FOCUS

on Renewable Natural Resources

Volume 3 Number 1

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

A Decade of Resource Decisions in Idaho

The next decade promises to be a critical one for Idaho. During the next ten years, important decisions will be made on Idaho's land base pertaining to roadless areas, wilderness allocation, recreational use allocations and natural research areas, to name a few. These decisions will affect the economic as well as the environmental character of our state, and its citizens in every walk of life.

To make decisions on land allocation is not easy. A complex array of scientific, social, political and bureaucratic processes is involved, and often a long period of time passes before decisions are finally made on a given area of land. Once decisions are implemented, their effects become real and eventually affect the lives of people in the region.

The adequacy and integrity of our land resources data base are the very foundations of this decision-making process. To put it succinctly, to be able to make the "right" decisions, one must have good information readily available. For instance, data on soil productivity and terrain, as well as the resources supported by the land, are vitally important. A critical question relates to the interdependency of those resources. Decisions affecting timber production invariably affect wildlife, water quality, grazing values and fish habitat. Resource specialists and planners must strive for an equitable balance as they contemplate resource decisions.

To protect and wisely use Idaho's renewable natural resources, it is imperative that careful research data be generated and utilized in making land decisions.

The Forest, Wildlife and Range Experiment Station feels a keen responsibility in this critical era. It is charged by legislative mandate to assist the public and all resource agencies in meeting the need for reliable research data. Research information is needed not only in making land allocation decisions, but also in providing the data base on which wise management of forests and rangelands must depend. The Experiment Station cannot and must not make the decisions on land allocation which logically belong to the people of Idaho and the American public. However, it must assist, to the extent permitted by its material and human resources, in carrying out the research programs that will help safeguard the integrity of decisions made by the people and our political leaders.

Now in its 38th year, the Experiment Station, through its scientists and resource specialists, has established itself as a prime source of scientific information. The transfer of this new know-how takes place through a variety of means, including not only publications and reports, but also through personal contacts with a variety of people, including resource managers and public officials. Workshops and other group meetings are also a common occurrence in this technology transfer.

As you look over this annual report, I hope that you will share your thoughts with us. Your input will provide essential feedback from those we especially attempt to serve – the people of Idaho.

A. A. Moslemi

FOCUS

Volume 3 Number 1

1976 Annual Report

FOREST, WILDLIFE AND RANGE
EXPERIMENT STATION

John H. Ehrenreich, Director
Ali A. Moslemi, Associate Director

Susan R. Hieb, Editor
Trudi Peek, Artist

University of Idaho
Moscow, Idaho 83843

Cover: The Snake River winds through the upper portion of central Idaho and northeastern Oregon on this enlarged section of color composite satellite imagery, recorded in May 1973 from the earth resources satellite – LANDSAT. Lewiston is located at the confluence of the Snake and Clearwater rivers, center. The Snake flows through Hells Canyon on the right. Also on the right are the Wallowas. Moscow and the Dworshak Reservoir can be seen in the upper right. The Blue Mountains and Umatilla National Forest are on the left. Scale is approximately 1:700,000.

Remote Sensing in Natural Resources

Fuel shortages and severe drought have shaken this nation aware to the fragility of the climate and the need to conserve our resources. Scarcity of oil reserves placed a heavier demand on hydro-electric power at a time when western winter snow and rain levels fell far below normal. A dry spring found nearly empty reservoirs, reduced flow in rivers, and crops withering in the fields. Blowing topsoil and a rash of grass fires replaced expected April rains. Late plowing was advised to hold vital moisture in the ground. Dry forest conditions increased the vulnerability of trees to attack by disease and to the danger of fire.

After years of remarking how small the earth has grown, we are startled by the number of areas which demand constant and synchronous surveillance. How to be everywhere at once, watching scores of environmental factors will tax our most advanced scientific technology.

Capabilities of remote sensing devices to survey and resurvey the same areas of land and water can provide data to pinpoint change. Scientists studying disease outbreaks in forest stands are able to detect canopy changes on aerial color infrared film at the same time or before a forester on the ground observes them. Remote sensing devices can provide imagery of large areas for mapping projects. Overflights of smaller areas, such as a single community, offer city planners an objective, visual record of growth and signal potential problem areas. Radio collars have enabled wildlife researchers to track life patterns and movements of a wide variety of animals, including badger, deer, elk and bear. Fish migrations are monitored through the use of ratio tags.

Without being complete in itself, remote sensing is a fast, and often economical source of data which can aid resource management efficiency. Once remote sensing data are included in a computerized information system, and resource areas are mapped on a geographic grid, resource management for wildlife, timber production, grazing, recreation or other use can be planned with an eye to the whole resource picture. Data pertinent to a single use can be scrutinized, and management changes can readily be recorded as part of the data base.

Remote sensing brings together aerial photography and the language of satellite technology. Basically, it includes detection and identification of objects at a distance, without physical contact. Remotely sensed objects can be identified by shape, size, molecular structure, reflectance in the electro-magnetic spectrum, and orientation to known objects. Photographic film taken with specially adapted aerial cameras often provides the best and least expensive imagery. Scanners, television and radar are other remote sensors which produce images much like photographs. Whether an individual wants to restrict the definition to collecting data from an airplane, satellite or other airborne observation point, or includes tracking animals by radio telemetry and recognizing objects in the water by sonar, remote sensing offers a breakthrough in obtaining information on the world around us.

Many of the projects which employ remote sensing techniques are featured in this year's edition of the annual report.

IRRIGATED CROPLANDS SURVEYED FROM SATELLITE IMAGERY

Robert C. Heller
Joseph J. Ulliman
Kim A. Johnson

Imagery obtained from an earth-orbiting satellite, called LANDSAT, can provide an initial survey of irrigated croplands when it is collected far enough into the growing season to detect vegetative cover, yet before harvesting.

Professor Robert C. Heller, Associate Professor Joseph J. Ulliman and graduate researcher Kim A. Johnson of the College of Forestry, Wildlife and Range Sciences Remote Sensing Laboratory, working with the Department of Water Resources, selected primary sample units of 4 square miles on a 2 mile by 2 mile grid on three test sites in southern Idaho. The grids, photographically reduced, corresponded to the 1:1,000,000 scale standard in 7.5-inch LANDSAT color composite transparencies. The researchers found that they could identify irrigated croplands from LANDSAT imagery taken between the last week in July and the first week in August. Crops could not be identified at that scale; however, the actual percentage of irrigated croplands was estimated accurately (plus or minus 6 percent at 1 standard deviation). Many fields were too small to be delineated on the LANDSAT imagery.

Color infrared photography at the larger scale of 1:125,000 of some of the same areas was taken from U-2 aircraft in May and October, which provided a detailed and accurate estimate of irrigated cropland acreages.

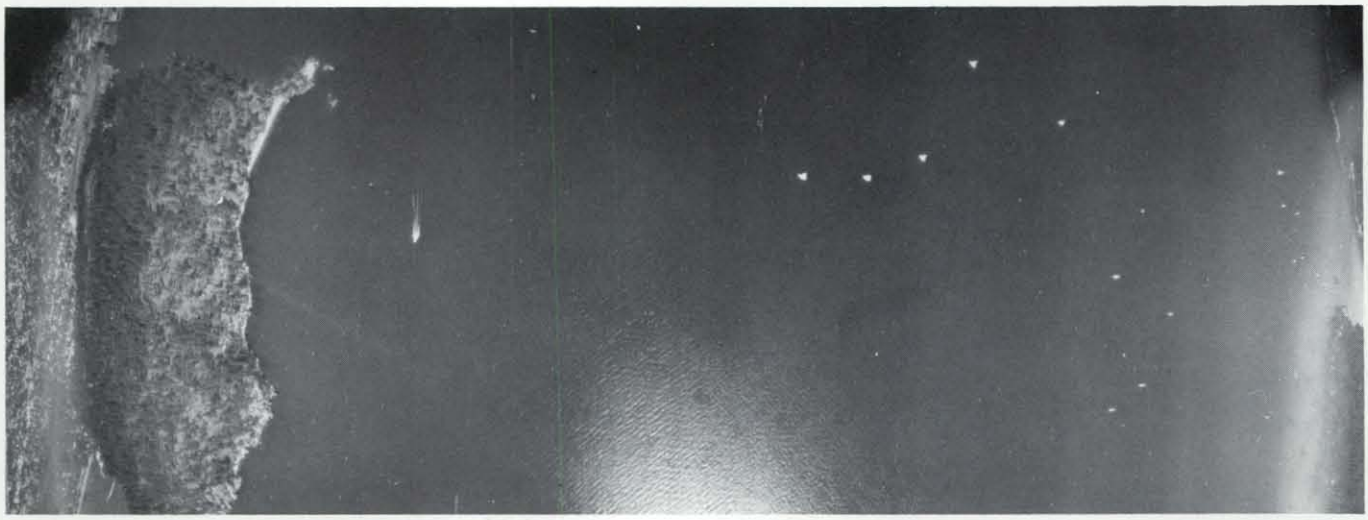
More specific assessments of acreage were then made from 1:8000 (large scale) 70mm aerial photography and site visits to establish "ground truth."

The researchers painstakingly transferred the location of primary sample units from the LANDSAT imagery to the U-2 photography, to U.S. Geodetic Survey (USGS) maps by measuring proportional distances from identifiable points at the different scales used. Scale changes and grid imperfections made individual transfer of each primary sample unit necessary; however, the researchers felt that their ability to pinpoint the same locations on a map, on small scale U-2 photography, and on LANDSAT imagery, supported the idea that primary sample units can accurately be located on the ground using LANDSAT imagery.

Use of satellite imagery to map irrigated croplands in Idaho would enhance water resource planning for the state by providing accurate, up-to-date information on the growth of irrigated agriculture. The farming of artificially watered land in Idaho is a major industry which uses an estimated 5 to 6 million acre feet of water each year. From 1950 to 1970, this industry has increased at the average annual rate of 60,000 acres; annual growth rates of 36,000 to 46,000 acres are predicted through 2020. Constant revision of water-related land use is essential for water resource planning, though difficult to maintain through conventional mapping due to the spread of agricultural lands throughout the state. The project to determine whether remote sensing techniques could supply the information was a joint effort of NASA, USGS, the Pacific Northwest Regional Commission and various state and local agencies.

By superimposing imagery from 2 different years' growing seasons on optical image combining apparatus in the remote sensing laboratory, researchers were able to show newly irrigated lands. Expansion of irrigation has been curtailed in areas of the state where groundwater was being depleted by pumping. Both awareness of the problem and policing of the subsequent restrictions have been made possible by remote sensing techniques.

Aerial photography taken over predetermined areas along flightlines, can aid foresters on the ground by providing rapid and economical surveys. This diagrammatic sketch suggests the scope of coverage available through the use of remote sensing techniques. Cameras, fixed in special mounts in the cabin of an airplane, can record images at regular intervals. After processing, stereopairs of aerial photographs can be viewed using stereo viewing equipment.



Sailboats are identified by a sail or mast, and power boats by the presence of a wake on this black and white photograph taken with a panoramic camera from an Idaho Air National Guard jet aircraft in a study of boating use on Idaho's lakes and reservoirs.

BOATING USE ESTIMATED FROM AERIAL INTERPRETATION

Robert C. Heller
Philip J. Murphy

Pleasurecraft use has become less than a pleasure in some parts of the country, where city and suburban boat owners have traded freeway traffic snarls for long lines at boat launching ramps, and crowded waterways once afloat.

In Idaho, lakes and reservoirs are expected to see a user increase of almost 50 percent by the year 2000, according to Idaho Department of Parks and Recreation figures. Professor Robert C. Heller and graduate researcher Philip J. Murphy of the Remote Sensing Laboratory, College of Forestry, Wildlife and Range Sciences, carried on an investigation of remote sensing techniques to estimate boating use in 1976 during summer months on six selected Idaho lakes. The study, for the Idaho Department of Parks and Recreation, is intended to show whether remote sensing can be used to successfully measure recreational carrying capacity of lakes.

Black and white 5-inch negatives at a scale of 1:4000, taken with a panoramic camera from Idaho Air National Guard jets, were used for photo interpretation. Two additional overflights of Lake Coeur d'Alene were made by the College of Forestry, Wildlife and Range Sciences, using 35mm oblique photography at a scale of 1:3000 with an event recorder. Data recorded included types of boating activity, types of boats found at docks and marinas, and the number of spaces available. Maps were drawn showing the location of different types of boats. Sailboats were identified by the presence of a sail or mast. Power boats were recorded as moving if there was a wake, and water-skiing use was identified by the presence of two wakes.

Lakes and reservoirs observed in the study included Lake Coeur d'Alene, Cascade Reservoir, Dworshak Reservoir, Lucky Peak Reservoir, Magic Reservoir and Blackfoot Reservoir. The lakes ranged in size from 3800 acres at Magic Reservoir, to 30,000 acres for Lake Coeur d'Alene.

Both high use and carrying capacity data applied only to Lake Coeur d'Alene. Using multiple regression analysis, the researchers found that the presence of many marinas and docks is related to large boat populations, and that moving and non-moving boats seemed to congregate in the same areas. The areas were large enough, however, that a non-moving fishing activity might be going on at one end, while a water-skier was recorded in another portion of the same area. Also, as the summer progressed, more moving than non-moving boats were recorded, possibly, the researchers thought, because fishing had deteriorated, and people were either fishing less, or moving about to different areas more frequently.

The researchers recommended that future use of small format 35mm color film and an event recorder be favored over the large format (5 inch) black and white negatives, due to cost of materials and ease of interpretation. The small format cameras can also be adapted to use with small aircraft, lowering the flight cost for increased intervals of data collection. Correlating user information with the remote sensing data was also suggested.

During the course of the study, the researchers found that current boating use is below the maximum carrying capacity figures set by the Idaho Department of Parks and Recreation.

Fisheries Resources

ZERO NIGHTTIME FLOW STUDY COMPLETED ON SNAKE RIVER

Kemper McMaster
Robert G. White
T. C. Bjornn
Rudy R. Ringe

Demand for electricity in the Pacific Northwest has, and will continue to increase pressure to generate more electric power at Snake River hydroelectric dams. To supply power during high demand periods and to utilize available water most efficiently, producers regulate power production or discharge to coincide with fluctuating demands. The result is a modification of seasonal run-off pattern, often with extreme daily and hourly fluctuations in flow. This type of operation is referred to as peaking. In general, periods of high demand and therefore high discharge are associated with daylight hours and weekdays, while low demand and low discharges are associated with nighttime and weekends, when demand for electricity is lower.

To maximize power production, the U.S. Army Corps of Engineers has proposed to reduce nighttime (2300-0700 hours) discharge through lower Snake River dams to 0 cubic feet per second (cfs) during the summer and fall. During this period, discharge in the Snake River ranges from 20,000 to 60,000 cfs, well below the flows needed to operate the six turbines at each dam at full efficiency (120,000 cfs). Storage of water at night and discharge through the turbines during the day would best meet the demands for electricity, but fishery managers were concerned that such flow regulations would interfere with the upstream migration of adult salmon and steelhead.

During 1975 and 1976, personnel of the Idaho Cooperative Fishery Research Unit assessed the effects of zero nighttime flows in lower Snake River reservoirs on the upstream migration of adult chinook salmon and steelhead trout. Principal investigators for the project were graduate researcher Kemper McMaster, Assistant Professor Robert G. White, Professor T.C. Bjornn and Research Associate Rudy R. Ringe. The first phase of the study utilized radio telemetry and mark-recapture techniques to evaluate response of test fish to reduced nighttime flows. Adult salmon and steelhead were captured at Little Goose Dam, tagged with internal transmitters or magnetic wire and transported to release sites above Ice Harbor Dam. Individually identifiable radio-tagged fish were monitored 24 hours a day from a boat or pickup truck during 7-day alternating test periods of 0 and 10,000 cfs nighttime flow. Magnetic- and radio-tagged fish were recaptured at Little Goose Dam as they passed through a magnetic detector in the fish ladder. Both number of successful fish and their rate of travel could thus be determined.

From July to October 1976, the U.S. Army Corps of Engineers controlled flows on a 2-day rotating schedule of 0 and 20,000 cfs nighttime flow. Effects of these flows on upstream migrating salmonid populations were evaluated by monitoring fish passage at all lower Snake River dams related to the particular nighttime test flow condition.

After evaluating data collected during the 2 years of the study, it was concluded that zero nighttime discharge had no observable effect on behavior or rate of migration of adult chinook salmon or steelhead trout. The results of this study will be used by the Corps of Engineers to most efficiently utilize water for power production at lower Snake River dams without adversely affecting the upstream migration of the anadromous salmonids.

PLANKTON STUDIES AID IN RESERVOIR MANAGEMENT

C. Michael Falter
John S. Irving
Paul F. Woods

Identifying the water level inhabited by plankton in Libby Reservoir on the upper Kootenai River in Montana will help shape management of deep reservoirs in Idaho and other states.

Associate Professor C. Michael Falter and graduate researcher John S. Irving are evaluating the plankton population and studying the effects of drawing off water from different levels of the 350-ft-deep reservoir on the minute to microscopic organisms at the base of the fish food chain. Only in the last 5 years have dams had the capacity for changing the depth of water to be drawn off, through selective withdrawal. At the Libby Dam, this is accomplished by an underwater weir on the upstream face of the dam, above the outlet ports. As gates or drop logs are lowered into this weir, water is drawn off from higher in the water column.

According to Falter, this is of major importance, because plankton is often concentrated at a specific water layer. If withdrawal of water from the dam is removing

that layer, it is also removing food on which the reservoir fish depend. Since northern lakes are often food-limited, retention of plankton in the reservoir becomes a prime management concern.

The project is funded through the Army Corps of Engineers, Seattle District. Researchers are also working with the Montana Department of Fish and Game, to keep them abreast of findings in the zooplankton studies, as Montana is studying fish-zooplankton relationships.

In the field work portion of the study, the researchers are collecting water and plankton samples as the Corps releases water from different depth layers. Loss of plankton from the lake is being monitored. An eventual goal of deep reservoir research is management which optimizes both reservoir and downstream recreation benefits. Commercial harvest possibilities of non-game fish also figure into the future of these reservoirs.

Another area of the study is a limnological evaluation of the reservoir. This state of the habitat report will utilize physical, chemical and biological data accumulated over the 5-year period from 1972 to 1977. Graduate researcher Paul F. Woods will rely heavily on a computer to interpret the data on hand.

Heat content of a lake has been noted as a major factor in production of plankton blooms. From study of these physical, chemical and biological profiles of the reservoir, scientists are able to construct predictive profiles, estimating plankton bloom location, and its probable concentration. Due to lower water levels in 1977, they expect to see well defined stratification of temperature and plankton in the reservoirs, supplying a set of extreme conditions to such modeling.

SCIENTISTS MONITOR SNAKE RIVER ECOLOGY

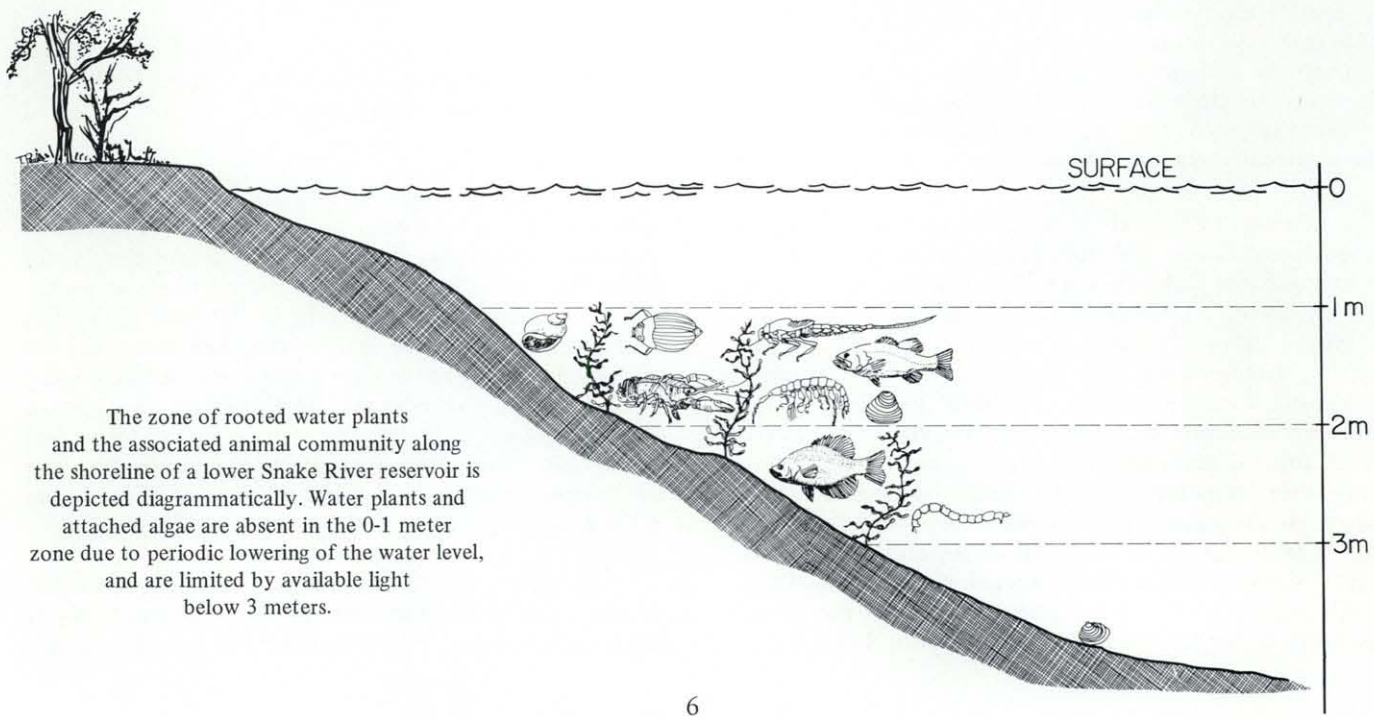
C. Michael Falter
Al J. Lingg
James M. Leonard
Wayne R. Dorband

In a limnology study of the lower Snake River, scientists from the University of Idaho and Washington State University are monitoring physical, chemical and biological water quality in four "run-of-the-river" dams, to assess the effect of those impoundments on the river itself.

Project investigators are University of Idaho Professor of Fisheries Resources C. Michael Falter, Research Associate James M. Leonard and graduate researcher Wayne R. Dorband of Fisheries Resources, and Professor of Bacteriology Al J. Lingg, in cooperation with the Washington State University Sanitary Engineering Department.

The four Snake River dams under study, Ice Harbor, Lower Monumental, Little Goose and Lower Granite, are up to 130 ft deep, with average low flow retention time of 8 to 11 days, supporting good plankton production with the warm, nutrient-rich water.

Water weeds in lower water along the shore zone have developed a smallmouth fish habitat. Crayfish, aquatic earthworms, juvenile insects, and clams form the "benthos" or layer of bottom inhabitants. The present aquatic ecology study is directed toward relation of benthos to shore zone beds of macrophytes (fresh water relatives of kelp),



The zone of rooted water plants and the associated animal community along the shoreline of a lower Snake River reservoir is depicted diagrammatically. Water plants and attached algae are absent in the 0-1 meter zone due to periodic lowering of the water level, and are limited by available light below 3 meters.

and changes in the plankton population of microscopic and pinhead-sized floating plants and animals. Researchers are looking at the location inhabited by plankton to determine cross-channel or down-river differences.

Run-of-the-river impoundments, unlike deep water reservoirs, normally have enough water movement to keep water temperatures fairly even throughout the dam. Looking to the reduced flow in rivers in 1977, scientists are anticipating thermal stratification even in the flow-through dams for the first time. Low dissolved oxygen may also be expected. Plankton produce high levels of oxygen during the daylight hours, but during summer nights in past years the oxygen saturation has dropped to 60 percent. In 1977, nighttime oxygen levels of 20 to 30 percent could hamper fish survival or migration. Another low-water problem under study is the impact of periodic drying on the shore zone water weeds. These plants which grow from 2 to 10 ft depth, have repeatedly been left on dry ground as water is withdrawn from the dams. Their survival plays a major part in the ecology of the Snake River. Here, too, remote sensing comes into play. Researchers have flown the Snake River to photograph its shallow water zones with color and color infrared film. The photographs have helped the researchers in mapping the shoreline zones and determining plant density ranges.

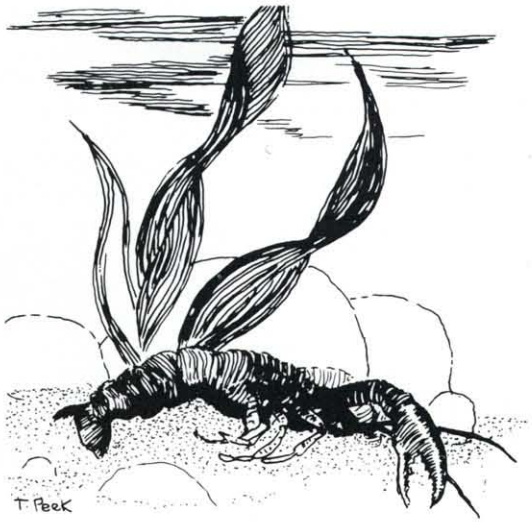
SALMONID BACTERIAL DISEASE TRACED TO FOUR ORGANISMS

George W. Klontz
Terrell R. Huddleston

In their continued study of Enteric Redmouth Disease (ERM), an acute to chronic systemic bacterial disease of salmonids, primarily rainbow trout, Professor George W. Klontz and graduate researcher Terrell R. Huddleston have discovered at least four different organisms that can cause the syndrome in Idaho.

The four serologically and biochemically distinct Gram negative bacteria, not yet taxonomically classified, have been designated as RM Bacterium, Grey Isolate, Sucker Isolate and Flat-white Isolate. Biochemical and antigenic properties, already documented for RM Bacterium, are being studied for the latter three.

The disease has spread throughout Idaho and to a dozen western and mid-western states in the last 10 to 15 years, presumably by the transport of asymptomatic carrier fish from public and private fish hatcheries to new watersheds. Some 8 to 9 million rainbow trout raised commercially and publicly in Idaho's Hagerman Valley are killed annually by ERM. This is a loss of roughly one-third of



the fish raised each year, and an economic loss to Idaho of more than $5 million.

Recent data from in-depth studies of the potential reservoirs for organisms causing ERM document the complexities of the disease. Clinically healthy fish from springs, head-ditches and ponds harbor ERM-causing organisms intestinally. Crayfish residing in the springs had a 30 percent incidence of carriers of the disease-causing organisms, while snails, sculpins, suckers and dace in springs were all negative for RM Bacterium. Mud from the mud-water interface in both springs and ponds was shown to have 1000 ERM-causing organisms per gram.

Apparently RM Bacterium, the major cause of ERM, cannot live freely for extended periods in water. It does require a biological reservoir for its maintenance. But it can survive for about 2 months in spring and pond mud. A study done in the laboratory, in which daily quantitative cell counts were done indicates that RM Bacterium can live 2 to 3 weeks in an aquatic medium without plants or animals.

Data acquired to date suggest that ERM-causing organisms are shed continually from resident rainbow trout and crayfish in the springs. Water flowing into selected fish ponds had 100-800 RM Bacterium per ml. If the fish in the pond were healthy there was an average increase of 200 organisms per ml at the outfall of the pond; however, if there was an ERM episode occurring, or if one were within a few days of occurring, the outfall bacteria counts increased 25-30 fold. Infection of fish apparently occurs via the gastrointestinal tract. Outbreaks,

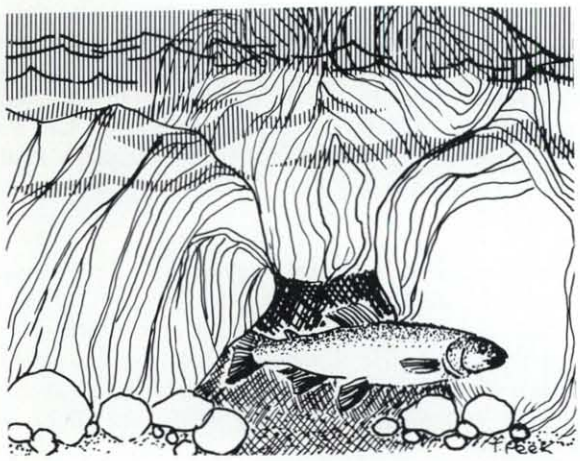
which are cyclic, are related more to a particular trout farm than to the area.

In the past year, interest has been renewed by commercial biologic firms to produce and test immunizing agents against several bacterial disease of fish – ERM in particular. One such immunizing agent was field tested last year in Idaho with promising results. However, with the discovery that there are at least four bacteria involved in ERM outbreaks, and that there are at least two strains of RM Bacterium, the use of a single strain of RM Bacterium to produce an immunizing agent for ERM will probably be modified. Removing fish from the springs supplying the hatcheries has also been found successful in preventing outbreaks of the disease.

Food and Drug Administration approved antibacterial drugs – mainly sulfamerazine and Terramycin – used to control ERM in Idaho cost an estimated $125,000 a year. The widespread use of these drugs has encouraged drug-resistent strains of RM Bacterium, until one commercial farm has reported that neither drug will interrupt the mortality pattern following an ERM outbreak.

A potentially significant economic problem is developing at the state and international level, as both the Canadian government and the U. S. Congress have regulations pending to restrict international and interstate shipment of live fish and/or eggs. The Canadian regulations specifically stipulate that live (and/or processed) fish entering Canada must be certified free of RM Bacterium.

Idaho trout hatcheries, both public and private, now produce more than 70 percent of the nation's trout. Commerical fish farmers operate a large nationwide live fish market for stocking fee fishing ponds, and are attempting to establish markets for commerical food fish in Canada. Restriction of trade due to ERM would have a severe economic impact.



RAINBOW AND CUTTHROAT TROUT RESPOND TO REDUCED STREAM FLOWS

David H. Bennett
John A. Easterbrooks

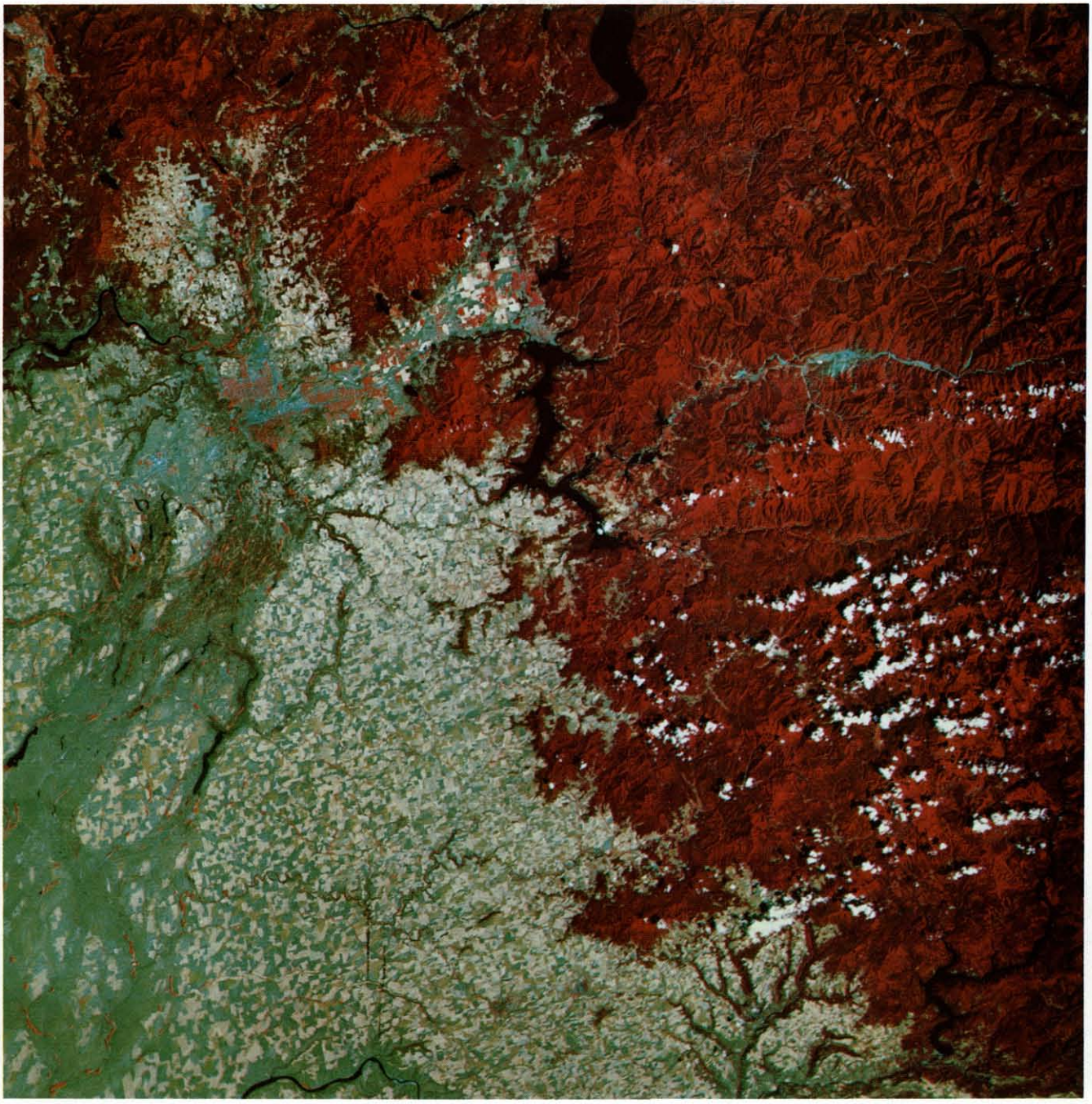
Growing needs for hydroelectric power and water for irrigation in the drought-parched western United States may be pitting people against fish, in use of water resources. This competition for water use has stimulated an intensive research effort to evaluate water requirements of aquatic life.

When normal stream flow is reduced, how are fish densities, average fish body size, and requirements for instream cover affected? Assistant Professor David H. Bennett and graduate researcher John A. Easterbrooks are attempting to answer this three-part question by examining depth and instream cover requirements of rainbow and cutthroat trout under controlled conditions in two artificial stream channels.

The artificial stream channels have been prepared to simulate a riffle-run section of a natural stream. As in most Idaho streams, the bottom consists of fine to coarse gravel with a few boulders positioned in the channel for cover. The major difference between the artificial and natural streams is that water withdrawals from the stream channels are conducted in a regulated manner to test the response of the target fish to the reduced stream flow while other physical and chemical conditions are held constant.

Results of withdrawal tests using hatchery rainbow and cutthroat trout show that fish abundance can be adversely affected by decreasing water depths. Fish abundance decreased slowly until water depths in the artificial channels dropped to 13 centimeters. Further reductions in depths caused more drastic reductions in fish density. For example, when water withdrawals dropped stream depth to 8 centimeters, only 50 percent of the fish remained in the channels. Changes in the total weight of fish in the stream channels responded similarly.

Tests are being initiated to compare responses of wild rainbow and cutthroat trout with those of hatchery fish. Additional tests are planned to evaluate the importance of instream cover to fish abundance during periods of water withdrawal. Once completed, these tests will aid fisheries management agencies in formulating maintenance flow requirements for streams with rainbow and cutthroat trout.



Croplands create a patchwork effect in the center of a LANDSAT satellite color composite, obtained in August 1973 over northern Idaho. Farmed acreage separates Washington's scablands on the left from Idaho's Bitterroot range on the right. Moscow Mountain breaks up the farmland pattern in the lower quadrant of the imagery. Dworshak Reservoir is found below and to the right. The city of Spokane and Lake Coeur d'Alene can be located in the upper center. To the right of Lake Coeur d'Alene, the blue area denotes barren land surrounding lead and zinc smelters at Kellogg. Healthy, growing vegetation is red in color. Clouds appear as white puffs over the Bitterroots. Scale 1:1,000,000.

Range Resources

CATTLE SHOW GAINS ON CRESTED WHEATGRASS

Lee A. Sharp
Kenneth D. Sanders

Yearling cattle grazing crested wheatgrass pasture in the spring and fall have consistently averaged gains of 2 pounds per day in spring, and 1 pound per day in fall, and exceeded 2.5 pounds per day in the spring of 1976. Gains per acre in the spring averaged 48 pounds with light grazing and 53 pounds with heavy grazing.

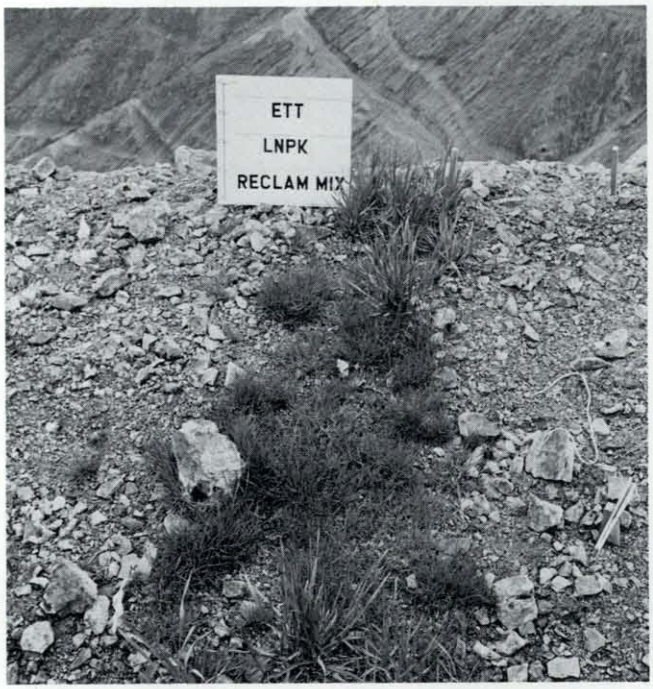
Grazing data have been collected by Professor Lee A. Sharp over a 22-year period at the Point Springs Experimental Area in southeastern Idaho.

Although the above performance is considerably higher than can be expected on native range, researchers at the University of Idaho initiated a study in 1976 to obtain even higher gains on crested wheatgrass. The use of growth stimulating drugs to increase the gains of yearling cattle in feedlots and of young nursing calves has been common practice in recent years. However, the effect of such drugs on the performance of yearling cattle grazing crested wheatgrass pastures has not been clearly established.

During the spring and fall grazing trials in 1976, Assistant Professor Kenneth D. Sanders and Sharp implanted half the yearling cattle with zeranol, an hormone-like drug that increases the retention of nitrogen in the body, resulting in faster growth.

Implanted animals averaged 2.62 pounds per day gain during the spring, as compared with 2.55 pounds per day for the control animals. During the fall, the implanted animals outgained the control animals 0.12 pounds per day (0.95 and 0.83 pounds per day, respectively). However, individual gains of the implanted animals were not consistently higher than those of the control animals. Due to this variation, the results are not conclusive evidence that the zeranol significantly increased the performance of yearling cattle grazing crested wheatgrass pastures.

This study will be contined to further evaluate the effect of zeranol on gains of cattle grazing crested wheatgrass. Researchers will also continue to monitor the effect of light, moderate and heavy stocking rates on crested wheatgrass pastures, and various intensive management programs.



Experimental plots have been established on denuded soil near the smelter area at Kellogg. Here introduced grasses with lime and fertilizers grow on terraces overlooking barren slopes.

REVEGETATION EXPERIMENTS CONDUCTED AT KELLOGG

Howard Loewenstein
Franklin H. Pitkin
John E. Mitchell
Danny B. Carter
John E. Hansen
Roger R. Gordon
Edward Pommerening

As the search for available energy sources broadens, more attention has been directed toward mining, and the waste products of mining. Not only fossil fuels, but also minerals and metals are recovered in mining operations.

The effects of mining on the water, timber, wildlife and recreational resources are still largely unknown. Past experiences, concerned only with efficiency in obtaining minerals and ore, have left scarred lands and polluted streams. In order to prevent future land degradation, the Surface Environment and Mining (SEAM) Program was established in 1972 as a part of the U.S. Department of Agriculture. Over 60 research projects dealing with reclama-

tion were initiated by SEAM in its first 4 years, in an effort to gather information on all phases of the problem. Research projects have been established in soil and overburden analysis, spoil placement, hydrology, revegetation, microbiology, wildlife and air pollution.

One SEAM project, operated by forest and range scientists at the University of Idaho, is studying revegetation on land denuded by lead and zinc smelter emissions at Kellogg. Objectives are to establish trees, shrubs and grasses on the bare mountain slopes, tailings dikes and river flats in the area. These efforts are designed to reduce erosion, improve water quality and increase aesthetic aspects.

The Kellogg valley in northern Idaho's Coeur d'Alene Mining District, which has produced gold, silver, lead and zinc since the 1880s, has suffered repeated disturbance to its vegetation in this century. Once as green and lush as the surrounding forestland, the area around Kellogg appears as barren soil on satellite imagery of northern Idaho, page 9. Several major forest fires in the early 1900s ravaged the western red cedar-western hemlock forest of the valley and slopes, and alder, willow and cottonwood along the streambanks.

A lead smelter was built in 1917, and a zinc smelter in 1928 to process metal ore. Both were allowed to operate without emission controls until 1954, when a sulfuric acid plant was established to recover sulfur from stack gases. Heavy metal particulates and sulfur dioxide deposited in the soil have had a devastating effect, which must be overcome in order to return the land to its native vegetation. Steep slopes in the smelter area have added to the difficulty of revegetation.

Graduate researchers Danny B. Carter and John E. Hansen, working with Professors Howard Loewenstein and Franklin H. Pitkin, and Assistant Professor John E. Mitchell, are studying the effects of lime and fertilizers in experimental plantings of selected tree seedlings and grasses. Austrian pine, Scotch pine, ponderosa pine and black locust have been chosen for study with the addition of lime to reduce soil acidity. Plantings making use of both lime and fertilizers include Idaho fescue, a bunch grass; Reubens reclamation mixture, a combination of rhizomatous grasses; Douglas-fir and Austrian pine.

In a greenhouse study, heavy metals found in the Kellogg area have been introduced into uncontaminated soil, for an examination of soil toxicity. Wheatgrass was planted in the soil samples to provide a measurement of the effects of different combinations and levels of metals on emergence, growth and tissue accumulation.

Research Associates Roger R. Gordon and Edward Pommerening are engaged in a project using container-grown and bareroot plantings of trees and native shrubs in the denuded area. They have also developed an extensive terracing program for erosion control on steep hillsides. An additional 100,000 trees are scheduled for spring planting, as an overall 70 percent plant survival record indicates that large-scale revegetation can begin.

In addition to the SEAM allocation, the project has been supported by Greater Shoshone County, Inc., the Bunker Hill Company and the University of Idaho.

GRASSLANDS ECOLOGY ON THE SNAKE AND SALMON RIVER SYSTEMS IN IDAHO

Edwin W. Tisdale
Minoru Hironaka

Grasslands along the Snake and Salmon rivers and their tributaries occupy about 1.5 million acres, comprising a unique and important type of vegetation in this otherwise forested or cultivated region. The river valleys are remarkable for their steep slopes, great range in elevation and mild winter climate. These characteristics, along with their production of highly nutritious forage, make them extremely valuable for use by domestic livestock, deer and other wildlife. Recreational values are high also. A sizable portion of the area has recently been designated as the Hells Canyon National Recreation Area, a tribute to the area's highly valued recreation resource.

Prior studies of these grasslands have been geographically localized and limited in scope. The present study, conducted by Professors Edwin W. Tisdale and Minoru Hironaka, is intended as a comprehensive one, to include classification of the vegetation and determination of its productivity, growth patterns and response to various uses. The plan is to bring together and analyze existing information, contained in three master's theses from the College, and unpublished data from the files of the project leader, the U. S. Forest Service, Soil Conservation Service and other agencies. Supplemental field and laboratory studies will be carried out as needed.

Progress during 1976 included development of a work plan, initial field work and collection of existing data. Field work in the Sheep Creek area of Hells Canyon was sufficient to develop a sampling method suited to the rugged terrain and to sample 15 stands of grassland, most of them in relatively undisturbed condition. Several study sites were also located for sampling in 1977. The 1976 data, plus those from the earlier mentioned studies, are being compiled for computer analysis.

Forest Resources

TUSSOCK MOTH RESEARCH MOUNTS AIR, GROUND ATTACK

Robert C. Heller
Karel J. Stoszek
Charles R. Hatch
James A. Moore
Harold L. Osborne
Peter G. Mika
Wayne A. Miller

An example of the added dimensions remote sensing has brought to forest management is the all-out war on timber losses to the Douglas-fir tussock moth.

Stand evaluations on the ground by Professor Karel J. Stoszek and Research Associates James A. Moore, Harold L. Osborne and Peter G. Mika have been supported by aerial photo interpretation conducted by Professor Robert C. Heller and graduate researcher Wayne A. Miller. Models capable of relating changes in tree biomass characteristics to the effect of various management strategies are being developed by Professor Charles A. Hatch, station statistician, and Mika.

The Douglas-fir tussock moth (DFTM), one of the most destructive defoliators of fir stands in Idaho and the Pacific Northwest, erupts in cyclic infestations, the most recent of which began in 1972. Over 800,000 acres had been defoliated by the fall of 1973, the year the epidemic broke out in the Palouse Range of northern Idaho.

Major defoliation occurs during the initial year of the infestation, then fades within three years, as natural predators and disease increase and overtake the burgeoning insect population.

Heller and Miller obtained duplicate transparencies of color infrared (CIR) film (scale 1:4000) taken of 16 randomly located six-mile-long flight lines in the Blue Mountains region of northeastern Oregon and southeastern Washington. The initial overflight study was conducted by the Forest Pest Control Branch of State and Private Forestry, U.S. Forest Service Region 6, with flight lines to be flown and photographed each year from 1973 to 1977. The Forest Service study was designed to provide information on the impact of DFTM to fir stands; whereas, the College of Forestry, Wildlife and Range Sciences study was aimed at defining the stand and site conditions most favorable to DFTM outbreaks.

Heller and Miller set out to correlate tree, stand and site information from aerial photography and identify site factors pointing to DFTM susceptibility. The researchers visited selected study sites to gain familiarity with the vegetation and its shape and color tone on film. Ground data, such as aspect and slope, were also obtained to verify measurements taken from the aerial photographs. All 712 plots were evaluated for elevation, slope, aspect, physical location, crown closure, stand level, density of all species on the plot, density of fir species on the plot, stand purity, radiation index and levels of defoliation.

Using a non-linear computer program, RISK, the researchers identified the following independent stand variables as highly related to defoliation: locations at lower elevations, on eastern and southeastern exposures, on or near ridgetops, and open-grown, multistoried or high density. Stands of fir mixed with other species were found to be equally as susceptible as stands composed entirely of fir.

The study generally complements stand study findings by Stoszek's group, conducted north of the Clearwater River in Idaho.

STAND STUDY

The primary responsibility of the stand study is silvicultural prescription, identifying characteristics of sites which may make them susceptible to infestation, and suggesting management alternatives.

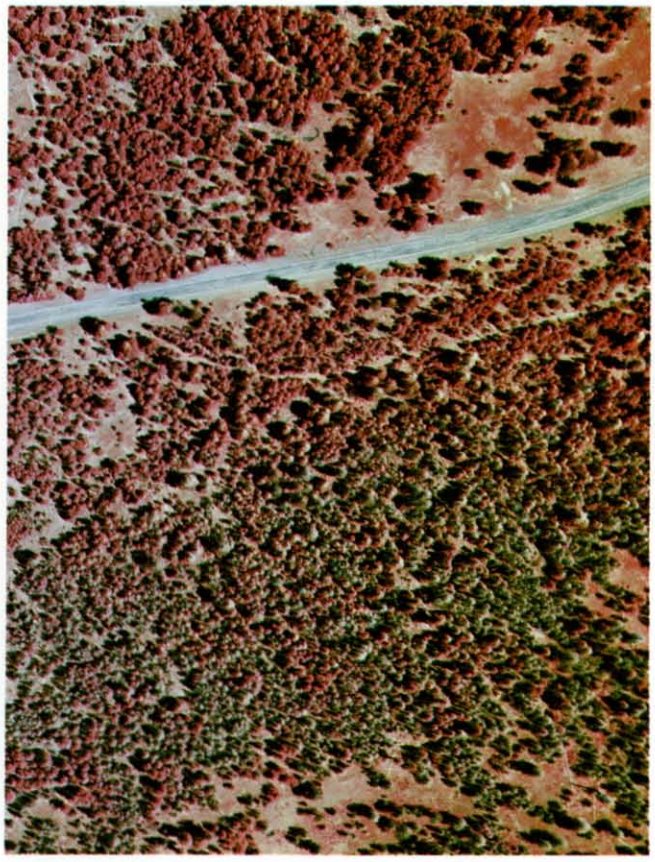
Ridgetops, upper slopes and steep south-facing slopes were found to be the most susceptible sites in the northern Idaho study. Differences between findings in the two studies may be due to different degrees of resolution in the risk rating models. The stand study in northern Idaho was done on the ground level, encompassing specific areas rather than watersheds, and identifying factors which could not be detected from the air.

Stoszek, Moore, Osborne and Mika were able to determine that tree structure (the species of trees within a stand) plays a major role in the susceptibility of the stand to defoliation. Where both were present, grand fir were preferred over Douglas-fir in the early stage of the outbreak as host trees. Heller and Miller were able to differentiate firs from other tree species on the 1:4000

CIR photos, but could not distinguish or separate the fir species.

Tree age, another major factor in defoliation, was also documented through the stand study, but could not be measured from the air. Stoszek, Moore, Osborne and Mika found that young trees, in even and uneven aged stands, were usually not affected. The stand study research will be directed in coming months to the physiological differences of the young trees. Is it their rapid growth and general vigor which protect them? Research data will also be collected with an eye toward the construction of a mathematical model to predict outbreaks.

On the basis of findings to date, Stoszek's team recommends a prescription of 1) keeping trees healthy and growing by thinning, and 2) favoring Douglas-fir over grand fir on grand fir/pachistima habitat types. In their studies, the researchers found that the larvae favor the successional climax tree in a given habitat type. Existing on the driest sites which can sustain them, these trees may be stressed for both water and nutrients, making them more vulnerable than trees lower in the successional order, to insect attack. A prescription manual is being developed from the findings of field researchers on private, state and federal lands in northern Idaho. Chapters will include chemical, biological and silvicultural controls, and outbreak detection systems.



Overflights of the Blue Mountains in northeastern Oregon readily show the extent of Douglas-fir tussock moth defoliation. Healthy trees and vegetation are red on the color infrared film. Foliage of trees under attack appears green. Scale 1:4000.

The frequency and probability of outbreaks are keyed to combinations of site and stand variables reported by Stoszek and Heller. This information, and the relationships developed in the Palouse Range study by Hatch and Mika, will become part of the DFTM Pest Management System. That system is comprised of three models: the DFTM Outbreak Model, the Stand Model and the Socio-economic Model.

MODELS DEVELOPED

The Outbreak Model provides probable effects of an uncontrolled DFTM outbreak on stand growth and mortality. It is capable of modifying those effects by incorporating the impact of control alternatives which act directly on the insect. The Stand Model provides expected trajectories for each of several resources. These trajectories (expected resource outputs through time) serve as inputs to the Socio-Economic Model which translates them into socio-economic impact terms.

The Stand Model portrays the current and future appearance of trees in a stand in terms of their species, diameter, height and crown length and on the basis of stand site characteristics. The Outbreak Model determines the probable effects of a DFTM outbreak on the basis of insect densities, tree foliage biomass per 1000 square inches of branch surface area, and the ratio of a tree's new foliage biomass to its old foliage biomass. This study developed equations which convert the characteristics of a tree contained in the Stand Model to foliage biomass per 1000 square inches and new/old foliage biomass estimates (the tree characteristics needed by the Outbreak Model). The transformation of tree characteristics from one model to the other makes it possible to evaluate the influence of all types of alternative management strategies on the impact of DFTM outbreaks.

Data for this study were collected on destructively sampled grand fir and Douglas-fir trees in the Palouse Range of northern Idaho. These data were collected at the same sites and in conjunction with studies described by Stoszek. Transformation equations were developed for both species over a range of tree and stand site conditions. This coming year it is expected that this data base will be expanded to include grand fir, Douglas-fir and white fir in the DFTM outbreak areas of the Southwest, northern California and eastern Oregon and Washington regions.

Funds for these projects have been provided by the U. S. Department of Agriculture DFTM Program.

SECONDARY PLANT GROWTH FOLLOWS DISTURBANCE PATTERN

Anita F. Cholewa
Frederic D. Johnson

Vegetation at or near climax is used in determining forest habitat types in the northern Rocky Mountain region, though little is known of successional relationships of particular types. For this reason, graduate researcher Anita F. Cholewa and Professor Frederic D. Johnson have formulated this description of intermediate (seral) communities of the Douglas-fir/ninebark habitat type to determine its secondary successional sequence. This zone is important in timber production, leading Idaho's Douglas-fir yield. Many of the shrubs found in the understory are important browse species; grazing potential is also high.

The shrub-dominated physocarpus (ninebark) union is found in the northern rockies at or near the lower limits of forest development. It is reported throughout northern and central Idaho, western Montana, in the Wallowa and Blue mountains of Oregon and southeastern Washington, and in northeastern Washington. The union forms two associations throughout this region, with Douglas-fir and with ponderosa pine.

Study area stands in Latah County, Idaho, were found on essentially climax sites which had not been disturbed since the early 1900s, and on disturbed sites which had been logged only, burned only, logged and burned, grazed, and logged and grazed. Data included cover estimates of shrubs and herbaceous plants, frequency of herbaceous plants, and height, age and diameter of all trees within the sample plots.

Sites undisturbed since 1900 have a 68 percent shrub cover of ninebark. Other common shrubs include snowberry, ocean spray, thimbleberry, baldhip rose, and shiny-leaf spirea. The herbaceous layer contains Piper's anemone, heartleaf arnica, western meadowrue, mountain sweetroot, northern bedstraw and elk sedge.

In stands disturbed by burning, redstem ceanothus and shiny-leaf spirea are favored, having 10 times the coverage achieved on logged sites. Redstem ceanothus is known to possess seeds which remain dormant in the soil for long periods of time, then germinate following high fire temperatures. Shiny-leaf spirea, a rhizomatous shrub, may also have seeds with this characteristic. Two other shrubs, ocean spray and baldhip rose, appear to be favored on logged sites, having twice the coverage in these areas as on sites disturbed by other means. Thimbleberry does well on sites which have been both logged and burned.

Thistle and other invader plants appear in the understory on an area which had been grazed and logged in the physocarpus union of northern Idaho. High density of shrubs is characteristic of all disturbances.

Root sprouting, noted by many researchers, is especially noticeable in the burned sites – on ninebark, redstem ceanothus, Rocky Mountain maple and ocean spray. Root sprouting also occurs, but to a lesser extent, on logged sites.

In the herbaceous layer, rhizomatous bluebunch wheatgrass is the sole species to be found only on burned sites. Northern bedstraw, roundleaf alumroot and pinegrass have higher cover and frequency values in burned areas than on other sites. Trail plant and heartleaf arnica favor logged stands. Species found on logged and burned sites include showy aster and St. John's-wort.

Grazed sites are difficult to describe because the nature of the grazing affects vegetative composition. All of the grazed sites have been grazed continuously for many years, but at different intensities, resulting in varying plant composition.

On grazed sites, snowberry and shiny-leaf spirea occupy less crown space by half than they hold in sampled stands at climax or following other disturbances. Nootka rose is the only shrub with higher cover in grazed sites than on other disturbed sites. Considerably less shrub cover is found on grazed sites than on logged and/or burned stands.

Species composition in the herbaceous layer of grazed sites shows the most change, as would be expected since cattle are primarily grazers. A number of species show a marked decrease in cover and frequency in grazed stands, including northern bedstraw, mountain sweetroot, western meadowrue and elk sedge. Species which tend to increase or invade these grazed areas include big cerastium, western gromwell, sheep sorrel, common dandelion and Kentucky bluegrass.

In grazed and logged sites, the order of grazing, before or after logging, makes some differences in the shrub cover composition, but not in the total coverage. Ninebark comprises the majority of the cover in both. Sites grazed prior to logging tended to have twice the coverage of shiny-leaf spirea, snowberry, ocean spray and nootka rose. High numbers of species are found in the herbaceous layer which do not appear on other disturbed sites. Many of the logged and grazed sample sites are near farmlands, and probably received wind-blown seed from adjacent fields, or during logging or grazing activities.

Trees under 7.6 meters in height are considered as reproduction (new growth). All tree regeneration on sampled sites is natural, and consists of Douglas-fir, with some ponderosa pine. Reproduction is most successful on logged sites, averaging 95 stems per hectare and exhibiting good growth. On grazed areas, reproduction is present, but averages only 27 stems per hectare. Seedlings and saplings under 1.5 meters are conspicuously absent in grazed areas. Reproduction on burned sites apparently did not become established until 5 to 10 years after fire. Reproduction in undisturbed or climax stands was successfully established years ago and now occupies intermediate or codominant positions in the overstory.

It is difficult to determine how long a particular site may require to return to the climax state after disturbance. Seccondary succession is affected by the initial state of the vegetative composition, the intensity of the disturbance, and the previous disturbance history.

VOLUME TABLES DEVELOPED FOR SMALL TREE LOGGING

Gerald M. Allen
David L. Adams
Geoffrey L. Houck
Charles R. Hatch

Sawmills which utilize logs formerly considered too small in diameter for lumber production have recently been introduced into northern Idaho. Most available volume tables do not include board foot values for trees in the smaller diameter classes. This study by Assistant Professor Gerald M. Allen, Professors David L. Adams and Charles R. Hatch, and Research Technician Geoffrey L. Houck developed small-tree board foot and cubic foot volume equations and tables for Douglas-fir, western larch, lodgepole pine and grand fir and a composite equation and table for these four species.

Trees from the Athol, Elk City, Orofino and Bovill areas of northern Idaho formed the data base. Each tree was felled and bucked into 8-foot sections. Smalion's formula was used to compute the cubic foot volume inside the bark of each tree. Board foot volumes were obtained by diagramming the small end of each 8-foot section into the maximum number of 2 x 2's, 2 x 3's and/or 2 x 4's that could be sawed from it. Volume equations were developed using regression analysis and the following mathematical model:

$$V = a_0 + a_1 D^2H$$

where: a_0 and a_1 are least squares regression coefficients

D is diameter (in inches) outside bark at breast height

H is total tree height (in feet)

V is total cubic foot volume above a 1-foot stump or board foot volume above a 1-foot stump.

Both the equations and tables have been published in Forest, Wildlife and Range Experiment Station Note No. 27.

RESEARCHERS APPLY CLUSTER ANALYSIS IN WOOD DECAYING FUNGI RESEARCH

Arthur D. Partridge
Elmer R. Canfield
Stephen D. Hobbs

Statistical techniques used in the study of plant community dynamics have been successfully applied to wood decaying fungi research by Forest Resources investigators.

During two summer field seasons, a research crew of nine examined 74 randomly selected stands of mixed conifers in a sampling area that extended from the Salmon River to the Canadian border. Decayed wood and soil samples were returned to the experiment station for extensive laboratory analysis.

An agglomerative cluster analysis technique was employed to separate the sample stands into groups of similar species composition. Groups identified by the cluster analysis were superimposed on an ordination of the same sample stands approximating an elevational gradient based on the presence or absence of 167 plant species. The occurrence of eight different decay fungi was measured against changes in stand composition along this gradient, which was used as an indirect approximation of temperature and moisture regimes. Support for the role of plant succession in the distribution of some fungi was also borne out.

Use of cluster analysis and ordination was just one method of investigating the ecology of wood decaying fungi used by Professors Arthur D. Partridge, Elmer R. Canfield and Stephen D. Hobbs, graduate researcher. Another vegetative aspect of the study identified plant indicator groups associated with sites that had high probabilities of infestation by various fungi.

Stands were also evaluated by chemical and physical soil properties and by topographic site characteristics. Four clusters were identified as discrete groupings based on the quantitative values of 32 soil and topographic variables. A stepwise discriminant function analysis was used to reduce the number of variables examined to nine soil characteristics, which provided the best statistical discrimination between groups. Fungi frequencies were found to vary between groups and were evaluated in terms of the nine soil variables analyzed. The statistical methodology employed was judged suitable for development of hazard rating schemes. The researchers pointed out that the laboratory time needed for soil analysis was relatively long when compared with that required for the identification of plant indicator groups in the field.

Advanced decay is evidenced by clumps of honey-colored mushrooms (*Armillaria mellea*).

EQUATIONS PREDICT TREE CROWN CHANGES THROUGH MANAGEMENT

Charles R. Hatch

The Stand Prognosis Model was developed by Albert R. Stage in 1973 to evaluate the impacts of present and proposed management practices on tree growth. Most management practices directly or indirectly influence the size and position in the stand of a tree's crown and, thus, influence future tree growth.

This study by Professor Charles R. Hatch developed mathematical relationships capable of reflecting changes in a crown's dimensions and position in the stand as a result of management practices. The data consisted of 39,139 individual sample tree records located on plots established as part of the management planning inventory on 13 national forests in northern Idaho, eastern Washington and Montana.

Separate equations were developed by habitat type for each of the following species: western white pine, whitebark pine, lodgepole pine, ponderosa pine, western larch, Douglas-fir, grand fir, subalpine fir, Engelmann spruce, western red cedar, western hemlock and mountain hemlock. Stand and tree variables used to predict the change in the crown ratio of a tree following a management practice included basal area per acre, a measure of stand density, diameter at breast height, total tree height and/or the tree's percentile in the basal area distribution.

UPDATED FOREST MAP TO AID RESEARCH USE

Joseph J. Ulliman
Philip J. Murphy
William A. Befort

Painstaking years of work by survey parties have given way to use of satellite imagery and aerial photography for the preparation of maps. Three mapping projects have recently been completed by the Forest, Wildlife and Range Experiment Station, providing a current map of the University of Idaho Experimental Forest; a delineation of the land use of Idaho for the Pacific Northwest Regional Commission's Land Resources Inventory Demonstration Project, highlighted in the 1975 annual report; and a charting of mountain pine beetle outbreaks in northwestern lodgepole pine forests from 1945 to 1975, which will be published as part of an Experiment Station bulletin.

With the influx of new faculty members in 1974 came a renewed interest in utilizing the College's Experimental Forest for management, research and teaching. Existing map coverage consisted of three USGS quadrangle maps at two different scales. Specialized maps of individual units also existed, but did not indicate their relationship to the forest as a whole. A single map, which would include all units of the Experimental Forest at a larger scale and have a smaller and more consistent contour interval, was needed.

In the spring of 1975, a mapping program proposal was approved by Professor and Forest Manager, Franklin H. Pitkin. Funds for the project were made available from the sale of timber on the Experimental Forest. Graduate researchers Philip J. Murphy and William A. Befort carried on extensive field work during the summer of 1975. Murphy interpreted aerial photos obtained for the project, and updated detail. All corners of the Experimental Forest boundaries were located on the ground, pinpricked onto the photos, and recorded in a field notebook. The team also established supplemental horizontal and vertical control for the aerial photo stereoplotting. Major features in the field and the original survey field notes at the Latah County Recorders office were checked and the details were transferred to a base map. Contours were taken from USGS maps. Updating by graduate researcher Will J. Summers, Pitkin and forest field crews continued until the summer of 1976, when drafting was begun. The map, itself, was edited according to basic stylistic guidelines by Befort and project director Joseph J. Ulliman. The finished product represents a scale of 1:15,840 (4 inches = 1 mile), with a contour interval of 20 ft. The map also contains, besides standard USGS symbols, photo centers for the 1973 photography, fences and gates, and the Experimental Forest unit boundaries. The map has been prepared for use in aerial photo and measurements classes, engineering and harvesting courses, ecology courses, wildland recreation courses, land management planning, summer camp, and for all those engaged in research on the forest.

MOUNTAIN PINE BEETLE IMPACT ON LODGEPOLE STUDIES

Ronald W. Stark
John A. Schenk
David L. Adams
Ronald L. Mahoney
Nicholas L. Crookston
David L. Kulhavy

The integrated pest management (IPM) mountain pine beetle (MPB) project, sponsored by the National Science Foundation and the Environmental Protection Agency, is a cooperative venture involving professional scientists and technical assistants of the University of Idaho, Washington State University and the USDA Forest Service, through a grant administered by the University of California Berkeley.

This program emphasizes the application of available knowledge to management problems rather than the generation of new information. There are three objectives:

1) To develop methods for evaluation of the impact of the mountain pine beetle throughout the range of lodgepole pine, considering all values implicit in the resource;

2) To develop insect population and forest stand models and other methodologies which will permit determination of local and regional trends in beetle populations and prognoses of stand development and impacts;

3) To develop management decision models from the first two, which will aid in action decisions (no action is implied). These models are to include choices of strategies for population regulation based on the state of the art.

Project investigators are Professors Ronald W. Stark John A. Schenk and David L. Adams, Research Associates Ronald L. Mahoney, Nicholas L. Crookston and David L. Kulhavy, University of Idaho; Professor Alan A. Berryman and Research Associate Donald G. Burnell, Washington State University. Major cooperators are Principal Research Scientists Albert R. Stage and Walter E. Cole and Research

Scientist Gene A. Amman, USDA Forest Service Intermountain Forest and Range Experiment Station.

Research has been concentrated on the probable impacts MPB infestations have on two major forest uses, recreation and water. The USDA Forest Service, Region 4, is making a major study of MPB impact on timber productivity. Restrictions to recreational usage caused by downed trees, potential danger from falling trees, and a negative reaction to the appearance of infested trees were anticipated as major areas of impact. The number of recreationists continuing to use the campgrounds in infested areas, however, did not decrease appreciably.

In 1975 studies were initiated on the effects of MPB outbreaks on water runoff. We hypothesized that the magnitude of streamflow would increase after mortality from bark beetles reduced timber stocking. Comparisons between runoff and snow accumulation before and after infestation on one watershed supported this hypothesis. Data from additional areas are currently being analyzed.

A major part of the MPB project has centered on modeling bark beetle populations, and linking these models to a stand growth simulator principally developed by Stage. Data for the models have been drawn from extensive studies in both Canada and the United States.

Factors affecting MPB populations are separated into two groups, those which are directly related to the behavior and density of the beetle population, and those controls which are generated by the beetles' environment. Production of beetles from infested trees is determined by the interaction of these variables. How suitable a given tree is for beetle reproduction and survival, and the resistance of host trees to attack are two variables affecting beetle population density. The number of trees on a stand, and weather conditions are examples of environmental factors. Indicators of habitat suitability and resistance are being developed through the use of crown competition factor, habitat indicators, and insect-pathogen interaction.

Researchers are working to develop equations which could directly predict the expected level of tree mortality should an infestation occur in a given stand. Equations which predict mortality from infestation and risk of infestation are being integrated to form a simple and practical tool for resource managers.

Results of this and other research, especially newly developed management alternatives, will be presented in a symposium on Mountain Pine Beetle Management in Lodgepole Pine Forests, April 25-27, 1978, at Washington State University, Pullman. Sponsoring institutions are Washington State University, the University of Idaho, USDA Forest Service and the Society of American Foresters.

THINNED STANDS YIELD MARKETABLE TREES FASTER

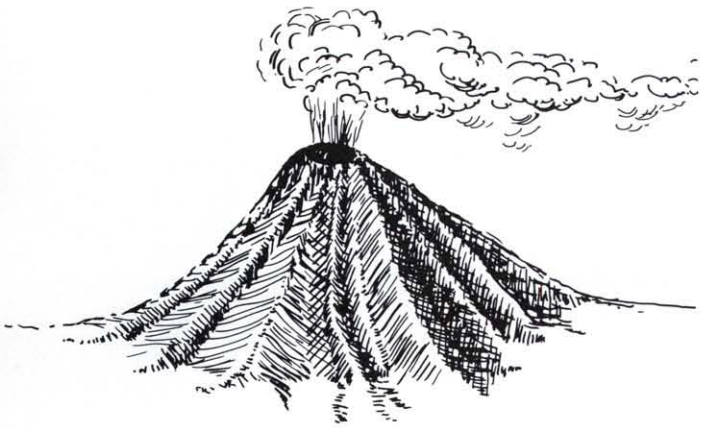
Donald P. Hanley
David L. Adams

Experiments in thinning young ponderosa pine plantations on the University of Idaho Experimental Forest have shown that the average crop tree on a thinned plot will produce 4.5 times more wood fiber per year than a tree on an unthinned plot.

Research Instructor Donald P. Hanley and Professor David L. Adams found that removing the least vigorous young-growth ponderosa pine from plots meant decreased competition for the more vigorous crop trees. For the landowner, this would mean an earlier, and usually higher return, because selected trees would reach marketable size sooner. Additionally, thinning results in a more vigorous plantation, usually less vulnerable to insect and disease problems.

Thinning was carried out from 1959 to 1964 on tree stands established between 1941 and 1943. Trees from thinned stands averaged 4.5 years to grow 1 inch in diameter, while the average tree from an unthinned plot required 16.7 years to achieve the same growth. Average tree diameter, basal area per acre, cubic foot volume per acre and cubic foot volume per tree were chosen as the basis of analysis for growth comparisons with significant results between thinned and unthinned plots.

Log sections cut from two same-aged ponderosa pine show a dramatic difference in growth. The cross section at left, from a thinned plot, is 12.7 inches in diameter. The one at right, from an unthinned plot, is 4.2 inches in diameter.



VOLCANIC ASH SOILS ROB PLANTS OF PHOSPHORUS

Harold G. Brown
Howard Loewenstein

Volcanic ash derived soils cover northern Idaho, laid down centuries ago during the eruption of Mt. Mazama, in southern Oregon.

By its nature, the volcanic soil holds and fixes phosphorus so that plants cannot use it. Weathering compounds the problem, as rain releases iron and aluminum hydroxides, which increase phosphorus fixing. For foresters, this poses a major problem, especially in revegetation. Larger trees can get along with less phosphorus, and have also established root systems extensive enough to reach below the 0 to 30-inch ash soil layer. Seedlings, which require a high rate of phosphorus for growth, are often difficult to establish.

In a greenhouse study, graduate researcher Harold G. Brown and Professor Howard Loewenstein have tried adding varying amounts of phosphorus to young plantings of Douglas-fir. They found that large amounts of phosphorus, at a rate of 7.5 tons of P_2O_5 per acre, encouraged increased growth, but no change was apparent with generally accepted levels. Soils for the experiment were collected from three different sites. Because the high levels of phosphorus needed to produce increased growth are impractical on a field basis, the researchers recommend that containerized plantings be used, giving the plant its own protective environment, and/or the addition of triple super phosphate in the planting hole.

NSF GRANT SUPPORTS UNDERGRADUATE RESEARCH

Joseph J. Ulliman

Associate Professor Joseph J. Ulliman directed an Undergraduate Research Participation project sponsored by a National Science Foundation grant to the College of Forestry, Wildlife and Range Sciences.

The program brought eight talented students to the College for research and independent study under faculty supervision, over a 10-week period during the summer of 1976.

Wayne Apostolik, a Forest Products junior, worked on a project to establish reliable methods of estimating volume of residue in slash piles along roads and landings, under the direction of Associate Professor Leonard R. Johnson. In a continuation of that project, Joseph Baugh, a junior in Forest Resources, worked on a study to correlate residue volumes in the woods to timber sale information, under Assistant Professor John E. Houghton and Johnson.

Forest Resources senior Larry Dawson, under Professors John P. Howe and Chi-Wu Wang, studied wood properties of fast-growing trees under intensive management of thermal water treatment and ground heating. Also working with Wang, Greg Outcalt, a Forest Resources junior, researched clonal variation and accelerated growth of forest trees under thermal water irrigation and ground heating at ERDA's Idaho National Engineering Laboratory site, Idaho Falls, and the Hanford Reactor Site, Hanford Reservation, Washington.

Robert Hagevik, a Wildlife-Fisheries Resources junior, researched a natural resource planning problem under the direction of Associate Professor George H. Belt, relating to control of dust at mining sites. His work emphasized defining the problem and developing a prototype model.

Constance Sathre, a junior biology major from Carleton College, Northfield, Minnesota, worked under Professor Charles R. Hatch developing biomass deterioration and decomposition models.

Two students from the College of Letters and Sciences, Mark Sheton, junior majoring in biology, and Paul Luther, a senior zoology major, worked in the areas of remote sensing and satellite imagery interpretation. Sheton, under the direction of Professor Robert C. Heller and Ulliman, worked on a sub-project to interpret and classify crops on satellite imagery for water resources. Luther's project, also using machine aided classification of satellite imagery for forest resources, was supervised by Ulliman and graduate researcher William Befort.

Wildland Recreation Management

COMPUTER MODELING DEVELOPED FOR WILDERNESS MANAGEMENT EDUCATION

John H. Schomaker
Clifford C. Mitchell

The Wildland Recreation Management Program hopes to eliminate educational deficiencies from wilderness management training at the University of Idaho by introducing computer application and applied management strategies. The tool to be used to overcome this deficiency is a large-scale wilderness traffic simulation model recently developed by the U. S. Forest Service.

Simulation models are artificial constructs expressing the structure and behavior of a real system through a set of mathematical relationships which, like all models, simplify reality to a greater or lesser degree. The simulation model is not an exact replica of the real system. The model is intended to serve as a laboratory for conducting experiments on the simulated, instead of the real, system. It is intended to assist wilderness managers in their decision making process and not to be their sole guide.

The primary problem retarding educational use of the U. S. Forest Service model is its adaptation for educational purposes. The model is large and expensive to run in the manner currently used by the U. S. Forest Service. The main thrust of this project, by Assistant Professor John H. Schomaker and Clifford C. Mitchell, graduate researcher, is to adapt the wilderness simulation model for undergraduate, wilderness management and special topics course use. The project is supported by McIntire-Stennis funds.

During the fall semester of 1976, two major objectives were accomplished. The model language (GPSS V) had to be adapted for use on the University's computer. and the model had to be run, producing understandable results. The model was successfully run using information supplied by the U. S. Forest Service for a hypothetical wilderness. Sample cases were developed and run using the supplied data and an instructional module for class use was begun.

The adapted model and sample cases to be used in the Wilderness Management course will allow each student to make wilderness management decisions related to controlling overall use, encounter levels between user parties and the quality of the wilderness experience. Students can be presented with problems in wilderness management –too many encounters between users in a wilderness, for example. Each student will then be able to apply his or her own solution to the problem and see the results of that decision. Output from the model will graphically depict implications of various management decisions in a wilderness area. Use of the model will bring a new "field" dimension to classroom education.

LAND MANAGERS SEEK TO MEASURE SCENIC QUALITY

John H. Schomaker
Rebecca A. Wooden

With the rise in concern for environmental quality, public pressure has led land managers to consider the intangible as well as the measurable resources of national forest lands. Landscape architects are attempting to identify and record, through research, those components of landscapes which are regarded as high in scenic quality. Assistant Professor John H. Schomaker and graduate researcher Rebecca A. Wooden are developing a methodology to incorporate public opinion into this evaluation process.

Fifty color slides of actual landscape modifications have been selected to depict varying degrees of visual impact. The modifications include timber harvests, road construction and utility installations viewed from a distance. Landscape architecture student Colie Hough has prepared black and white, and color sketches to depict the photographed scenes. The sketches have been duplicated for projection in slide form.

The color slides and sketches will be randomly ordered and presented to students for a measure of preference. Subjects will be asked to evaluate the scenes depicted in the slides by assigning each scene a value from zero (very low in scenic quality) to nine (very high in scenic quality). These ratings will be analyzed to determine the correlation between the ratings of actual photographs and ratings of their corresponding sketches.

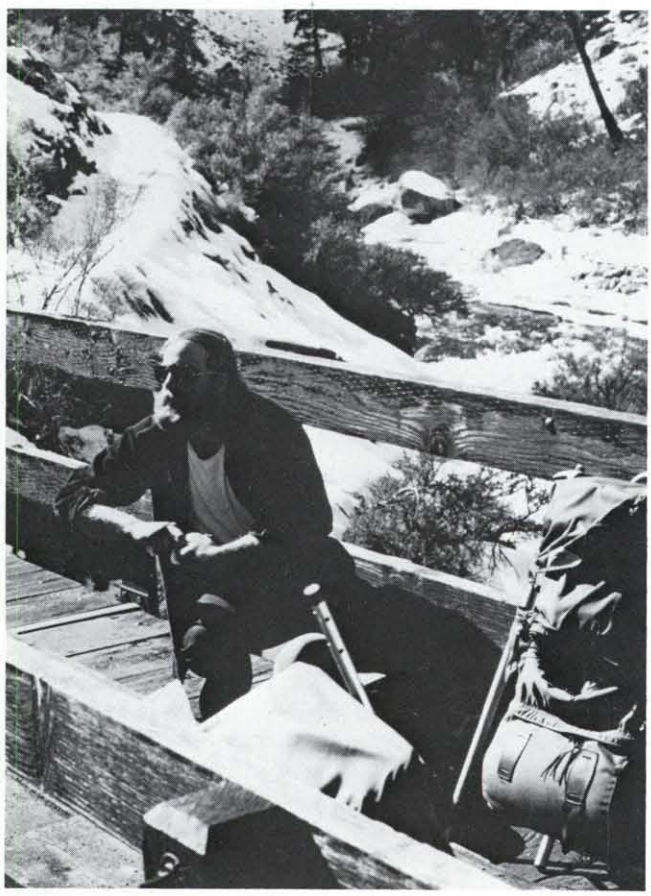
These data will indicate the accuracy with which land managers can predict public response to landscape modifications through the use of graphic representations of the proposed changes. It is hoped that this method will provide managers with a useful tool for incorporating public opinion into the decision making process.

EDUCATION SEEN AS WILDERNESS PROTECTION TOOL

James R. Fazio
William W. Bramlette

How much wilderness visitors know about the land they are using and where they receive their information is the subject of a study by James R. Fazio, associate professor and graduate researcher William W. Bramlette. The information will be useful to wilderness managers concerned with the impact of increasing numbers of recreationists.

A premise underlying the study is that in many areas of Idaho and the Northwest the big question is not whether more land should be added to the wilderness system, but how *quality* of existing wilderness can best be protected. Some argue that camping use must be rationed, or allowed only at designated sites. Fazio and Bramlette believe that if recreationists can be educated so their use will have as little impact as possible on the resources and fellow visitors, then the day when it might be necessary to limit the numbers of people using the wilderness can be staved off, at least for the foreseeable future.



Backpacking and other recreational use of wilderness areas have grown to the point that researchers are concerned about preserving the quality of the wilderness that exists. Studies are underway to monitor the effects of different user-education methods for agency managers.

To help agency managers use education as a management tool, William Bramlette, a graduate student in the Wildland Recreation Management program determined which users were most lacking in information about the wilderness. Preliminary returns from his questionnaire show that on the average airplane users, hunters and private horse users have the least understanding about the concept of wilderness. Commercial outfitters, organized group leaders and backpackers fared somewhat better. The questions were in the form of a multiple choice test which was given to 600 recreationists during the summer of 1976 in the Selway-Bitterroot Wilderness Area. Questions were grouped into the categories: How wilderness is managed, Why areas are set aside as wilderness, User ethics, Knowledge of safety and equipment, and Characteristics of the area's natural environment. Less than one-third of all the visitors had heard of the term "low impact camping," a concept being promoted by educators and the U.S. Forest Service in an attempt to protect wilderness quality.

Most visitors completing the test cited the U.S. Forest Service as the source of information for their answers, with friends and relatives receiving the second highest mention. Respondents who had not had access to an information source, but relied on their own experience, were least able to provide correct answers. A general awareness check found a better grasp of wilderness information among those who read books and magazines than among those who watched television predominantly.

The Forest Service has been most successful in reaching visitors through wilderness rangers and personnel who greet each visitor in entering the area. In this approach, all recreationists encountered in the wilderness are offered selected information through personal contact and conversation. This appears to be a much more effective approach than use of television or radio announcements, or hoping that people will read literature available from agencies.

In a second part of the study, wilderness related literature which is mailed by agencies to potential wilderness recreationists on request was collected on a nationwide basis. Material is being subjected to content analysis to determine where more emphasis might be needed in educational efforts. Readability tests and evaluation of graphic quality are also being conducted on the literature sample.

Fazio, a member of the University of Idaho Wilderness Research Center technical board, is continuing the study in an effort to help wilderness managers communicate more effectively with the visiting public.

Wildlife Resources

CANADA GOOSE POPULATIONS IDENTIFIED FROM BANDING DATA

William B. Krohn
Elwood G. Bizeau

An examination of banding information from Canada geese captured in the Rocky Mountain region over the last four decades has yielded a picture of two distinct populations of western Canada geese. More than 19,000 band recoveries and the work of other wildlife biologists were studied during the course of the project.

Canada geese are social birds with strong family bonds. Young geese spend most of their first year with parents, and often continue to associate later on. The family learning pattern and habitual use of the same areas throughout life form isolated population units, recognized by interrelated nesting and wintering ranges. Canada geese living in the western United States and southwestern Canada have long been suspected of having a number of separate populations.

In 1974, the Idaho Cooperative Wildlife Research Unit undertook a study of the distribution, habitats and management of Rocky Mountain Canada geese. Project investigators for the study were Professor Elwood G. Bizeau and graduate researcher William B. Krohn. Wildlife agency personnel from Alberta, Idaho, Montana, Wyoming, California, Nevada, Utah, Colorado, Arizona and New Mexico cooperated on the project. Financial support was provided by the U.S. Department of the Interior Fish and Wildlife Service and the Idaho Department of Fish and Game.

Banding records maintained by the U.S. Fish and Wildlife Service on computer tapes were converted to usable print-outs by Karen K. Falke, University of Idaho Computer Services, who planned the computer programming. Barbara A. Schrader, undergraduate University of Idaho wildlife student, plotted band recoveries on maps, pinpointing the actual range of the population.

Rocky Mountain geese nest from east-central Arizona to southern Alberta, and from western Nevada to northwestern Colorado. They winter from central and southern California to central Arizona and as far north as American Falls Reservoir in southeastern Idaho.

Consultations with wildlife specialists in California, Oregon and Washington led to recognition of a second, and less migratory, population of western Canada geese, the Pacific population. The nesting range of Pacific geese extends from central British Columbia into northern California and south-central Oregon, and from the east side of the Cascade Mountains in Washington to southwestern Idaho, northern Idaho and western Montana. Pacific geese, which are more sedentary than Rocky Mountain birds, regularly winter on and near their nesting areas. However, the wintering range of the Pacific population does extend into the northern part of central California.

Canada geese migrate between their summer and winter ranges during fall and spring. Less well known are their summer migrations to and from molting areas, where they shed old flight feathers and grow new ones. Molt migrations are undertaken by most Canada geese one or more years of age, except those adults which stay with their young on nesting areas. The locations of 18 molting areas in the intermountain region are known; but more than half of the molters in the Rocky Mountain population migrate each year to the Northwest Territories of arctic Canada.

An inventory of habitats known to be used by Rocky Mountain geese showed that they have ample amounts of nesting, molting and wintering areas. Furthermore, there was no evidence that habitats were limiting the population. Considerable mortality occurs prior to the hatching of eggs, or before young geese can fly. Man-made nesting structures reduce egg loss during incubation

and appear to be a practical means for increasing the population's productivity.

Sport hunting was found to be a major source of mortality, accounting for more than 90 percent of all deaths of geese old enough to fly. The number of waterfowl hunters in the Rocky Mountain region is growing faster than the overall increase in the region's human population. Thus, growth or maintenance of the Rocky Mountain population will eventually require more restrictions on hunting.

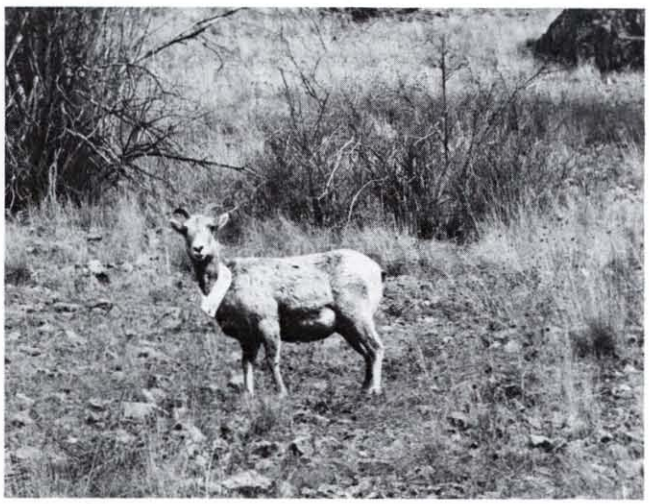
Other management recommendations included means for standardizing population surveys and management guidelines expressed in terms of posthunting population levels. The complete results of this study will be submitted to the U. S. Fish and Wildlife Service for publication in the Resource Publication Series.

BIGHORN SHEEP DATA COLLECTED AT TAYLOR RANCH

James W. Bennett
Ernest D. Ables

The University of Idaho Wilderness Research Center's Taylor Ranch field station in the heart of the Idaho Primitive Area was the focus of a recently completed 2-year Rocky Mountain bighorn sheep study.

Conducted by graduate researcher James W. Bennett and Associate Dean Ernest D. Ables of the College of Forestry, Wildlife and Range Sciences, the study was supported by the Forest, Wildlife and Range Experiment Station and the Wilderness Research Center.



Use of radio collars has enabled researchers to track ewes and rams to their respective summer ranges, in an area previously thought to be uninhabited by bighorn sheep.

Intensive observation of bighorn sheep has become possible through use of year-round facilities at the Taylor Ranch.

Primary objectives of the study were to establish baseline information on the social organization, population structure and productivity of the bighorn population wintering in the vicinity of Taylor Ranch. Migratory routes and daily movement patterns of selected sheep were determined. Food habits data were also collected.

The facilities at Taylor Ranch allowed year-round occupancy, making possible intensive observation of the sheep on their wintering grounds, across the Big Creek canyon from the ranch. This winter range was occupied by the sheep for approximately 7 months each year, from October through April.

Five ewes and three rams were fitted with radio collars while on the winter range, then tracked, via air and ground telemetry, to their respective summer ranges. Lambing and summer ranges for a portion of the ewes which winter near the Taylor Ranch have been discovered approximately 50 miles to the southwest. The ewes take about 4 days for the spring migration movement in early May, before they have had their lambs. The discovery of this migratory route and the location of the summer range in an area previously thought to be uninhabited by sheep may become important in the mitigation of boundaries for the proposed River of No Return Wilderness Area.

Lamb production and survival during the 2 years of the study was relatively good, and the population appears to have increased over the past 5 years.

Sheep fecal pellets were collected throughout the study in order to determine food habits using the microtechnique method. Laboratory analysis of food habits data is now being conducted.

HUNGARIAN PARTRIDGE HABITAT USE STUDIED ON THE PALOUSE PRAIRIE

Glen W. Mendel
Steven R. Peterson

The Hungarian partridge is becoming an increasingly important game bird in some regions of Idaho. Very little is known about the "Hun" in Idaho, which makes management of this species difficult. Assistant Professor Steven R. Peterson and graduate researcher Glen W. Mendel have initiated a study of the Hun in the Palouse region of Idaho.

The research is primarily concerned with obtaining information about Hungarian partridge habitat use in relation to agricultural cropping practices. Also, Hungarian partridge habits, general life history, and productivity will be briefly investigated.

A 3100-acre study area is systematically searched once each month; data are collected on Hungarian partridge habitat use, and records are kept of the farming practices.

A collection of 275 Hun wings was obtained from hunters during the fall of 1976. Sex, age, hatching date and a productivity index have been ascertained from the wings. Huns were found to have good productivity in Latah and Nez Perce counties. The peak hatching period came at the end of June in 1976. The wing collection will be repeated during the 1977 hunting season.

The field work for this project will continue until March of 1978, so that any seasonal variations in habitat use by Huns can be investigated.

WOODPECKER HABITAT STUDIED IN BLUE MOUNTAINS

Evelyn L. Bull
Steven R. Peterson

Color banding pileated woodpeckers, and counting the nests of these and seven other species which inhabit Oregon's Blue Mountains are aspects of a study designed to explore habitat requirements of woodpeckers in the Pacific Northwest.

Little is known of their needs, and information essential for the protection of the species in intensively managed forests is needed. Evelyn L. Bull, graduate researcher, and Assistant Professor Steven R. Peterson are

working in the Blue Mountains to determine nesting and habitat requirements of eight woodpecker species found in the Pacific Northwest. From these data, the researchers will determine the existence and extent of resource partitioning, and the establishment of territorial requirements for each species. These include the pileated woodpecker, common flicker, white-headed woodpecker, hairy woodpecker, Williamson's sapsucker, yellow-bellied sapsucker, black-backed woodpecker, three-toed woodpecker, and northern three-toed woodpecker.

Nests are located in the spring of each year so that nesting and feeding activity can be observed. Feeding, primarily on standing dead trees and dead downed material, is being recorded over a 1-year period, emphasizing the habitat being used for feeding. Recommendations will later be made as to the number and species of dead standing material needed to support a specific woodpecker population.

Additional information on territory size, nest site fidelity, mate selection, fledgling dispersal and recruitment into the breeding population will be obtained from banding information. Both adult and nestling pileated woodpeckers will be color banded for this portion of the study.

PRAIRIE FALCONS, PREY OBSERVED IN NATURAL AREA

Gayle M. Sitter
Brad W. James
Steven R. Peterson

What are the main prey items of prairie falcons, and how much food do they need to successfully raise their young to flightstage? These questions are under study in the Snake River Birds of Prey Natural Area (BPNA) by Gayle M. Sitter, graduate researcher; Brad W. James, undergraduate student; and Steven R. Peterson, assistant professor.

The BPNA was set aside in 1971 by the Bureau of Land Management (BLM) to protect one of North America's densest populations of nesting raptors. Currently the BLM is involved in a massive research effort to predict what effect possible agricultural development on adjacent lands will have on the raptor populations. This research effort is actually several related studies that are funded by the BLM and concentrate on the prey base, competing predators and the raptors themselves.

The study on prairie falcons is very important since they are the most abundant raptor in the BPNA, with 165 pairs nesting along 60 miles of river canyon. The objectives of this study are to define the food necessary to fledge prairie falcons, examine nesting density in relation to cliff topography, and investigate post-fledging mortality.

To study the food habits, several representative nests are selected for placement of remotely controlled movie cameras. Dawn to dusk observations from blinds near these scrapes give detailed information on types and approximate quantity of prey brought to the scrape, and the duration of the feeding visits. The camera is triggered to provide a film record of the feeding visit. Information gathered in this way is later compared with the prey remains found in the nest.

During periodic cliff searches, any dead prairie falcons are aged by feather development, and cause of mortality is recorded. These searches also provide first-hand knowledge of relationships between cliff topography and the different nests. Incidental observations of bird behavior help explain territory size and aggressive tendencies between pairs of birds and neighboring young.

Some of the adult birds were captured and equipped with tiny radio transmitters. This was done with the cooperation of Dr. Thomas Dunstan of Southern Illinois University, who is studying the hunting behavior of the raptors. With his help the researchers are able to calculate the total time spent and the distances traveled while hunting. From direct observation prey items can be identified for each successful hunting trip.

The research, started in 1975, has shown that prairie falcons rely heavily on townsend ground squirrels as their main prey item. They also take various lizards and a wide assortment of birds. During periods of low ground squirrel numbers, these other sources become more important as prey items and some individual prairie falcons seem to prefer a diet of mostly birds.

Preliminary findings show that aggression between adults and the young from adjacent nests may be a big mortality factor for young falcons during their first few weeks of flight. The high density of prairie falcons in the BPNA may compound the problem of physical aggression against young.

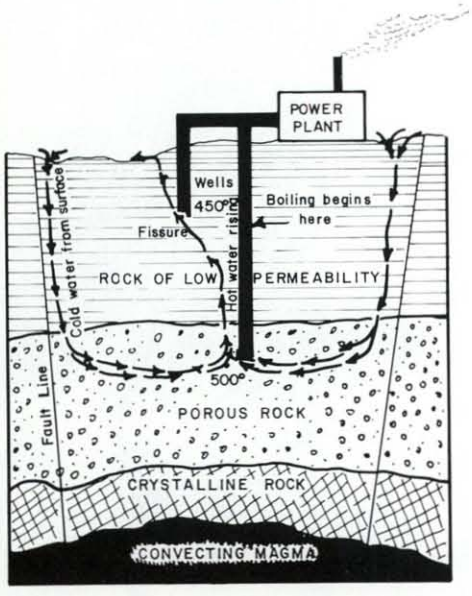
Forest Products

ALTERNATIVE ENERGY SOURCES STUDIED FOR NORTHWEST

Leonard R. Johnson
George M. Simmons
James N. Peterson

Alternative energy sources have attracted a great deal of popular attention because they seem so plentiful and renewable. However, their lack of economic availability has prevented more rapid development.

The quantities of energy available to the Northwest from sun, wind, ocean, biomass, and geothermal water were investigated in a study conducted jointly by Associate Professor Leonard R. Johnson of the College of Forestry, Wildlife and Range Sciences and Assistant Professors George M. Simmons and James N. Peterson of the College of Engineering. Another part of this study examined the cost required to convert these sources to usable forms of energy. Detailed analysis was focused on the more promising energy sources: solar heat, solar-thermal electric, wind generators, geothermal water, wood residue, and municipal waste.



Geothermal water, while not hot enough to generate electricity economically in the Northwest, can be used for space heat and process steam over short distances.

It is technically feasible in all cases to produce usable energy (space, steam, electricity) from these sources. While they could provide some percentage of Northwest energy requirements, none appears to offer an immediate solution to the energy shortage.

Solar-thermal electric plants and wind power generation both require energy storage. The Northwest provides a unique mechanism for this in our hydroelectric dams. When the sun is shining or wind blowing, water can be stored behind the dams; when these sources cannot produce electricity, it can be generated through turbines. However, cost still dims the prospect of solar-thermal plants, and economical generation of wind power depends on the speed of the wind. There are presently inadequate data throughout the Northwest on areas where the wind consistently blows at sufficient speeds.

Solar collectors for space heating are commercially available now and can supply a portion of the hot water and/or heating needs of a home. Currently, when coupled with the conventional heating system needed for back up, the cost of a solar system exceeds that of strictly conventional systems.

Wood currently supplies about 5 percent of the Northwest's energy requirements. This use is largely within the forest products industry, where it is likely to remain. Mill residues can be used for fuel at less than the cost paid for conventional fuels, while forest residues can be recovered for a cost about equal to current prices of oil and natural gas. The problem in considering a switch to wood fuel is obtaining some assurance that there will be a continuity of the supply.

Municipal wastes in some areas can be converted to energy for less than the amount paid for disposal methods. In the Northwest, however, most municipalities are too small to support their own energy recovery facility.

Geothermal water in most areas of the Northwest is not hot enough to generate electricity economically. It can be used for space heat and process steam within 50 miles of the source of water, the maximum piping distance. This alternative becomes more economical for users closer to the water source.

This project is one phase of a Northwest Energy Policy Project, funded by the Pacific Northwest Regional Commission. Published results of this phase are available in the form of a final report through the National Technical Information Service, Springfield, Virginia.

TREE SPECIES RESPOND TO THERMAL WATER USE

Chi-Wu Wang
John P. Howe

Research projects studying the effects of thermal water on tree production and growth have found that several tree species respond well to soil heating and irrigation treatments.

Professors Chi-Wu Wang and John P. Howe have introduced warm and cold water irrigation, and soil heating through the use of a subsurface grid of thermal water pipes and subsurface irrigation on three sites chosen for their climatic differences. These include high cold desert at Arco, site of the ERDA Idaho National Engineering Laboratory; low warm desert at Richland, Washington, Hanford Reactor site 2; and the geothermal project of Raft River in southern Idaho.

Hybrid poplars grew vigorously at the Hanford site, with over 95 percent survival during the first year. Green ash also grew well at that site. At Arco, conifers proved more frost resistant as a group than the hardwood species. Among the conifers tested are several species and provenances of pine, spruce and Douglas-fir. Lodgepole pine has been the most successful of the conifers. The difference is statistically significant in the 8-replicate field test.

Assistant Professor Kjell Christophersen and Professor John Howe examine cabinet work using lumber cut from dead white pine. The natural blue color found in the sapwood is growing in popularity for home panelling and other household wood furnishings.

Pipelines are laid out for use in a soil heating project utilizing thermal water in tree biomass production.

DEAD PINE PRODUCES NATURAL BLUE PANELLING

John P. Howe
Kjell A. Christophersen
Peter J. Hudson

Convert old white pine snags into premium quality panelling? This is an idea being investigated by Professor John P. Howe, Assistant Professor Kjell A. Christophersen and graduate researcher Peter J. Hudson.

The sapwood of white pine snags develops an attractive bluish color. At his mill in Coeur d'Alene, Frank Andrews makes every effort to recover as much of this stained lumber as possible when the logs are sawed. After drying, most of this lumber containing blue stain is made into interior panelling. Some is also used for cabinets, furniture and picture frames.

This project is designed to show both the technical and economic feasibility of product development from stained white pine snags. Hopefully, high value products such as panelling will help pay the way "out of the woods" of products such as chips which come from low value material.

This is a step towards salvaging the millions of board feet of white pine that die in Idaho's forests each year and are never utilized. Indeed, Idaho's overall annual timber losses from insects and disease combined now exceed the total amount of timber removed by logging.

Idaho's forests would benefit from this improved utilization which would reduce fire hazard, reduce damage by insects and disease, and permit the start of new generations of trees.

Other cooperators are the Potlatch Corp., Diamond International Corp., Roth Brothers and North Idaho College.

Continuing Education Programs

The need for updating the skills of professionals in the field has prompted the College's involvement in continuing education programs, workshops and seminars on the campus and in the field. During the past year, the College has sponsored a short course in communications, a workshop on aerial photo interpretation, a 2-day seminar on controversial Indian fishing rights on western fisheries, a short course in habitat typing, a national workshop on fish population control, a western states symposium on forest protection, a series of seminars on land-use planning, two woodland owners' conferences, an elk-logging-roads symposium, and publication of its proceedings. A program of speakers and displays was organized in conjunction with Natural Resources Week.

CEFES PROGRAM

Perhaps one of the most significant efforts of the College in the field of continuing education has been its participation in the program of Continuing Education in Forestry, Ecology and Silviculture (CEFES). Forestry employees in the northwest taking this course spend 3 months in intensive study on the campuses of each of the participating schools – the University of Idaho, the University of Montana and Washington State University. The teaching staff at each institution is responsible for one month of the program. Field foresters who complete the rigorous program and prepare a thesis can earn a master's degree without taking 2 years off from their work in the field.

Now in its fifth year, the program has met with enthusiastic response from foresters and their superiors in the U.S. Forest Service Regions One and Six. The College plans to continue its participation in the program as a regular procedure. Completion of the course has become a major part of the process leading to certification of silviculturists in the Northern Region.

Each summer the administrators and professors for the CEFES course visit forest areas to familiarize themselves with the conditions and problems the CEFES students face in the field. In 1976, the tour visited forest areas in northeastern Oregon.

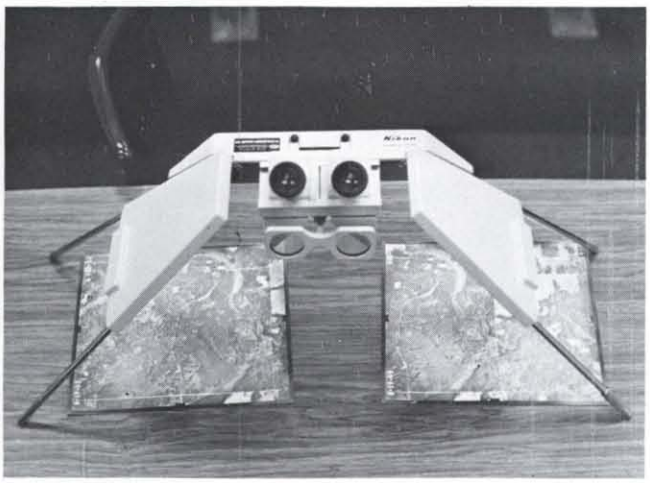
COMMUNICATION SHORT COURSE

For the second year in a row, the College hosted foresters and other resource managers engaged in a continuing education effort to upgrade communication skills. Known as the communication short course for natural resources personnel, the week-long program was directed by Associate Professor of Wildland Recreation Management, James R. Fazio. Instructors came from several disciplines on campus, as well as from the U.S. Forest Service. A featured speaker was Professor Douglas L. Gilbert of Colorado State University, author of the textbook, *Natural Resources and Public Relations*.

Participants in the short course were introduced to the basics of public relations and communications. With the emphasis on actual involvement, teams of participants created title slides, presented a slide show, and made 10-minute video-taped productions. Course work also included public involvement techniques, working with teachers and young people, working with the mass media and improving photography.

Funding to initiate this continuing education program was provided by the American Forest Institute and Wildlife Management Institute, both headquartered in Washington, D.C.

Professors Ernest Ables and David Adams, participating in a summer CEFES field tour, study a newly planted forest revegetation project in northeastern Oregon.



A mirror stereoscope is used to view a stereopair of aerial photographs. The photos are taken with 60 percent overlap to provide the ability to see forested areas in the third dimension.

FOREST HABITAT TYPES

Land and resource managers met in short course classroom and field sessions to examine the use of habitat types as an ecological framework for management of forested lands. Basic principles of synecology and the philosophy and techniques of habitat type classification were reviewed in the classroom. Ecosystem classification methodologies were explained in broad perspective.

University of Idaho Professor Frederic D. Johnson and Research Forester Robert Steele of the USDA Forest Service Intermountain Forest and Range Experiment Station, Boise presented the course. Resource experts in silviculture and wildlife were Milo Larson, silviculturist for the Palouse District of the Clearwater National Forest, and Professor James M. Peek, respectively. Different areas of the state will be selected for the habitat course each year, to give land managers familiarity with the diverse habitats found in the State of Idaho.

Northern Idaho and eastern Washington habitat types were studied in the field, where indicator plant species were identified and techniques of habitat type mapping were outlined.

The week-long program included field experience in identification, mapping and interpretation of habitat types. Current central Idaho habitat type classifications, and new classifications for the Nezperce National Forest area were presented in slide form.

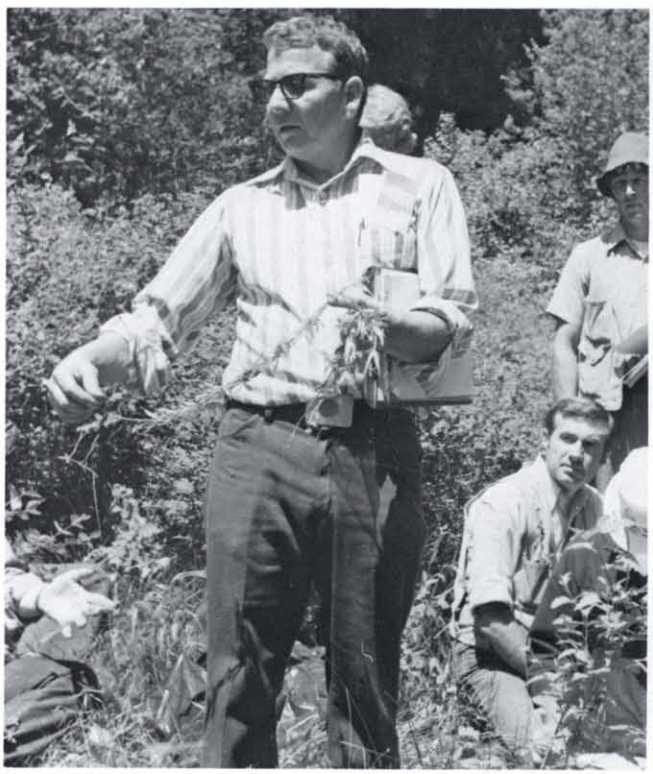
The course was offered in cooperation with the USDA Forest Service Intermountain Forest and Range Experiment Station. Course credits were awarded through the University of Idaho Office of Continuing Education.

AERIAL PHOTO INTERPRETATION-AERIAL PHOTOGRAPHY WORKSHOP

This one-week workshop is conducted annually for natural resource land managers and persons who have not had training in aerial photo interpretation techniques, or who need a refresher.

The workshop emphasizes fundamentals of aerial photography and interpretation, including demonstrated applications and much practical work with aerial photos. Such subjects as ways of obtaining aerial photographs, small format camera systems, principles of photo interpretation, vegetation and landform interpretation, measurements on aerial photos, mapping with aerial photos, and multistage sampling are covered. Advanced remote sensing systems are also introduced with a critique on their effectiveness and cost.

Associate Professor of Forest Resources, Joseph J. Ulliman directs the workshop, assisted by Robert C. Heller, Research Professor of Forest Resources and Professor of Geology William B. Hall. The workshop is sponsored by the College of Forestry, Wildlife and Range Sciences and the Office of Continuing Education which offers 3.2 continuing education credits for the program.



Identification of indicator plants plays an important part in recognizing habitat types. Daily field sessions brought students into direct contact with plants under a variety of growing conditions. Here, Professor Frederic Johnson introduces a plant and describes its characteristics.

In Memoriam

Ernest W. Wohletz

Ernest W. Wohletz, who from 1953 to 1971 guided the College of Forestry, Wildlife and Range Sciences as its dean, died in the closing months of 1976. For more than 20 years, the development of the College and the life of Wohletz were one in direction. So firm was his belief that students must be grounded in the basics of forestry, he was able to interest them, in spite of themselves, in the courses which he taught. Wohletz earned bachelor's and master's degrees in forestry from the University of California Berkeley. He spent 2 years with the U. S. Forest Service, and returned to teach for 2 years at Berkeley before coming to the University of Idaho. Familiar with the operation of forestry summer camp at the University of California, he joined the forestry faculty in 1937 just as the then School of Forestry was launching its own summer camp program on Payette Lake. His direction of instruction and construction, from tent stage to lodge, filled more than a dozen years. His interest in the camp never waned, and he remained one of its staunchest advocates. His teaching duties in biometry, mensuration, economics and policy, in addition to his constant presence at summer camp, brought him into close contact with forestry students for 35 years. His selection as Dean in 1953 was warmly endorsed by faculty, students and almuni alike. And so it was that the Nekoma, North Dakota native, who grew up in Los Molinos, California, took over the official running of the College. He had already served as the first Associate Director of the Forest, Wildlife and Range Experiment Station, established in 1939.

Under his Deanship, the faculty increased three-fold, and the student enrollment more than doubled. Doctoral programs were initiated within the College, and financial support for research grew until teaching and research time allotments were rewarded equally. The Point Springs Experimental Area in southern Idaho was added for range research in 1955. The Idaho Cooperative Sport Fishery Unit, a federally-supported program, was obtained in 1963, augmenting the fisheries program wich had begun in 1950. As the College expanded and overflowed Morrill Hall, plans were made for the new $3.5 million classroom and research building, which was dedicated in 1971, the year in which Wohletz retired. A highly regarded professional, he held office, including the chairmanship, in the Society of American Foresters Inland Empire Section, and served on the SAF Committee for the Advancement of Forestry Education, the national agency for accreditation of forestry schools. He served as the University representative to the old Pacific Coast Athletic Conference, and was a member of the natural resources committee of the U. S. Chamber of Commerce, and the Western Forest and Conservation Association's land use committee. The scholarship established following his retirement has now become a fitting memorial, the Ernest Wohletz Forestry Scholarship Fund, continuing to aid those forestry students to whom he dedicated his life.

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 Professor (Wildlife Resources)
Bjornn, Theodore C., Leader, Cooperative Fishery Research Unit and Professor (Fisheries Resources)
Booth, D. Terrance, Range Research Scientist
Bottger, Richard F., Assistant to the Directors
Burlison, Vernon H., Extension Forester and Extension Professor
Canfield, Elmer R., Associate Professor (Forest Resources)
Chacko, A. Jim, Visiting Research Scientist (Fisheries Resources)
Chacko, Rosy, Research Scientist (Forest Resources)
Cheng, Fong-Chian, Research Scientist (Fisheries Resources)
Christophersen, Kjell A., Assistant Professor (Forest Products)
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, Professor (Fisheries Resources)
Fazio, James R., Associate Professor and Chairman (Wildland Recreation Management)
Flinders, Jerran T., Associate Professor (Wildlife Resources)
Garton, Edward O., Assistant Professor (Wildlife Resources)
George, Willard L., Research Technician (Wildlife Resources)
Godfrey, L. Bruce, Associate Professor (Range Resources)
Gordon, Roger R., Research Associate (Forest Resources)
Hanley, Donald P., Research Instructor (Forest Resources)
Harris, Margaret M., Research Associate (Forest Resources)
Hash, Howard S., Research Associate (Wildlife Resources)
Hatch, Charles R., Experiment Station Statistician and 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 and Chairman-elect (Forest Products)
Hornocker, Maurice G., Leader, Cooperative Wildlife Research Unit and Professor (Wildlife Resources)
Houck, Geoffrey 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 Instructor (Wildlife Resources)
Ivins, Robert E., Research Associate (Wildland Recreation Management)
Johnson, Frederic D., Professor (Forest Resources)
Johnson, Leonard R., Associate Professor (Forest Products)
Kessler, Winifred B., Assistant Professor (Wildlife Resources)
Kibbee, Darline L., Wilderness Research Center Editor
King, John G., Assistant Professor (Forest Resources)
Klontz, George W., Professor and Chairman (Fisheries Resources)
Koehler, Gary, Research Technician (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)
McLaughlin, William J., Assistant Professor (Wildland Recreation Management)
Medema, E. Lee, Assistant Professor (Forest Products)
Messick, John P., Research Associate (Wildlife Resources)
Mika, Peter G., Research Associate (Forest Resurces)
Miller, Brian A., Research Technician (Range Resources)
Mitchell, John E., Assistant Professor (Range Resources)
Mitchell, Kenneth J., Associate Professor (Forest Resources)
Moore, James A., Research Instructor (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)
Orme, Mark, Research Associate (Wildlife Resources)
Osborne, Harold L., Research Associate (Forest Resources)
Partridge, Arthur D., Professor (Forest Resources)
Peek, James M., Associate Professor and Chairman (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)
Reggear, Robert C., Experimental Forest Assistant Manager
Ringe, Rudy R., Research Associate (Fisheries Resources)
Sanders, Kenneth D., Assistant Professor (Range Resources)
Scanlin, David C., Assistant Research Professor (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., Professor (Forest Products), Assistant Dean, Coordinator of International Programs
Stark, Ronald W., Professor (Forest Resources)
Stellmon, Barbara B., Lab Technician (Forest Resources)
Stoszek, Karel J., Associate Professor (Forest Resources)
Thurow, Thomas, Research Technician, Taylor Ranch
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 Research Unit and Assistant Professor (Fisheries Resources)

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.

FISHERIES RESOURCES

Response of selected salmonids to flow reductions in artificial stream channels. D.H. Bennett.

A survey of existing information on Franklin D. Roosevelt Lake. D.H. Bennett, R.G. White.

Development of a generalized model to predict spawning success of fishes in reservoirs with fluctuating water levels. D.H. Bennett.

Habitat selection and spatial interaction in allopatric and sympatric populations of cutthroat and steelhead trout. T. C. Bjornn.

Behavior of juvenile steelhead trout in fluctuating and constant temperatures. T. C. Bjornn.

Life history of St. Joe River cutthroat trout. T. C. Bjornn.

Salmon and steelhead production and yield studies, Lemhi Big Springs Creek. T. C. Bjornn.

Special angling regulations in management of cutthroat trout. T. C. Bjornn.

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

Yield of salmon and steelhead smolts as related to escapement – Lemhi River. T. C. Bjornn.

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

Aquatic resources of Silver Creek at the Nature Conservancy site. T. C. Bjornn.

Wolf Lodge Creek cutthroat trout studies. T. C. Bjornn.

Evaluation of various hatchery rearing conditions on the seaward migration of steelhead trout. T. C. Bjornn.

Lower Snake River limnology. C. M. Falter.

Factors controlling Dworshak Reservoir productivity. C. M. Falter.

Conversion of U. S. Coast Guard launch to limnological research vessel. C. M. Falter.

Limnologic evaluation and zooplankton dynamics of Lake Koocanusa, northwest Montana. C. M. Falter.

Efficacy of selected antibiotics in the prevention and control of bacterial kidney disease. G. W. Klontz.

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

Control of enteric redmouth disease in rainbow trout. G. W. Klontz.

Aquaculture discharge quality. G. W. Klontz.

Epidemiology of respiratory disease of juvenile anadromous salmonids. G. W. Klontz.

Development of selective fish toxicants. Craig MacPhee.

Selective chemicals for the control of the threespine stickleback. Craig MacPhee.

Selective chemicals for the control of suckers. Craig MacPhee.

Effects of reduced nighttime flows on adult chinook salmon and steelhead trout in the lower Snake River. R. G. White.

Potential effects of peaking on fish and aquatic macroinvertebrates in South Fork Boise River below Anderson Ranch Dam. R. G. White.

RANGE RESOURCES

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

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

Successional patterns of vegetation in Boise National Forest. K. D. Sanders.

Mineral supplements for control of larkspur poisoning in cattle. L. A. Sharp.

Evaluation of range seeding. L. A. Sharp, K. D. Sanders.

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

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

An investigation of multiple-use capabilities of forest-associated range in the Central Idaho Batholith. L. A. Sharp, Minoru Hironaka.

Ecology of the grasslands of the Snake River and Salmon River systems in Idaho. E. W. Tisdale, Minoru Hironaka.

FOREST RESOURCES

Scaling defective cedar logs. D. L. Adams.

Regeneration of meadow associated forest stands in central north Idaho. D.L. Adams.

Fugitive dust emission from haul roads associated with surface mining. G. H. Belt.

Predicting the effects of forest practices on streamflow using the equivalent clearcut area model. G. H. Belt.

Dow Corning silicone antitranspirant study. G. H. Belt, J. G. King.

The impact of artificial defoliation of forest trees. E. R. Canfield, A. D. Partridge.

Wood-inhabiting fungi. E. R. Canfield.

Administration of McIntire-Stennis programs. J. H. Ehrenreich.

Evaluation of Forest Practices Act in relation to water quality. J. H. Ehrenreich.

Intensive culture of forests of red cedar, western hemlock and grand fir habitat types. J. H. Ehrenreich, D. L. Adams, J. M. Peek, Howard Loewenstein, K. J. Stoszek.

Crown ratio models. C. R. Hatch.

Modeling forest biomass. C. R. Hatch.

Classification of tree and stand variables into foliage biomass estimates. C. R. Hatch.

Inventory of irrigated lands on selected areas in southern Idaho. R. C. Heller.

Identification of preferred Douglas-fir tussock moth sites. R. C. Heller, J. J. Ulliman.

Remote sensing study of recreational boating use. R. C. Heller.

Ecology, distribution and utilization of Idaho woody plants. F. D. Johnson.

Stump key for northern Rocky Mountain conifers. F. D. Johnson.

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

Development and field application of techniques for monitoring sediment from forest roads. J. G. King.

Biological relationships of high mountain streams in the Gallatin and Madison river basins, Montana. J. G. King.

The biology and ecology of the wounded tree beetle *Nosodendron californicum*. D. L. Kulhavy, H. L. Osborne.

The influence of grand fir stand characters and management practices on bark beetle population and damage levels, stand regeneration and growth. J.A. Schenk, J.A. Moore, D.L. Adams, R.L. Mahoney.

Hazard rating lodgepole pine stands for mountain pine beetle. J.A. Schenk, R.L. Mahoney.

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

University of Idaho experimental forest research. Howard Loewenstein, D. L. Adams.

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

Disease-insect interactions in forest trees. A. D. Partridge, E. R. Canfield.

Idaho tree diseases and defects. A. D. Partridge, E. R. Canfield.

Techniques to identify, quantify and predict decays and diseases of timber in the inland northwest. A. D. Partridge, E. R. Canfield.

Mass production of lodgepole and jackpine hybrids. F. H. Pitkin, Howard Loewenstein.

Seedling container development. F. H. Pitkin.

Revegetation of areas affected by mining in Idaho. F. H. Pitkin, Howard Loewenstein, J. E. Mitchell.

Impact of initial density and juvenile spacing on yield. K.J. Mitchell.

Influence of competition from nearby trees on the selection of western hemlock plus trees. R.D. Stevens, D.R. Reimer, K.J. Mitchell.

Integrated pest management: for control of major pine bark beetles. R. W. Stark.

Relationship of site and stand attributes and management practices to Douglas-fir tussock moth epidemics. K. J. Stoszek, J. A. Moore, P. G. Mika, H. L. Osborne.

Host conditions and insect relationships of lodgepole pine and mountain pine beetles. K. J. Stoszek.

Physiological environment of grand fir in relation to DFTM hazard sites. K. J. Stoszek, P. G. Mika, H. L. Osborne.

Aerial photo interpretation key for west-central Idaho. J. J. Ulliman.

Aerial photo volume table for west-central Idaho. J. J. Ulliman.

Occurrence of farming practices in Idaho: with special reference to remote sensing. J. J. Ulliman.

Practical application of aerial photography, aerial photo interpretation to land management needs. J. J. Ulliman, R. C. Heller.

Genetic studies of *Larix*. C.W. Wang.

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

ERDA Raft River geothermal water ground heating and biomass production. C. W. Wang.

Cooperative forest-tree improvement program for the Inland Empire Region. C. W. Wang.

Cooperative ponderosa pine improvement program of southern Idaho. C. W. Wang.

Demonstration of thermal water utilization in forestry, Arco and Hanford projects. C. W. Wang, J. P. Howe.

WILDLAND RECREATION MANAGEMENT

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

An analysis of economic and social factors of skiing in northern Idaho. J. E. Hoffman.

An analysis of economic and social factors of state parks in northern Idaho. J. E. Hoffman.

Relative value of water-related outdoor recreation activities. J. E. Hoffman.

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

Computer modeling in wilderness management education. J. H. Schomaker.

A conceptual framework for understanding recreation – Fishbein model and wilderness recreational use. J. H. Schomaker.

WILDLIFE RESOURCES

Bighorn sheep research in the Idaho Primitive Area. E. D. Ables.

Inventory of riparian habitats and associated wildlife along the lower Clearwater River and Dworshak Reservoir. D. A. Asherin.

The Rocky Mountain population of the Great Basin Canada goose. E. G. Bizeau.

Distribution and density of chukar partridge populations along the Snake River. E. G. Bizeau.

Reestablishing whooping cranes in the western United States. E. G. Bizeau, R. C. Drewien.

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

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

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

Ecology of the black bear in west-central Idaho. M. G. Hornocker.

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

Predator-prey relationships on the Snake River Birds of Prey Natural Area. M. G. Hornocker.

The population dynamics of the river otter in north-central Idaho. M. G. Hornocker.

Pocket gopher behavior in relation to bait attractants. K. E. Hungerford.

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

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

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

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

Relationship of productivity and biomass of forest communities and associated ungulates to forest fire. J. M. Peek.

Winter movements and behavior of a Pahsimeroi mountain goat herd. J. M. Peek.

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

Physical properties of western white pine. A. D. Hofstrand.

Technical and economic practicality of new lumber products made from Idaho's dead pine trees. J.P. Howe, Kjell Christophersen.

Technical and economic practicality of dowel-laminating crossties before drying. J. P. Howe.

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

Skidding systems to match small log utilization machines. L. R. Johnson.

Investigation of unconventional energy sources. L. R. Johnson.

Compilation of growth and yield data. A. A. Moslemi.

Idaho Forest Productivity Study. K. M. Sowles, C. R. Hatch, Kjell Christopherson.

Idaho statewide 208 water quality management project. K. M. Sowles, A. D. Partridge, J. H. Ehrenreich.

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