FOCUS
on Renewable Natural Resources

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VIVIAN DREWIEN
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University of Idaho
Forest, Wildlife and Range Experiment Station
College of Forestry, Wildlife and Range Sciences
Moscow, Idaho

The Wise Use of Resources in Idaho

Habitat, ecosystem, logs, tussock moth, whooping cranes, seed wafers, rest-rotation, biomass, jobs, environment, wilderness, enteric redmouth disease, balance, trade-offs, and many other terms are encountered in this publication. What does this collection of new and old words mean to Idahoans?

Idaho is a resource state. The welfare of Idahoans depends on the wise use of the bounty that nature has so generously bestowed upon this land. The term "wise use" means different things to Idahoans of different viewpoints. To some, it may mean a larger wilderness area; to others, intensive management of all productive sites in the state for timber; to still others, a larger elk population so the hunter will be successful in his efforts. Wise use cannot easily be defined when one attempts to apply it to a complex, highly interconnected ecological reality. Management decisions which do not take into consideration this interconnectedness are likely to be bad decisions.

Wise decisions must take into account not only the ecological reality of nature, but also the needs of today's Idahoans, and those yet unborn. As Idahoans we generally enjoy a stable economy and quality surroundings. We expect these basic characteristics to be maintained and improved wherever possible. To provide for the additional jobs needed in the years to come, a greater economic base is essential. The timber industry, cattle ranching, fisheries, tourism, recreation and water essential to support agricultural, industrial and urban activities provide the very foundations of Idaho's economy. They must be managed with the judicious use of the latest information provided by natural resources scientists.

Our research efforts are based on the necessity of improving the economic base of our state, while paying important and highly justifiable attention to the magnificent environmental values of Idaho.

What is it worth to save the whooping crane from extinction? What is so important to learn about the biology of the American badger? How about the other creatures such as wolverines, Columbia ground squirrels and rainbow trout? To maintain a quality environment is vital to our well-being. The unwise use of our land resources can decimate our plant and animal neighbors and endanger our own life style.

In dealing with the natural environment, we have become keenly aware of the interconnected nature of our surroundings. In the pages of this issue you will note the concern of our scientists to determine the effects of grazing on stream quality and fish populations, find the influence of logging activities on elk populations, and discover a cure for endemic fish disease.

The need to improve the state's resource base is a major responsibility. Several projects presented in this report address vital issues relating to renewable natural resources in Idaho. Techniques are being developed to economically recover total forest biomass, beginning with small logs. Such efforts, coupled with the development of genetically superior trees, efficient regeneration of Idaho's non-stocked forest lands, fertilization and thinning programs, will bring handsome economic returns from every dollar invested in research.

The annual timber losses from insects and disease combined now exceed total timber removed by logging. Protecting forest stands from four notorious insects—the tussock moth, spruce budworm, the fir engraver and the mountain pine beetle—could increase Idaho's timber base substantially. During the past year, encouraging progress has been made toward the development of management tools against forest pest attack, particularly under the USDA Douglas-fir tussock moth program.

Our team of scientists, graduate and undergraduate students, technicians and administrators is determined to provide a sound knowledge base to aid resource managers in fulfilling their increasingly complex responsibilities to the land and its people.

A. A. Moslemi

FOCUS
Volume 2 Number 2

1975 Annual Report

FOREST, WILDLIFE AND RANGE
EXPERIMENT STATION

Dr. John H. Ehrenreich, director
Dr. Ali A. Moslemi, associate director
Susan R. Hieb, editor

University of Idaho

Front Cover: The painting of "Corny," a whooping crane, and his sandhill crane adoptive parents is by Mrs. Vivien Drewien. Courtesy of Mr. and Mrs. Richard W. Rigby, Bosque Del Apache National Wildlife Refuge, San Antonio, New Mexico. Photo by Gary R. Zahm.

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Wildlife Resources

WHOOPING CRANE FOSTER PLAN BRINGS ENDANGERED BIRDS TO IDAHO

Dr. Rod Drewien
Elwood Bizeau

The conscience of a continent has been captured in the last year by an unusual foster-parent experiment aimed at preserving the majestic whooping crane from extinction.

In the winter of 1974-1975, only 49 whooping cranes (*Grus americana*) existed in their natural wild state. Found only in North America, they have declined to their present population level from an estimated 1500 to 2000 birds in the 19th century. Great, white birds with black wingtips, the red crowned adults weigh in at about 20 pounds, attain a height of 5 ft and a 7-ft wingspread–second only to the endangered California Condor in size.

Although the whoopers can be traced to the Paleozoic era, man's egg-collecting, illegal hunting of the big white birds and encroachment onto former nesting areas have steadily decimated their numbers. The only known nesting area for wild whooping cranes was discovered in 1954 in Wood Buffalo National Park in Canada's Northwest Territories, on the 60th parallel, just north of the Alberta border. The whoopers migrate annually from their nesting grounds in northern Canada to winter on Aransas National Wildlife Refuge on the Texas Gulf Coast, a direct flight distance of about 2500 miles.

In southeastern Idaho, a few years earlier, the Greater Sandhill Crane (*Grus canadensis tabida*), a separate species, but in the same genus as the whooper, was the subject of preliminary research by wildlife scientist Elwood G. Bizeau. In 1968, Dr. Maurice Hornocker and Bizeau, administrators of the Idaho Cooperative Wildlife Research Unit, decided to undertake long-term research on the greater sandhill crane population in that area. Principal researcher for the project, Roderick C. Drewien, began his work of capturing and marking cranes in the Grays Lake area in 1969, where he examined their breeding ecology. As his studies progressed, Drewien collected his data into profiles of adult crane nesting pairs, detailing their annual family group migrations from Grays Lake, 800 miles south to Bosque del Apache National Wildlife Refuge, with leisurely spring and fall stopovers in Colorado's San Luis Valley.

His research led him to a comparison of the breeding biologies of the sandhill and whooping cranes. By 1974, Dr. Drewien had marked more than 600 sandhill cranes and followed many pairs through nesting, rearing of young and migration. Because sandhill cranes lay two eggs, but usually raise only one chick to the flight stage, Drewien experimentally removed one of the two eggs from a number of sandhill nests to see if the egg-napping would disturb the nesting cranes.

Similar egg-taking from whoopers had been done by Dr. Ray Erickson, head of the U.S. Fish and Wildlife Service Endangered Species Research Program, in cooperation with the Canadian Wildlife Service, at Wood Buffalo National Park. Neither species appeared to be upset by the removal of one egg from the nest.

Already familiar with the production, movement and survival records of many pairs of sandhill cranes at Grays Lake, Drewien asked for permission to select carefully

Whooping crane chick hatched by sandhill crane foster parents on Grays Lake nesting marshes.

screened sandhills as adoptive parents for whooping crane eggs. Adoption red tape extends even to cranes, it would seem, as negotiations continued for 2 years.

The proposal was presented to the U.S. Fish and Wildlife Service, the Canadian Wildlife Service, private organizations with a long-time interest in the whooping crane, such as the Audubon Society, and all state wildlife agencies located along the sandhill migration route.

The project received official approval a few weeks before the beginning of the whooping crane nesting season in 1975. The University of Idaho and the U.S. Fish and Wildlife Service signed a contract to perform the biological follow-up on the project with Dr. Drewien as principal investigator.

The international adoption went off smoothly. Nine of the 14 eggs taken to Grays Lake on 29 May of 1975 hatched. Six whooper chicks survived to the age of flight, adapting readily to the foods offered by their devoted foster-parents. Bugs, frogs and barley on the nesting grounds prepared them to thrive later on the sorghum, alfalfa and corn sandhill winter diet instead of the Gulf Coast shellfish savored by the Aransas whoopers.

Begun in 1975, the egg transplant program will be continued in succeeding years, with sandhill foster parents hatching and rearing the whooper chicks, flying south in October and hopefully returning in the spring to southeastern Idaho. The young of the previous year are ejected from the family group during their northbound flight, between the San Luis Valley and Grays Lake. Some 40 of the Grays Lake sandhill parents have been bringing their yearling young back to the vicinity of the nesting grounds, but there is no assurance that this will happen with the whoopers. Wild whooping crane non-breeders from the Wood Buffalo National Park population summer not with their parents, but disperse to unknown summering areas.

Last December, four of the sandhill-whooper families selected their wintering spots in New Mexico, with two families settling at Bosque del Apache National Wildlife Refuge, one choosing a state waterfowl sanctuary north of Bosque Refuge, and a fourth opting for a private ranch in the valley. Two of the six foster-parent families which migrated from Grays Lake last fall were not found last winter. Return migration began this spring in February, with all four adoptive families returning to the San Luis Valley in Colorado for a 7-week stay before heading north.

Whooping cranes probably begin breeding in the wild at 5 to 7 years of age, still many years off for the yearling foster-chicks. In addition to testing the foster-parent approach, follow-up research by Drewien will yield valuable information on the adaptive behavior of whoopers for any future restoration efforts attempted by the U.S. Fish and Wildlife Service and the Canadian Wildlife Service.

Numerous examples already exist of successful cross-species adoptions by foster parent birds and mammals.

The project's ultimate objective is to establish a new nesting colony of wild whooping cranes in southeastern Idaho, which would follow the traditional and less hazardous migration pattern of the sandhill adoptive parents. Such an additional population would help to safeguard the existence of the whooper, a small homage from man to these great birds of the North American continent.

Early support for Drewien's sandhill crane research in Idaho was provided by the Audubon Society, the U.S. Fish and Wildlife Service and the Welder Wildlife Foundation. The National Science Foundation later added a substantial grant as the project progressed to the relationships between the breeding biologies of whooper and sandhill cranes. The Canadian Wildlife Service has contributed sound advice on the overall project and has efficiently handled the egg transfer from Wood Buffalo to Grays Lake. The Idaho Fish and Game Department has been a strong supporter of the project, as well as the state wildlife agencies of Colorado and New Mexico, where the transplanted whoopers spend a portion of their annual cycle. The U.S. Fish and Wildlife Service, particularly several refuge personnel and federal game agents in the three states, has provided invaluable assistance in protecting the whoopers in their new habitat.

1976 Postscript

Although all four of the adoptive parent birds returned to Grays Lake this summer, their behavior has resembled that of the wild whooping crane parents, in that they did not bring their yearling foster-chicks with them.

Three of the year-old whoopers have been located in the northwest—in the Blackfoot area, south of Grays Lake; in Big Timber, Montana, northeast of Livingston; and in Vernal, in northeastern Utah. Bizeau feels that the fourth whooper may still be located and identified.

In the second year of the egg transplant project at Grays Lake, another four whoopers have survived to the flight stage. Bizeau noted that the first 2 years of the program have coincided with a higher wild survival rate for young whooper chicks at Wood Buffalo National Park, where the parental responsibility has been decreased to one egg per nest. Averaging an annual population gain of fewer than 10 birds in recent years, the wild whoopers added 10 new birds to their flock last year and 12 this year.

BADGER STUDIES CONDUCTED IN BIRDS OF PREY NATURAL AREA

John P. Messick
Dr. Maurice G. Hornocker
Jack Whitman

The numbers, life patterns and food habits of the American badger (*Taxidea taxus*) in the Snake River Birds of Prey Natural Area south of Boise are under study by Research Associate John P. Messick and Professor Maurice G. Hornocker of Wildlife Resources.

The area was established by the U.S. Bureau of Land Management in 1971 to protect one of the densest populations of breeding raptors in North America. This unique concentration may result primarily from a combination of nest sites afforded by the canyon walls, and food supplies composed mainly of Townsend ground squirrels (*Spermophilus townsendii*), jack rabbits, and smaller rodents. Badgers are probably the most important non-avian predator that also exploits these prey populations. Information on the ecology and impact of badgers should provide data essential to the management of the raptors utilizing the area. The Bureau of Land Management is supporting the study.

Objectives in this research are to (1) ascertain the density, sex and age structure, and other characteristics of the badger population; (2) describe their movements, activity, and social organizations; and (3) gather information on the food habits of badgers.

This work was begun early in 1975, utilizing techniques common to many population studies. Most badgers are trapped at their dens and digs with foot traps and anesthetized using a syringe fitted to the end of a broom handle. During the summer, badgers were captured using an aircraft landing light to pick out their eyeshine, netted, and finally physically subdued prior to immobilization. Occasionally, badgers can be netted during the daytime.

Ears are tattooed and fitted with eartags. Weights and body measurements are recorded and fleas and blood are collected for indirectly assessing the possible occurrence of plague in the ground squirrel population. This study is being conducted by two other University of Idaho researchers, Dr. Donald Johnson and graduate student Wayne Melquist.

Trapping and marking efforts, through capture-recapture technique and visual sightings, should provide data on abundance, distribution and population structure. Monthly collections of badgers from outside the study area, but in similar habitats, yield information on the reproductive history and performance of individuals.

Certain badgers are fitted with radio transmitters as an aid in documenting their movements, activity and interactions with other badgers.

Much of the field work during the summer of 1975 was conducted by Jack Whitman, an undergraduate in the College of Forestry, Wildlife and Range Sciences, who is currently analyzing badger scats.

During 1975, 2793 trap days (defined as one trap set for 24 hours), supplemented by spotlighting and daytime netting, produced 97 captures representing 75 different badgers. Most badgers were taken within a 3 by 5 km area (1.8 by 3 mile), and the distances between capture and recapture sites were seldom greater than 1.5 km (0.9 mile). Based on these data, the researchers believe that the density of badgers on the study area is quite high.

Superficial examination has revealed that badgers probably utilize Townsend ground squirrels more than any other prey item. Scorpions and lizards are evident in samples collected during the summer.

This project will continue for a least one additional year. More information is needed on the dispersal of young badgers and the sources of mortality. The fossorial lifestyle of badgers creates problems for the physical attachment of a transmitter, and this hampered operations during 1975. Smaller radio collars should allow researchers to secure more complete data on movements, activity and predation by badgers.

An American badger, eartagged and tattooed, emerges from its den on the Snake River Birds of Prey Natural Area.

ELK BEHAVIOR STUDIED ON LOGGING, WILDFIRE SITES

Dr. James M. Peek
Larry L. Irwin

What happens to forage sources for big game animals after logging or wildfire burns change the ecology of a site, and what changes occur in elk behavior on these locations in terms of habitat selection?

These are questions Dr. James M. Peek, associate professor of wildlife management and Larry L. Irwin, research associate, are trying to answer in the cedar-hemlock zone of northern Idaho.

Monitoring elk has provided valuable information for wildlife managers in areas where the ecology has been dramatically changed.

One part of the study is directed toward building growth and development models for shrub communities that invade recently logged or wildfire-burned areas in this zone. Such information would be helpful to silviculturists who wish to speed conifer regeneration to the stage of commercial harvest, and to wildlife managers who wish to enhance or prolong shrub stages on big game winter ranges. This phase began in summer 1974 and is approximately 60 percent complete.

The second part involves studying responses by elk to intensive timber culture (logging) activities. This involves constant monitoring of radio-collared elk to learn more about forage preferences, use of logged areas, and use of specific forest types. This work, within the Coeur d'Alene River drainage, is only partly completed. Eight female elk were marked during spring 1975. They used recently logged areas in summer and a shrub field created by a 1931 wildfire in winter. Three of the eight were killed by hunters during the 1975 season. Their transmitters were recovered and will be used again. Plans are currently being made to radio-collar additional elk, including yearling and adult males within the logged area, and within a nearby unlogged and unroaded drainage. A road closure in one drainage is being implemented through cooperative efforts with the Idaho Fish and Game Department and the U.S. Forest Service to evaluate responses of elk during hunting. Information will help forest and wildlife managers integrate cooperative plans for timber harvest and big game habitat improvement.

Funding for this project was received from the U.S. Forest Service. Two papers, detailing the findings of this study, are being prepared for publication, one as a contribution to the Symposium on Elk, Logging and Roads held on the University of Idaho campus in December of 1975.

DATA ON WOLVERINES GATHERED IN MONTANA

Dr. Maurice G. Hornocker
Howard S. Hash
Gary Koehler
Pete Ramirez

Little is known of the population ecology of the largest land-dwelling member of the weasel family, the wolverine. Although it has a vast range in the northern latitudes around the world, few scientists have attempted to study wolverines in their natural habitat. Two notable exceptions were both Europeans. The few wolverine studies carried out in North America have been concerned with the species' breeding biology and with information obtained from carcasses collected by fur trappers.

The 1973 edition of *Threatened Wildlife of the United States* listed the wolverine under "Status-Undetermined Mammals." A status-undetermined species is "... one that has been suggested as possibly threatened with extinction but about which there is not enough information to determine its status. More information is needed..." Clearly there was a need for research on this little-known animal.

In 1973, The Idaho Cooperative Wildlife Research Unit initiated an investigation of wolverine populations in northwestern Montana. Initial support for the project was provided by the Flathead National Forest and the University of Idaho's Wilderness Research Center. Now in its third year, the research is supported by the U.S. Forest Service, the National Science Foundation, the National Geographic Society, the Boone and Crockett Club, the New York Zoological Society and the Audubon Society.

Personnel involved are Unit Leader Maurice Hornocker, the principal investigator, Howard S. Hash, research associate in charge of field operations, Gary Koehler, research associate and Pete Ramirez, graduate assistant.

The research is designed to study wolverines by observing marked individuals in a free-ranging population. The work is being carried out in the South Fork of the Flathead River drainage in northwestern Montana. Wolverines are captured in live-traps, immobilized with drugs, individually marked and released for future identification. They are also fitted with collars containing miniature radio transmitters. By locating and following these radio signals, individuals may be studied, undisturbed, through a season, from season to season, and year to year.

By January, 1976, 17 different wolverines had been captured. Thirteen of these have worn radio transmitters for continuous periods up to 11 months. More than 300 radio locations recorded on these wolverines have supplied information on range and movements, food habits, seasonal habitat use, and many other aspects of the species' biology and ecology.

Concurrent with work on the wolverines is an appraisal of their suspected food supply – small mammals. The numbers and different kinds of small mammals such as ground squirrels, mice and voles are being investigated in different vegetative types. Other species of predators also occupy the study area; their numbers and possible relationship with wolverines are being studied.

It is hoped the results of this research will not only provide knowledge about this little-known animal heretofore unavailable, but will enable better management of the wolverine where it occurs.

LEOPARD ECOLOGY STUDY COMPLETED IN AFRICA

Dr. Maurice G. Hornocker
Dr. Ted Bailey

Preliminary results of a 2-year leopard ecology study in Africa's Kruger National Park have shown leopards to be highly adaptable in a protected setting.

University of Idaho Wildlife Resources Professor Maurice G. Hornocker and Research Wildlife Biologist Ted Bailey have expressed concern that the resilience of leopard populations in the Park should not be mistaken as a sign of a secure status for leopards elsewhere. Like many large African mammals, particularly carnivores, the leopard appears to have a precarious future outside of parks and reserves. Although isolated areas may always retain a few leopards, the continued exploitation of leopard populations at the present rate may insure an endangered status for the leopard, a status that it has not yet received.

World-wide concern over the status of the spotted cats reached a peak in the late 1960's and early 1970's when large numbers were being killed annually for their fur. At that time an estimated 20,000-40,000 leopards were being killed in Africa each year, mainly for export to European fur buyers. Concern over the status of the leopard prompted the International Union for the Conservation of Nature and the World Wildlife Fund to urge and later fund research into the ecology and status of leopards in Africa.

The lack of basic ecological and biological data on leopards required a study with goals to obtain detailed quantitative information on a population level. In 1973 the University of Idaho, University of British Columbia, the South African National Parks Board, and the Conservation Division of Kruger National Park initiated a study to obtain such data. The project was supported financially by the National Science Foundation.

During the study, 30 leopards were captured 112 different times and 24 leopards were fitted with 35 radio collars. Radiotracking periods extended from 8 days to 18 months and 2,691 locations of leopards were obtained by radiotelemetry techniques, captures and visual observations. Over 30,000 units of information were obtained on leopard locations, movements, activities, habitat utilization, food habits and kill rates. Leopards were visually observed on 135 occasions for a total of 2,329 minutes and 55 kills of leopards were located and examined. Counts of prey in both study areas were made almost monthly.

The data obtained provided quantitative information on leopard numbers and density. Although the average density of leopards in the study areas was great, there was a direct correlation between leopard density and prey density with the density on one area over three times as great as on the other. Leopard populations remained relatively stable throughout the study period, despite a rapid turnover in one study area. The reproduction rate appeared relatively low, but adult deaths were apparently compensated for by immigration of leopards from surrounding areas within the Park. Adult leopards efficiently utilized their rather small home areas by avoiding other leopards of the same sex. Spacing was enhanced by vocalizations and scent marking at strategic travel routes within home ranges. Leopards were adaptable not only to a wide variety of natural changes in their environment but also to changes caused by man in the Park.

The researchers feel that changes in women's fashions with a stigma against the wearing of furs from spotted cats will accomplish more than national or international regulations attempting to reduce the hunting of leopards and flow of skins.

Forest Products

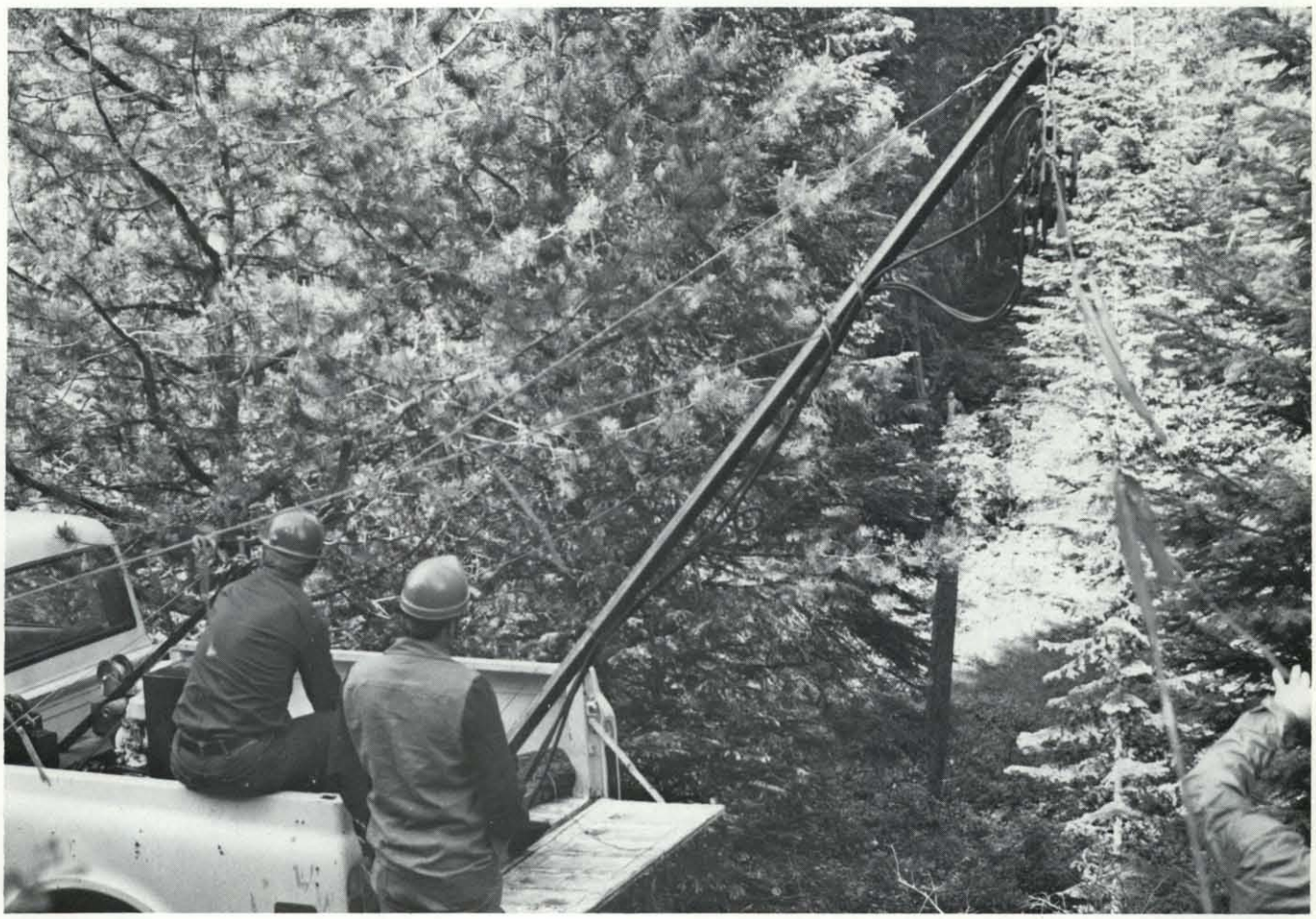
TEAM EXPLORES SKIDDING DESIGN FOR SMALL TIMBER

Leonard R. Johnson
Dr. John E. Houghton

Equipment is currently available to process small trees, tops and other marginal timber into usable, transportable products as whole-tree chips or rough sawn lumber. Moving the raw material to a landing, a relatively level area large enough to accommodate the necessary trucks and machinery, is called skidding, wherein the problem lies.

The need for a skidding system designed specifically for small timber has prompted a study undertaken by Leonard Johnson and John Houghton, assistant professors of Forest Products. Economically moving the small trees cut during commerical thinning operations, and the tops cut from saw logs is the object of their concern. At a landing, the small trees could be cut with a portable sawmill, and the tree tops could be converted into chips. The study involves designing a skidding machine on paper in terms of its required production capability and cost. Specifications will be established through analysis of the volume and size of timber to be processed. Production capability and cost of existing small log processing equipment will be used as a base.

Field data collected during the summer of 1975 are being converted to a format suitable for a general purpose logging simulation model. Using the model, skidding system potential can be determined for various market conditions. Both increased per acre fiber yield and increased returns from forest stands are potential benefits of the study.



A yarder moves a tree from the area of the cutting operation. Systems designed for better utilization of small timber will help the resource managers deal with a variety of problem areas.

COMPLETE LOG UTILIZATION SEEN AS KEY TO INDUSTRY

George W. Preble
Dr. John P. Howe
Arland D. Hofstrand

With Idaho's large virgin timber stands gone and lumbermills throughout the state faced with the prospect of utilizing smaller, second growth trees and logs, the timber industry must look to complete log utilization and manufacturing efficiency to maximize profits and stay in business.

Great numbers of 1 x 4's, coming from the small log production line, have often been converted into chips for lack of marketability. Graduate student George W. Preble, under the direction of Forest Products Professor John P. Howe and Associate Professor Arland D. Hofstrand in a project sponsored by the Idaho Forest Industries, has investigated the face-laminating of 1 x 4's to produce 2 x 4 studs. The research also involved the assistance of Borden Chemical, Potlatch Corporation and the Western Wood Products Association (WWPA). A relatively new cross-linking polyvinyl acetate (PVA) adhesive was used for the research.

The research involved setting up a cold press laminating procedure, measuring the warp which came about by laminating and the testing of glue line integrity. Analysis of data indicated excellent dimension stability of the laminated studs within all species and moisture content groups. All warping averages were below WWPA allowances. Glue line shear strengths were three to four times the required values. However, the required WWPA water resistance of the adhesive was lacking. Delamination test results from a water vacuum-pressure procedure proved to be inadequate for approval.

Failure of the cross-linking PVA used in water resistance has led to the analysis of several new adhesives. Good delamination results have been obtained with a new PVA. It is hoped that further examination of this adhesive will lead to WWPA acceptable results.

FULL-FOREST UTILIZATION OFFERS NEW POSSIBILITIES

Dr. John P. Howe

Cork and wax from Douglas-fir bark. A fodder vitamin supplement prepared primarily from coniferous foliage. A tree puller that harvests the tree with taproot intact. These are commercial realities today and are examples of the mind-boggling possibilities on the horizon under full-forest utilization in the Rocky Mountain area. Here logging residues alone frequently exceed 100 tons of green and dead wood fiber per acre.

In the summer of 1975, working for Allied Chemical Corporation, John P. Howe, professor of Forest Products, initiated work to define the kinds of underutilized plant material (biomass) now growing on Idaho's forest and range lands. The second phase of this project will study how this underutilized material can be used to supplement the nation's shortages of shelter material, food (human and animal), chemicals, fiber and fuel.

Investigators have begun a study of grazing impacts in stream-meadow areas on the fish which use the streams to spawn and rear their young.

Range Resources

TEAM STUDIES GRAZING IMPACT ON STREAM-MEADOW ECOSYSTEMS

Dr. Lee A. Sharp
Frank A. Hayes
Dr. Walt Megahan
Dr. William Platts

The Idaho Batholith, a granitic intrusion encompassing about 16,000 square miles of central Idaho and western Montana, is recognized for the diversity of its harvestable resources including timber, wildlife, fisheries, and production of forage for livestock and wildlife. Its unstable granitic soils and steep topography have made this region's susceptibility to erosion a major concern.

Grazing, an established practice on the Batholith meadows since the late 1800's, has provided summer forage to complement winter grazing land for sheep, and later, cattle. Current management is through systems which defer or rest pastures from use the entire grazing season or for only a portion of the season. The small tributaries which flow through these meadows before joining as major waterways leaving the Batholith, provide vital spawning and rearing habitat for anadromous and resident fish populations. The need for determining grazing impacts, or methods of assessing such impacts on stream-meadow ecosystems is recognized by range and fishery resource managers.

An investigation was started in July 1975 to ascertain the nature and degree of conflict on stream-meadow areas utilized for summer range and to establish a foundation for recording changes in streamside and meadow habitat. A multidiscipline team of investigators, with coordinators Dr. Lee Sharp and graduate student Frank Hayes from the University of Idaho and Dr. Walt Megahan and Dr. William Platts from the Intermountain Forest and Range Experiment Station, chose three study streams withjn the Batholith in lodgepole-pine and spruce-fir vegetation types. Two stream-meadow areas are currently under rest-rotation grazing and the third has been ungrazed for about a decade. Of the grazed areas, one has been managed with a rest-rotation system since the mid-1960's. A similar grazing system was formally begun in the second area in 1975. Information on vegetation, stream stability and alteration, and animal behavior has been recorded from field observations and low-flight 70mm color infrared (CIR) photography. Permanent line transects were established to obtain on-ground data. The capabilities of the infrared film provide a technique for detecting seasonal changes in growth activity of vegetation. The 70mm CIR system furnishes a base for monitoring habitat change with aerial photography viewable in three dimensional stereoimagery.

Current research information obtained from these meadow areas when combined with previous records of grazing use and vegetation inventory, will offer resource managers a more concrete representation of the impacts of grazing systems on stream-meadow ecosystems. This knowledge will also be important for making ecological decisions concerning these and other similar resource regions.

COLUMBIA GROUND SQUIRREL, SHEEP DIET CHOICES COMPARED

Ronald Lambeth
Dr. Minoru Hironaka

Three areas in the Nez Perce and Payette National Forests were observed and sampled by graduate student Ron Lambeth and Range Resources Professor Minoru Hironaka to determine the type and quantity of forage consumed by the Columbia ground squirrel (*Citellus columbianus*), a native grazer in grasslands and forest opening communities above the Salmon River.

The study, a part of the McIntire-Stennis funded Idaho Batholith Project, looked at south facing areas which were used by sheep at three different levels of grazing intensities.

Ground squirrels are believed to be a seral, or intermediate species related to grazing disturbances. During the course of the study, the researchers hope to test this theory, determine the influence of the ground squirrel on plant succession, and ascertain whether the species competes with or complements sheep grazing.

Trap-retrap data indicated higher populations of ground squirrels on the most heavily sheep-grazed plot. But while most of the plant species favored by sheep were palatable to the rodents, the most important plant species in the ground squirrel diet through the season were less appealing to sheep.

WELL-MANAGED GRAZING OFFERS BENEFITS IN CONIFEROUS ZONE

William J. Summers
Dr. John E. Mitchell

Livestock grazing of the mixed conifer range has long been a point of contention among forest, range and wildlife resource managers. Correct grazing practices can produce an interim economic return between cutting cycles, as well as furnish a biological method for reducing fire hazard and understory competition with tree seedlings. Reduced tree regeneration and growth, depleted watershed quality and direct competition with wildlife, however, have been attributed to incorrect animal stocking rates.

Livestock distribution detemines the intensity, timing and duration of grazing in the mixed coniferous forest. Grazing damage stems from poor cattle distribution. Ineffectual distributions result in more frequent and intense use of natural meadows and logged areas near water. A poor distribution also results in the improper timing and duration of grazing on reseeded skid trails and landings used in logging operations. Grazing before revegetation is established increases soil erosion and promotes noxious weed invasion on disturbed areas. Due to the lack of understanding of animal management in the area, most of the mixed coniferous forests are currently underutilized.

Studies of animal stocking rates and distribution are being conducted on the University Experimental Forest by graduate student William J. Summers and Assistant Professor John E. Mitchell of Range Resources. The forest is dominated by mixed conifers and is representative of this forest zone. The 12,000-acre grazing allotment is composed of University, Forest Service, State and private lands, which have been grazed season-long, usually from May to October, for nearly 40 years. Research during the 1975 field season evaluated forage production and utilization on different areas of livestock concentrations. Animal movements were recorded for the purpose of determining natural distribution patterns on the allotment.

Data showed that the cattle established daily patterns of travel among grazing areas. The specific routes included salt, forage and water locations. Distribution at any given time was related to the hour of the day and indirectly to animal behavior. Grazing intensity and frequency were increased on locations touched by more than one travel pattern, but natural movements of the domestic animals within the larger area averted continuous grazing even in heavy use areas.

Two fences will be introduced and salt locations moved to encourage a change in distribution during the following grazing season. Researchers will evaluate the effects of planned distribution patterns in preventing overuse of key areas on the allotment.

Grazing on the school forest provides a study area for cattle impact on forage, and a chance to evaluate distribution and stocking plans.

Project results will support better grazing management in the mixed coniferous forest and aid resource managers in improving compatibility of grazing with other forest uses.

RESEARCHERS PREPARE RANGE CLASSIFICATION SYSTEM

Dr. Minoru Hironaka
Dr. Maynard Fosberg

Renewed interest in classifying rangelands on the basis of site potential has sparked a range project utilizing vegetation and soils information to establish habitat types on shrub and grasslands in southern Idaho, undertaken by Dr. Minoru Hironaka of Range Resources and Dr. Maynard Fosberg of the Plant and Soil Sciences Department. Numerous failures to predict the outcome of management and manipulation practices on rangelands have made such a classification system desirable.

Seral, or changing vegetation on rangelands and misidentification of plants has made recognition of site potential based on vegetation alone difficult in the past. Now, relying on soils and site characteristics, areas that have potential of supporting the same climax vegetation are classified as belonging to the same habitat type, regardless

of differences in species composition of the existing vegetation. The premise is that all areas of the same soil belong to the same habitat type.

Habitat type classification of forest land has proven highly useful in the Inland Empire and Intermountain region. The primary difficulty associated with developing a habitat type classification of non-forest vegetation has been the lack of examples of climax vegetation due to disturbance.

Using soil/site and vegetation information, particularly presence of shrub species, most non-forest stands can be tentatively classified as to habitat type. The existing vegetation is classified into community types within each habitat type. The relationship of community types to one another is determined to show the order of succession.

A field sampling technique is being developed to enable a technician to identify community types and their respective habitat types, based on current vegetation. A key to community types will be one of the final products.

The development of the classification will thus provide a means to delineate all areas of similar potential which can be recognized by the current vegetation. Furthermore, the classification scheme provides for the logical storage and easy retrieval of information pertinent to management of rangelands under the multiple-use concept.

TRAMPLING DAMAGE RECORDED FOR SUB-ALPINE VEGETATION

Dr. John E. Mitchell
Elizabeth Coombs

Overuse of campsites is a problem in many of our backcountry areas where trampling has removed vegetal cover, leaving the soil bare, compacted and subject to erosion. Once this point has been reached, site recovery will be extraordinarily slow, even if all use is prohibited.

Researchers Dr. John E. Mitchell and graduate student Elizabeth Coombs have begun work on a study designed to find an early warning signal that could indicate site deterioration to the wilderness manager before all ground cover is removed.

During the 1975 summer field season, the study team surveyed campsites receiving varying amounts of use in the Idaho Primitive Area's Bighorn Crags. Looking for changes in the species composition of the plant communities, they recorded the relative frequency of occurrence and amount of ground covered by each plant species. While some species simply died out as trampling increased, others were found to increase in quantity under light trampling, offering managers a sensitivity reference point for site evaluation.

Work will continue in the Crags, testing the indicator value of these species. In addition to cataloguing increasing and decreasing species, the investigators plan to examine the attributes which make the indicator (increasing) species trampling resistant. Expanding the study of indicator species in this way will increase the utility of the results, making them applicable to other backcountry areas. The study should then provide guidelines for wilderness managers in areas wholly different from the Bighorn Crags.

FOREST-ASSOCIATED RANGE STUDIED IN BATHOLITH

David Griggs
Dr. Minoru Hironaka

Another group of studies in the Idaho Batholith has been funded by the McIntire-Stennis to investigate multiple use capabilities of forest-associated range in the central part of the region.

The objectives of one project, conducted by graduate student David Griggs and Range Resources Professor Minoru Hironaka, were to quantitatively characterize the major plant communities, classify the habitat types, their respective seral or changing vegetation and indicate probable successional trends.

To meet these objectives, data were collected in the west-central Idaho Batholith during two field seasons on three study areas representing summer grazing allotments in the upper ponderosa pine, Douglas-fir and spruce fir zones. Sixty-nine stands representing most major vegetation types within this forest associated range were sampled, identified, and quantitatively characterized.

The lack of remnant of near-climax vegetation for classifying seral plant communities, understanding their successional relationships and probable trends, and identifying the climax plant association of their respective habitat types led to a different approach to analysis than traditionally used for habitat typing. This approach includes the use of multivariate techniques to provide an objective framework for study of the sampled vegetation stands. Two hypotheses were developed. The first was that a numerical hierarchical classification analysis could be used to reduce the stands to interpretable ecological groups which, at given levels of the hierarchy, would correspond to community types and habitat types. The second hypothesis is that ordination analysis could be used to display successional relationships of the community types within respective habitat types.

Forest Resources

FERTILIZATION, THINNING PRODUCE FASTER GROWING TIMBER STANDS

Dr. Howard Loewenstein
Franklin H. Pitkin
David Scanlin

Forest fertilization studies conducted on three underlying rock-types in northern Idaho have found that thinning in combination with fertilization can and will produce larger trees in faster growing stands.

Forest Resources Professors Howard Loewenstein and Franklin H. Pitkin, and Research Forester David C. Scanlin are involved in an ongoing project to study the ages and species of trees on specific sites which will show the greatest response to fertilization and thinning. The project is funded by McIntire-Stennis Act funds, the Intensive Timber Culture Program (U.S. Forest Service), the Potlatch Corporation, and the Forest Utilization Research Program (State of Idaho).

Douglas-fir and grand fir stands in northern Idaho were stratified by the major underlying rock-type; the three types considered were granitic rocks of the Idaho Batholith, metamorphic rocks belonging to the Belt Series, and basalt rocks. Each stand incorporated two replicates (plots) of three treatments and a control. Treatment consisted of either thinning alone, fertilizing alone with 200 pounds per acre of urea-nitrogen, or the combination of thinning and fertilizing.

A subsample of trees on each plot was selected and each tree of the subsample was measured for initial height, diameter at breast height, age, crown ratio, and past 10-year diameter increment. The species, crown class and general condition of each tree were also recorded. For two growing seasons following treatment, each tree was remeasured.

In general, statistical evaluation at the end of 2 years revealed that both thinning and fertilizing increased diameter, basal area and volume growth in most stands, with thinning producing a slightly greater effect than fertilizing, on the average. Thinning slightly decreased height growth as compared to the control trees, but fertilization increased it. Fertilization in conjunction with thinning produced considerably greater responses (in diameter, basal area and volume growth) than did either treatment alone. The combination overcame the negative effect of thinning on height growth, but did not increase it as much as did fertilizing alone.

Both species showed variations in growth response to treatment within and among the rock-type classifications. It is not clear, at this point, whether these differences are actually due to the influence of the rock material or to other site differences such as aspect, slope, elevation, site index, habitat type, etc. Subsequent analysis of 4-year response data will include these factors and may shed light on these differences.

HAZARD RATING SYSTEM DEVELOPED AS AID IN TREATING PEST OUTBREAKS

Dr. John A. Schenk
Dr. David L. Adams
James A. Moore
Ronald L. Mahoney

Early identification of grand fir stands potentially or currently susceptible to fir engraver (*Scolytus ventralis*) outbreaks is essential for a successful pest management strategy. Forestry resources researchers began work in 1972 both to develop a rating system for timber stand hazards and to determine the influence of silvicultural and tree harvesting practices on beetle population and damage trends.

Professors John A. Schenk and David L. Adams, with Research Associates James A. Moore and Ronald L. Mahoney, have already worked out a hazard rating system, one of the research objectives, based on easily obtained forest inventory (cruise) data and relatively simple computation. The resulting model offers aid to managers in the selection of treatment priorities.

Two models have been developed that provide a means for early identification. One model is based on the interaction of the frequency of occurrence of two groups of understory plant species. One group represents the drier extreme of the ecological range of grand fir; the other group represents the more moist condition. This model can be used to rank grand fir sites according to the degree of susceptibility to engraver outbreaks.

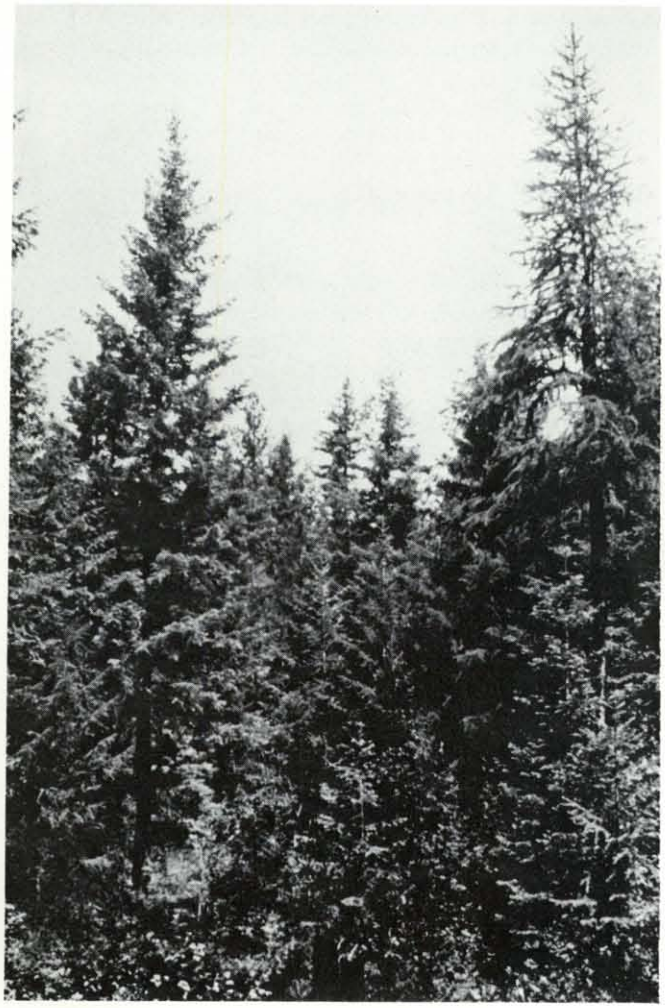
The second model is based on the interaction of tree competition (density), and the amount and availability of host trees (tree species diversity) for use in rating grand fir stands for engraver-caused tree mortality hazard.

RESEARCHERS PROJECT IDAHO TIMBER SUPPLY

Kenneth M. Sowles
Dr. Charles R. Hatch
Gerald M. Allen
Geoffrey L. Houck

In a project undertaken by four researchers from the Forest, Wildlife and Range Experiment Station in 1975, the most recent forest inventory data from each organization managing commercial forest land within the state were analyzed to provide a projection of Idaho's timber supply through the year 2045.

Working on the project were Kenneth M. Sowles, associate professor of wood utilization and marketing; Charles R. Hatch and Gerald M. Allen, associate and assistant professor, respectively, in Forest Resources, and Geoffrey L. Houck, research technician. Estimates of Idaho's present and future expected timber supplies were developed under a contract issued to the Idaho Department of Lands by the Pacific Northwest Regional Commission.



Projections of timber supplies in the state of Idaho through 2045 have been completed for the northern and southern part of the state.

The supply projections, in net cubic feet, were established for northern and southern Idaho for a given set of yield assumptions and utilization intensities. A stand table projection model, the Timber Resource Analysis System (TRAS), was used in the study. Used by the Forest Survey, USDA Forest Service, it is well adapted to making aggregate, long term projections for large areas.

The researchers found that commercial forest land owners should be able to maintain 1975 levels of timber supply through 2045 if present forest management practices are continued. Changes in the emphasis placed on social, economic and environmental management objectives would result in a change in productivity, depending on the emphasis that might be imposed on management.

The report also summarizes the seven major forest inventory systems currently used in Idaho by stated objectives, stated variables of interest, stratification scheme, sampling design, type of sample plot used and field procedures. Alternative ways of developing or supplementing a statewide system of forest inventory are discussed.

The report also illustrates a prototype information retrieval system utilizing data banks for summarized stand information and summarized individual tree records. This system can use existing forest resource inventory data.

The research and findings from this project are being compiled into two experiment station papers for publication.

PONDEROSA PINE SEEDLINGS CHOSEN FOR SELECTIVE BREEDING PROGRAM

Dr. Chi-Wu Wang

Selection of 80,000 ponderosa pine seedlings from superior parent trees in southern Idaho in 1975 marked the beginning of second stage selective breeding for long-range improvement, a part of the cooperative ponderosa pine improvement plan.

The seedlings, chosen from the best natural stands recognized in the first generation test and from adjacent stands of similar heredity and environment, were raised at

the Lucky Peak Nursery for the establishment of four second generation progeny test seed orchards in the spring of 1976.

Test materials were selected throughout the ponderosa pine regions of southern Idaho, from White Bird to Mountain Home by project cooperators, which include the Idaho State Department of Lands, the U.S. Bureau of Land Management, the U.S. Forest Service and the Southern Idaho Forestry Association.

The cooperative program, initiated in 1960, is one of the University of Idaho's major contributions to the southern part of the state. Professor of Forest Resources Chi-Wu Wang is the principal investigator for the University.

The first generation test of 271 progeny families distinctly indicated that superior growth rate and vigor characteristics were not distributed at random; 48 to 58 percent of the total variance in height was associated with stands, and 19 to 25 percent of the total variance was associated with progeny families.

The superior progenies were 38 percent better in growth rate than the ordinary planting stock in southern Idaho. Cone crops in bushel quantities are ready for collecting from the superior parent trees, which are mostly in the prime seed producing age of 50-100 years.

For the improvement of ponderosa pine in northern Idaho, a similar progeny test seed orchard of 20 acres was established in Tensed, north of Moscow. This project was conducted in cooperation with eight wood using industries and state and federal agencies.

RESEARCHERS COLLECT DATA TO PREDICT BEETLE OUTBREAKS

Dr. John A. Schenk
Ronald L. Mahoney
James A. Moore
Dr. David L. Adams
Dr. David A. Hamilton

The prediction of mountain pine beetle (*Dendroctonus ponderosae* Hop.) outbreaks requires a knowledge and quantification of those environmental variables associated with population increase of the beetle. Prevention or suppression of outbreaks can be accomplished by alteration of the environment to acquire and maintain unfavorable beetle habitat.

The hypothesis of forestry college researchers is that high density pure stands of lodgepole pine may be subjected to extreme competitive stress under adverse site conditions, thus providing an abundance of weakened (less resistant) host material. By measuring stand density (competitive stress) and tree species diversity (amount and availability of habitat) and quantifying their relationships to beetle-caused tree mortality (stems and volume per acre), a model can be developed which can predict the probability and severity of damage. This model also can provide the information requisite to a successful prevention control strategy through alteration of stand structure.

Project investigators are Forest Resources Professors John A. Schenk and David L. Adams, Research Associates Ronald L. Mahoney and James A. Moore, and Research Forester David A. Hamilton, Jr. of the U.S. Forest Service Intermountain Forest and Range Experiment Station.

Data gathered to meet objectives of concurrent subprojects of the National Science Foundation/Integrated Pest Management/Mountain Pine Beetle Programs, and numerous data from the U.S. Forest Service have been utilized in the development of preliminary models specific to a geographic (climatic) region. The inter-regional incompatibility of any single model is due, in part, to divergent sampling techniques, insufficient data base within a climatic region, the influence of site and inter-regional differences on the mathematical relationships between variables, and to the variability of the climatic factors between regions, in relation to their effect on mountain pine beetle populations. Thus, emphasis during 1976 will be complete model development by accounting for these incompatibilities.

During the 1976 field season, we hope to gather data to provide the required base for development of a model specific for a climatic region. Within this same region, the variation between a given stand structure and beetle-caused tree mortality due to site differences will be accounted for in a study proposed by Ron Mahoney. This study intends to account for the influence of site difference by expressing relationships in a model utilizing under-story plants as indicator variables. This site hazard rating model will be used to modify the stand hazard rating model to account for site influence. With an adequate intra-regional model thus developed, its application can be expanded to other regions by accounting for inter-regional influences. A subproject proposed by graduate student Nicholas Crookston intends to quantify these inter-regional influences on beetle populations. Thus, the final model would utilize variables representing stand structure (as the primary measure of availability and suitability of beetle habitat), site (as a measure of habitat quality and stand resistance) and climate (as a measure of its direct effect on the beetle population).

The basic objective is to provide an easily attainable and practical method of predicting the location and severity of beetle outbreaks, and information requisite to the implementation of a prevention control strategy. Also, the model could be interfaced with stand simulation models to provide realistic probabilities and consequences of management alternatives in lodgepole pine stands.

PATHOLOGISTS EXAMINE DISEASE, INSECT FREQUENCY

Dr. Arthur D. Partridge
Dr. Elmer R. Canfield
Dr. Rosy Chacko

Following a number of years of work examining the relative occurrence of disease and insects in random forest plots, forest pathologists Arthur D. Partridge and Elmer R. Canfield have concluded that disease and insects frequently occur in combination.

Working primarily in the northern part of Idaho, the researchers choose stands of trees for study on both Forest Service and private lands, such as those belonging to Potlatch Corporation and Diamond International. Reports are made to the forest managers on the frequency of occurrence and location of disease and insect problems. The team looks for all the causes which contribute to the death of a tree, rather than restricting the final report to a single cause. Occurrence data will be evaluated to form a base for predicting the cycles that are likely to occur in a given area.

Statistically, in 1975, they found 67 percent of the trees affected with some kind of stem disease, 29 percent with insects and disease, 13 percent harboring insects only, and 30 to 35 percent completely healthy.

Samples from this diseased tree stump have been evaluated in the laboratory to aid scientists in prediction of disease and insect frequency.

Research Scientist Rosy Chacko and a team of five graduate students help in the analysis of all aspects of the site chosen, and of the four sample trees, which are taken down and dissected on each plot. During the summer field season, undergraduates also take part in the project, where they are exposed to a broad spectrum of problems affecting trees.

Everything about a tree is recorded; the defoliation or decay and root condition become part of its history. To adequately study the roots, the researchers must use dynamite to gain access to the root area. Root samples and cultures are taken back to the lab for proper identification of root disease. Stand measurement and age, tree measurement, plants found on the site, slope and aspect are all noted as the data background for final evaluation and prediction. An outgrowth of the program has been the preparation of a disease and insect problem descriptors bulletin designed for field use and identification, scheduled for 1976 publication.

TREE BIOMASS AND PRODUCTIVITY ESTIMATED FOR NORTHERN IDAHO HABITAT TYPES

Dr. David L. Adams
Donald P. Hanley
Glenn H. Deitschman

Tree biomass and potential productivity were estimated for three prime timber growing habitat types in northern Idaho by Forest Resources Professor David L. Adams, Research Associate Donald P. Hanley and Glenn H. Deitschman of the U.S. Forest Service Intermountain Forest and Range Experiment Station. The study area included grand fir/pachistima, western red cedar/pachistima and western hemlock/pachistima habitat types.

Biomass and productivity information is essential for selecting research emphasis and as a basis for judging gains in production resulting from silvicultural practices. Twelve unmanaged mature stands were analyzed using inventory records over a 10-year period. Foliage, branchwood, peeled bole, bark and root weights were estimated for each tree using regression equations developed by numerous researchers.

Productivity was measured by assessing the change in biomass during the measurement period. Standing biomass averaged 438.5 M lbs/acre, while periodic annual productivity averaged 12.0 M lbs/acre/year. The empirical estimates obtained in this study were within the published range of measured productivity values for similar forest types. FWR Experiment Station Bulletin 14 includes complete results of this project.

STREAMSIDE VEGETATION EXAMINED IN HELL'S CANYON

Frederic D. Johnson
Thomas B. Miller
John Johnson

Detailed studies of plant communities in the Hell's Canyon stretch of the Snake River are non-existent, in spite of growing interest in the streams adjacent to this large river.

Recreational pressure on the Snake and Salmon rivers is gaining rapidly. Hell's Canyon is now a National Recreation Area, and the Salmon River is high on the candidate list as a Wild/Scenic River. People who raft or kayak down the river, as well as hikers, are attracted to the side streams. Here shade and drinking water are found in canyons whose summer temperatures frequently exceed 100 degrees. Here in the streambottoms major trails converge. Here also both wildlife and domestic livestock congregate.

A study conducted by Fred Johnson, professor of Forest Resources; Thomas Miller, graduate research assistant, and John Johnson, field assistant, offers the first concentrated examination of the streamside vegetation in this unique canyon. The project, funded by the Stillinger Trust Foundation, has taken two field seasons to complete.

Overflying the canyon first with Professors Robert C. Heller and Joseph J. Ulliman, the study team photographed the area with true color and color infrared film. This was essential in determining which streams would be best to sample for the project. The area on each side of the river is essentially grassland, with limited, or gallery forest areas located in the streambottoms. At stream level, transects were taken at regular intervals for several miles up the selected major side streams. For comparison, similar transects were established in the Salmon River.

Unable to find previous vegetational studies for steep mountain streambottoms in the western United States, North America, or any other part of the world, the researchers had to formulate a new sample system. Expecting diversity, they in fact found over 80 species of woody plants, more than 40 of which were not native to the area.

Numerous kinds of trees have escaped to this secluded canyon. Some are so widespread that they appear as native trees, completely naturalized. Sweet cherries and English walnuts were found, and three or four species of plums, two species of raspberries, mulberries and black walnuts, all growing with the natural wild streamside vege-

Gallery forests of non-native trees have been discovered in the streambottoms of the Snake River in the Hell's Canyon National Recreation Area, where they provide shade for recreationists, wildlife and livestock.

tation. On the slopes above were wild populations of apricots. So remote are these canyons, only the sweet cherry and the raspberries have been previously reported anywhere in the western United States as escaped plants.

The studies were keyed in on white alder, essentially a Sierran species occurring to the north as scattered populations in the low canyons of eastern Oregon. In the warm, deep canyons of the Snake and Salmon it becomes prevalent, and is the dominant species in many streams. Why is this Sierran tree so common this far north? The most convincing answer is temperature. The biotemperature in the middle stretches of these canyons is higher than at either end – a considerable variation on the usual upstream temperature gradient. By some classifications, the climate of these canyon bottoms would be subtropical, and yet they are only slightly more than 200 miles south of the Canadian border. White alder can be expected in streambottoms up to 3000 ft in Hell's Canyon, but only to 2500 ft in the cooler Salmon River canyon. White alder is a temporary species, and if the mud-rock flows typical of these steep canyons do not occur for a period of several decades, then it appears that white alder will be replaced by water birch, netleaf hackberry or chokecherry, depending on elevation.

One of the most interesting features to come from this work is a prediction of future vegetation. Should streams become stable for a period of years what will the streambottoms look like a generation from now? The success of the escaped and naturalized trees is the key to the answer. Since many of these exotic trees are more shade tolerant and also make much larger trees, the streamside forest of the future will contain black locust, black walnut, English walnut and sweet cherry in the overstory, a forest even more unique than the white alder stands of today.

IDAHO LAND USE MAP PRODUCED FROM SATELLITE IMAGES

Robert C. Heller
William Befort

LANDSAT I satellite images taken 590 miles above the earth were transferred to U.S. Geological Survey base maps in 1975, providing a land use map for the state of Idaho.

William Befort, teaching assistant and graduate student in the College of Forestry, Wildlife and Range Sciences, accomplished the task from May to September of that year under the direction of Robert C. Heller, professor of remote sensing. The original delineations were done in 3 months, an almost impossible feat by any other method for as short a time period.

This undertaking was part of a Land Resources Inventory Demonstration Project supported by the Pacific Northwest Regional Commission, with the cooperation of NASA and the U.S. Geological Survey. Land use maps of Idaho, Oregon and Washington have been produced at scales of 1:250,000; 1:500,000 and 1:1,000,000. The original land classifications were made from 1:1,000,000 false-color LANDSAT images, optically enlarged through a Bausch & Lomb zoom transfer scope onto the USGS base maps. Because of the very small scale, only gross classifications (Level I) could be made. These were urban and built-up land, agricultural land, rangeland, forest, water, wetland, barrenland, tundra and permanent ice and snow. The maps, on a Cronaflex base with transparent overlays at the three scales listed, are available through Northwest Cartigraphs in Eugene, Oregon. A set of maps and a price list are available for inspection in Boise through Paul Cunningham, Idaho Task Force Representative. There is a good possibility that the land use maps will be printed in color at one scale.

FOREST GROWTH, YIELD DATA COMPILED FOR EASY RETRIEVAL

David A. Erickson
Dr. Albert R. Stage

Existing data on forest growth and yield are widely scattered among many sources. A cooperative agreement between the University of Idaho and the USDA Forest Service has been established to compile this information nationwide.

This study is working to congregate the data and put it on a machine-readable file, making it accessible, at the (USDA) Ft. Collins (Colorado) Computer Center (FCCC).

The principal investigator, David A. Erickson, cooperative research technician, has been working under the direction of Albert R. Stage, principal mensurationist at the USFS Intermountain Station in Moscow. Erickson is working with each member of the Growth Processor Committee, headed by Stage and NFS Regional Representatives to that committee to obtain available data on geographic areas within their responsibility. The total of growth and yield information and growth simulators assembled have come from USFS Regions 2 and 6. Current work comprises collection of data from the eastern United States. Trips to other Regions will be taken in the near future to complete the collection of presently available yield knowledge.

Erickson has become knowledgeable in the use of FCCC's UNIVAC system. Files of yield data are stored there, formatted in a way to be useful as input to an

economic analysis program, MULTIPLOY (Row). Several growth simulators are functioning to produce managed yield tables in such a format.

A bibliographic retrieval program, FAMULUS (Yerke et al.), is being used to store descriptions of each yield data file. The retrieval information includes species or forest type, author, title, abstract, recommended area of application and the physical location of the particular file in the FCCC system.

The yield information files at FCCC will be maintained to allow for data modification, ensuring that they are up-to-date and correct. Consequently, they will function as a useful, centralized, constantly available source for use in economic and comparative yield studies of forest resources.

FOREST CONDITIONS AFFECT TUSSOCK MOTH OUTBREAK SEVERITY

Dr. Karel J. Stoszek
Harold L. Osborne
James Moore
Peter G. Mika

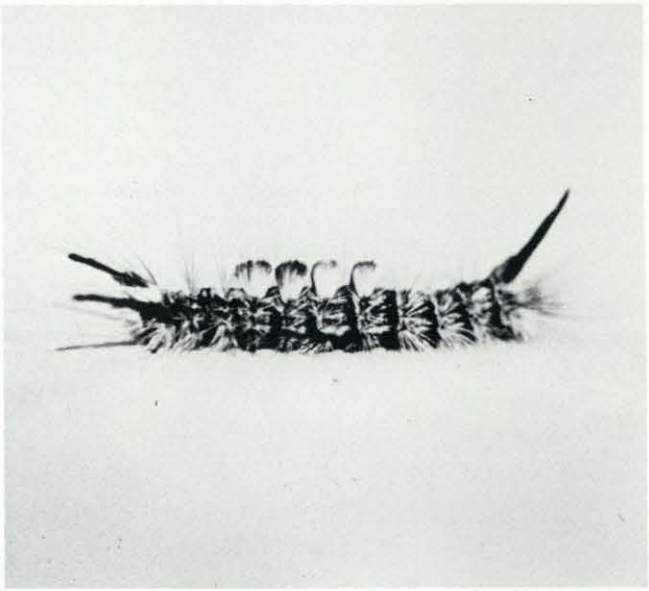
Are there relationships between the severity of Douglas-fir tussock moth (DFTM) defoliation and the condition of the tree stands and the tree growing site? Can we identify (risk-rate) stands that are susceptible to severe defoliation by the DFTM? In addition, what timber management practices increase the susceptibility of northern Idaho forests to more frequent and severe defoliation by the tussock moth? Finally, are there management practices and silvicultural systems that have the potential to reduce the severity of or prevent future DFTM outbreaks?

These are some of the questions addressed by Associate Professor in Forest Resources, Karel Stoszek, and Research Associates James Moore, Harold L. Osborne and Peter G. Mika. The research team is identifying relationships between various site, stand and tree characteristics that influenced the severity of DFTM defoliation during the 1973 outbreak in the Palouse Range of northern Idaho.

Preliminary results indicate that stand age, tree species composition, structure (even-age, one-storied, multi-storied) and the location of the stand on the mountain slopes have a substantial bearing on the intensity of tussock moth defoliation. The upper slopes and ridge tops, particularly those sites with south-easterly, southerly and south-westerly aspects, seem to have the highest risk or probability of DFTM defoliation when covered by mature and overmature stands of grand fir and Douglas-fir. The severity of DFTM defoliation increases with the proportion of grand fir trees in the forest stand canopy; stands composed primarily of Douglas-fir were substantially less affected by the tussock moth. (It seems that the name Douglas-fir tussock moth is a misnomer, at least under the conditions of northern Idaho.) Results show that one-storied stands less than 50-years-old with a high risk species composition on high risk locations are virtually unaffected by the DFTM. Stands located on lower slopes and at the base of foothills were similarly less affected by the DFTM outbreak in 1973.

The above results are substantiated in part by Robert Heller, research professor in remote sensing, and Wayne Miller, graduate assistant. Their study used aerial photography to delineate DFTM outbreak areas in eastern Oregon, and correlated certain site and stand characteristics to the probability of DFTM defoliation.

Information derived from this study dovetails with the efforts by Associate Professor and Experiment Station Statistician Charles Hatch, who is working to develop models that assess DFTM defoliation impact on tree growth. The studies by the College of Forestry scientists are a part of a 4-year research and development program designed to develop comprehensive integrated controls of the tussock moth. The project is jointly funded by USDA, Cooperative State Research Service and other agencies, involving numerous scientists from all major western universities, public and private organizations. The projects are directed by Kenneth Wright and a team of coordinators headquartered in Portland, Oregon. Research conducted at this college and studies involving other aspects of forest stand dynamics, coordinated by Dr. Albert Stage of the



The Douglas-fir Tussock Moth, seen here in larval stage, has caused extensive damage to timber in Idaho and the Pacific Northwest.

Forestry Sciences Laboratory at Moscow, tie-in with results of forest entomology studies involving tussock moth population dynamics and with the work on the socio-economic impact caused by DFTM outbreaks.

The results of DFTM studies in the College of Forestry, Wildlife and Range Sciences are providing forest managers with information they need to predict where, how often and to what extent pest outbreaks will damage the resource they are managing. The knowledge of predictive and preventive measures becomes especially important under intensive forest resources management programs. Once these measures are incorporated into the silvicultural prescriptions, the high risk stands located on high risk sites can be made less vulnerable to tussock moth attacks.

SEED WAFER PLANTING COULD CUT PLANTING COSTS

Dr. David L. Adams
Margaret M. Harris

Planting a seed with its own favorable environment attached, in the form of a tablet, or "seed wafer," may offer a more effective reforestation method that would cut planting costs by $30 per acre, according to Professor of Forest Resources David L. Adams and Research Associate Margaret M. Harris.

Studies were initiated in 1975 under a STAR grant to evaluate germination potential of waferized tree seeds following encouraging results of seed wafer reforestation in the field in 1974.

Forest land in the Rocky Mountain Region is being cut faster than it can be regenerated. In Idaho, the annual harvest from clearcutting alone exceeds 18,000 acres, while only 15,000 acres are reforested. Green and Setzer, in *The Rocky Mountain Timber Situation, 1970,* have predicted that a sixfold increase in regeneration efforts must be made to reverse the trend which anticipates 4 million acres of non-stocked forest land in the Rocky Mountain Region by 1980, an alarming increase from the 2.7 million acres recorded in 1970.

More effective reforestation must combine economy with ease of operation, while establishing successful regeneration.

The seed wafer, developed by Paul E. Johnson in 1969, is composed of vermiculite, a methyl cellulose binder and activated carbon. Liquid fertilizer can be added to provide nutrients for the emerging seedling, but wafers containing this ingredient cannot be stored for long periods, as the fertilizer will eventually kill the seed.

The vermiculite in the wafer provides a favorable moisture environment and permits rapid seedling germination. Furthermore, the wafer acts as an anticrustant in the area immediately surrounding the seed. Control of competing vegetation can be maximized since the activated carbon in the wafer absorbs herbicides and effectively protects the emerging seedling. The unit cost of the wafer is very small, as it can be manufactured in bulk quantities with a high-speed machine. In addition, the wafers are produced in a uniform size so that regardless of seed size, a single planting machine can be used.

During the fall Research Associate Margaret Harris travelled to Pennsylvania State University to become familiar with the operation of a prototype machine designed for making seed wafers. This machine is now on loan to the University of Idaho. Five species of western conifer seeds were obtained from the U.S. Forest Service nurseries in Coeur d'Alene and Boise, and from the Forestry Sciences Laboratory in Moscow for use in this project. Three integrated experiments have been designed to test waferized Douglas-fir, lodgepole pine, western larch, ponderosa pine and western white pine, for germination differences, and to compare germination capabilities with naked seed. An additional experiment will evaluate three methods of planting the wafers. If the seed wafers can be used successfully, it is estimated that the savings applied to the acreage annually clearcut in Idaho would amount to $540,000 per year. The ultimate value of returning non-stocked lands to production would be many times this amount.

Wildland Recreation Management

SURVEY RESEARCH CONSIDERS QUESTIONNAIRES IN SCHOOLS

Robert E. Ivins

The intent of this study is to determine what relationship exists between the attitudes and behavior of parents and the attitudes and behavior of their children related to outdoor recreation for planning purposes. The study is being conducted by Robert E. Ivins, research associate in Wildland Recreation Management.

If the young people in school reflect the attitudes and behavior of their parents, the young people could be surveyed at schools regarding outdoor recreational needs and desires. Such a survey conducted at schools would produce a good return rate of questionnaires. Moreover, this method with a high questionnaire return rate would reduce one of the major defects associated with the mail-out/mail-back method most widely used in survey research today.

QUESTIONNAIRE WILL EXAMINE NON-CONSUMPTIVE USE

Lawrence Belli
Dr. James R. Fazio

Recreation related to wildlife was considered to be hunting and fishing. Today it is realized that another important group of wildlife users shares in the concern for this resource. These are the people who use wildlife for a variety of purposes that do not involve harvesting the animals. Photography, painting and observation are among the non-consumptive uses.

A questionnaire has been developed by graduate student Larry Belli and Assistant Professor James R. Fazio of Wildland Recreation Management to learn more about the characteristics of non-consumptive wildlife users in Idaho. Questions answered in this study will include such things as the relative importance of non-consumptive use, the amounts of money expended in this kind of recreation, socio-economic characteristics of the recreationists, the nature of their activities and where they occur.

The results will aid wildlife officials in decisions related to the management of non-game species, and should provide insight on the amount of support for wildlife management programs that might exist within this specific public.

WILDERNESS INFORMATION SOURCES AND CHANNELS ARE STUDIED

Dr. James R. Fazio
William Bramlette

As increasing numbers of people seek a variety of recreational experiences in the nation's limited wilderness areas, agency personnel are looking for more effective methods of reducing human impact on these areas. Use rationing, permits, limited access and closures seem less palatable management options than attempts to teach people how to reduce the physical and social effects of their visits. However, for such efforts to be effective, much more needs to be known about communication between the managing agency and the wilderness recreationist.

In the present study, James R. Fazio, assistant professor, and William Bramlette, graduate student in Wildland Recreation Management, are attempting to find out where wilderness recreationists obtain certain kinds of information that might be expected to influence their behavior while in the wilderness. Information has arbitrarily been divided into the categories of biophysical, wilderness concept, wilderness management, ethics and equipment/safety. The relative degree of knowedge of these subjects, as well as initial sources used by the recreationists, will be determined. The channels, or "how" recreationists receive this information will also be determined.

A portion of the Selway-Bitterroot Wilderness Area in Idaho was selected as the study area. The results, however, should help wilderness managers throughout the Northwest improve the efficiency of their efforts to use communications as a management tool.

One portion of this study takes an entirely different approach. It involves examination of the "message" segment of the communication model. Information that is typically disseminated by agencies is being analyzed to determine subject emphasis, readability and efficiency of responses to mailed inquiries.

Wilderness recreationists entering the Selway-Bitterroot Wilderness Area by private airplane are interviewed at the Moose Creek Ranger Station.

RESEARCHER TO MEASURE RESPONSE TO VISUAL CHANGE

Dr. John H. Schomaker

Federal land management agencies are increasingly concerned about the visual impact of activities on the public lands. Assistant Professor of Wildland Recreation Management John Schomaker, in cooperation with the U.S. Forest Service, is developing a method for measuring the public's response to proposed visual alterations of the environment.

The goal of the work is to identify which of several alternatives will be the most aesthetically pleasing to the public. Changes to be considered are road construction, timber harvesting and utility line construction.

TEACHER EDUCATION PLAN PREPARED FOR REFUGE

Dr. James R. Fazio
Carl Brown

When the primary purpose of an area is wildlife research, how can its personnel best provide assistance to local schools in upgrading teacher education? This project centers on Rachelwood Wildlife Research Preserve, a privately owned hunting and research preserve in western Pennsylvania.

James R. Fazio, assistant professor, and graduate student Carl Brown are developing a plan and teaching materials for actual use in improving teacher competence in the areas of environmental and conservation education.

Fisheries Resources

REDUCED WATER FLOW AT DAMS STUDIED FOR EFFECT ON FISH

Dr. Ted C. Bjornn
Dr. Robert G. White
Rudy Ringe
Kemper McMaster

As public demands for electrical power increase, new methods are being sought to conserve output from hydroelectric plants for peak consumer periods. Because the need for power is less during the night, the suggestion has been made to reduce the flow of water through the dams on the lower Snake River during those hours, keeping more water in reserve to run the power plants during the day.

Federal and state agencies responsible for the anadromous fish which must use fish ladders at the power plants on their ascent from the ocean up fresh water rivers to spawn, have recommended a water flow schedule that will conserve water, but keep flow sufficient for movement of adult chinook salmon and steelhead trout over the dams.

Drs. T. C. Bjornn and R. G. White of the Idaho Cooperative Fisheries Research Unit, Rudy Ringe, research associate, and Kemper McMaster, graduate student, of Fisheries Resources, are conducting a study for the Corps of Engineers through the Idaho Water Resources Research Institute to determine the effect of slowing or stopping the water flow at night on the migration and behavior of the adult chinook and steelhead. The study was begun in 1975.

Adult steelhead and salmon are being monitored with radio tracking methods during three flow regimes. Each regime utilizes peak flow during the daytime hours, paired with an uncontrolled nighttime flow, a regulated 10,000 cu ft per second flow or a 0 cu ft per second flow.

In July and August 1975, adult chinook salmon were magnetic- or radio-tagged, then transported to release sites in Ice Harbor and Lower Monumental pools. Transportation by 300 gallon fish tank truck, was 1-2 hours, depending upon release sites. The rate of fish movement from the release site to the magnetic separator at Little Goose dam was determined for each test flow. Behavior and fish movement patterns were monitored on a 24-hour basis with radio receivers.

During September and October, the study continued with steelhead trout being collected at Little Goose Dam. They, too, were magnetic-and radio-tagged, released, and then tracked and monitored to establish rate of movement, behavior pattern and time and number of returns reaching Little Goose Dam collection facilities.

The December-February portion of the study is designed to assess the effects of reduced nighttime flows with daytime peaking flows on over-wintering steelhead. Upon completion, a report of findings will be submitted to the Army Corps of Engineers and Idaho Water Resources Research Institute.

SALMON INNOCULATED IN DISEASE PREVENTION PROGRAM

Kevin H. Amos
Dr. George W. Klontz

Like their human counterparts, adult Chinook salmon at the Rapid River Hatchery in Central Idaho lined up last summer for preventive injections, in this case against a bacterial kidney disease.

Graduate student Kevin Amos and Professor George W. Klontz of Fisheries Resources, in two previous summers of research, had determined that the antibiotic Erythromycin phoshate gave significant protection against the disease, with no noticeable effect on the offspring of treated females. Stepping up the injections from a control group to all adults in the spring spawning run is looked to as a means of cutting the pre-spawning mortality which had increased at the hatchery each year from its construction in 1968 until 1973, when the loss due to kidney disease was estimated at 32 percent.

Following initial testing in 1974, researchers in the 1975 field season injected two-thirds of returning adult fish each day at the hatchery trap during the spawning run, with the remaining fish as controls. Tagging scheme changes at weekly intervals helped the researchers evaluate the antibiotic's effectiveness on a short and long term basis, and gave a better idea of the epidemiology of kidney disease at the hatchery.

If the project, funded by the Idaho Department of Fish and Game, is successful in controlling the disease, losses of adult chinook salmon on their spawning run should be reduced, helping to ensure a steady salmon population.

FISHERY IMPACT STUDY MADE AT TETON DAM

Dr. Ted. C. Bjornn
John S. Irving
F. Steven Elle

As part of a pre-study conducted to determine the impact on fishery resources of the ill-fated Teton Dam, Ted C. Bjornn, leader of the Idaho Cooperative Fishery Research Unit, and graduate students John S. Irving and F. Steven Elle carried out research on the Teton River fish populations in 1974 and 1975.

The Teton River has provided a fishery for native cutthroat trout, whitefish, and stocked rainbow and brook trout. The Teton Dam, completed in 1976, was intended to create a reservoir impounding a 17-mile segment of free-flowing river. The earth-fill dam collapsed as the reservoir was being filled on 5 June of 1976, destroying Sugar City, and sending flood waters over much of the area.

Building another dam on the Teton River at this site remains a major question. According to figures obtained during the course of the fishery study, Bjornn said 60 percent of the anglers interviewed favored the Teton Dam project, with 21 percent opposed. Of Idaho residents interviewed, 67 percent were in favor of the project. Researchers found 68.3 percent of the anglers contacted preferred stream fishing, while only 9.1 percent favored lakes or reservoirs.

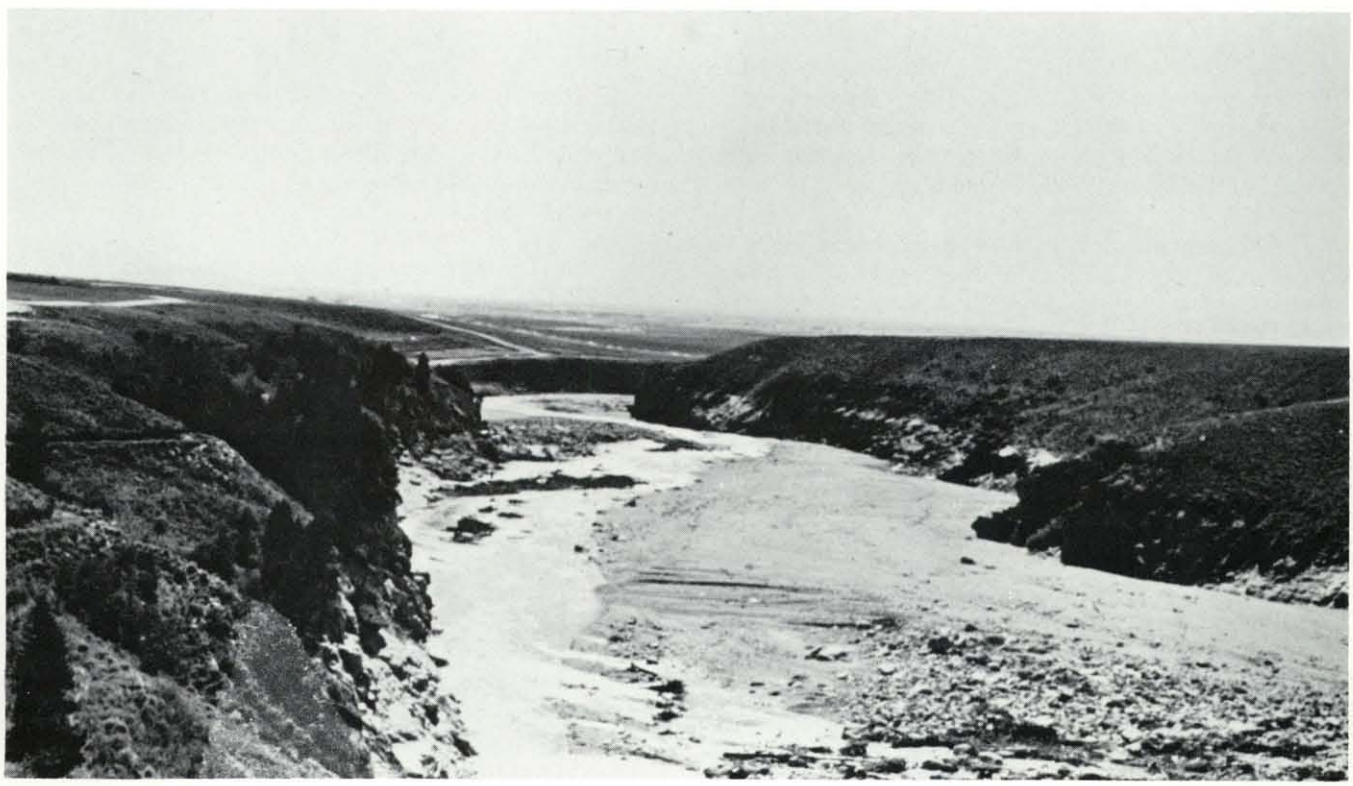
Data obtained in the study are still useful in terms of fishery management on the Teton River.

The researchers assessed the status of native fish populations by collecting information on species composition, relative fish abundance and density, age and growth, mortality rates and movements of trout species.

Nine fish species were collected from the Teton River and its tributaries. Overall, whitefish comprised 55.6 percent of these, brook trout 16.8 percent, cutthroat trout 14.5 percent, wild rainbow trout 6.6 percent, suckers (Colorado and Utah combined) 3.7 percent, and hatchery rainbow 2.8 percent. Redside shiners, longnose dace and sculpins were also collected but researchers did not assess their abundance.

During 1974 and 1975, researchers tagged 5580 trout, of which 532 (9.5 percent) have been recaptured by project personnel or anglers.

A creel and aerial census was used to assess the fishery of the Teton River. Information on the number of anglers, angler hours, catch rate and harvest of fish was collected by both census methods. Researchers estimated that anglers fished 26,502 hours in the Teton River during the summer of 1974 and caught an estimated 37,900 game fish. The summer catch rate was estimated at 1.43 fish per hour.



Streamside vegetation and fishery-protecting habitat have been swept away by flood waters from the Teton Dam disaster.

RESEARCHERS STUDY DISEASE AFFECTING RAINBOW TROUT

Roy E. Larson
Dr. George W. Klontz
Mark P. Dulin
Terrell Huddleston

Enteric Redmouth Disease (ERM), an infectious disease primarily affecting rainbow trout, is the subject of two research projects begun in 1975 under the leadership of Research Technician Roy E. Larson and Fisheries Professor George W. Klontz, assisted by graduate students Mark Dulin and Terrell Huddleston.

In the 1950's the disease was endemic to Idaho's Hagerman Valley in the emergence of the Snake River Plain aquifer, known as Thousand Springs. In the last 10 to 15 years, the causative organism has been transported via live, asymptomatic carrier fish throughout the United States and Canada. In a few places the introduced RM bacterium has become endemic and caused repeated epizootics.

The albino or Idaho Golden trout seems less susceptible to ERM than the pigmented rainbow trout. Outbreaks of ERM have occurred spontaneously in coho salmon and cutthroat trout. It is not known if other salmonids are affected by ERM, as others are not reared in the endemic areas.

The research team began its study with individual fish-farm inventories of the status of the disease, followed by a conference bringing together as many trout farmers and biologists as possible to collate their ideas and understanding of the disease, its causes and progress.

A systematic and detailed pathogenesis study is underway as the third part of the project. The springs supplying Clear Springs Trout Company, Clear Lakes Trout Company and Snake River Trout Farm in the Thousand Springs area will be or have been electroshocked to remove all resident fish and strays from the downstream rearing ponds, as the fourth objective. Snails and crayfish in the springs are being examined microbiologically for RM bacterium, to determine whether they are carriers of the organism. As the fifth part of the research, a parenteral immunizing agent against ERM is being tested.

The researchers have determined that outbreaks of ERM are cyclic in pattern and occurrence, with the cycles related more to a particular trout farm than to the geographic area. There is an indication that the outbreaks often follow handling stress by 3 to 5 days. In the early history of the disease, 6-inch to 9-inch fish were most often affected by outbreaks. In the last 2 to 3 years, the larger, 9-inch to 12-inch fish have been the most affected, increasing the economic losses to fish hatcheries signifficantly.

The reservoir of the RM bacterium is considered to be resident fish in the fish farm water supplies. This is an established conclusion, as fish chronically ill with ERM have been removed from several of the springs at various times. The bacterium is transmitted from fish to fish via the water. There is no evidence suggesting that there might be egg transmission. Infection apparently occurs via the gastrointestinal tract or the respiratory epithelium, with more evidence pointing to the former.

The research is being funded by the Idaho Research Council under the Short Term Applied Research (STAR) program, and by the Pacific Northwest Regional Commission. Quantitative data from the research will be used in developing effective means to prevent and/or control ERM in Idaho trout farms. The ERM immunizing agent which is being tested as part of the research, is patentable, and should provide royalty funds for further research.

STREAM HABITAT AFFECTS SIZE, GROWTH OF YOUNG SALMON

Dr. Ted C. Bjornn
Paul Sekulich

Three forest streams of central Idaho were studied during 1974 and 1975 to determine the effects of sediment and other habitat components on the carrying capacity, or number and weight of young salmon that could live and grow in those streams.

Dr. Ted C. Bjornn and graduate student Paul Sekulich of Fisheries Resources, centered their studies on Knapp, Marsh and Cape Horn creeks in Custer County. Supplemental data were collected from artificial channels at Hayden Creek Research Station. The densities (numbers per square meter) of juvenile steelhead trout (*Salmo gairdneri*) and chinook salmon (*Oncorhynchus tshawytscha*) were determined for selected sites. Other study data monitored significant limiting factors of fish abundance, the effect of fine sediment ($<$6-mm diameter) on fish density, and the usefulness of late summer and fall fish weir counts for determination of fish abundance.

Fish density decreased in Marsh and Knapp creeks after mid-August of 1974, indicating that their carrying capacities had been reached. Increases in Cape Horn Creek fish densities as the field season progressed were caused by fish moving into pool areas used as sampling sites.
sites.

While the density or weight of fish that could be maintained by a stream remained relatively constant, fish growth (g/day) was inversely proportional to fish density. Growth rates slowed as a result of crowding in the rearing areas. Stocking fish in artificial channels at high rates also caused reduced growth.

The addition of fine sediment into Knapp Creek resulted in a greater loss of anadromous fish below the sediment influx location than above. This differential loss was statistically non-significant, and density changes were attributed to causes other than sediment entry.

Weir counts were successful in monitoring changes of fish abundance in Knapp Creek only. Emigrants from intermittent tributaries and side channels of Marsh Creek probably inflated weir counts in that stream, thus precluding an accurate determination of changes in fish abundance. Fish introduced into Cape Horn Creek migrated into study sites rather than leaving the stream.

Researchers found that the maximum average biomass density that could be achieved during the summer months by supplementing natural stock in streams was 5 to 5.5 grams per square meter of juvenile chinook salmon.

Results of this project will be submitted to state and federal agencies concerned with maintaining fishery stock for commercial and recreational use.

This fish weir was placed on Cape Horn Creek to count juvenile chinook salmon migrating downstream.

ARCTIC GRAYLING MONITORED IN HIGHWAY CULVERT TESTS

Dr. Craig MacPhee
Dr. Fred J. Watts

In a 3-year study completed in 1975, Drs. Craig MacPhee and Fred J. Watts, professors of Fisheries Resources and Civil Engineering, respectively, recorded the sustained swimming speed of various length classes of Arctic grayling (*Thymallus arcticus*) in inclined culverts with regulated flows and velocities.

The purpose of the study was to establish design criteria for culverts that will ensure the maintenance of grayling populations in streams traversed by the proposed Alaska Pipeline and its supporting highway.

Both 18.3 and 30.5-m tiltable highway culverts tested the swimming performance of Arctic grayling and longnose sucker (*Catastomus catastomus*) at flows of 0.6 to 1.9 meters per second. A 2-week spawning migration provided fish with an upstream drive to ascend a culvert in 1 and 2-day tests. At water temperatures of 5-8°C, 25, 50 and 75 percent of the grayling succeeded in ascending a 30.5 m culvert at flows of 6.2, 5.6 and 5.0 times the fork length of the fish, respectively. At slightly warmer temperatures of 9-12°C, 25, 50 and 75 percent of the grayling succeeded in ascending the culvert at flows of 4.7, 4.2 and 3.8 times the fork length of the fish, respectively. Suckers swam at about two-thirds the speed of grayling. The state of maturation of females affected the upstream drive of grayling.

Regulated flows in a circular flume determined the speed that grayling volunteered to swim in 10-minute and 1-hour tests. The swimming capability of grayling (141-172 mm) in fork length increased about 80 percent with an increase in temperature from 0 to 14°C. At 8°C grayling attained mean sustained speeds (10 min) of 0.55, 0.69, 0.82 and 0.96 meters per second for fork lengths of 15, 20, 25 and 30 cm, respectively. At 8°C grayling cruised (1 hour) at 94 percent of the sustained speed. Grayling migrating downstream were less motivated to swim vigorously than those migrating upstream.

This study has implications for the passage of trout through highway culverts in Idaho. The maximum "safe" water velocities determined for design fish in Alaska would be "safe" minimal velocities for the successful upstream passage of trout if one makes the likely assumption that trout have equal to or better swimming capabilities than grayling. This project was funded by the U.S. Fish and Wildlife Service, Anchorage, Alaska.

Appendix

EXPERIMENT STATION SCIENTISTS

Ables, Ernest D., Associate Dean and Professor (Wildlife Resources)
Adams, David L., Professor and Chairman (Forest Resources)
Allen, Gerald M., Assistant Professor (Forest Resources)
Anderson, Hal N., Research Technician (Forest Resources)
Asherin, Duane A., Research Wildlife Biologist
Bailey, Theodore N., Research Wildlife Biologist
Belt, George H., Associate Professor (Forest Resources)
Bennett, David H., Assistant Professor (Fisheries Resources)
Bizeau, Elwood G., Assistant Leader, Cooperative Wildlife Research Unit and Associate Professor (Wildlife Resources)
Bjornn, Theodore C., Leader, Cooperative Fishery Unit and Professor (Fisheries Resources)
Bottger, Richard F., Assistant to the Directors
Burlison, Vernon H., Extension Forester and Extension Professor
Canfield, Elmer R., Associate Professor (Forest Resources)
Chacko, Rosy, Research Scientist (Forest Resources)
Cheng, Fong-Chian, Research Scientist (Fisheries Resources)
Claar, James J., Research Associate (Wildlife Resources)
Dalke, Paul D., Emeritus Professor (Wildlife Resources)
Deters, Merrill E., Emeritus Professor (Forest Resources)
Drewien, Roderick C., Research Wildlife Biologist
Eckroth, Wallace, Assistant Forest Nursery Supervisor
Ehrenreich, John H., Dean, Experiment Station Director and Professor (Range Resources)
Erickson, David A., Research Technician (Forest Resources)
Falter, C. Michael, Associate Professor (Fisheries Resources)
Fazio, James R., Assistant Professor and Chairman (Wildland Recreation Management)
Flinders, Jerran T., Associate Professor (Wildlife Resources)
George, Willard L., Research Technician (Wildlife Resources)
Godfrey, E. Bruce, Associate Professor (Range Resources)
Gordon, Roger R., Research Associate (Forest Resources)
Hanley, Donald P., Research Associate (Forest Resources)
Harris, Margaret M., Research Associate (Forest Resources)
Hash, Howard S., Research Associate (Wildlife Resources)
Hatch, Charles R., Experiment Station Statistician and Associate Professor (Forest Resources)
Hayes, Susan A., Research Technician (Wildlife Resources)
Heller, Robert C., Research Professor (Forest Resources)
Hieb, Susan, Experiment Station Editor
Hironaka, Minoru, Professor (Range Resources)
Hoffman, Joseph E., Assistant Professor (Wildland Recreation Management)
Hofstrand, Arland D., Associate Professor (Forest Products)
Hornocker, Maurice G., Leader, Cooperative Wildlife Research Unit and Professor (Wildlife Resources)
Houck, Jeoffrey L., Research Technician (Forest Resources)
Houghton, John E., Assistant Professor (Forest Products)

Howe, John P., Professor and Chairman (Forest Products)
Hungerford, Kenneth E., Professor (Wildlife Resources)
Irwin, Larry L., Research Associate (Wildlife Resources)
Ivins, Robert E., Research Associate (Wildland Recreation Management)
Johnson, Frederic D., Professor (Forest Resources)
Johnson, Leonard R., Assistant Professor (Forest Products)
King, John G., Assistant Professor (Forest Resources)
Klontz, George W., Professor and Chairman (Fisheries Resources)
Koehler, Gary, Research Associate (Wildlife Resources)
Larson, Roy E., Research Technician (Fisheries Resources)
Lazelle, Monta, Herbarium Research Associate (Forest Resources)
Leonard, James M., Research Technician (Fisheries Resources)
Lewis, Arlow, Caretaker, Taylor Ranch
Loewenstein, Howard, Experiment Station Assistant Director and Professor (Forest Resources)
MacPhee, Craig, Professor (Fisheries Resources)
Mahoney, Ronald L., Research Associate (Forest Resources)
McFadden, Max W., Research Forester (Forest Resources)
Messick, John P., Research Associate (Wildlife Resources)
Mika, Peter G., Research Associate (Forest Resources)
Mitchell, John E., Assistant Professor (Range Resources)
Moore, James A., Research Associate (Forest Resources)
Moslemi, Ali A., Associate Dean, Experiment Station Associate Director, Coordinator of Graduate Programs, Professor (Forest Products)
Neuenschwander, Leon F., Assistant Professor (Forest Resources)
Osborne, Harold L., Research Associate (Forest Resources)
Partridge, Arthur D., Professor (Forest Resources)
Peek, James M., Associate Professor and Chairman-elect (Wildlife Resources)
Peterson, Steven R., Assistant Professor (Wildlife Resources)
Pitkin, Franklin H., Professor (Forest Resources), Experimental Forest Manager and Forest Nursery Superintendent
Pitkin, George G., Assistant Forest Supervisor
Pommerening, Edward, Research Associate (Forest Resources)
Prausa, Charles R., Research Associate (Forest Resources)
Reggear, Robert C., Experimental Forest Assistant Manager
Ringe, Rudy R., Research Associate (Fisheries Resources)
Sanders, Kenneth D., Assistant Professor (Range Resources)
Scanlin, David C., Research Forester (Forest Resources)
Schenk, John A., Professor (Forest Resources)
Schomaker, John H., Assistant Professor (Wildland Recreation Management)
Seale, Robert H., Emeritus Professor (Forest Resources)
Sharp, Lee A., Professor and Chairman (Range Resources)
Sowles, Kenneth M., Associate Professor (Forest Products), Assistant to the Dean, Coordinator of Special Programs
Stark, Ronald W., Professor (Forest Resources) and Coordinator of Research
Stellmon, Barbara B., Lab Technician (Forest Resources)
Stoszek, Karel J., Associate Professor (Forest Resources)
Tisdale, Edwin W., Emeritus Professor (Range Resources)
Ulliman, Joseph J., Associate Professor (Forest Resources)
Wang, Chi-Wu, Professor (Forest Resources)
White, Robert G., Assistant Leader, Cooperative Fishery Unit and Assistant Professor (Fisheries Resources)
Wohletz, Ernest W., Emeritus Dean and Professor (Forest Resources)

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PH.D. DISSERTATIONS

Burns, David Charles. 1975. The importance of three habitat types to rainbow trout (Salmo gairdneri) in Sand Springs Creek, Idaho.

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MASTERS THESES

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Stuehrenberg, Lowell Curtis. 1975. The effects of granitic sand on the distribution and abundance of salmonids in Idaho streams.

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RESEARCH PROJECTS AND INVESTIGATORS

To save space, abbreviated project titles have been given. If additional information is needed, please write to the principal investigators or the Office of Associate Dean for Research.

WILDLIFE RESOURCES

Chukar partridge dispersion along the middle and lower Snake and Columbia rivers. E. G. Bizeau.

Rocky Mountain population of the Great Basin Canada goose: Its distribution, dynamics and habitat. E. G. Bizeau.

Experimental reestablishment of whooping cranes in western United States. E. G. Bizeau.

Experimental transplanting of wild wood duck broods in northern Idaho. E. G. Bizeau.

Effects of fire on marten distribution and abundance in the Selway-Bitterroot Wilderness Area. M. G. Hornocker.

Home range activities and reproductive biology of the black bear in west-central Idaho. M. G. Hornocker.

Ecology of the leopard in Kruger National Park. M. G. Hornocker.

Inventory of riparian habitats and associated wildlife along the Columbia and Snake rivers. M. G. Hornocker, E. G. Bizeau, D. A. Asherin.

Ecology of the wolverine in northwestern Montana. M. G. Hornocker.

Diversity and density of small mammal populations in known-age clearcuts. M. G. Hornocker.

Ecology of badgers on the Snake River Birds of Prey Natural Area, Idaho. M. G. Hornocker.

Inventory of riparian habitats and associated wildlife along the lower Clearwater River, Idaho. M. G. Hornocker, E. G. Bizeau, D. A. Asherin.

Evaluating pocket gopher damage to forest trees in Idaho. K. E. Hungerford.

Pocket gopher behavior in relation to control. K. E. Hungerford.

Pocket gopher feeding preferences for ponderosa pine strains. K. E. Hungerford.

Transmission of tree root diseases by pocket gophers. K. E. Hungerford.

Habitat use by the great horned owl. K. E. Hungerford.

Distribution and behavior patterns of mule deer in the Pahsimeroi Valley, J. M. Peek.

Effects of rest-rotation grazing systems upon wildlife populations inhabiting the East Fork of the Salmon River, Idaho. J. M. Peek.

Habitat use patterns and populations of bighorn sheep in Glacier National Park. J. M. Peek.

Raptor nesting and feeding behavior in the Snake River Birds of Prey Natural Area. S. R. Peterson.

Estimation of raptor tolerance to human disturbance. S. R. Peterson.

Ecology of the Hungarian partridge on the Palouse Prairie. S. R. Peterson.

Resource partitioning among woodpeckers in the Blue Mountains of Oregon. S. R. Peterson.

FOREST PRODUCTS

Characteristics of the Idaho forest industry. E. B. Godfrey.

Moisture influence on linear expansion, moduli of rupture and elasticity for Plystran and all wood core test specimens. A. D. Hofstrand.

Rapid method of measuring linear expansion of composite building board. A. D. Hofstrand.

Full-forest utilization for Idaho. J. P. Howe.

Effect of irrigation on Douglas-fir and white fir growing on Potlatch Corporation lands. J. P. Howe.

Influence of forest sites on wood properties of inland Douglas-fir. J. P. Howe.

Development of laminated railroad ties. J. P. Howe.

Development of laminated structural lumber. J. P. Howe.

Skidding systems for small log utilization. L. R. Johnson, J. E. Houghton.

SAPLOS simulation applied to logging systems. L. R. Johnson.

Wood residue as an energy source. A. A. Moslemi, L. R. Johnson, J. E. Houghton.

RANGE RESOURCES

Habitat type classification for grasslands and shrublands of southern Idaho. Minoru Hironaka.

Investigation of multiple use capabilities of forest-associated range in central Idaho Batholith. Minoru Hironaka, L. A. Sharp.

Grazing in the coniferous zone. J. E. Mitchell.

Impact of camping on vegetation in the Bighorn Crags. J. E. Mitchell.

Revegetation of mine spoils in northern Idaho. J. E. Mitchell, F. H. Pitkin, Howard Loewenstein.

Rangeland development and improvement. L. A. Sharp, K. D. Sanders.

Evaluation of meadow condition in central Idaho. L. A. Sharp.

Evaluation of range seeding. L. A. Sharp.

Range resources of the west. L. A. Sharp, W. E. Folz, E. G. Godfrey, E. W. Wohletz.

FOREST RESOURCES

Commercial thinning of second growth forests. D. L. Adams.

Scaling defective cedar logs. D. L. Adams.

Revegetation of meadow associated types on the Palouse District, Clearwater National Forest. D. L. Adams.

Height growth of Douglas-fir on three habitat types on the University of Idaho Experimental Forest. D. L. Adams.

Intensive Timber Culture. D. L. Adams, G. H. Belt, E. R. Canfield, Rosy Chacko, D. P. Hanley, M. M. Harris, L. L. Irwin, Howard Loewenstein, A. D. Partridge, J. M. Peek, S. R. Peterson, D. C. Scanlin, K. J. Stoszek, A. A. Moslemi (project director).

Evapotranspiration model. G. H. Belt.

Artificial defoliation of grand fir. E. R. Canfield, A. D. Partridge.

Volume table construction. C. R. Hatch.

Modeling forest biomass. C. R. Hatch.

Development of crown ratio models. C. R. Hatch.

Douglas-fir tussock moth growth impacts. C. R. Hatch.

Douglas-fir tussock moth program. R. C. Heller.

Irrigated land study in southern Idaho. R. C. Heller, J. J. Ulliman.

Evaluation of riparian habitats from aerial color photography. F. D. Johnson, J. J. Ulliman, R. C. Heller.

Ecology of white alder. F. D. Johnson.

Distribution and ecology of Idaho woody plants. F. D. Johnson.

IBP coniferous biome study. F. D. Johnson.

Forest site indicators. F. D. Johnson.

Ecological resiliency as a tool for water resource planning. J. G. King.

Natural sedimentation rates for forested watersheds. J. G. King.

Effect of Dow Corning silicone antitranspirant on surface evaporation. J. G. King, G. H. Belt.

Forest fertilization: Its influence on stands of Douglas-fir and grand fir in Idaho. Howard Loewenstein, F. H. Pitkin, D. C. Scanlin.

University of Idaho Experimental Forest research. Howard Loewenstein, G. M. Allen, D. L. Adams.

Seedling growth and survival in coniferous species. Howard Loewenstein, F. H. Pitkin.

Priest River Experimental Forest soil-site study. Howard Loewenstein.

Methods to describe and evaluate tree problems. A. D. Partridge.

Idaho tree diseases and defects. A. D. Partridge.

Disease-insect interactions in forest trees. A. D. Partridge.

Seedling container development. F. H. Pitkin.

Influence of natural stand characters and management practices on fir engraver populations and damage levels and on stand regeneration and growth. J. A. Schenk, D. L. Adams.

Hazard rating of lodgepole pine stands for mortality by mountain pine beetle. Subproject of Integrated Pest Management/Mountain Pine Beetle study (cf. Stark). J. A. Schenk, D. L. Adams.

Bionomics and control of cone and seed insects. J. A. Schenk.

Idaho forest productivity study. K. M. Sowles, G. M. Allen, C. R. Hatch.

Mountain pine beetle and root disease. R. W. Stark, A. D. Partridge.

Integrated pest management: The principles, strategies and tactics of pest population regulation and control in major crop ecosystems–major pine bark beetles–lodgepole pine. R. W. Stark.

Site, stand and tree characteristic relationships to Douglas-fir tussock moth defoliation on the Palouse Range of northern Idaho. K. J. Stoszek.

Effect of silvicultural techniques on mountain pine beetle. K. J. Stoszek.

Experimental forest mapping project. J. J. Ulliman.

Genetic studies of ponderosa pine. C. W. Wang.

Forest tree breeding in Idaho. C. W. Wang.

Effect of thermal water on tree growth and wood quality, INEL and Hanford projects. C. W. Wang, J. P. Howe.

Hybridization of western larch. C. W. Wang.

South Idaho cooperative ponderosa pine improvement project. C. W. Wang.

North Idaho Inland Empire cooperative tree improvement project. C. W. Wang.

WILDLAND RECREATION MANAGEMENT

Wilderness information sources and channels utilized by recreationists in the Selway-Bitterroot Wilderness Area. J. R. Fazio.

Management plan for Idler's Rest Nature Preserve. J. R. Fazio.

Non-consumptive wildlife users in Idaho. J. R. Fazio.

Methodology in survey research for outdoor recreation planning. R. E. Ivins.

Off-road vehicle study. J. E. Mitchell, J. H. Schomaker.

Public preference of landscape modifications. J. H. Schomaker.

FISHERIES RESOURCES

Carrying capacity of streams for rearing salmonids as affected by sediment and other components of the habitat. T. C. Bjornn.

Sediment in streams and its effects on aquatic life. T. C. Bjornn.

Fishery resources impact study at the Teton Dam. T. C. Bjornn.

Parr smolt transformation in summer-run steelhead trout and chinook salmon. T. C. Bjornn.

Habitat selection and interaction of cutthroat and steelhead trout. T. C. Bjornn.

Effects of fluctuating and constant water temperature on autecology of steelhead trout. T. C. Bjornn.

Hunter preference survey. T. C. Bjornn.

Evaluation of methods for increasing native cutthroat stocks in northern Idaho. T. C. Bjornn.

Distribution and behavior of Idaho fishes: Yield of seaward migrant chinook salmon and steelhead. T. C. Bjornn.

Effects of reduced nighttime flows on adult steelhead trout and chinook salmon. T. C. Bjornn, R. G. White.

Effects of altered flow regimes, temperature and river impoundment on adult steelhead trout and chinook salmon. T. C. Bjornn, R. G. White.

Lower Snake River reservoirs limnology. C. M. Falter.

Lake Pend Oreille zooplankton production. C. M. Falter.

Idaho Primitive Area stream ecology. C. M. Falter.

Life history and control of Philonema agubernaculum. G. W. Klontz.

Control of bacterial kidney disease in spring chinook salmon at the Rapid River Hatchery. G. W. Klontz.

Research on control of Enteric Redmouth Disease in rainbow trout. G. W. Klontz.

Efficacy of kelp meal as a source of dietary protein for certain herbivorous fishes. G. W. Klontz.

Production in a constant temperature trout stream. Craig MacPhee.

Aquatic studies with silicone antitranspirant. Craig MacPhee, F. C. Cheng.

Development of toxicants selectively lethal to threespine stickleback. Craig MacPhee.

Development of toxicants selectively lethal to suckers. Craig MacPhee.

Swimming performance of arctic grayling in highway culverts. Craig MacPhee, F. J. Watts.

Effects of river fluctuation resulting from hydroelectric peaking on selected aquatic invertebrates and fishes. Craig MacPhee, M. A. Brusven.

Migratory behavior of the longnose sucker. Craig MacPhee.

Methodology for recommending stream resource maintenance flows for large rivers. R. G. White.

Effects of irrigation withdrawal in the Teton River on fisheries resources. R. G. White.

AGENCY AND FUNDING SUPPORT

Abbott Laboratories
Aerojet Nuclear Company
Agency for International Development
Agricultural Research Service (USDA)
Alaska Fish and Game Department
Allied Chemical Corporation
American Forest Institute
Anaconda Forest Products
Army Corps of Engineers
Bennett Lumber Company
Boise Cascade Corporation
Boise National Forest
Boone and Crockett Club
Bunker Hill Company
Bureau of Land Management (USDI)
Clearwater National Forest
Cooperative State Research Service (USDA)
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Payette National Forest
Potlatch Corporation
Public Land Law Review Commission
Rachelwood Wildlife Research Preserve
South Idaho Forestry Association
Stillinger Trust
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U.S. Bureau of Reclamation
U.S.D.A. Forest Service, Intermountain Forest and Range Experiment Station
U.S.D.A. Forest Service, Northeastern Forest Experiment Station
U.S. Department of Navy/Naval Undersea Center
U.S. Fish and Wildlife Service
University of Idaho Experimental Forest
University of Idaho Forest Nursery
University of Massachusetts (Peace Corps)
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