to messages about donation opportunities or they are less receptive to them.

Another important influence on donation behavior is the way Idahoans prepare their taxes. Most donors (65.3 percent) prepared their own tax returns. In contrast, most nondonors (63 percent) used a professional. Of the donors who used a professional, 65 percent indicated that their preparer had informed them about the checkoff. On the other hand, only 31 percent of the nondonors had been informed of the checkoff by their tax preparer. Overall, about 44 percent of Idaho's taxpayers hired tax preparers who failed to inform them about the checkoff.

Significantly, 34 percent of nondonors cited being uninformed by their tax preparers as a reason for not donating. Other common reasons were not having enough information about how their contributions would be used (given by 32 percent), not being able to afford to contribute (given by 26 percent), and not receiving a tax refund (given by 16 percent).

One survey question asked people to rate how strongly they support or oppose particular nongame projects. Reintroducing endangered species received the strongest backing, with 80 percent of all respondents indicating support. Wildlife interpretive centers had the least support, but was also the project about which respondents knew least. Other projects, including nongame wildlife research, the natural heritage program, raptor rehabilitation, information and education programs, and the building of bird feeders and nesting boxes, were supported by 60 to 75 percent of the respondents.

The survey also asked people to show how they would distribute nongame funds among several specified uses. Respondents allocated the most money to purchasing land (34 percent of the budget) and the least to building observation centers (12 percent of the budget). Caring for animals, educating the public, and conducting research received 21 percent, 17 percent, and 16 percent of the budget, respectively.

Asked to distribute nongame funds among animal groups, respondents allocated 43 percent of the budget to threatened and endangered species, 19 percent to birds, 17 percent to mammals, 13 percent to fish, and 9 percent to reptiles and amphibians.

Respondents' support for alternative funding sources ranged from a high of 77 percent support for using fishing and hunting license revenues to a low of 24 percent support for an increase in the sales tax. Of those who identified themselves as hunters, 63 percent favored use of license revenues. Seventy-two percent of anglers favored such use.

Based on our findings, what recommendations can we make for planning the future of Idaho's Nongame Wildlife and Endangered Species Program? Our recommendations include:

— Increase Idahoans' awareness of the program and checkoff using those media we found to be most effective in reaching the public: newspaper, television, and *Idaho Wildlife* magazine.

— Stress popular animals groups and management projects in promotions and management, especially projects that aid animals, such as providing bird feeders, rehabilitating raptors, and reintroducing endangered species.

— To most efficiently promote the program and checkoff, target well-educated males whose household incomes exceed $20,000 and who live in Idaho's larger cities.

— Target professional tax preparers in efforts to increase checkoff donations. Those efforts should stress that concerned people need to remind their accountants that they want to donate. At the same time, find out whether and how the department can enlist more help from tax preparers in informing their clients about the checkoff.

Charles C. Harris is assistant professor of wildland recreation management; Kerry P. Reese is assistant professor of wildlife resources; and Tracy A. Miller is a graduate student in the Department of Wildland Recreation Management. *Funding for this research was provided by the Idaho Nongame Wildlife and Endangered Species Program.*

Pilot-scale plant cleans paper mill waste

by David H. Bennett, C. Michael Falter, and Alton G. Campbell

An out-of-the way door in the basement of the College of Forestry, Wildlife and Range Sciences opens into a laboratory containing 400-gallon green vats, their tea-colored contents frothing and smelling of sulfur. A collection of white piping connects vat to vat. This set-up, which uses fungi, protozoans, and bacteria to digest organic wastes, is probably the largest pilot-scale system in western North America for cleansing paper mill waste water.

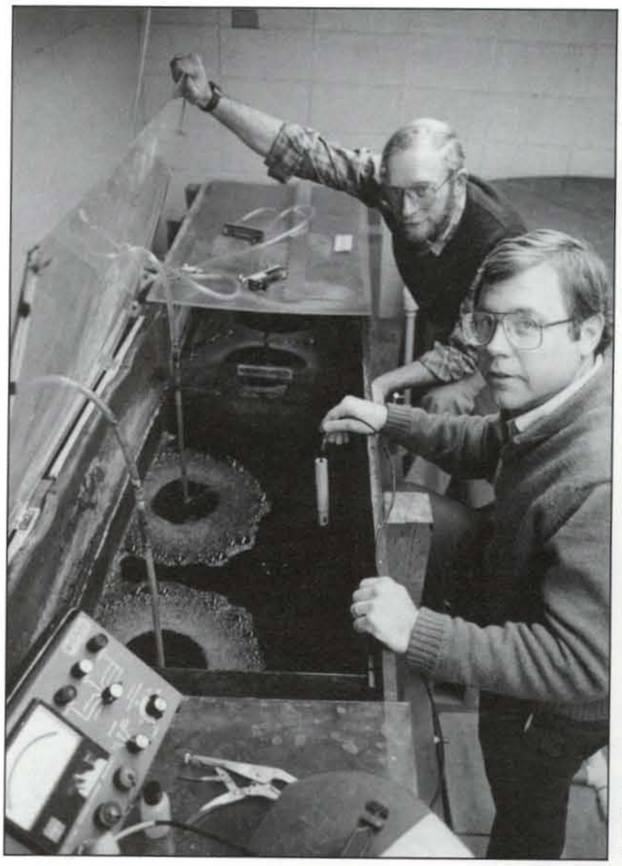
Upstairs from our "biotreatment laboratory," two more laboratories determine how well the waste treatment worked. One measures waste water chemistry. Another tests the effluent on fish and other aquatic life. Together, these laboratories provide the capability to help the pulp and paper industry solve its water pollution problems.

So far, we have helped two paper mills study potential waste treatment systems. Before starting operations, both wanted assurance that their proposed treatment systems would produce waste water clean enough to pass strict state of Washington standards. By simulating the proposed treatment plants and then testing the treated effluent, we were able to evaluate and modify the systems' capabilities to satisfy waste water and toxicity reduction standards.

The biotreatment laboratory currently can treat waste water using any of three common treatment processes—lagoon, activated sludge, and carousel. In each process, microbes consume organic waste and toxic resin acids from pulp and paper mills. A variety of conditions can influence the microbes' efficiency and, therefore, the quality of the finished effluent.

In the past, pulp and paper mill effluents had only to pass chemical tests to comply with receiving water standards. But 1985 U.S. Environmental Protection Agency regulations require that new and existing mills evaluate waste water toxicity directly on fish and other aquatic life.

In our "biomonitoring laboratory," fingerling rainbow trout determine the treated effluent's "acute" biological toxicity. To pass state of Washington standards for new mills, 80-100 percent of the fish placed in 100 percent effluent must survive for 96 hours. Other, long-term biological tests, examine the effects of dilute effluents. One gauges the growth and survival of newly hatched fathead minnows. Another determines whether near-microscopic crustaceans, called *Ceriodaphnia*, can survive and reproduce for seven days in the diluted effluent.



Gerry Snyder

David Bennett (top) and Alton Campbell examine paper mill waste being digested in a "facultative lagoon" waste treatment system, part of the college's new biotreatment laboratory.

For all these tests, we use samples of freshly treated effluent. Most other laboratories must run chemical and biological tests on effluent shipped days before from a separate treatment facility. These laboratories can never be sure that the samples they receive are fresh or representative. Moreover, waste water tends to lose its toxicity over time.

Our biotreament laboratory also benefits from its large size. Most laboratories designed to simulate full-scale plants can treat only a few gallons at a time, but our pilot-scale plant is capable of treating several thousand. That means our results are more likely to match those of the full-scale plant.

In the future, we expect to simulate waste treatment systems for other pulp and paper mills, particularly new and expanding mills. The laboratory can, however, be modified to mimic almost any system for treating municipal or industrial organic wastes. This winter, for example, a delegation from Costa Rica expressed interest in using our facilities to design treatment systems for coffee wastes.

David H. Bennett and C. Michael Falter are both professors of fishery resources. Alton G. Campbell is associate professor of forest products.

Biotechnology laboratory opens doors

With the opening of the college's Biotechnology Laboratory in August 1987, the college's efforts in tissue culture and molecular biology gained new space and equipment. Tissue culture is Carol Stiff's domain. She coaxes tiny plant fragments to grow into whole plants. Steven Brunsfeld is the molecular biologist, gazing sidelong into plants to their fundamental molecules—DNA and the enzymes they specify. Having pooled their equipment, these two researchers now hope to merge their talents, someday mass producing "engineered" trees carrying genes for such beneficial traits as herbicide tolerance.—*Editor*

Growing test-tube trees and shrubs

by Carol M. Stiff

Plant regeneration from tissue culture begins with small plant fragments such as stems, leaves, and seed tissue. Placed in a sterile, controlled environment containing all the nutrients to support growth, the parts grow into whole plants.

Tissue culture can produce more plants in less time, less space, and with smaller cuttings than conventional vegetative methods such as grafting or rooting cuttings. Besides growing replicas of parent plants, tissue culture permits the use of chemicals or foreign DNA to create new variations.

Our research deals with the practical application of tissue culture to forestry and range. We are developing techniques to mass propagate individuals having superior characteristics such as disease resistance, herbicide tolerance, and the ability to sprout after fire.

Once we have developed plantlets in the laboratory, the next step is to transfer them to the Forest Research Nursery. The college is unique among forestry schools in having an operational nursery. This pairing of biotechnology laboratory and full-scale nursery should enable Idaho to become outstanding in the field of applied plant biotechnology.

The project that started the micropropagation section of the Biotechnology Laboratory is the development of a system to mass propagate blister rust resistant western white pine from needle fascicles. Although fascicles have been rooted in the past, they have lacked well-developed fascicle buds and have not survived. We induce the fascicle bud to develop on the parent plant, then culture the bud in vitro.


Gerry Snyder

Carol Stiff and Steven Brunsfeld share the Biotechnology Laboratory for their respective research projects that use tissue culture and enzyme electrophoresis.

Thus far, shoots have grown from fascicle buds, and roots have been induced on some of the shoots. Experiments are in progress to improve rooting efficiency and to acclimate the plantlets to the greenhouse environment.

A second project—micropropagation of Idaho hybrid poplar—will allow the Forest Research Nursery to mass-produce hybrid poplars from just a few parent trees. We are growing plantlets from single-node stem cuttings about an inch long. These cuttings are cultured in vitro, and within four to six weeks they elongate into rooted shoots averaging six nodes. The rooted shoots are cut into one-node sections and cultured on fresh medium. In this way, hundreds of plants can be produced from a single cutting, and production can continue year-round. This year, we plan to grow several thousand poplars. From culture, they will be planted in containers, acclimated under mist, then transferred to the greenhouse.

In another poplar project, we are seeking plants tolerant to the herbicide Roundup®. We are culturing poplar leaf pieces in a medium that induces shoots and also contains glyphosate, the active ingredient in Roundup®. Only those cells that are tolerant to glyphosate will survive to form plantlets. Resistant poplars will be mass propagated through tissue culture and then field tested.

We are also evaluating techniques for mass-producing western larch from embryos, cotyledons, and axillary buds. These techniques could provide a means of reproducing genetically superior stock and ensuring a steady supply of plantlets even when seed supplies are low.

We have recently expanded into the micropropagation of shrubs—sagebrush and bitterbrush. The plantlets we produce will be used in hybridization experiments aimed at producing shrubs that can both sprout following fire and be eaten by wildlife and livestock. These shrubs could help restore southern Idaho's degraded rangelands.

In research that holds considerable financial promise, we are micropropagating black cherry from New York and Pennsylvania stock. Later, we will test how well the plantlets grow in Idaho's climate and soils. Those strains that grow best may be mass propagated through tissue culture, then grown by farmers to supplement their incomes.

Plantlets grown through tissue culture are unlikely to replace seedlings raised from seed at the Forest Research Nursery. However, tissue culture is likely to replace conventional vegetative propagation methods, provide elite individuals when no seed is available, and produce superior trees for stocking the seed orchards that ultimately furnish the nursery with its seed.

Carol M. Stiff is a research associate in the Department of Forest Resources and supervisor of the Forest Research Nursery's micropropagation unit. Her colleagues include Research Associate R. Kasten Dumroese (poplar), master's candidate John L. Edson (larch), Extension Forester Ronald Mahoney and master's candidate Yvonne Carree (black cherry), and Professor of Range Resources Minoru Hironaka and undergraduate Mark Mousseaux (sagebrush/bitterbrush). The Forest Research Nursery, including the micropropagation unit, is directed by Associate Professor David L. Wenny.

Genetics of wildland plants

By Steven J. Brunsfeld

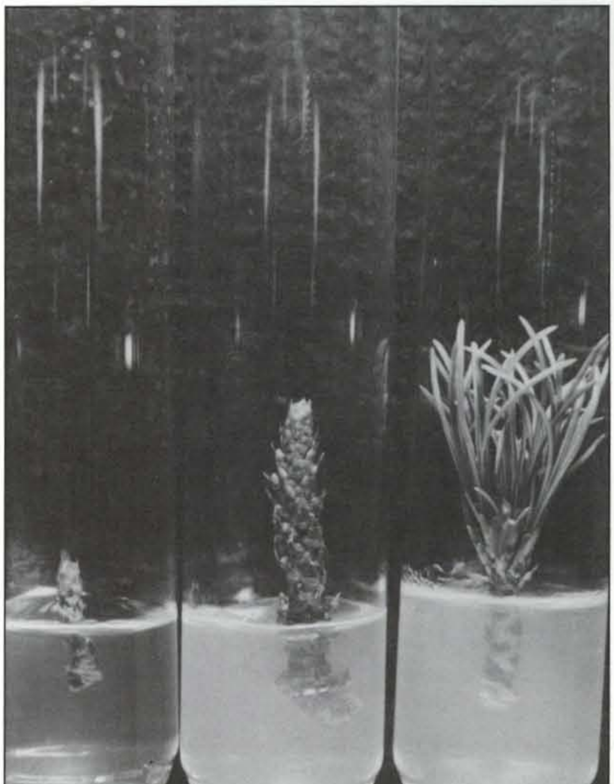
One of the biggest differences between agriculture and forestry is that unlike crop species, wildland species are usually not genetically uniform. They can be enormously variable and tend to consist of many different ecotypes that are genetically "tuned" to different habitats and climatic regions. Thus, for example, a species growing in northern Idaho may be genetically and biologically different—and require different management—from the same species growing in southern Idaho.

In recent years, there has been an explosion of powerful new techniques that allow us to delve deeper into the basic biology, physiology, genetics, and ecology of organisms. We can now sharpen our focus to the molecular level and read an organism's molecular "blueprint"—DNA. Part of my research interests involves gaining insights into the ecology and distribution of wildland plants by illuminating their genetic structure.

I use two techniques, enzyme electrophoresis and DNA restriction fragment analysis, to help circumscribe the natural genetic races that exist in the wild. Enzyme electrophoresis involves analyzing the different genetic forms, or alleles, of an enzyme by separating them in an electrical field.

DNA restriction fragment analysis involves searching for mutations in DNA by cutting it with "restriction enzymes" that recognize certain sequences in the genetic code. The distribution pattern of mutations provides information on the genetic structure of the species. Once this genetic structure is known, one can attempt to correlate it with the distribution of ecological traits (e.g., palatability, growth rate, habitat preference, response to fire, etc.).

One of my current research projects is an analysis of the coyote willows, an important group of streambank-stabilizing shrubs whose identification has confused field biologists for more than a century. This work, funded by the National Science Foundation, employs the molecular techniques outlined above to reveal the basic genetic differ-



Carol Stiff

What began as a naked needle fascicle will grow into a blister rust resistant western white pine.

Carol Stiff

Undifferentiated tissue from an Idaho hybrid poplar grew into a profusion of shoots when cultured on a medium containing nutrients and growth hormones.

ences that underlie the bewildering morphological variation in this widespread group of shrubs. This work will redefine and clarify the boundaries of species in the group, which should end field identification problems.

In the coming year, I will be applying these molecular techniques to bitterbrush. This shrub varies considerably throughout its range in morphology, palatability, and response to fire, but we do not currently understand whether this variation is related to the presence of different genetic races that haven't yet been recognized in the field.

After we discover the nature of the genetic variation in bitterbrush, we will be able to correlate it with, and possibly find genetic markers for, valuable traits such as the ability to resprout following fire. Understanding the genetic structure of bitterbrush will greatly aid efforts to breed bitterbrush for planting in shrub restoration programs.

Steven Brunsfeld is an instructor in the Department of Forest Resources. He is currently conducting the DNA portion of his research at Washington State University. He hopes to be able to transfer his DNA work to the Biotechnology Laboratory.

Getting in control of deadly IHN

by James L. Congleton

A spokesman for the commercial trout industry recently identified infectious hematopoietic necrosis (IHN) as "the single most important constraint to the profitability and continued growth of the commercial coldwater aquaculture industry in the western United States." He estimated direct and indirect losses to the Idaho trout industry, which produces about 80 percent of the rainbow trout reared in North America, at $2 million to $3 million annually.

Ironically, when IHN disease was first described in the 1950s, fish culturists did not recognize it as a serious problem. Today, virulent strains of IHN virus cause catastrophic mortalities of salmon and trout in hatcheries operated by commercial fish farmers and by public agencies. Losses may be as high as 80 to 100 percent if the disease strikes soon after the young fish hatch. As yet, there are no effective methods for controlling the disease.

Our search for control methods begins with the observation that some species of salmon and trout are resistant to the disease and that some individual fish are more resistant than others. What are the resistance factors that allow some fish to remain healthy when exposed to the virus, while other fish die or become permanently disfigured? To answer this question, we are investigating the basic immune mechanisms of fish.

Resistance to viral infection in fishes is believed to depend on defense mechanisms similar to those in mammals. Both fishes and mammals develop specific immunity to viruses (that is, the immune system learns to specifically recognize and destroy a particular virus). Specific immunity develops relatively slowly, however, and does not provide significant protection until days or weeks after first exposure to a virus.

Other, more rapidly effective defense mechanisms may determine whether animals exposed for the first time to a pathogenic virus live or die. These rapid defense mechanisms are nonspecific (effective against a wide range of disease organisms). We are studying two types of cells—macrophages and natural killer cells—believed to contribute to the nonspecific resistance of fishes. Because of the economic importance of the rainbow trout to Idaho, we have chosen it as our experimental animal.

The macrophage (from the Greek words meaning "big eater") is a mobile cell that ingests viruses and other microorganisms foreign to the body. After ingestion, many types of viruses are inactivated. In mammals, macrophages can also recognize and destroy virus-infected cells, interrupting viral replication. In addition, mammalian macrophages produce agents such as interferon that cause other cells to become resistant to viral infection.

We plan to investigate these modes of macrophage activity to see if they are important for resistance to IHN virus in rainbow trout. In the first year of the project, we developed techniques to separate macrophages from trout kidneys and culture them in the laboratory. We have infected the cultured macrophages with IHN virus, and found that the virus resists inactivation and can replicate within the macrophage. Further work will explore how the virus interacts with macrophages in live trout.

The natural killer (NK) cells of mammals bind to and kill host cells that have been altered by viral infection or by cancerous change. Our initial studies of natural killer cells in trout have shown that they kill mouse YAC cells (commonly used as "targets" in assays of NK cell activity) over a remarkably wide temperature range (4-25^{0} C). This indicates that NK activity would not be suppressed by normal temperature fluctuations in trout rearing ponds. Currently we are attempting to determine if trout NK cells can recognize and kill IHN-infected host cells.

The nonspecific or "natural" resistance of mammals to viruses and other pathogens often increases dramatically with the injection of certain agents derived from the cell walls of bacteria or fungi. The mechanisms are complex, but in many instances they involve stimulation of macrophage or NK cell activity.

We are testing various microbial products for their ability to stimulate cultured trout macrophages and NK cells, using methods for cell isolation and maintenance developed in the first year of the project. Preliminary results indicate that trout macrophages are stimulated by endotoxin, a component of the cell wall of many common bacteria. Next, we will determine if endotoxin enhances the ability of the trout macrophage to combat IHN virus.

Our work on the fish macrophage and NK cell should open new approaches for the control of IHN virus and other fish diseases. Chemical stimulation of the virus-fighting properties of the rainbow trout macrophage or NK cell may improve resistance to the virus. Selection of fish stocks with superior macrophage or NK activity may also be an effective control measure. Finally, because the macrophage plays a central role not only in nonspecific resistance to viruses but also in development of specific immunity, our findings may assist efforts to develop a vaccine against the IHN virus.

James L. Congleton is associate professor of fishery resources. Working with him are Sandra S. Ristow, assistant professor in the Department of Animal Science at Washington State University, and Research Technicians Anne R. Greenlee and Consetta M. Helmick. *Funding for this three-year project is provided by the Western Regional Aquaculture Consortium (U.S. Department of Agriculture).*


Scott Spiker

James Congleton studies the immune mechanisms of fish as he seeks methods for controlling infectious hematopoietic necrosis, a deadly disease of salmon and trout.

Survival by fire: whitebark pine

by Penny Morgan and Stephen C. Bunting

High in the backcountry of Yellowstone National Park, the Shoshone National Forest, and the Bridger-Teton National Forest, we are studying how whitebark pine forests respond to fires much like those that occurred in the Yellowstone area last summer.

Whitebark pine forests comprise a major part of the subalpine forest zone, where their irregular, twisted crowns add interest to the views from high elevation ridges. Whitebark pine seeds are large and nutritious. Wildlife, including squirrels, Clark's nutcrackers, and grizzly bears, eat the seeds to survive the long, harsh winters.

Although whitebark pine is common at elevations above 2000 meters (6,500 feet) throughout the northern Rocky Mountains and Pacific Northwest, whitebark pine forests are declining throughout much of their range. This progressive loss is probably the result of effective fire suppression and advancing succession.

We are studying the regeneration and development of whitebark pine following fire, its rates of replacement by more shade-tolerant and less fire-resistant conifer species, and its cone production, all as they interrelate and are influenced by past fires. Since it is not a commercial timber species, whitebark pine has been little studied, so we are also contributing basic ecological knowledge about the species.

We have found that fires rejuvenate and maintain the productivity of seral whitebark pine stands, which are those most valuable to wildlife. Whitebark pine often regenerates in recent burns. But in the absence of frequent fires, on most sites in and around Yellowstone the whitebark pine are gradually replaced by subalpine fir and Engelmann spruce.

Frequent fires prevent or slow the replacement of whitebark pine by these more shade-tolerant and less fire-resistant conifers. Fires thus promote the long-term maintenance of whitebark pine forests.

Last summer, we began a study of the fire history of selected whitebark pine stands in Wyoming. Often the large trees survive fires, as evidenced by multiple fire scars on their trunks. Based on those scars, we have discovered that fires occurred as often as every 30 to 70 years in whitebark pine stands until the mid-1900s.

We also aged whitebark pines and associated conifers to determine when each species regenerated and how fast they

Gerry Snyder

Penny Morgan and Stephen Bunting use fire scars on whitebark pine sections to learn how often fires occurred in Wyoming's subalpine forests. Whitebark nuts nourish Clark's nutcrackers, red squirrels, and grizzly bears.

are growing. We have found that in the absence of fire, the other conifers increase in number and size.

Wildlife species rely on abundant whitebark pine cone crops that occur about every four years in vigorous stands. We think, however, that whitebark pine may produce fewer cones as other conifers begin to dominate the site. To find out, we climbed trees and sampled cone production, which we will relate to stand structure and fire history.

Our information should prove useful to land managers charged with improving and maintaining wildlife habitat and scenic values. Since fires influence the patterns of regeneration, growth rates, and successional development, prescribed fire may be a useful technique for managing the whitebark pine.

Penny Morgan is assistant professor of forest resources. Stephen Bunting is professor of range resources. *Their study is funded as a cooperative agreement with the USDA Forest Service Intermountain Research Station.*

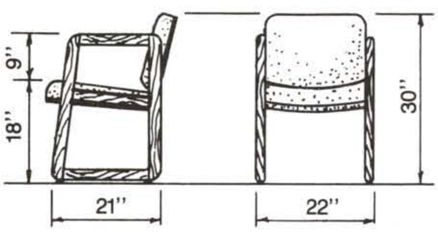
Research produces directory of wood products manufacturers

by Thomas M. Gorman

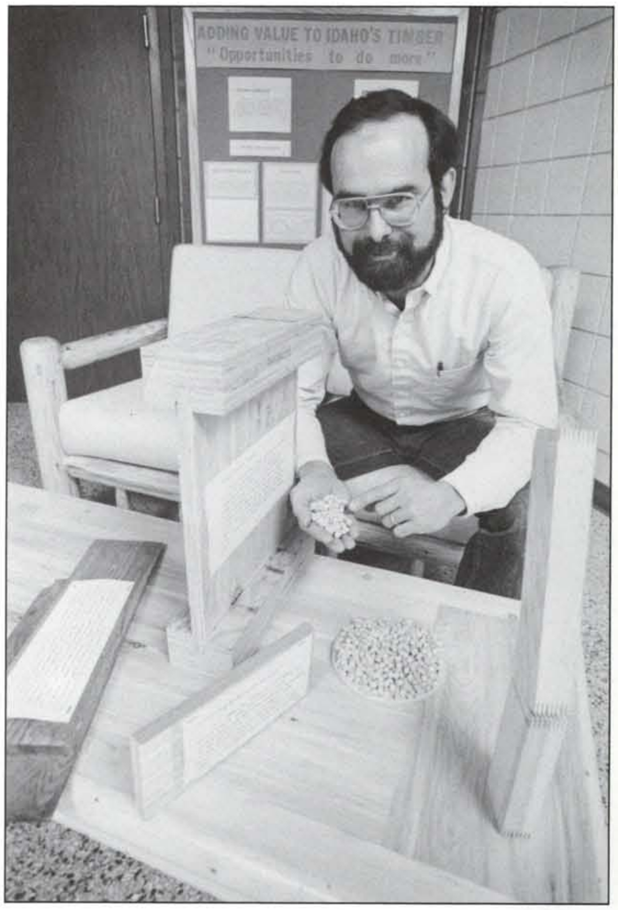
Currently in Idaho, 1.8 billion board feet of timber are harvested annually, generating approximately $750 million in sales of lumber and plywood and keeping over 14,000 people employed. Because most of the timber is converted to construction lumber, Idaho's forest products industry is highly dependent upon housing starts, foreign competition, and available timber supplies.

One way to increase the stability of Idaho's forest products industry is through additional manufacturing of secondary, "value-added" products. Secondary manufacturers take over where the sawmills leave off, converting primary products such as plywood and lumber into secondary products such as doors, windows, toys, and furniture.

I am currently examining the potential for increasing secondary wood products manufacturing in Idaho. The first step was a mail survey to identify existing secondary wood products manufacturers followed by meetings with manufacturers all over the state. That effort culminated in the *Directory of Idaho Secondary Wood Products Manufacturers,* published in 1989 by the Idaho Forest, Wildlife and Range Experiment Station. The directory complements the *Directory of Idaho Primary Wood Processors* by Robert Govett and Patricia Miller, published by the station in 1987. First of its type in the Northwest, the secondary products directory lists over 200 Idaho firms and the products they make. These range from arrows and cabinets to wood pellets and structural joists. In addition to showing the range of secondary wood products manufacturing in Idaho, the directory will assist purchasers in locating these firms, encouraging them to "buy Idaho."



The survey of secondary manufacturers indicated that annual sales of Idaho secondary wood products presently amount to about $200 million. The potential for additional secondary manufacturing has yet to be determined. However, Idaho grows a number of tree species such as ponderosa pine and western white pine suitable for a variety of high-value products. Which products to emphasize will depend on market demand, nationally and internationally.



Scott Spiker

Value-added wood products manufactured in Idaho include I-beams made from laminated veneer lumber and plywood, wood pellets, finger-jointed millwork, and western log furniture.

I hope to continue my research by identifying specific opportunities for increased secondary wood products manufacturing. This research would include locating new markets for existing products and exploring the potential for new products. Products made from residues, or wood wastes, for example, help to increase mill revenues and reduce the volume of wasted wood. The research would also identify products being made out of state with Idaho lumber, looking for opportunities to manufacture those products in Idaho.

Thomas Gorman is assistant professor of forest products. His research was supported by a McIntire-Stennis federal grant.

To Hells and back: trouble in paradise

by Stewart D. Allen

According to the Chinese calendar, 1989 is the year of the snake. The same is true at the University of Idaho, where a unique research and planning effort will contribute to a new recreation management plan for the Snake River in Hells Canyon.

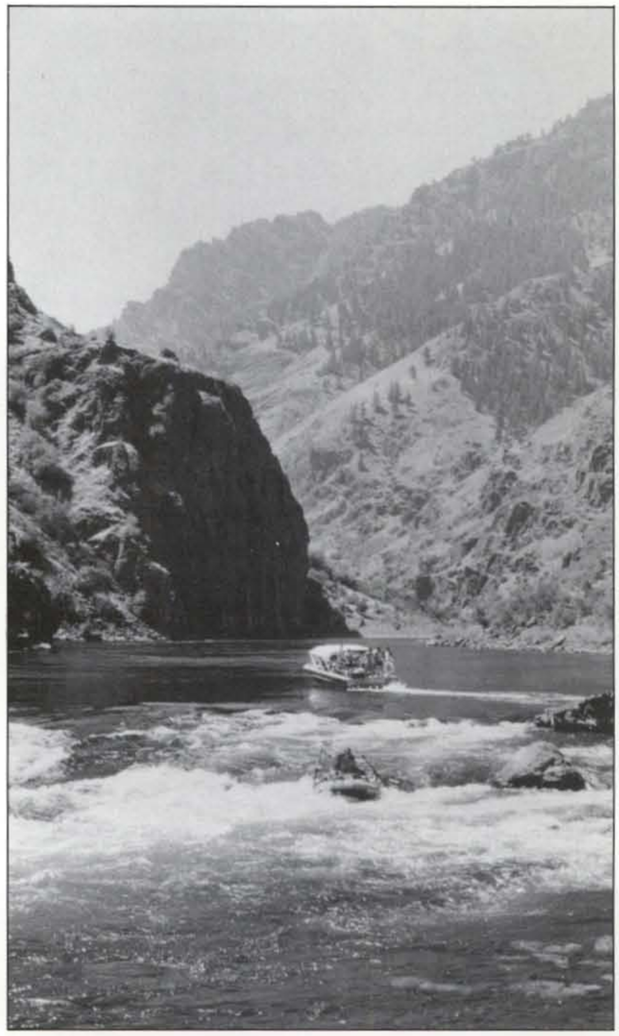
Located on the Idaho-Oregon border, the Snake River in Hells Canyon has a lot going for it. With a maximum depth of 7,900 feet, it's called the deepest gorge in North America. Steelhead and chinook salmon run here on their long trip from the Pacific, inspiring an equally prolific run of anglers. Giant, prehistoric-looking white sturgeon, the largest game fish on the continent, lurk in deep, clear pools. Pictographs found throughout the canyon tell the history of the canyon and its former dwellers.

Rapids like Granite, Wild Sheep, Water Spout, and Rush Creek get the juices flowing for boaters at any water level. And the craggy walls of the remote canyon limit road access, so boaters don't have to share their experience with cars. What's more, Hells Canyon Dam provides enough water for floating or powerboating year-round, and the river's low elevation keeps winter temperatures moderate (at least to steelheaders, although that's probably an unrealistic standard). As a result, the river has acquired a national reputation for powerboating, rafting, and kayaking.

Congress recognized this 67.5-mile section of the Snake in 1975, adding it to the National Wild and Scenic Rivers system and creating Hells Canyon National Recreation Area. The act gave management responsibility to the Forest Service, which adopted a management plan in 1981 to protect the river while allowing for recreational use.

Unfortunately, the river is just a little too attractive, drawing over 100,000 float and powerboaters annually. Faced with increasing recreational use and abuse, the Forest Service hired myself and colleagues in the Department of Wildland Recreation Management to collect data on boating use and to guide the development of a new recreation management plan.

A complete list of concerns would fill this issue of *Focus,* but here's a quick look. Competition for campsites is intense during the summer use season and the Forest Service is hard-pressed to adequately maintain them. Stories abound about conflicts among boaters, from radical environmental groups rafting the river and provoking motorized groups to powerboaters pulling guns on rafters after being "mooned." However, there are no data on the type or extent of conflicts.



Pat O'Herren

The Snake River in Hells Canyon is part of the Wild and Scenic River system. Although no roads line the remote canyon, the river brings 100,000 boaters to it each year.

Another issue is fairness; many floaters question the equitability of a management plan that sets strict use-level limits on floating during the high use season (mid-May to mid-September), but does not limit powerboat access. An earlier version of the plan did limit powerboat use on the upper river, but this provision was scrapped by the assistant secretary of agriculture in his 1984 decision on a series of appeals.

Many float and powerboat outfitters feel that planned improvements at Pittsburg Landing will lead to more crowding and compound existing problems. Scheduled improvements include upgrading the boat ramp area; adding a parking lot, campground and interpretive displays; and improving the access road from the town of Whitebird—a ride as thrilling as running the rapids.

Even the canyon's geologic pedigree is questioned—is Hells Canyon really the deepest gorge on the continent when it's nearly 10 miles between canyon rims at the river's deepest point?

One point of agreement among all groups, including the Forest Service, is that the existing management plan is no longer adequate. Development of the new management plan will take two years, primarily because it will involve extensive public participation. We will organize and facilitate a task force composed of representatives from river user groups; local, state, and federal agencies; landowners; outfitters; and others who have a stake in how the river is managed.

The task force will develop the new plan during monthly meetings starting late summer, 1989. The team will identify the most important physical, biological, and social characteristics of the river, then attempt to reach consensus on management actions to keep the impacts of recreational use at (or below) mutually agreed-upon levels.

This is a new process for federal agencies charged with managing rivers; they aren't used to turning over the planning process to diverse groups and interests—some of whom in this case filed appeals to the original management plan. But the Forest Service is funding the study and promises to do its best to implement the new plan.

The first stage of the planning process is a survey of floaters and powerboaters that we began in May 1988 and will complete in May 1989. Sampling is complex on a river where the put-ins double as take-outs, the access points are remote even by Idaho standards, and use occurs year-round. Simply determining how many people boat Hells Canyon is difficult; we installed hidden cameras at key access points and flew over the canyon in airplanes to count boats and visitors.

To date, nearly 2,000 floaters and powerboaters have been asked to complete a questionnaire about their experiences on the Snake. Questions include what attracted them to the river, what added to or detracted from their trips, and whether they favor or oppose various management alternatives. Over 75 percent have responded, reflecting river users' high levels of interest. The data will be entered onto the university computer and analyzed by summer 1989 so the Task Force will have a solid information base as it wrestles with the complex management issues.

The outcome will be a river management plan based on the needs and preferences of a wide range of river users, beginning a new era of user-developed recreation management. And what better time to begin the planning effort than the year of the snake?

Stewart D. Allen is visiting assistant professor of wildland recreation management. Edwin E. Krumpe, associate professor of wildland recreation management, is co-principal investigator. Other researchers include Research Associate Robert Ratcliffe and master's student Lynn McCoy.

Powerboats, kayaks, and rafts share the Snake River in Hells Canyon—sometimes uneasily. The U.S. Forest Service asked the college's assistance in bringing together diverse user groups to help prepare a new management plan for the popular river.

Pat O'Herren

Wood pellets: a look at standards and small-scale production

by Richard L. Folk

The forest products industry has recently recognized a new potential to add value to the forest resource—converting wood wastes to energy as "wood pellets." Wood pellets are particles of wood pressed into small cylinders measuring about 1 inch long and 5/16 of an inch in diameter. Burned in residential pellet stoves or institutional boilers, pellets burn cleaner than firewood and cost less than electric heat.

Richard Folk

Richard Folk tests wood pellets in a residential pellet stove, measuring heat output, ash production, and creosote buildup. Pellets have been made from such materials as wood chips, newspaper, and rape stalks.

The development of wood pellet manufacturing in the region has recently expanded from a small number of large pellet producers supplying a few hospitals, schools, and other institutions to an increasing number of large and small producers servicing the growing institutional and residential heating markets. The equipment and processes for large-scale pellet production are well established. But small producers face considerable problems with the equipment, processes, and economic feasibility of small-scale production.

Moreover, for large and small manufacturers alike, there is no set of widely accepted pellet quality standards. Also lacking are standard tests for some important pellet characteristics.

Our research is aimed at determining the technical and economic feasibility of small-scale pellet manufacturing in the Intermountain and Pacific Northwest regions. Secondarily, the research is aimed at improving and developing standards for pellet quality and procedures for testing pellet characteristics.

The feasibility research applies to the many small primary and secondary wood products companies looking for ways to avoid residue disposal costs or make additional products. Now in development, a computerized economic model will help these small manufacturers decide whether or not to invest in pellet manufacturing for local markets. The model considers inputs such as cost of capital, equipment, raw materials, operation, maintenance, sales, marketing, and overhead as well as profit to arrive at a pellet price that can be compared with other heating fuels.

Our in-plant study at the Browning Cut Stock Company in Juliaetta, Idaho, is documenting just how pellet manufacturing can be done on a small scale. Browning Cut Stock produces window and door parts, moulding, millwork, wooden toys, and other specialty products from high-quality ponderosa pine. The residues generated—sawdust, trim ends, edgings, and planer shavings—are insufficient for long-term contract sales to pulp and paper mills or particleboard plants and often become a disposal problem.

Browning Cut Stock has modified used cattle feed pelleting equipment to produce fuel pellets. Although a popular approach among small manufacturers, it is hardly straightforward. On the contrary, being part bargain hunter, engineer, machinist, welder, electrician, and magician appear to be definite assets when building a wood pellet plant.

We are also studying the entire pellet production process, looking for ways to cut costs. Our experience at Browning Cut Stock shows that residue drying may be too costly for small manufacturers. Instead, small manufacturers may want to start with a mixture of green and dry residues.

Also at Browning Cut Stock, we are examining the feasibility of producing pellets from agricultural crop residues, whole-tree chips, and newspaper. One farm crop that has shown promise is rape. The rape stalk can be baled like wheat straw with farm machinery then hogged and hammered with sawmill equipment.

Other manufacturers, experimenting with "raw material recipes" that increase heat value and reduce manufacturing costs, have used blends of fir, pine, or spruce. Some manufacturers add plastic. Fuel pellets have also been made of bark, corn cobs, peanut shells, and coconut husks.

Pellet fuel quality has a major influence on residential stove performance. In a stove donated by Welenco Manufacturing of Lewiston, Idaho, we are burning pellets from a variety of sources, measuring pellet heat output, ash production, creosote buildup, and stove maintenance. Along with performance, we are measuring pellet fuel characteristics that affect burning, including density; Btu content; the contents of moisture, ash, and fines; and durability. Durability—or the quality of staying whole during handling—is currently not recognized as a standard.

Pellets for testing come to our laboratory from new pellet manufacturers and from people who build, sell, and service pellet stoves. After testing dozens of brands, we have identified pellet moisture content, noncombustibles content, and fines content as the three characteristics most important in stove performance. Within the next year, we hope to publish our pellet test results and begin a more comprehensive study leading to the development of pellet fuel standards for the Northwest and Intermountain regions.

Richard Folk is a Ph.D. candidate and research associate in the Department of Forest Products. Also a principal investigator, Robert L. Govett is associate professor of forest products. *Funding has been provided by the U.S. Department of Energy's Bonneville Power Administration.*

Appendix

Experiment Station Scientists

Department of Fish and Wildlife Resources

Ables, Ernest D.
Professor and Department Head
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

Chandler, Gwynne L.
Research Associate

Chandler, James A.
Research Associate

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

Dunsmoor, Larry
Research Associate
Reservoir fisheries

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

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

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

Mitchell, Brad
Visiting Associate Professor
Limnology; estuarine ecology; ecology, physiology, and culture of decapod crustaceans; zooplankton ecology

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

Nelson, Lewis, Jr.
Professor
Continuing education, 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.
Assistant Professor
Wetland 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.
Associate Professor
Project Leader (Biology), Cooperative Park Studies Unit
Wildlife habitat management and 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
Wood utilization and processing, wood pellets

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

Hofstrand, Arland D.
Professor Emeritus
Anatomy and mechanical properties of wood

Johnson, Leonard R.
Professor
Timber harvesting systems, wood energy, recovery and processing of forest residues

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

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

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
Curator, Forestry, Wildlife and Range Sciences Research Herbarium
Vegetation ecology, autecology, systematics, molecular biology of woody plants

Burlison, Vernon H.
Extension Forester Emeritus
Extension Professor Emeritus

Canfield, Elmer R.
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
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 and Department Head
Forest mensuration and statistics

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

Experiment Station Scientists

Hendee, John C.
Professor
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 upon forest lands and woody plants, dendrology—temperate and tropical

Loewenstein, Howard
Professor Emeritus
Forest soils and tree nutrition

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

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

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

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
Currently 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, the 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
Associate Dean for Research and International Programs
Associate Director, Idaho Forest, Wildlife and Range Experiment Station
Associate Member, Department of Range Resources
Forest and range ecology, fire management, prescribed burning, site preparation for conifer release

Osborne, Harold L.
Assistant 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

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 Associate
Tissue culture

Stiff, Charles T.
Assistant Professor
Forest growth and yield, inventory, modeling and simulation

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
Small format aerial photography and interpretation

Vander Ploeg, James L.
Research Associate
Growth-yield, forest nutrition

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

Department of Range Resources

Bunting, Stephen C.
Professor
Integrated range resource management, range management planning, grazing systems

Ehrenreich, John H.
Professor
Range ecology, international forestry

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

Johnson, Kendall L.
Professor and Department Head
Range extension, shrubland ecology and management

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

Robberecht, Ronald
Assistant Professor
Ecophysiology, autecology, range ecology

Sanders, Kenneth D.
Professor
Range extension, range nutrition, range 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

Allen, Stewart D.
Visiting Assistant Professor
Environmental psychology, river recreation, research design and methodology

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

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

Harris, Charles C.
Assistant 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
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
Director, Wilderness Research Center
Wilderness and dispersed recreation management, recreation and tourism behavior and the decision process, interpretation and communication, administration, facilities management, research methods

McLaughlin, William J.
Associate 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

Research Projects and Investigations

This listing shows the range of work in progress through the College of Forestry, Wildlife and Range Sciences during 1988. If additional information is needed, 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

Behavioral interactions of bighorn sheep with deer and elk. E.D. Ables, H.A. Akenson

Effects of winter recreationists on elk in Yellowstone National Park. E.D. Ables, E.F. Cassirer

Sociodemographic studies of coyotes on the Arid Lands Reserve at Richland, Washington. E.D. Ables, R.L. Crabtree

A wildlife preserve management plan for Burkina Faso. E.D. Ables, T.E. Damiba

Role of vocalizations in coyote society. E.D. Ables, K.F. Fulmer

Application and testing of an index of biotic integrity to assess the impact of land use activities on receiving streams in central and southern Idaho. D.H. Bennett

Assessing the impact of land use activities on the health of Idaho's streams. D.H. Bennett

Assessment of disposal of dredge material in Lower Granite Reservoir. D.H. Bennett

Dredging in Lower Granite Reservoir. D.H. Bennett

Evaluation of bass populations in northern Idaho. D.H. Bennett

Food and predator-prey relationships of smallmouth bass in Brownlee Reservoir. D.H. Bennett, L.K. Dunsmoor

Development of a recreation area planning document for Power Lake, associated with Box Canyon Reservoir. D.H. Bennett, C.M. Falter

Effluent biotreatment design and biomonitoring to project receiving water toxicity. D.H. Bennett, C.M. Falter, A.G. Campbell

Response of chinook salmon fry to steelhead and brook trout predators and cover. T.C. Bjornn

Response of salmon and trout to water temperatures and substrate particle size. T.C. Bjornn

Evaluation of habitat for salmonids in the Boise River. T.C. Bjornn, G.M. Asbridge

Fish response to solar input, riparian vegetation, and instream cover in second-growth forest streams of Southeast Alaska. T.C. Bjornn, M. Brusven, R. Keith, N. Hetrick

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

Development of sampling techniques and life history information for yellow perch in Cascade Reservoir. T.C. Bjornn, R.G. Griswold

Production of kamloops rainbow and bull trout in Pend Oreille Lake tributaries. T.C. Bjornn, B.G. Hoelscher

Potential production of cutthroat trout in Priest Lake tributaries. T.C. Bjornn, D. Irving, P. Cowley, R. Strach

Development and testing of models to estimate supplementation requirements for salmon and steelhead stocks. T.C. Bjornn, J. McIntyre, A.F. Byrne

Carrying capacity of streams as related to physical and biological factors. T.C. Bjornn, W.R. Meehan, C.R. Steward

Effects of small hydroelectric developments on aquatic invertebrates and fish. T.C. Bjornn, W. Minshall, K. Bovee, S. Rubin

Evaluation of the proposed use of Bear Lake National Wildlife Refuge as a sediment and nutrient trap for inflows to Bear Lake. T.C. Bjornn, C.M. Moffitt, K.P. Reese, C.M. Falter, J.H. Milligan, R.W. Tressler, R.E. Myers, C.J. Cleveland

Evaluation of methods for controlling bacterial kidney disease in chinook salmon. T.C. Bjornn, C.M. Moffitt, J.A. Schreck

Physical and biological factors limiting coho salmon smolt production in Slippery Creek Drainage. T.C. Bjornn, P.E. Porter

Fall chinook trapping at Ice Harbor Dam. T.C. Bjornn, R.R. Ringe

Sedimentation and embryo survival in natural redds of chinook salmon and steelhead in relation to sediment transport. T.C. Bjornn, C.R. Steward, C.M. Chandler

Sturgeon life history, migration, and genetics. E.L. Brannon, A.L. Setter

Methods for control of infectious hematopoietic necrosis virus. J.L. Congleton

Attached benthic algae growth rates in Lake Pend Oreille embayments. C.M. Falter

Sediment and nutrient export from the Twin Lakes watershed. C.M. Falter

Stream benthos in the southern Cascades of Washington state. C.M. Falter

Snake River low flow limnology. C.M. Falter, B.D. Mitchell

Avian predators of the western spruce budworm. E.O. Garton

Developing indicators for wilderness wildlife. E.O. Garton

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

Population ecology of trumpeter swans and whooping cranes. E.O. Garton, R. Gale

Status and habitat requirements of boreal owls in northern Rocky Mountains. E.O. Garton, G.D. Hayward, P.H. Hayward

Habitat selection of fisher in northern Idaho. E.O. Garton, J.L. Jones

Black bear population management strategies in national parks. E.O. Garton, J.A. Keay

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

Home range analysis methods. E.O. Garton, F.A. Leban

Aerial census methods for elk and mule deer populations. E.O. Garton, M.D. Samuel, B. Akerman, J. Unsworth

Translocation as a species conservation tool: Status and strategy. D.B. Griffith, J.M. Scott, J.W. Carpenter, C. Reed

Idaho citizens survey on nongame wildlife and the Idaho income tax check-off program. C.C. Harris, K.P. Reese, T.E. Miller

Dynamics of sympatric populations of mountain lions, bobcats, and coyotes in the Frank Church—River of No Return Wilderness. M.G. Hornocker, G.M. Koehler

Ecology and demography of a lynx population in north-central Washington. M.G. Hornocker, G.M. Koehler

Ecology of the mountain lion in southwestern New Mexico. M.G. Hornocker, K. Logan, L. Sweanor, F. Smith, B. Spreadbury

Ecology of the mountain lion in the Yellowstone ecosystem. M.G. Hornocker, K. Murphy, J. Tischendorf

Population dynamics of mountain lions in central Idaho. M.G. Hornocker, H. Quigley

Evaluation of candidate antibacterials. G.W. Klontz

Evaluation of ornamental fish diets. G.W. Klontz

Fish production capacities of multiple-use water systems. G.W. Klontz

Nature and fate of the *Yersinia ruckeri* carrier state in rainbow trout. G.W. Klontz

Determination of dosage and duration of oral administration of erythromycin thiocyanate to treat bacterial kidney disease in chinook salmon. C.M. Moffitt

Natural immunity to infectious hematopoietic necrosis and bacterial kidney disease in salmon and trout. C.M. Moffitt, J.L. Congleton

Movements and habitat use of bighorn rams, Salmon River, Idaho. J.M. Peek, G.L. Ballard

Umatilla Indian Reservation white-tailed deer investigations. J.M. Peek, J.H. Bell

Grizzly bear use of ungulate winter ranges in the greater Yellowstone area. J.M. Peek, G.I. Green

Observability, movements, and dispersal of bull elk in the Blackfoot drainage of western Montana. J.M. Peek, M.A. Hurley

Evaluation of elk depredation on cropland. J.M. Peek, M.A. Jarmer

Moose habitat selection on the Copper River Delta, Alaska. J.M. Peek, J.G. MacCracken

Sitka black-tailed deer habitat use investigations. J.M. Peek, J.D. Mankowski

Bull moose behavior and habitat use investigations in the Denali National Park and Reserve, Alaska. J.M. Peek, D.G. Miquelle

Mountain goat habitat use investigations at Pend Oreille Lake. J.M. Peek, K.S. Naylor

Habitat use, home range, and movements of white-tailed deer in northern Idaho. J.M. Peek, G.R. Pauley

Thermoregulation in shrub steppe mule deer. J.M. Peek, G. Sargeant

Evaluating potential effects of wolf predation on the ungulate complex of the East Front in Montana. J.M. Peek, D.J. Vales

Evaluation of bull elk habitat use in Yellowstone National Park, Wyoming. J.M. Peek, D.J. Vales

An evaluation of augmentation of the Selkirk Mountain caribou herd. J.M. Peek, C.D. Warren

Habitat selection by Sitka black-tailed deer in intensively managed forests of southeastern Alaska. J.M. Peek, J.J. Yeo

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

Behavior and ecology of tundra swans, Arctic National Wildlife Refuge. J.T. Ratti, M.J. Monda

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

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

Ecology of sympatric sage and sharp-tailed grouse in Idaho. K.P. Reese, A.D. Apa

Relationships of old-growth wildlife species to vegetative characteristics of snags. K.P. Reese, V.D. Boyd

Spring movements and nesting ecology of sharp-tailed grouse in south-eastern Idaho. K.P. Reese, D.R. Meints

Reintroduction of sage grouse into the Sawtooth Valley. K.P. Reese, D.D. Musil

Winter movements and habitat use of sage grouse in the Big Desert of southeastern Idaho. K.P. Reese, M.D. Robertson

Spring movements and nesting ecology of sage grouse in southeastern Idaho. K.P. Reese, W.L. Wakkinen

Species richness: A guide to protecting future biological diversity in Idaho. J.M. Scott, H. Anderson, B.A. Csuti, S. Caicco

Gap analysis of species richness: A guide to protecting biological diversity in the Pacific Northwest. J.M. Scott, B. Csuti, S. Caicco, B. Butterfield, H. Anderson

Vegetation community change along the Snake River, Idaho. J.J. Ulliman, J.M. Scott, R. Balice

Integrating database management and resource monitoring methods at Glacier National Park. R.G. Wright

Resource monitoring and inventory using GIS techniques in North Cascades National Park. R.G. Wright

The development of resource databases for national parks in the Pacific Northwest. R.G. Wright

Native plant revegetation, Northwest national historic sites. R.G. Wright, S.C. Bunting

The development of a fire management plan and fire history for Craters of the Moon National Monument. R.G. Wright, S.C. Bunting

Computer modeling techniques applied to resource management. R.G. Wright, R. Hoffman

The development of baseline inventory and monitoring techniques for small mammals and birds at Craters of the Moon. R.G. Wright, R. Hoffman

Seasonal nutrient quality of deer forage within old-growth and recent clearcuts in Southeast Alaska. J.J. Yeo, C. Race

Department of Forest Products

Effluent biotreatment design and biomonitoring to project receiving water toxicity. D.H. Bennett, C.M. Falter, A.G. Campbell

Chemical characterization of lodgepole pine. A.G. Campbell

Supercritical fluid extraction of pine. A.G. Campbell

Pre-treatment of CTMP effluent. A.G. Campbell, R. Engerbritson

Boron as a factor in lignin biosynthesis. A.G. Campbell, H. Honghan

Wood ash as a soil additive. A.G. Campbell, E. Lazare

Boron as a factor in differentiation. A.G. Campbell, G. Shetty

Determining measures of quality, testing methods, and product standards for densified wood fuel pellets. R.L. Folk, R.L. Govett

The feasibility of producing densified fuel from wood residue with punch press technology. R.L. Folk, R.L. Govett

Technical and economic assessment of using small and medium-sized processing equipment to produce densified fuels for small and local markets. R.L. Folk, R.L. Govett, H.W. Lee

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

Practical considerations in the export of forest products. R.L. Govett

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

Marketing of Christmas trees. R.L. Govett, M. Mount

An assessment of Chile's future role in Pacific Rim markets. A. Jelvez, K. Blatner, R.L. Govett

Analysis of mechanized logging systems. L.R. Johnson

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

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

Summary of residue recovery systems and costs. L.R. Johnson

Supplement to Biomass Guidebook: Small to medium-scale wood combustion systems. L.R. Johnson, A.G. Campbell, L.A. Kirkland, R.E. Taylor

Harvesting and transportation of chunkwood from residues. L.R. Johnson, H.W. Lee, M.M. Hughes

Analytical, economical, and financial evaluation of wood burning bioenergy systems for Idaho. H.W. Lee

Economic evaluation of the results of non-industrial private forest landowner survey for southern Idaho. H.W. Lee

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

Non-industrial private forest landowner survey for southern Idaho. H.W. Lee, J.E. Force

Production and site compaction from mechanical feller-buncher. H.W. Lee, L.R. Johnson

Assessment of potential targets to use biomass resources. J. Meimban, R.L. Govett

Risk analysis and economic feasibility of various co-generation capacities in the forest industry of Idaho. J. Meimban, R.L. Govett

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

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

Hog fuel drying. H.P. Steinhagen

Department of Forest Resources

The grand fir mosaic. D.L. Adams, D.E. Ferguson

Animal damage to western redcedar regeneration. D.L. Adams, R.T. Graham

Relationships between low light intensity, foliar nitrogen, and susceptibility of Douglas-fir to *Armillaria ostoyae* (Romagnesi) Herink. D.L. Adams, G.I. McDonald, A.C. Koehn

Soils of the grand fir mosaic. D.L. Adams, R.L. Mahler, M. Sommer

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

Afghan refugees' fuelwood use and its implications for forest management and refugee administration. D.L. Adams, Z.A. Tayyib

Fall planting schedules for conifers in northern Idaho and western Montana. D.L. Adams, D.L. Wenny, R.T. Graham, M. Daa

Methods for predicting erosion from forest practices. G.H. Belt

Modeling fugitive dust emissions. G.H. Belt

Whitebark pine fire ecology and management. S.C. Bunting, P. Morgan

Research Projects and Investigations

Analysis of coastal and disjunct populations of *Cornus nuttallii*. S.J. Brunsfeld

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

Ecology, distribution, and taxonomy of *Crataegus suksdorfii* in the northern Rockies. S.J. Brunsfeld, F.D. Johnson

Mathematical statistics for scientists. B. Dennis

The stochastic logistic equation. B. Dennis

The use of species abundance distributions. B. Dennis

Statistics for population estimation using radio isotope tagging. B. Dennis, R.L. Crabtree, E.O. Garton

Implementation of grasshopper stage-development models for IPM. B. Dennis, W.P. Kemp, P.L. Munholland

An evaluation of the efficacy of granular Banrot® to control *Fusarium* root disease in containerized Douglas-fir seedlings. R.K. Dumroese, R.L. James, D.L. Wenny

Evaluating the effects of coating styroblock containers with cupric carbonate on incidence and severity of *Fusarium* root disease. R.K. Dumroese, R.L. James, D.L. Wenny

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

Nutrient deficiency symptoms of ponderosa pine and Douglas-fir seedlings. R.K. Dumroese, M.E. Montville, D.L. Wenny

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

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, W. Du

Genetics and nutrition of field-planted Douglas-fir. L. Fins, G.E. Rehfeldt, V. Aston

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

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

An evaluation of the user's role in wood energy for residential heating in Idaho. J.E. Force

Public involvement in the national forest planning process. J.E. Force

The use of spatial analysis to identify areas to involve people in native tree planting in Mali. J.E. Force, M. Diallo

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

The relationship of site characteristics and fuelwood collecting following timber harvest. J.E. Force, L.F. Neuenschwander, S. Bernatas

People's participation in agroforestry using the GRAAP technique in Burkina Faso. J.E. Force, P. Sawadogo

Strengthening forestry education and research in Indian state agricultural universities. C.R. Hatch

Modeling agroforestry systems. C.R. Hatch, S.P. Dhall

Utilization of wood biomass from agroforestry systems in India. C.R. Hatch, A.A. Moslemi, A.N. Kaushal

103 wilderness laws: Milestones and management direction in wilderness legislation, 1964-1987. J.C. Hendee, J.A. Browning, J.W. Roggenbuck

Development of a system to micropropagate bitterbrush and sagebrush. M. Hironaka, C.M. Stiff, M. Mousseaux

Pathogenicity of selected *Fusarium* isolates from Douglas-fir seed and seedlings. R.L. James, R.K. Dumroese, C.J. Gilligan, D.L. Wenny

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

Ecology and distribution of Idaho woody plants, Phase II: Shrubs. F.D. Johnson

Introduction to pan-tropical trees. F.D. Johnson

Wild trees of Idaho. F.D. Johnson

Escaped and naturalized woody plants of Idaho. F.D. Johnson, S.J. Brunsfeld

Naturalized woody plants of the intermittent inundation zone on the Middle Snake River. F.D. Johnson, J.E. Cronk

Succession in *Abies lasiocarpa/Xerophyllum tenax* habitat type in central Idaho. F.D. Johnson, M.J. Simpson

An expert system for preparing work authorizations. A. Kendall, B. Attri, M.W. Stock

Non-industrial private forest landowner survey for southern Idaho. H.W. Lee, J.E. Force

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

Visitor Services Project phase III: Evaluating interpretive effectiveness. G.E. Machlis

Visitor Services Project: An examination of visitor use patterns at the White House/the Mall, Statue of Liberty National Monument, Everglades National Park, Delaware Water Gap National Recreation Area, Golden Gate National Recreation Area, Lincoln Home National Historic Site, and Yellowstone National Park (post fire). G.E. Machlis, D.E. Dolsen, M.A. Littejohn, D.E. Madison

Evolution of Idaho markets for upland hunting rights. C.W. McKetta

The feasibility and desirability of short-run economic timber market analyses. C.W. McKetta

Modeling Idaho rural landowner policies toward posting, hunters, and hunting rights transactions. C.W. McKetta, N.A. Bolon

Econometric estimation of the supply and demand for softwood stumpage in southwest Colorado, 1960-1986. C.W. McKetta, J.T. Powers

Effects of the 1986 federal tax reform act on non-industrial private forest timber investment in North Idaho. C.W. McKetta, E.J. Weiner

Cost-Benefit analysis for fuelwood project investment in Burkina Faso: The case of Ouagadougou. C.W. McKetta, B.O. Zida, J.E. Force

Research Projects and Investigations

Black cherry: A high-value alternative crop for Idaho farms and woodlands. R.L. Mahoney, C.M. Stiff, Y. Carree

Nursery stock evaluation on private land. R.L. Mahoney, D.L. Wenny

Forest economic and policy technical assistance to social forestry programs in Southeast Asia. E.L. Medema

Data base development for model testing. J.A. Moore

Development of a compatible whole-stand/individual tree growth and yield model. J.A. Moore

Develop state-of-knowledge on the ecology and silviculture of ponderosa pine in the western United States. P. Morgan

Use of prescribed fire in young maritime pine (*Pinus pinaster*) plantations in northern Portugal. P. Morgan, S.C. Bunting, H. Botelho

Photographic series for appraising slash fire hazard in Idaho. P. Morgan, B. Shiplett

Fuel variability in uneven-aged ponderosa pine stands. P. Morgan, I. Saphra

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

Microsite variability and safe site influences on western larch establishment. L.F. Neuenschwander, B.P. Oswald

Effect of site preparation techniques on juvenile conifer growth. L.F. Neuenschwander, K.T. Wellner, H.L. Osborne

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

Herbicides have great potential for managing forest vegetation. H.L. Osborne

Horse logging 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 to provide material that will be useable as fuelwood. H.L. Osborne

Computerized diagnosis of seed and seedling diseases. A.D. Partridge

Black stain root disease-bark beetle relationships. A.D. Partridge, C.L. Bertagnole

Hazard tree evaluation. A.D. Partridge, R.T. Tinnemore

Modeling the natural resource economy of Idaho. M.H. Robison

Modeling the west-central Idaho highlands timber economy. M.H. Robison, S.A. Katzer

Micropropagation of western white pine using needle fascicles. C.M. Stiff, D.L. Wenny

Production of herbicide-resistant poplar from leaf tissue culture *in vitro.* C.M. Stiff, D.L. Wenny

Effects of fugitive cement kiln dust on forest productivity. C.T. Stiff

The northern Rocky Mountain version of the timber resource inventory model. C.T. Stiff, C.W. McKetta, R.O. Barkley

Implementation of a site classification system for upland pine forests in central Honduras. C.T. Stiff, M. Molina

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

An evaluation and comparison of two distance-independent forest projection models in the Inland Northwest—Part 2. C.T. Stiff, D.A. Patterson

Estimating the risk of escape of prescribed burns. M.W. Stock

Silvicultural expert systems. M.W. Stock, L.L. Amell

Predicting the spread of wilderness fires. M.W. Stock, J.M. Saveland

Ecosystem dynamics under stress. K.J. Stoszek

Using polymer gels for improved soil water retention in potted white birch (*Betula pendula* Roth) production. R.R. Tripepi, D.L. Wenny, R.K. Dumroese

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

Vegetation and morphology change along the Snake River in Wyoming. J.J. Ulliman

Practical remote sensing applications using VLSI hardware. J.J. Ulliman, J.R. Busch, G.K. Maki

Accuracy test of ARC/INFO TIN generated data. J.J. Ulliman, A. Fahsi

A comparison of photogrammetric plotting instruments for road updating. J.J. Ulliman, J. Johnson

Vegetation community change along the Snake River, Idaho. J.J. Ulliman, J.M. Scott, R. Balice

Cost-Benefit analysis of selected agroforestry systems in northeastern Thailand. A. Wannawang, G.H. Belt, C.W. McKetta

Fast forest biomass production from Idaho hybrid poplar. D.L. Wenny

The effects of mechanical and chemical root pruning on root egress of ponderosa pine seedlings. D.L. Wenny

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

A growing regime for containerized pines. D.L. Wenny, R.K. Dumroese

A growing regime for containerized spruces. D.L. Wenny, R.K. Dumroese

A growing regime for containerized western redcedar. D.L. Wenny, R.K. Dumroese

An attempt to improve survival and growth of seedlings in southern Idaho using polymer gels. D.L. Wenny, R.K. Dumroese

Clonal propagation of western larch (*Larix occidentalis* Nutt.). D.L. Wenny, J.L. Edson, L. Fins

The influence of N/K status on the quality of containerized Douglas-fir seedlings. D.L. Wenny, R.W. Kingsbury

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

N:K ratios in conifer seedlings and subsequent susceptibility to *Armillaria.* D.L. Wenny, J.A. Moore, J. Schwandt, J.R. Olson

Mass clonal propagation of hybrid poplar. D.L. Wenny, C.M. Stiff, R.K. Dumroese, Y. Carree

Ponderosa pine and western larch response to mechanical stress in the greenhouse. D.L. Wenny, J.R. Tonn

Development of ponderosa pine in containers: A comparison between non-treated and chemically root-pruned seedlings. D.L. Wenny, Z-G. Wang

Department of Range Resources

Shrub establishment following wildfire. S.C. Bunting, S.J. Jirik

Effects of fire on western juniper woodland soils. S.C. Bunting, M. Hironaka, V.A.G. Miller

Effects of juniper occupancy on soil. S.C. Bunting, M. Hironaka, R. Josaitis

Fire ecology of whitebark pine. S.C. Bunting, P. Morgan

Fire ecology of *Pinus pinaster* forests, Portugal. S.C. Bunting, F. Rego

Effects of grazing on postburn grass productivity. S.C. Bunting, R. Robberecht

Analysis of agroforestry practices worldwide and of related possibilities for economic development. J.H. Ehrenreich

Breeding of palatable, resprouting, native shrub cultivars for the Great Basin cheatgrass type. M. Hironaka

Forest soil/vegetation relations in the Fairbanks, Alaska, area. M. Hironaka, M.A. Fosberg, D.M. Kenney

Development of a system to micropropagate bitterbrush and sagebush. M. Hironaka, C.M. Stiff, M.R. Mousseaux

Animal grazing/forest regeneration cooperative study. J.L. Kingery

Study to evaluate the grazed-class method for estimating livestock utilization. J.L. Kingery, C. Boyd

Project to analyze cattle, deer, and elk diets on cutover areas in northern Idaho. J.L. Kingery, K.C. Roscoe

Development of a monitoring program to assess changes in plant community composition on cutover areas. J.L. Kingery, J. White

Use of prescribed fire in young maritime pine (*Pinus pinaster*) plantations in northern Portugal. P. Morgan, S.C. Bunting, H. Botelho.

Ecophysiology and mechanisms of plant interference for an adventive species in disturbed rangelands. R. Robberecht

The response of *Bouteloua scorpioides* to water stress at two phenological stages. R. Robberecht, J.B.M. Alcocer-Ruthling

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Ph.D. Dissertations

Ackerman, Bruce B. 1988. Visibility bias of mule deer aerial census procedures in southeast Idaho. *Major professor: E.O. Garton*

Boo, Roberto M. 1988. Community types and their successional relationships in southwest Idaho. *Major professor: M. Hironaka*

Brockhaus, John A. 1987. An analysis of the effect of interactive clustering, image segmentation, and the empirical selection of wavebands on analyst time and classification accuracy of thematic mapper simulator data. *Major professor: J.J. Ulliman*

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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 the past year. Programs scheduled for 1989 are also listed.

More information is available from Continuing Education, College of Forestry, Wildlife and Range Sciences, Moscow, Idaho, 83843, (208) 885-6441.

Continuing Education

1988

January 4-8	Microcomputer Applications in Wildlife and Fisheries Biology—Moscow
January 6-8	Applications and Use of Personal Computers for the Forest Industry—Coeur d'Alene
January 19-20	Integrated Watershed Management—Boise
January 25-29	Statistical Methods and Data Analysis for Wildlife and Fisheries Biologists—Moscow
January 26-March 1	Natural History of the Nez Perce Reservation: A Short Course for Tribal Wildlife Technicians—Moscow
January 27-28	Riparian Management Workshop—Moscow
February 1-12	Leadership and Communications Workshop—Moscow
February 2	University of Idaho Research Nursery Technical Workshop and Advisory Committee Meeting—Clark Fork
February 3	Nursery Herbicide Workshop—Clark Fork
February 11	Inland Empire Tree Improvement Cooperative Annual Meeting and Workshop—Tree Improvement: The Next Steps—Post Falls
March 2-3	Inland Empire Forest Engineering Conference—Moscow
March 7-25	Log Scaling School—Lewiston
March 8-11	Idaho Travel and Tourism Institute—Moscow
March 14-18	Aerial Photography/Remote Sensing Workshop—Moscow
March 15-17	Fire Behavior—Moscow
March 21-25	Advanced Natural Resource Communication—Moscow
April 12	Forest Fertilization and Nutrient Management Workshop—Moscow
April 13	Log Quality and Log Manufacturing—Moscow
April 15-17	Interpersonal and Communication Skills for Resource Professionals—Clark Fork
April 18-22	Executive Leadership of Political and Social Forces in Natural Resources—Moscow
April 29-30	Idaho Society of Energy and Environmental Education Annual Meeting—Moscow
May 4-6	Communications Workshop—Boise
May 26	Range Monitoring Workshop—Oakley
June 12-18	Natural Resource Conservation—Ketchum
June 13-July 22	Land Use Planning for Community Forestry and Natural Resource Development—Moscow
June 14-15	Seed and Seedling Problem Diagnosis—Moscow
June 22-25	Riparian Workshop—Idaho Falls
June 23-24	Southern Idaho Christmas Tree Growers Short Course—Boise
June 30	Fire History Workshop—Jackson, Wyoming
July 10-16	Fish and Wildlife Ecology Workshop—McCall
July 20-22	Densified Wood Fuel (wood pellets): Manufacturing, Marketing, and Use—Moscow
September 14-16	4th Annual Symposium on the Management of Research Forests—Moscow
September 19	Meadow Grazing Management Workshop—Driggs
September 23-24	Woodland Workshop: Integrated Natural Resource Management—Post Falls
September 26-30	Coordinated Management—Jordan Valley, Oregon
October 3-28	CEFES: Continuing Education in Forest Ecology and Silviculture—Moscow
October 11-14	National Recreation Area Symposium—Sun Valley
October 11-14	Geographic Information Systems in Northwest Parks—Shenandoah National Park, Virginia
October 17-21	Dry Kiln Workshop—Moscow
October 21-22	Project Wild—Nampa
October 24-26	International Conference on Fiber and Particleboards Bonded with Inorganic Binders—Moscow
November 7-12	Environmental Interpretive Methods for El Salvador's Museums and Parks—San Salvador, El Salvador

1989

January 16-27	Mass Media Applications for Public Natural Resource Education—Trinidad and Tobago
January 23-27	Statistical Methods and Data Analysis for Wildlife and Fisheries Biologists—Moscow
February 13-24	Forest Regeneration and Site Preparation—Moscow
February 15	University of Idaho Research Nursery Advisory Committee Meeting—Post Falls
February 16	Inland Empire Tree Improvement Cooperative Annual Meeting and Workshop—Taking Advantage of Genetic Gain: Tree Improvement and Regeneration—Post Falls

February 16	Logging Safety: A Training Seminar—Moscow
February 22	Fire in the Urban-Wildland Interface: Could Moscow Mountain Burn Like Yellowstone? (panel discussion)—Moscow
March 1-2	Inland Empire Forest Engineering Conference—Moscow
March 3	Designing with Wood—Post Falls
March 4	Woodland Workshop for Private Landowners and Advisors—Lewiston
March 6-17	Leadership and Communication Workshop—Moscow
March 6-24	Log Scaling School—Lewiston/Clarkston
March 28	Idaho Woodland Council—Moscow
March 31-April 2	Interpersonal Communication Skills for Natural Resource Professionals—Clark Fork
April 7	Designing with Wood—Ketchum
April 7	Log Scaling Demonstration—Princeton
April 7	Log Scaling and Log 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 Natural Resource Professionals (Pakistan Forest Service—Moscow
May 24-25	Forestry Advisors' Workshop—Moscow
June 20	Nursery Soils Management Workshop—Coeur d'Alene
June 22-26	Long Term Ecological Studies of Birds (Cooper Ornithological Society Symposium—Moscow
June 12-July 21	Land-use Planning for Community Forestry and Natural Resources Development—Moscow
July 9-15	Fish and Wildlife Ecology Workshop—McCall
August 21-22	Log Furniture Workshop—McCall
September 24-27	Society of American Foresters National Convention—Spokane
October	Dry Kiln Workshop—Moscow
October 5	Timber Bridge Design Workshop—Coeur d'Alene
October 23-November 10	CEFES: Continuing Education in Forest Ecology and Silviculture—Moscow

Outreach

1988

January 16-17	Animal Tracks in the Snow—Clark Fork
February 27	Beginning Fly Tying and Casting—Clark Fork
March 26-27	Waterbirds—Clark Fork
March 30	Shade Tree Workshop—Moscow
April 9	Introduction to Falconry—Clark Fork
May 7	Lakes and Streams of the Northwest—Clark Fork
May 15	Spring Mushrooms—Clark Fork
May 28	Urban Forestry and Ornamental Trees—McCall
June 4	Mushrooms of the McCall Area—McCall
June 6-10	Grizzly Bear Biology, Ecology, and Management—Yellowstone National Park
June 11-12	Elk of Yellowstone: Biology and Ecology—Yellowstone
June 13	Wellness Testing—McCall
June 13-18	Natural Resource Workshop—Ketchum
June 14-16	Eagles and Hawks of the Greater Yellowstone—Teton Science School
June 14-18	Large Mammals of Yellowstone—Yellowstone National Park
June 22	The Wolf Recovery Program—McCall
June 25-26	Birds of Prey/Peregrine Recovery Program—McCall
June 25-28	Field Botany: Flora of the Tetons—Teton Science School
June 26	Ethnobotany—Clark Fork
June 27-30	Perception: Keeping A Field Journal—Teton Science School
July 6-8	Fire Ecology of the Greater Yellowstone—Teton Science School
July 9	Timber Supply and Community Stability in Idaho—McCall
July 10-16	Elderhostel: Wild Country Botanizing—Clark Fork
July 17-23	Elderhostel: Wild Nature of Idaho—McCall
July 18-22	Understanding Animal Behavior—Teton Science School
July 24-28	Alpine Ecology—Teton Science School
July 25-28	Pattern in Nature—Teton Science School
July 27	Mountain Lions of the Frank Church—River of No Return Wilderness—McCall
July 27-29	River Channels—Teton Science School
July 30	Early History of North Idaho—Clark Fork
August 8-12	Nature Illustration—Teton Science School
August 9	Governor's Timber Supply Study—McCall

Continuing Education and Outreach

August 12-16	Landscape Watercolor Painting—McCall
August 20-21	Payette Lakes—the Story of Ancient Glacier Bulldozers—McCall
August 27-28	Wildland Photography—McCall
August 28	Wildlife Photography—Clark Fork
September 10	Native Ornamental Trees—Clark Fork
September 19	The Idaho Tourism Study—McCall
September 25	Fall Mushrooms—Clark Fork
October 1	Forests of the Northern Rockies—Clark Fork
October 15 & 16	Fossil Collection and Geologic Tour of the Lake Pend Oreille Area—Clark Fork
November 5	Herbs and Herb Crafts—Clark Fork
Ongoing	Project WILD Workshops
Ongoing	Project Learning Tree Workshops

1989

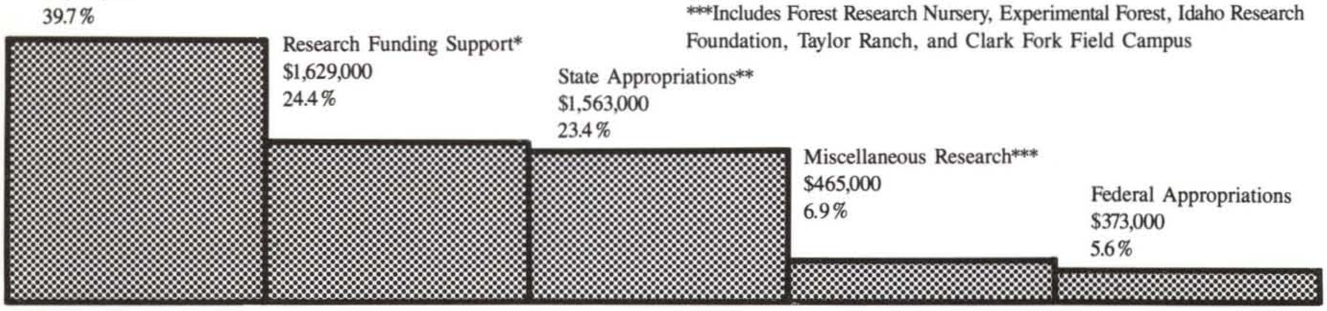
January 14 & 15	Animal Tracks and Winter Ecology—Clark Fork
February 4 & 5	Rocks and Minerals—Clark Fork
February 22	Fire in the Urban-Wildland Interface: Could Moscow Mountain Burn Like Yellowstone? (panel discussion)—Moscow
February 25	Beginning Fly Tying and Casting—Clark Fork
March 4	Woodland Workshop for Private Landowners and Advisors—Lewiston
March 18	Panhandle Country Fishing—Clark Fork
April 1	Wetland Ecology and Water Birds—Clark Fork
May 6	Community Forestry Day—University of Idaho Experimental Forest
May 20-21	Forest Management for Small Acreages—Clark Fork
June 5-8	Hoofed Mammals of Grand Teton and Yellowstone National Parks—Teton Science School
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 11	Weed Identification—Clark Fork
June 12-17	Natural Resources Workshop for School Teachers—Ketchum
June 13-16	Eagles and Hawks of Greater Yellowstone—Teton Science School
June 13-17	Large Mammals of Yellowstone—Yellowstone National Park
June 17	Mushroom Identification—McCall
June 18-24	Natural Resources Workshop for School Teachers—Harrison
June 21-23	The Greater Yellowstone Ecosystem—Teton Science School
June 24-25	Getting Published—Clark Fork
June 24-27	Interpreting Tracks and Sign—Teton Science School
June 24-27	Field Botany: Flora of the Tetons—Teton Science School
July 3-7	Illustrating from Nature—Teton Science School
July 8-9	Wild Flower Identification—McCall
July 9-15	Elderhostel: Wild Country Botanizing—Clark Fork
July 14-15	Animal Behavior—Teton Science School
July 16-21	Elderhostel: The Wild Nature of Idaho—McCall
July 16-21	Alpine Ecology—Teton Science School
July 22-25	Pattern in Nature—Teton Science School
July 26-28	River Channels—Teton Science School
July 29	Archeology and History of McCall—McCall
July 30	History of the Pend Oreille Country—Clark Fork
July 31-August 4	An Island Ecosystem: Conserving Biological Diversity in the Greater Yellowstone—Teton Science School
August 2-4	Wildfire: Fire Ecology of the Greater Yellowstone—Teton Science School
August 12-13	Wildland Photography—McCall
August 13-17	Ecology Through the Lens—Teton Science School
August 17-21	Landscape Watercolor Painting—McCall
August 19 & 20	Outdoor and Nature Photography—Clark Fork
August 19-20	Writing Workshop: How to Get Published—McCall
September 1-3	Wildlife Management Policies and Practices—Teton Science School
September 18	Research Presentation: The Future of Hells Canyon—McCall
October 7	Fire, Man, and the Environment—Clark Fork
October 21 & 22	Fossil Collecting and Geologic Tour of the Lake Pend Oreille Area—Clark Fork
November 11	Herbs and Herb Craft—Clark Fork
Ongoing	Project WILD workshops
Ongoing	Project Learning Tree workshops

Agency and Funding Support

Agency for International Development
AID Bureau for Science and Technology
Agriculture Research Service
Alaska Fish and Game Department
American Forest Institute
Bennett Lumber Company
Boise Cascade Corporation
Boise National Forest
Bonneville Power Administration
Champion Timberlands
Clearwater Resource Conservation and Development Area
Clearwater National Forest
Clearwater-Potlatch Timber Protective Association, Inc.
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
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 Parks and Recreation
Idaho Department of Lands
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.
Mississippi State University
Montana Fish and Wildlife
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
Roger Guernsey
Rust International Corporation
South Idaho Forestry Association
Stillinger Trust
St. Regis Paper Company
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
USDI Bureau of Indian Affairs
USDI Bureau of Land Management
USDI Bureau of Reclamation
USDI Fish and Wildlife Service
USDI National Park Service
U.S. Department of Navy/Naval Undersea Center
Universidad National, 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
Viking Systems International
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 1988 Financial Picture

Research expenditures, shown by funding source, totaled $6,682,000 for the fiscal year 1987-88.



*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: 1985-1988

	Departments					
	Fish & Wildlife Resources	Forest Products	Forest Resources	Range Resources	Wildland Recreation Management	Total
1985						
Books	0	0	2	0	1	3
Chapters in Books	0	0	2	0	3	5
Refereed Publications	15	4	11	8	5	43
Other Publications	7	9	33	7	14	70
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 FTEs[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 FTEs	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

[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 60 of the college's faculty members conduct research, as do most of its 176 graduate students. About one-third of the faculty's time is spent on research, much of it paid for through outside grants and contracts.

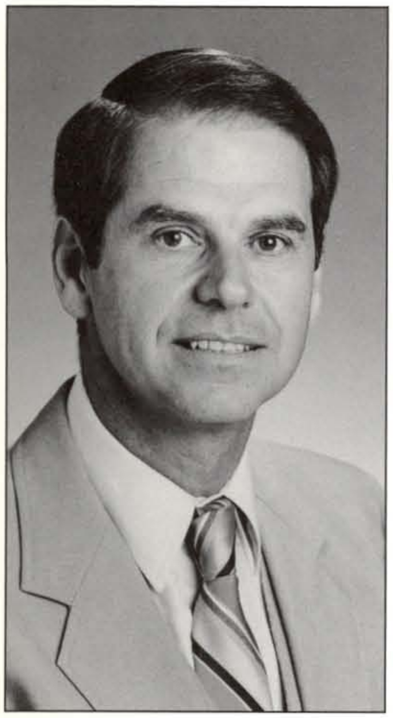
During both the 1987 and 1988 fiscal years, income from outside grants and contracts totalled $2.9 million. From July 1 to December 31 of 1988, college faculty won $1.3 million in grants and contracts. For every dollar appropriated by the state for experiment station research during fiscal 1988, faculty grants and contracts brought in $1.90.

Changes: 1985-1988

	1985 vs. 1988 Percent Change	4-year Total
Graduate Student Enrollment	+9%	—
Outside Grants & Contracts[2]	+5%	10.3 million
Refereed Publications	+27%	255
Other Publications	+40%	326
Chapters in Books	−20%	27
Books	−33%	14

[2] Fiscal years

From the Director



John C. Hendee

Change and commitment in our centennial year

The year 1989 marks the centennial of the University of Idaho and the 80th year of the College of Forestry, Wildlife and Range Sciences. To celebrate the centennial and commit the university to a second century of distinction, we've held a number of special events and launched a Centennial Fundraising Campaign.

During the spring and summer of 1988 we planted and dedicated University of Idaho centennial groves of seedlings in all 44 Idaho counties. Each grove consists of five species raised at the university's Forest Research Nursery: Douglas-fir, ponderosa pine, western larch, Idaho hybrid poplar, and western white pine. Each species represents qualities to which the university is committed—strength and stability, perseverance and longevity, growth and diversity, high technology, and scenic beauty. The dedication of each of the centennial groves by University of Idaho President Richard Gibb was a festive occasion that gave forestry and our college high visibility.

Thanks to the tremendous help of alumni and friends, the college's fundraising campaign has made considerable progress. The campaign focuses on increasing scholarships and teaching-related assets to strengthen our ability to recruit the nation's finest students to natural resource careers and provide them with the hands-on experience and broad education that will prepare them for leadership. So far, our college campaign has yielded one million dollars.

The college currently has 310 undergraduate students and 170 graduate students, a 25 percent increase in enrollment during the past two years. We are pleased with this success in recruitment and to see that natural resource management is again gaining in popularity as a career choice.

Change is a constant companion of higher education. Most of our students still come straight from high school, but we teach increasing numbers of non-traditional students who are older, experienced, and may even be pursuing a second career. About one-fourth of our students are women, and 12 percent are international students.

We also offer continuing education programs for professionals. During 1988, the college offered 42 continuing education programs on subjects as diverse as meadow grazing, remote sensing, and interpersonal communications.

Our faculty members, through their involvement with students, their contacts with resource managers, and their own research, are bringing new knowledge to the classroom and developing new and better ways of practicing resource management. The rate of change in the natural resource professions is accelerating. During the past two decades, there has been such unprecedented change in natural resource management that our graduates of two decades ago have had to learn entirely new ways of practicing natural resource management. And what about today's students? Where is natural resource management headed?

Wherever that may be, we are emphatic in our belief that Idaho and the Northwest need to make the most of all their natural resources and not emphasize one use at the expense of others. We listen carefully to our outside advisory groups to keep abreast of their views and of changes in natural resource issues. Our college Guidance Council of state, regional, and national leaders represents all natural resource interests. Our Forest Research Nursery Advisory Committee represents Idaho's seedling industry and reforestation interests. The College of Forestry, Wildlife and Range Sciences Alumni Association and its board of trustees represents our 3,600 alumni. Technical steering committees guide our cooperative tree improvement and forest nutrition research programs. Advice from these external groups helps to make all our programs more timely and relevant.

I hope you have enjoyed this year's *Focus*. If you have any questions or comments, please feel free to write or call. We appreciate knowing how our programs and information can better serve you.

Where Tradition Meets the Future

1889-1989

University of Idaho

University of Idaho

Idaho Forest, Wildlife and Range Experiment Station
College of Forestry, Wildlife and Range Sciences
Moscow, Idaho 83843