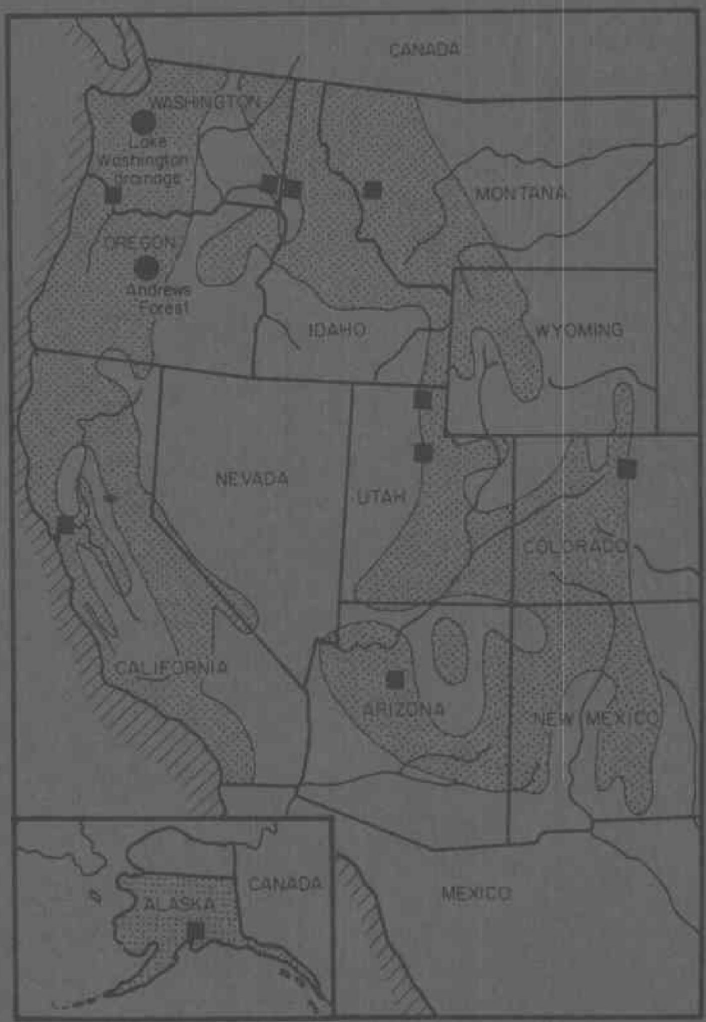
CONIFEROUS FOREST BIOME

ECOSYSTEM ANALYSIS
INTERNATIONAL BIOLOGICAL PROGRAM



PROPOSAL FOR 1973 AND 1974

VOLUME II

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Vol. II APPENDIX

4. PROGRESS REPORT OF THE YEAR-1 and YEAR-2 PROGRAMS

4.1. General

4.1.1. Objectives

The objectives during 1971, the first year of operation of the Biome, were: (1) to review available information for the development of preliminary models with an emphasis on the terrestrial-aquatic interface system, and (2) to initiate studies of poorly understood processes and elucidate functional relationships such as (a) productivity relations between trophic levels and to sources of energy and nutrients, (b) effect of nutrients on energy conversions in systems, (c) effect of biogeochemical and environmental factors on nutrient and energy transfers, (d) effect of manipulations of terrestrial systems on the transfer processes, (e) effect of competition, harvest, and terrestrial manipulations on fish production, and (f) effect of meteorological conditions on specific processes within the ecosystems.

The objectives for 1972 are: (1) to complete the selected ecosystem descriptions at the intensive sites, (2) to develop additional information for modeling of transfer mechanisms and pathways of nutrients, particulate matter, energy, and water at various levels of detail, (3) to model assembled information on aspects of (a) disruptive influences by terrestrial consumers on producers, (b) environmental influences on terrestrial primary production, and (c) extrapolation from one scale of study to a larger scale, and (4) to further develop the coordination program.

This progress report is based mainly on the information of the individual subproject annual reports published in the Biome internal report series (see section 4.3). The more general observations are based on minutes of Biome meetings and informal discussions with participating scientists.

4.1.2. Accomplishments and new developments

Cooperation between the University of Washington, Oregon State University, and the USDA Forest Service Pacific Northwest Forest and Range Experiment Station has increased considerably, replacing much of the original competition at various levels of interaction. Meetings, exchanges of information, and phone conferences are being conducted on a nearly routine basis, strengthening the ties between the main institutions of the program. Several natural but complementary differences in existing programs and research strategies between the three institutions have now been welded into a mutually satisfying program that arose much stronger than was expected by many sceptical observers, including the funding agency.

Unique developments resulting from the cooperative approach to ecosystem analysis are still in the preliminary and testing stages, but a few examples already can be mentioned. Most of the developments are associated with efforts to generate information on linkages between subsystems, previously neglected by traditionally defined subject matter categories. For example, considerable effort has been made to focus attention on the terrestrial-aquatic interface involving transfer processes of materials, water, and energy. A number of separate studies on unit watersheds have been partially reoriented to serve, in addition, a function in the terrestrial-stream interface studies. Similarly, a number of investigators have developed a unique interdisciplinary interface project focused on transfer processes in a small terrestrial-lake system. At a more detailed level of resolution, a group of investigators have developed and tested a soil-plant-atmosphere interface study involving a few 27.4-m trees, one of which has been encased in situ in a weighing lysimeter.

A new technique utilizing tritium in transpiration and biomass measurements of large trees also has been incorporated in the current program. Similarly, the application of paired-theodolite surveying techniques using a laser spot-marker to map tree dimensions is being tested with large trees. Equipment and techniques recently developed for fish population dynamics studies are now being tested extensively and incorporated in the lake studies. Application of marine science techniques to the measurement of oxygen consumption in lake water in conjunction with other decomposition studies is a rather interesting development resulting from closer cooperation between participants in the aquatic disciplines.

4.1.3. Impacts on Biome community

The integration of research programs in the Coniferous Forest Biome has already had a definite impact on the participating scientists, institutions, and the public in general. For example, several U.S. Senators visited the two intensive sites last summer for orientation on the current controversies of land use practices and related research being conducted, and one of them admitted in public afterward that his opinions had been modified. The further planning and development of an ecosystem-oriented program for future years has forced participating scientists of various traditional discipline-oriented research endeavors to work together with some spectacular results. For example, scientists studying fire behavior and fire ecology in the Biome region have been coordinated to develop a study program using ecosystems analysis and modeling techniques. This effort has been very successful and a working group established itself to pursue conceptual and mathematical modeling of the role of fire in forest ecosystems. A similar development can be quoted for scientists studying the role of diseases in forest ecosystems.

Interactions between individual investigators from different disciplines are amazingly frequent and productive, resulting in a better familiarity with the research needs of other participants. Time, energy, and attention of the scientist can now be focused on the main specialty problems at hand with much less concern for the development of supporting information, which is taken care of by others.

Frequent discussion focused on the assembly of conceptual models resulted in the formulation of several subsystem word models that are now being distributed for wider review and criticism within the Biome. Considerable influence from the mathematically oriented participants has been perceived in the sharpening of conceptual hypotheses, model structure, and definition of missing crucial information. Vice versa, the mathematical modelers have been able to learn from the biologists and to adjust to their views.

The impact of the Biome program on the educational programs of the participating institutions is pronounced. Graduate students introduced to the concept of multidisciplinary ecosystem analysis are fired by the imaginative new possibilities and the increased efficiency in acquisition of professional information. The idea of precise formulation of conceptual models and the subsequent expressions of these models in mathematical functions suitable for computer-assisted integration is one that intelligent students value very highly. Half a dozen formal university courses at UW and OSU have been initiated or expanded to incorporate the conceptual and mathematical modeling efforts of the Biome in the curriculum. The participation of these students in IBP and the Coniferous Biome research may itself lead to some of the best long-range benefits of the program. Educational impact on a higher level has been noticeable by the presence of visiting scientists from other countries and faculty members on leave from other institutions who are studying our approach and modeling efforts.

4.1.4. National and international cooperation

On a national level of cooperation there has been considerable interaction with the other Biomes and with other institutions, especially the USDA Forest Service. Scientists invited from the Grasslands and Desert Biomes assisted the research committees in the formulation of subprograms. Participation in national meetings and workshops by scientists from the Coniferous Biome has been influential in widening the scope and identifying the relative position of Biome work. A cooperative program for the development of a semi-intensive site in the ponderosa pine--grassland area has been initiated with active participation by the USDA Forest Service. A visit by members of the Coniferous Biome executive directorate to the Deciduous Biome has been very fruitful in terms of program orientation, comparison of strategies, and the development of cooperative programs. Planning for better information exchange between Biomes, a cooperative program on photosynthesis, and information and model development of successional trends in ecosystems has been initiated.

Direct international contacts have existed through individual initiatives and visits by some Biome participants from the very beginning of the Biome program development. Cooperative projects therefore were developed at an early stage. The program currently incorporates three separate ventures: one project involves the analysis and modeling of photosynthetic field data collected by German investigators, and the other projects are on-site field studies of soil mesofauna and of old-growth tree biomass by visiting Japanese scientists. In addition, a world-renowned participant of the ecological sciences group from Canberra, Australia, will be a visiting scientist during the summer of 1972 to assist with tree physiological investigations, and to study the structure and operation of the Biome.

The success of the efforts with international coöperative project developments has stimulated more interest in this direction and new direct channels of communication with participants in IBP efforts in Europe and Southeast Asia will be established during the year. The Fifth Assembly of the IBP in Seattle during August/September 1972 will materially assist efforts by this Biome in international exchange of information.

4.1.5. Workshops and symposia

Workshops have been conducted in the Biome to develop a better integration of ongoing and new studies within subsystem programs. The decomposition processes committee under the direction of Taub held a workshop on 23-24 April 1971 to develop an integrated program. Units and data recording of biomass, fluxes, species density, community structure, and indexes of decomposition were discussed. Representatives were present from the Grasslands Biome, the Desert Biome, and the Eastern Deciduous Forest Biome.

The aquatic group of scientists in the Biome organized a workshop on the strategies of modeling of aquatic systems on 16-19 February 1972 in Corvallis. It was attended by more than 30 scientists, with representatives from the other Biomes and from several non-IBP organizations. There was considerable interest in the discrepancies that have been found in the biomass model predictions of the sockeye salmon lake system, such as the apparent lack of correlation between zooplankton and salmon biomass fluctuations. A report by Donaldson, Sedell, and Warren will summarize the results of this workshop.

The Grasslands Biome organized a series of modeling workshops early this year which were attended by three predoctoral participants of the Coniferous Biome. They reported considerable satisfaction with the techniques and instruction employed and gained a better appreciation of the modeling effort in the Grasslands Biome. They are now contributing to the development of working models to be published as a Grasslands Biome technical report, which will be available for wider distribution.

The genetics technical committee in our Biome held a workshop during April 1972 to define the modeling concepts as related to ecosystem functions and to establish a working basis for integrated work with the various research committees. A report will be issued by Stettler for wider distribution within the Biome and to form a basis for discussions during the Western Forest Genetics Association meeting, August 1972, Corvallis, Oregon.

Similarly, the coordination site subsystem programs on fire, disease, and historical climates intend to organize several workshops during 1972 to focus on the problems of information exchange and conceptual modeling of the influence of fire, disease, and climate in forest ecosystems.

A Biome symposium was held on 23-24 March 1972 concurrent with the Northwest Scientific Association annual meeting at Bellingham, Washington and was organized by Franklin, Cole, and Waring. The program first introduced a general view of the Biome philosophy, research strategy, and activities, with some examples of large subsystem programs. General conceptual and mathematical models developed during the past year were then presented. More detailed studies and models of subsystems processes, state variables, and research techniques concluded the symposium. The reports were variable in quality, but it was important that for the first time Biome participants, including many from the coordination programs, were in direct contact with people and work examples representing the total program efforts on the intensive sites. Total attendance was estimated at about 140 people, including representatives from the Eastern Deciduous Forest and Grasslands Biomes. The proceedings containing the full papers will be published by the USDA Forest Service Northwest Forest and Range Experiment Station during the summer of 1972.

4.2. Subsystem program and subproject reports

4.2.1. Integration division

Modeling management. The first year of operation of the Biome has resulted in a number of conceptual word models of total ecosystem and subsystems, and a few mathematical computer models of subsystem processes. These results are presently in circulation for critical review within the Biome. The conceptual word models form a basis for much of the future program planning. The mathematical models are being tested with data collected over the past year and refinements are being made to eliminate discrepancies. Further model validation by new data sets from different sites and over more seasons is being planned. This simulation of ecosystem processes with computer models results in advance information because of the applied time compression. Limitations, however, are imposed on these predictions by a variety of unknown internal interactions cancelling out discrepancies and biases, and by the very limited information on the limits of confidence of the estimated output values. The relative immobility of expensive field equipment imposes severe limitations on the measurement of variation in space, but some good information on variation in time has been accumulated.

It has been remarked that the Coniferous Forest Biome has a truly democratic structure indeed, which very much reflects the desires of the participating scientists. The absence of a central model defining the scientific tasks of participants has been pointed out by many critics of this program. This lack of authority, however, also is the strength of the Biome program in that creative new adaptations or concepts are allowed to emerge and to influence the structures of our ecosystem concepts, which in turn change with the acquisition of new information. This finds an expression in the development of subsystem and process models deemed important by the various research groups in the context of the long-term and annual objectives of the Biome research program. Efforts also are being made to develop an overall ecosystem model that can accommodate these subsystem models in a modular hierarchial fashion by the definition of compatible couplings. During the first few years of Biome research these total ecosystem models will remain word models useful to direct general program efforts. In later years, mathematical ecosystem models will be developed based on the subsystem and process computer models presently being assembled.

As was pointed out above, the modeling activities in the Biome are fairly diffuse throughout the organization. Each of the research committees within the terrestrial and aquatic divisions is assisted by a specialist modeler who is in turn a member of the modeling management group. Reports of these subsystem modelers on past work and results are included with those of the corresponding research committees. Report abstracts of the ecosystem modelers follow in the next few paragraphs.

Another major activity was in the area of theoretical model structures and concepts. Papers were presented by Overton and co-workers on these ideas at the AIBS meeting in August 1970 and at the Northwest Simulation Conference in April 1971. Several points are of interest. The universe-coupling structural approach to the ecosystem model is considered as contrasted to the state-variable approach generally assumed. The universe-coupling approach seems at this point to lend itself nicely to modular hierarchial model structures allowing variable (nested), temporal resolutions.

A note was prepared by Overton on the subject of sensitivity analysis, calling attention to the connection with conventional statistical ideas (e.g., propagation of error) and defining what appears to be a major unresolved problem of complex systems, i.e., the problem of too many variables for adequate study of system behavior. Since propagation of error is basic to problems of validation, it appears that solution of this problem should receive high priority in the modeling effort.

Another major activity was a series of discussion-workshop sessions, which was called "Round One of Model Synthesis." This consisted of a series of four consecutive, weekly, two- to three-hour sessions for each of the major subsystems and required some six months for completion. Questions raised for each subsystem were: (1) identification of the other subsystems; (2) identification of internal structure of the subsystem of concern; (3) a definition of resolution in time, space, organization, and precision, and (4) general consideration of ongoing projects in light of model developments of "Round One." Reports were written for each subsystem and an overall report has been published (Biome contribution 23).

Warren and his co-workers, mainly with non-IBP funding, developed graphical and logical models of the production of fish consumers based on biomass and age structures. Density phenomena were used in the trophic steps from light and nutrients to algae, herbivores, and consumers, including competitive pathways. Presently, mathematical models for individual consumers are being developed, including variation with data from various sources. The mathematical models utilize difference equations with positive and negative feedback loops. The equations describe recruitments, mortality, consumption, metabolism, and growth patterns. Data assembled from lake and stream systems in the Biome are being used, as no complete set from a single site is available. The work is closely related to the sockeye lake models being developed with existing data from the Alaskan Wood River lake systems, Oregon's Lookout Creek, and the Weyerhaeuser St. Helen's streams in Washington. A publication reporting the above work is available (Biome contribution 2).

Hatheway reproduced the Grasslands Biome total ecosystem model on the University of Washington computer and studied it to evaluate its structure and applicability to coniferous forest ecosystems. Many differences in root/shoot ratios, herbivorous influences, and aspects of aquatic ecosystem sections kept this effort merely to an exercise. Overton at Oregon State University studied the questions of resolution, time and space variability, compatibility of nested units of time measurements, and the use of "information" as a carrier variable.

Ecosystem interfaces. Interface studies represent a degree of cooperation and planning that is difficult to achieve within the existing structures of scientific investigation. One such effort, however, is already taking shape in an atmospheric-terrestrial interface study, focusing around the newly established lysimeter containing a large forest tree in the Thompson Research Center. Fritschen/Kinerson/Cox built the 366-cm-diameter and 122-cm-deep lysimeter around the root ball of a 28-m Douglas-fir tree during the summer of 1971, using IBP funds from the intensive site budget and federal surplus equipment and materials. The weighing mechanism is a coiled, water-filled rubber tube under the lysimeter and is connected to a standpipe. Weight differences are corrected for temperature effects and presently are recorded continuously by a differential pressure transducer. Sensitivity for the 29-metric-ton system is 22 ppm. The tree is loosely guyed to three surrounding instrument- and crown-access towers, and the lysimeter is drained by suction from buried ceramic tubes. A report describing the installation has been published (Biome contribution 41).

This system will be the centerpiece of studies on (1) photosynthesis and gas exchange by Walker/Reed, (2) transpiration and water transfer by Scott, (3) mineral cycling analysis by Cole/Gessel, and (4) meteorological methodology by Fritschen/Gay/Belt. The tree will remain under close scrutiny by Walker/Driver for possible physiological or pathological damage.

The terrestrial-aquatic interface is being studied in two subdivisions of effort: (1) terrestrial-stream systems, and (2) terrestrial-lake systems.

The terrestrial-stream system is brought to focus by Waring/Fredriksen/Hall on the calibrated unit watershed 10 of the Andrews research site. The previously mentioned terrestrial producer and consumer inventory and process studies are being oriented partly toward the evaluation of outputs to the stream system. Populations of insects, amphibians, and reptiles are being investigated to evaluate their role in the interface transfer processes. Routine water analysis from past calibration studies will form the basis for nutrient cycling and system addition-and-loss models. Information developed on stream ecology, production, consumers, and decomposers will be incorporated in further planning of an integrated interface study.

The terrestrial-lake system is being developed by Cole/Olson/Whitney in the Findley Lake unit watershed of the Lake Washington--Cedar River drainage. Snow accumulations remained until mid-July and interfered with much of the work planned for this year. Ugolini/Bockheim surveyed the watershed for its geologic and soil features. Many of the slopes range from 30% to 40% grade and widespread talus is present on east and west slopes. The geology is mainly andesitic with mixed materials and highly variable parent materials. Podzols have been observed with thick organic top layers, weak A-2 horizons associated with volcanic ashes, and weak B horizons of cemented organic matter and iron. Some well-drained meadows have stratigraphic records since the last major glaciation (Evans Creek Stade, Frazier Glaciation, 15,000 to 20,000 years ago). Del Moral conducted a vegetation survey utilizing 27 plots and describing species, density, cover, and frequency. Seven vegetation types were distinguished and the distribtuions were mapped, but most vegetation is relatively homogenous old-growth *Abies amabilis*. Ordination analysis is presently in progress. Tsukada collected six 1-m-long cores of the lake bottom under about 20 m of water. Paleoecological analyses will be made of diatoms, pollen, and other indicators. The techniques were developed with non-IBP studies of sample cores from Angle Lake near the Seattle-Tacoma Airport. Paulson identified populations of microscopic benthic invertebrates and reported that mayflies and caddis flies were the dominant consumers in the lake. Amphibians were observed breeding within six weeks after the snow cleared from the lake's surface. Welch/Spyridakis initiated aquatic studies by analysis of water samples in terms of nutrient content and primary productivity, which was determined as 370 mg of carbon m^{-2} day^{-1}. Visibility in the lake was to 15 m depth. The fishless lake has been confirmed to be unmanipulated by man. Reports on the first year's work have been published (Biome contributions 11 and 20).

Coordination programs. Coordination programs with nonintensive areas elsewhere in the Biome have been developed under the leadership of Laycock. The major function of these programs is to acquire a much wider data base for the validation and extrapolation of the subsystem and process models presently being developed from the intensive sites. The coordination of a multitude of ongoing ecological research programs is also an important function of the IBP effort.

There are four kinds of projects proposed for coordination programs: (1) those closely associated with programs at the intensive sites, (2) those involving the acquisition of existing information from other areas in the Biome, (3) those developing models describing influences on ecosystems such as fire and disease, and (4) those that link intensive site studies to other total ecosystem and subsystem studies in the Biome region.

Coordination studies intimately linked with the intensive sites include the simulation of hydrologic properties of unit watersheds by Riley and associates at Utah State University, tritiated water experiments to estimate transpiration and biomass by Kline of Argonne National Laboratory, photosynthetic studies on ponderosa pine and other conifers in the Sierra Nevada of California by Helms at the University of California at Berkeley, studies of aquatic insects by Gaufin at the University of Utah, and validation of an Oregon State University stand-level primary production model by Daniels and Hart of Utah State University.

Information acquisition includes a review of hydrologic literature and unpublished data by Hart and associates at Utah State University and a review of stream and lake systems by Gaufin and associates of the Intermountain Aquatic Biome Consortium, including Maslin of Chico State College. There will also be a review of the subalpine forest literature by Barney of Colorado State University and an analysis of unpublished stream system data by Haydu of Weyerhaeuser, Longview, Washington.

Studies focused on certain parts or influences operating upon or within forest ecosystems are exemplified by investigations on fire in coniferous forests and associated aquatic ecosystems under the direction of Behan at the University of Montana, studies on the role of diseases in forest ecosystems under the direction of Partridge at the University of Idaho, historical analysis of tree growth to discover the influence of past climates on present-day structure of coniferous forests under the direction of Fritts at the University of Arizona.

Total ecosystem analyses are being conducted at the Lubrecht Experimental Forest of the University of Montana; at Little South Fork of Cache la Poudre River by Colorado State University; at San Juan weather modification project sites by Colorado State University; at Logan Canyon in the Cache National Forest by Utah State University and the USDA Forest Service Intermountain Forest and Range Experiment Station; at the Northern Arizona University School Forest, the Fort Valley Experimental Forest, and the Beaver Creek watershed by the University of Arizona and USDA Forest Service Rocky Mountain Forest and Range Experiment Station; and at Priest River Experimental Forest by the University of Idaho, Washington State University, and the USDA Forest Service Intermountain Forest and Range Experiment Station.

4.2.2. Terrestrial division

Vegetation biomass and structure studies. Lavender has compiled a literature and he has planned work in connection with studies on litterfall. His review of the extensive world literature on biomass and weight relationships in coniferous forest stands revealed that no data are available from trees even approaching the size and age of the old growth at the intensive sites. This is equally true of volume and yield tables and other forestry mensurational information. Hence it has been concluded that some biomass harvests will be essential in order to establish the validity of extrapolating published information and relationships to old-growth and high-volume stands.

Work on nondestructive measures of biomass and productivity continued in cooperation with the U.S. Army Corps of Engineers. Theodolite measurements were made of trees at the Thompson Research Center before and after the 1970 growing season. Results have been analyzed and published, and the technique appears promising for nondestructive measurement of dimensional changes of trees and stands (Biome contribution 33). Theodolite measurements of old-growth trees at the Andrews research site will be made with improved instrumentation during 1972.

Problems of spatial and temporal variation in vegetation had been recognized and inventory and environmental studies are focused on these aspects. Dyrness/Franklin/Zobel continued inventory and mapping of vegetation communities at various degrees of intensity on the Andrews Forest. Twenty-three forest communities were characterized by similarity and ordination analyses indicating that strong temperature and moisture gradients are operative. A resulting checklist of vascular plants has been published by the USDA Forest Service as contribution no. 1 to the Biome work. Fourteen reference stands were selected for more detailed studies. Furthermore, detailed vegetation mapping (scale 1:2000) of selected unit watersheds was undertaken and finished, recording vegetation types, regeneration, and overstory and understory characteristics such as composition, age, and coverage. A publication of these efforts is in preparation.

Zobel/Dyrness/Waring/McKee pursued field studies of environmental factors in conjunction with the above vegetation inventory studies by the installation of air and soil thermographs, and by periodic measurements of moisture stress in the reference stands. Understory vegetation was periodically sampled for chemical analysis, and phenological data were recorded. The data indicated the formation of an elevational temperature inversion with clear warm-weather patterns. Predawn plant moisture stress was low during this relatively moist year with a late spring and a 1.25-cm rainstorm during mid-August.

Modeling efforts were made by Waring tp predict spatial diversity from integrated environmental indexes. Prediction of daily transpiration can be based on predawn moisture stress, air temperature, and air humidity. The ratio of actual to potential transpiration appears to be a very useful index of integrated environmental factors. Correlation of this index with a productivity index (dominant heights, steady-state forests) accounted for 86% of the variation in height. The result of these efforts has been published (Biome contribution 26).

Preliminary work toward development of a standard model for forest productivity has been initiated by Overton. The computer models that already exist, such as those by Lee and Arney, have been reviewed and alternative approaches are being developed. Assistance was given in the development of sampling plans for several programs on the Andrews site, particularly for biomass sampling of large old-growth trees.

Vegetation process studies. Some process studies initially developed with non-IBP funding have been integrated and are currently being developed further at the Thompson research site. Walker/Salo studied CO_2 assimilation as influenced by light and temperature under controlled greenhouse conditions and in the field. The greenhouse studies with Douglas-fir seedlings in air-conditioned cuvettes indicated that considerable assimilation occurs during the dark (<46 lx [<500 fc]) and cold (0-5°C) winter conditions of the mild climate. The field studies focused on spatial variation in tree crowns, using temperature-controlled cuvettes calibrated against the greenhouse instrumentation. Additional data on air temperature, precipitation, radiation, water stress, and stomatal opening were collected concurrently. Data runs of four selected days during the past summer indicated water stress to be the limiting factor for photosynthesis on clear, warm days, while light became limiting on overcast, cool days. Maximum daily CO_2 assimilation occurred on the overcast days, however. These preliminary experiments will be repeated with the tree-weighing lysimeter developed by Fritschen. Results have been published (Biome contribution 44).

Scott/Lassoie studied water relationships of the same Douglas-fir trees and also did some work with vine maple. Data on transpiration rate by heat pulse velocity, water stress by pressure chamber, relative leaf resistance by transpiration rate measurements of small leaf sections, stomatal aperture by infiltration pressure, and stem dimensional changes by dendrographs have been collected. Environmental factor measurements included net radiation, air temperature, relative humidity, and evaporation from a porometer. Data from eight selected days during the past summer indicated that strong dehydration occurred when evaporative demand was greater than the water-supplying power of the tree-soil system. The water storage in the stem and the shrinkage were closely related to the amount of water transpired per day. Soil moisture stress was important, as cumulative effects persisted even on days of low evaporative demands with closed stomata. These preliminary studies will be repeated and calibrated with the tree-weighing lysimeter project. Results of the work with vine maple have been published (Biome contribution 43).

Webb reported on a modeling study of the net assimilation rates of terrestrial plants. The data were obtained from controlled environment chambers with monitoring data acquisition and control functions linked to the central computer. The steady-state relative net photosynthesis was modeled in terms of temperature-dependent respiration and light- and temperature-dependent photosynthesis. Laboratory data on the CO_2 exchange rates of a small alder community (*Alnus rubra* B.) was used to evaluate the model parameters. The model is continuous and correlates well in the temperature range of 0-50°C for light levels between 0-1 langley min^{-1}. A publication reports the above results (Biome contribution 39).

Hatheway/M. Smith/S. Smith have developed linked submodels based on photosynthesis and the movement of water through the soil-tree-atmosphere system in a stand of coniferous trees. Principal input variables for computer simulation include direct and diffuse short-wave radiation; profiles of air temperature, relative humidity, and CO_2 concentration; and an initial profile of soil moisture content. The model predicts total and net photosynthesis, respiration, root and leaf moisture stress, transpiration, and leaf temperatures over periods of several hours or a few days, on a per-unit-area basis.

Consumer studies. Taber-Nellis made a preliminary survey of the bird and mammal populations in the Cedar River watershed area. More detailed inventory and food habit studies were conducted in the study areas of Findley Lake and Thompson Research Center. This information forms the basis for further development of a research program integrated with the primary production and decomposition research groups. A publication of the results is in Biome contribution 36.

Black/Voth/Taber concentrated on an annotated bibliography of small mammals classified in four categories: (1) mammal groups and species, (2) plant groups and species, (3) research methods, and (4) population dynamics. Final selection of 1400 references was based on the influence of animals in the ecosystem, deemphasizing taxonomic and anatomic studies. The resulting publication has a key-word list, an author list, and journal indexes (Biome contribution 16, in press). The information is used to identify the important contributions of relevant data and concepts, and to plan strategies for future surveys, successional trends, and ecosystem perturbation studies. The listings will be expanded later to include other mammal species, birds, amphibians, and reptiles.

Nagel/Strand continued process studies of insect-tree interactions initiated by non-IBP funds. An annotated bibliography of 125 references of the effects of insects on foliage as a controlling function in energy flow models has been assembled. Categories are: insect effects on tree functions and physiology, effect of food quality on insects, and insect energetics. Preliminary modeling of existing data was accomplished, and the efforts pinpointed gaps of necessary information, specifically in energy conversion coefficients for insects and the effect of insects on the fresh-needle input of the detritus pathway. The modeling efforts have been published (Biome contribution 25). Field sampling procedures for continued process studies are being developed with non-IBP facilities and funding.

Milne/Strand/Overton/Rydell worked on modeling of population dynamics and pointed out that complex mathematical functions need biologically meaningful constants and parameters in order to maintain the interst of both mathematicians and biologists. Furthermore, a complex model is built out of numerous subprocesses, requiring precise identification of pathways of input units.

Two major objectives were accomplished: (1) A summary of the work done during 1970/1971 on a single-species intraspecific competition model was written. (2) A multispecies predator-prey model, incorporating the competition mechanism of the single-species model, was developed almost to completion.

The single-species model is a computer program describing the dynamics of a population of insects in a situation in which food shortages form the only rrestraint upon population growth. This model deals with energy flow from food through the population's age classes, and simulates reproduction, development, and starvation as influenced by these flows. Simulated population fluctuations, average densities, and other properties generated by this model correspond closely with results observed by experiments and show the need for revision of some model mechanisms.

The multispecies model currently simulates the Douglas-fir beetle's relationship with two predators, the hairy woodpecker and a clerid beetle. This model incorporates the intraspecific competition mechanism mentioned above, a closely analogous interspecific competition mechanism, and the predation mechanism. Its terminology and data requirements permit investigation of any food chain of any number of predaceous species. Its design permits an investigator to study various hypotheses regarding the extent to which certain species, omitted from the modeled food chain, influence the population changes of the species included in the simulation. At present the predator-prey model is complete, but contains mechanical difficulties that have prevented its successful operation thus far.

Decomposition studies. Taub/Denison/Gilmour/Lighhart worked together to develop a coordinated approach to a terrestrial-aquatic integrated study program of decomposition processes. Discussions led to a definition of the decomposer section of the ecosystem model, and standardization of measurements to solve problems of species enumeration and chemical transformation data. With this as a basis, the future work will be more oriented and coordinated with the terrestrial and aquatic producer studies. Several seminar series at Oregon State University and a course on "energy-material transfers" at the University of Washington were organized by the participants of this group.

Denison made a survey of the macrofungal fruiting bodies and microfungi on decomposing foliage and developed a collection of reference cultures for the Andrews Experimental Forest area. Future studies of decomposition rates will need homogeneous cultures of these decomposer organisms. Information collected is on species frequency and distribution, association with litter type or plant species, and the stage of decomposition of the substrate. The information will be incorporated with a publication on cryptogamic species of the area. Next year the survey will be completed, litterbag studies will be initiated, and nitrogen-carbon evolution by decomposition will be measured. Denison also initiated studies of nitrogen-carbon fixation processes by epiphytes on old-growth live trees. Sampling rigging and schemes have been developed with the objective of evaluating biomass, nitrogen, and carbon contents of epiphytes. The epiphyte study information has been published (Biome contributions 31 and 34).

Driver/Minyard investigated the significant processes of cellulose and lignin degradation in forest litter decomposition. In the past, most studies of forest litter fungi have resulted in reports of fungi of the hyphomycete group. The most common decomposers of the major constituents of wood, cellulose, and lignin, however, are members of the Basidiomycetes. Therefore a major effort of this series of studies will be to develop information relative to the fungi of the basidiomycete class and the processes of primary decomposition characteristically carried out as a part of the nutrient turnover within a Douglas-fir ecosystem.

Initial efforts in accomplishing this approach have consisted of striving to establish the site and time that basidiomycetous fungi initiate litter decomposition. This was accomplised by trapping needles of Douglas-fir at three levels aboveground and attempting to isolate the fungi occurring on individual needles at various periods throughout the study period (September to April).

The results of the above trials lead us to the following conclusions: (1) After eight months of effort with the various techniques, no fungus of the sidiomycete class has been positively identified. (2) The filter paper incubation technique has resulted in the demonstration that initial fungal invaders of needles are in the classes Ascomycetes and Fungi Imperfecti. (3) The results of this phase of the investigation will be passed on to other members of the decomposer Biome group to add to their data and extend this approach to describing needle litter decompostion in a Douglas-fir stand. The above study has been published (Biome contribution 42).

The workers in this project are now in the process of focusing on the evaluation of the initial rate of decomposition of the wood of Douglas-fir and western hemlock. The initial processes of decomposition start while the tree is still in the living stage and continue after the tree has fallen to the forest floor.

Edmonds made a survey of existing models of terrestrial decomposition processes, most of which were at relatively coarse levels of resolution, involving the measurement of litterfall inputs, litter weight losses, leaching, and gaseous loss outputs. More detail was given for wood decay organisms as related to white rot fungi. Decay rates were greater for smaller logs, for higher sapwood/hardwood ratios, for wood located farther off the ground, and for higher incidence of beetle activities. A simple computer model was developed.

Geochemical studies. Considerable numbers of data in various forms are available and efforts have been made during the past year to review these as to possible incorporation in modeling efforts. Zinke reviewed plant-available nutrient storage information of the top meter of soils of the California area including exchangeable nutrients, total nitrogen, and carbon. This information has been correlated with soil profile, and vegetation characteristics have been described with the data. During the study it appeared that crucial information on bulk density of soils was usually lacking.

Van Cleve assembled information on hardwood litter loss rates in the Alaska area using data on chemical elements, biomass, and energy. Asymptotic exponential functions were developed by regression to describe the decay with recurring inputs of litter. Best correlations are for weight-energy relationships and for nitrogen and potassium loss rates. Calculated biological half-lives of nutrient elements indicated differences between tree species, most rapidly for nitrogen from aspen litter (63 days half-life).. Litterbag techniques were found to underestimate loss rates. Changes in energy-weight correlations were to be expected as lignin/protein ratios changed during stages of decomposition. Differential removal of low-energy carbohydrates and high-energy fats contributed to these changes. Nitrogen content (associated with proteins) increased downward in the litter layer; this increase was related to the degree of decomposition. A publication resulted from these studies (Biome contribution 13).

Lavender initiated nutrient cycling studies in old-growth reference forest stands of the Andrews site. Each plot received eight randomly placed litter traps and four 51-cm rainwash collectors that were rotated over 20 random points. Tree stems larger than 20 d.b.h. and crowns were mapped and crown photos were taken from the litter and rainwash sampling points. Chemical analyses confirmed patterns, measured on the Thompson site, of high transfer rates during the fall and low rates during the late winter. No ammonium, less than 7 ppm nitrate, but up to 55 ppm total nitrogen were recorded in rainwash collections. Rainwash and litter weights were related more to crown density patterns than to forest type or elevation. The data have been related to litter decomposition, nutrient storage contents of the soil, biomass of aerial vegetation parts, and the addition-and-loss values of nutrients of the total system. The information has been published (Biome contribution 30).

Cole/Gessel/Grier continued studies, initiated by non-IBP funding, of mechanisms of nutrient processes in young-growth forest of the Thompson research site. The ongoing long-term studies have accumulated many data evaluating nutrient cycling processes, and mechanisms associated with reforestation and fertilizer manipulations are presently being reviewed for modeling purposes. New data are being added continuously by the experiments. Information of the past year, with a long, wet spring and an extraordinarily dry and sunny summer, has been used to validate predictions of biogeochemical process models developed from the earlier data. Several detailed studies of mechanisms of mineral cycling processes have been pursued. Trapp of the Montpellier Institute in France worked as a visiting scientist on the dynamics of specific elements in the soil system. Non-IBP funding supported studies by Grier on the effects of fire and by Crane on the effects of urea fertilization on nutrient behavior in the forest soil. The results have been reported in theses and publications (Biome contribution 28).

Fredriksen/Moore reported on non-IBP studies of nutrient budgets of forested unit watersheds in the Andrews Experimental Forest now incorporated in the Biome program. The annual nutrient loss follows the pattern of annual runoff, which is dominated by winter rain storms. Largest amounts of nutrients (96% calcium) are lost during the winter period, and there are very small losses during the dry summer months. Transport of nutrients as sediments from the steep headwater streams was relatively unimportant compared with the loss of nutrients in dissolved form during the low flow periods. Soil losses may become more important over longer time spans when widely spaced catastrophic erosion by landslides is considered. Landslides may move a large proportion of the soil mantle and incorporated nutrients from the watersheds. A publication reporting the above information is available (Biome contribution 29).

Biometeorology studies. Fritschen/Gay/Belt worked together to formulate directions within the Biome research framework and to develop coordinated research efforts. Much attention was placed on vertical and horizontal energy and water transfer processes within the microclimate environment of a forest ecosystem. After aerial and ground surveys, a site was selected in the Thompson research area, and instrument towers were erected in conjunction with the atmospheric-terrestrial interface tree-weighing lysimeter project. The objective there is to calibrate meteorological methods with the absolute lysimeter data. During the summer of 1971 Fritschen/Gay made some preliminary test runs with non-IBP equipment and funding to check experimental designs and instrument compatibilities. Belt reviewed information on a fast-response (<1 sec) humidity sensor. Barium fluoride films are difficult to handle and calibrate; a Lyman hygrometer was found to be satisfactory but very expensive. The best compromise may be an adaptation of psychrometer principles for a multisensor program as required by the project. A report on the cooperative study has been published (Biome contribution 40).

Fritschen improved on the existing weather monitoring system of the Thompson site and installed additional systems at the tree-weighing lysimeter. The recorded analog data of air and soil temperatures, vapor pressure, solar and net radiation, wind speed and direction, and precipitation are enumerated by computer programs at the University of Washington. Development of sophisticated recording climatological stations at Findley and Chester Morse Lakes, and at the Andrews Forest administration site, was postponed after reevaluation of program priorities. It appeared more efficient to employ more and cheaper standard weather instruments within the unit watershed areas of the Andrews Forest itself.

Hydrology studies. Most of the activities in aspects of hydrology have been focused on the modeling of existing information. Brown/Rothacher/ Fredriksen/ Overton at Oregon State University have developed an overall hydrological model in a series of seminars, and already have coordinated detailed modeling information assembled by Riley and Burgy with non-IBP studies elsewhere in the Biome region. The results of these efforts have been published (Biome contribution 24).

Hydrologic data of the AEC-supported Fern Lake project have been used by Chapman/Olsen/Fowler to develop a lake section of the above-mentioned overall hydrologic model of a watershed. This has required adaptation of previously published models on potential evapotranspiration and soil-water movements in this ecosystem. The aim is to develop a computer model that will simulate the actual observed water flow in various measuring groups and then will acount for the total water distribution. A publication resulted from these initial efforts (Biome contribution 12).

Water input and redistrubution processes in the forest canopy are being studied by Cole/Machno. Above-crown irrigation and below-crown collection systems have been operative during the past year. Supporting data on relative humidity, net radiation, air temperature, and wind speed are being recorded on the Thompson site, in addition to air and soil temperatures, and soil moisture content of the irrigated study plot. A water balance model has been formulated with the data to predict accurately the soil moisture contents between field measurements. The water transfer data have been modeled in cooperation with Hatheway, incorporating measurements of soil moisture. A publication with the results has been made (Biome contribution 27). Water storage and transfer processes of individual trees are being investigated by Scott/Lassoie as already mentioned in the section on terrestrial producer processes.

4.2.3. Aquatic division

Stream systems. A considerable amount of information has been accumulated by past non-IBP studies by Warren/Lyford/Hall/McIntire. Much progress on system modeling has been achieved in the past involving all trophic levels. Current studies have been focused on the continuation of these modeling efforts, incorporating the existing data.

McIntire studied periphyton communities in stream stystems and used data assemblages of microorganisms to model primary production processes. In the model the state and driving variables are linked by complex feedback loops and intermediate modules, which combine to control rate variables. The model assumes no input of carbon by detritus, but solely photosynthesis inputs by the periphyton organisms. The time interval for modeling simulation patterns of less than four years is five days, and for more than ten years is up to 30 days. Present work is concentrated on an expanded model with a grazing organism (snail) and detritus inputs (500 g m^{-2} $month^{-1}$) during the fall.

Lyford/Hall/McIntire/Highly/Sedell/Donaldson have developed conceptual and work models for stream systems with emphasis on the terrestrial-aquatic coupling interface. The stream model from the Eastern Deciduous Forest Biome has been used as a basis. The conclusion was that the major flow in pathways is from terrestrial to aquatic systems with little reverse effect. Also, a stream exerts little conservation of nutrients as the system has little biomass and a continuous output is a pervasive feature. It is recommended that the hydrology, nutrient cycling, and aquatic groups consider the spatial resolution and structure in more detail. Some work in the larger tributaries of Lookout Creek is necessary. From the aquatic point of view, there appears to be more detail in chemistry than is needed for primary productivity modeling. More general methods of chemical monitoring such as for conductivity or total dissolved solids might be sufficient. The significance of the aquatic-terrestrial pathway of nutrients by way of plant roots has not been evaluated. More attention must be focused on the role of sediments in aquatic systems, as they represent the most disruptive influence of terrestrial perturbation. A publication reporting the above results has been made (Biome contribution 45).

Stober/Malik are studying consumption processes by invertebrate organisms in the Cedar River stream system. The eight sampling sites established near U.S. Geological Survey gaging stations include drift sampling systems, which have been standardized with Oregon State University procedures. Detritus is also being quantified. Benthic production is being evaluated from the standing crop data differentiated in size classes. Additional data include water temperature and velocity, and routine nutrient analyses. Preliminary results indicate that impoundment by lakes has marked effects on the temperature and dissolved materials in the river water below the impoundments. This work will be related to unfished populations of resident fish isolated from an expanding salmon population below the impoundment structures.

Lake systems. The lake program is focused on a comparison of four lakes in a sequence of high-elevation oligotrophic to lowland eutrophic conditions that are due to differences in topology, climate, and influences by man. Evaluation and modeling of the trophic dynamics will be by way of three subdivisions within each lake: (1) the water column, including the rapidly changing community of phytoplankton, microbes, and zooplankton; (2) the benthos, including the slowly changing community of larger littoral plants, sediments, and longer lived invertebrates; and (3) the higher consumers, including the longer lived invertebrates and highly mobile fish populations. A publication by Taub/Burgner/Welch/Spyridakis describing the program is available (Biome contribution 21).

As with the stream systems, it is fairly difficult to draw lines between trophic levels within the individual studies. Christman/Welch/Spyridakis expanded on studies of chemical equilibria and primary productivity initiated earlier by non-IBP funding and focused on Lake Sammamish. Considerable information on nutrient cycling and primary productivity for Lake Washington is available from long-term non-IBP studies by Edmondson. The IBP effort expanded the aquatic program to include Chester Morse and Findley Lakes in the inventory and process studies. The lakes were sampled in the main water bodies and near inflow and outflow streams. The data indicated an increase of 4 to 20 times in chemical and biological parameters from the oligotrophic Findley Lake down to the highly eutrophic, lowland Lake Sammamish. In the same sequence, as the carbon assimilation rate increases there is a higher chlorophyll content (plankton biomass) in primary productivity aspects. Studies of the water and bottom sediment interactions indicated coarser particle sizes and higher carbon/nitrogen ratios in the lakes at higher elevations. More detailed studies are being pursued and the above information has been made available in two publications (Biome contributions 14 and 47).

During the past year Wydoski conducted and extensive literature review of the aquatic resources in the Lake Washington drainage system. Similar information provided by Cole on terrestrial aspects has been combined with Wydoski's material, and the whole will appear as Biome Bulletin 1 (contribution 15) in the near future. Wydoski also assembled a checklist of the fishes in the Lake Washington drainage system.

Whitney/Wydoski developed fish sampling techniques and schemes to estimate the relative abundances of nonsalmon species such as peamouth and northern squawfish. Several kinds of fishing gear are being used to overcome the selective bias of each kind: gill nets of nine mesh sizes are being used (horizontal for benthic-littoral zones, vertical for pelagic-benthic zones) and fyke nets are used in shallow bays. Frequent sampling and stomach analysis will delineate food habits to enumerate energy transfer pathways. This work is closely coordinated with similar kinds of studies by Burgner/Mathison/Thorne, who employed electronic sensor techniques in midwater locations. Some preliminary data have been accumulated on the daily movements of the fishes being studied. Concurrent related non-IBP studies investigate other fish species such as brown bullhead and yellow perch with similar techniques and sampling schemes. The studies record life history data, age, growth, length/weight ratios, size, maturity age, and food habits. All information will be combined and focused into mathematical models of the production of aquatic consumers. A number of theses and a publication describing the results will be published soon.

Burgner/Mathison/Thorne employed echo-sounding gear developed in non-IBP studies to evaluate spatial distributions of salmonoid fish on a daily basis.

The resolution of the echo sounder is a 2.5-cm fish at 100 m depth. Analysis of data tapes is being accomplished on a computer available from Sea Grant funding. Sixteen transects have been established in Lake Washington and concurrent fish sampling with 3-m trawl nets is being coordinated with Whitney. Echo-sounder runs during September indicated the presence of an adult salmon population of about 290,000 individuals. These data must be checked against counts made by the Washington State Department of Fisheries. Similar work and sampling is being planned for Chester Morse Lake, of which a depth contour map has been drawn. Preliminary sampling indicated the presence of only rainbow trout, mountain whitefish and Dolly Varden. A publication describing the above techniques is available (Biome contribution 48).

Rogers/Eggers concentrated on the modeling of existing sockeye salmon information from the Alaskan Wood River lake system to prepare a foundation for the four-lake sequence as studied in the Lake Washington--Cedar River drainage system. Much effort has been spent in attempts to resolve linear relationships that seem to be suspect. Data from lakes have been used to develop a simple model with the intent to expand it to other more complex lakes. Lake Washington has relatively independent limnetic and littoral zones, but sockeye salmon and stickleback move seasonally in between. Literature review yielded several equations to describe the phytoplankton and zooplankton in the limnetic zones. The scarcity of data makes modeling in the winter season difficult, thus simple approximations must be used. Data consist of biomass and numbers of consumers, lake volume and area, abiotic factors, food habits, density of planktonic organisms, and abundance of emergent aquatic insects. Population estimates were performed by fish catches and echo sounding, and surveys were made of egg deposit by aerial and ground inspection. The results indicated the presence of only few linear relationships and the question is whether this scarcity is due to the presence of curvilinearity, to adequate sampling, to unknown complex interactions, or to random abiotic influences. Phytoplankton shows a peak production in July, and is followed by a peak production in zooplankton during September. The biomass of salmon appears to be dependent on egg deposit variables and independent of the biomass of food organisms. Egg survival is affected by lake level and general winter conditions. Complexities are introduced by fish movements from littoral habitats in spring to pelagic habitats in summer and winter.

Male has developed a collection of assumptions regarding the physical and biological processes that interact to form an aquatic ecological system. These have been formulated mathematically in such a way that they suggest experiments that may be performed to investigate the truthfulness of the assumptions or to estimate the parameters contained in the mathematical formulation. The present version of the aquatic production model contains six primary variables: (1) phytoplankton, (2) zooplankton, (3) sockeye salmon, (4) organic matter, (5) nitrate, and (6) phosphate. The submodels for the primary variables depend upon the environmental variables, time, depth, and a number of other variables. The above two modeling studies have been reported in a combined publication (Biome contribution 22).

Aquatic decomposition studies have been coordinated by Taub and Lighthart for the four-lake sequence of the Lake Washington--Cedar River drainage. Considerable effort has been focused on the formulation of integrated research programs for 1972, involving aspects of oxygen uptake by organisms as an indicator of the composition rates, the evaluation of detritus pathways, and nitrogen transformations. Standardization of sampling schemes, techniques, and units of measurement has been accomplished. A strong suggestion was made to use detritus materials caught by trawl net operations of other aquatic studies. Preliminary models of aquatic decomposition processes have been formulated with the assistance of Male from the modeling group.

Lighthart reoriented ongoing non-IBP studies for inclusion in the 1972 program and has a modeling effort of radioactive carbon fluxes based on Gaussian saturation distribution functions for phytoplankton and zooplankton and for decomposer activities. A preliminary study funded by non-IBP sources is focused on the production of ^{14}C-labeled detritus materials for the anticipated 1972 IBP studies. The preliminary results have been published (Biome contribution 46).

4.2.4. Services division

Central office. Gessel/Riekerk guided operations in the central office located at the College of Forest Resources, University of Washington, and were assisted by Bolger/Hancuff in accounting and secretarial services. The major activity of the central office in 1971 focused on the formulation and development of a new proposal for 1972. Organization of committee meetings and the maintenance of communications with representatives elsewhere in the Biome required considerable coordination and effort. Installation of a conference telephone substantially improved communications between the two institutions of the core program. The half-time services of an editor (Ellis) were secured in the latter stages of proposal development. Accumulation of IBP-related library materials has been initiated, will be expanded continuously, and is available for consulation by all participants. Recently, office space (now Room 178, Bloedel Hall) has been tripled in area to accommodate the secretary (Gregg), the assistant (Olson) to the intensive site director, the half-time editor (Ellis), and the administrative assistant (Riekerk).

Of the technical committees, the chemical standardization committee under Behan has been most active and has issued a series of recommendations on procedures and reference materials. The committee on remote sensing has not met, but chairman Colwell has undertaken the review of ongoing and proposed studies in the Coniferous Biome region and is in the process of discussing research programs with the various project leaders. A report will be forthcoming by the end of this year. Several representatives of the Coniferous Forest Biome have been in Europe and in Japan participating in or reviewing IBP-related ongoing studies. Reports on these activities are available in the central office. The genetics committee under Stettler has met several times to formulate a direction and strategy for a genetics program associated with the various organisms of the Biome region, with an emphasis on the Douglas-fir trees. A chronic lack of funding has considerably reduced the scope of the anticipated genetics program.

Information bank. The initial efforts of the information bank under Bare were on the development of standard computer systems for abstracting progress reports, technical publications, data sets, and bibliographies. A half-time research assistant assembled information of data storage and retrieval system needs of principal investigators. Full-time programmer Hamerly worked on a bibliography program of references on mammals in the Biome assembled by Black/Taber, a bibliography of Lake Washington drainage studies by Wydoski/Cole, and a program for a Biomewide mailing list. A data management news note series was initiated to keep the principal investigators in the Biome up to date on activities, and information on the input format for project abstracts and data for computer storage was distributed. Computer summaries and storage of Lake Washington water chemistry, biological, and zoological data have been initiated with the help of Male. Coordination meetings have been attended by Bare concerning inter-Biome information storage and retrieval systems.

Lake Washington--Cedar River drainage intensive site. Cole/Burgner/Taub/Walker formed a steering committee with the objective of coordinating and ensuring the integration of the various ongoing research programs. A series of weekly meetings of the Washington group of scientists has been covering aspects of integration of sampling activities, sample analyses, and measurements of supporting data needed by the various programs. Business meetings covered administrative and accounting procedures, progress reports on proposal developments, and progress reports on study projects.

Several improvements have been made at the various sites of intensive study within the Lake Washington drainage area, including a well at the Thompson research site to provide groundwater samples, water for irrigation purposes, and some insurance for fire protection. The survey of Chester Morse Lake yielded a depth contour map, and access to the lake by boat and trailer has been constructed in a protected bay. Access to the Findley Lake watershed has been improved by the construction of a foot trail minimizing damage to the surrounding soil-vegetation systems and approaching the watershed downstream from the lake outlet. The intensive site area has been the focus of numerous visits by dignitaries from state and federal levels, including the NSF site review committee, U.S. Senator McGee, and Van Dyne of the Grasslands Biome. Many visitors are expected during the coming year in association with the Fifth Assembly of the International Biological Program scheduled at the University of Washington for August/September 1972.

H. J. Andrews Experimental Forest intensive site. Waring/Franklin/Overton were instrumental in establishing a weekly series of discussions focused on the problems of cooperation and integration of ongoing studies, definition and formulation of word models, and reports of ongoing projects. Considerable progress has been made in the aspects of conceptual modeling of ecosystem sections.

Waring/McKee reported on several improvements of the Andrews intensive site including the installation of a mobile home to provide space for meetings, sleeping quarters, and food facilities for an additional nine scientists. An access trail looping through the intensive study site of watershed 10 has been completed during the past spring. Similarly, a 20-m^2 grid has been imposed on experimental watershed 10, serving as a reference for all the ongoing studies on this unit. A number of visitors inspected the Andrews Forest research site, including representatives from Japan and Austria and from the Grasslands and Deciduous Forest Biomes, and special committees such as the Federal Research Natural Area group. Visiting scientists conducted several seminar series or workshops, including Fritts from the University of Arizona, Patten from the University of Georgia, and Riley from Utah State University. Coordination between departments within the Oregon State University and between OSU and the USDA Forest Service has been developed to a high level involving transfer of funds and use of vehicles, equipment, and laboratory facilities.

4.3. Reports of Biome Investigations

4.3.1. Biome contributions

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5. SUBPROJECTS

5.1. List of Study Proposals

Terrestrial--Food Chain Processes

Terrestrial--Biogeochemical Processes

Geochemical processes

Benthic zone processes

Higher consumer dynamics

Aquatic--Stream Systems

Ecosystem Integration--Coordination Program

Services--Technical Committees

5.2. Individual Subprojects

5.2.1. Modeling management

SYSTEM MODELING, SAMPLING, AND PARAMETER ESTIMATES

Principal Investigator

D. G. Chapman, University of Washington

Coinvestigators

W. H. Hatheway, University of Washington
W. S. Overton, Oregon State University

Sponsoring Committee

Ecosystem Integration--Modeling Management

Relation to Research Committee Program

Input is needed from the process and ecosystem modelers of the various research groups (Male, Strand, Reed, Riley).

Expected results will benefit the overall ecosystem models based on unit-watershed and habitat-level studies, and the modeling efforts in the coordination programs (Behan, Partridge).

OBJECTIVES

1. Explore the theoretical development of systems models and submodels.

2. Continue work on development of a low-resolution system model for the Cedar River watershed or subsystems thereof.

3. Work toward low-resolution compartment models for biomass and water on the H. J. Andrews Experimental Forest.

4. Model an aquatic system, completing work on Fern Lake and continuing work on Findley Lake within the Cedar River watershed.

5. Improve the submodel of net assimilation in Douglas-fir and of the movement of soil nutrients through a Douglas-fir ecosystem.

6. Continue development of growth models of Douglas-fir at several levels of resolution.

7. Support model development of other research groups.

8. Supervise the sampling, experimental design, and data analysis for the Biome.

APPROACH

Central Modeling and Modeling Sciences

The overall objectives of building modular hierarchical models for the various systems investigated by segments of the Biome program has progressed well in 1972. General model structures have been conceptualized for the static (non-evolutionary) case and committed to computer programs. Computer technology developed elsewhere, specifically in the Grasslands Biome, has been used to this end, although some of the computer algorithms have originated in our program.

The primary central modeling efforts for 1973 (continuing into 1974) will be:

1. Develop the capacity to structure models in the general forms adopted and accommodate possible needs for change in the forms established.

2. Develop the conceptual model structures for evolutionary and control systems and the parallel computer technology, and investigational and analytic strategies to accommodate these structures.

3. Develop strategies for the study of model behavior.

4. Construct and commit to computer program specific models (a) for the Biome study sites (e.g., Thompson research site, the Andrews Forest, and particular watersheds), (b) for the organizational levels under investigation by the Biome, and (c) for generalization of ecosystems under environmental variation.

5. Assist subject personnel in studying the behavior of the specific models so constructed.

Specifically, Overton will concentrate on model forms and structures for succession and successional behavior, particularly as oriented to terrestrial communities. This follows the work on static community and stand models in year 2.

A new modeler is being sought to join the University of Washington group to assist Chapman, Hatheway, and Male particularly in central modeling, and in model coordination between research committees and between the Washington and Oregon groups. Overton and Lemberski will continue the development, begun in year 2, of strategies for investigating the behavior of models. It is perceived that this work will lead to improved strategies for investigating the behavior of real systems. Project personnel will continue to provide services in sampling and experimental design, and in data analysis and parameter estimation. It is anticipated that the postdoctoral position at Oregon State University will be filled with the service function as a primary focus. Responsibilities for this activity at the University of Washington will be shared.

Process Models, Particularly Terrestrial

We have been constructing a computer simulation model that is intended to represent the activities of a small forested area over time periods of a few hours up to a few days. This model is built up from submodels that describe physiologically significant processes in woody vegetation: photosynthesis transpiration, uptake of water and nutrient elements by roots, their transport to leaves and storage tissues through the vascular system of the plant, and mobilization of the products of photosynthesis and their derivatives in growth and reproduction. The model is intended to complement and provide a unified conceptual framework or theory for the physical process studies being conducted at the Allan E. Thompson Research Center, Cedar River watershed. It is being extended to include abiotic processes such as transport of water and nutrient elements in the rooting zone of a forest soil, stribution of sunlight, and circulation of air in forest canopies.

The computer model, which is written in Fortran IV, consists of a number of subroutines connected by "common" statements. Each subroutine represents an identifiable physical or biological process. Because each subroutine is separate, it can be modified or completely altered without disrupting the performance of the rest of the model. Inputs to the model include measured variables of the physical environemnt such as weather station data. Outputs include rates of photosynthesis and transpiration in several canopy layers, rates of uptake of water and nutrients, and descriptions of movements of the latter in the soil and plant. The model is documented by a mimeographed description, which is modified from time to time as subroutines are added or altered.

In 1973-1974 we intend to improve models of several important processes. The first version of the model consisted of a selection of published process models and others intended frankly as stopgaps, which enabled us to produce computer output. In consultation with experimental scientists we have identified important deficiencies and are taking steps to correct them. In the first part of 1972 our attention has been directed to improving process models describing photosynthesis and respiration (Reed) and water and nutrient transport in soils (Hatheway, Machno, Hamerly) and in the vascular system of trees (Winter, Hatheway). In 1973-1974 we will concentrate on submodels representing physical processes in the atmosphere. Special attention will be given to parameter estimation and model validation at the Allan Thompson site. We are not certain that this detailed model will be useful in broader stand, watershed, and ecosystem models, but we intend to study ways of simplifying it to those ends.

Aquatic Models

Models formulated during 1972 to explain the more important cycles of essential nutrients and organic matter will be adapted to encompass a sequence of lake systems that exhibit a substantial range of eutrophication. These models should have the capability of identifying for each lake system those phases of the cycling process that would be most sentistive to environmental change or perturbation. The analysis of these models should in addition provide a more thorough understanding of the nature of the eutrophication process and the differential extents by which it is controlled by terrestrial nutrient input and internal cycling mechanisms.

A modeling concept, referred to as an optimal strategy approach, appears to be a promising tool for analyzing complex community dynamics. Some of the aspects of an aquatic system this tool will be used to analyze are: (1) seasonal and long-term succession, (2) description of the community of prey organisms a predator would be expected to prey upon, (3) estimation of the growth dynamics of predators as a function of the community structure of the prey, and (4) changes in prey community structure as a result of optimal feeding strategies by the predator.

McIntire and Hall will concentrate on aquatic model structures and produce the specific aquatic models for the Andrews streams.

TROPHIC RELATION MODEL BASED ON DENSITY-DEPENDENT PROCESSES

Principal Investigator

Charles E. Warren, Oregon State University

Coinvestigators

Gerald E. Davis, Oregon State University
John P. Mullooly, Oregon State University

Sponsoring Committee

Ecosystem Integration--Modeling Management

Relationship to Research Committee Program

Input is needed from stream study groups at the Andrews Experimental Forest, Cedar River, and Weyerhaeuser stream study sites; the Intermountain Aquatic Consortium; and the four-lake studies of the Lake Washington drainage research program.

Expected results will benefit subsystem modeling of streams and lakes (Male), to be validated with nonintensive site data (Gaufin).

OBJECTIVES

1. Incorporate into the system of logical and empirical generalizations, forming the conceptual foundation for analysis of trophic processes on the basis of density relationships, additional generalizations necessary and sufficient to explain the production of a product of interest on the basis of the productivity, or productive capacity,of its ecosystem, as ecosystems of increased complexity are considered.

2. Further elaborate the computer simulation model, which leads through dynamic functions to the relationships of the system of density generalizations, so that whatever data are available on aquatic systems in the Biome can be better exploited both within this model and as it couples with models of the terrestrial systems.

3. Analyze and synthesize by the system of generalizations and by the simulation model data available on streams and lakes being studied in the Biome so as to define the productivity of these aquatic systems, so as to relate them to the terrestrial systems, and so as to be able to make predictions of the production of aquatic organisms under different conditions that might develop in the Biome.

4. Continue development of the general theory (as a scientific deductive or axiomatic system) of density relations defining the productivity of ecosystems for products of interest, so that theorems abstracted from the empirical generalizations based on particular products of interest can be applied with scientific confidence to such products of interest as timber, range livestock, and big game species.

APPROACH

The system of generalizations on which we base our analyses of trophic processes leading to the production of products of interest are supported by a considerable body of empirical evidence and logical considerations. In their most primitive form, however, these generalizations become less sufficient as ecosystem complexity increases. We believe that this is not because the phenomena defined by the density relationships fail to continue operating but because they are obscured by overlying processes. Thus we will examine data on productivity and product of interest not simply explained, attempt to determine why these data are not simply explained, and then add sufficient additional generalizations to the conceptual system to make it more adequate for dealing with natural systems of greater complexity.

Our computer simulation model has been built with functions expressing the most fundamental relations of nutrient availability, nutrient utilization, respiration, growth, recruitment, mortality, and competition. As we deal with ecosystems of greater complexity of operational units influencing these phenomena, we can thus relatively easily add these units to the model, with similar functional forms, so keeping the model sufficient.

The data to be analyzed and synthesized through use of the generalizations and the model will be from streams in the Andrews Experimental Forest, from Berry Creek, from the Weyerhaeuser Corporation Experimental Streams at Mt. St. Helens, and from the sockeye salmon lake systems studied by University of Washington scientists.

Beginning with primitive terms and the axioms relating these terms, we will deduce the most fundamental theorems underlying the systems of empirical generalizations. Additional primitive terms and axioms will be used as necessary to deduce theorems sufficient to handle ecosystems of greater complexity. The logical consequences will be checked against experience gained through studies of terrestrial as well as aquatic systems within the Biome to determine the correspondence between these logical consequences and experience.

5.2.2. Terrestrial--Primary production

PHYSIOLOGICAL PROCESSES WITHIN THE MIXED CONIFER FOREST OF CALIFORNIA

Principal Investigator

John A. Helms, University of California, Berkeley

Sponsoring Committee

Terrestrial--Primary Production

Relationship to Research Committee Program

Input is needed from the terrestrial primary production processes work group of the Thompson Research site (Scott, Walker, Reed, Hatheway) and the transpiration studies at OSU (Webb, Waring).

Expected results will benefit the modeling efforts of Reed and Hatheway, specifically extrapolation of the data base, and the environmental grid study by Emmingham.

OBJECTIVES

1. Compare quantitively the physiological processes of the major plant species within the mixed conifer forest in terms of net photosynthesis, dark respiration, transpiration, and foliar water stress.

2. Relate these processes to natural environmental conditions both diurnally and seasonally.

3. Generate quantitative models that describe the relative capability of the major understory vegetation to develop within its natural environment.

APPROACH

The proposed study is a logical extension of current research in California on gas exchange in conifers. Considerable experience has been obtained in technique and methodology (Helms 1964, 1965, 1970, unpublished MSS). The major equipment and facilities required for the proposed study are therefore available at a well-established forest research station used for interdisciplinary research.

The study will be located at the University of California's Blodgett Forest Research Station situated at 1300 m in the Sierra Necada of California. The major conifers in this area include a mixture of Douglas-fir, ponderosa pine, white fir, incense cedar, and sugar pine.

Net photosynthesis, dark respiration, and transpiration will be measured by gas-exchange procedures using multiple sampling chambers. A single Siemens cuvette will be used as a standard reference. Major environmental parameters monitored will include radiation (Eppley pyrheliometer and Talley Industries Sol-A-Meters), air temperature (thermocouples), leaf temperature (inserted thermocouples), and saturation vapor pressure deficits. Air temperature, leaf temperature, and atmospheric moisture levels will be monitored continuously within all sampling chambers.

Data acquisition will be handled by an already available system consisting of the following: a 50-channel scanner, digital voltmeter (Non-Linear Systems, model X-1), magnetic tape transport (Digi-Data Corp.), 4-K Nova computer (Data General Corp.), teletype (ASR-33), and strip chart recorders for visual checking in analog form.

Physiological processes will be characterized for sun and shade foliage on each species studied. Within-tree sampling will conform to Biome criteria. Comparisons will be made between species in terms of diurnal and seasonal patterns, compensation and saturation points, development of foliar water stress, and stomatal behavior. Quantitative descriptions characterizing the data available for Biome analysis will be made.

Year 3 will be spent primarily in developing and testing a working system to measure processes in the field. Delivery and installation of the Siemens unit will require two to three months after funds are secured. The interfacing between this unit and the computer-controlled data acquisition system will be designed and built. Subsidiary sampling cuvettes will be constructed and correlations will be made between these simple chambers and the controlled-environment cuvette of the Siemens system. Initial measures comparing physiological processes in Douglas-fir and ponderosa pine will be made.

PHOTOSYNTHESIS MODELING AT THE LEAF, TREE, AND STAND LEVELS

Principal Investigator

Kenneth L. Reed, University of Washington

Sponsoring Committee

Terrestrial--Primary Production

Relationship to Research Committee Program

Input is needed from CO_2-assimilation studies (Walker/Scott), the extrapolation sites (Helms, Emmingham/Waring, Webb, and Fritschen).

Expected results will benefit Walker/Scott, Emmingham/Waring, Webb, Helms, and central modeling.

OBJECTIVE

Develop hierarchical models for tree and forest stand growth using data generated by process studies as well as forest biomass and structure studies.

APPROACH

A current leaf-level model of photosynthesis will be selected from the literature. This model will be modified to be used in conjunction with the gas-exchange technique of estimating net photosynthesis. The parameters of the model will be estimated by nonlinear least-squares parameter estimation from field data, requiring specific experiments designed to provide the necessary data. Given the model and estimates of the parameters, the model will be validated by comparison with other data gathered in subsequent experiments. A series of programs will be placed on tape to analyze and process the field data as they come in on magnetic tape from the data-logger systems. This will ensure that the voluminous field data are analyzed with minimum turnaround. The leaf-level model will be useful for (1) studying photosynthesis as a function of environmental variables; (2) studying the effects of preconditioning, nutrition, and the like; (3) comparing the response surface of other species with each other and with Douglas-fir; and (4) studying the relation of photosynthesis, respiration, and translocation to plant growth.

A model of stomatal behavior in coniferous species will be developed for use in simulation studies and in the general leaf-level models. The leaf-level model will be incorporated into a digital simulation model for use by Waring and Emmingham. A second leaf-level model may be developed as a partial differential equation model.

Photosynthesis at the tree level will be modeled from two levels of resolution: (1) by extrapolation and modification of the leaf-level model, and (2) by development of a new model based on consideration of the tree as a homogeneous object, possibly a translucent hollow cone. This second model will probably be a partial differential equation model, predicting photosynthesis at the crown level. The first model will possibly be evaluated by pooled data from the entire crown, or from a stratification system. The leaf-level response surface will be necessary for development of the higher level models.

The stand-level model will also be approached from two levels of resolution: (1) by extrapolation of the tree model and by incorporating models of interaction between trees, and (2) by consideration of the ecosystem as a three-dimensional translucent volume, homogeneous in all directions. This last model will again be a partial differential model, or something similar. The stand-level model will be used in a new simulation model of photosynthesis and transpiration of ecosystems, into which ecosystem characteristics such as stand density, aspect, slope, and water availability will be incorporated. This model will again be used by Emmingham and Waring in their ecosystem classification system and growth study.

ASSIMILATION AND WATER RELATIONS STUDIES

Principal Investigator

D. R. M. Scott, University of Washington

Coinvestigators

R. B. Walker, University of Washington
K. L. Reed, University of Washington

Sponsoring Committee

Terrestrial--Primary Production Processes

Relationship to Research Committee Program

Input is needed from biometeorological studies and tree-weighing lysimeter work, tree-level subsystem modeling (Hatheway), and biomass and structure work.

Expected results will benefit tree-level and stand-level modeling studies (Reed), biomass and structure group, and aquatic littoral subsystem studies.

OBJECTIVES

1. Acquire data for the modeling of Douglas-fir tree physiological and growth processes in field conditions.

2. Extend field studies to include western hemlock trees.

3. Acquire instrument mobility to study tree growth processes on other sites in the Cedar River area as well as on the Andrews Experimental Forest.

APPROACH

The 1972 efforts are concentrated at the Thompson site. Data are being gathered to permit modeling of net photosynthesis, dark respiration, transpiration, and seasonal diameter increase on these 40-year-old Douglas-firs. In the net photosynthesis measurements, emphasis is on securing data for response surfaces to light intensity, temperature, and water stress. Through accompanying biomass and structure studies, we expect to be able to make reasonable extrapolations to the behavior of the stand. We recognize some of the pitfalls in the latter, but are unaware of any alternative means for assessing the response of stands to these variables over enough time to model seasonal production. With respect to transpiration, cuvette measurements and ^3H_2O methods will be compared with results from the hydraulic lysimeter. This work is being done with equipment that was on hand before the initiation of Biome studies, plus some new material developed during 1971, and the single Siemens climate-controlled cuvette previously on lease but purchased with 1972 funding. The largest deficiency in the existing equipment is in the strip-chart recorder manual data handling system. Funds available for 1972 will permit start of the acquisition of a data logger system.

For 1973 we envision extending the work on the 40-year-old Douglas-fir stand to other ages of this species to permit modeling of the developing stand and of different age classes. Further, we will extend the studies to the most important other overstory species, western hemlock. Although these studies will be done also in the Cedar River watershed, sites other than the Thompson Center will be used as necessary. Thus some mobility will be developed during this year, requiring the expansion of measuring capability, and the acquisition of a part of a second Siemens system to enable measurements of effects of limiting factors to be made rapidly at sites used for short periods.

Experience attained in 1973 will make possible limited movement to the Andrews and associated sites in 1974 for studies of older age classes than are available readily in the Cedar River area, and also will allow for inclusion of a wider variety of environments. This will necessitate the purchase of additional rolling stock and the balance of the second Siemens unit, and data handling ability will have to be improved. Thus our request for equipment for 1973 includes a small computer to be used with the data logger, and these two items will make the "heart" of the mobile system to be operated in 1974.

Throughout we expect to emphasize the acquisition of those data needed to develop realistic process, tree, and stand models.

PHENOLOGY AND STAND GROWTH MODEL BASED ON ENVIRONMENTAL-PLANT INDEXES ACROSS THE BIOME

Principal Investigator

Richard H. Waring, Oregon State University

Coinvestigator

William H. Emmingham, Oregon State University

Sponsoring Committee

Terrestrial--Primary Production

Relationship to Research Committee Program

Input is needed from CO_2 assimilation studies (Walker, Reed, Webb, and Helms), and extrapolation and validation sites coordinated by Laycock.

Expected results will benefit biomass and structure, central modeling, biological decomposition processes, and terrestrial food chain processes.

OBJECTIVES

1. Develop a predictive model of phenological development.

2. Relate integrated environmental plant indexes to forest growth and composition across the Biome.

APPROACH

To meet these objectives, the coordination program committee is helping to establish special reference sites where stand production, as well as certain environmental measurements, will be determined. Vegetation analyses will include cover estimates of major vascular plants. Stand production studies will include estimates of tree foliage from litterfall, as well as of bole, volume, and age distribution. Phenological observations will also include cambial activity in reference plants.

In each stand, air and soil temperatures, seasonal plant moisture stress patterns, foliar nutrition, and accumulated snow depth and precipitation will be monitored. At a nearby open site short-wave radiation and dew point will be recorded. These data will be processed locally where possible and made available for modeling. The information will help place each of the sampled ecosystems in an environmental grid representing drought, transpiration, temperature, light, nutrition, and mechanical stress. Transpiration and photosynthesis will be simulated from environmental data using already available models. Multiple regression and multivariant analyses will help establish the relationship between stand growth and plant moisture stress, transpiration, temperature, nutrition, mechanical stress, and photosynthesis.

Data from some sites will be incorporated to develop a general model while information from other sites will serve to test the model's validity. We will strive to approach extremes in the Coniferous Forest Biome representing alpine, arctic, coastal, montane, and savanna forest types.

During the first year only a few sites will be studied. They will be selected on the basis of (1) vegetation and climate, (2) the adequacy of existing instrumentation, and (3) the availability of technical assistance. With the development of an operational model, the appropriateness of additional sites can be critically evaluated.

ASSIMILATED CARBON TRANSFER AND UTILIZATION WITHIN A TREE: MODELING THE ENVIRONMENTAL CONTROLS

Principal Investigator

Warren L. Webb, Oregon State University

Sponsoring Committee

Terrestrial--Primary Production

Relationship to Research Committee Program

Input is needed from photosynthesis process studies at the Thompson research site, and environmental data from intensive site studies as well as from coordination program.

Expected results will benefit the tree and stand growth model (Reed) and the environmental-plant indexes grid (Waring).

OBJECTIVE

Model the effects of season, light, temperature, and water potential on photosynthate movement in Douglas-fir.

APPROACH

Information on the control and the seasonal patterns of photosynthate transfer from assimilating needles to other plant parts is needed to model tree behavior in terms of growth and in terms of consumer utilization. Photosynthate translocation data complement the extensive CO_2 assimilation work providing the basis for modeling the energy flow processes in terrestrial primary producers.

A gas-tight controlled environment chamber will be used for steady-state ^{14}C and ^{13}C labeling of carbon assimilated by seedlings preconditioned in different environments in both the field and in other controlled environment chambers. Isotopes will allow a comprehensive study of the tightly coupled translocation system and will provide data for modeling the functional interactions of light, leaf temperature, water potential, and seasonal effects on translocation.

A working model has been formulated and the current project (Seasonal Variation of CO_2 Absorption and Translocation in Douglas-fir Seedlings) will establish experimental procedures for ^{14}C work and will investigate the seasonal translocation pattern under a single field environment. The model developed in 1973 and 1974 can be field tested in 1975.

BIOMASS DETERMINATIONS IN CONIFEROUS STANDS ON THE H. J. ANDREWS EXPERIMENTAL FOREST

Principal Investigator

John F. Bell, Oregon State University

Coinvestigator

Denis P. Lavender, Oregon State University

Sponsoring Committee

Terrestrial--Primary Production

Relationship to Research Committee Program

Input is needed from root biomass and site mapping studies.

Expected results will benefit the processes and biogeochemical groups.

OBJECTIVES

1. Determine weights of foliage, twigs, branches, bark, and living and dead bole wood of selected Douglas-fir trees.

2. Determine N, P, K, Ca, Mg content of each under (1) above.

3. Develop relationship between foliage and other respiring tissue in the aerial portion of a tree and (with data from root biomass study) relationship to respiring root tissue.

APPROACH

The initial project for determining the biomass of old-growth Douglas-fir trees proposed to determine the quantities and nutrient contents of the several tissues of an old-growth Douglas-fir tree by systematically severing and lowering the limbs to the ground until the entire crown was dismantled. The limbs were then to be divided into the recognizable age classes, the foliage was to be separated from the twigs, and the mass of each crown component was to be determined. The branchless bole was to be felled and core samples were to be taken at intervals to provide an estimate both of total living and dead material and of current annual increment.

The experience of the group studying epiphytes under Dr. W. Denison this past year, however, indicates that it is practical to "rig" a tree, using rock climbing techniques, to permit a relative accurate inventory of the individual branches in situ.

The inventoried branches are then sampled according to a design based upon statistical probability to determine the complement of foliage, branches, and other crown components in the tree. This methodology will be validated and evaluated for its potential in estimating tree crown parameters on an area basis in 1972. If the techniques tried prove useful, it is proposed to complete the sampling of old-growth stands and to initiate a similar program in second-growth stands (watersheds 6, 7, 8) in 1973, and to complete the latter in 1974.

Where possible, trees sampled in each of the three years will be subjected to root biomass determinations. In addition, subject to the availability of the respective methods, sample trees will be evaluated by either the tritiated water or the laser beam theodolite technique, or both.

This project will require input from the root biomass study. (Actually, these are parallel studies, with a common objective, to determine quantities of nutrients and respiring tissues in old-growth Douglas-fir, and in second-growth Douglas-fir and possibly hemlock.)

The output of this study will be of primary importance to the processes group as it will contain the data necessary to relate the measurements of metabolic activity to gross and net productivity of the stand. It will also establish the "ground state" against which the effects of future permutations may be evaluated.

It is impossible to define exactly the distribution of effort during 1973 and 1974. It is expected, however, that the sampling of old-growth stands will be completed no later than mid-1973 and that the remaining effort will be devoted to sampling and characterizing 130-year-old Douglas-fir and western hemlock stands.

SUCCESSIONAL CHANGES IN COMPOSITION AND STRUCTURE OF CONIFEROUS FORESTS

Principal Investigator

Jerry F. Franklin, Oregon State University (USDA-FS)

Coinvestigators

R. H. Waring, Oregon State University
C. T. Dyrness, Oregon State University (USDA-FS)
D. R. M. Scott, University of Washington
R. DelMoral, University of Washington

Sponsoring Committee

Terrestrial--Primary Production

Relationship to Research Committee Program

Input is needed from forest biomass and structure and ecosystem modeling groups, working groups on fire and disease influences, historical climate studies, and the Deciduous Forest Biome plant succession modeling group.

Expected results will benefit groups working on forest biomass and structure and fire and disease influences, aquatic lake programs, sediment core and soil formation studies, and food chain process modeling studies.

OBJECTIVE

Adapt or develop a predictive model(s) for changes in composition, biomass, and structure for the major coniferous forest communities found in the Coniferous Forest Biome.

APPROACH

We will begin by examing the philosophy, predictive capabilities, and data requirements of the several successional models already in existence or under development. The successional model under development by the Deciduous Forest Biome will be a major focal point. Informal liaison has been conducted with the Deciduous group during 1972 and will be intensified. This coordination will encourage development of a model adaptable to the needs of both Biomes.

Once the model(s) deemed most appropriate has been identified, cooperatively developed with the Deciduous Biome, or conceptualized by investigators, the next step will be to collect the necessary biological data. These will come primarily from the literature and unpublished sources, although some additional collection of field or laboratory data undoubtedly will be required.

The temperature and subalpine coniferous forests at the intensive study sites will be the initial subject for development and validation of the model. A great many data are available on the composition, structure, and successional behavior of these forest stands. Temperate stands are primarily Douglas-fir and western hemlock; subalpine stands are true firs and mountain hemlock. Beginning in 1974, we plan to extend the work to other major coniferous forest formations including, in particular, ponderosa pine and boreal spruce types.

ROOT BIOMASS OF OLD-GROWTH DOUGLAS-FIR

Principal Investigator

R. K. Hermann, Oregon State University

Sponsoring Committee

Terrestrial--Primary Production

Relationship to Research Committee Program

Input is needed from old-growth tree biomass and epiphyte sampling studies, geology and soils studies, soils decomposition and faunal work, and soil solution ionic dynamics modeling efforts.

Expected results will benefit biomass and structure group, tree and stand level process modeling work, and terrestrial biogeochemical studies.

OBJECTIVES

The objectivs are (1) to establish allometric relationships between aboveground and belowground biomass, and (2) to investigate the relationship between biomass of needles and biomass of the fine-root fraction. The latter relationship appears to be of considerable interest from the standpoint of planning subsequent studies of the productivity of such ecosystems.

APPROACH

Preliminary work for field studies in the summer of 1972 in the form of an extensive literature review have indicated that the difficulties in carrying out the assigned task will be even greater than had been anticipated originally. We had planned to analyze all available information from studies of root biomass of trees for relationships between biomass of roots and that of the other components of trees. We had assumed that from such an analysis sufficient data could be extracted to serve as a basis for construction of prediction equations extending to trees 450 years of age. Although the review has not yet been completed, it already has become quite obvious that this approach will be unworkable. Available results are simply too sketchy to yield enough information for the construction of prediction equations.

A second complicating factor is our inexperience in retrieving root biomass from trees of dimensions such as those with which we will have to work. We were unable to find any references to root excavation methods that would be of assistance to us. Consequently, we shall have to devote a considerable portion of our efforts during the 1972 field season to exploratory studies aimed at developing a suitable method for (1) excavating large root systems, and (2) determining the extent of the work necessary to separate the various size components of an entire root system. Furthermore, we shall use some core sampling in an attempt to evaluate the usefulness of this method for estimates of amounts and distribution of fine roots in an old-growth Douglas-fir stand.

STRUCTURE AND BIOMASS OF PLANT ASSOCIATION TYPES OF CEDAR RIVER

Principal Investigator

David R. M. Scott, University of Washington

Coinvestigators

Roger delMoral, University of Washington
Jerry Franklin, USDA Forest Service, Corvallis, Oregon

Sponsoring Committee

Terrestrial--Primary Production

Relationship to Research Committee Program

Input is needed from terrestrial geochemical (geologic and edaphic survey) studies.

Expected results will benefit studies on terrestrial primary production processes, terrestrial food chain processes, and terrestrial biological decomposer processes; modeling management; and coordination program.

OBJECTIVES

1. Establish sampling points in each tentatively established stratum.

2. Collect data at sampling points that will describe the biomass and structure of primary producers, allow for successional interpretation, and serve as a basis for refinement of sampling, description, classification, and ultimately productivity.

APPROACH

Reconnaissance, summary of existing information, tentative delineation of major units as related to physical environment, and cultural treatment have been accomplished with minimal financial support in 1972.

The Cedar River watershed contains representative areas of several broad forest associations. The lower elevations fall into the *Tsuga heterophylla* zone of Franklin and Dyrness (1970); those parts above 760-915 m would be considered in the *Abies amabilis* zone, and there is evidence of small areas of *Tsuga mertensiana* zone at very high elevations at the extreme eastern edge of the watershed. Imposed on these broad types are the periodic catastrophic natural disturbances, primarily fires, of the past, and man's cultural activity of the last half century. The lower watershed, the *Tsuga heterophylla* zone, is covered by young stands, either natural or man-created, of the principal pioneer species of the association, *Pseudotsuga menziesii* and *Alnus rubra*, that originated after the logging of the twenties. The upper watershed contains either much older stands originating in natural disturbances from two to ten centuries ago or young stands of pioneering species established naturally or artificially after logging in the last two decades.

There are existing inventory data of a traditional forestry type and very recent (1970) aerial photographs available. Most of the watershed is readily accessible for inventory purposes from the extensive road system. There will be a specific procedure or approach for each segment of this study as outlined above.

The approach to describing the composition and structure of the major units and reference stands will be as follows: establishment of permanent plot boundaries, collection of frequency and coverage data on understory plants, and analysis of forest stand structure including stem maps. Emphasis will be on numerous linear measurements of tree and shrub specimens so that the data can be immediately extrapolated to estimates of biomass and nutrient capital as necessary formulas become available through destructive analysis and other work. Exact details of sampling will vary with organism size and needs on that particular study site; again, however, they will emphasize basic linear measurements.

SITE CHARACTERIZATION, BIOLOGICAL AND ENVIRONMENTAL MONITORING, AND MAPPING

Principal Investigator

Donald B. Zobel, Oregon State University

Coinvestigators

C. Theodore Dyrness, USDA Forest Service, Corvallis
Jerry Franklin, USDA Forest Service, Corvallis

Sponsoring Committee

Terrestrial--Primary Production

Relationship to Research Committee Program

Input is needed from geologic and soil studies on the intensive sites (Kays, Swanson, Porter, Ugolini), and environmental-plant indexes grid study (Waring).

Expected results will benefit the enlargment of small-scale process studies (Reed, Lavender/Grier), the extrapolation of the reference stand information, and the stand growth and ecosystem modeling (Waring, Overton).

(See also last paragraph of this proposal.)

OBJECTIVES

1. Complete characterization and mapping of the composition and structure of the plant communities in selected reference stands and plots at the Andrews Forest and complete terrestrial producer inventories on unit watersheds necessary to support modeling efforts.

2. Continue monitoring environmental and biological features (e.g., phenology, plant moisture stress) of the reference stands at Andrews Forest as essential to interpretation of other other studies carried out in these same areas.

3. Complete soil-vegetation mapping of the Andrews Forest with emphasis on the unit watersheds and characterize quantitatively several vegetation classification units not intensively sampled previously.

4. Summarize and analyze the data collected as required by cooperating projects. Correlate vegetation units with other stand characteristics measured. Provide a stratification of community types as desired by modelers. Prepare the data collected for publication.

APPROACH

This work is essential to and serves the Biome program (1) as a stratification for research work at the intensive study sites, (2) by providing data needed by other research projects and for development of various ecosystem models, and (3) as the basis for extrapolation of the research results geographically and from a stand to a total-watershed level of resolution. Most of the characterization work is concentrated on portions of the intensive study sites of special significance, such as unit watersheds and reference stands. The series of reference stands spans the soil-vegetation mosaics on the unit watersheds and moisture and elevational gradients within the intensive study site. The use of reference stands allows extrapolation of much of the research from the stand to the watershed level and provides the opportunity to study phenomena along identified environmental gradients. Consequently, the reference stands are focal points for much of the terrestrial research activity, e.g., studies of decomposer populations, litterfall, throughfall, nondestructive measures of stand productivity, and so on. The continuation of monitoring of environment and biological patterns is necessary to gain estimates of the widely variable parameters that are of even minimal reliability as being representative of the sites used. Characterization work, previously limited to climax community types, will be extended to earlier successional stages.

The approach to describing the composition and structure of the plots of interest will be done as in past years: collection of frequency and coverage data on understory plants, and analysis of forest stand structure including stem maps. Emphasis will be on numerous linear measurements of tree and shrub specimens so that the data can be immediately extrapolated to estimates of biomass and nutrient capital as necessary formulas become available. Exact details of sampling in unit watershed inventories will vary with organism size and needs on that particular watershed; again, they will emphasize basic linear measurements.

Monitoring of environmental and biological features will be continued in reference stands and includes (1) phenology of major plant species including pollen release and cambial growth of tree species, (2) air and soil temperature, and (3) plant moisture stress. Phenological measurements will be chiefly on understory conifers and on shrubs and herbs shown to be suitable in earlier years. Temperature will be measured with recording thermographs and moisture stress will be determined with a Scholander-type pressure chamber. These monitoring activities will be fully coordinated with other interested projects, to ensure that there is no duplication of effort and that data are collected in their most useful form.

Mapping of the H. J. Andrews Forest will be completed, based on the vegetation-soil classification already developed and standard mapping procedures. In all cases, the work will be closely coordinated with that of scientists working on soil and geologic inventory.

By the end of year 4 we expect to complete the following work: Temperature and biological monitoring data are to be made available to cooperating projects as soon as requested, in the form available when needed. Composition and structure of new reference stands and supplementary plots (including some successional community types) will be determined. Analytic vegetation data for all plots will be incorporated into the earlier community descriptions and the classification system will be modified as necessary. All temperature, moisture stress, nutritional, and phenological data will be summarized and analyzed. Along with vegetation sampling results, these data will be used to prepare an ordination and stratification of vegetation types, and then of watershed or other sampling units as needed by the modelers. Relationships between various measurements and vegetational sampling and monitoring activities, and of the analysis of data obtained, will be prepared for publication.

PROCESSES OF ENERGY TRANSFER ASSOCIATED WITH INSECTS INFESTING DOUGLAS-FIR OF THE CEDAR RIVER WATERSHED

Principal Investigator

R. I. Gara, University of Washington

Coinvestigator

Gary B. Pitman, Boyce Thompson Institute for Plant Research

Sponsoring Committee

Terrestrial--Food Chain Processes

Relationship to Research Committee Program

Input is needed from the Andrews site insect consumer study (Nagel), primary production, biogeochemical processes, and consumer modeling studies.

Expected results will be directly applicable to the decomposer group and the disease working group (Partridge).

OBJECTIVES

Insect-host interactions that transform Douglas-fir into a major source of insect food will be analyzed. To these ends, host factors (i.e., in terms of availability, susceptibility, and suitability) encouraging herbivore predation will be studied by: (1) correlating distribution of host material with insect dispersal centers; (2) determining the effects of host vigor and food quality of aggregation of insects, primarily scolytids; and (3) relating external events (e.g., defoliation, drought, and wounding) on incidences and spread of infestation.

APPROACH

As host material becomes available, the exploitative capacity of Douglas-fir insects will be estimated by detailing host selection processes and strategies. This will be done by artifically weakening or cutting trees and subsequently studying the distribution and abundance of insects responding to this material. Physical and chemical properties of the host material that are attractive to the insect groups will be analyzed. Methods of determining host selection strategies will include various olfactometric and trapping techniques.

Energy transfer from host material to insect biomass will be based on the host selection and colonization efficiencies of the various insect herbivores. This will be related to host quailty, vigor, or condition, as well as to location and abundance of host material.

Data gathered from these studies will be used to develop descriptive models of energy transfer; efficiency categories will be based on individual host allocation processes. Confirmatory experiments (to establish the models) will manipulate host material in ways to encourage infestations of selected insect taxa, primarily scolytids. Manipulative techniques will evolve from the studies on host material factors promoting insect attack.

Findings by the OSU group. studying consumers of foliage of western Cascade forests, will directly relate to the Cedar River study. While OSU endeavors focus on energy transfer between upper crown herbivores and primary production, the Washington study focuses on main-stem relationships.

5.2.3. Terrestrial--Food chain processes

INSECT HERBIVORES IN DOUGLAS-FIR FORESTS, WITH SPECIAL EMPHASIS ON ENERGY AND MATERIAL FLOWS

Principal Investigator

W. P. Nagel, Oregon State University

Coinvestigators

G. E. Daterman, USDA Forest Service, Corvallis, Oregon
B. E. Wickman, USDA Forest Service, Corvallis, Oregon

Sponsoring Committee

Terrestrial--Food Chain Processes

Relationship to Research Committee Program

Input is needed from the Cedar River site insect consumers study (Gara), terrestrial primary production, terrestrial biomass and structure, geochemical processes, ecosystem modeling group, and consumer modeling study.

Expected results will benefit terrestrial biomass and structure, terrestrial decomposition processes, ecosystem modeling, and disease working group (Partridge).

OBJECTIVES

1. Describe and characterize energy and material flows through a forest canopy consumer, the spruce budworm. This information will serve to measure parameters of the biomass transfer model developed in 1971/1972.

2. Continue to inventory dominant taxa in Douglas-fir stands of various ages to assist in evaluating successional change.

APPROACH

1. Utilizing both natural Douglas-fir foliage and artificial diets, the following will be estimated for each of the larval instars of the spruce budworm: biomass; O_2 consumption; growth rates; ingestion rates; transfer rates of Na, Ca, K, N, and a heavy heavy metal; cost of assimilation; and fate of the remainder. Sources of supply of energy and elements in natural foliage will be assessed by age of food and canopy position. Calorimetry work will be done with a microbomb calorimeter and respirometry will be done with a Gilson differential respirometer.

2. Sampling, collecting, or both will be conducted in several Douglas-fir stands of different ages in the H. J. Andrews Experimental Forest. All strata will be sampled within a given stand at approximately the same general location. The number of spatial replicates will depend upon both the taxa of concern and the stratum within the stand. Temporal replication will be a function of the life histories of the principal taxa.

Aboveground samples will be obtained directly from the trees and in various types of mechanical collecting devices. The use of light traps, suction traps, rotary nets, and the like will all be attempted at various levels above the ground. Relative abundance indexes can be obtained in these collecting devices.

Surface samples for insects will be obtained from pitfall and perhaps chemical attraction traps. Quadrat sampling of the litter surface will also be attempted. Logs and stumps can be examined mechanically but the most practical means will be through the use of emergence traps and cages.

Subterranean insect forms will be sampled in emergence traps and from excavations. Sampling for these insects will be coordinated with that of personnel studying decomposer organisms, with much of the sampling being done simultaneously.

SURVEY OF VERTEBRATE POPULATIONS IN THE CONIFEROUS FORESTS OF THE WESTERN CASCADES

Principal Investigator

Ronald A. Nussbaum, Oregon State University

Sponsoring Committee

Terrestrial--Food Chain Processes

Relationship to Research Committee Program

Input is needed from biomass and structure studies, environmental indexes grid modeling work, and consumer modeling study (Strand).

Expected results will benefit terrestrial biomass and structure, terrestrial decomposition processes, and ecosystem modeling groups.

OBJECTIVES

1. Sample populations of stream-associated amphibians with special emphasis on obtaining estimates of amphibian-related energy flow across the aquatic-terrestrial interface.

2. Sample amphibians and reptiles along elevational, moisture, and successional gradients to determine spatial and temporal distributions, densities per habitat-type, food habit relationships, and, for the dominant species, estimates of secondary productivity.

3. Continue sampling populations of small mammals and birds to estimate densities and species diversity, both spatially and temporally, and to estimate secondary productivity for the dominant species.

APPROACH

In order to estimate energy flow across the aquatic-terrestrial interface, as effected by amphibians, it will be necessary to conduct demographic studies on both the larval (aquatic) and transformed (terrestrial) populations of the three, or perhaps four, species involved (*Ascaphus truie, Dicamptodon ensatus, Rhyacotriton olympicus, Rana boylei*). Marking methods will be used to study the populations, and the Jolly method (Jolly 1965) will be used to estimate densities. Removal methods of density estimation for amphibians will also be experimented with. These include the "time-out" method, the regression method, and the maximum likelihood method. In addition, drift fences with both pitfall traps and funnel traps will be constructed along 50-m stretches of stream to monitor seasonal movements of amphibians to and from streams. Preliminary demographic data are available for *Dicamptodon ensatus* (Nussbaum and Clothier, unpublished) and for *Ascaphus truei,* and will serve as guidelines for the proposed research.

Stomach contents will be analyzed in order to determine food chain relationships. The reproductive cycle of each species will be determined through analysis of population structure and examination of the reproductive organs through the yearly cycle.

Streams can be classified into innumerable categories based on such variables as volume, flow, elevation, temperature, slope, type of substrate, cover, successional stage, sediment load, and the many interactions. Three different sizes of streams in old-growth stands will be sampled. Streams with minimal upstream disturbance will be used. In addition, streams in clearcut areas will be sampled to attempt an assessment of the effects of clearcutting on amphibian populations. As far as possible, streams that have long records of environmental monitoring will be used for these studies.

Two general types of sampling will be used to accomplish the second objective. The first method will be reconnaissance-level sampling to determine in a qualitative manner the spatial and temporal distribution of amphibians and reptiles on the H. J. Andrews Experimental Forest. Methods will include hand collecting, pitfall and funnel trapping in association with drift fences, and aquatic funnel trapping. Information on food habits and reproduction as well as distributional data will result from this activity. The possibility of quantifying data from drift fence catches will be explored.

The second method will involve intensive sampling to obtain quantitative estimates of density, biomass, and, in the case of the dominant species, secondary productivity. Because of the extremely patchy distributions of reptiles and amphibians, and because of their highly seasonal activity, they will be a particularly difficult group to sample. There are no known, reliable methods for accurately sampling terrestrial reptiles and amphibians in coniferous forests; and, for western and northern coniferous forests where species diversity and densities are low, the literature on this subject is nonexistent. Initially I propose to sample along three transects established along an elevational gradient. Each transect will run from a stream bottom to a ridge top, thereby establishing a moisture gradient within each transect. Twenty 1.0×10^{-4}-ha plots ($4\ m^2$) will be located systematically along each transect. Type of cover will be mapped for each plot, and an attempt will be made to remove all reptiles and amphibians from each plot by intensive collecting by hand. Possible alternative sampling procedures include removal collecting with regression analysis as mentioned above for the interface studies, and "nearest-neighbor" methods of density estimation. Sampling will be done during the periods of maximum surface activity in the spring and fall.

The third objective is related to the proposed research for 1972. In 1973, I anticipate that about 10% of the total effort will be devoted to continuation of intensive and extensive sampling of birds and mammals on the H. J. Andrews Experimental Forest. Extensive sampling will be limited to specialized habitats such as bogs, meadows, and open rocky ridges. Intensive sampling will be done on a limited scale, in clearcut areas of different ages for comparison with data gathered in 1972 in old-growth stands. Procedures will follow closely those proposed for 1972.

THE ROLE OF CONSUMERS IN SUCCESSIONAL DYNAMICS

Principal Investigator

Mary Ann Strand, Oregon State University

Coinvestigators

W. Scott Overton, Oregon State University
Ronald A. Nussbaum, Oregon State University

Sponsoring Committee

Terrestrial--Food Chain Processes

Relationship to Research Committee Program

Input is needed from terrestrial biomass and structure, consumer inventory, and population dynamics modeling studies.

Expected results will benefit ecosystem modeling, forest succession modeling study (Franklin), and disease working group.

OBJECTIVES

1. Develop the conceptual basis for modeling the role of consumer organisms as an interactive force in successional dynamics.

2. Develop and investigate prototype models of energy flow through the consumer subsystem during successional stages.

3. Develop a generalized model for successional dynamics of consumers and their effect on the succession of other organisms to be included in a larger model of ecosystem succession.

APPROACH

The importance of consumers in a ecosystem is probably greatest during the successional stages, when consumers may exert control on the development of plant communities. Animal populations may influence plant community by preferential feeding on certain species resulting in a differential survival of the plants. Other behavioral characteristics of consumers may have an effect on succession. Rodents by their habit of caching seeds may influence community composition after a fire. Douglas-fir seeds are preferred over hemlock or cedar for storage and these cached seeds may survive fire to give Douglas-fir an advantage during early successional stages. Disturbances of some plants are strongly influenced by fruit-eating birds. For example, the invasion of *Ribes* into a community is dependent upon the presence of these associated birds. The importance of consumers in successional dynamics is apparent; however, discussions of plant succession often do not consider the effect of consumers. For these reasons, we feel it is appropriate to put a major effort into investigating consumers as an interactive force in succession and into developing models of this aspect of the role of consumers in the forest ecosystem for examination and insights into the consequences of their actions.

To formulate the conceptual basis for modeling, an extensive review of existing literature will be undertaken. New conclusions with respect to consumer interactions during succession will be sought. The literature will be critically reevaluated to help discover the role of consumers in successional dynamics and to find data to be used in measuring parameters of the models. We hope that this literature review will suggest new experimentation, which we will pass on to the consumer committee for consideration.

The model structure will be investigated by the formulation of prototype models. Using the food chain concept developed in the first year of consumer modeling, we will select subsystems for which appropriate literature exists and construct prototype models. The structures of these models will be compared and evaluated for incorporation in the generalized model structure.

The second year of this project will be devoted to further extension of the conceptual model, using knowledge gained in research conducted by the Coniferous Forest Biome--IBP. Parameters will be measured for the model and simulation experiments will be conducted to test the consequences of our assumptions. After appropriate testing and refinement, the consumer succession model will be coupled to other models concerned with plant and decomposer organism succession.

Although experimentation is not included within this project, we hope to benefit from ongoing and completed projects from this Biome and elsewhere. Workshop meetings will be held several times each year to discuss the appropriateness of our conceptualization with other concerned biologists. We intend to use some of the travel and service and consulation monies to bring in or visit people with expertise in fields that will benefit our project. We hope to serve as an organizing project to link the other consumer projects together into a coordinated program.

TERRESTRTAL VERTEBRATE CONSUMERS OF CEDAR RIVER INTENSIVE SITES: PARAMETERS FOR MODELING

Principal Investigator

Richard D. Taber, University of Washington

Coinvestigators

Donald McCaughran, University of Washington
Richard Weisbrod, University of Washington (NPS)

Sponsoring Committee

Terrestrial--Food Chain Processes

Relationship to Research Committee Program

Input is needed from terrestrial primary production, terrestrial biomass and structure, ecosystem modeling, and consumer modeling studies.

Expected results will benefit terrestrial biomass and structure, terrestrial decomposition processes, and ecosystem modeling groups.

OBJECTIVES

1. Determine energy and material flow paths through terrestrial vertebrate consumers.

2. Contribute toward production process models.

APPROACH

We plan to inventory populations by season, emphasizing important species such as elk, black-tailed deer, and snowshoe hare, and establishing reliability of estimate. With above, and knowledge of liveweights, we expect to develop estimates of biomass; with 1 and 2 above and knowledge of metabolic expenditures, develop estimates of energy flow; for significant species, establish food habits, consumption, and foraging stratum; for significant species, establish body composition, life expectation (turnover) and mortality--i.e., material accumulation, translocation, and dissolution; for significant species, establish patterns of waste deposition and dissolution; and through selective exclosure samples, develop estimates of impact of consumption on producer species.

In all studies of the terrestrial vertebrates of the Cedar River intensive sites, there is an emphasis on determining the relation of sampling intensity to the level of resolution in the data obtained. It may be anticipated that as models are developed there will be a highly variable need with regard to desirable levels of resolution. As more accurate estimates are needed with respect to any of the parameters under study, we will be able to make a good estimate of the additional sampling, and hence the cost, that will be entailed.

5.2.4. Terrestrial--Biogeochemical processes

FLUXES IN SOIL SOLUTION CHEMISTRY: A STUDY OF THE MECHANISMS AND PROCESSES INVOLVED

Principal Investigator

Dale W. Cole, University of Washington

Coinvestigator

S. P. Gessel, University of Washington

Sponsoring Committee

Terrestrial--Biogeochemical Processes

Relationship to Research Committee Program

Input is needed from meteorology, terrestrial geochemical processes

Expected results will benefit hydrology at Findley Lake, water column processes at Findley Lake, terrestrial primary production at Thompson.

OBJECTIVES

1. Study the dynamics of solution chemistry within the forest ecosystem (a) as a function of ecosystem position by determining changes in solution chemistry as water passes from one ecosystem component to another, (b) as a function of seasonal or climatic changes by monitoring solution chemistry over these periods, and (c) as a function of a specific wetting front.

2. Relate the above changes in solution chemistry to the specific mechanisms and processes effecting such changes.

3. Evaluate the significance of such changes in terms of ecosystem behavior including ion availability, uptake, and leaching losses.

4. Develop descriptive and predictive models defining such changes: These models will be based on the processes involved; they will have as their basic structure the water transport model discussed in the biogeochemical position paper.

APPROACH

The solution passing down through the ecosystem will be intercepted and collected at a series of discrete positions including: (1) stem of the tree (stemflow), (2) directly above the forest floor (throughfall), (3) beneath the forest floor, (4) beneath the A_1 horizon (10 cm depth), (5) beneath the B horizon (50 cm depth), (6) deep within the C horizon (approximately 100 cm depth). Additions to the system by way of precipitation and particulate materials and losses from the system as observed from sampling the groundwater system will also be collected.

Changes in solution chemistry will be monitored at the above ecosystem positions using continuous collection procedures. Samples will be removed for chemical analysis on a monthly basis to develop the budgets on elemental redistribution within the ecosystem. In addition, the chemistry of these solutions will be continuously assessed periodically by means of *p*H and conductivity flow cells located in the solution collection lines. This flow information together with associated environmental conditions will be recorded by means of a data logging facility. With this procedure it will be possible to monitor rapid fluxes in solution chemistry such as those associated with a wetting front. By studying both monthly changes and these rapid fluxes it will be possible to understand more clearly the mechanisms most directly responsible for these ion transport relationships.

The more detailed phases of this program will be conducted at the Thompson Research Center and focused on the second-growth Douglas-fir of this site. In this way roles of elemental cycling and redistribution can be tied into the other process studies organized at this site. Advantage can be taken of the facilities and past programs that have already been completed for this area. A similar series of collection will also be made at the higher elevation study area at Findley Lake in conjunction with Ugolini's program on soil weathering processes. The collection, sampling, and continuous monitoring flow systems have been designed and field tested. A compact portable system to assess rapid fluxes in the acidity of these solutions is now being assembled.

FLUXES IN THE ELEMENTAL COMPOSITION OF FOREST STANDS

Principal Investigator

D. W. Cole, University of Washington

Coinvestigator

S. P. Gessel, University of Washington

Sponsoring Committee

Terrestrial--Biogeochemical Processes

Relationship to Research Committee Program

Input is needed from meteorology and terrestrial geochemical processes. Expected results will benefit primary production processes.

OBJECTIVES

1. Assess the short-term and long-term fluxes in the elemental composition of Douglas-fir foliage.

2. Establish the mechanisms responsible for these fluxes, both internal and external to the tree system.

3. Follow these fluxes at several additional sites (with strikingly different forest communities) to better understand the importance of internal and external cycling as it relates to the overall nutrition and efficiency of elemental utilization by a forest system.

APPROACH

The exchange of elements between components of an ecosystem is an obvious consequence of a number of transfer mechanisms. It has not been established, however, what importance these cycling and transfer processes play in the overall functioning of an ecosystem. It seems that certain forest systems such as the Douglas-fir are heavily dependent on an external cycling arrangement, that is, where the elements are returned to the tree through litterfall, and a decomposer food chain. In other ecosystems where decomposition processes are perhaps too slow to provide an adequate source of supply of nutrient elements (for example, where it is too dry, wet, or cold), the forest stand could be more dependent on an internal recycling strategy. It is proposed to study these internal and external cycling relationships in detail for second-growth Douglas-fir at the Thompson research site. This phase of the study will be closely linked to the solution chemistry studies also proposed for this forest stand.

A comparative base providing extrapolation to other forest types and environmental conditions will be established in two ways:

1. Field studies will be made under contrasting environmental and species composition conditions. Initially a comparison will be made between the Douglas-fir at the Thompson site and true fir at Findley Lake. The forest ecosystem

at Findley Lake has a far shorter growing season and period for rapid decomposition. Consequently it could be postulated that internal cycling could play a more critical role in this forest ecosystem.

2. Laboratory studies will be made under controlled greenhouse and environmental conditions. A series of species known to accumulate and recycle elements will be studied under controlled conditions. The specific rates, times, and mechanisms of internal and external cycling will be established by observing changes in elemental composition associated with changes in the phenology of the individuals. The susceptibility of ion leaching prior to and following abscission will be documented.

EFFECT OF MANIPULATIONS AND VEGETATION COVER CONVERSION ON NUTRIENT RETENTION, MOBILIZATION, AND LOSS IN FOREST ECOSYSTEMS

Principal Investigator

R. L. Fredriksen, Oregon State University

Coinvestigator

D. G. Moore, Oregon State University

Sponsoring Committee

Terrestrial--Biogeochemical Processes

Relationship to Research Committee Program

Input is needed from aquatic and soil erosion studies, hydrology, primary productivity modeling, and geochemistry.

Expected results will benefit soil microbiology, decomposer group, hydrology, ecosystem modeling group, and ionic dynamics modeling study (Strand).

OBJECTIVES

1. Determine nutrient loss from manipulated and undisturbed forest ecosystems.

2. Determine changes in soil solution chemistry and the mechanisms of nutrient mobilization in soils and forest floors of manipulated and undisturbed forest ecosystems.

APPROACH

This study will provide estimates of nutrient input and loss from Douglas-fir forests and the change in nutrient budget (input minus loss) that results from timber harvest or vegetation cover conversion. Estimates of nutrient loss from processes of soil erosion and leaching will be made. Chemical composition of streams will be extended to include relationships to chemistry of the soil solution. With knowledge of nutrient flux in the soil solution the connection can be made between changes in stream water chemistry and biological processes in the soil. Measuring the retention properties of the soil will indicate the effect of these processes on soil solution and stream chemistry, either through physical adsorption or through the interchange and uptake process. The work proposed here will establish the basic chemical budget for the forest and the connection through the soil solution to biological processes of nutrient uptake and nutrient return through canopy wash, decomposition, and root exudation.

Chemical budgets for Douglas-fir forests on experimental watersheds are calculated by taking the difference between input in precipitation and loss in streamflow. Chemical input from atmospheric fixation is the responsibility of another study. Equipment has been developed for the continuous sampling of dissolved and suspended contents of streamflow. Volume of streamflow is measured by stream gaging facilities. Precipitation quality is sampled at the top of an 18-m tower, and measurement of precipitation quantity is provided by a rain gage network. Analyses of water and sediment are performed by wet chemistry methods.

Soil solution sampling will be done by extraction of fresh soil cores taken from the soil profile. The solution thus obtained will be analyzed for the chemicals of interest that it contains. The chemical content of the soil solution will then be compared with the rate of soil biological processes as indicated by soil temperature and the physiological availability of water.

The chemical retention capacity of soils will be evaluated by the application of solutions containing organic and inorganic substances to a soil tension lysimeter system installed in the field. The relationship of the quantity of chemical substances applied to the quantity recovered in leachate will indicate the retentive capacity of the soil system.

Nutrient budget data from Douglas-fir forests have a time resolution of three weeks. These measurements represent the nutrient fluxes from the forest on an entire experimental watershed. The soil solution work will estimate chemical contents as related to phenological period. Once the techniques are developed, solution chemistry will be measured for several contrasting forest habitat types.

Data will be tabulated by the principal investigators in specified measurement units. Statistical analyses will be performed as required to show the time and space relationships. The relationships of nutrient flux and nutrient mobilization thus determined will be contributed to the development of quantitative models.

The nutrient budget program will continue with the same intensity of activity in 1973 and 1974. Mobilization and retention work in soil solution will emphasize reference stands in 1973; more emphasis will be given to manipulated ecosystems in 1974.

STUDIES OF GEOLOGY, ROCK WEATHERING, AND SEDIMENTARY PROCESSES IN THE H. J. ANDREWS EXPERIMENTAL FOREST

Principal Investigator

M. Allan Kays, University of Oregon

Coinvestigator

Frederick J. Swanson, University of Oregon

Sponsoring Committee

Terrestrial--Biogeochemical Processes

Relationship to Research Committee Program

Input is needed from hydrology, meteorology, and soil study groups.

Expected results will benefit the vegetation and soil classification work (Dyrness, Franklin), the nutrient balance studies (Fredriksen), and the hydrology studies (Harr).

OBJECTIVES

1. Map the distribution of lithologies, structural features, and surface deposits and examine their relationships with the geomorphic development of the study site.

2. Determine chemical variations within and among the principal rock units.

3. Analyze products and processes of rock weathering in coordination with studies of soil genesis.

4. Make additional observations on bed-load sediment movement, to be combined with existing data and fed into calculations of denudation rates.

5. Monitor distribution, rates, and styles of mass movement.

APPROACH

Rocks of the Little Butte Volcanic Series, Sardine Formation, and recent flows of the High Cascades form the physical substrate and a nutrient reservoir for the H. J. Andrews forest ecosystem. The geology of this area has been mapped only in a reconnaissance fashion by Peck and others (1964) and by Lexa and Duncan (1972, personal communication). The prior work is so general, however, that the details of the geologic and geomorphic development of the site will be a major part of this study and will combine results of previously proposed work by Kays and Dyrness.

An understanding of the critical chemical relations between the geological and biological aspects of the area requires a study of the processes and products of rock weathering. A part of this geochemical study will also outline the chemical variation within and among different rock types, a factor that may exercise significant control over the development and distribution of soil types and plant communities, as well as landforms.

Geomorphic development of a drainage is also closely tied with mappable geologic features and processes of mass movement and sediment transport. Styles and rates of mass movement can be monitored with simple surveying techniques to expand on the work of Dyrness (1967) and others. This process accelerates removal of nutrients from the drainage by sediment transport. Data from the proposed study of bed-load movement will be combined with observations made previously on solution, suspension, and coarse sediment removal from selected drainages to estimate denudation rates by these processes.

Methods

Detailed geologic mapping will be done on existing photographic and topographic bases. During the mapping program representative bedrock samples will be collected for chemical and petrographic analysis using X-ray fluorescence and other equipment available at the University of Oregon. Sampling for the rock weathering studies will be coordinated with soil study programs. Chemical analysis, petrographic, and X-ray diffraction techniques will be used to examine nutrient release and weathering products of various bedrock types in different stages of breakdown.

Observations of sediment movement will employ scour chain and painted gravel techniques as well as existing and proposed sedimentation basins on small watersheds. Areas for mass movement studies selected during the geologic mapping program will be surveyed and staked so that periodic checks of movement can be made easily.

Resolution

Time resolution of the process-oriented aspects of this project is on a very coarse scale. It will be most instructive to estimate the net effects of both episodic and slow, continuous processes over periods of years and decades.

Spatial resolution will vary from an overview of the entire Lookout Creek drainage (objectives 1 and 2) to the detailed sampling at certain sites within watershed 10 (objective 3). Objectives 4 and 5 can be accomplished only by first taking an overview and then doing detailed studies in selected, representative locations. Reduction of chemical data will use available computer programs and facilities at the University of Oregon.

These studies will begin in summer and fall of 1972, partially supported by funds already granted to M. A. Kays and C. T. Dyrness. At that time we will initiate all phases of fieldwork. Data collection and compilation and sample processing are expected to continue through 1973, possibly further, depending on progress and results of the study to that date.

SURFICIAL GEOLOGY OF THE CUMBERLAND AND EAGLE GORGE QUADRANGLES, WASHINGTON

Principal Investigator

S. C. Porter, University of Washington

Sponsoring Committee

Terrestrial--Biogeochemical Processes

Relationship to Research Committee Program

Input is needed from the four-lake program, the Findley Lake program, Thompson site program, and the geologic mapping efforts of the Andrews Experimental Forest.

Expected results will benefit the interpretation and modeling of the eutrophication sequence in the four-lake program, the hydrology of the Findley Lake and Thompson sites research, and the ecosystem modeling effort for large drainages.

OBJECTIVES

1. Detailed exploration and mappling of the surficial geology of Cumberland and Eagle Gorge quadrangles is the main objective.

2. Geologic maps and representative rock samples will be assembled to assist the ecosystem research and modeling efforts in the extrapolation of site-specific models by stratification of geologic features.

3. Attempts will be made to estimate the general groundwater hydrology of the areas in cooperation with the hydrological surveys being made.

APPROACH

The flux of nutrients in a forest ecosystem is very much affected by, among other things, the physical setting, the potential source of nutrients, and the geochemical and pedological processes involved in the release, mobilization, and fixation of elements and compounds. The physical setting of an ecosystem is the landscape, which reflects the cumulative effects of all processes that have sculptured the land.

In essence the landscape is the result of types and arrangements of geologic materials, events, and processes. The understanding of a given landscape is is a broader sense the understanding of the environment and its development, and can be gained when the composition and structure of the rocks is known, when past events are reconstructed, and when the processes are recognized and evaluated. Much insight on the formation and evolution of an environment can be gained if the geologist (geomorphologist) and the pedologist investigate a given area from the point of view of their respective disciplines. The purpose of geologic investigation is to help implement this approach and to provide information on both the static and the dynamic aspects of the environment.

Findley Creek, a tributary of the Cedar River, was glaciated during the Pleistocene epoch. The present landforms and surficial deposits within Cedar River drainage basin are largely related to glacial processes that modified the underlying bedrock. Although a part of the glacial record is present in the Findley Creek Valley, an understanding of the complete Quaternary history of the valley will require an investigation of the entire Cedar River drainage basin. Special emphasis will be placed on the study of Findley Creek Valley, as that is one of the primary IBP study sites in the drainage basin. The valley head is a well-formed cirque and Findley Lake itself is either a tarn or moraine-dammed lake. Details of the surficial geology of the drainage basin are unknown, for no detailed work on the glacial deposits above Chester Morse Lake have yet been undertaken.

Although the bedrock geology of the drainage basin has been studied in reconnaissance by Hammond (1963), detailed mappling of the bedrock has not been carried out. The bedrock geology of the Cedar River basin is beyond the primary aim of the present study, but special attention will be directed toward determining the character and distribution of bedrock units within the IBP study site in the Findley Creek tributary basin. Apparently the bulk of the basin is underlain by the Cougar Mountain Formation, a Miocene succession of lava flows and associated clastic volcanic rocks (Hammond 1963). Several small intrusive bodies of granite cropping out near the head of the valley are regarded as part of the Snoqualmie batholithic complex.

Topographic maps and aerial photographs of suitable scale are available for the entire drainage basin and will be used as a base for plotting data collected in the field. Delineation of the nature of geologic materials at the ground surface should provide important information bearing on the character of the parent materials of soils that have developed and on which plants are growing. Such data should help in evaluation of possible variations in plant productivity that are a function of geologic differences.

The study proposed here will be used as a thesis problem for a master's degree in geologic sciences. It is anticipated that field mapping can be completed during a single long summer field season and laboratory work can be completed during the following academic year. A full-time research assistant's position is requested for the investigator so he can devote full effort during the academic year to completion of the project.

PROTOTYPE MODELING OF IONIC DYNAMICS IN THE SOIL SOLUTION

Principal Investigator

Mary Ann Strand, Oregon State University

Sponsoring Committee

Terrestrial--Biogeochemical Processes

Relationship to Research Committee Program

Input is needed from biogeochemical process studies, geology and soils inventory studies, and ecosystem modeling efforts.

Expected output will benefit biogeochemical process studies, fire influence working group, and tree-level subsystem modeling effort (Hatheway).

OBJECTIVES

1. Develop the conceptual basis for modeling the dynamics of ion interchange and uptake in the soil solution.

2. Develop a prototype model for nitrogen exchange in the soil solution.

3. Develop a generalized model of ionic dynamics incorporating environmental variation and successional trends.

APPROACH

Based primarily on published literature, the models developed by this project should suggest research in biogeochemical cycling. An initial survey (70 references) suggests the existence of adequate information to develop an initial model, although none of the references reviewed refers to the process of ionic exchange as a dynamic process. An annotated bibliography will be developed.

Researchers allude to the wholeness of the ionic dynamics system but have attempted to study only isolated fragments of the system. We propose to take a system analysis approach and look at the process as a dynamic interaction between the soil microorganisms, plant roots, and the physical components of the soil.

Nitrogen is the most studied of cycled nutrients, so the prototype model will be based on nitrogen dynamics. The properties of populations of living microorganisms with respect to uptake and release of this element will be investigated as a function of environmental variables. In 1974 the model will be generalized to accommodate nutrients other than nitrogen.

We expect to build on data from contemporary Biome studies, using workshops and informal meetings with Biome personnel and by personal exchange with specialists in other Biomes. By 1974 this project should be supplemented by experimental studies directed at testing the prototype.

Interchange and uptake processes are central to the cycling of nutrients in an ecosystem, so this model is of importance to the modeling effort of the Biome. The models developed will couple the decomposition process model with primary production and hydrology.

NUTRIENT LOSSES DUE TO SOIL EROSION ON STEEP FORESTED SLOPES WITHIN THE CONIFEROUS BIOME

Principal Investigator

Douglas N. Swanston, USDA Forest Service, Corvallis, Oregon

Sponsoring Committee

Terrestrial--Biogeochemical Processes

Relationship to Research Committee Program

Input is needed from hydrologic and subsurface flow studies (Rothacher and Harr) to determine the role of water as a controlling factor in erosion losses; nutrient mobilization and retention studies (Fredriksen and Moore) to determine nutrient levels in the soil mass; soil and site description work (Kays and Dyrness, Knox and Parson, Franklin and Dyrness) for information on soil, parent material, and vegetation characteristics and distribution; and geological studies (Kays and Dyrness, Swanson) to evaluate the mineralogical and chemical nature of the soil mantle.

Expected results will benefit biogeochemical cycling groups, the water transport modeling group, and the coordination program.

OBJECTIVES

1. Determine the relative amounts and rates of erosion and nutrient loss attributable to these two processes as controlled by: (a) vegetation cover, (b) parent material type and structure, (c) basic soil type and physical characteristics, and (d) local variations in precipitation and groundwater movement.

2. Compare the erosion rates and subsequent nutrient losses from these two erosion processes on manipulated and undisturbed sites.

3. Research and review available literature dealing with erosion and nutrient transport on forested lands.

APPROACH

Soil erosion is an important link in the nutrient cycling system between ion release from soil minerals, fixation within the soil mantle, and ultimate nutrient losses to streamflow. This project will investigate the relationships of single-particle erosion and mass soil movement to mineral transfer and nutrient losses from steep, forested watersheds within the Coniferous Biome.

Experimental design includes an extensive review of the literature dealing with soil erosion and nutrient transport; an evaluation of erosion processes and controlling factors operative within the study site; a period of intensive monitoring to determine actual erosion rates and nutrient losses, followed by monitoring to detect rate changes and increases in loss due to disturbance; and final analysis of results.

Instrumentation is already available for measurement and estimation of total sediment and nutrient loss. Estimates of loss due to soil mass movement will be made by careful mapping of study site slopes initially and following each major storm period to determine location and approximate volume of any new landslides. Natural soil creep and any acceleration of creep will be monitored with strain gage probes and by triangulation of marker stakes on the slope. Surface erosion will be monitored with stratigically placed collection troughs and by estimates of differences between total sediment yield and volume of sediment produced by soil mass movement. This will require construction of a sediment collecting basin at the gaging site, a project expected to be completed by the USDA Forest Service before 1973. Analysis for basic soil properties needed to define sliding mechanisms will be performed by the Forest Service using established analytical techniques.

Instrumentation and monitoring will begin immediately and will extend through both project years. Literature review and evaluation of controlling factors will be done during the first year. Analysis of monitored data and final definition of mechanisms and rates of nutrient transport by erosion processes will be performed during the second year.

DYNAMICS OF WEATHERING AND SOIL-FORMING PROCESSES

Principal Investigator

F. C. Ugolini, University of Washington

Coinvestigator

M. J. Singer, University of Washington

Sponsoring Committee

Terrestrial--Biogeochemical Processes

Relationship to Research Committee Program

Input is needed from Andrews site geology, weathering, and erosion studies (Kays, Swanson, Swaniston), nutrient balance manipulation studies (Fredriksen, Moore), and hydrologic and aquatic biology studies.

Expected results will benefit the modeling of ionic dynamics of soil solutions (Strand), the tree-level sybsystem model (Hatheway), aquatic lake and stream studies, and the Findley Lake interface study.

OBJECTIVES

1. The function of the soil component in the structure of the Findley Lake basin ecosystem will be quantified by studying the soil moisture regime and soil-water flow in selected profiles.

2. The dynamics of soil formation will be studied by characterizing the suspended material and ionic content of the soil water sampled by tension lysimeters. In detail, this objective will be reached by measuring: (a) the amounts of water moving through the soil profile, (b) the seasonal dynamics of the soil moisture regime, and (c) the soil temperature profile.

APPROACH

Soil, the thin ubiquitous unconsolidated mantle of material that supports a diversity of life from microscopic bacteria to giant coastal redwoods, and the processes of water and nutrient flux within the soil profile are the subjects of this investigation. Geologic, atmospheric, aquatic, and biological systems meet at the terrestrial interface. Thus it is desirable to study intensively the interface characteristics and the processes that cross its boundaries. Soil is a major component of the interface and is a major component in the structure of an ecosystem. Soil is not a static component; rather, it is continuously evolving. During this evolution, the soil profoundly affects the biological community growing within and above it by varying in its ability to supply water, nutrients, and support. Water, another major component of the interface, links all the systems, reacts with the soil, and is altered by it. Some of the processes in which these components take part are understood qualitatively and some are not understood at all. This study will attempt to delineate processes and quantify others in the soil-water system. As these processes become understood, the evolution of the soils, the evolution of the ecosystem in which the soils occur, their effects on each other, and their effects on other ecosystems will be more fully understood.

Specifically, the goals of this study are to gather data on the character of the soil-water system and to measure the translocation of water and solids through the soil-water system. These goals, when achieved, will assist in developing a fuller understanding of the dynamic processes that produce a soil and upon which an ecosystem depends. Specific results from this particular coniferous forest ecosystem will have general applicability in a range of coniferous forest ecosystems.

The proposed study area is the Findley Lake basin in the upper reaches of the Cedar River watershed. Findley Lake watershed is a small cirque, less than 259 ha, located in the Snoqualmie National Forest in Washington's Cascade Mountains.

The generalized goals of the IBP are to gather sound biological information on the structure and function of ecosystems, and to use this information in assessing the impact of management decisions on ecosystems. The information would be incomplete without a detailed study on the processes taking place within the soil component of each ecosystem. Soil water, which is the medium of nutrient flux, and soil-water flow, which is the mechanism of this flux, are of major importance in soil and ecosystem processes. Of the nine principal resource problems of the Coniferous Biome where IBP research contributions are expected (Gessel et al. 1971), the soil component and soil-water flux are of direct importance in six and of indirect importance in all nine problem areas. Intelligent, correct decisions on allocation of land resources, productivity and productivity maintenance on forest lands, productivity of surface waters, role of land management in water quality and quantity, the impact of management practices on forest lands, and the potential for using forest land to control and absorb some suburban agricultural pollutants cannot be made without adequate knowledge of the soil component of the ecosystem.

A simple delineation of the soils present in an area is only a small part of the information necessary to evaluate the function of an ecosystem. Characterization of individual soil profiles does not provide all the information necessary to understand how the soil fits into the overall structure of an ecosystem. To fully understand these factors, it is necessary to investigate the dynamic processes occurring within the soil profile. These processes are biological, chemical, and physical; they interact to produce the soil ped. It is unrealistic to separate these interacting processes in order to study the soil ped. Yet, it is exceedingly difficult to study all. One method of circumventing some of these problems is by studying water movement in the soil. By studying water flux through the ped, an investigator looks at the reactants and reaction products and thus, gets a detailed view of the processes taking place within the ped. Further, by characterizing the water before it enters the soil, as it passes through the soil, and as it leaves the solum, one gains valuable information on how the soil is affecting the water. The charactization of the soil profile delineates the end products of a combination of processes that have produced the soil ped. This study will quantify the rates at which the processes are occurring and the time of their occurrence.

In the Findley Lake basin there are variable soil conditions that affect the percolation of water into the subsurface materials and the volume of surface runoff. Quantitative characterization of these conditions will yield valuable information for researchers studying the hydrology and water budget of the watershed.

Three major soil groups have been mapped by Olson and co-workers (in press) in the Findley Lake basin. The groups were based on three types of parent materials, which were then subdivided further according to the vegetation that the material supported. The research proposed here will be conducted on the forested member of each parent material. The three materials are (1) talus, (2) mixed materials, and (3) residual materials. Three replicate plots will be established on the talus. The talus supports little or no vegetation. Three replicate plots will be established on the soils formed under forest on mixed materials, and three replicate plots will be established on soils formed under forest on residual soil materials. Together, the talus (16.2%), forested soils of mixed materials (56.2%), and forested residual soils of the ridges (17.5%) compose 89.9% of the soils in the Findley Lake basin.

Precipitation, soil temperature, and soil moisture tension will be sampled (measured) weekly throughout the spring, summer, and autumn months when snow accumulation permits. Throughfall and soil moisture (lysimeters) will be sampled twice a month from the time the snowpack has melted to when the equipment is buried by snow in the fall. Monthly snow samples will be taken during the winter, and lake and stream water samples will be taken monthly for comparison purposes.

Precipitation will be measured by one double-swing 30-cm capacity recording rain gage equipped with a one-week clock. It will be placed on the non-vegetated rim area of the watershed. This sampler will gather data on time, intensity, and duration of precipitation, as well as collect samples for elemental analysis.

Throughfall will be sampled in the mixed material and residual material areas by five replicate funnel-type collectors per sampling site, for a total of 30 collectors. Stemflow water will be collected from five trees within the forested mixed material site using standard techniques. Tension lysimeters will be used to sample the soil solution at various depths within the soil peds on the three types of parent materials. Tensiometers will be employed to characterize the water status of the soils in situ during the field season. Infiltration rate will be measured for each site using standard techniques reported in the literature. Percolation rates for the different sites will be determined by standard techniques as described in the literature. Bulk density will be determined for horizons within the three soil groups by either a standard clod-coating method, or by the irregular-hole method.

Soil temperature measurements will be made for several depths at one site in each soil-vegetation group. These measurements will help to place the soils into the new soil classification system, and will provide another parameter for describing the soil.

There are expected to be 75 samples collected from the 39 lysimeters, 30 throughfall stations, five stemflow collectors, and rain-gage sampling period, or 150 samples per month. Each sample will be divided for analysis of total and water-soluble constituents. Thus it is expected that there will be 300 analyses for each element per sampling month. This sampling frequency and analytical procedure yields approximately 4500 analyses for Fe, Al, and Si over a five-month field season.

The plot design and sampling design are such that readily accessible library programs may be employed for statistical analysis of the data. Other manipulations will be handled by programs written by the researchers.

BIOGEOCHEMICAL CYCLE OF THE CONIFEROUS FOREST BIOME

Principal Investigator

F. C. Ugolini, University of Washington

Coinvestigator

M. J. Singer, University of Washington

Sponsoring Committee

Terrestrial--Biogeochemical Processes

Relationship to Research Committee Program

Input is needed from Andrews site geology, weathering, and erosion studies (Kays), Swanson, Swanston); nutrient balance manipulation studies (Fredriksen, Moore); and hydrologic and aquatic biology studies.

Expected results will benefit modeling of ionic dynamics in soil solutions (Strand), the tree-level subsystem model (Hatheway), aquatic lake and stream studies, and the Findley Lake interface study.

OBJECTIVES

1. Initiate a preliminary program of sampling for assessing processes and rates at Thompson and Andrews sites.

2. Attempt a preliminary comparison among different drainage basins.

APPROACH

Classical geochemical studies have emphasized the relation between chemical weathering and climatic zones. Mountainous areas have been considered mainly affected by physical erosion and scarce chemical denudation. Contrary to this belief, data have been obtained in the southern Cascades showing that the rate of chemical alteration is high and comparable to that of warmer and more humid regions. Our work on the alpine soils of the northern Cascades has also shown advanced degrees of weathering. Weathering is dependent on temperature distribution, quantity of rainfall, leaching potential, rock structure and composition, pH, E_h, and time. For a given basin, the rivers and drainage waters tend to average the multifold variations and provide a composite picture of the soluble products of weathering. Gross analysis of rivers from different basins can therefore illustrate the type of the rate of weathering and the impact of man.

Solutions and suspensions will be obtained through lysimeters and by collecting seepage and river water. The collected samples will be analyzed for major cations and for silica, aluminum, iron, and phosphorus. During the first year, only a low level of resolution will be obtained. Refinements in locational sampling, in sample frequency, and type of analysis will be made in the following years.

The data of this project are of concern to hydrology, mineral cycling, limnology, and the primary producer. Upon completion of the project, the data will be deposited in the information bank and made available to interested investigators.

DECOMPOSERS ON LIVNG TWIGS AND FOLIAGE

Principal Investigator

George C. Carroll, University of Oregon

Coinvestigator

Charles Driver, University of Washington

Sponsoring Committee

Terrestrial--Biogeochemical Processes

Relationship to Research Committee Program

Input is needed from biomass and structure, meteorology.

Expected results will benefit primary production processes and biogeochemical cycling.

OBJECTIVES

1. Complete survey of mycelial fungi occurring on (and in) leaves and twigs of maple and alder. Such a catalog already has been finished in detail for Douglas-fir, and superficial lists have been compliled for western red cedar and western hemlock.

2. Sample and identify populations of microorganisms occurring as single cells on leaf and twig surfaces, e.g., yeast, algae, and bacteria.

3. Extend such floristic studies to other validation sites within the Coniferous Biome.

4. Complete estimates of standing crop biomass for microorganisms found in great abundance on leaves and twigs. Estimates already completed for Douglas-fir suggest values of 10 kg ha^{-1} for fungi (excluding yeasts) and similar values for crustose lichens.

5. Estimate turnover rates of microbial populations occurring on twigs or leaves.

6. Determine consequences of microbial metabolism on the leaves and needles on which the organisms live.

APPROACH

Foliage and green twigs of Douglas-fir, maple, and alder compose a major portion of the total photosynthetic surface within the Coniferous Biome. So far as the net primary productivity of the Biome depends on the efficient functioning of this surface. Microorganisms living on or within the needles may exert a disproportionately large influence on the overall activities of the forest. Obvious effects may include the direct use of of carbohydrates produced by the needles and hastened senescence of the needles through infection. More subtle effects may involve increases in the leaching of soluble carbohydrates from the needles by rain.

Samples of foliage and twigs from trees of varying ages are examined under the microscope, and individual fungi are removed for identification and culture. Yeasts and bacteria are sampled by washing leaf surfaces with a mild detergent, by sonic oscillation in water, and by making impressions of the leaf with sterile sticky tape. Organisms isolated in these ways will be cultured, identified, and screened for metabolic activities.

Numbers of microbial single cells will be counted and estimates of cell number per unit surface area of leaf of a given age class will be made. Assumptions about the average density of the microbial cell will yield estimates of standing crop biomass.

Monitoring of populations of spores released into the air and of single cells released into water running off needle, leaf, and twig surfaces during the rainy season will give estimates of turnover rates for resident microbial populations. Comparison of total organic carbon and dissolved organic carbon in the runoff water should provide independent estimates of these same rates.

Crude estimates of the degree to which hastened senescence can be attributed to heavy microbial infection may be obtained by comparing respiratory and photosynthetic rates of leaves of the same size and age that show differing degrees of fungal infection.

Increases in leaching caused by microbial activity may be indicated by increased etching of the leaf cuticle (as revealed under SEM). With Douglas-fir, where a succession of needles of varying ages can be obtained from the same twig, direct measurement of leached carbohydrate from individual needles may be attempted.

DECOMPOSER PROCESS STUDIES

Principal Investigator

William C. Denison, Oregon State University

Coinvestigator

George C. Carroll, University of Oregon

Sponsoring Committee

Terrestrial--Biogeochemical Processes

Relationship to Research Committee Program

Input is needed from biomass and structure, meteorology, and geochemical studies; and from the coordination program on the influence of diseases.

Expected results will benefit subsystem modeling of ionic dynamics in soil solutions, geochemical nutrient cycling and weathering studies, and forest biomass accumulation studies.

OBJECTIVES

1. Provide ecological characterization of fungi identified as of major importance in litter decomposition.

2. Develop simulated and seminatural systems (microcosms) for study of rates and pathways of litter decomposition under controlled conditions.

3. Continue field studies of rates of decomposition of litter components.

4. Initiate development of methods for measuring the nutrient storage and transport capacity of litter and soil fungi.

5. Utilize mapping techniques developed in 1971 and 1972 to determine distribution of major, functionally defined groups of decomposers at the Andrews and Cedar River sites.

APPROACH

Construction of models incorporating decomposer fungi requires examples of ecological behavior (e.g., growth rates, decomposition rates, specific substrates, response to environmental variables) of "typical" decomposer fungi. Existing literature treats few specific fungi other than pathogens or industrial ferments. We propose to provide this ecological characterization for fungi involved in specific stages of decomposition on the intensive study sites.

We are accumulating a collection of cultures of decomposer fungi occurring with high frequency within major litter elements, e.g., Douglas-fir needles. As work progresses in 1973 this collection will be "edited" to provide a restricted number of examples for detailed study. Routine cultural procedures exist for testing of maximum minimum, and optimum temperatures, *p*H, nutrient level, and the like, and responses to light and specific solutes. Selected cultures will be tested for ability (and rates) to degrade cellulose, lignin, amino acids, and sugars. Use will be made of other substrates (e.g., chitin, waxes) when appropriate.

We plan to develop microcosms to simulate litter decomposition under controlled conditions. Some of these will be of small size (e.g., 1 liter) , and will contain limited numbers of defined elements (fungi and other microorganisms from culture, "standard" samples of cellulose, lignin, and so on) while others will be larger (up to 25 m^3) and will contain nearly intact pieces of forest floor. These microcosms will be used to measure both rates of disappearance of substrate and release of solutes and gases.

Field studies of rates of decomposition of specific litter components, including standard samples as they become available, will continue in collaboration with Driver and Lavender. We will assist Pike in developing methods for parallel studies of lodged litter and in situ decomposition of epiphytes.

We will undertake development of methods for studying nutrient storage and transport by litter and soil fungi, probably as an adjunct to the microcosm studies, though the form of this study is not presently defined.

We are developing methods for field mapping of fungi, both individual species and functionally defined groups, that are not dependent upon fruiting body formation. By 1973 we should be able to test these methods for fungi important in the intensive sites to provide a basis for extrapolation of models developed at the site or stand level to larger geographical areas.

Data from these studies will be used primarily in developing models at the watershed level and in developing and testing Strand's ionic dynamics model.

General ecological characterization should begin in 1972 and peak in 1973, to be followed by specific studies of key fungi. Microcosm studies will begin in 1973 and will increase in importance subsequently. Field studies of litter decomposition will continue, though at a low level, to provide a measure of annual variations. Future development of nutrient storage and transport studies will depend upon estimates of the importance of this function subsequent to initial modeling and testing. Probably by 1974 it will either become a major separate project or be discontinued altogether. Assuming that mapping of major decomposer groups is practical at a reasonable price, its application will be an important aspect of future extrapolation studies.

FURTHER STUDIES ON THE CHARACTERIZATION OF PRIMARY DECOMPOSITION OF THE WOOD COMPONENTS OF THE DOUGLAS-FIR ECOSYSTEM

Principal Investigator

Charles H. Driver, University of Washington

Coinvestigator

William C. Denison, Oregon State University

Sponsoring Committee

Terrestrial--Biogeochemical Processes

Relationship to Research Committee Program

Input is needed concerning production of the wood components (cellulose, lignin, and extractives) of foliage, limbs, bole, and roots of Douglas-fir and western hemlock of the ecosystem, from biomass and structure.

Expected results will benefit biogeochemical cycling (a description of the processes and rates of primary decomposition of the wood of Douglas-fir and western hemlock.

OBJECTIVES

These data should provide the information required to model initial decomposition and provide further information for describing secondary decomposition as a part of the carbon cycle within the ecosystem.

APPROACH

Fungal decay processes and rates of primary decomposition will be further studied by describing the changes in solubilities of wood components (cellulose, lignin, and extractives) while under field and laboratory conditions. Such solubility monitoring will be continued in order to characterize that portion of the carbon cycle passing through a decomposition microorganism functioning within a Douglas-fir ecosystem.

These data will then be used to describe the processes materially affecting the reduction phase of the Douglas-fir biomass. By this approach, that portion of the carbon cycle passing through the decomposer as a part of the nutrient cycling within the Douglas-fir ecosystem will be applied in modeling the total ecosystem.

In addition, a special effort will be made to establish benchmark evaluations of the cellulose burial studies recommended by the Tundra Biome decomposer group. At the same time a wood stake (Douglas-fir and western hemlock) decay test will be conducted at the cellulose burial test site. This approach would provide a correlation of the suggested standard cellulose decomposition test results with meaningful wood decomposition processes. Such a correlation will have further value when solubility changes of wood components are also described.

Similar comparative evaluations could be conducted at sites of all conifer ecosystems studies, e.g., the Andrews and possibly the Tundra sites.

Denison will provide samples for analysis from several levels on standing, live trees. Rigged trees used in other studies will be cored using a 12-mm-increment borer at 10-m intervals up the tree. Isolation from these cores will provide information about frequency of wood-rotting fungi. A subset of the cores will be used for chemical analysis and a set will be sent to Driver for long-range studies of release of nutrients.

ENERGY FLOW AS DETERMINED BY RATES OF LITTER DECOMPOSITION

Principal Investigator

C. M. Gilmour, University of Idaho

Coinvestigator

C. T. Youngberg, Oregon State University

Sponsoring Committee

Terrestrial--Biogeochemical Processes

Relationship to Research Committee Program

Input is needed from other decomposition studies, soil solution ionic dynamics modeling effort, soil microfauna studies, and geochemical process studies.

Expected results will benefit substystem modeling program, coordination programs, and geochemical process studies.

OBJECTIVES

1. Determine energy balances associated with the rates of decomposition of forest litter samples.

2. Estimate that portion of primary productivity that channels through the decomposer pathway.

APPROACH

Litter decomposition is a sequential process, mediated by a succession of organisms. Of primary importance are the terminal oxidative steps whereby we can quantitate the energy expended and energy remaining in the form of stabilized organic matter (humus fractions). In forested areas, primary vegetative production constitutes a major segment of the energy reservoir. The determination of turnover rates becomes mandatory in terms of energy flow, end product identification, and related impact on nutrient cycling.

The study of energy flow makes clear that certain key ecosystem parameters must be measured. These have been organized as follows:

Input Data--Carbon

1. Weight of standing forest foliage prior to shedding will be determined as a part of the primary productivity studies.

2. Site selection, location of litterfall traps, and sampling design will be carried out by Dr. Youngberg (OSU).

3. Chemical analysis of litter will be carried out as follows: (a) total carbon by dry combustion and total nitrogen by Kjeldahl analysis; (b) water-soluble carbon by persulfate oxidation.

Output Data

Here we are primarily concerned with ecosystem metabolism and more specifically with carbon flux. Instead of direct calorimetry we shall measure chemical changes in substrate carbon (input) whose potential energy is know. For example, as much heat is produced by the complete oxidation of one mole of glucose in a bomb calorimeter as in a living organism. If we assume that 50.0% of the input carbon (as glucose) is quickly converted to cell substance and 50.0% is mineralized to CO_2, then we can estimate that one-half of the input energy is liberated as heat. The remainder constitutes slow turnover reservoir energy that may be calculated as residual organic matter.

The decomposition processes will be studied primarily by electrolytic respiration techniques. Interval and cumulative oxygen uptake will be determined by measuring the volume of H_2 evolved at the negative electrode of an Electrolyte respirometer. Carbon dioxide evolved is determined by removal of the KOH vial and titration of the alkali with standard acid (*p*H 8.3 to *p*H 4.6). The data are expressed either as a rate value (QO_2) or as milligrams of O_2. With glucose used as the basis of energy flux calculations, we are now in a position to calculate energy flow.

The H. J. Andrews Experimental Forest will be the primary study site. Watershed site selections and sampling design will be conducted by Dr. Youngberg in cooperation with Dr. Denison (OSU).

Regression equations have been formulated which equate the level of water-soluble carbon and the 30-day cumulative recovery of carbon dioxide from diverse litter samples. A system model depicting the already described energy flow patterns (coniferous forest) remains to be formulated. It appears clear, however, that the compartment model concept for the element carbon will serve as a sound basis for equation formulation. It remains to bring in the time dimension along with the described additions (fixed) and losses (decomposition) as a descriptive word model. The final mathematical model will express rates of change in litter carbon.

A COORDINATED STUDY OF MOVEMENT OF ELEMENTS FROM VEGETATION TO SOIL IN CONIFEROUS ECOSYSTEMS

Principal Investigator

Charles C. Grier, Oregon State Univeristy

Sponsoring Committee

Terrestrial--Biogeochemical Processes

Relationship to Research Committee Program

Input is needed from structure and biomass of type communities (plot areas), meteorological data including annual course of air and forest floor temperature and precipitation, data from process studies of litter decomposition, and data from specific studies of elemental return.

Expected results will provide a coordinated, standardized approach to study of movement of elements from standing vegetation to the soil, comparisons of the rates and amounts of elemental transfer from standing vegetation to soil across a broad spectrum of coniferous forest types, relationships between climatic factors and elemental return, relationships between stage of community development and return of elements, and comparative data of mineralization rates and elemental turnover.

OBJECTIVES

1. Provide Biomewide coordination of studies of the movement of elements from standing vegetation to the soil.

2. Coordinate collection and analytical procedures to ensure compatibility of data with modeling objectives and the objectives of the biogeochemical cycling committee.

3. Establish a clearinghouse for all data relating to rates and processes of elemental return.

APPROACH

The movement of elements from standing vegetation to the soil surface is an important segment of the biogeochemical cycle of a coniferous forest ecosystem. Information on this elemental transfer, from sources throughout the Biome, is necessary to the Biome research program to meet the needs of modelers and also researchers in fields where this information is a necessary input. These needs would best be met by a coordinated program of sample collection and analysis, data processing, and data interchange between investigators at both the Andrews and Thompson study sites and the coordination programs. The coordinator would provide a clearinghouse for data of elemental return, a source of methodological information for studies in the planning stage, and liaison between the field investigators, modelers, and the biogeochemical cycling committee.

Standardized, cross-Biome methods of collection and stratification of litterfall, stemflow, throughfall, nutrient input by precipitation and dust, and study of the grosser aspects of litter decomposition and mineralization will be developed in consultation with the biogeochemical cycling committee and the investigators directly involved in these studies.

Efforts will also be made to establish plots at coordination areas across the Biome so that elemental return can be evaluated across the full spectrum of coniferous forest types.

The coordinator would also assemble data of the biomass and structure and relevant meteorological factors for the communities under study and compile these data together with the data of elemental return in a standardized format. These data would be stored in the Biome information bank.

ROLE OF MICROFAUNA IN BIOGEOCHEMICAL CYCLING

Principal Investigator

Harold J. Jensen, Oregon State University

Coinvestigator

Gerald W. Krantz, Oregon State University

Sponsoring Committee

Terrestrial--Biogeochemical Processes

Relationship to Research Committee Program

Input is needed from biomass and structure, biogeochemical processes, and consumer dynamics modeling studies.

Expected results will benefit terrestrial food chain processes, biogeochemical processes, and subsystem modeling groups.

OBJECTIVES

1. Complete faunistic surveys begun in 1972.

2. Develop estimates of biomass and key nutrients transferred through grazing of microfauna on decomposers.

3. Develop estimates of nutrient storage and transfer by microfauna.

APPROACH

Microfauna (protozoans, nematodes, acarids, and so on constitute a major portion of the living organic matter in soil. They are involved in decomposition and in storage and transfer of nutrients, and are an important lower link in the food chain. No model of a forest ecosystem would be complete or functional without inclusion of data from this group.

Faunistic studies initiated in 1972, following sampling patterns established for reference stands, will be completed for the Andrews site in 1972 and extended to Thompson and Findley Lakes in 1973. Although primarily faunistic, these surveys will identify dominant populations and indicate suitable organisms for detailed examination in providing examples for modeling.

Many animals classed as microfauna feed on decomposers. This forms a link with the food chain and, through excretion, with the entry of nutrients into soil solutions. We will develop estimates of transfer of key nutrients in this way (1) by measurement of increase in decomposer biomass following removal of microfauna from litter by soil sterilants, and (2) by applying turnover rates of microfauna in culture to estimates of soil populations.

The microfauna are a nutrient reservoir. We propose to test the properties of this reservoir by subjecting columns containing simulated and natural litter and soil to leaching by water containing varying concentrations of nutrients. Populations of microflora and microfauna will be varied both as to density and taxonomic composition.

Faunistic studies should be completed at the Andrews site in 1972 and at Thompson and Findley Lakes in 1973. Subsequent studies will focus on two other objectives. Extrapolation to other sites elsewhere in the Biome will require further faunistic surveys if they are not already available for the sites chosen.

COORDINATED NUTRIENT CYCLING AND LITTER DECOMPOSITION STUDY

Principal Investigator

Denis P. Lavender, Oregon State University

Coinvestigators

William C. Denison, Oregon State University
James R. Sedell, Oregon State University

Sponsoring Committee

Terrestrial--Biogeochemical Processes

Relationship to Research Committee Program

Input is needed from terrestrial primary production, physical processes and modeling management groups.

Expected results will benefit terrestrial primary production biomass and structure, terrestrial biogeochemical processes, and modeling management.

OBJECTIVES

1. Monitor movement of nutrient elements and organic material from tree crowns to the litter layer in reference stands in the Cedar River watershed and on the H. J. Andrews Experimental Forest.

2. Coordinate litter decomposition studies at the stand and watershed levels and between the two intensive sites.

3. Monitor the movement of organic material from tree crowns to streams on the H. J. Andrews Experimental Forest.

4. Coordinate chemical analyses used in cross-study comparisons.

5. Develop standard procedures for sorting litter components and set up a central litter-sorting facility.

6. Acquire, produce, and distribute samples of "standard" litters and litter components.

APPROACH

The movement of nutrients in litterfall and throughfall has been monitored in nine plots in old-growth stands on the Andrews Experimental Forest. These stands were chosen to represent the range of site conditions, from relatively warm, dry sites at the lower elevations to moist, cool areas near 1,300 m, which occur in the Douglas-fir zone of this forest. A summary of the data collected thus far indicates that the quantities of nutrients cycled are related to the degree of crown cover or to the basal area of the sample plot; but no specific evidence relates nutrient movement to the sequence of communities sampled, although the total accumulated biomass in steady-state systems may reflect environmental control.

It is proposed, in any case, that only two of the plots in old-growth stands be retained for the 1973 program and these plots be supplemented by four similar plots located in the younger (135-year-old) Douglas-fir stands on watersheds 6, 7, and 8 on the Andrews Experimental Forest. The experimental design of this phase of the proposal, then, will consist of six plots, each of which will have eight 0.25-m^2 litter traps, and four 51-cm rain gages.

Both old-growth stands to be sampled in 1973 are located on watershed 10 of the Andrews Experimental Forest. To facilitate collection procedures and extrapolation of data, both the above collection devices and the plastic cones employed to collect material for both the decomposition and stream study will be located in the same area of the reference stands.

Litterfall in second-growth stands on the Andrews Experimental Forest will be monitored in plots located with reference to plant communities so that the range of temperature and moisture on these watershed is sampled. Similarly, these plots will be the same size as those in the old-growth stands, 2023 m^2 the rain gages and litter traps will be located randomly, and each area will be stem mapped. Finally, the crown cover for each litter trap and rain gage will be scaled from vertical photographs.

Current results of the throughfall and litterfall collections in old-growth stand demonstrate that the quantities of nutrients moved by the two processes vary by element. For example, the great majority of the calcium and the majority of the nitrogen and phosphorus returned to the soil was moved in the litterfall, while most of the potassium and magnesium were returned in throughfall. Therefore, it will be necessary to establish rain gages in the second-growth plots. However, water analyses are both costly and time consuming and the second-growth plots are well within the snow zone much of the winter. Current experience indicates that the difficulty of collecting representative throughfall and litterfall samples is greatly magnified during periods of heavy snow accumulation, and therefore only a minimum number of collections of throughfall for chemical analyses, scheduled to sample periods wherein the range of concentrations occurs (based on current experience), will be programmed. Similarly, litter collections will be confined largely to the snow-free period. Two litter traps per plot, eight in all, on the second-growth stands will be equipped with reservoirs to catch the leachate from the trap. Analyses of this material, corrected for the quantities of nutrients in the throughfall for the same period, should provide an estimate of the nutrients washed from the litter after it was deposited. Neither litter decomposition nor movement of organic material into streams will be monitored on the plots in the second growth stands.

Collection devices similar to those described above will be installed in appropriate stands in the Cedar River watershed to monitor the movement of nutrient elements and organic material from tree crowns to the litter layer and to collect the material necessary for decomposition studies.

It is proposed that a technician stationed at the H. J. Andrews Experimental Forest be responsible for all litter and throughfall collections made in both 1973 and 1974. The collections and plot maintenance will require about one-fourth of his time. Similarly, litter collections in the Cedar River watershed will be the responsibility of a technician assigned to this intensive site.

All litter collections from both the Cedar River and the H. J. Andrews plots will be sent to Corvallis for processing. A full-time technician will be responsible for separating the collections into the several classes, i.e., reproductive organs, foliage, twigs, branches, bark, epiphytes, etc., and drying and grinding the material to be analyzed chemically. Facilities necessary for this work are available in the Forest Research Laboratory.

Samples of "standard litter" and litter components will be acquired from inter-Biome sources where possible. Standard litters of varying composition will also be developed locally.

Driver will coordinate litterfall and decomposition studies at the intensive sites in the Cedar River watershed; Denison will coordinate similar studies at the watershed level in Oregon. Lavender will coordinate studies at the reference stand level and oversee development of the central litter processing facility.

Field measurements of rates of accumulation and disappearance of litter and its several components are basic to proposals falling under the biomass and structure and biogeochemical cycling programs. They are also central to the Biome program as a whole, especially to the development of whole-system models. Currently, methods of collecting litter, sorting it, and preparing it for analysis or for exposure to decomposers or consumers vary with the needs of the individual program. The object of the above outlined proposal, then, is to provide common bases for comparison of results from studies at the stand or watershed level and between studies at the two intensive sites.

FIXATION, UPTAKE, AND RELEASE OF NITROGEN BY EPIPHYTES

Principal Investigator

Lawrence H. Pike, Oregon State University

Sponsoring Committee

Terrestrial--Biogeochemical Processes

Relationship to Research Committee Program

Input is needed from biomass and structure, biogeochemical cycling, meteorology, and food chain processes, and ecosystem modeling groups.

Expected results will benefit biomass and structure, biogeochemical cycling, primary producers, and terrestrial-stream interface studies.

OBJECTIVES

1. Extend biomass sampling of epiphytes to watershed 2 and one of the high 15 in the Andrews Forest, and to the Findley Lake watershed.

2. Expand studies of nitrogen fixation by *Lobaria oregana* in watershed 10 to include temporal and spatial variation.

3. Investigate the importance of free-living blue-green algae and bacteria on tree surfaces as a source of fixed nitrogen.

4. Study in situ decomposition of epiphytes and lodged litter.

5. Investigate release of nitrogen from *Lobaria oregana* and its uptake by other epiphytes.

6. Initiate studies of input of heavy metals via the epiphyte system.

APPROACH

Techniques for sampling epiphyte biomass concurrently with the sampling of biomass of the host tree are now routine for old-growth Douglas-fir. Methods may have to be modified somewhat for the Findley Lake watershed in particular. Epiphyte biomass estimates in kilograms per tree and kilograms per hectare will be made for major epiphyte groups--bryophytes, *Lobaria oregana,* other cyanophilous lichens, and lichens with green-algal phycobionts.

As the primary importance of the epiphytes in biogeochemical cycling may be in nitrogen transformations, studies of the role of epiphytes in nutrient cycling will center on this element. Analyses for other key nutrients will also be made when appropriate.

Seasonal studies of nitrogen-fixation rates by the acetylene reduction assay require access to rigged trees on a year-round basis. These studies will center on *Lobaria oregana*. The importance of free-living bacteria and blue-green algae on tree surfaces (bark and foliage) will also be investigated.

Modification of the litterbag technique will be used for measuring decay rates and nutrient losses of lodged litter. Rates of decomposition of *Lobaria oregana* in situ will be estimated by developing a model of growth of new lobes and of attrition from older parts of individual thalli.

The ability of epiphytes to release and take up nitrogen from water on tree surfaces will be investigated by laboratory studies. These studies will concentrate on losses of nitrogen to solutions by bryophytes and non-nitrogen-fixing lichens.

Epiphytes are well known for their ability to concentrate substances from their environment. An initial assessment of the importance of the epiphytes as a pathway for entry of heavy metals into the forest ecosystem will be made by analysis of important epiphyte species for a variety of heavy metals. A process model is being developed for transfer of nitrogen in the epiphyte subsystem.

Biomass sampling will be done during the summer of 1973 (Andrews "high 15") and 1974 (Findley Lake and Andrews watershed 2). Samples to be analyzed for heavy metals will be collected during sampling in 1973. Studies of nitrogen fixation rates and growth and decomposition will be conducted during growing seasons 1973 and 1974. These studies will move from watershed 10 in 1973 to watershed 2 in 1974. Studies of nitrogen release and uptake will be conducted in the laboratory during 1973.

5.2.5. Terrestrial--Physical processes

WATER BALANCE FOR LAKES WASHINGTON, SAMMAMISH, AND CHESTER MORSE: CEDAR RIVER DRAINAGE BASIN

Principal Investigator

S. J. Burges, University of Washington

Sponsoring Committee

Terrestrial--Physical Processes

Relationship to Research Committee Program

Input is needed from non-IBP hydrologic studies (Ribco), from the Findley Lake hydrologic study (Wooldridge), and the hydrologic modeling effort (Riley, Harr).

Expected results will benefit the four-lake program (Taub et al.) and the hydrologic modeling (Riley).

OBJECTIVES

1. Crude water budgets will be made for the three lakes to enable evaluation of nutrient inflows to the lakes.

2. All significant surface inflows will be located and their respective contributions to each lake will be evaluated.

3. Principal surface inflows that contribute substantially to nutrient transport will be identified. Recommendations for locations and frequency of sampling on these sources will be made.

APPROACH

Existing USGS stream gage data will be employed together with estimates of precipitation and evaporation for each lake to obtain water balances. Simple decay models may be necessary to identify local inflow and groundwater contributions. The balance will be attempted for an annual period with subsequent refinement to shorter time periods. The final resolution of time scale will be limited by data uncertainty and inability to quantify subsurface flows. Data collected and filtered by the CH_2-M-Hill Company will also be used.

After completion of the water budgets, the significant surface inflow sources, as a function of season, will be identified and a decision will be made with respect to the necessity of gathering data on the ungaged sources. Land areas contributing to the lake will be investigated to find those portions that may yield nutrients directly to the lakes during storms. Recommendations will be made (to E. B. Welch) concerning sampling and measurement procedures for these potential source areas so that adequate data important to nutrient inflow to the lakes can be recorded. Simple information models will be provided to assist with any necessary data collection.

ENERGY AND HYDROLOGIC BALANCE COMPARISONS OF STAND DENSITIES OF DOUGLAS-FIR

Principal Investigator

Leo J. Fritschen, University of Washington

Sponsoring Committee

Terrestrial--Physical Processes

Relationship to Research Committee Program

Input is needed from meteorology, nutrient cycling, and primary production process studies at the Thompson site.

Expected results will benefit tree- to stand-level process modeling studies (Hatheway, Reed) and hydrologic model refinements (Riley).

OBJECTIVE

Compare the energy and hydrologic balances of Douglas-fir of different stand densities.

APPROACH

During the calendar years 1971-1972, a 38-cm-d.b.h., 28-m Douglas-fir tree from a naturally regenerated stand was installed in a weighing lysimeter; the container of the weighing lysimeter is 366 cm in diameter and 122 cm deep. This installation has a sensitivity of 630 g, which is equivalent to 0.06 mm of water. It is proposed that another tree be installed in a similar weighing-type installation, the second tree to be in a Douglas-fir plantation in the adjacent area. The plantation trees are more closely spaced, nominally 183 cm x 244 cm, and are about the same height; however, the stem diameter is smaller and the ground area is smaller.

There are data already available on the history of soil nutrient and water cycling on the plantation; therefore it is desirable to have a complete water and energy balance analysis of the plantation system. By installing a tree from the plantation in a lysimeter, direct comparisons can be made of the energy budget and the hydrologic budget of the plantation tree and the tree in the naturally regenerated stand. Since these trees have different root areas and different crown size and density, comparisons can be made of the evapotranspiration, the crown interception, and throughfall as a function of storm intensity and duration. Since the trees are in the same general area, the climate and environmental factors will be essentially the same for both installations.

Similar techniques for construction would be used for the second installation as for the first. Basically, a soil container approximately 244 cm in diameter, the basic spacing of the trees, and about 122 cm deep would be built around the root ball of the second tree. This container, soil, and tree would then be raised to allow the assembly and construction of a second container. A weighing mechanism would be installed on the bottom of the second container. The first container with tree and soil would then be lowered back on the weighing mechanism. A drainage system would be provided at the bottom of the soil column in the inner can to adjust the soil moisture tension in the lysimeter and to maintain it similar to that of the adjacent areas by applying a regulated vacuum to the drainage outlet. In addition, the system would be used to remove the excess water that might accumulate in the bottom of the can during the winter period of high rainfall.

The direct comparison of hydrologic and energy balances of the two Douglas-fir trees of different stand densities would provide data essential to modeling the balances of the forest. Since these two forests are typical of western Washington, the model should be able to predict the energy budget and hydrologic budget of different forest densities. It will provide for the optimum stand density in a general climatic area.

MOVEMENT OF WATER THROUGH FORESTED AND DEFORESTED SOILS IN STEEP TOPOGRAPHY

Principal Investigator

R. Dennis Harr, Oregon State University

Sponsoring Committee

Terrestrial--Physical Processes

Relationship to Research Committee Program

Input is needed from hydrology modeling studies (Riley), Cedar River data analysis work, and geology and soil erosion studies.

Expected results will be used to help develop the comprehensive hydrology model for the Coniferous Biome. In addition, these data will assist in modeling the nutrient cycling system. A considerable amount of this study will be conducted in conjunction with a separate study of nutrient losses by soil erosion on steep, forested slopes. Inputs and outputs of these two studies will be exchanged continually.

OBJECTIVE

The objective of this proposed study is to refine the description and empirical relationships of subsurface movement of water obtained during 1972. Changes in these relationships following future timber removal will help evaluate the effect of timber removal on the subsurface movement of water.

APPROACH

This proposed study will continue to examine the path and timing of precipitation and snowmelt water as it moves through the soil to the stream. Description of the porous medium through which water moves will be refined. Additional field drilling, field measurements, and laboratory soil analyses will supplement data obtained during 1972. Tracer studies will indicate direction and rate of movement of water through the soil and the underlying saprolite.

The subsurface movement of water will be studied intensively during the following selected winter and fall storm events on small, stream-to-ridge sections of watershed 10 of the H. J. Andrews Forest and a second area which will remain unlogged. Water input (precipitation and snowmelt) will be determined by recording rain-gage and snowmelt lysimeters. Neutron probe measurements will indicate changes in soil moisture content during and between storm events. Water outflow from each study area will be measured with a collection system and water level recorder. Soil-water energy gradients will be determined with piezometers and tensiometers.

Relationships will be developed between process components for individual storm events and between-storm periods for each study slope. Changes in these relationships following future timber removal will indicate the effects of timber removal on the movement of subsurface water.

COMPUTER SIMULATION OF FOREST WATERSHEDS

Principal Investigator

J. Paul Riley, Utah State University

Coinvestigators

Chung-Chih Shih, Utah State University
Richard Hawkins, Utah State University
Cheng-Lung Chen, Utah State University

Sponsoring Committee

Terrestrial--Physical Processes, Hydrology

Relationship to Research Committee Program

Input is needed from hydrologic process studies, watershed instrumentation sites, and lysimeter evapotranspiration study.

Expected results will benefit nutrient and energy cycle studies, and ecosystem and tree-level process modeling.

OBJECTIVES

1. Further examine the components of the runoff hydrograph for selected areas through the spectral analysis technique.

2. Introduce stochastic elements into the hydrologic watershed model.

3. Test the general applicability of the model by applying it to other drainage areas.

4. Add the water quality dimension to the hydrologic model.

APPROACH

During the current phase of the study a fundamental hydrologic simulation model is being developed and tested for subwatershed 2 within the Andrews Experimental Forest in Oregon. As far as possible, the model includes general hydrologic concepts, and is based to a large extent on developments that have been made under the simulation program at Utah State University. Sensitivity studies are being conducted to gain insight into the operation of the prototype system, and particularly to establish the relative importance of various processes within the system. Provision is made in the model for the three basic components of the outflow hydrograph, namely, base flow, interflow, and surface runoff. A time increment of one day is being used in this study.

The study outlined for 1973 and 1974 will proceed in accordance with the following steps:

1. Through a spectral analysis study an attempt will be made to examine the components of runoff hydrographs for subwatersheds 2 and 10, which are located,

respectively, within and adjacent to the Andrews Experimental Forest. This step was initially proposed for the current phase of the study but was delayed because of funding limitations. Runoff from a watershed consists of both surface and subsurface components, with the subsurface portion usually resulting from interflow and base flow in an effluent stream. Because of the interdependence between surface and subsurface runoff, it is difficult on the basis of historical records to separate the total runoff hydrograph into the three components of surface flow, interflow, and base flow. This problem can be approached, however, by analyzing the cross-correlation (or, equivalently, cross-covariance) between the precipitation and runoff processes. For example, for the prolonged dry season the runoff may be due mainly to base flow, while for certain light precipitation events it may be caused by both base flow and interflow. The cross-correlation analysis of the precipitation and runoff processes will make it possible to plot the corresponding runoff hydrograph for each individual case. Once this is accomplished, time series models for the respective runoff events will be formulated on the basis of the conservation of mass principle. The models probably will consist of two parts, a deterministic harmonics part and a residual stochastic part. With reference to the deterministic portion, periodicities will be determined by the spectral analysis technique (or the analysis of the power spectrum), and the coefficients will be estimated by the least-squares method from available historical records. For simplicity, the stochastic part of the model will be considered to be completely random with its mean equal to zero. Results from this analysis will be compared with those obtained from the simulation model, and adjustments to the model will be made as considered appropriate.

2. Subject to data limitations, an attempt will be made to develop density functions and, where appropriate, joint probabilities, for certain components of the model and input functions. The objective of this step is to provide the model with some capability for predicting variation associated with random processes.

3. In order to demonstrate the general applicability of the model in a geographic sense it will be applied to other selected drainage areas, including the following: (a) subwatershed 10 near the Andrews Experimental Forest, (b) other selected drainage basins within the Andrews Experimental Forest, and (c) the Chicken Creek watershed near Farmington, Utah. This last is an experimental watershed operated by the USDA Forest Service and for which good-quality hydrologic and other data are available. Personnel from the Forest Sciences Laboratory of the Intermountain Forest and Range Experiment Station at Logan, Utah, have expressed willingness to cooperate on this aspect of the study.

4. During 1973, initial steps will be taken to link various water quality parameters, including sediment and certain specific nutrients, to the hydrlogic model. The aim of this study will be to provide the model with the capability to predict total sediment yields and nutrient outflow rates under various conditions of watershed management. Initially at least, this step will be based largely on previous experience gained under the simulation program at Utah State University. This aspect of the study will be particularly emphasized during 1974.

HYDROLOGY AND WATER BALANCE OF FINDLEY LAKE

Principal Investigator

D. D. Wooldridge, University of Washington

Sponsoring Committee

Terrestrial--Physical Processes, Hydrology

Relationship to Research Committee Program

Input is needed from the Cedar River watershed hydrologic survey (Burges) and the hydrologic survey and modeling efforts at Andrews Experimental Forest (Harr, Riley).

Expected results will benefit the land-lake interface study, and the hydrologic modeling efforts (Riley).

OBJECTIVES

An initial study of the water balance of Findley Lake is proposed. The water balance study would establish meteorological and stream gaging stations for year-round measurements. A detailed hydrologic survey of the watershed would be accomplished defining quantities of precipitation as rain, snow, and estimations of condensation and rime ice, disposition of precipitation, and transfer of moisture in the hydrologic cycle.

As snow is expected to be the major component of precipitation and also is very influential as an ecological factor at that elevation, initial studies of the energy balance of the snowfields will be required. Specifically, the initial objectives of the water balance study are:

1. Establish quantity and forms of precipitation input including a precipitation network monitoring total water input and snow accumulations.

2. Evaluate magnitude of interception, stemflow, and throughfall.

3. Evaluate the quantitative disposition of precipitation as soil moisture, groundwater, free water, and surface runoff as streamflow.

4. Initiate study of suspended and dissolved stream water quality.

5. Initiate study of snowpack energy balance.

APPROACH

Water is the most dynamic element in most ecosystems. Its absence or over abundance influences physical, biological, and chemical processes. Precipitation falling on vegetated areas is influenced by three processes, interception, evapotranspiration, and infiltration. Intercepted water is retained on the foliage, stems, and forest floor. In each case, the physical quantity of water in each process can be altered by evaporation to the atmosphere, or altered chemically by the solution, addition, or absorption of certain chemical elements in flow processes.

A water balance study quantitatively established components of the hydrologic cycle. Quantities and forms of precipitation are identified and disposition of this precipitation is partitioned into storage or flow contributions. The stream hydrograph is usually considered to have three component sources of flow: base flow, interflow, and surface runoff. Base flow is contributed from nonsaturated flow in soil, groundwater, and channel storage. An excess of precipitation develops an excess of soil moisture flowing under the force of gravity, thus contributing to interflow. A rainfall rate in excess of the soil infiltration capacity contributes to surface runoff.

The climate of the Cascades is divided into a wet season (October through April) and a dry season (May through September). Water available for streamflow and support of life processes is deposited in the mountains during the wet season largely as snow cover. This seasonal snow cover acts as a reservoir, providing soil moisture and streamflow for the dry season. Many phases of the ecological system are dependent upon this snow cover and processes that influence the snowpack accumulation and melt.

Hydrologic systems of Findley Lake and many headwater tributaries of the Cedar River, as well as downstream tributaries are dominated by snowpack accumulation and melt. The process of snow accumulation is primarily a function of synoptic weather systems that migrate across the Cascades. Very little can be done to alter the precipitation output of these systems without massive weather modification. Once the snowpack has accumulated, however, it may be manipulated to alter total water yield and timing of flow.

Routine methods will be used in establishing stream gaging and meteorological stations (Toebes and Ouryvaev 1970). A detailed hydrologic survey of the watershed will define the approximate magnitude of surface and underground flow and storage components. Definition of the water balance and hydrologic cycle is basic to definition of both suspended and dissolved elemental movement of materials. Conductivity of the outflow stream from Findley Lake, and certain major contributing water sources to the lake, would be measured continuously for conductivity and sampled spatially for chemical analyses.

The initial results will establish the dynamics of water balance, identifying major storage components and rates of flow processes. The data will be presented as both short-term (individual storm) and long-term (water year) balances. Concentrations and total losses of certain suspended and dissolved materials will be correlated with hydrologic processes.

MEASUREMENT OF WATER VAPOR AND CARBON DIOXIDE FLUXES BETWEEN FOREST AND ATMOSPHERE

Principal Investigator

George H. Belt, University of Idaho

Coinvestigators

Leo J. Fritschen, University of Washington
Lloyd W. Gay, Oregon State University

Sponsoring Committee

Terrestrial--Physical Processes

Relationship to Research Committee Program

Input is needed from tree-level evapotranspiration studies (Scott), tree-weighing lysimeter studies (Fritschen), and hydrology and geochemical studies.

Expected results will benefit biometeorological stand-level evapotranspiration modeling studies and ecosystem modeling efforts.

OBJECTIVES

1. Refine estimates of water vapor flux in and above a forest stand by a second series of measurements.

2. Estimate vertical flux of carbon dioxide above the forest stand.

APPROACH

Need and rationale for work proposed here is discussed in the 1972 proposal, page 8.147. Refinement of measurements under objective (1) will take the form of improved spatial sampling in terms of three-dimensional modeling, as well as enhanced sensor performance, both based upon field experience. The second year's data will also help define variability expected in the vapor fluxes, and aid in the extrapolation of data. The vapor flux measurements will be accomplished by use of previously described eddy correlation methodology.

Recently developed vapor pressure sensors,* in conjunction with Gill-type propeller anemometers, will be used for the measurements.

Carbon dioxide flux measurements will be made above the stand using a volumetric sampling system such that the gas volume sampled is proportional to the product of the vertical velocity components and the concentration of carbon dioxide. Carbon dioxide samples obtained in the field will be stored and subsequently analyzed in the laboratory. The measurement system described will generate time-integrated (2- to 4-hr) estimates of the carbon dioxide flux and with other meteorological measurements will permit evaluation of the variability of carbon dioxide uptake in relation to climatic parameters. Estimates of vapor on carbon dioxide exchange rates obtained in this study will be used to model mass and energy exchange and will complement related studies in hydrology and terrestrial production.

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*Brady array crystal sensors supplied by Thunder Scientific Corporation are presently under test.

A STUDY OF THE RELATION BETWEEN RADIANT ENERGY AND PHOTOSYNTHETIC APPLICABLE RADIATION AT DIFFERENT LEVELS WITHIN THE FOREST CANOPY AT THE CEDAR RIVER SITE

Principal Investigator

Inge Dirmhirn, Utah State University

Sponsoring Committee

Terrestrial--Physical Processes

Relationship to Research Committee Program

Input is needed from biometeorological studies, tree-level primary production studies, and environmental-plant indexes modeling effort.

Expected result will benefit tree- and stand-level primary production modeling (Reed, Hatheway) and ecosystem coordination programs.

OBJECTIVES

1. Measure the spectral composition of the solar radiation in different levels within the forest.

2. Compare this measured spectrum with simultaneous measurements of the solar and net radiation.

3. Determine the relation between the photosynthetic active radiation and the measured solar (net) radiation and develop a mode for conversion for the forest type.

APPROACH

A study is proposed to determine the spectral composition of the radiative flux entering and penetrating the forest canopy and to compare this spectral composition with the solar and net radiation.

A large amount of solar radiation entering a forest is scattered as well as absorbed by the plant mass (trunks, branches, needles, leaves, etc.). During this process the spectral composition of the initial radiation changes and the resulting spectrum is low on wave bands used by the plants for photosynthetic processes.

Measurement of the spectral composition of solar radiation will be done in different levels within the forest, along with the measurements of solar and net radiation. A Leiss double quartz prism Monochromator adapted for field use will be used for other studies on the Cedar River site, will be used for instrument support, to reduce costs.

Maximum and minimum deviation of the spectrum under the canopy from the unfiltered spectrum outside the canopy will be determined and a characteristic relative spectrum will be defined by statistical methods.

Simplification will have to be employed to reduce the originally large varieties of flux density produced by branch movement within the canopy and on the forest floor. Neutral transmission and reflection methods for spatial integration of the radiative flux will be employed.

Simultaneous measurements and recordings of the integrated spectrum over the entire wave range or large parts of it will be done on the site of the recorded spectrum and outside the forest to control the time variations of the radiative flux during the course of the measurement of the spectrum.

The relative spectrum will be compared with the simultaneously measured radiative flux density. A definite relation between these two parameters is expected for one forest type.

From the spectral composition the photosynthetic effective radiative energy will be determined by integration. The blue and red part of the spectrum will be derived independently. Together with the radiative flux density these two parameters will be used to develop an index that will characterize the radiative climate of the particular forest. This will enable us to use future radiative flux density measurements alone to conclude to the entire radiation climate (energetic and photosynthetic) of this same forest type.

The measurements will be done on the Cedar River site where concurrent micro-meteorological measurements are planned. Our study is designed to fit into and expand the results from these measurements. Cooperative work will be done with scientists from the University of Washington (Fritschen), Oregon State University (Gay), and the University of Idaho (Belt).

When measurements of the radiation flux are used to correlate the findings in photosynthesis, the results are necessary to translate the measured radiation into photosynthetically applicable radiation. In cases of low light intensity the threshold for photosynthesis occurring on the forest floor can be determined only by knowing the spectral composition of the remaining radiation at the particular location.

SOIL-PLANT-ATMOSPHERE-WATER RELATIONS OF DOUGLAS-FIR USING A WEIGHING LYSIMETER

Principal Investigator

Leo J. Fritschen, University of Washington

Sponsoring Committee

Terrestrial--Physical Processes

Relationship to Research Committee Program

Input is needed from the biometeorological studies (Gay, Belt, Fritschen), the primary production process studies (Walker, Scott), the process modeling efforts (Hatheway), and the hydrologic modeling efforts (Riley).

Expected results will benefit the hydrologic modeling detail, the tree-stand-forest extrapolation modeling (Reed), and the primary production process studies.

OBJECTIVES

The objectives of the work herein proposed are to study the flow of water and energy from the soil through the plant into the atmosphere in relation to soil, plant, and atmospheric potentials and the atmospheric evaporative demand; to study the shrinking and swelling of plant tissue in relation to evapotranspiration; and to study interception of precipitation by the vegetation in relation to storm intensity and duration.

APPROACH

The weighing lysimeter installation at the Thompson research site will be used as the focal point of these studies. The flow of water and energy will be studied by determining the component potentials. Soil-water potential will be determined with 16 thermocouple psychrometers located in the soil container. Dendrometer bands will be installed at five locations on the tree trunk to ascertain changes in tree water storage. The atmospheric water potential will be calculated from meteorological measurements. The combination of these factors will yield evapotranspiration rates of Douglas-fir in relation to soil-water content (potential) and atmospheric demand. Plant potentials and stomatal aperture will be measured by Dr. Walker.

Part of the evapotranspiration is the evaporation of intercepted water from the plant canopy. Plant interception will be determined as a weight increase if throughfall into the soil container is prevented. The throughfall will be monitored separately with a plastic watershed over the soil.

ASSESSMENT OF SENSIBLE HEAT, LATENT HEAT, MOMENTUM, AND CARBON DIOXIDE FLUXES BY METEOROLOGICAL METHODS AND THEIR EVALUATION. I.

Principal Investigator

Leo J. Fritschen, University of Washington

Coinvestigators

Lloyd W. Gay, Oregon State University
George H. Belt, University of Idaho

Sponsoring Committee

Terrestrial--Physical Processes

Relationship to Research Committee Program

Input is needed from tree-level primary production and evapotranspiration studies (Walker, Scott, Reed) and tree-weighing lysimeter studies (Fritschen).

Expected results will benefit biometeorological stand-level primary production, evapotranspiration, and energy budget studies, and ecosystem modeling efforts.

OBJECTIVES

1. Determine the magnitude of the vertical fluxes of sensible heat, latent heat, and carbon dioxide at the lysimeter tree location on the Thompson Research site.

2. Determine the relative magnitude of the horizontal advection of sensible and latent heat to the total flux of sensible and latent heat.

3. Determine which of the meteorological methods for flux determination would be most appropriate in forest areas.

APPROACH

Knowledge of the fluxes of momentum, sensible heat, latent heat, and carbon dioxide for short time periods is necessary for the evaluation of photosynthetic and water use efficiency of various plant sepecies or plant layers of an ecosystem. Meteorological methods have been developed from physical theory to predict these fluxes. Meteorological models have several advantages for determining these fluxes. These advantages include nondestructive sampling and portability.

To achieve the objectives, it is proposed that three instrument towers be erected to form a horizontal triangle with sufficient distance on each base leg to evaluate the horizontal gradients of temperature and vapor pressure. The towers will be instrumented with conventional slow-response profile equipment to allow for vertical calculations of fluxes by the aerodynamic and energy balance methods, and with fast-response sensors for eddy correlation technique. The horizontal gradients of temperature, vapor pressure, and wind speed will be used to calculate the magnitude of the horizontal advection.

This study will be conducted in the area of the lysimeter installation at the Thompson research site. The towers established at the lysimeter site will be one leg of the triangle. The difference in evapotranspiration and sensible heat between the lysimeter and meteorological models will give an estimate of the horizontal advection at that point; however, this estimate applies to a single tree and it is necessary to know how representative a single tree is of a larger area.

The number of sensors and recording equipment required for this study is so large that it is impossible for a single group to undertake this project. Therefore the Biome meteorological committee will pool all of its instrumentation at the Cedar River watershed for a short period to collect the necessary data. Dr. Gay will be responsible for the mean profiles, Dr. Fritschen will be responsible for the fast-response equipment, and Dr. Belt will be responsible for the fast-response humidity sensors and computer programs.

As part of this study, the fluxes of sensible heat, latent heat, carbon dioxide, momentum, and radiation will be determined at three locations above the forest canopy and by layers within the forest canopy with three independent meteorological methods. The magnitude of the horizontal advection of the above fluxes will be assessed. The three meteorological methods of flux determination will be evaluated for use in and above the forest canopy.

ASSESSMENT OF SENSIBLE HEAT, LATENT HEAT, MOMENTUM, AND CARBON DIOXIDE FLUXES BY METEOROLOGICAL METHODS AND THEIR EVALUATION. II.

Principal Investigator

Lloyd W. Gay, Oregon State University

Coinvestigators

Leo J. Fritschen, University of Washington
George H. Belt, University of Idaho

Sponsoring Committee

Terrestrial--Physical Processes

Relationship to Research Committee Program

Input is needed from tree-level primary production and evapotranspiration studies (Walker, Scott, Reed) and tree-weighing lysimeter studies (Fritschen).

Expected results will benefit biometeorological stand-level primary production, evapotranspiration, and energy budget studies, and ecosystem modeling efforts.

OBJECTIVES

1. Refine mean-profile models used to estimate the fluxes of energy between the forest and the atmosphere.

2. Evaluate the latent, sensible, and radiant energy fluxes taking place over a range of site conditions and climatic regimes.

APPROACH

The basic studies of mass, momentum, and energy flow between the forest and the atmosphere have been outlined in detail in the work plan approved for 1972. The 1973/1974 program is an extension of these basic energy budget studies to a wider range of environmental conditions at Cedar River and to a range of sites within the Biome.

This project combines three independent methods for evaluating the budgets of mass, momentum, and energy. The methods are commonly referred to as aerodynamic, lysimetric, and eddy correlation; each has certain advantages and disadvantages with respect to the others. Fortunately, the methods can be favorably combined at one site through the instrumentation and experience available to the three cooperators. This joint proposal is thus divided into three subprojects; Gay has responsibility for the aerodynamic methods, Fritschen for the eddy correlation estimates of sensible heat, and Belt for the eddy correlation estimates of latent heat. The lysimetric studies are organized in a separate project. The mutually supportive nature of these three methods provides a unique opportunity to define the processes that govern the exchange between the forests and the atmosphere.

The aerodynamic estimates are derived from exchange models based upon measurements of the gradients of wind, temperature, and vapor pressure above the forest canopy, combined with measurements of the radiant energy transformed in the forest, and estimates of changes in stored energy in the soil and biomass. The studies scheduled for 1973 include a range of variable weather conditions.

Models that predict the mass, momentum, and energy cycles between the forest and the atmosphere will be refined after extension of the measurements to a wider range of site conditions in the summer of 1974. This will enhance the development of the basic hydrologic model, and will complement a range of related studies in the Biome program.

5.2.6. Aquatic--Lake systems

CARBON BIOMASS AND FLUX THROUGH SPECIFIC AQUATIC BACTERIAL GROUPS

Principal Investigator

Bruce Lighthart, Western Washington State College

Sponsoring Committee

Aquatic--Lakes Systems

Relationship to Research Committee Program

Input is needed from primary and secondary production studies and modeling efforts, and from biogeochemical process studies.

Expected results will benefit primary and secondary production modeling studies and the aquatic coordinating program; also they should provide a simplified key to aquatic bacteria in Northwest lakes, information on changes in bacterial group prevalence in time and space in the four Biome lakes, and an estimate of carbon flux and pool sizes of the bacterial groups in the water columns of the four Biome lakes.

OBJECTIVES

1. Obtain pure cultures of aquatic bacteria and treat them to a characterizing battery of tests.

2. Delineate groups of isolates with overall similarity.

3. Prepare a simplified key to the formed groups.

4. Observe the changes in the group prevalences in time and space in Lakes Findley, Morse, Sammamish, and Washington.

5. Estimate the carbon biomass of each group in proportion to the total bacterial biomass in lake-water samples.

6. Evaluate the carbon flux through each bacterial group in the lake-water samples.

APPROACH

The bacteria are essential and primary organic remineralizers in the aquatic realm. They exist in freshwaters in great numbers and kinds. It has been only in recent years that both enumeration and identification of such numbers has been approachable. With the advent of digital computers and mass culture inoculation techniques, identification has been possible.

It is proposed that the first step in a two-step program be to use mass inoculation techniques to isolate, identify, and prepare a simplified key of aquatic bacteria in the Biome lakes: Findley, Chester Morse, Sammamish, and Washington. The inoculation and identification steps will be performed by an ongoing mass bacterial testing system and computer program that clusters items (bacteria) into groups based on the overall similarity of a large number of item attributes (bacterial tests). The groups of bacteria obtained from the clustering step will be differentiated by their attribute composition and the unique attributes of each group will be used to prepare a simplified identification key.

The second step in the program will be to evaluate the biomass and the flux of carbon within each of the delineated groups as they appear in time and space in the Biome lakes. Biomass of bacteria in the lakes will be evaluated by direct carbon analysis of bacterial concentrates from differential centrifugation and numerical estimation from direct counts. The group biomass will be a proportion of the total biomass.

Estimates of flux of carbon through the various groups of bacteria will be carried out with pure cultures drawn from the clustered groups and incubated in Millipore-filtered solutions of radioactive dissolved organic carbon (DOC) obtained from in situ with ^{14}C bicarbonate. Uptake of the tracer by the inoculated bacteria will be measured in a scintillation counter.

EXPLORING THE AQUATIC CARBON WEB

Principal Investigator

Bruce Lighthart, Western Washington State College

Coinvestigator

John A. Bollinger, Western Washington State College

Sponsoring Committee

Aquatic--Lake Systems

Relationship to Research Committee Program

Input is needed from the aquatic primary production studies (Welch, Spyridakis), the detritus decomposition studies (Taub, Pamatmat), and the lake system modeling efforts (Male).

Expected results will benefit the decomposition subsystem modeling, and the primary and secondary production studies.

OBJECTIVES

It is considered that the compartment analysis will act as cross-links in a time series of parallel measurements of several of the compartments made by other investigators in the Biome study program. The carbon web methods instrumentation is proceeding as planned for the first year of the study. The results indicate that differentiation between the Biome lakes will be clear-cut.

With the methods developed to evaluate the flux and standing stock of the aquatic carbon compartments, it is proposed that the following third-year objectives be met:

1. Observe the critically important little-known bacterial decomposer compartment in greater detail, particularly with respect to coupled oscillations with diurnal algal production of dissolved organic carbon, and carbonaceous and proteinaceous decomposition rates during an annual cycle.

2. Observe effects of heat and nutrient perturbations in the compartments of the system.

3. Increase the efficiency of the information gathered per unit effort.

4. Provide cross-links in the aquatic model between other Biome investigators' measurements, e.g., primary producers (algae), various consumers (herbivorous and carnivorous zooplankton), and decomposers (bacteria).

APPROACH

Carbon is a thread that runs through, and ties together, the living and dead components in an aquatic system of interacting compartments. The compartments are delineated on the basis of function for living components and physiochemical form for the nonliving components. The living carbon compartments in the aquatic realm are the algae that fix solar energy via organic synthesis, ultimately driving the entire food web; the herbivorous and carnivorous zooplankton that feed on the algae and other zooplankton, respectively; and the bacteria, which complete the circle by remineralizing DOC and dead particulate carbonaceous material (detritus) back to inorganic carbon forms.

This system of compartments may be evaluated in terms of carbon content (standing stock) and kinetics (flux) of carbon transfer between compartments, and those data may be put into model form, using compartment analysis techniques such as those developed for compartmentalized biochemical systems. The standing stock or biomass of each compartment is evaluated either by indirect calculations based on numerical counts and protoplasm carbon content assumptions or, more preferably, by direct measurement of zonal centrifuge separation of compartments with subsequent carbon measurement. The flux of carbon between compartments is measured in situ with specific carbon-14 tracers such as commercially available ^{14}C bicarbonate, algal protein hydrolysate, starch, and synthesized DOC and detritus.

The objectives listed above may be reached by: (1) maintaining the present quarterly interval between analyses at the four Biome lakes (and possibly performing the measurements at three depths: epi-, meta-, and hypolimnions); (2) incorporating phosphorous-32 or -33, sulfur-35, or both along with carbon-14 in the measurement systems and scintillation counting several nuclides simultaneously, thus increasing information efficiency with little added effort; (3) observing the rates and pool sizes of the bacterial compartment metabolizing carbon-14 starch and protein in situ during each of the monthly experiments; and, (4) observing the perturbance effects on the experimental systems of samples by incubating samples from the hypolimnion in the epilimnion and by adding sewage, phosphate, nitrate, etc., to systems and observing changes in rate and pool size in the various carbon compartments with time.

The results of the study are expected to yield information on the rates of carbon transfer between compartments and the carbon pool sizes of each compartment in the four lakes, at three depths during one 12-month cycle. It is further expected that initial perturbation of the system compartments due to heat changes and nutrient additions will be elucidated. Cycles of sulfur, phosphorous, or both, may also be elucidated similarly to the carbon evaluations.

OXIDATION OF ORGANIC MATTER IN THE WATER COLUMN

Principal Investigator

Theodore T. Packard, University of Washington

Sponsoring Committee

Aquatic--Lake Systems

Relationship to Research Committee Program

Input is needed from studies on stream systems, lake productivity and hydrology, terrestrial-aquatic interfaces, and aquatic biogeochemistry.

Expected results will benefit aquatic biogeochemical process studies, and the model on primary and secondary production in water-column subsystems.

OBJECTIVES

1. Determine the annual rate at which organic matter is oxidized in the entire water column from the lake surface to the bottom.

2. Determine daily and seasonal variations in the vertical distribution of the oxidation rate.

3. Determine the relative contribution to the total oxidation rate of different size fractions of plankton.

APPROACH

Oxidation rates will be calculated from measurements of the respiratory electron transport system (ETS) activity in the plankton and bacteria (Packard 1969). The ETS method has been tested extensively in the marine environment (Packard, Healy, and Richards 1970) where it successfully detected carbon oxidation rates as low as 40 μg C liter^{-1} in the deep sea.

Phase 1

The epilimnia, thermoclines, and hypolimnia of Lakes Findley, Chester Morse, Sammamish, and Washington will be sampled monthly to determine the vertical distribution of the oxidation rate.

Phase 2

Quarterly determinations will be made of daily variations and the relative importance of six size fractions of the plankton.

Phase 3

Calibration of the method will be accomplished in two ways. (1) Simultaneous measurements will be made of ETS activity and oxygen consumption of cultured lake organisms. Oxygen changes will be detected by both electrode (Kanwisher

1959) and Winkler (Conover 1956) techniques. (2) The ETS activity in the hypolimnetic plankton will be compared with oxygen consumption estimated from changes in oxygen concentration in the hypolimnetic water column (Barnes and Collias 1958).

NUTRIENT BUDGETS IN THE LAKES OF THE CEDAR RIVER WATERSHED

Principal Investigator

D. E. Spyridakis, University of Washington

Coinvestigator

R. F. Christman, University of Washington

Sponsoring Committee

Aquatic--Lake Systems

Relationship to Research Committee Program

Input is needed from studies in meteorology, hydrology, biogeochemistry, stream-lake interface studies, geology, and soils.

Expected results will benefit work on water column, water nutrient status, respiration, carbon web and nitrogen transformation, detrital inputs, oxidation of organic material and production of littoral materials.

OBJECTIVES

1. Repeat selectively the key nutrient measurements of previous years as related to environmental factors, and extend to previously neglected aquatic systems.

2. Determine mixing patterns as they influence nutrient dynamics and distributions.

3. Relate land use practices to aquatic biogeochemical properties.

APPROACH

Realization of the overall objective of quantification of the chemical element cycle in the lake water proper of Cedar River watershed lakes will require continuation and expansion of the present studies into years 3 and 4 and include the following objectives:

1. Selective repetition will be made of year-1 and -2 measurements of key nutrient concentrations and related environmental parameters and processes in the four lakes (Findley Lake, Chester Morse Lake, Lake Sammamish, and Lake Washington) and extension of those measurements to incorporate water bodies previously cursorily investigated or completely neglected, such as surface water inflow and outflow, rain- and groundwater, and surface runoff. Measurements of the exchange of nutrients in the sediment-water interface in situ will be investigated in years 3 and 4 and will utilize experience gained in similar current laboratory studies of simulation of nutrient regeneration in isolated intact sediment-water columns. Delineation of the role of suspended particulate matter on the supply of nutrients to a lake will be undertaken and will include measurements of the

rate of deposition of inorganic materials, organic materials, or both as a function of depth, season, inflow, and outflow sediment loadings.

2. The mixing patterns in the lakes, as they determine the distribution of the sediment-derived trophogenic substances in the water column, will be determined. mixing mechanisms conditioned by such factors as mean depth, extent of the shoreline and littoral and surface area of the lake, wind, temperature, release of gases, and the activity of burrowing animals and fish will be investigated. Since direct measurement of the extent of mixing in a lake is per se extremely difficult to attain, indirect measurements of mixing will be undertaken. The study of the mixing mechanisms in Lakes Sammamish and Chester Morse together with the needs of other lake oriented investigations will require the establishment of a climatological station in each lake for measurement of temperature, wind velocity, precipitation, solar intensity, and barometric pressure. It is anticipated that the climatological information will be provided by the meteorological and hydrological investigations of the Coniferous Forest Biome.

3. Land use practices, soil, and geological, hydrological, and climatological characteristics in the Cedar River watershed will be related to the chemical and biological makeup of the Chester Morse Lake, Cedar River, Lake Sammamish, Lake Washington, and Findley Lake.

Data acquired under objectives 1, 2, and 3, when combined with past and current studies in the lake, river, and stream waters and the terrestrial and interface intensive sites of the Biome, will help to delineate and evaluate the relative contribution of the various sources of nutrients to the trophogenic status of the lake, and to relate it to watershed activities and characteristics. This in turn will provide a means of predicting the concentrations of a given nutrient in a lake water and suggest methods of lake productivity management.

NITROGEN TRANSFORMATIONS

Principal Investigator

Frieda B. Taub, University of Washington

Coinvestigator

James Staley, University of Washington

Sponsoring Committee

Aquatic--Lake Systems

Relationship to Research Committee Program

Input is needed from chemical budget data for water column and benthos, biogeochemical process studies, and stream-lake interface studies.

Expected results will benefit chemical budget data and benthic production modeling efforts.

OBJECTIVES

1. Complete sampling and analyses of nitrogen fixation in the four lakes and estimate its importance in the nitrogen budgets.

2. Estimate quantitative role of microbically mediated nitrogen transformations based on (a) net changes in the nitrogen compounds, and (b) microbial numbers as estimated in 1972.

3. Attempt to evaluate the relative importance of denitrification (loss of fixed nitrogen as N_2) in the total lakes budget.

APPROACH

The nitrogen cycle is generally accepted as an important cycle within lakes. Hutchinson summarized the three possible sources of nitrogen input to lakes as: (1) influents to the lake, including groundwater, (2) precipitation on the lake surface, and (3) fixation in the lake and its sediments. The losses to the lake can occur (1) through effluents, (2) by diffusion of volatile nitrogen compounds from the surface (probably usually insignificant), (3) by denitrification in the lake, and (4) in the formation of permanent sediments.

The overall nitrogen budget will be calculated by Dr. Spyridakis, who will be measuring both the influents and effluents, as well as the precipitation and sediments. It will be the role of the biologist in this project to help explain some of the transformations and possible imbalances.

It has long been known that numerous organisms can fix atmospheric nitrogen and incorporate it into their own organic matter in the chemical oxidation state equivalent to NH_3. Nitrogen fixation by blue-green algae in situ in water and by bacteria in collected sediments was demonstrated in Lake Erie by Howard et al.

(1970), but they did not compare the nitrogen fixation with the other aspects of the nitrogen budget.

The loss of fixed nitrogen from lakes through denitrification is more likely to be an important phenomenon, especially in highly productive lakes (Hutchinson 1957).

It is well recognized that nitrogen undergoes many oxidative and reductive steps in the aquatic environment. Next to phosphate, and sometimes silicon, its availability is likely to limit or modify algal growth.

Methods

N_2 fixation

Work will be continued to estimate the importance of nitrogen fixation by blue-green algae in the water column and by anaerobic bacteria in the sediments. Comparison with other aspects of the nitrogen budget within each lake should indicate whether this route is an important input. Comparisons between the lakes should indicate whether Lake Sammamish, which has significant blue-green algal blooms and an anaerobic hypolimnion during the summer, therefore has greater nitrogen availability. Since the acetylene reduction technique will be used in common with the terrestrial studies, the information will be comparable on an area basis provided that the various assumptions in the technique are consistent throughout the Biome. This work will be done in cooperation with Dr. Spyridakis.

Denitrification (N_2 loss)

In the absence of an analogous enzymatic method for the reaction opposite to nitrogen fixation, a cruder technique must be employed. The environment in which nitrogen release would be most likely to occur is in the narrow layer where lake sediments are anaerobic and where significant organic material may occur to encourage the process of denitrification by organisms. Bottles will be implanted within the lake sediments and collected if they show gas, and analysis will be conducted for H_2S, O_2, and N_2. When the gas content is significantly enriched with nitrogen, then it can be deduced that denitrification is occurring. During this preliminary sampling, bottles will be placed only in locations that are being serviced by divers in conjunction with other studies, most of them at fairly shallow depths. For greater depths, preliminary studies on undisturbed, removed sediment samples will be done in the laboratory.

Exchanges with fixed nitrogen forms

Transformations within fixed nitrogen forms will probably be going on simultaneously, and only net changes will be apparent. The net effects will be estimated by determination of the changes in the vertical profiles of fixed nitrogen of various types.

Bacterial enumerations

Standard dilution techniques and others to be developed with Dr. James Staley will be used.

PHYTOPLANKTON PRODUCTION AND GROWTH RATE RESPONSE RELATED TO ENRICHMENT

Principal Investigator

E. B. Welch, University of Washington

Sponsoring Committee

Aquatic--Lake Systems

Relationship to Research Committee Program

Input is needed from aquatic biogeochemical process studies, subsystem modeling, and terrestrial-stream-lake interface studies.

Expected results will benefit aquatic lake production modeling studies, aquatic coordination program (Gaufin), and secondary production studies.

OBJECTIVES

1. Establish second year of season pattern and magnitude of phytoplankton productivity, biomass, and physiochemical controlling factors in three lakes.

2. Develop relationships between growth rate of three size groups of natural phytoplankton and natural and experimentally altered limiting nutrient content, light, and temperature in three lakes.

3. Relate nutrient supply to measurements of trophic state and determine the rate of change in trophic state resulting from manipulation of nutrient supply.

APPROACH

The mechanisms that control phytoplankton productivity in lakes will be studied through models developed to describe the dynamics of macronutrient movement within the water column. The models will be developed from in situ and experimental data from the four Cedar River drainage lakes already established as representative of a gradient from oligotrophy to eutrophy. If able to predict seasonal macronutrient movement through the phytoplankton in these four contrasting lakes, the model will then be further refined by extrapolating to other sites in this and other Biomes.

To validate and facilitate construction of the models, the seasonal pattern of phytoplankton productivity, biomass, light penetration, oxygen-temperature profiles, species composition, and concentrations of the various forms of , N, P, C, and Si will be determined at one station in three lakes. Data on these variables from Lake Washington are being furnished by W. T. Edmondson. Adequate definition of the pattern can be obtained from two-week sampling intervals during the active growing season and monthly during the remainder of the year. Growth rates will be derived from productivity and biomass data and related to the most-limiting-nutrient and physical variables.

Experimental work will be continued to obtain more precise functional relationships between limiting-nutrient content and growth rate of the natural phytoplankton under varying light and temperature conditions. Experiments of about one week's duration conducted with lake water in the laboratory have been found to be most appropriate to obtain positive response to nutrient enrichment. The limiting nutrient will be determined in lakewater batch cultures preliminary to determining the relationship between increased limiting-nutrient content and growth rate. The maximum growth rates attained at the various median concentrations of nutrient over the week-long exposure will be used to construct the Michaelis-Menton relationship. If relationships developed from batch cultures are inadequate, continuous-flow experiments will be used. Since limitation varies seasonally among nutrients, the interaction of two nutrients on growth rate response will also be tested. Growth rate of three size fractions of phytoplankton will be estimated from ^{14}C assimilation and biomass data determined by separating sample particulates (from in situ productivity as well as laboratory batch cultures) onto 50-μ, 5-μ and 0.45-μ pore size filters.

Trophic state variables derived from the seasonal measurements indicated above will be related to nutrient supply from internal as well as external sources of nutrient in the four lakes. A general description of the rate of change in trophic state to be expected from alteration of nutrient supply should be possible from comparison of the trophic response in Lakes Sammamish and Washington resulting from diversion (in sewage) of over one-half their P and one-fifth their N supply. The slow response in Lake Sammamish relative to that of Lake Washington promises to contribute new understanding to this management technique.

ZOOPLANKTON PRODUCTION AND PHYTOPLANKTON CONSUMPTION IN LAKES OF CONTRASTING ENRICHMENT

Principal Investigator

E. B. Welch, University of Washington

Coinvestigator

Paul R. Olson, University of Washington

Sponsoring Committee

Aquatic--Lake Systems

Relationship to Research Committee Program

Input is needed from water column chemistry, aquatic primary producers, decomposers, and lake hydrology.

Expected results will benefit decomposers, aquatic higher consumers, secondary producers, and aquatic coordination program.

OBJECTIVES

1. Establish second year of secondal pattern of zooplankton density and species composition in three lakes.

2. Determine rates of consumption of three size groups of phytoplankton in situ twice during the growing season as a function of phytoplankton density in the four lakes of varying enrichment.

3. Estimate production from considerations of birth rates determined by crustacean egg counts, as well as from total food consumption.

APPROACH

Density of zooplankton will be estimated in three lakes from abundances and average sizes of the principal species in samples collected by vertical hauls from the photic zone and total lake water column. Collections will be made with a one-half-meter closing net twice per month during the active growth period and once per month the remainder of the year. Densities in Lake Washington are available from W. T. Edmondson. Diurnal distribution will be studied in late spring and summer.

Consumption rate of phytoplankton will be determined in situ in at least spring, summer, and fall in each of the four lakes. Short-term measurements will be made in dark bottles with ^{14}C-tagged phytoplankton. Partitioning of the consumption into three phytoplankton size groups can be accomplished by intial and final sample filtration through a series of 50-μ, 5-μ and 0.45-μ pore size filters. The sample times will be chosen according to phytoplankton density to obtain functional relationships between consumption rate and food density. With functional relationships of this type, it should be possible to develop models that will link with growth models for the same size groups of phytoplankton. Such study could demonstrate if cell-size feeding selectivity is an important mechanism determining carbon flow through the phytoplankton and zooplankton compartments as enrichment increases.

Production of zooplankton will be estimated from birth rates,which are determined from egg-female ratio counts and from density changes of the various species. This work will be coordinated with similar work done in Lake Washington by W. T. Edmondson.

THE ROLE OF AQUATIC INSECTS IN THE ENERGY BALANCE OF FINDLEY LAKE

Principal Investigator

Robert I. Gara, University of Washington

Sponsoring Committee

Aquatic--Lake Systems

Relationship to Research Committee Program

Input is needed from the aquatic primary production and secondary production studies, and from the terrestrial-lake interface group.

Expected results will benefit primary production and food chain process groups, and the terrestrial-lake interface program.

OBJECTIVE

Determine the contribution of aquatic insects in a small undisturbed lake to net production in a partially closed system.

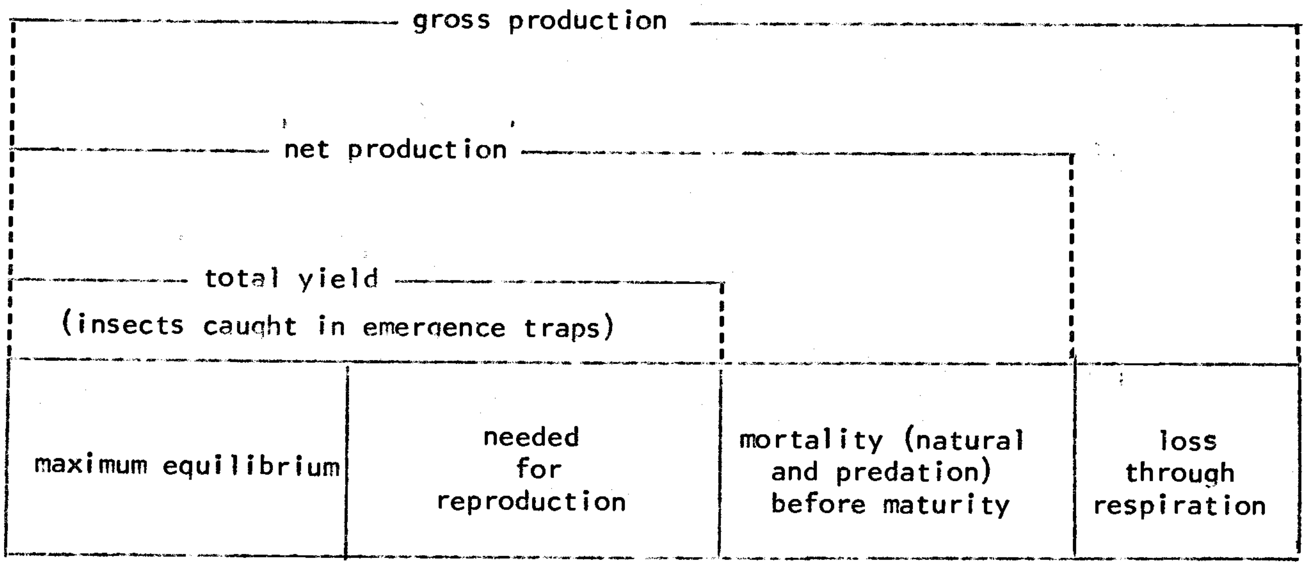
APPROACH

During 1973 the lake will be broadly stratified according to available habitats. Initial sampling will be used to obtain preliminary estimates of means and variances within and between strata. These data will be used to determine the necessary sampling intensity to obtain biomass and abundance estimates within the desired confidence limits. Also during 1973 the trophic levels and their species composition will be determined.

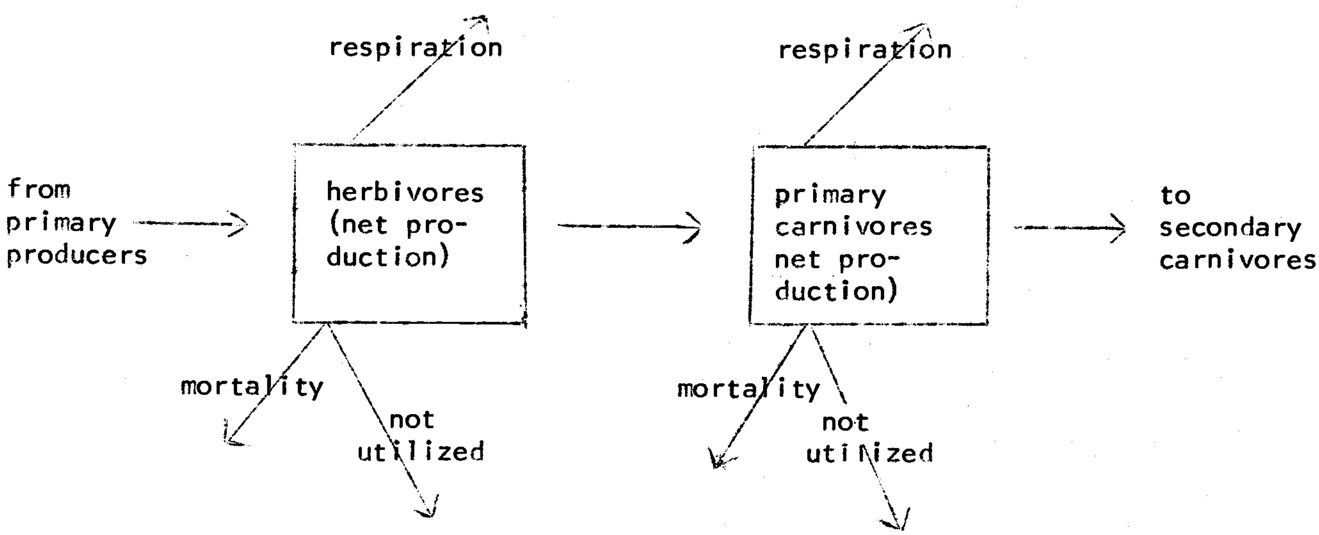
During 1974 sampling will be carried out on a monthly basis. A sample will consist of a combination of a bottom core, an artificial substrate, and an emergence trap at each station. The numbers and total weight by species will be recorded for each station. The data will allow determination by species of temporal biomass change and its contributuon to net production within each trophic level.

The production estimates will be presented in a manner that will allow them to be easily incorporated into a production model for the whole system. The data will also be representative of other undisturbed lakes with similar physical and biological parameters.

Components of production: (see diagram on following page.)



Food chain to which aquatic insects in Findley Lake are expected to belong:



DEGRADATION OF ORGANIC COMPOUNDS IN FRESHWATER SEDIMENTS BY BACTERIA

Principal Investigator

Jack R. Matches, University of Washington

Sponsoring Committee

Aquatic--Lake Systems

Relationship to Research Committee Program

Input is needed from other studies on oxygen uptake by bacteria in sediments to correlate population numbers, O_2 uptake, and mineralization; and on oxidation of organic matter in water columns.

Expected results will benefit bottom-related process modeling efforts (Male), detritus consumption studies, biogeochemical process studies, and sediment core analysis studies.

OBJECTIVES

The objectives of this investigation are to determine the total functional activities of the bacteria (aerobes, facultative anaerobes, and obligate anaerobes) in freshwater sediment. These functions are important in the overall recycling of nutrients and are important in the overall primary productivity of a body of water.

APPROACH

During year 2 and into year 3, the bacterial flora of sediments will be tested for their ability to degrade organic compounds. This mineralization will be tested, using simple organic compounds such as glucose, acetate, and alanine during the early parts of the study. Later work will involve the use of much more complex substrates such as polysaccharides, polypeptides, and proteins. These tests will be run to measure the response of sediment microorganisms to low concentrations of organic solutes, many ^{14}C labeled.

Substrates labeled with ^{14}C will be added in small amounts to a series of small serum bottles. Unlabeled substrates will also be added. The volumes in each serum bottle will be made equal by the addition of sterile distilled water. Sediment samples collected with a coring device will be added to each of the serum bottles. Prior to use, the samples held in the refrigerator will be warmed to room temperature.

Dry weight will be determined so that the desired sample weight can be added. Sediments will be added to the substrate in the serum bottles. The sediment carrying large quantities of microorganisms will serve as the inoculum. Sediments collected from different depths will be compared. After addition of sediment samples, the serum bottles will be capped immediately with a serum cap pierced with a small plastic rod and cup assumbly containing a folded piece of filter paper.

Mineralization will be allowed to proceed for a predetermined length of time and then the reaction will be stopped by killing the bacteria and releasing all dissolved $^{14}CO_2$ by the addition of acid. The $^{14}CO_2$ will be absorbed by the addition of β-phenylethylamine to the filter paper. The filter paper is placed in a vial containing scintillation fluid and counted on a scintillation counter. These types of data have shown that mineralization is proportional to total uptake and total uptake usually follows Michaelis-Menten kinetics when measured over a range of substrate concentrations.

Total bacterial plate counts will be run on the sediments to determine the number of aerobes, facultative anaerobes, and obligate anaerobes present. Other techniques to be tried in year 2, such as gas chromatography of end products of glucose metabolism, will be used in year 3.

LITTORAL PRIMARY PRODUCTIVITY

Principal Investigator

Paul R. Olson, University of Washington

Sponsoring Committee

Aquatic--Lake Systems

Relationship to Research Committee Program

Input is needed from studies on terrestrial and aquatic primary production processes, terrestrial-aquatic interface, and biogeochemical processes.

Expected results will benefit modeling of aquatic lake system productivity, and studies on higher consumer dynamics and water-column biogeochemical processes.

OBJECTIVES

1. Evaluate the rates and patterns of annual primary production of the periphytic and macrophytic communities of Lakes Washington, Sammamish, Chester Morse, and Findley.

2. Evaluate the species compositions of the littoral benthic primary producers.

APPROACH

A number of papers have stressed the importance that nonplanktonic primary producers may play in lake ecosystems (e.g., Knight and Ball 1962, Wetzel 1964, Davies 1970, Gruendling 1971). Both macrophytes and periphyton may contribute significant amounts of primary production to lakes. The following approach will yield reliable data on littoral primary production within a minimum of research time.

Because of the nonhomogeneity of the various periphytic communities of lakes, estimates of production will be based on analyses of communities that develop on uniform artificial substrates. Gravimetric analyses (ash-free dry weights) of collections from various periods of immersion will yield growth curves from which the production rates will be computed for each month. The substrates will be suspended at various depths, and should provide data on the seasonal relationships of primary production to depth. Samples will also be preserved and analyzed for species composition. Collections of the natural communities will also be studied and correlated with the artificial substrate communities. The types of substrates available will be analyzed and used to modify total lake production calculations.

Macrophyte production will be estimated from harvests of plant material at various stages of development. Corrections will be made for any observed premature shoot death during the growing season. Species compositions of these communities will also be analyzed.

The primary production rates of the littoral communities will be determined. These data will be important in establishing the values of the various sources of energy fixation in the lakes. The seasonal trends in littoral productivity will provide estimates of the food available to the benthic consumers, as well as the amount of material that may become detritus. Since uniform substrates will be used, the productivity data and the species compositions will be comparable among the lakes, and should further contribute to the understanding of their trophic conditions.

BENTHIC OXIDATION OF ORGANIC MATTER

Principal Investigator

Mario M. Pamatmat, University of Washington

Sponsoring Committee

Aquatic--Lake Systems

Relationship to Research Committee Program

Input is needed from studies on morphometry of lakes, seasonal temperature profile, seasonal oxygen profile, anaerobic bacterial metabolism, benthos biomass distribution, estimate of insect emergence, vertical migration of aquatic insect larvae, allochthonous input to the lakes, primary production, and metabolism in the water column.

Expected results will benefit studies on the carbon cycle, the nutrient cycle, the oxygen budget, sediment core analysis, and bottom-related process modeling (Male).

OBJECTIVES

The objectives of this study are to estimate (1) the flux of organic matter to the bottom, (2) its oxidation in the bottom, and (3) the rate of accumulation of organic matter in bottom deposits.

APPROACH

Of the total organic matter input to a lake (autochthonous plus allochthonous), part is mineralized in the water column and part settles to the bottom. Part of the sedimented organic matter is mineralized through benthic community metabolism, and part is lost back to surrounding land as emergent aquatic insects, for example, and to the water column through predation.

The second-year study will involve more intensive measurements of benthic oxygen uptake over a wider area of the lake. The frequency of measurements will be dictated by the seasonal fluctuation and areal variation expected to be shown during year 1972. From these seasonal measurements the annual oxygen uptake by the entire lake bottom will be estimated.

The supply of organic material to the bottom will be directly estimated by using sediment collectors deployed at various places and depths. The sediment collected will be analyzed for its content of organic carbon and nitrogen, chlorophyll, and phaeophytin, and its total caloric content for direct comparison with benthic energy flow.

Experiments will be conducted to test the sensitivity of the community to changes in the rate of supply of organic matter to the bottom. Such information will be helpful in assessing the effect of eutrophication on benthic community metabolism and the latter's effect on the oxygen budget of the lake.

The rate of accumulation of organic matter and inorganic material in bottom deposits will be estimated indirectly by difference between the estimated annual sedimentation (from sediment collectors) and the sum of (1) annual total oxidation in the bottom and (2) losses due to insect emergence and predation. The rate of sediment accumulation in the lake bottom could also be estimated by radiocarbon dating. These results would be a mean estimate for thousands of years, however, which could be very different from the present rate of accumulation. It would be informative to compare the estimates resulting from the two techniques.

DETRITAL INPUTS INTO HIGHER TROPHIC LEVELS

Principal Investigator

Frieda B. Taub, University of Washington

Sponsoring Committee

Aquatic--Lake Systems

Relationship to Research Committee Program

Input is needed from primary production, zooplankton production, respiration, decomposition, and terrestrial-stream interface studies.

Expected results will benefit studies on zooplankton production, benthic invertebrate production, benthic fish production, limnetic fish production, and the general model of lake production.

OBJECTIVES

1. Complete sampling and analysis of data on quantities and proximate chemical analysis of detrital materials in the four lakes, to complete an annual cycle and get data on at least a second spring, summer, and fall.

2. Identify organisms that use detrital materials as foods, and their position in the food chain.

3. Estimate upper and lower rates of input by allochthonous and autochthonous materials.

4. Begin to quantify the standing crop of organisms that utilize detrital materials and estimate their production (order of magnitude).

APPROACH

Much of the energy of primary productivity becomes detrital and either directly (as fragments), or in the form of microbial biomass, reenters higher trophic levels, specifically as food for zooplankton and benthic feeders, and is passed along to their consumers. Because lakes receive terrestrial detritus (allochthonous inputs), the heterotrophic food chain can be larger than that supplied by the autochthonous production.

Several problems are apparent in evaluating the role of detritus in the food chain. Much of the detrital material may approach biological inertness, while a small portion may be biologically very active. Attempts will be made to distinguish between those portions. The most difficult estimate to make is the regeneration of microbial biomass on nondigestible fragments that serve as carriers and are repeatedly reingested. The significance of the proposed research is to help evaluate the hypothesis that detrital material may account for significant inputs into fish production.

Sampling

Most of the samples will be collected by or with other investigators.

Large fragments

Estimates of returning anadromous fish, and their fates, will be obtained from the fish studies. Confirmation of carcasses and their decomposition and conversion into other organisms will be studied. Estimates of large detrital materials will be made whenever towed net samples are made. Large detrital samples are expected to be rare, but will be several orders of magnitude larger than the more ubiquitous smaller materials.

Intermediate fragments

Zooplankton net tows can be expected to collect coniferous needles, terrestrial insects, and the like.

Small fragments

Seston samples will be collected as part of the primary sampling procedure. Estimates of proportions of phytoplankton and detritus will be made.

Chemical Analyses

Oxidizable carbon will be estimated using oxidizing agents of varying potentials. These estimates will be compared with measurements of biological oxygen demand (BOD). Kjeldahl N will be determined. Biologically oxidizable carbon-to-nitrogen ratios will be calculated. The apparent productivity of this material, as judged by the communities of organisms which seem to be subsisting on it, will be compared with this C:N ratio.

Chlorophyll and pheopigment analyses will be used to estimate ratio of active to semidigested materials. Bomb calorimetry will be conducted on samples subjected to progressive oxidations, including the BOD procedure, to evaluate the proportions of energy available to microbes (to be compared with sediment O_2 on uptake data). Similar studies on detritus, detrital feeders, and their fecal material may be planned for the following year.

Food Chain Studies

Organisms apparently living in and on detrital materials will be assumed to be detrital feeders unless their stomach contents indicate otherwise. Feeding behavior and stomach contents of other organisms, especially fish, will be used to identify detrital feeders. Biomass, caloric content, and general identities of benthic organisms will be made (if taxonomic work cannot be done here during the course of the experiments, approximate samples will be preserved and stored for later identification). Production estimates may be made from literature values. (No detailed studies of life histories, instar analyses, growth rate, assimilation rates, or efficiencies are anticipated.) Biomass and production rates of large invertebrates and fish will be obtained from other research groups. The amounts of detrital material potentially consumed in the course of this production will be estimated.

Detrital Inputs

Estimates will be made of autochthonous sources as a proportion of primary productivity by limnetic phytoplankton and littoral plants. Inputs via streams (measured either by Cedar River studies, or by this project) and runoff, will be estimated.

DYNAMICS OF LIMNETIC FEEDING FISH

Principal Investigator

Robert L. Burgner, University of Washington

Coinvestigator

Richard E. Thorne, University of Washington

Relationship to Research Committee Program

Input is needed from primary and secondary lake production studies (Welch, Olson), abundance and feeding habits of higher consumers (Whitney, DeLacy), and aquatic lake modeling efforts (Male).

Expected results will benefit primary and secondary lake production dynamics modeling studies, and aquatic biogeochemical process studies.

OBJECTIVES

1. Determine planktivore fish production rates in three lakes of significantly different nutrient status, topography, and climate.

2. Relate production rates to possible controlling factors, including recruitment, physical and chemical environment, food availability and characteristics, behavior and competition, and predation and other removal.

3. Develop submodels and incorporate them into a total system trophic dynamics model.

4. Explore opportunities for validation elsewhere.

APPROACH

Seasonal limnetic fish population parameters will be obtained by combined echo sounder--net sampling technique. Full field sampling will continue on Lake Washington and Lake Sammamish at two-month intervals through the first half of 1973, with supplemental sampling thereafter to round out information. Full-scale sampling on Chester Morse Lake will be delayed until 1974 to coordinate with simultaneous studies by Whitney, Wydoski, and DeLacy.

Numbers, length frequencies, and mean weight of each species by age group will be determined to measure mortality rate, growth rates, and biomass changes for each sampling period. Conversion of biomass to calorie, carbon, phosphorous, or other units will be calculated as needed. Distribution, vertical and area, will be measured by the combined echo sounder--net sampling technique to relate to physical and chemical environmental factors, including temperature, light, and oxygen.

Sampling schedules will be coordinated with DeLacy's personnel so that boat time will be shared to correlate fish distribution and stomach contents with vertical distribution and species composition of zooplankton. Additional diel fish and plankton sampling will be needed for DeLacy's food habits and feeding strategy study.

Coordination of sampling times and data collection with Welch, Christman, Spyridakis, and Edmondson will make it possible to utilize their physical, chemical, and biological data to a large extent. The effects of changing trophic status of Lake Washington on young sockeye growth and behavior has already been reported in a preliminary manner in theses by Woodey (1972) and Isakksson (1970). The comparison of behavior of Lakes Washington and Sammamish under decreased enrichment will be extended to limnetic feeding fish by this project. Sampling will also be coordinated with that of Wydoski and Whitney with respect to predatory fishes because the echo-sounder tapes will provide information on distribution of larger fish targets.

Information on abundance of the parent sockeye population and other salmon will be collected by Washington State Department of Game for Cedar River on Lake Washington and for Issaquah Creek on Lake Sammamish. The adult salmon population in Lake Washington will also be estimated by use of echo sounders by the Fisheries Research Institute under a Sea Grant project. Thus the production of young sockeye per adult spawner can be computed. The study by Stober of aquatic production in the Cedar River will intertie with the sockeye study and provide an interface between the streams above Chester Morse Lake, the lake, the Cedar River, and Lake Washington.

This proposal is contingent on 18 days' free use of the College of Fisheries M/V Commando for graduate student thesis work on Lake Washington (normal charter rate $450 per day). It is also contingent on personnel sharing with a Sea Grant study concerning Lake Washington sockeye in order to accomplish the field sampling.

Information from the project will be used in a number of submodels, including Warren's trophic dynamics model, feeding strategy models, nutrient gains and losses from the system through lakeward and seaward migrations of anadromous fish, and predator-competitor models.

Extrapolation of limnetic fish information will depend on availability of data from other lakes. The year-round data on numbers and biomass are unique and may not be available from any other lake on the Coniferous Biome. Seasonal data (summer) will be available from the following sockeye salmon lakes: Iliamna, Clark, and the Wood River lakes in Alaska; Shuswap Lake in British Columbia; and Lake Quinault in Washington (data are being collected by similar techniques by Fisheries Research Institute personnel). It may be desirable to extend the technique to other lakes in the Coniferous Biome, such as Flathead Lake, where kokanee (nonanadromous sockeye) are perhaps the most abundant fish.

Because of limited funding levels, beginning of intensive sampling of Chester Morse Lake will necessarily be delayed until 1973. Because Chester Morse Lake is a trout-whitefish-char lake, techniques will be modified to obtain data comparable to that in Lake Washington. An intensive study under other funding is currently being made of trout-char populations in Ross Lake (in the North Cascades but at a similar elevation and at a similar nutrient level). The methods used and data collected will be similar at Chester Morse Lake, and will provide a comparison of an unfished natural population with the fished population of Ross Lake.

FEEDING HABITS AND BEHAVIOR OF JUVENILE SOCKEYE SALMON

Principal Investigator

Allan C. DeLacy, University of Washington

Sponsoring Committee

Aquatic--Lake Systems

Relationship to Research Committee Program

Input is needed from higher consumer dynamics modeling, studies on aquatic water-column primary and secondary production, and littoral studies.

Expected results will benefit higher consumer dynamics modeling (Male), and littoral and water-column productivity studies.

OBJECTIVES

1. Expand current studies on the quantitative estimation of food consumed by juvenile salmon in Lake Washington to include juvenile sockeye and kokanee in Lake Sammamish and also other limnetic feeding species in the two lakes.

2. Examine the extent on inter- and intraspecific size-selective feeding by juvenile sockeye upon zooplankton and how this apparent feeding strategy changes with changing zooplankton species composition.

3. Investigate the influence of light and temperature upon the vertical distribution of juvenile sockeye in relation to their diel periodicity.

4. Compare the findings from Lake Washington with those from Lake Sammamish.

APPROACH

Quantifying the amount of food consumed by zooplankton juvenile sockeye and other limnetic feeding species will provide essential information on the energy flow between the primary and secondary consumer levels in the limnetic environments of Lake Washington and Sammamish. Coupling this with studies involving size-selective feeding strategies will provide information that relates directly to the population dynamics of both the sockeye and zooplankton stocks. In addition, investigations into the influence of light and temperature upon the diel feeding periodicities of the sockeye will yield information concerning two of the factors that control both the amount of food consumed and the size and kinds of food organisms fed upon. A comparison of Lakes Washington and Sammamish will relate to questions involving lakes of differing productivities.

Field sampling of juvenile sockeye salmon (*Oncorhynchus nerka*) and other limnetic feeding species in Lakes Washington and Sammamish will be conducted at 2- to 4-hour intervals through 24-hour periods in spring, summer, and fall. Approximately three to four sampling dates are anticipated. Samples of fish will also be selected from the catches made by Burgner and Thorne. Although their catches are not to be made through a 24-hour sampling period, they will still provide very useful supplementary information.

Sampling stations with clearly contrasting fish density differences will be sought in both lakes. The choice of sampling sites will vary and will be made through reference to the results found by Burgner/Thorne and DeLacy under current projects.

The primary field collection gear will be surface and midwater trawls. Accumulative collection devices such as traps or gill nets are not appropriate since the collections must be time-specific. The fish samples will be anesthetized and immediately preserved to prevent quantitative changes in the stomach contents.

Zooplankton collection gear will be one-half-meter plankton nets and Miller high-speed plankton samplers. Data collection will be coordinated with the zooplankton studies being conducted by Welch and Olson, and with the continuing work in Lake Washington by Edmondson and associates.

Information concerning the quantitative consumption of food and factors affecting feeding strategies should provide for increased precision and accuracy in the modeling of the pelagic ecosystems of Lakes Washington and Sammamish.

RELATIVE ABUNDANCE AND BIOMASS OF SELECTED BENTHIC AND LITTORAL FISHES IN THE LAKE WASHINGTON DRAINAGE

Principal Investigator

Richard R. Whitney, University of Washington

Coinvestigator

Richard S. Wydoski, University of Washington

Sponsoring Committee

Aquatic--Lake Systems

Relationship to Research Committee Program

Input is needed from studies on higher consumer dynamics and feeding habits, lake productivity modeling studies, and stream studies.

Expected results will benefit lake productivity modeling efforts, energy balance studies, and aquatic biogeochemical studies.

OBJECTIVES

1. Determine the distribution and relative abundance of selected benthic and littoral fishes in three lakes with different nutrient status.

2. Expand these estimates of relative abundance into terms of biomass.

3. Obtain data on the life history of selected species that will be needed to model their importance in the productivity of the ecosystem, i.e., feeding habits, growth rates, and the like.

APPROACH

Our work has shown that much of the fish production in Lake Washington is in the form of nonsalmonoid and nongame species. To our knowledge, the species composition of Lake Sammamish is similar to that of Lake Washington. Preliminary sampling of Chester Morse has indicated that the rainbow trout, Dolly Varden, and mountain whitefish are the major species in the lake. Findley Lake is devoid of fish.

Because all gear are selective as to the sizes and species that are captured, we have chosen to use horizontal gill nets with nine mesh sizes to sample the benthic and littoral zones, vertical gill nets with the same mesh sizes to sample the pelagic and benthic zones, and fyke nets to sample the shallow bays. Burgner and Thorne will be studying the lakes in the drainage with the use of an echo integrator and a midwater trawl. Our studies have shown that gill nets, particularly the vertical type, supplement their data very nicely by providing information on size, age, and species composition of the larger targets that are recorded on the integrator. We will be comparing our catch-per-unit-of-effort data from nets with the estimates of fish abundance from acoustical techniques. This comparison may provide us with a base line for estimates of fish abundance from catches in nets. We will place emphasis on Lake Washington during 1973 and spot check Lakes Sammamish and Chester Morse.

During 1971, our sampling of Lake Washington gave us a good insight into the species composition of the lake, their relative abundance, and the answers to some questions on sampling. Twenty-two of the 35 species that are reported in the watershed inhabit the lake. Twelve of these species are considered to be abundant to common; the six species that are abundant include sockeye salmon, peamouth, northern squawfish, yellow perch, brown bullhead, and prickly sculpin. Species considered as common include longfin smelt, carp, large-scale sucker, three-spine stickleback, largemouth bass, and black crappie.

From the 1971 data on species obtained during 1972 we will design a sampling scheme and schedule that will enable us to get reasonable estimates of relative abundance of key species from the catch-per-unit-effort data in 1973. During 1974 we will find existing gaps in our data from Lake Washington by sampling during different seasons or by placing emphasis on using different gear.

Other non-IBP but related studies by unsupported students will supply us with data on the life histories of major fish species. Studies will include an analysis of age and growth, length-weight relationships, sex ratios, size and age at sexual maturity, and food habits. These data will be useful in the feeding strategies model.

A similar approach will be taken to sample Lakes Sammamish and Chester Morse. During 1973 we will sample these two lakes on a spot check basis to obtain necessary information to design a sampling scheme and schedule. As our effort in Lake Washington decreases in 1974, we will systematically sample Lakes Sammamish and Chester Morse to determine the relative abundance, distribution, and biomass of fish in these lakes, which are of different nutrient status. Chester Morse offers a unique opportunity to study an unexploited fish population. When we see the way in which the three species have come into equilibrium with one another, perhaps we can understand better what has happened to that equilibrium in lakes where there is differential fishing mortality on the species. This will help us isolate the effects of the different nutrient statuses of the lakes.

Our work will provide estimates of relative abundance and biomass of selected benthic and littoral fishes in three lakes of different nutrient statuses. In addition, our work will provide data on the life history of endemic and introduced fish species that have not been reported previously for lakes in the Pacific Northwest.

5.2.7. Aquatic--Stream systems

AN ECOSYSTEM APPROACH TO SMALL STREAMS IN A CONIFEROUS FOREST

Principal Investigator

John R. Donaldson, Oregon State University

Coinvestigators

James Sedell, Oregon State University
James D. Hall, Oregon State University
J. H. Lyford, Oregon State University
N. H. Anderson, Oregon State University
Richard L. Fredriksen, USDA Forest Service, Corvallis
William C. Denison, Oregon State University
J. M. Trappe, USDA Forest Service, Corvallis

Sponsoring Committee

Aquatic--Stream Systems

Relationship to Research Committee Program

Input is needed from terrestrial and aquatic biogeochemical studies, stream system modeling, aquatic coordination program, and hydrology studies.

Expected results will benefit terrestrial-stream interface modeling effort, lake system models, large river models, and the coordination program.

OBJECTIVES

1. Complete the determination of the structure and productivity of small coniferous forest streams.

2. Determine the origin and fate of dissolved organic material with particular reference to its relation to microbe types and densities.

3. Carry out experiments using radioactive isotopes to estimate energy and mineral rate processes between compartments in streams and to determine the extent of terrestrial-stream interactions originating in the stream.

4. Incorporate stream data into a systems model that interrelates the terrestrial and aquatic components of the watershed ecosystem.

APPROACH

In years 3 and 4 we propose to focus more effort on the role of dissolved organic material in the stream and on experiments using radioisotopes as an aid to discovering rate processes between compartments within the stream and between the stream and terrestrial compartments. This work will be done in streams of the Andrews Forest and in the experimental stream, Berry Creek.

A significant problem not being dealt with in year 2 is the dimension of the dissolved organic fraction (DOM) and the utilization of that fraction. The DOM from leaf leachate, algal excretion, and soil solution represents a significant organic pool that turns over quite rapidly, even though a large amount of rather refractory matter may be expected. Cummins (1971), attempting to model woodland streams in a deciduous forest, estimated that about 50% of the total DOM input was reflocculated into fine particulate organic matter (FPOM). This occurred by flocculation around air bubbles, colloidal settling, and chemical precipitation. The other half was metabolized by microbes of which he estimated 50% passed off as respiratory CO_2 and 50% went into production of microbial FPOM. The DOM compartment is a vital coupling between the dynamics of the stream biota and such Biome investigations as stream hydrology and biogeochemistry.

Little is known concerning the many changes in quantity and quality of DOM that are produced by the biological processes in and near streams. The functional role of DOM in stream metabolism is also understood poorly and that information which is available is essentially circumstantial. Inferences have been drawn from physiological studies of bacterial and algal cultures under laboratory conditions. Technological difficulties have delayed the transition from laboratory to field investigations. The approach planned, to determine the dynamics of DOM in forest streams, involves an investigation of the processes of microbial decomposition of allochthonous material, measuring the quantity and quality of DOM involved, and examining the fluxing between physical and biotic compartments in and along the streams.

The variety of stream conditions provided in the Andrews watershed, from virgin forest to recent clearcutting, provides excellent situations in which to measure the types and amounts of DOM and hopefully to develop a budget. Integral to the measurements will be a study of the functional microbial groups involved in the decomposition of the large organic material such as leaves, woody pieces, and salmon carcasses. The expertise of an investigator with knowledge of the biochemistry of microbial decomposition will be required.

The examination of the fluxing of DOM along the stream course will be carried out using radioisotopic techniques. Carbon-14 and phosphorus-32 will be used in mass balance techniques developed by Saunders, and Elwood and Nelson. Isotopes of selected elements will be incorporated into biogenetic material such as salmon carcasses and the pathways and turnover rates of these elements following decomposition will be investigated.

Primary productivity measurements will be well enough developed by year 3 to allow attention to be shifted somewhat to the energy input to the stream from allochthonous riparian material. In addition to the decomposition studies already mentioned, an estimate of the large woody pieces (greater than 10 cm) above, in, and near the streams will be made. This will be done in cooperation with terrestrial biomass investigations on the Andrews Forest.

The primary production and allochthonous energy source studies will use the aforementioned ^{32}P material balance method. The technique consists of computing a material balance of ^{32}P following a 30- to 60-min pulse release. Total standing crop and effective stream bottom area can be calculated by equating the quantities of ^{32}P per unit area of substrate on the stream bottom and per unit weight of periphyton on these substrates to the total quantities of ^{32}P retained in the study reach of the stream. By monitoring the ^{32}P in the periphyton and stream water over time, rates of change in the various compartments can be estimated. The production rate of periphyton and the grazing rate of periphyton can then be estimated.

The significance of the movement of nutrients from the stream water to the riparian vegetation is not known. The ^{32}P technique allows one to measure this movement of nutrients from the aquatic to the terrestrial aspect. This would establish an essential coupling between freshwater systems.

An additional study in the year-3 program will be the role of streambed mosses in fixing energy and cycling nutrients. Their associated invertebrate fauna make them an important compartment in a stream's trophic structure.

Studies on the production of benthic invertebrates will be completed in year 3. Particular attention will be paid to the chironomid larvae, pupae, and adults. This group, which represents the greatest numbers and probably greatest biomass of all of the aquatic insect groups, has been somewhat neglected in the first two years. By use of a foam gathering method, the associated exuviated pupae and emerging adult midges will be identified and quantified. W. P. Coffman (University of Pittsburg) will be consulted on the identity of the midges. Feeding experiments with the major invertebrate species will determine ingestion and assimilation rates as affected by the quality and quantity of food.

Predator-prey experiments will be designed to examine the roles of crayfish, salamanders, and fish in the stream, and their influence on the community composition and numbers of aquatic insects. The higher consumer portion of the study will also relate the contribution of allochthonous and autochthonous production to the production of fish biomass and to determine how the relationship may be altered by logging or other land management practices. The role of amphibians in the consumer dynamics of the stream areas in which they are located is being investigated by the terrestrial consumer people. The involvement of stream researchers in this effort will strengthen the aquatic terrestrial interties.

The Andrews stream program for years 3 and 4 is to be focused on aquatic-terrestrial couplings. Apart from viewing the stream as receiving the bulk of its energy from forest litter, the extent to which the stream delays the export of minerals and nutrients, to which it returns them to the forest, or both, is not known. Stream research during years 3 and 4 will be geared to provide some of these answers.

AQUATIC PRODUCTION IN A SOCKEYE SALMON RIVER

Principal Investigator

Quentin J. Stober, University of Washington

Coinvestigator

Arden R. Gaufin, University of Utah

Sponsoring Committee

Aquatic--Stream Systems

Relationship to Research Committee Program

Input is needed from small-stream production and dynamics studies on the Andrews site, the four-lake study program, higher consumer dynamics group, and hydrology and terrestrial biogeochemical groups.

Expected results will benefit stream system model validation, lake system program, and hydrology models.

OBJECTIVES

1. Determine the structure and productivity of stream invertebrate communities within a coniferous forest river influenced by impoundment and discrete resident and anadromous fish populations.

2. Determine the relative importance of terrestrial detritus as an energy input to river biota.

3. Relate the density of the resident and anadromous fish populations to the availability and utilization of the benthic food supply.

APPROACH

The study of the Cedar River is designed to complement the Andrews Forest unit watershed studies. The Cedar River, by virtue of its larger size, colder temperatures, lower mineral content, and differences in geology and in terrestrial manipulation, will provide a basis for extrapolation to a larger system. Additional complementary aspects of the Cedar River system stem from river impoundment in Lake Chester Morse, as well as diversion of water to the City of Seattle, which results in a highly regulated river discharge. The impoundment and diversion effectively divide the river into three discrete sections: the natural river above the reservoir, the river below the dam which is subjected to the effects of impoundment, and the river below the diversion which receives additional discharge manipulation and is the sockeye producing section of the river. There are three discrete fish populations in the river consisting of unfished resident fishes in the upper and middle sections, and those in the lower section under major influence of an expanding sockeye population. The Cedar River is the aquatic interface between Lake Chester Morse and Lake

Washington, both of which are receiving major attention in the aquatic lake studies of the Coniferous Forest Biome.

A study of the multiple-use aspects of the Cedar River watershed currently under way by a number of governmental agencies (Ribco) will provide detailed complementary information on hydrologic modeling, land use, and weather, as well as on other aspects of the basin. The effort funded by IBP does not overlap, but will provide much-needed biological information on the Cedar River that is presently lacking.

The production of aquatic invertebrates and resident and anadromous fish in the three sections of the Cedar River will be determined. These aspects are complementary to the Andrews stream studies. The stream fish assessment at the upper stations will intertie with lake fish assessment in Lake Chester Morse and with resident-anadromous fish relations in the lower Cedar River. Spawning distribution of sockeye in the Cedar River will be determined by the Washington State Department of Fisheries (WSDF). An additional complementary study concerns the utilization of different allochthonous materials by aquatic invertebrates. While primary emphasis will be directed toward Cedar River stream ecology, the data will be intertied with the Andrews study and with a study under direction of Gaufin in the intermountain area. Inclusion of the study will provide a beginning for extrapolation of stream studies. It is also important from the standpoint of assessing impact of logging on stream production.

Six sampling stations have been established on the Cedar River in riffle areas near USGS gaging stations. Two stations are above Lake Chester Morse on the Cedar and Rex Rivers, two at locations on the Cedar River below the lake but above the diversion, and two in areas below the diversion.

Physical and chemical data common to all stations will include characterization of river bottom type and definition of the wetted area at various flows. River discharge will be taken from USGS gaging stations. Temperature will be continuously recorded. Water chemistry will be obtained in conjunction with the lake biogeochemical cycling studies.

Invertebrate standing crop data are being collected with a series of Coleman and Hynes pots at each station. Sampling is conducted at each station monthly as streamflow permits. A production measurement will be adapted after the "community" method suggested by Hynes and Coleman (1968) with corrections by Hamilton (1969) or by calculating the annual turnover ratio (TR) for the entire benthic fauna (Waters 1969).

Drift samples are collected once per month in 24-hour sets at each station with a modified Miller sampler. Allochthonous material is being quantitated in the drift as well as in the benthic sampling pots. Detritus will be quantitated by dry weight and caloric values will be determined.

Fish populations will be sampled during the summer low-flow period with an electric shocker at each of the six stations. Data to be collected will include population size, feeding behavior, food habits, growth rate, movement rate, and production. This effort will be restricted largely to the resident species, since the WSDF is continuing studies of the sockeye salmon.

5.2.8. Ecosystem integration--Coordination program

INFLUENCE OF FIRE IN CONIFEROUS FOREST ECOSYSTEMS A PROBLEM ANALYSIS

Principal Investigator

Mark Behan, University of Montana

Sponsoring Committee

Ecosystem Integration--Coordination Program

Relationship to Research Committee Program

Input is needed from ecosystem modeling efforts, biogeochemical studies on decomposition, and nutrient cycling processes.

Expected results will benefit the ecosystem modeling geochemical processes studies, the working group on disease influences, and the information bank.

OBJECTIVE

Define and interpret the role of fire in the function of ecosystems in western coniferous forests.

APPROACH

Wild-land fires have traditionally been viewed as a negative and destructive force, or a "tool" of management. Recognizing that we have acquired conditioned attitudes regarding fire, we may be suggesting solutions to ecosystem functions and land management problems that disregard fundamental relationships because we have not asked the right questions. If fire serves as a decomposing agent throughout much of the Coniferous Biome, can we understand the functioning of coniferous ecosystems without accounting for this cyclic role of fire? Such an omission will surely lead to discontinuities in our comprehension of food chains, energy flow, and nutrient cycling within these systems.

The working group will consist of scientists from the University of Montana and from the following units of the USDA Forest Service: Northern Forest Fire Laboratory and the Forest Sciences Laboratory of the Intermountain Forest and Range Experiment Station, and Region One of the National Forest Systems. Nearby scientists in the National Park Service will be included in some meetings and workshops and outstanding experts on the role of fire in ecosystems from all over the United States will be brought in for at least one workshop each year. The group will function in three major areas: review of pertinent fire literature, inventory of ongoing work in fire ecology, and preliminary modeling of the role of fire in ecosystems.

The main concern in searching the "fire literature" will be the enhancement of our understanding of fire as an ecosystem process, and as an important function in the northern Rocky Mountains. As with other "basic elements" in ecosystems, fire's influence cuts through nearly all other ecosystem relationships, at all levels of organization. Since the information storage, retrieval, and data bank development activities will function in compiling much of the fire/

ecosystem details, it is viewed that the literature review will have the function of making an interpretative overview of currently published materials. A well-indexed annotated bibliography will be developed for publication, first as a Coniferous Biome internal report, and later synthesized into a formally published review paper.

An annotated inventory of unpublished current research, significant to understanding the role of fire in the coniferous forest, will also be prepared. The format of presentation of this inventory will be compatible with the published material review effort.

Our objectives would be submodels that relate fire to specific segments of the ecosystem. These models would be process or function oriented and would apply directly to the areas of study. They would be broad enough for easy extrapolation to the total Coniferous Biome, however. The modeling of fire and fire-influenced systems may present some problems that have not been encountered in other IBP efforts, and may offer some challenge to the Biome's modeling group. The occurrence of fire has a strong probabilistic element, thus simple deterministic models may not be adequate for our purposes. The aftermath of fire is a nonequilibrium system, so dynamic models based on the mechanics of component interactions are a necessity. The alternative is a system of time-ddependent models that are mathematically intractable and probably less useful.

TEST OF ENVIRONMENTAL GRID MODEL FOR PRIMARY PRODUCTION IN WASATCH FRONT ENGELMANN SPRUCE

Principal Investigator

T. W. Daniel, Utah State University

Coinvestigator

George E. Hart, Utah State University

Sponsoring Committee

Ecosystem Integration--Coordination Program

Relationship to Research Committee Program

Input is needed from the environment-plant indexes study (Emmingham), and tree- and stand-growth modeling efforts (Reed).

Expected results will benefit other coordination programs, ecosystem modeling studies, and primary production process studies.

OBJECTIVES

The project is designed to gather the data needed to test the applicability of the Waring model for primary production to Engelmann spruce performance along the Wasatch Front.

APPROACH

At the Utah State University forest in Logan Canyon the following records will be taken on three Englemenn spruce saplings approximately 2 m tall: internal water stress with the pressure bomb, stomatal behavior with a porometer decided upon for use with the Waring model, phenology of growth on the saplings and cone phenology on larger trees as cones are accessible and available, cambial growth initiation and a sequence of determinations until cambial growth ceases, and leaf foliage analysis for previous year's foliage during present year's growth period and mature foliage of present year after cambial growth ceases. Environmental measurements will include continuous soil temperature record at 20 cm and a hygrothermograph record at 1 m aboveground in the open along with an actinograph record. A series of records will also be made at the site of the saplings. A composite sample from each of three auger holes down to 61 cm will be analyzed for nutrient level of N, P, Ca, and K. The records from the saplings will be made at least at monthly intervals and more frequently at inflection points to ensure adequate records.

The College Forest has an area of 1037 ha with a variety of cover types: herbaceous meadows, aspen slopes, lodgepole pine stands of several ages, mixed conifers, and Engelmann spruce--subalpine fir in uneven-aged or even-aged small-group stands. The elevation at the Engelmann spruce plots is approximately 2590 m. Precipitation has averaged about 76 cm per year, but a weather modification project may give a higher average for the period of its duration.

Snow accumulates to a depth of 244-274 cm in the small timber-enclosed meadows and the open meadows with a slight northeast slope retaining a snow cover until the first week in June. Intermittent rains may last well into June but also June may be quite dry. July, August, and September are usually dry. A few light rains may occur sporadically at any time with 1.3- to 2.5-cm storms in some years during August. Soil was derived from the Wasatch conglomerate formation. In the study area, the soil is a silty clay loam with some gravel and occasional boulders.

SURVEY AND EVALUATION OF AVAILABLE DATA FOR MODELING FORESTED WATERSHEDS

Principal Investigator

George E. Hart, Utah State University

Coinvestigator

Richard H. Hawkins, Utah State University

Sponsoring Committee

Ecosystem Integration--Coordination Program

Relationship to Research Committee Program

Input is needed from hydrology and stream studies, the ecosystem modeling group, and meteorology studies.

Expected results will benefit other coordination programs, ecosystem modeling studies, and primary production process studies.

OBJECTIVES

1. Identify the necessary hydrometeorological parameters for model formulation and verification.

2. Locate and describe watersheds in the Coniferous Biome for which data are presently available for modeling.

3. Evaluate the quality and utility of such data for future use in the computer model under development.

APPROACH

The development of a hydrologic model for watersheds with coniferous vegetation is an important component in the interface project. This model, by estimating soil water storage, serves as a linking mechanism to primary productivity models. The initial modeling of watershed 2 on the H. J. Andrews Experimental Forest is under way and experience is being gained as to data needs. Interest in extending the modeling efforts to other watersheds is rapidly developing as evidenced by independent requests for work at Wenatchee, Washington, and at Farmington, Utah. It is now appropriate to identify and evaluate the potential sources of available hydrometeorologic data within the Biome to provide for the orderly extension of the model to diverse vegetation and climatic environments.

The first step would be to review published hydrologic information from small forested drainages within the Coniferous Biome. In addition to the recognized coniferous types, we would survey the associated forest vegetative types such as aspen and pinyon-juniper. The main sources of data are the USDA Forest Service (research and barometer watersheds), USDI Geological Survey, USDA Agricultural Research Service, and NOAA. Other possible sources would be USDI Bureau of Reclamation, USDI Bureau of Land Management, USDA Soil Conservation Service, state water boards, municipalities, universities, and industry. This review would have two forms: a library search and a mailed questionnaire. We would seek information on precipitation, streamflow, climate, soil water, soil description, geology, topography, and vegetation type and density. From this, tentative criteria for sensitity and duration of record would be established.

Following the review, visits would be made to selected field locations that appear to have more applicable data (about 15 sites). At this time the records would be examined for completeness, and the accuracy of measurements (instrument calibration) would be evaluated. No attempt would be made to compile the data into computer format, although computer compatibility would be one criterion considered. Data compilation would be done by either the modeling projects or the information bank as the need arises.

In the final phase, an evaluation of each site would be made with respect to the quality of data, the representativeness of the individual watershed, and its potential for modeling. The report would give details on each site that has potential for model verification and would establish criteria for quality and relevance of data for hydrologic modeling.

The results of this survey would yield an enlarged data base for future computer simulation of forest watersheds. The initial work (Riley, Israelson, Hart, Chen) on simulation is restricted to the Andrews Experimental Forest and the data survey would identify and evaluate other watersheds that may be suitable for further testing and validation of the initial model. It would develop specifications and design criteria to provide uniform data if additional gaged watersheds were to be developed with the Biome.

WEYERHAEUSER EXPERIMENTAL STREAMS STUDY: MODELING OF TROPHIC PROCESSES

Principal Investigator

E. P. Haydu, Weyerhaeuser Company

Sponsoring Committee

Ecosystem Integration--Coordination Program

Relationship to Research Committee Program

Input is needed from stream study modeling efforts (Sedell, Stober), terrestrial-stream interface studies, and aquatic coordination program (Gaufin).

Expected results will benefit stream study model validation.

OBJECTIVE

The objective of this proposal is to test the applicability of concepts developed at Oregon State University that model trophic processes assuming the existence of density-dependent factors. These models will be tested against a body of information (biomass, growth rate, and production at all trophic levels) developed at the Weyerhaeuser Experimental Streams Study site.

METHODS

The study covered by this proposal will be conducted at an experimental streams facility located in the Cascades. The station has on it three man-made streams each several tens of meters long. The three streams were constructed so that they are as nearly identical to each other as possible. Part of the flow of a constant-temperature (6°C) spring is diverted into each stream at a rate of 2.5 $m^3 s^{-1}$ (0.9 cfs). The streams contain a number of riffles, alternately 7.6 and 15 m long and 1.2 m wide, separated from one another by a pool 3 m long. A riffle and the pool below it are separated from other riffle-pool sequences by rotary screens that permit drift to pass but keep the fish in their designated study unit.

Continuous studies have been under way at this site since 1965; several reports and publications have been put forth concerning these studies. All of the important physical and chemical parameters have been monitored. A great deal of background biological information has also been gathered: life history and phenological data for all the major plant and animal species, species composition, feeding habits of the fish and benthic invertebrates, primary production, and growth rates and production of fish and benthic invertebrates.

Our biological monitoring program will be augmented to contribute more effectively to development of the density-dependent models now being studied at Oregon State University. Our full program will include: determination of the biomass, growth rate, and production of trout; the trout's feeding habits and food consumption and conversion; benthic plant and animal species composition;

benthic plant, animal, and detrital biomass; benthic plant and animal production; plant pigment analyses; the species composition and biomass of drift; insect emergence; and routine chemical determinations of some 16 constituents plus trace metals.

These data will, of course, be collated and analyzed to meet our needs. In order to best utilize this information to check the applicability of the OSU models, however, the services of a biologist familiar with the intricacies of mathematical modeling and specifically with the OSU models would be required. If the proposal were funded, we would retain the services of a graduate student or postdoctoral worker early in 1973. At that time, we will have generated a total of one year's data in our amplified monitoring schedule; we also will have on hand seven years' additional data, a substantial portion of which will be applicable to testing the models. We would expect the person retained under this proposal to become intimately acquainted with our data and our conclusions and then to test the models against this information.

As part of the study of stream and lake systems in the Coniferous Forest Biome, Dr. Charles Warren and his associates have undertaken the analysis of trophic processes using density-dependent models. Data from several aquatic systems in the Biome are being used, since no one study has considered all of the details that should really be incorporated into these models.

In pursuing the aims of our experimental streams study, we have developed and will continue to develop a large body of information on the dynamics of our particular stream community. This information will include measurements of the biomass, growth rate, and production of entire trophic levels or of key species components of each of the trophic levels. The information we gather would provide a means of testing the models derived at Oregon State University (to see how generally true these graphical and logical models are). To the extent that our data and conclusions do not agree with these models, the results of the studies done under the proposal might suggest ways to modify the models so that they would accommodate our data.

The experimental stream systems we are studying were designed to be as natural as possible with the maximum amount of experimental control. Thus we feel that modeling studies of these streams will be of value in trying to learn more of natural systems. Further, we will have on hand a body of information that will include aspects not adequately covered in other studies. This is particularly true of the data we have on the feeding, growth, and production of the primary and secondary carnivores of the streams, the benthic invertebrates.

INFLUENCE OF PLANT DISEASE ON FUNCTIONAL ECOSYSTEMS OF WESTERN CONIFEROUS BIOMES: A PROBLEM ANALYSIS

Principal Investigator

Arthur D. Partridge, University of Idaho

Sponsoring Committee

Ecosystem Integration--Coordination Program

Relationship to Research Committee Program

Input is needed from ecosystem modeling efforts, biogeochemical studies on decomposition, and nutrient cycling processes.

Expected results will benefit the ecosystem modeling and biogeochemical process studies, the working group on fire influences, and the information bank.

OBJECTIVES

We will define and interpret the role of plant diseases on the function of ecosystems in western coniferous biomes in terms of ongoing Biome programs.

APPROACH

We recognize that much desired information concerning the role of disease in the Biome does not exist. Therefore, we intend to develop a problem analysis using existing information and retrieval systems (e.g., SOLAR, INTREDIS) to create an analog model of the disease-interaction systems of major forest types within the Biome. This will be a working, sequential program that will evolve, as information assembles, to more sophisticated symbolic models and to definitive problem analyses in the major forest types. In time, this may become a base for individual disease-plant interaction models.

In defining the initial analog model we intend to develop information classifications using the agencies and personnel of the Biome region and suggestions developed from existing intensive sites. We foresee possible classification by functions or portions of the Biome affected, causes of disease, form of impact on biological systems, and so on, but we intend to keep all classification flexible in accordance with total Biome programming goals.

First we will search information sources primarily for diseases affecting Biome vegetation. Diseases affecting animals, insects, and the like may be recorded for future compilations, but will not constitute an objective of search and will not be categorized. Initially, we will categorize each disease or disease-like condition as follows:

Group I: Disease: causal organism, substrate or host, affected part, nature of disease (systemic, local, etc.)

Group II: Effect on Biome: Plant succession, energy system, decomposition, etc.

Other classifications may originate as the model develops. Newly established parameters, needs, and inputs by all Biome participants will affect this phase of our work.

Next we will develop models of existing conditions as a means of implying how they affect Biome functions and to identify areas of research meeded to correlate our input with the overall Biome model as it develops. We propose no direct fieldwork for 1973 and 1974. By 1974, however, we expect that the models will begin to identify research needs. Through coordination with other Biome programs, priorities considering these needs may be set by the end of 1974.

COORDINATION OF THE CONIFEROUS FOREST BIOME AND LUBRECHT ECOSYSTEM PROJECT

Principal Investigator

Lawrence K. Forcier, University of Montana

Coinvestigator

Robert F. Wambach, University of Montana

Sponsoring Committee

Ecosystem Integration--Coordination Program

Relationship to Research Committee Program

Input is needed from Biome ecosystem modeling group, other coordination programs, validation and extrapolation of subsystem models by research committees, and environmental-plant indexes model (Waring).

Expected results: By December 31, 1973 and 1974, a report will be submitted to the Biome containing:

1. The progress made toward a summary of the existing data base available on the site including (a) type of data (temperature, precipitation, tree density, DBH, etc.); (b) format (field sheets, IBM cards, magnetic tape, etc.); (c) gaps in data (if any); (4) summaries (extent, accuracy); (d) statistical analyses (if any); (c) restriction of availability of unpublished data to Biome (if any).

2. Status of data not yet reported in (1); time schedule for completion (must be completed by December 31, 1974).

3. Details of ongoing work (progress reports) at the coordination area including (a) type of data available; (b) expected format; (c) expected summary or statistical analysis; (d) restrictions on availability to Biome (if any).lowers strike against the

OBJECTIVE

The objective is to facilitate communication of methods, results, and concepts issuing from the ecological research of the Coniferous Forest Biome and the Lubrecht Ecosystem Project.

APPROACH

The exchange of information between the two research groups would be achieved through reports and site visitations. The Lubrecht Ecosystem Project would produce semiannual reports designed specifically to inform researchers affiliated with the IBP. Those reports normally would be written in early November and early May, although the first report would be produced in January 1973. The fall report would summarize the methods, early results, and modeling efforts of the previous spring, summer, and fall. The spring report would summarize activities and events of the previous six months and would project the undertakings of the summer months. Both summary reports would emphasize areas of special interest to the Biome. In 1973 emphasis would be placed on the conceptual modeling efforts of the Lubrecht group. Preparation of the necessary report will require a significant effort by a research associate. It is therefore proposed that one-fourth of this individual's salary be supplied by the Biome. The necessary clerical and printing costs would be borne by the project.

Four site visitations are proposed for each of the two years considered in this proposal. Two leaders of the Lubrecht Project would make a major visit each year to the H. J. Andrews Experimental Forest. The purpose of this visit would be to present information on the Lubrecht Project to the Biome researchers. It would also be desirable to plan three additional visits annually to Coniferous Biome research areas. While these trips would be made by only one researcher, they would guarantee timely and full discussion of problems encountered and accomplishments achieved by researchers from both the high-precipitation areas studied by the Biome and the Lubrecht group.

The Lubrecht Ecosystem Project is a long-term effort designed to determine the safe limits of forest manipulation in the northern Rocky Mountain region and to provide needed ecological information on forest function, a necessary prerequisite to sound planning and management (see chart). Furthermore, there is a critical need to integrate this biological and physical information within the socioeconomic framework of the region. This integration can be achieved with a carefully designed, holistic forest management model. In order to develop a model of value to forest management decisionmaking, the project is necessarily interdisciplinary and multiphased. Although investigators from diverse disciplines will conduct the research, the common objective of each researcher and each study phase will be to ascertain the safe limits of forest manipulation in the northern Rockies.

Responsibilities Chart for the Lubrecht Ecosystem Project

Lubrecht Ecosystem Project (Forcier, Wambach)

- Section II. Watersheds
  - A Selection, surveying, fencing (Forcier, Steele, Eddleman)
  - B Manipulations (Wambach)
- Section III. Physical measurements
  - A Precipitation (Knudsen, Forcier)
  - B Runoff (Konizeski, Knudsen)
  - C Water chemistry (Forcier)
  - D Soil nutrients (Nimlos)
  - E Soil formation (Thompson)
  - F Erosion (Curry)
  - G Energy (Steele, Forcier)
- Section IV. Vegetative studies
  - A 1. Tree distribution (Forcier, Blake)
    - 2. Tree productivity (Forcier)
    - 3. Tree phenology (Faurot)
  - B 1. Shrub distribution (Eddleman, Pengally)
    - 2. Shrub productivity (Eddleman, Pengally)
    - 3. Shrub phenology (Eddleman, Pengally)
  - C 1. Herb distribution (Eddleman)
    - 2. Herb productivity (Eddleman)
    - 3. Herb phenology (Eddleman)
  - D 1. Litter production (Forcier, Knudsen)
    - 2. Litter breakdown (Faust
  - E Microorganisms (Faust)
- Section V. Animal studies
  - A Aquatic invertebrates (Sheldon)
  - B Terrestrial invertebrates (Lowe)
  - C Small mammals (Metzgar)
  - D Large mammals (Ream)
  - E Fish (Sheldon)
  - F Birds (Frissell)
- Section VI. Extensive studies — Team: Blake, Curry, Nimlos, Pengally
- Section VII. Modeling — Team: Wambach, Bryan, Faurot, Forcier, Loftsgaarten, Morris, Sheldon

AQUATIC COORDINATION BETWEEN THE CONIFEROUS FOREST BIOME AND THE INTERMOUNTAIN AREA STREAM-LAKE STUDIES

Principal Investigator

Arden R. Gaufin, University of Utah

Sponsoring Committee

Ecosystem Integration--Coordination Program

Relationship to Research Committee Programs

Input is needed from other ecosystem coordination programs, intensive site lake and stream studies, and ecosystem modeling groups.

Expected results will benefit lake and stream modeling efforts, hydrology, and information bank.

OBJECTIVES

1. Identify existing sets of data available at aquatic research stations outside the intensive study sites, and encourage and coordinate analysis of those data sets of value in extrapolation or in filling in process information gaps.

2. Encourage closer exchange of data and integration of stream-lake studies elsewhere in the Biome with intensive site studies.

3. Encourage collection of missing information needed to make data sets more useful in extrapolation.

4. Coordinate and extend stream studies for evaluation of role of allochthonous and autochthonous sources of nutrients for aquatic invertebrate production.

APPROACH

Coordination will be achieved through the Intermountain Aquatic Biome Consortium. (The Consortium presently represents more than 10 universities in the Coniferous Biome.) A committee consisting of aquatic scientists representing the Consortium will work with the intensive site aquatic committee chairmen to develop the studies.

The coordination program is being initiated in year 2. Information on facilities, programs, and available data at biological stations in the Biome east of the Cascade Mountains is presently being assembled by cochairman Gaufin. Areas of interest include Flathead, Bear, Jackson, Eagle, Utah, and Mead Lake watersheds, the Logan River and Temple Fork, and Flathead River. The committee will begin formulation of whichever sets of data have greatest potential in terms of validation of intensive site results on aquatic production and terrestrial-aquatic interaction. Work on allochthonous-autochthonous stream inputs will be coordinated.

During year 3 funds will be allocated through the Consortium for interchange, analysis, and modeling of chosen data sets and to encourage collection and analysis of missing data at sites where a useful background of data exists. Both stream and lake data sets will be considered, with preference to those sites with best general background of pertinent terrestrial data. Because of the recognized importance of allochthonous food sources in streams and the influence of terrestrial manipulations on type and quantity of allochthonous materials entering streams, cross-Biome study of fate and use of allochthonous materials will begin in year 3, with comparisons among Andrews Forest streams, Cedar River, and intermountain area streams. Data on Temple Fork and Flathead River are expected to be included.

COORDINATION OF THE CONIFEROUS FOREST BIOME AND THE NORTHERN WASATCH FOREST ECOSYSTEM STUDY

Principal Investigator

George E. Hart, Utah State University

Coinvestigator

Norbert V. DeByle, USDA Forest Service, Logan, Utah

Sponsoring Committee

Ecosystem Integration--Coordination Program

Relationship to Research Committee Programs

Input is needed from Biome ecosystem modeling group, other coordination programs, validation and extrapolation of subystem models by research committees, and environmental-plant indexes model (Waring).

Expected results: By December 31, 1973 and 1974, a report will be submitted to the Biome containing:

1. The progress made toward a summary of the existing data base available on the site including (a) type of data (temperature, precipitation, tree density, DBH, etc.); (b) format (field sheets, IBM cards, magnetic tape, etc.); (3) gaps in data (if any); (d) summaries (extent, accuracy); (e) statistical analyses (if any); (f) restriction of availability of unpublished data to Biome (if any).

2. Status of data not yet reported in (1); time schedule for completion (must be completed by December 31, 1974).

3. Details of ongoing work progress reports at the coordination area including (a) type of data available; (b) expected format; (c) expected summary or statistical analysis; (d) restrictions on availability to Biome (if any).

OBJECTIVE

The objective to facilitate communication of results, methods, and concepts issuing from the ecological research of the Coniferous Forest Biome and the Northern Wasatch Ecosystem Project.

APPROACH

Exchange of information between the two research groups will be achieved through reports and site visitations. Initial contacts will be made through travel to the intensive sites and by correspondence with research committee chairmen in the Biome. Particular emphasis would be directed toward the terrestrial pro ducer, aquatic, and hydrology committees. About three visits are anticipated for each of the two years under this proposal, with both the Andrews and Cedar River sites encompassed in the same trip. The purpose of these trips would be a mutual exchange of information on modeling progress, problems, and research direction on the Wasatch area and the intensive sites. This information exchange would specifically include developments in the Intermountain Station and in the Desert Biome at Utah State University.

A comprehensive summary of past and present ecological research within the Wasatch Mountain area will be made by a thorough search of published and unpublished research reports, data summaries often filed and forgotten, graduate theses, and ongoing research dealing with the forest ecosystem of the Wasatch Mountains. Both basic process studies and land management applications would be covered in anticipation of the ultimate need of the Coniferous Biome for manipulation or impact studies. A short abstract would be prepared for each study. We expect that several hundred individual studies would be unearthed, and thus we would allocate two full years for adequate appraisal and reporting on past and present research.

Complex interactions between man and the wild-land ecosystem are particularly evident in the Wasatch Mountain range in northern Utah. High-density urban areas lie at the foot of a 2740-m mountain range whose climate is characterized by heavy snowfall and dry, cool summers. A substantial research effort has been mounted for 30 years along ecological lines in wildlife, range, water, recreation, and forest biology by the Intermountain Station and Utah State University. In addition to these land uses, weather modification by cloud seeding is rapidly becoming an operational reality in this area. Much of the past and present research could complement and extend the modeling efforts of the Coniferous Biome on the intensive sites.

This proposal would improve communication between the research groups operating in the Wasatch Mountains (Intermountain Forest and Range Experiment Station, USDA Forest Service, and Utah State University) and the intensive sites of the Coniferous Biome. Information exchange would be facilitated by a research coordinator at Utah State who would identify local projects that could be used for extension of models developed at the intensive sites. The coordinator would, by travel and correspondence, become familiar with conceptual and applied aspects of model formulation with the validation in appropriate studies in the Wasatch Mountains. A principal responsibility of the coordinator would be to prepare a comprehensive summary of the historical research record, which would emphasize those studies with modeling potential.

The following chart shows the research functions and assignments of the two agencies doing research in the northern Wasatch Mountains. Considering the combined efforts of the Intermountain Forest and Range Experiment Station of the USDA Forest Service and the Ecology Center, Desert Biome, Agricultural Experiment Station and Water Resource Research Center of the Utah State University, the current commitment for general ecological research in the Wasatch area is conservatively estimated at $2 million per year. Cooperative units of the Bureau of Sport Fisheries, Utah Fish and Wildlife Department, USDA Forest Service, and Utah State add to this resource base.

Organization Chart of the Northern Wasatch Forest Ecosystem Project

Forestry Sciences Laboratory, Intermountain For. Range Exp. Stn. USDA Forest Service

- Watershed rehabilitation
  - Watershed rehabilitation (Packer)
  - Forest hydrology (Farmer)
  - Microclimatology, instrumentation (Richardson)
  - Plant water relations (Brown)
- Water yield improvement
  - Plant ecology, soils (DeByle)
  - Forest hydrology (Johnston)
  - Forest hydrology (Doty)
  - Tree physiology (aspen) (Schier)
- Mgt. & Ecology of mountain rangelands
  - Plant ecology, range mgt. (Laycock)
  - Plant physiology (McDonough)
  - Systems ecology, modeling (Bartos)
- Forest diseases
  - Tree and shrub pathology (Krebill)
  - Plant pathology (Nelson)

Aspen ecosystem program

College of Natural Resources and related departments, Utah State University

- Hydrologic models & processes
  - Hart (forest science)
  - Hawkins (forest science)
  - Coltharp (range science)
  - Riley (civil engineering)
  - Gifford (range science)
- Plant ecology
  - West (range science)
  - Daniels (forest science)
  - New position (forest science)
- Animal ecology
  - Low (BSFW)
  - Spillett (BSFW)
  - Wolfe (wildlife resources)
  - Wagner (wildlife resources)
- Systems ecology
  - Goodall (range science)
  - Bridges (wildlife resources)
- Aquatic ecology
  - Helm (wildlife resources)
  - Kramer (BSFW)
  - Koob (wildlife resources)

THE CONIFEROUS FOREST BIOME AND THE CEDAR-HEMLOCK ECOSYSTEM PROGRAM

Principal Investigator

Frederic D. Johnson, University of Idaho

Coinvestigator

Charles A. Wellner, USDA Forest Service, Moscow, Idaho

Sponsoring Committee

Ecosystem Integration--Coordination Program

Relationship to Research Committee Program

Input is needed from Biome ecosystem modeling group, other coordination programs, validation and extrapolation of subsystem models by research committees, and environmental-plant indexes model (Waring).

Expected results: By December 31, 1973 and 1974, a report will be submitted to the Biome containing:

1. The progress made toward a summary of the existing data base available on the site including (a) type of data (temperature, precipitation, tree density, DBH, etc.); (b) format (field sheets, IBM cards, magnetic tape, etc.); (c) gaps in data (if any); (d) summaries (extent, accuracy); (e) statistical analyses (if any); (f) restriction of availability of unpublished data to Biome (if any).

2. Status of data not yet reported in (1); time schedule for completion (must be completed by December 31, 1974).

3. Details of ongoing work progress reports at the coordination area including (a) type of data available; (b) expected format; (c) expected summary or statistical analysis;d) restrictions on availability to Biome (if any).

OBJECTIVE

The objective is to facilitate communication of methods, results, and concepts issuing from the ecological research of the Coniferous Forest Biome and the Cedar-Hemlock Ecosystem Program (a cooperative program between the Intermountain Forest and Range Experiment Station, USDA Forest Service, in Moscow, Idaho, and the University of Idaho and Washington State University).

APPROACH

The exchange of information between the two research groups will be achieved through reports, data, and site visitations. Selected personnel of the Cedar-Hemlock Ecosystem Program will travel to Seattle and Corvallis to attend Biome seminars and to consult with Biome personnel. Visits from Biome scientists will also be sought. Funding from the Biome will help in the finding and description of existing data from research in the Cedar-Hemlock Ecosystem Project that may prove useful in modeling in the Coniferous Biome. Literature and data abstracts will be prepared to conform to the format specified for the Biome information bank. Yearly written reports to the Biome will summarize progress.

DESCRIPTION OF COORDINATION RESEARCH

The western red cedar--western hemlock forest ecosystem of northern Idaho, northeastern Washington, and western Montana is biologically the most productive of all Rocky Mountain forests. It covers between 2 and 4 million hectares and is made up of rich mixtures of vegetation including many commercially important tree species. In addition to timber, it has many other values. Because of its mountains, streams, and lakes, it has outstanding esthetic, scenic, and recreational values. It is the source of much of the water in the Columbia River and is the home of many species of fish and wildlife. Wise management for its many values consistent with environmental quality is extremely important.

The Cedar-Hemlock Ecosystem Program will include research in classification of the ecosystem; studies of processes, nutrient cycling, hydrologic cycling, biomass and productivities of all trophic levels, water, esthetics, recreation, factors affecting productivities (fire, insects, diseases, climate, genetics), and productivities under alternatives of use. A large data base on the cedar-hemlock and associated forest types exists at the Priest River Experimental Forest of the USDA Forest Service, where studies were started in 1911.

This research will help develop an understanding of the genetic and ecologic makeup of the ecosystem, the driving forces and processes involved, and how these may be manipulated to produce the products and services needed by man consistent with a quality environment. This research will determine the basic potential of the ecosystem to produce timber products, wildlife, water, esthetics, and recreational opportunities, and how the cover can be cultured and manipulated to best express these productivities.

COMPONENTS AND POSSIBLE PARTICIPATION
CEDAR-HEMLOCK ECOSYSTEM PROGRAM*

Component	Forest Service INT	Forest Service R-1	Universities UI	Universities WSU	Universities Other	State of Idaho	USDI-BSFW	IBP Conif. Biome	IBP Insect Mgmt.	Indus.
Classification	X	X	+	+						
Inventory	X	X			+					
Processes										
Nutrient cycling	X	+	+	+				+		
Hydrologic cycling	X	+	+	+				+		
Other	X	+	+	+				+		
Productivities										
Biomass										
Timber products	X	X			+			+		+
Forage	X	X	+	+				+		
Wildlife		X	+	+		+	+			
Fisheries		X	+	+		+	+			
Water	X	X	+	+						
Esthetics		X	+	+						
Recreation		X	+	+						
Total	X	+	+	+				+		
Factors affecting productivities										
Fire	X	X						+		
Insects	X	X	+	+		+			+	+
Diseases	X	X	+	+		+		+		+
Climate	X	X								
Genetics	X	X	+							+
Culture	X	X	+	+	+			+		+
Synthesis systems	X	X	+	+	+			+		+
Alternatives of use	+	X	+	+						

*X = present organization, + = proposed additional organization, ◯ = participation already underway.

COORDINATION OF THE CONIFEROUS FOREST BIOME AND THE SOUTHWESTERN ECOSYSTEM PROJECTS NEAR FLAGSTAFF

Principal Investigator

Ernest A. Kurmes, Northern Arizona University

Coinvestigators

Harry Brown, USDA Forest Service, Flagstaff
Gilbert H. Schubert, USDA Forest Service, Flagstaff

Sponsoring Committee

Ecosystem Integration--Coordination Program

Relationship to Research Committee Program

Input is needed from Biome ecosystem modeling group, other coordination programs, validation and extrapolation of subsystem models by research committees, and environmental-plant indexes model (Waring).

Expected results: By December 31, 1973 and 1974, a report will be submitted to the Biome containing:

1. The progress made toward a summary of the existing data base available on the site including (a) type of data (temperature, precipitation, tree density, DBH, etc.); (b) format (field sheets, IBM cards, magnetic tape, etc.); (c) gaps in data (if any); (d) summaries (extent, accuracy; (e) statistical analyses (if any); (f) restriction of availability of unpublished data to Biome (if any).

2. Status of data not yet reported in (1); time schedule for completion (must be completed by December 31, 1974).

3. Details of ongoing work progress reports at the coordination area including (a) type of data available; (b) expected format; (c) expected summary or statistical analysis; (d) restrictions on availability to Biome (if any).

OBJECTIVE

The objective is to facilitate communication of methods, results, and concepts issuing from the ecological research of the Coniferous Forest Biome and the study areas listed.

APPROACH

The establishment of a coordination program at Flagstaff would promote cooperation between forest ecosystem researchers in the Southwest and those involved in research at the Coniferous Forest Biome intensive sites. The primary objective of funding in the coordination area in FY-1973 would be to allow a systematic compilation of existing pertinent data from the several sources listed above.

It is estimated that this would require the full time of two research assistants for three months. A second immediate objective would be for the project leaders to visit one or both of the intensive sites, to become more familiar with overall objectives and techniques of study of the Coniferous Forest Biome. The project leaders should also participate in any seminars or workshops held by the Biome research committees. This would lay the necessary foundation for continuing work in FY-1974. The work in 1974 might include collection of specific data needed, or validation or extrapolation of submodels developed by that time.

Flagstaff, Arizona, has been a center of research and data collection on the southwestern coniferous forest since 1908, when the USDA Forest Service established the Fort Valley Experiment Station approximately 16 km northwest of town. Its activities, although concentrated on ponderosa pine, include work in the mixed conifers of higher elevation. The Rocky Mountain Forest and Range Experiment Station moved its local offices to a new building on the Northern Arizona University campus in 1963.

Northern Arizona University, through its biology department, and, since 1959, through the School of Forestry also carries out research in forest ecology. The Museum of Northern Arizona, a privately endowed organization established in 1926, does some biological work, and acts as the coordinator for the Colorado Plateau Environmental Advisory Council. In this capacity, the museum serves as a clearinghouse for reports on environmental research in the region.

The USDA Forest Service Beaver Creek Pilot Watershed, established in 1957, occupies 111,375 ha approximately 64 km south of Flagstaff. Climatologic, hydrologic, and vegetative data have been collected on both ponderosa pine and pinyon-juniper areas on the watershed in rather fine detail. A staff of 11 resident scientists is continuing to test and evaluate the possible consequences of various resource management practices. Some of this work has been done in cooperation with Northern Arizona University, the University of Arizona, the Museum of Northern Arizona, and Colorado State University. The project staff is well along in the development of computer simulation models, other analytical procedures, and guides for use in identifying the various products of an area resulting from alternative management practices as well as estimating the costs, benefits, and environmental effects of each alternative practice. The Beaver Creek studies should prove particularly useful to the Coniferous Biome study.

Beaver Creek Watershed Evaluation Project Organizational Chart*

Beaver Creek Project (Brown) †

- **Section II. Watersheds**
  - A Selection (Brown, Baker)
  - B Manipulations (Brown, Baker, Clary, Larson, Avery)
- **Section III. Physical measurements**
  - A Precipitation (Brown, Baker, Avery)
  - B Runoff (Brown, Champagne, Baker)
  - C Water chemistry (Johnson--UA)
  - D Soil nutrients (Klemmedson--UA)
  - E Soil formation (Hendrix--UA)
  - F Soil physical properties (Campbell)
  - G Sedimentation (Brown, Baker, Champagne, Simons--CSU)
  - H Erosion (Avery)
  - I Energy (Avery)
- **Section IV. Vegetative studies**
  - A 1. Tree distribution (Larson)
    - 2. Tree productivity (Larson)
    - 3. Tree phenology (Larson)
  - B 1. Shrub distribution (Clary)
    - 2. Shrub productivity (Clary)
    - 3. Shrub phenology (Clary)
  - C 1. Herb distribution (Clary)
    - 2. Herb productivity (Clary)
    - 3. Herb phenology (Clary)
  - D 1. Litter production (Clary, Klemmedson--UA)
    - 2. Litter breakdown (Klemmedson--UA)
- **Section V. Animal studies**
  - A Terrestrial invertebrates (Young--Mus. North. Ariz.)
  - B Small mammals (game) (Patton, Ffolliott--UA)
  - C Small mammals (nongame) (Hungerford--UA, Bateman--NAU)
  - D Large mammals (game) (Neff--AGFD, Reynolds)
  - E Large mammals (carnivors) (Turkowski)
  - F Large mammals (livestock) (Clary)
  - G Birds (Balda--NAU, Reynolds)
- **Section VI. Role of fire**
  - To be assigned 1972
- **Section VII. Social studies**
  - A Economic studies (O'Connell)
  - B Aesthetics (Daniel--UA)
  - C Recreation (King--UA)

Fort Valley Experimental Forest Organization Chart

Section II. Management units
- A Selection (Schubert, Jones)
- B Manipulation (Schubert, Jones)
- C Land-use planning (Schubert, Jones, Malin)

Section III. Physical Measurements
- A Precipitation (Heidmann, Jones, Rietveld, Trujillo)
- B Temperature (Heidmann, Jones, Rietveld, Trujillo)
- C Wind (Trujillo)
- D Soil-water relations (Heidmann, Jones Rietveld)
- E Soil freezing (Heidmann)

Section IV. Vegetative studies
- A Tree distribution (Schubert, Jones, Malin)
- B Tree growth (Schubert, Heidmann, Jones, Rietveld)
- C Tree phenology (Schubert, Jones, Rietveld)
- D Tree improvement (Schubert, Pitcher--R3)
- E Vegetative competition (Schubert, Heidmann, Jones, Rietveld)
- F Litter decomposition products (Rietveld)
- G Cone production (Schubert, Rietveld)
- H Frost-heaving (Heidmann)
- I Habitat classification (Schubert, Jones Malin, Berry--NAU)
- J Stand density--wood quality (Schubert, Voorhies--NAU, O'Keefe--NAU)

Section V. Animal studies
- A Small animals (Patten
- B Tree-animal relations (Schubert, Heidmann)
- C Birds (Balda--NAU)

Section VI. Physiological studies
- A Plant-moisture stress (Jones, Rietveld)
- B Phytotoxins (Rietveld)
- C Root regeneration (Schubert, Rietveld)

Section VII. Plant disease studies
- A Dwarf mistletoe (Lightle)
- B Silvicultural control (Heidmann)

Section VIII. Prediction modeling
- A Forest yields (Myers--project 1301)
- B Management models (Myers--project 1301)

Section IX. Extensive studies Team: Schubert, Heidmann, Jones, Rietveld

Beaver Creek Watershed Evaluation Project Organizational Chart (continued)

- Section VIII. Extensive studies (off Beaver Creek)
  - A Subwatershed studies on sedimentary soils (Thames--UA)
  - B Wildlife (Reynolds)
  - C Mapping systems (Turner)
- Section IX. Modeling studies
  - A Ecosystem models (systems analyst to be assigned 1972)
    Physical and biological submodels (Baker, Larson, Clary, Avery)
  - B Management models (O'Connell, Boster, Turner, Gieske)

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*Attachment to "A proposal to establish a Coniferous Forest Biome (IBP) Coordinating Site at Flagstaff" by NAU School of Forestry, 2/72. Participating USDA Forest Service scientists are listed without affiliation; affiliations are shown for cooperating scientists. Study areas of major emphasis are underlined.

†Work unit title: National multiple use evaluation of watershed practices.

Northern Arizona University Faculty Involved in Studies Pertinent to the Coniferous Forest Biome IBP

School of Forestry:

T. Eugene Avery	Forest measurements and photogrammetry
Richard W. Berry	Forest ecology
E. Lee Fitzhugh	Wildlife
Ernest A. Kurmes	Forest ecology
L. Dudley Love	Range and watershed
Charles O. Minor	Forest measurements
Timothy G. OKeefe	Tree growth
A. Jay Schultz	Forest soils
William P. Thompson	Forest economics
Glenn Voorhies	Tree growth
Donald E. Wommack	Tree improvement

College of Arts and Sciences, Department of Biology:

Russell Balda	Ornithology
William Gaud	Ecology
C. Daniel Johnson	Entomology
Oliver W. Johnson	Herpetology
Terry A. Vaughan	Mammalogy

COORDINATION OF THE CONIFEROUS FOREST BIOME AND THE LITTLE SOUTH PARK, CACHE LA POUDRE RIVER WATERSHED STUDY

Principal Investigator

Edwin W. Mogren, Colorado State University

Coinvestigator

James R. Meiman, Colorado State University

Sponsoring Committee

Ecosystem Integration--Coordination Program

Relationship to Research Committee Program

Input is needed from Biome ecosystem modeling group, other coordination programs, validation and extrapolation of subsystem models by research committees, and environmental-plant indexes model (Waring).

Expected results: By December 31, 1973 and 1974, a report will be submitted to the Biome containing:

1. The progress made toward a summary of the existing data base available on the site including (a) type of data (temperature, precipitation, tree density, DBH, etc.); (b) format (field sheets, IBM cards magnetic tape, etc.); (c) gaps in data (if any); (d) summaries (extent, accuracy); (e) statistical analyses (if any); (f) restriction of availability of unpublished data to Biome (if any).

2. Status of data not yet reported in (1); time schedule for completion (must be completed by December 31, 1974).

3. Details of ongoing work progress reports at the coordination area including (a) type of data available; (b) expected format; (c) expected summary or statistical analysis; (d) restrictions on availability to Biome (if any).

OBJECTIVE

Our objective is to facilitate communication of methods, results, and concepts issuing from the ecological research of the Coniferous Forest Biome and the Little South Fork Watershed Study (Little South Fork of the Cache La Poudre River Watershed Study, Colorado State University).

APPROACH

The exchange of ideas and information between scientists in the two programs would take place through periodic written reports and site visitations. Reports of the work done by the Little South Fork program scientists that would be of interest to the Biome researchers would require additional effort on the part of the research associate and a portion of this person's salary will be paid by the Biome.

In addition to the reports several researchers from the Little South Fork program will periodically visit the intensive sites to gain a better understanding of the Biome program and exchange information of mutual interest.

Ultimately, it is anticipated that the research on the Little South Fork can be integrated into the Biome program as the eastern extension of the Coniferous Forest Biome. In addition, through a better understanding of the Biome program, the local researchers could more satisfactorily undertake validation and extrapolation studies when these efforts become a part of the Biome program.

The Little South Fork research program is a continuing, multidisciplinary study of the forest-oriented resources of the Front Range of the Rocky Mountains in Colorado. Over the past 10 years more than 40 resource studies have been completed in the 25,900-ha Little South Fork watershed. Many of these studies have common objectives with the Coniferous Forest Biome effort.

Research has been conducted within the watershed over the past ten years in the following areas: (1) fisheries biology, (2) hydrologic properties of soils, (3) watershed modeling, (4) forest canopy geometry, (5) soil-site relationships for forest trees, (6) snow hydrology, (7) forest tree growth, (8) fire ecology, (9) genetic characteristics of forest trees (10) range-soil relationships, (11) water quality, (12) recreation, (13) wildlife-plant coaction, and (14) climatology. The potential for expanded research within the watershed is outstanding. Its size, elevational differences, diversity of vegetation, climatic gradients, streams and lakes, and general excellent accessibility recommends the Little South Fork as an exceptional coordination area within the Coniferous Forest Biome project. Located within the watershed at 2700 m elevation is the Pingree Park Campus of Colorado State University. This field campus serves as a biological station, a forestry summer camp, a field ecology and natural resources training center, and a natural resources and ecology research center. Facilities include field season housing for 180 students with attendant maintenance facilities, two classroom buildings, a dry laboratory, 11 faculty cabins, and a wet laboratory--dormitory--research building designed and equipped for year-round use.

Presently, the College of Forestry and Natural Resources is reviewing the overall research program. The purpose of the effort is to bring the substantial amount of information into a form that can be modeled and put into a unified framework useful in resource management and as a guide for future research. The present funding of the program is $327,000 annually.

Organization of the Little South Fork Watershed Project

Watershed

Water yields; Meiman, Striffler, Dils
Water, Energy Balance; Meiman
Precipitation; Striffler
Soil Composition and Nutrients; Reid

Physical Measurements

Meteorology; Teller, Striffler
Remote Sensing; Miller

Vegetative Studies

Genetics; Fechner
Plant Water Relations; Mogren
Water stress; Mogren, Barney, Reid
Mycorrhizal Structures; Reid
Phenology; Fechner
Primary Production; Mogren

Insects and Disease

Disease; Crews
Insects; Reid, Fechner, Wygant

Modeling

Landscape model; Miller
Environmental quality; Dyer
Multiple use; Shirley, Terwilliger
Environmental Data System; Whaley
Ecosystem modeling; Jamison

Animal Studies

Large mammals; Steinhoff, Nagy, Gilbert
Small mammals; Steinhoff, Hein

Recreational Use; Alden

COORDINATION OF THE CONIFEROUS FOREST BIOME AND THE SAN JUAN ECOLOGY PROJECT

Principal Investigator

Harold W. Steinhoff, Colorado State University

Sponsoring Committee

Ecosystem Integration--Coordination Program

Relationship to Research Committee Program

Input is needed from Biome ecosystem modeling group, other coordination programs, validation and extrapolation of subsystem models by research committees, and environmental-plant indexes model (Waring).

Expected results: By December 31, 1973 and 1974, a report will be submitted to the Biome containing:

1. The progress made toward a summary of the existing data base available on the site including (a) type of data (temperature, precipitation, tree density, DBH, etc.); (b) format (field sheets, IBM cards, magnetic tape, etc.); (c) gaps in data (if any); (d) summaries (extent, accuracy); (e) statistical analyses (if any); (f) restriction of availability of unpublished data to Biome (if any).

2. Status of data not yet reported in (1); time schedule for completion (must be completed by December 31, 1974).

3. Details of ongoing work progress reports at the coordination area including (a) type of data available; (b) expected format; (c) expected summary or statistical analysis; (d) restrictions on availability to Biome (if any).

OBJECTIVE

Our objective is to facilitate communication of methods, results, and concepts issuing from the ecological research of the Coniferous Forest Biome and the San Juan Ecology Project of Colorado State University.

APPROACH

Liaison will consist of an interchange of information and ideas. Six San Juan Ecology Project leaders will visit one or more of the Coniferous Forest Biome sites in Washington and Oregon in 1973. Four Biome project leaders will visit the San Juan study area. Then visits will be made again in 1974, but the proportion by each research group and the project leaders involved will depend on needs that become evident in the 1973 visits. This is a most important aspect of the liaison. The first-hand acquaintance of scientists in the two research groups, each on the field study area of the other, will lead to fruitful generation of ideas simultaneously by everyone involved in a visit. Techniques and methods of expression of data will be improved and made more comparable.

Reports will be systematically exchanged between the two groups. The San Juan Ecology Project will provide its annual technical report each November to the project leaders designated by the Coniferous Forest Biome. This is a very comprehensive and expensive report, and the extra copies will require financing through this proposal. Quarterly reports of the San Juan Ecology Project will be provided to each Coniferous Forest Biome project leader who wishes them.

A composite mailing list will be maintained for both projects, containing information on the project activity of each project leader. This will facilitate correspondence between individual members of the two projects, and this type of communication will be encouraged.

The availability of other information such as publications, motion pictures, and videotapes will be announced to the composite mailing list with each mailing of the quarterly reports on about 1 January, 1 April, 1 July, 1 October 1973 and 1974.

The forest ecosystems team leader will assume responsibility for maintaining an overview of this liaison effort. He will serve as a source of local information on the Coniferous Forest Biome for project leaders of the San Juan Ecology Project, and for other ecologists in Colorado. His effort will be supported as a part of the liaison project funding.

In October 1970 the USDI Bureau of Reclamation initiated the Colorado River Basin Pilot Project (designated "Project Skywater"), a winter cloud-seeding program to increase snowfall in the San Juan Mountains of southwestern Colorado. One-half of the seedable storms, or one of every four winter storms, are randomly selected for seeding during the period 1 October to 1 May each year from 1970 to 1974. A 16% increase in snowfall is expected in the 3370 km^2 target area in the eastern half of the San Juan Mountains southwest of the Continental Divide above 2900 m elevation.

Colorado State University, the University of Colorado, and Fort Lewis College have formed a consortium known as the San Juan Ecology Project ". . . to study the ecologic effects of artificially increased snowfall on the ecologically related resources in the San Juan Mountains which are of economic and/or of public interest to man."

Forest ecosystems research includes tree and herbaceous plant phenology, phytoscciology, tree biomass, tree moisture stress, and studies of mammals. Tundra ecosystems research includes plant ecology, geomorphology, and animal ecology. Project-wide coordination concerns the ecological overview, dendro - chronology.

The projects have been under way since 1 September 1970. Each has completed a full field season. The group has developed into a coordinated team, with each individual project leader pursuing the objectives of his own project and modeling the processes involved, but with complete awareness of the other projects and reliance on them for components of his own study.

The attached chart shows the organization of the San Juan Ecology Project. Current funding is a four-year, $881,000 contract with the USDI Bureau of Reclamation. Projects currently funded are those listed above.

Organizational Structure of the San Juan Ecology Project

- Steering committee
  - Project coordinator (Teller)
    - General administration (Teller)
    - Systems analysis (Smith)
    - Alpine tundra ecosystem & paleoecology (Ives)
      - Palynology (Nichols) — 2
      - Tundra plants (Webber & Bock) — 4
      - Dendrochronology (Glock) — 6
      - Toads (Campbell) — 12
      - Tundra animals (Bock) — 17
      - Historical climatology (Barry) — 18
      - Avalanches (Alford) — 21
      - Tundra geomorphology (Caine) — 22
      - Photomapping (Ives & Andrews) — 23
      - Air photography (General Services)
    - Forest and aquatic ecosystems (Steinhoff)
      - Herb. phytosoc. (Johnson & Wasser) — 1
      - Tree phytosociology (Dix) — 3
      - Phenology (Owen & Fechner) — 5
      - Herb. productivity (Wasser) — 7
      - Moisture stress (Reid) — 8
      - Tree biomass (Mogren) — 9
      - Spruce beetles (Wygant) — 10
      - Frogs (Spencer) — 11
      - Birds (Ryder) — 13
      - Beaver (Hein) — 14
      - Elk (Steinhoff) — 15
      - Small mammals (Steinhoff & Spencer) — 16
      - Microclimate (Striffler) — 19
      - Silver (Teller & Mayeax) — 20
      - Aquatic (Everhart, Behnke, Erickson, Pennak) — 24, 25, 26
      - Downstream (Schumm) — 27
    - Field supervision & logistics (Owen)
  - Advisory group

Project Number

5.2.9. Services--Technical committees

CONIFEROUS FOREST BIOME INFORMATION CENTER

Principal Investigator

B. Bare, University of Washington

Coinvestigator

S. Overton

Sponsoring Committee

Services--Technical Committees

Relationship to Research Committee Program

Input is needed from all investigators in the form of standard reference and data abstracts.

Expected results will benefit modeling efforts and statistical analysis.

OBJECTIVES

The objectives of the Coniferous Forest Biome information center are (1) to create and maintain an information bank, (2) to provide computer programming assistance to investigators, and (3) to coordinate data processing activities within the Biome.

APPROACH

As the scope of activities within the Biome expands during 1973-1974 the need for a centralized data depository and information center becomes increasingly important. Scientists within the Biome must be afforded services that provide them with a means to store, retrieve, and otherwise manipulate bibliographic as well as numeric information. Not only will access to Biome-wide information keep scientists well informed of ongoing research and publications within the Biome, it will also greatly encourage communication between investigators. This problem of communication and coordination is particularly acute in a program of integrated research.

Presently, the information center employs one full-time programmer, a part-time key-punch operator, and a part-time administrator. The tempo of activities has increased considerably during the past calendar year, with our efforts being almost equally divided between the development of an information storage and retrieval system and the provision of data processing assistance to scientists within the Biome. We have developed several segments of an information storage-retrieval system for bibliographic information (i.e., abstracts), and we currently are investigating systems for doing the same for numeric data. We have also begun to assemble and store masses of data provided by scientists within and without the Biome. Last, we have provided service to the Biome director's office in the form of a computerized mailing list system.

In order to fulfill the goals and objectives as outlined above, the Biome information center plans to undertake the following activities during calendar year 1973. We anticipate the continued handling of two basic types of information. The first is bibliographic information, which may take on one of the three following forms: (1) abstracts of data sets; (2) abstracts of progress reports, Biome publications, or any other articles written as a result of participation in the IBP; and (3) abstracts of articles and publications being assembled as parts of selected bibliographies for different investigators within the Biome.

Our first priority item will be to finish development of a remote job entry information storage and retrieval system that will allow investigators to search a large bibliographic data base to locate desired references or source documents. This system will use the generalized bibliographic format as developed by the inter-Biome information storage and retrieval committee as implemented at the Oak Ridge National Laboratory. We currently use this format to prepare abstracts of data sets and publications, which we then submit to the Environmental Information System at Oak Ridge. We will continue to submit abstracts to Oak Ridge, but in addition (as outlined above) we propose to develop our own on-line information storage and retrieval system. This will allow investigators to search their own bibliographic data bases for pertinent literature citations.

In addition to the proposal for handling bibliographic literature information, we also propose to provide a storage and retrieval system for numeric data. This system will allow for the orderly storage of large data sets, but it will lack the efficient searching and cross-referencing features that are such an important aspect of the bibliographic storage and retrieval system. The system to be used for storing and retrieving numeric information will be a slightly modified version of a system developed by the Grasslands Biome at Colorado State University.

The major support items this project relies on are the resources of the Univeristy of Washington's Computer Center. Since being chosen as the data exchange center for the Coniferous Forest Biome in 1970 we have devoted our efforts to the development of systems that operate on the Control Data Corporation 6400. While the configuration of our 6400 is one of the smallest in the world, we generally have not been constrained by the lack of computer resources. One area that has impeded our progress, however, has been the lack of facilities for handling time-sharing applications. We now anticipate that modifications in the operating system for the 6400 will allow us to implement time-sharing versions of our bibliographic search program by the first quarter of 1973. This upgrading in the 6400 operating system as well as the addition of new hardware will enable us to provide the type of literature search service that our investigators are demanding. In addition, this will allow us to link up with our remote intensive study sites much more effectively.

We are requesting that a half-time research assistant be employed in 1973 to aid the development of our information storage and retrieval system. The addition of this person will complement the work being undertaken by our programmer, in that it will allow us to research more thoroughly the nature of information storage and retrieval systems, the effectiveness and efficiency of various systems, and the interfacing of our information systems with available statistical analysis packages. In addition, this assistant will relieve the load on our programmer by aiding in the preparation of abstracts and by participating in general preparation of information for entry into our system.

With the development of the above described information storage and retrieval systems, and with the modest incrase in our manpower resources, we will be able to provide a much needed service to investigators within the Biome. Not only will this allow investigators to be more efficient, it will also facilitate communication between investigators within the Biome. Last, it will enable us to satisfy the objectives established for the project.

WASHINGTON INTENSIVE SITE, CEDAR RIVER--LAKE WASHINGTON DRAINAGE BASIN

Principal Investigator

Dale W. Cole, University of Washington

Sponsoring Committee

Services--Technical Committees

Relationship to Research Committee Program

OBJECTIVES

1. Provide field facilities for research participants at the Washington intensive site. These new facilities include boat access, storage, and docking at Chester Morse Lake; trails and buildings at Findley Lake; and facility improvements at the Thompson site.

2. Provide a technical supporting staff and necessary equipment for the year-round collection of data.

3. Provide meteorological stations at the intensive study areas.

4. Provide travel to the field research areas for the program participants.

5. Develop and maintain a central chemical laboratory available to all Biome personnel.

6. Coordinate all local meetings, visitations, information exchange, and fiscal aspects of the Biome program in Washington.

APPROACH

To help in the administration of the Washington site, an associate site director was hired during year 2. It is the responsibility of the associate director to develop the facilities at the field sites and coordinate the activities of the personnel working at these field stations. In addition, the associate director is responsible for the day-to-day liaison with the personnel of the City of Seattle Water Department. Part-time and hourly personnel are being requested to help in the facility and maintenance program.

During year 2 the first phase of developing a central chemical analysis laboratory was initiated. Additional funds are requested to complete the development of these facilities and to provide a full-time technician to oversee their proper use and maintenance. Technician funds are also requested to install and maintain the meteorological stations.

With current funds most of the facilities have been completed at the Thompson site. This includes the placement of underground power, water, and communications lines to the tree-weighing lysimeter, as well as construction of a conference building that has sanitary, sleeping, and cooking facilities. Funds are requested to maintain these facilities, together with those that will be constructed during the current summer at Findley Lake.

The initial construction on the boat-launch and laboratory facilities at Chester Morse Lake will be started this current summer. Funds are requested to complete this facility and to purchase additional boats for the sampling program.

Funds are also requested to help supply the central office and provide secretarial services for the administrative and research personnel of the program.

CENTRAL OFFICE MANAGEMENT

Principal Investigator

S. P. Gessel, University of Washington

Coinvestigator

J. F. Franklin, USDA Forest Service

Sponsoring Committee

Services

Relationship to Research Committee Program

Input is needed from the Biome directors, and from the various technical committees and study sites.

Expected results will benefit the communication between Biome participants, coordination of research activities, budget accounting, and publication needs.

OBJECTIVES

1. Provide services in administration, accounting, and publication.

2. Assist with the coordination and work of research and technical committees, and study sites.

3. Facilitate the intra-Biome communication among participants, such as conferences, workshops, and visiting scientists.

4. Assist with inter-Biome conferences and workshops.

APPROACH

Personnel and Facilities

The central office, located in Bloedel Hall, University of Washington campus, provides essential services and coordination for the Biome. A branch office in the School of Forestry Building, Oregon State University, coordinates the H. J. Andrews site programs in close cooperation with the central office. The Cedar River--Lake Washington site coordination office shares space and facilities with the central office, as do the information bank services and process modeling management working groups.

Principal administrative costs for the Biome are contributed by the institutions involved in the Biome research, namely, the University of Washington, Oregon State University, and the USDA Forest Service, through time of the director and deputy directors. Office space and all necessary services such as light and heat are provided by the University of Washington as part of the general overhead. Included in this is office and laboratory space for many individual researchers and technicians. In addition, Oregon State University provides office space for the site director.

In order to carry on the day-to-day activities of the Biome operation, Dr. Hans Riekerk functions as an office administrator and executive secretary. In his position Dr. Riekerk also holds the title of Research Assistant Professor on the staff of the College of Forest Resources. He is responsible for efficient operation of the office, and oversees communications, publications, services and coordination. He has an office staff consisting of an administrative assistant, a typist, and a part-time editor. The above are all Biome employees.

All grant contract negotiations and records are handled by the grant and contract office of the University of Washington as part of the overhead financing. In addition the Biome office keeps close accounts on all research expenditure at the University and does all requisition processing, employment, and similar routine. We employ a bookkeeper who works in the College of Forest Resources accounting office on Biome business.

Travel

Travel must be considered from several points of view related to the total management and research progress of the Biome. First, there is the need for the Biome administrative staff to travel to all parts of the Biome to confer with researchers and plan the orderly development of Biome activity. There is also the need for the Biome director or his representative to travel to inter-Biome and international meetings. These meetings may be for either administrative or research purposes. Second, the importance and role of intra-Biome meetings by research, technical, or administrative committees, including conferences and workshops, has been clearly demonstrated and must be expanded. Coniferous Biome philosophy is to insist that each researcher and each research group be aware of research throughout the Biome and the role of their activity with respect to the total model. Therefore workshops and conferences will continue to be a mainstay of Biome operation and must be provided for. The Biome office will plan these and therefore the fund request for the total Biome is included in the central office budget.

Communications

The widespread geographic area over which the Biome operates makes adequate communication of vital importance. The regular circulation of newsletters, both of general interest and covering particular specialized needs; the frequent use of long-distance telephone communication; and, above all, the organization of meetings of people working in different parts of the Biome in the same field of specialization are all required. Carefully planned meetings of a limited group of specialists (workshops) will make possible the exchange of ideas and information about techniques in a far more effective way than any other mechanism.

Essential program services include the provision of technical assistance or consulation on special problems of wide significance to the integrated research effort, such as data analysis, processing taxonomy, environmental monitoring, and chemical analysis. It is expected that program services offered through the office of the Biome director will promote liaison between investigators at major study sites.

Program services will be provided in several ways. Special and technical committees (such as committees on chemical analysis, data processing, and biometrics) are established and funded so that they can meet as needed. Special capabilities and expertise that develop at various sites will be made available to the Biome by an effective communication net and special consultantships.

Editorial Services

As the work develops, considerable volumes of reports and other documentation will be produced, and much of the editorial work involved should be taken off the shoulders of investigators. It is proposed to expand the duties of the half-time editor to encompass these requirements. This additional service, together with the editorial and production services contributed by Oregon State University, should ease the burden on Biome investigators of publishing or otherwise circulating their findings.

Laboratory Services

Central organization is desirable for certain analytical procedures where expersive equipment is required, where there are economic savings possible from large-scale operation or automation, or where uniformity and consistency call for it. There are in existence in institutions within the Biome a number of laboratories with excellent capabilities that are not fully used. As far as possible, arrangements will be made to use such facilities for routine determinations for the whole Biome, wherever centralization would be advantageous. If facilities are required that cannot be provided in this way a central unit will be set up for the purpose under the Biome director.

Taxonomic Services

For many groups of organisms in the Biome region taxonomic studies have been in progress for many years, collections and expert advice are available in most institutions, and difficulties in identification are unlikely to arise. There are, however, certain groups that are less well known and for which the expertise is more difficult to obtain. It is not proposed to set up facilities for identification at the central Biome office, but to concentrate the tasks of identification at institutions where these difficult groups have been under study for a considerable time and where valuable taxonomic collections have been built up.

Workshops

Conferences and workshops will continue to be a necessary major activity in the Biome. In the course of developing the year-3 proposal, each research committee expressed a need and desire to hold one or more specific workships or technical conferences, usually to bring all participating research workers up to the same level of competence or to explore methodology in specific fields. The workshop requests all have been combined into one organizing activity of the central office in order to provide the necessary related services.

Visiting Scientists

Because of concentration of research work at the intensive sites there is a need to bring scientists from other institutions to participate in various research programs. These will be researchers who have specific capabilities in certain critical areas of research or who will be acting as principal investigators at coordination areas in subsequent years. In the latter case these scientists will become familiar with research techniques and modeling procedures so that specific validation studies can be carried out at the appropriate coordination area.

OREGON INTENSIVE SITE, H. J. ANDREWS EXPERIMENTAL FOREST

Principal Investigator

R. H. Waring, Oregon State University

Sponsoring Committee

Services--Technical Committees

Relationship to Research Committee Program

Coordination of all work on the intensive site

OBJECTIVES

1. Provide physical facilities for housing participants at the Oregon Instensive site.

2. Provide a technical supporting staff and necessary equipment for the year-round collection of data.

3. Facilitate laboratory analyses, computer access, and publications procedures of the Biome at Oregon State University where possible.

4. Coordinate all workshops, visitations, information exchange, and fiscal aspects of the Biome program in Oregon.

APPROACH

At the H. J. Andrews Experimental Forest two technicians are in residence. An additional man is needed to aid in sampling soil moisture regimes at the instrumented watersheds. For coordination and compatability with the USDA Forest Service program, a neutron probe and scaler is requested. The new technician will also have responsibility for collecting litter and precipitation samples at the various reference stands.

Methods developed by Denison in sampling epiphytes are adaptable for nondestructive biomass measurements. For this reason, funds are requested to contract with tree climbers to conduct all sampling planned in the crowns of old-growth trees.

In addition to thermograph and moisture stress measurements in each reference stand, a climatological station serves as a base reference. As future studies will be more intensive at higher elevations, an additional station will be required in 1974. Data are summarized and distributed to all participants.

The major channels of communication are through publications, a high-speed computer terminal, telephone conferences, and direct exchange. The site director's office provides support for such communication in Oregon.

The supporting staff in Corvallis consists of a secretary, a laboratory technician responsible for all water chemistry analysis, an accountant (funded from overhead), and student help in analyzing hydrological and climatological data and for meeting demands for short-term integrated field studies.

6. DETAILED RESEARCH SITE DESCRIPTIONS

6.1. H. J. Andrews Experimental Forest

The H. J. Andrews Experimental Forest occupies the entire 6075-ha drainage basin of Lookout Creek, a tributary of the McKenzie River, in the central western Cascade Range of Oregon. The experimental forest is located about 64 km east of Eugene, within the Willamette National Forest. It is about 8 km from Blue River, the forest headquarters and location of existing field laboratory and living facilities. As mentioned earlier, its selection as a study site is based on: (1) typical representation of coniferous forest stands and environment (both virgin and manipulated); (2) long history of research, especially on water and mineral cycling in unit watersheds, and classification, development, and structure of plant communities; (3) presence of eight smaller, gaged, unit watersheds consisting of two sets of three and one of two watersheds (Figure 6.1); (4) complete control of the experimental area by a public research agency; and (5) proximity to major universities with interested staffs.

In addition to the actual experimental forest, the adjacent upper Blue River watershed, Wildcat Mountain and Ollalie Ridge Research Natural Areas, and recently completed Blue River Reservoir offer additional study sites. Oak Creek and Berry Creek, discussed later, are linked with the Andrews Forest in an integrated series of proposals to study the aquatic component and aquatic-terrestrial links in coniferous forest ecosystems.

6.1.1. Administration

The H. J. Andrews Experimental Forest is administered by the USDA Forest Service for research purposes. Human influences in the area are controlled by the USDA Forest Service Pacific Northwest Forest and Range Experiment Station to accomplish given research objectives. Activities can be directed as requested or necessitated by the IBP, provided they do not conflict with the research program of the experiment station. Forest Service administration assures necessary continuity and control. As a part of the Willamette National Forest road maintenance, timber harvest, fire control, and similar routine activities are carried out for the Andrews Forest by the Blue River Ranger District.

6.1.2. Resources

Environment. The H. J. Andrews Experimental Forest occupies a mountainous tract with topography, geology, soils, and climate typical of the western slopes of the Cascade Range. Lookout Creek is a headwaters drainage (Figure 6.1) within the western Cascades province. Narrow bottomlands occur along the lower part of the Lookout Creek. Topography is geologically mature with a well-devloped drainage system and sharp ridges. The upper end of the drainage has more gentle undulating topography, probably resulting partially from alpine glaciation.

The geology of the area has been described by Peck (1964). Detailed stratigraphic work is currently being done at the University or Oregon and mineralogic work at Oregon State University. Two major formations are the Sardine and Cascade Andesite Series. All rock formations are of volcanic origin, with tuffs, breccias, and basalts predominating in lower elevations and Cascade andesites on the ridges.

A report of the recent soil survey and soil maps for the entire experimental forest are available. Detailed maps of soils and characterization studies of soil types have been conducted on the smaller unit watersheds. The major soil groups are reddish-brown lateritics and brown podzolics. Deep colluvial soils are common at lower elevations, and soils from volcanic ash are common on high ridges.

The climate of the Experimental Forest is maritime. Precipitation records are collected at two recording and 10 standard storage gages and on two snow courses. The average annual precipitation since 1952 is 239 cm, about 90% of which falls from October through April. Evapotranspiration averages near 53 cm annually. Extreme temperatures are rare. At lower elevations snow seldom accumulates in all-winter snowpacks. Above 914 m in elevation snowpacks may exceed 1 to 1.25 m. Temperature and relative humidity records have been collected since 1957, and long-term climatic records are available from the nearby NOAA National Weather Service station at McKenzie Bridge (No. 5362).

Lookout Creek, the adjacent 2835-ha Blue River watershed, and eight smaller unit watersheds (within the Andrews Forest)ranging from 1 to 10 ha are gaged (Figure 6.2). The two larger watersheds have been studied since the inception of the U.S. Army Engineers' Willamette Snow Laboratory in 1947. Gaging of the earliest set of the tributary unit watersheds began in 1950 and 1952. Annual streamflow averages about 65% of the precipitation and follows the same seasonal pattern of high flows in winter months and base flow during the summer. Peak winter flows may be 1000 times greater than low summer flows. Except during extreme floods, water is of excellent clarity and general quality. Details of streamflow and water quality in three of the unit watersheds are outlined in Rothacher et al. (1967) and Rothacher (1965). Groundwater information is available only for the adjacent Willamette Basin Snow Laboratory study area.

Biota. There are three major vegetative (life) zones based on climax forest types: (1) the *Tsuga heterophylla* zone, (2) the *Abies amabilis* zone, and (3) the *Tsuga mertensiana* zone. These are roughly comparable to Merriam's humid transition, Canadian, and Hudsonian life zones.

Tsuga heterophylla zone: Elevation of this zone is from lowest part of Lookout Creek (411 m) to about 1067 m. Major cover type is *Pseudotsuga menziesii* with varying mixtures of western hemlock (*Tsuga heterophylla*) and western red cedar (*Thuja plicata*). The major age class is 350 to 450 years old, but there are considerable areas 125 to 175 years in age. Approximately 20% of this zone has been clearcut in small blocks that range in age from 0 to 16 years. Several large blocks (2876 ha) are completely virgin forest.

A full change of habitat and community types typical of the zone are present--from very dry with Douglas-fir the predicted climax (*Pseudotsuga/Corylus cornuta* association) to riparian herb and fern-rich communities with hemlock and cedar the climax (*Tsuga-Thuja/Polystichum-Oxalis*)association. Other important associations are *Tsuga Acer circinatum-Gaultheria shallon*, *Tsuga/Rhododendron macrophyllum-Gaultheria*, and *Tsuga/Coptis laciniata*. Small components of sugar pine (*Pinus lambertiana*), incense cedar (*Libocedrus decurrens*), red alder (*Alnus rubra*). Bigleaf maple (*Acer macrophyllum*), and grand fir (*Abies grandis*) are present but are confined primarily to specific habitats.

Abies amabilis zone: The elevation of this zone is 1067 to 1524 km. The major cover type is a mixed-conifer stand of Pacific silver fir (*Abies amabilis*), noble fir (*Abies procera*), Douglas-fir, western hemlock, and western white pine (*Pinus monticola*). Age classes are the same as in the *Tsuga heterophylla* zone. Cutover areas range from 0 to 14 years old. Several large blocks are completely virgin forest.

The range of habitat and community types typical of the zone are present from the dry *Abies amabilis/Xerophyllum tenax* association on lithosols to the very wet *Abies amabilis/Opopanax horridum*. Other important communities include *A. amabilis/Vacinium ovalifolium* and *A. amabilis/Achlys triphylla*, several seasonal ponds that support semiaquatic biota, and extensive areas of *Acer circinatum/talus* and *Alnus sinuata*/snowslide communities, which are widespread and important northwestern nonforest communities.

Tsuga mertensiana zone: This is an intermittently represented zone on the high ridges and peaks at 1524 to 1615 m (highest point in the watershed). Major species are mountain hemlock (*Tsuga mertensiana*), Pacific silver fir, noble fir, Alaska cedar (*Chamaecyparis nootkatensis*), and subalpine fir (*Abies lasiocarpa*). There are innumerable rock outcrop habitats and subalpine meadow areas. The most important forest association is the *Tsuga mertensiana/Xerophyllum tenax* association.

The main streams and tributaries within the Andrews Forest support a native fishery of cutthroat and rainbow trout and sculpin. Columbia black-tailed deer and black bear commonly occur within the drainage. Some beaver, coyote, bobcat, and an occasional cougar have been seen, and a small herd of elk is sometimes present on the forest. The small-mammal and ground-feeding bird populations have been the subject of extensive research over a 10-year period (see, e.g., Gashwiler 1959 and 1965).

History. Most of the experimental forest was originally covered by 450-year-old virgin coniferous forests. Prior to establishment of effective fire control programs, wildfires burned portions of the watershed resulting in the younger timber stands of approximately 60, 125, and 250 years of age.

Before 1948 the experimental forest had no roads or other developments except for a few ridgetop trails to fire lookouts on the two highest points. Beginning in 1950, about 1% of the area has been cut each year as a part of the experiment station's research program. There are now about 64 km of roads, giving good access to the entire area and 1215 ha of clearcuts of various sizes from 0.04 to 10 ha, 0 to 18 years of age. All aspects and slopes are represented. Most of these clearcuts have been broadcast burned to reduce fire hazard and planted or seeded with tree seedlings.

6.1.3. Past and current research

Hydrologic cycle and water quality. A major part of the past and current research consists of studies of streamflow and water quality and the effect of various manipulations on these items. This has necessarily involved studies of general climate, interception, stemflow, soil moisture storage and depletion, etc., as well as monitoring of streamflow, suspended sediment, bed load, dissolved chemical load, and water color and temperature. Many of these basic data have been published (see bibliography section 6.1.6).

A keystone in the research program has been a series of gaged unit (tributary) watersheds, which will doubtless also be the focus of much of the IBP research. Manipulation was begun on the oldest set of watersheds (1, 2, and 3) in 1959 after a 6-year calibration period (Figure 6.2). (One of each set is, of course, a control watershed to be maintained indefinitely in an unmodified condition.) At the present time, all of watershed 1 and one-third of watershed 3 have been logged and burned for several years. The other two sets of watersheds are nearing the end of the calibration period and are presently planned for manipulation in 1972.

Abiotic. Much of the abiotic research on the H. J. Andrews Forest has been discussed or alluded to in the discussion of hydrologic research. It includes the collection of standard climatic data, characterization of the physical and chemical features of the major soil types, research on bedrock and soil mineralogy and their relations, and effects of different vegetation types on soil moisture depletion.

One study recently begun focuses on nutrient cycling in old-growth Douglas-fir forest and the effect of logging and burning on nutrient losses. Although numerous data on water chemistry and nutrient losses have been collected during other studies, they were inadequate. Consequently, this study was initiated, and uses continuous sampling devices that sample on the basis of volume flow, and two new watersheds (9 and 10), and involves comprehensive data collection on prelogging nutrient states.

Terrestrial producers. Most of the original terrestrial research program at the Andrews Forest involved development of timber management techniques, i.e., methods for the harvest and reforestation of old-growth Douglas-fir stands. During this period the standard forestry-type inventory and yield data were collected for the experimental forest, which provides data on production rates and biomass oriented toward commercial wood volume yield. Extensive autecological data on the reproductive habits of the major conifers were developed at the same time. Successional studies of plant communities were initiated about 1952 and provide a long record of vegetational population histories.

During the last decade work has concentrated on detailed successional plot studies on unit watersheds 1 and 3, including pretreatment investigation, and on comprehensive studies of the plant communities found on the experimental forest and their structure and relation to major environmental factors. Permanent, well-documented plots are a part of the successional study. A total of 300 vegetation-soil plots have been established as a part of the community studies and phenological and environmental data are now being collected from a sample of these. A floristic survey of the experimental forest has been completed and a checklist of vascular plants is being prepared for publication.

Aquatic biota. Although many physical features of free-flowing streams have been studied, research on the aquatic biota have been limited. Studies have been conducted on the effect of logging on a small tributary stream supporting native trout (e.g., effect on food supply) and on movement and reproductive habits of the native cutthroat trout.

6.1.4. Physical facilities at the H. J. Andrews Experimental Forest

There is a small field laboratory at Blue River (8 km from H. J. Andrews Experimental Forest) equipped primarily for preparation and preliminary analysis of soil, water, and plant samples. Facilities at the laboratory include electricity, hot and cold water, vacuum, ovens, balances, calculators, hood, glassware, soil samples, cameras, *p*H meters, and so on. Field installations include 12 recording, standard, and storage rain gages; two snow courses; a standard climatic station; 10 streamflow installations with continuous water temperature recorders, plus maximum-minimum thermometers; Kipp and Zonen radiometer for measurement of solar radiation; and numerous permanent sample plots with long-term records. Good roads provide access to all areas by car. Bus transportation is available to Blue River. Motels are available in the Blue River--McKenzie Bridge area along the McKenzie River (8-16 km and a five-man trailer facility is available for research personnel.

6.1.5. Active research projects

Most of the research projects presently active at the Andrews Forest are financed by the USDA Forest Service, whose scientists devote collectively about four to five man-years of professional time and about two man-years of technician time to the research program there. The present level of Forest Service research funding is about \$100,000 per year. Major research projects presently active (not including proposals pending funding by IBP and other sources) are shown in Table 6.1.

Table 6.1. Major research projects at the H. J. Andrews Experimental Forest.

Principal Scientist	Agency*	Study
Fredriksen	USDAFS	Nutrient cycling of a small watershed
Paeth	OSU	Mineralogy of soils derived from western Cascades tuffs and breccias
Kays	UO	Mineralogy of major volcanic rock types
Fredriksen	USDAFS	Soil moisture relationships during reestablishment of Douglas-fir forest
Dyrness	USDAFS	Physical, chemical, and hydrologic characteristics of indigenous soils
Dyrness	USDAFS	Disturbance of soil by logging
Fredriksen	USDAFS	Douglas-fir soil moisture use
Dyrness	USDAFS	Identification and characterization of major community and habitat types
Dyrness	USDAFS	Plant succession following logging and burning
Franklin	USDAFS	Vascular flora of H. J. Andrews Forest
Hermann	USDAFS	Productivity indexes in high-elevation conifer forests (stem analysis)
Zobel	OSU	Distribution and productivity of plant communities in relation to environment
Rothacher	USDAFS	Streamflow and water temperature
Rothacher	USDAFS	Effect of harvest in old-growth forests on streamflow and stream sedimentation

Table 6.1. Major research projects at the H. J. Andrews Experimental Forest (continued).

Principal Scientist	Agency*	Study
Fredriksen	USDAFS	Effect of logging on chemical quality of water
Rothacher	USDAFS	Changes in stream characteristics following shelterwood logging
Turrant	USDAFS	Additions of DDT to ecosystems in rainfall
Gashwiler	USDI-BSFW	Fluctuations in small-mammal populations
Gashwiler	USDI-BSFW	Feeding habits of small mammals and ground-feeding birds

*USDAFS = USDA Forest Service, OSU = Oregon State University, UO - University of Oregon, USDI-BSFW = USDI Bureau of Sport Fisheries and Wildlife.

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6.2. The Cedar River--Lake Washington Drainage System

The Lake Washington drainage basin includes the Lake Sammamish--Sammamish Slough branch, which primarily drains industrial, agricultural, and urban areas, and the Cedar River--Morse Lake branch, which drains the Cedar River watershed. These two branches converge at Lake Washington and drain through the ship canal into Puget Sound (Figure 6.3). These two drainage systems are very different in both physiography and the patterns of land use (Figure 6.4).

The Sammamish Valley drainage system is a relatively low-elevation watershed and is heavily subjected to the pressures of urbanization and agricultural practice. Although direct pollution of this water system has been restricted, the area still receives a very high input of nutrients through secondary sources.

In contrast to the Sammamish Valley, Cedar River watershed originates in the Cascade Mountains, primarily from forest ecosystems. This drainage includes several small lakes above the 1067-m elevation, a large reservoir system (Chester Morse Lake) at the 474-m elevation, and the Cedar River. All of the watershed above 183 m elevation is part of the municipal water supply of the City of Seattle. The forests of this watershed have been systematically harvested and reestablished during the past 60 years, providing a wide range of forest ages and types.

The Cedar River, with its relatively low nutrient composition, enters Lake Washington at its southernmost point, while Sammamish Slough, with its high nutrient load, enters on the north. The effect of these drainage systems on the quality of the lake has been discussed by Sylvester (1952) and Edmondson (1968).

A range of aquatic systems is found within the Lake Washington drainage including the following:

1. Lake Washington, the lowermost lake (89,519 ha, 64 m deep, 4.3 m elevation), has a documented history of eutrophication and is now in a rapid state of change, since municipal wastes only recently have been diverted from the lake. Fish populations are again of particular interest. The long-documented history of fish stocking permits an evaluation of its impact on total productivity.

2. Chester Morse Lake (680.7 ha, 35.4 m deep, 474 m in elevation) is the uppermost of the two large lakes in the Cedar River watershed. Although the lake level was slightly raised in 1902, the lake in other respects is the least disturbed major lake in the state. Access to the lake has been rigidly controlled since 1911 and no fish have been planted or harvested since that time.

3. Findley Lake, one of several small lakes in the drainage system, is located in a totally unmanipulated watershed of approximately 162 ha (see Figure 6.3). It is proposed to use the Findley Lake watershed in an integrated terrestrial-aquatic interface study in the second phase. The Findley Lake watershed is a small unit of the Cedar River drainage and is located at about 1128 m elevation. The watershed contains two small lakes with a total water area of 10.5 ha. The land area includes 155.4 ha of undisturbed mature fir-hemlock forest. The lake has no resident fish population but zooplankton are present in moderate abundance.

4. Studies of streams within the watershed can provide simultaneous measurements of inputs to the lakes and terrestrial-aquatic interrelationships. For example, the Rex River basin contains one of the major contributors to Chester Morse Lake (Rex River Creek, minimum flow 426 m sec^{-1}.. This basin was last logged at the lower levels in 1935 and is scheduled to be relogged during the next five years. Simultaneous study should be made of the terrestrial, stream, and lake responses to this manipulation.

5. Lake Sammamish (1981.7 ha, 30.5 m deep, 8.5 m elevation) represents an intermediate stage in lake evolution as it was oligotrophic until very recently and is now expected to undergo eutrophication as the surrounding forest is replaced by an increasingly urban community.

6.2.1. Administration

The Lake Washington drainage basin falls under a wide range of ownershipand administrative structures. The Municipality of Metropolitan Seattle (METRO) surveys and regulates the biology and chemistry of Lake Washington. The principal tributary, the Cedar River watershed, is administered by the City of Seattle Water Department. Both METRO and the Seattle Water Department are committed to the objectives of this Biome proposal. A letter of understanding between the city and the Biome director on the use of the Cedar River was included in the initial proposal.

6.2.2. History

The hydrological history of the Cedar River watershed has been documented since 1895. The City of Seattle Water Department has preserved this history in its annual reports and in a book, "The Seattle Water Department History 1854 to 1954," by Mary McWilliams (1958). The City of Seattle Water Department, in cooperation with other government agencies, maintains complete water quality and quantity records. Weekly measurements of bacteriological content are taken at 21 fixed points at Chester Morse Lake, and the Cedar River and it tributaries. Continuous monitoring of water temperature occurs at Chester Morse Lake. Water turbidity of the Cedar River is measured both at Landsburg and at Barnston, about 9.7 km upstream from Landsburg. A radiological station also exists at Landsburg. Measurements at Landsburg are checked manually every two hours. A complete chemical analysis of the Cedar River is routinely performed on water samples taken at station 12-1190 near Renton. In the Lake Sammamish watershed, water quality is monitored near the mouth of Issaquah Creek. Temperature data of the Sammamish River are collected near Woodinville. Seven stations in the Lake Washington drainage provide continuous records of river level fluctuations. The location of these stations are described in the year-1 proposal.

6.2.3. Environment

Precipitation within the Lake Washington drainage basin ranges from 89 cm annually at Seattle to 264 cm at Chester Morse Lake. Greater precipitation can be expected at higher elevations in the Cedar River watershed because of orographic effects. Seventeen permanent precipitation gages are scattered throughout the Cedar River watershed at various elevations with measurements made on a monthly basis. Continuous measurements of precipitation and air temperature are also made by the City of Seattle at its forestry headquarters at Cedar Falls. Air temperature is also recorded at Chester Morse Lake and at Landsburg. The forestry division of the City of Seattle Water Department maintains four mobile meteorological stations near logging areas from May to September. Precipitation, wind speed, air temperature, and humidity data are collected daily at these stations. Similar data are collected at a lookout tower on the watershed.

The Lake Washington drainage was heavily glaciated during the Vashon Stade of the Fraser Glaciation. The Puget lobe of the ice sheet flowed southeast across the Lake Washington basin covering most of the land area to an elevation of approximately 823 m. When the ice receded, various forms of glacial deposition occurred including glacial lake sediments near Issaquah, outwash deposits, and glacial till. These deposits constitute the primary soil parent material in the basin. Bedrock consists of consolidated sediments and volcanics of Tertiary age, with scattered bodies of igneous intrusives. Extensive research has been done on the bedrock geology and Pleistocene geology of the Lake Washington basin. Publications describing this research are found in various geological journals and theses at the University of Washington (see year-1 proposal).

The soils of the drainage basin are primarily brown-podzolic soils at lower elevations and podzols at higher elevations. The USDA Soil Conservation Service has mapped the soils of much of the basin. The information is published as the King County Soil Survey. A detailed soils map of the Findley Lake watershed was completed during this past summer.

6.2.4. Resources

One of the strong attributes of the Lake Washington basin as a study area is its location. The University of Washington campus is adjacent to Lake Washington and the ship canal through which this basin drains into Puget Sound. This facilitates the aquatic phase of the study. Most of the research area can be reached within two hours from Seattle. The research facilities at the Thompson research site were developed prior to IBP participation. They include a storage building, a research building, and a relatively complete data recording system. An AC power line was brought to the site in 1967 by the University of Washington and the City of Seattle.

During the first year of the Coniferous Biome program facilities at the Thompson site were improved in several ways: (1) A well was drilled and plumbed to the research building. (2) Sanitary facilities were installed. (3) A second study area was established approximately 762 m from the previously existing area, which required the construction of a new road and installation of an AC power line and a water line.

The facilities at the Findley Lake site are in the initial stages of development. A trail system to the lake (approximately 2.4 km) has been developed and tents have been erected for temporary overnight accomodations during construction of a permanent building.

Prior to the IBP numerous research projects in both limnology and terrestrial biology were conducted within this drainage basin. During the past year, under IBP sponsorship and coordination, many of these projects have been focused on the Biome objectives. The substance and diversity of these programs is outlined in the following discussion.

6.2.5. Terrestrial studies in the Cedar River research area

Intensive research on basic mechanisms of mineral cycling within a second-growth Douglas-fir ecosystem was initiated in 1961. It was first necessary to construct the field facilities, design specialized instrumentation, and develop systems of data acquisition, completion, and analysis. Many of the basic pathways and transfer functions among major components of this system have been defined. An initial accumulation and production model also has been developed (Dice 1970). An annotated listing of publications from this research area by subject area is available from the site director's office.

During Biome year 2 the terrestrial studies have continued to emphasize production processes and mechanisms of elemental transport. Current and projected research also includes detailed examination of net assimilation, energy balance, water budget, and dimensional analysis.

6.2.6. Aquatic studies in the Lake Washington basin

Historically, the aquatic system of the Lake Washington drainage basin has received extensive attention. A bibliography has been completed, along with a checklist of the fishes in the basin. Complete limnological surveys were conducted in the early 1920s and 1930s. These earliest studies, in fact, included measures of the fish production potential of the system. Throughout the 1950s, attention in the Lake Washington system was directed toward understanding the intricate relationship between primary and secondary production. From these studies the rapid tendency toward eutrophication became apparent, a result of sewage discharges; W. T. Edmondson was instrumental in calling attention to the problem. In the mid-1960s a sewage collection system that circumscribed Lake Washington was constructed to combat this problem. Subsequent limnological studies have documented impreovements in lake conditions and produced extensive information on phosphate-nitrate budgets and primary and secondary estimates, including zooplankton and bottom fauna.

Lake Sammamish, a tributary to Lake Washington, is undergoing eutrophication similar to that in Lake Washington a decade ago. Some significant nutrient inputs have been recently diverted from the lake; however, because of rural location, a trend toward eutrophication is expected to continue. Limnological and bacteriological studies have been conducted on this system in more recent years.

Both lakes are vital as nursery and migration areas for extensive salmonoid and other resident fish populations. Washington State fisheries management agencies and an experimental unit at the University have fish hatcheries that plant millions of migrant salmon. These migrate through the lakes, enter the ocean for a few years, and return as adult salmon to be harvested or to spawn. Within the Lake Washington system the salmon may travel up to 56 km to their point of origin.

In addition to the managed fish populations, there is an extensive native salmonoid population that uses tributary streams and the lake for spawning, rearing, and finally migration seaward. Sockeye salmon populations have increased greatly and are using all available spawning territory, possibly saturating the rearing area. From 907 to 2268 metric tons of sockeye are expected to return from the sea this summer, providing a tremendous amount of nutrient input (or objectionable pollution) when they die after spawning. Significant populations of resident fish are also present. Some play a significant role as predators and some an herbivorous role. Several provide a sport fishery.

Extensive fishery research on salmonoid behavioral and homing, spawning success, fry survival, selective breeding, and feeding patterns has been done in the system. More recently, esitmates of juvenile sockeye salmon populationshave been made with acoustic techniques involving echo integration. Population estimates of littoral species are also being made. Life history studiesof a majority of the fish in the system are under way or have been completed.

Before the IBP study was started, limnological or biological surveys had not been made of the upper Lake Washington system, including Chester Morse Lake, Cedar River, and the upper tributaries including Findley Lake. The area has had controlled access (since 1911), precluding fish management and harvest. The Chester Morse Lake fish population should be at a stable state and should provide an interesting contrast to the eutrophic lower lake system.

Because of the extensive wealth of background and continuing research on the Lake Sammamish and Lake Washington systems, the primary production measures hopefully can be supplemented by additional research at the decomposer and secondary levels, as well as at the tertiary consumer level.

6.2.7. Interface program

One of the most important objectives of the Coniferous Biome is to study the boundary conditions between the terrestrial and aquatic systems. An interface program examining the role of a terrestrial ecosystem on a freshwater body has been initiated at Findley Lake. This program is only in its very beginning stages and ecosystem components are still being defined. It is planned to concentrate many of our first efforts in analyzing this interface within the Findley Lake basin. Advantage will be taken of the Fern Lake studies and descriptive models in developing this program.

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6.3. Coordination Programs

6.3.1. Berkeley, California

Physical processes within the mixed conifer forest of California. Blodgett Forest Research Station, University of California. Photosynthesis process model extrapolation.

The study will be carried out in the Blodgett Forest Research Station of the University of California at an elevation of 1300 m in the Sierra Nevada near Georgetown, El Dorado County. The climate of the area is characterized as having wet winters and dry summers. Annual precipitation is between 125 and 210 cm with almost no rain occurring between April and October. This range of conditions from winter snows to summer droughts is ideally suited for the evaluation of differential species responses in photosynthesis processes. The major conifers in this area include a mixture of Douglas-fir, ponderosa pine, white fir, incense cedar, and sugar pine. This intimate mixture of tree species naturally growing on the same site permits direct comparisons of processes on trees with diverse ecological characteristics.

The proposed study is a logical extension of current research in California on gas exchange in conifers. Considerable experience has been obtained in technique and methodology (Helms 1964, 1965, 1970, unpublished MSS). The major equipment and facilities required for the proposed study are therefore available at a well-established forest research station used for interdisciplinary research.

Comparisons will be made between physiological processes in the species studied from both diurnal and seasonal standpoints. Process rates will be related to concurrent measures of environmental conditions, foliar water stress (Waring and Cleary 1967), and stomatal aperture (Fry and Walker 1967). When integrated, these measures will permit the characterization of physiological processes under a wide range of natural environmental conditions.

Quantitative descriptions of the interrelation between process rates and environment for species with divergent ecological character will be the final stage of the project. Past experience in quantitative analysis has paved theway for the development of stochastic models tp predict productivity from process rates. Recent contributions to model building include those of Idso 1968, Ledig 1969, and Botkin (1969). Assistance in developing models to describe system dynamics will be sought from participants within the Biome and all data will be made available for Biome analysis.

6.3.2. Flagstaff, Arizona

Coordination of the Coniferous Forest Biome and the southwestern ecosystem projects near Flagstaff. Northern Arizona University and Rocky Mountain Forestry and Range Experiment Station USDA Forest Service. Ecosystem studies coordination.

Flagstaff, Arizona, has been a center of research and data collection on the southwestern coniferous forest since 1908, when the USDA Forest Service established the Fort Valley Experiment Station approximately 16 km northwest of town. Its activities, although concentrated on ponderosa pine, include work in the mixed conifers of higher elevation. The Rocky Mountain Forest and Range

Experiment Station moved its local offices to a new building on the Northern Arizona University campus in 1963.

Northern Arizona University, through its biology department and, since 1959, through the School of Forestry, also carries out research in forest ecology.

The Museum of Northern Arizona, a privately endowed organization established in 1926, does some biological work, and acts as the coordinator for the Colorado Plateau Environmental Advisory Council. In this capacity, the museum serves as a clearinghouse for reports on environmental research in the region.

The USDA Forest Service Beaver Creek Pilot Watershed, established in 1957, occupies 111,375 ha approximately 64 km south of Flagstaff. Climatologic, hydrologic, and vegetative data have been collected on both ponderosa pine and pinyon-juniper areas on the watershed in rather fine detail. A staff of 11 resident scientists is continuing to test and evaluate the possible consequences of various resource management practices. Some of this work has been done in cooperation with Northern Arizona University, the University of Arizona, the Museum of Northern Arizona, and Colorado State University. The project staff is well along in the development of computer simulation models, other analytical procedures, and guides for use in identifying the various products of an area resulting from alternative management practices, as well as estimating the costs, benefits, and environmental effects of each alternative practice. The Beaver Creek studies should prove particularly useful to the Coniferous Biome study.

6.3.3. Fort Collins, Colorado

Coordination of the Coniferous Forest Biome and the Little South Fork, Cache la Poudre River watershed study. Colorado State University and USDA Forest Service. Ecosystem studies coordination.

The location of Colorado's coordination program within the International Biological Program/Coniferous Forest Biome is in the Front Range of the Rocky Mountains in north central Colorado. The Front Range represents an eastern extention of the Coniferous Forest Biome at this latitude. The area is characterized by abrupt elevational differences and steep climatic gradients. The soils of the area are generally shallow and immature. Elevation ranges from 1524 m to over 4267 m. Precipitation varies from 36 to over 76 cm with changes in elevation. Vegetational variation is pronounced with aspect and elevation and is represented by mountain shrub--juniper communities at the extreme lower elevations to the tundra community at the upper elevations. Within this range four distinct ecological life zones occur.

The specific study location within the Front Range is the watershed of the Little South Fork of the Cache la Poudre River. This watershed encompasses an area of 26,417.9 ha and includes elevational differences of 1829 to 3658 m. The watershed lies within the Roosevelt National Forest. Research over the past seven years has been conducted on the area under a cooperative agreement between the USDA Forest Service and Colorado State University.

Research has been conducted within the watershed over the past 10 years in the following areas: (1) fisheries biology, (2) hydrologic properties of soils, (3) watershed modeling, (4) forest canopy geometry, (5) soil-site relationships for forest trees, (6) snow hydrology, (7) forest tree growth, (8) fire ecology, (9) genetic characteristics of forest trees, (10) range-soil relationships, (11) water quality, (12) recreation, (13) wildlife-plant coaction, and (14) climatology. The potential for expanded research within the watershed is outstanding. Its size, elevational differences, diversity of vegetation, climatic gradients, streams and lakes, and general excellent accessibility recommends the Little South Fork as an exceptional coordination area within the Coniferous Forest Biome project. Located within the watershed at 2743 m elevation is the Pingree Park campus of Colorado State University. This field campus serves as a biological station, a forestry summer camp, a field ecology and natural resources training center, and a natural resources and ecology research center. Facilities include field-season housing for 180 students with attendant maintenance facilities, two classroom buildings, a dry laboratory, 11 faculty cabins, and a wet laboratory--dormitory research building designed and equipped for year-round use.

The faculty of the university both in the biological and physical sciences express keen interest in the ecosystem analysis program. The limiting factor in a research program in the Little South Fork area would not be research personnel.

Laboratory facilities at the Pingree Park campus and on the Ft. Collins campus would be available to the program. The first in a series of radiotelemetry stations for automatic recording of climatological data is presently being installed within the Little South Fork watershed. The second station is anticipated in the near future.

In addition to the cooperative agreement with the Roosevelt National Forest for use of the watershed of the Little South Fork, scientists of the Rocky Mountain Forest and Range Experiment Station are also available as consultants and participants in the program.

6.3.4. Fort Collins, Colorado

Coordination of the Coniferous Forest Biome and the San Juan Ecology Project. Colorado State University, University of Colorado and Fort Lewis College. Ecosystem studies coordination.

The target area, as originally defined by the U.S. Bureau of Reclamation, comprises an area of about 8800 km above the 2900-m contour, to the north and northeast of Durango. On its southern aspect, the topography consists of a series of parallel ridges and rivers running generally in a south-to-southwesterly direction. These include (from east to west) the upper portions of the San Juan, Piedra, Los Pinos, Florida, and Animas Rivers. On the western part of the area, the headwaters of the Mancos, Dolores, and San Miguel Rivers flow in a generally westerly and northwesterly direction, while the headwaters of the Uncompaghre and the Gunnison Rivers drain the northern sector.

The San Juan ranges possess a number of desirable climatic characteristicsfor winter weather modification. Their orientation to the prevailing southwesterly airflow provides excellent opportunity for maximum snow increases by cloud seeding. The area has relatively high average cloud temperatures and the terrain causes rapid lifting of air masses, which results in strong vertical motions.

The winter snowpack results from a high proportion of low-intensity storms, with daily averages under 1.3 cm on 80% of all snowfall days. Further details of precipitation variations can be found in the recent publication by Grant et al. (1969).

Topography is generally steep and rugged with elevations up to nearly 4800 m on the divide. More gently rolling alpine meadows are not uncommon between 3300 and 3800 m. In the central and northern part of the target area the mountains consist almost entirely of lavas and volcanic tuffs, with sedimentary formations dipping away from the central massif to the north, south, and west. The area has been subjected to at least three glacial episodes, interspersed with periods of uplift and heavy erosion. Landslides are common in the north-central part of the area (Fenneman 1939).

Vegetation is typical of the southern Rocky Mountains, with ponderosa pine at the lower elevations (2700 m), grading into Douglas-fir, aspen, spruce, and sub-alpine fir with increase in altitude. About one quarter of the area lies above the timber line. Range grasses are primarily Thurber's fescue and meadow sedges. Wildlife abounds, and includes elk, bighorn sheep, deer, beaver, and other small mammals, and a variety of birds.

The area from about 2400 m elevation, at the lower edge of significant cloud seeding effects, to timber line at between 3500 and 3600 m is a cline of decreasing precipitation. The result is a marked decrease in resistive stress with increase in elevation, which results in a rapid and sometimes abrupt change in vegetative type. This is a zone of high snow accumulation, particularly in the subalpine portion where snow may be blown from the alpine tundra. The resultant moisture in the spring, however, may be very transitory because of rapid snowmelt and runoff.

Physiography is not quite so variable in the subalpine forest ecosystems as it is in the alpine tundra. Erosion is not nearly so active, partly because of smaller average gradients and better developed root systems, which hold the soil in place. It is well known that forests markedly decrease siltation in streams and smooth minor flood peaks, although they may not affect the major floods, which are sometimes related to rapid runoff during snowmelt or to periods of high precipitation. Physiography does have some effect on vegetative type through exposure, with resultant shading, cooler temperatures, and less moisture stress on north-facing slopes. This effect becomes less important at higher elevations.

Producer communities occur in a mosaic-like pattern as distinct unit, stratal or transitional synusia, and associations somewhat in the following ascending elevational order above 2740 m in the San Juan weather modification area:

Community	Dominant(s)
Oak woodland	*Quercus gambelii*
Montane forest	*Pinus ponderosa*, *Abies concolor*, *Pseudotsuga menziesii*, *Populus tremuloides*
(Subalpine) parklands	*Populus tremuloides*, *Festuca thurberi*, *Poa pratensis*
(Subalpine) meadows	*Carex* spp., *Salis* spp., *Deschampsia caespitosa*
Subalpine forest	*Picea engelmannii*, *Abies lasiocarpa*

The elevational cline of physical factor complexes contributes to the above general altitudinal arrangement of producers. In any one elevational zone, however, the biotic and land-use influences add to the diversity of community pattern. Thus, through a broad central elevational zone, all but the lowest community may be modified by slope-exposure, geology, soil, biotic and/or land use influences. In fact, a variety of successional (seral) communities are to be found within the matrix of any one major cover type.

Current studies to gain a before-treatment perspective of the phytosociology and ordination of the grassland and meadow communities indicate that within these major communities cover, density, dominance, composition, and frequency are rather variable. Although stratified sampling will remove some of the variability, replication of sample stations to determine primary or biomass production will be essential, area by area. Measures of biomass production were not sampled and are here inferred from density and frequency, which have some degree of association to production.

Local records indicate that the chief communities in terms of areal extent are spruce-fir alpine forests and the aspen type. Engelmann spruce is the most valuable timber type in Colorado as well as in the San Juan Mountains. Not only is it used for primary and secondary (manufactured) timber products, but a plywood mill has been established near Cortez at the western edge of the San Juan National Forest to use this resource. The likelihood of a pulp mill in this area, or in western Colorado, adds to the value of this timber species. Aspen is used for posts and poles and is the source of match splints. An industry at Mancos at the southwest edge of the San Juan Mountains is exclusively dependent upon aspen wood.

From the standpoint of biomass production of forests, no known determinations have been made in this area. Foresters measure the merchantable products of trees (nearing maturity) in terms of board feet or cubic feet of usable wood, exclusive of branches, twigs, tops, and leaves. For instance, the inventoried range of standing crop biomass of merchantable timber in the spruce forest varies from less than 4.72 m^3 to more than 28.32 m^3 per hectare (5000 to 30,000 board ft/acre), and it is estimated that the annual incremental growth varies from less than 0.14 m^3 to over 0.38 m^3 per hectare (150 to 400 board ft/acre).

Open forest and herbaceous communities are grazed by domestic cattle and sheep, and to a certain extent by riding or work stock horses. In addition to the private ranches' seasonal or nominally year-long use, numerous grazing allotments are granted in the San Juan National Forest. The total of 196,000 animal-unit months in this category is divided about equally between cattle and sheep. Cattle generally graze the lower elevational types while sheep use the higher elevations, which often are the rougher areas that are less adequately watered. The grazing season for cattle normally extends from 1 to 20 June, as an opening grazing date, to 1 to 31 October, or a season varying from three to five months and averaging about four months. Sheep use at higher altitudes does notnormally begin until around 20 June to 1 July and terminates between 10 and 30 September for an average of about three months.

Chief among wildlife consumers are elk (*Cervus candensis*) and deer (*Odocoileus hemionus*), which range into subalpine meadows and forest, and higher in summer. They are driven by snow accumulated in winter to lower elevations at 2100 to 3500 m for elk and 2000 to 3050 m for deer, depending on severity of the winter. Bighorn sheep (*Ovis canadensis*) are found in certain restricted areas and are believed to respond somewhat to snow depth, but tend to seek special snow-free areas at high elevation, where they winter.

Common small mammals of the project area, as determined by a small-mammal census in July and August 1970, include the red-backed vole (*Clethrionomys gapperi*), Colorado chipmunk (*Eutamias quadrivittatus*), deermouse (*Peromyscus maniculatus*), and common shrew (*Sarex vagrans*). The first three are quite ubiquitous and are important because of their frequent interference with tree regeneration. They may receive greater protection from a longer period of snow cover and lusher vegetation produced by it, but a resultant delay in breeding may compensate.

Wild turkey (*Meleagris gallopavo*), blue grouse (*Dendragapus obscurus*), band-tailed pigeon (*Columbia fasciata*), and three species of woodpecker (*Dendrocopos* and *Picoides*), are the birds of primary economic importance. The first three are hunted, and the woodpeckers help control forest insects. The game birds migrate somewhat in response to snow and colder temperatures, so increased snow may reduce their range and thus their numbers. Augmented productivity of vegetation, as a result of increased moisture, could compensate by furnishing added energy for these birds.

Chorus frogs (*Rana pipiens*) have been found in every major drainage investigated during the summer of 1970. They are found to timberline and above in the San Juans, a significant extension of altitudinal and ecological range. They are strikingly absent in the Silver Mesa area, possibly because of interaction with tiger salamanders, which may be favored by the more permanent water areas there than in the Front Range. Both deviations from Front Range experience are probably related directly or indirectly to terrain and climate, primarily precipitation. This strengthens the belief that the species is very sensitive to climatic gradients.

Secondary consumers, the predators of the San Juan target area, include coyote and predominantly black bear. These do not occur in large numbers and are controlled by the USDI Bureau of Sport Fisheries and Wildlife, so they do not present a great threat to livestock or wildlife.

Very little is known of the invertebrate consumers of the San Juans, but the insects are probably important components of the ecosystem. Flies are unusually abundant there but grasshoppers and mosquitos seem only moderately abundant. A spruce bark beetle outbreak is newly discovered on the Taylor Mesa area west of the Dolores River.

Bacteria, which are mutualistic consumers in the rumen of the ungulates (deer, elk, etc.), are undoubtedly present, though as yet unstudied. They are essential to ecosystem function and to ungulate populations, both wild and domestic. Accumulation of silver and resulting toxicity could harm these bacteria and thus the entire system.

The decomposers, primarily bacteria and fungi, are a more important part of the ecosystem here than in the alpine tundra. They attack the much greater volume of vegetative biomass produced and recycle it through organic matter in the soil, which is developed considerably and to good depths in some areas. The decomposers are adapted to cool temperatures, and to an annual alternating cycle of abundant moisture in the spring and frequent water stress in the fall. It is believed that the slight increase in winter precipitation will have little detectable short-term effect on the composition or biomass production of the decomposer organisms. The silver, which is introduced from cloud seeding, may have a more profound effect, since bacteria seem especially susceptible to silver toxicity.

6.3.5. Intermountain Aquatic Biome Consortium

Aquatic coordination between the Coniferous Forest Biome and the intermountain area stream-lake studies. University of Utah and other western universities. Lake and stream systems review.

The directors of the University of Montana Flathead Lake Biology Station, the Utah State University Bear Lake Biology Station, University of Utah Great Salt Lake Station, Brigham Young University Utah Lake Station, and Chico State (California) Eagle Lake Station met in May 1969 under the auspices of the Utah State University Ecology Center to discuss the possibility of consorting on a regional aquatic ecology research plan and design. With that meeting and a subsequent meeting at Flathead Lake in July 1969, the group came to a realization that the facilities represented by the participating institutions and the faculty associated with those facilities represented a potentially strong and cohesive aquatic biology group--strong because the competencies represented by all the institutions covered a broad spectrum of ecological activity, and cohesive because the attention of the work, both research and training, was directed toward lakes very similar in origin, and toward students with very similar interests.

The two meetings revealed that a considerable amount of aquatic research had already been accomplished on the five lakes and that much valuable data existed that would contribute materially to modeling of ecosystem components in both the Desert and Coniferous Forest Biomes. It was proposed at the Flathead Lake meeting that a representative from each station attempt to assemble existing physical, chemical, and biological data for each lake that might serve for future Biome modeling purposes.

The information to be gathered for each lake will consist of the following:

1. Basin origin--geological: (a) period of formation, (b) geological processes involved, (c) geological history

2. Morphology and morphometry: (a) elevation, (b) area and volume, (c) depth, (d) shoreline development, (e) bathymetric maps available, (f) substrate

3. Physical characteristics: (a) temperature (stratification, heat budgets), (b) seiches, (c) currents, (d) levels, (e) hydrological balance, (f) sediments

4. Chemical characteristics: (a) geochemical characteristics, (b) chemical analyses of water

5. Biological characteristics: (a) enumeration of aquatic plants, phytoplankton, zooplankton, invertebrates, fish, birds, (b) productivity data

6. Water and land use

7. Current research projects

6.3.6. Logan, Utah

Survey and evaluation of available data for modeling forested watersheds. Utah State University. Hydrologic information and data review.

Interest in extending the hydrological modeling efforts to other watersheds is rapidly developing as evidenced by independent requests for work at Wenatchee, Washington, and at Farmington, Utah. It is now appropriate to identify and evaluate the potential sources of available hydrometeorologic data within the Biome to provide for the orderly extension of the model to diverse vegetation and climatic environments.

The first step would be to review published hydrologic information from small forested drainages within the Coniferous Biome. In addition to the recognized coniferous types, we would survey the associated forest vegetative types such as aspen and pinyon-juniper. Literature sources, such as Representative and Experimental Research Basins in the United States (International Hydrological Decade 1969), would provide a preliminary screening mechanism to identify watersheds that may be suitable for modeling from a standpoint of vegetation type, area, and scope of parameters measured. The main sources of data are the USDI Geological Survey (surface water and water supply papers), USDC/NOAA National Weather Service (climatological summaries), USDA Forest Service (research and barometer water watersheds), and USDA Agricultural Research Service. Other possible sources would be USDI Bureau of Reclamation, USDI Bureau of Land Management, USDA Soil Conservation Service (P.L. 556 watersheds), state water boards, municipalities, university research projects, and industry.

This review would have two forms: a library search and a mailed questionnaire directed toward administrative as well as research agencies. In the questionnaire, more detailed information would be sought on such topics as types of instruments, length of record, density of networks, resolution scale of data, and type of data output and storage. We would seek information on precipitation, streamflow, climate, soil water, soil description, geology, topography, and vegetation type and density. From this, tentative criteria for sensitivity and duration of record would be established. This information would be examined again for model compatibility and several (possibly 5 to 10) watersheds would be selected as future areas for hydrologic studies.

6.3.7. Logan, Utah

Computer simulation of forest watersheds. Utah State University. Hydrologic modeling research.

Previous work. Development of the computer simulation program in hydrology at Utah State University began in 1963 and since then has proceeded in stages to increasingly detailed models. The important underlying feature throughout the entire program has been that all of the separately described processes and phenomena are interlinked into a total system. Thus for each model it is possible to evaluate the relative importance of the various items, explore critical areas where data and perhaps theory are lacking, and establish guidelines for more fruitful and meaningful study in subsequent phases of the work.

The first hydrologic model, using a monthly time increment, gave good results for interbasin effects. The second hydrologic model was designed for an investigation of in-basin problems, but still used a large time increment. Under the third phase of the program a model was developed that simulates the hydrologic processes over small geographic units and short periods of time. Under the fourth phase of the simulation program other dimensions such as water quality and economics have been included. Through a current research project entitled "Hybrid Computer Simulation as Applied to the Management of Water Salinity within a Hydrologic System" a hybrid computer program has been developed and tested with data from the Little Bear River basin for linking the hydrologic and salinity flow systems. The model establishes a technique for predicting quality changes in the irrigation waters as they leach downward through the soil profile, thus enabling estimates of the quality of irrigation return flows.

Facilities. The laboratory portion of this study will be conducted in the Utah Water Research Laboratory, which is situated on the campus of Utah State University at Logan. The hybrid computing facilities consist of a new EAI-590 system with 16K words of core storage. Peripheral equipment includes an eight-channel strip-chart recorder, two variplotters, a digital plotter, an oscilloscope, a high-speed paper tape recorder and punch, an on-line teletype, a card reader, and an on-line printer. In addition, the hybrid computer center is equipped with a digitizer for converting analog data plots to digital form on computer tape.

The digital computing facilities available for general use at Utah State University include a direct teleprocessing connection to a Univac 1108 situated at Salt Lake City. In addition, on-campus facilities consist of an IBM 360/44. Other facilities available on a limited basis include an IBM 360/400 system operated by the State of Utah data processing center in Salt Lake City, and a CDC 6600 system operated by NCAR in Boulder, Colorado. Digital computing facilities might be used to check certain specific relationships of the simulation model.

If this proposed project is funded, adequate space and equipment for conducting the research program will be available at Utah State University.

6.3.8. Logan, Utah

Test of environmental grid model for primary production in Wasatch Front Engelmann spruce. Utah State University and Intermountain Forest and Range Experiment Station USDA Forest Service. Specific model extrapolation research.

The College Forest has an area of 1036 ha with a variety of cover types: herbaceous meadows, aspen slopes, lodgepole pine stands of several ages, mixed conifers, and Engelmann spruce--subalpine fir in uneven-aged and in uneven-aged by even-aged-small-group stands. The elevation at the Engelmann spruce plots is approximately 2591 m. Precipitation has averaged about 76 cm per year, but a weather modification project may give a higher average for the period of its duration. Snow accumulates to a depth of 244-274 cm in the small timber-enclosed meadows and the open meadows with a slight NE slope; a snow cover remains until the first week in June. Intermittent rains may last well into June but June may also be quite dry. July, August, and September are usually quite dry. A few light rains may sporadically occur at any time with 1.3- to 2.5-cm storms in some years during August. (Rainfall from 10 June and for July, August, and September 1971 was 6.8 cm of which 3.6 cm fell on 9 and 10 September.) Soil was derived from the Wasatch conglomerate formation. In the study area, soil is a silty clay loam with some gravel and occasional boulders. Soil moisture tubes (15-20 per plot) probe the area down to depths of 183-244 cm. Summer actinograph records have been taken for eight years and summer weather records since 1950. The weather instruments rain-gage, anemometer, Livingston porous cup atmometers, Piche evaporimeter, and an actinograph. Phenology of the meadow vegetation has been intensively followed from 1965 with extensive records for early development from 1948. Litter collection flats have been collected since 1948 and corresponding O-horizon samples were collected in 1958 and 1968. All trees from 137 cm and taller on four 2023-m^2 plots have been numbered and measured for diameter and height, and crown characteristics have been recorded. Fifteen trees in one plot carry dendrometer bands. Almost 300 trees have had annual condition records and cone counts since 1947.

Dr. Caldwell has the technique and the equipment to measure the CO_2 assimilation of the saplings in the field. Whether his other commitments will permit his working in the spruce plot for a short period cannot be estimated at this point. It will depend upon too many variables not the least of which will be the importance and amount of the data that the Waring model finds necessary for its predictions. Laboratory determinations for potted seedlings could be arranged.

6.3.9. Logan, Utah

Coordination of the Coniferous Forest Biome and the Northern Wasatch Forest Ecosystem Study. Utah State University and Intermountain Forest and Range Experiment Station USDA Forest Service. Ecosystem studies coordination.

The proposed study area is located on the Utah-Idaho border, 48 km northeast of Logan, Utah. Studies would be conducted in the vicinity of the USU forest. A diverse array of the three coniferous types, varying both in density and species composition, is present. That these three types are so completely represented within a narrow elevational band (1890-2652 m) is unusual. A relatively homogeneous climate pertains to each type. This climate is distinctly different from other regions for which northwestern conifer studies are anticipated. Upper Logan Canyon, representative of the Wasatch Mountains and the valley and range areas of Nevada, has a pronounced dry summer--wet winter precipitation pattern (5 cm summer versus 76 cm winter precipitation). Concentration of research effort will be made in water balances and in morphogenesis because of importance of summer water stresses to these studies.

Meteorology. A long-term climatic record for at least the four summer months has been obtained at a weather station on the USU forest at an elevation of 2530 m. Since 1950, continuous records of air temperature, relative humidity, and rainfall (amount and intensity), as well as daily wind measurements, have been taken. Intermittent evaporation measurements, made with Livingston and Piche evaporimeters, are available, as are soil temperature data taken in conjunction with seedling germination studies.

Hydrology. The streamflow record for the Logan River drainage (56,462 ha) is of exceptional length. Since 1896, flow data have been compiled and are available from the USDI Geological Survey. The topographic divides of the Logan Canyon basin, and of its numerous tributary drainages, are well delineated. Extensive geologic formations of limestone are present in the canyon, and deep seepage flow, either into our out of the drainage basin, may occur through these porous formations. The relatively high streamflow rates in midsummer from drainages supplied by very low summer rainfall are indicative of deep seepage. In proposing water balance studies for this area, we anticipate a major effort in delineating pathways of subsurface water movement and in determining the timing and magnitude of deep seepage losses. Most forest soils are characterized by high surface infiltration rates, root entries to deeper soil horizons, and high stone contents. Favored by these characteristics, subsurface flow is the predominant source of water yield from forested lands. Unfortunately, our understanding of subsurface flow processes in forest soils is meager. One of the objectives of water balance studies in conifer types, both in the proposed study area and elsewhere, should be the full examination of subsurface flow phenomena. Standardization of procedures throughout all study areas should be stressed.

Biotic systems. The three coniferous types of the upper Logan Canyon are represented throughout the Coniferous Forest Biome. Two are climax types (Douglas-fir and Engelmann spruce--subalpine fir) and one is a subclimax type (lodgepole pine). The proposed study of bud morphogenesis and shoot elongation would contribute to knowledge of the productivity of these species. It is appropriate that these morphologic studies be made in conjunction with water balance studies because of the possible relationship between bud development and several of the parameters of the water balance (soil moisture, air temperature, day length).

Taxonomy. The taxonomy of conifers is relatively simple, and local coverage is adequate for the purposes of this proposal. A reference collection of plants of the intermountain region is maintained by the botany department of Utah State University. Professor Art Holmgren would serve as consultant in plant taxonomy.

Population history. Phenologic records of ground cover in an open area have been taken intermittently. Since 1946, annual cone counts and height-diameter measurements have been taken on 300 trees, either Engelmann spruce or subalpine fir. Fifteen permanent plots in sapling and pole-sized stands have been inventoried at five-year intervals since 1958. Other information available on the population histories of the USU forest includes annual rodent censuses and litter accumulation measurements. Water balances in the aspen cover type in upper Logan Canyon have been studied from 1966 to the present, and provide background information on water balances of conifers.

6.3.10. Longview, Washington

Weyerhaeuser experimental streams study: Modeling of trophic processes. The Weyerhaeuser Company. Stream biology data review.

The study covered by this proposal will be conducted at an experimental streams facility located in the Cascades. The station has on it three man-made streams each several hundred meters long. The three streams were constructed so that they are as nearly identical to each other as possible. Part of the flow of a constant-temperature (6°C) spring is diverted into each stream at a rate of 25,485 $cm^3 sec^{-1}$. The streams contain a number of riffles, alternately 7.6 and 15 m long and 1.2 m wide, separated from one another by a pool 3 m long. A riffle and the pool below it are separated from other riffle-pool sequences by rotary screens, which permit drift to pass but keep the fish in their designed study unit.

Continuous studies have been under way at this site since 1965; several reports and publications have been put forth concerning these studies. All of the important physical and chemical parameters have been monitored. A great deal of background biological information has also been gathered: life history and phenological data for all the major plant and animal species, species composition, feeding habits of the fish and benthic invertebrates, primary production, and growth rates and production of fish and benthic invertebrates.

6.3.11. Missoula, Montana

Influence of fire in coniferous forest ecosystems. University of Montana and USDA Forest Service. Fire influences information review and modeling.

Scope, justification, and resources.

> Firehawks often confused us in welcoming visitors to our tribal lands by deliberately setting fire to grass and bushland to assist their scavenging. I have seen a hawk pick up a smouldering stick in its claws and drop it in a fresh patch of dry grass half-a-mile away, then wait with its mates for the mad exodus of scorched and frightened rodents and reptiles. When that area was burnt out the process was repeated elsewhere. We call these fires, Lauran.

This observation from Australia in Lockwood's book, I, the Aboriginal, provides a dynamic expression of interrelationships among fire, flora, and fauna. In the United States we now recognize the role that fire plays in maintaining Kirtland warbler habitat in jackpine stands in Michigan. A recent study (Bock and Lynch

1970) in California described significant bird species diversity due to the variety of habitats that resulted from the Donner Ridge fire in California. These examples are symbolic of fire-perpetuated food chains and habitats. If birds are thus affected, what of other living forms along food chains?

Wildland fires traditionally have been viewed as a negative and destructive force, or, at best, a transitory disturbance in forest systems, or a "tool" of management. Recognizing that we have acquired conditioned attitudes regarding fire, we may be suggesting solutions to ecosystem functions and land management problems that disregard fundamental relationships because we have not asked the right questions. For example, Olson (1963) never asked the question: Is fire a decomposer? Olsen utilized an exponential model to predict steady-state levels of energy storage and the balance of producers and decomposers in ecological systems. His analysis showed that many ecosystems in northern latitudes have continued to show positive net litter production levels for centuries, but he neglected to account for the fact that fire, as well as decomposing organisms, has played a role in determining rates of net litter accumulation. Daubenmire and Daubenmire (1968) have indicated that fire incidence in northern Rocky Mountain stands reaches a probability of certainty in 45-500 years. In many of these stands the fire cycle is much shorter.

Bloomberg (1950) described an interesting successional pattern in spruce stands on the eastern slopes of the Rockies in Alberta that relates to this question of fire as a decomposing agent:

> As the pure spruce stand establishes denser growth on the site, so these conditions are exacerbated to the point where insufficient light and heat can penetrate the canopy to aid the decomposition of vegetable matter on the forest floor. After the establishment of such a stand, reseeding from the mature trees results in a diminishing degree of successful regeneration as the stand closes and the severity of these conditions increases. The thickening humus layer prevents the delicate seedling rootlet from penetrating the mineral soil from which it will draw sustenance after the seed reserves are exhausted.

Bloomberg summarizes the case by saying that:

> . . . spruce regeneration is healthy and vigorous under a pine nurse crop, yet decadent or nonexistent under a canopy of its own species; that a regular succession of age classes, the classically supposed ideal for spruce, is mythical in the case we are considering; that the age-class distribution is directly attributable to fire. Further we are led to suppose that fire has a positive and causative effect on the establishment of spruce as a climax type. It would be well to stress that these principles were found to apply irrespective of site or other growth factors, and in the writer's range of experience and observation are widely prevalent on the eastern slopes.

It is also evident that excessive litter accumulation has been allowed to take place. On this view, fire is important to the well-being of forest stands in certain situations, for under Australian conditions fire can achieve what is done elsewhere, in moister climates, by the main litter degrading agents--mold and fungus attack.

The enigma, then, is this: If fire serves as a decomposing agent throughout much of a coniferous biome, can we understand the functioning of coniferous ecosystems without accounting for this cyclic role of fire? Such an omission will surely lead to discontinuities in our comprehension of food chains, energy flow, and nutrient cycling within these systems.

There are other interesting questions suggested by Dunbar's (1960) contrasting the highly stable production systems of tropical waters with the seasonal and longer term oscillations of temperate and polar waters. His thesis is that population oscillations are an expression of the immaturity of the system. He cites the stability of warm-adapted floras and faunas as an outgrowth of evolutionary maturity. These concepts provide an interesting frame of reference in which to consider ecosystem adaptations to equatorial and cool-temperate climates. In his discussion he assumed that oscillations are bad for any system and that violent oscillations are often lethal. Other outcomes might be reached using some of his same arguments, if you don't begin with his value judgment that population oscillations are categorically "bad." In what objective manner are we to determine that oscillations, even lethal ones, are "bad" to the functioning of biological systems? Is it even valid to extrapolate such a premise from an equatorial climate to a cool-temperate climate? It is true that the primary productivity of the tropical rain forest is significantly higher than any other major ecosystem on earth (Whittaker 1970). Dunbar states that there is an absence of climatic and seasonal oscillations in tropical and subtropical environments, which fosters much more complex ecosystems in which there is great multiplicity of energy paths along with overloadings that can be released. This last statement may be the key in critically looking at his argument. There are numerous pathways in tropical forests to facilitate energy conversion processes, the most significant being the optimal environmental conditions for microbial and fungal decomposition. It is interesting to note that the world's most highly productive forests are also characterized by the lowest levels of net accumulation of litter. In Lindeman's (1942) successional theory for the cool-temperate lake system, senescence of the lake began when organic matter production greatly exceeded decomposition rates. Does a similar senescence, or regressive productivity, occur in coniferous forests as litter production exceeds decomposition rates? Consider this question: Do population oscillations in cool-temperate regions, even lethal oscillations, contribute toward ecosystem stability over time because they serve to compensate for the multiplicity of energy conversion pathways characteristic of equatorial regions (but not present in higher latitudes)? The activity of decomposing organisms is limited in cool-temperate regions and organic debris accumulates over time. Is fire the oscillatory agent in these regions that serves a vital role in ecosystem functioning through cyclic energy conversion?

In the classical sense ecosystem stability seems to imply the freedom from oscillations as indicated by Dunbar. But in considering selected adaptations of higher latitude communities in terms of fire survival and regeneration mechanisms, then are not the fire cycles suggested by Whittaker and Woodwell (1969) and Vogl (1970) just as valid an approach to stability and the viability of ecosystems?

A more basic premise than one suggesting that oscillations are bad would be a statement that terrestial ecosystem stability is sustained through heating levels commensurate with energy conversion requirements. It is then immaterial whether heating rates are continuous (equatorial and microbial heating) or cyclic (wildland fire heating).

It is interesting to compare periodic pulses of fire within ecosystems with the periodic drawdown and flooding of freshwater marshes. Odum (1969) has traced marsh viability problems to absolute water control in the Everglades, whether the control is in terms of fixed-level impoundments or drainage. We might equate this approach to absolute fire control in the forests. Understanding of the functioning of fire-controlled forests might serve the best interests of ecosystem maintenance and productivity within those plant communities that have been regularly visited by fire. Heinselman (1970) indicated that fire policies have had the most powerful and pervasive effects:

> We have attempted to control forest fires for 50 years or more; in most areas we are now quite successful. Yet, by so doing we have sometimes accelerated successional changes over vast areas--causing the simultaneous aging of forest over entire landscapes, preventing the establishment of new pioneer plant and animal communities, eliminating the diversity of nature, and excluding the ecological niches of many forms of wildlife.

Heinselman equates these effects to a grand ecological experiment by inadvertantly trying to produce climax forests over vast areas--on a scale that may never have occurred before. Odum (1969) observed that although as individuals we readily recognize that we can have too many dams or other large-scale environmental changes, governments are so fragmented and lacking in systems analysis capabilities that there is no effective mechanism whereby negative feedback signals can be received and acted on before there has been a serious overshoot. Are the large fires in 1970 and 1971 (Wenatchee, southern California, the Everglades, and northern Minnesota), signs of negative feedback from the "grand ecological experiment"? Are we experiencing severe oscillations, rather than oscillatory stability, because of man's sudden intervention within ecosystems that have adapted to fire over evolutionary periods of time? Are we seeing the effects of fire control in plant communities that were formerly fire-controlled?

Although Slobodkin and co-workers (1967) have defined the balance of nature as the persistence of ecological systems resulting from their tendency to compensate for perturbations, we might question the amplitude of the perturbations today. Odum (1969) emphasized that pulse stability works only if there is a complete community adapted to the particular intensity and frequency of the perturbation: "Adaptation--operation of the selection process--requires time measurable on the evolutionary scale. Most physical stresses introduced by man are too sudden, too violent, or too arrhythmic for adaptation to occur at the ecosystem level, so severe oscillation rather than stability results."

Much has been written on the effects of wildland fires on ecosystems (Ahlgren and Ahlgren 1960; Lutz 1956; Cooper 1961; Daubenmire 1968), but in the United States there is a scarcity of information on the effects of vegetation on fire in context with fire periodicity and the evolutionary development and successional strategies of plant communities. Wildland fires must be included as integrated events associated with ecosystems. A hypothesis has been described (Mutch 1970) that treats this interaction between fire and the ecosystem:

> The vegetation brings certain properties to the ecosystem that condition the fire history, and the fire history determines, in part, the maintenance, regression, or succession of plant communities. Fire survival and fire adaptations of plant communities are common knowledge. What the hypothesis adds to this background in a frame of reference that considers fire-dependent plant communities as having energy properties that make them highly flammable.

This understanding of ecosystems and wildland fires sheds light on the amplitude of present-day fire perturbations. Highly flammable properties of plants can be detrimental to a community under a policy of complete fire protection, for the accumulation of very flammable fuels over a long period may lead to fires of an intensity that the community has not naturally experienced.

Loucks (1970) presented a fascinating causal relationship between periodic perturbations and primary productivity:

> The natural tendency in forest systems toward periodic perturbation recycles the system and maintains a periodic wave of peak diversity. This wave is associated with a corresponding wave in peak primary production. It is concluded that modifications of the system that preclude periodic, random perturbation and recycling would be detrimental to the system in the long run.

The IBP with its theme of "the biological basis of productivity and human welfare" provides a unique opportunity to investigate the effects of periodic perturbations on system productivity. Contributions in this area would be significant in helping to "not conquer the natural world, but to live in harmony with it."

Fire cuts across all environmental parameters. It exerts a direct control on primary and secondary succession. Vast areas of the Coniferous Biome are occupied by the so-called "fire climax." Within these stands fire has repeatedly set succession to earlier stages, perpetuated subcycles, and in some cases even set succession ahead. Obviously the fire is directly related to stand composition and structure. Forests evolving in harmony with such a process as fire must be somewhat dependent on fire for continued occupation of sites and maximum productivity.

It should be possible to relate fire to the rate at which forests grow; their condition, vigor, and resistance to insects and disease; their reproduction cycles and success; and their aerial distribution. Energy, nutrient, and organic compound cycles also can be related to fire. The same can be said for microorganisms, soil building factors, mammals, and hydrolygic functions. With so much of the coniferous environment related to fire, the reasons for understanding it are obvious. The fact that man is attempting to control fire and replace it with mechanical and chemical alternatives makes this work extremely important for land management direction, and alone is sufficient justification for this work.

The direct benefits of ecological fire research are many. One of the key benefits is the joining together of many disciplines and agencies to work on a control problem which is currently being ignored. It presents a chance to build a framework that could produce a more complete understanding of our coniferous ecosystems and help optimize management techniques. How can we manage "fire-types" without a thorough understanding of their relationship with fire? Is there a gene pool which must be preserved and maintained?

There are some direct economic and social benefits to be gained from the results of this work. A tremendous saving in fire control costs is certainly possible. We should begin to understand better the way in which land managers can maintain natural processes and landscapes in wilderness areas and national parks. There is a definite possibility that stand regeneration techniques can be much more efficient and productive.

Currently there is public pressure, real or imagined, to ban the use of fire in forest management. This is caused by air quality and esthetics problems, and our inability to show clearly the need for this use. A true understanding of fire's role in a coniferous biome would allow us to explain the biological reasons for including this environmental factor in our management of these systems.

A coordination program centered around a complete study of fire in the Coniferous Biome would not limit its first year's work to a geographical region. This is a necessity because most fire ecology work has been done outside the northern Rocky Mountains. We must rely on this work to guide us in designing a comprehensive program within the Coniferous Biome and describe the current status of this work. Subsequently we will definitely limit the scope of the research to the northern Rocky Mountain region.

Our objectives would be submodels that relate fire to specific segments of the ecosystem. These models would be process or function oriented and would apply directly to the areas of study. They would be broad enough, however, for easy extrapolation to the total Coniferous Biome. Some examples follow:

<u>Climate and fire</u>

- Micro
- Meso
- Seasonal

<u>Biomass and fire</u>

- Living vegetation
- Dead organic matter
  (combine to describe fuel)

<u>Soil and fire</u>

- Microorganisms
- Nutrients
- Allelopathogens

<u>Stand structure and fire</u>

- Dynamic
- Successional

<u>Aquatic systems and fire</u>

<u>Fire behavior characterization</u>

<u>Organisms and fire</u>

- Mammal
- Fish
- Insects
- Disease

All these submodels are interrelated to some extent. Various submodels could be combined for use in proposed Biome models. Lakes and streams deserve special attention as they are focal points of environmental changes in entire watersheds. Thus aquatic systems may be sensitive and accessible sites for monitoring terrestrial systems. The closed watershed approach to geochemical studies is an example of this approach. Conversely, aquatic systems and their biota are closely coupled with soil, vegetation, and other terrestrial aspects, so fire-induced changes in flow regimes, water chemistry, allochthonous detritus, suspended sediment, and light intensity may lead to major alterations of the structure and dynamics of aquatic ecosystems.

The western Montana area is unique with respect to the study of fire for many reasons. There is one of the most diverse groups of scientists, working directly on fire, studying fire-related problems, or interested in studying fire, within their own disciplines, that can be found anywhere in the world. Current work includes fire characterization, fire in the wilderness, fire ecology, nutrient cycling, silviculture, physiology, soils, forest typing, and so on. There is a great deal of existing coordination between the various scientists here in western Montana and within the United States. Bridges have been built between fire researchers and other biological workers. There are presently many international contacts being used routinely, especially in Australia, Canada, and Southeast Asia.

The western Montana area includes the following facilities and agencies either carrying on fire-related research or expressing a desire to be included in such work:

1. University of Montana

   A. School of Forestry: Ecosystems analysis, closed watershed studies, fire ecology, fire use in land management, fire chemistry, site productivity

   B. Department of Botany: Nutrient and energy cycling, wilderness processes, succession, allelopathy, ecosystem modeling, stand characterization

   C. Department of Mathematics: Modeling of ecosystems, experimental design, statistical analysis

2. USDA Forest Service

   A. Northern Forest Fire Laboratory: Fire modeling, fire ecology, fire in wilderness, fire behavior, biomass, meteorology, fire effects, and fire control

   B. Forestry Sciences Laboratory: Silviculture of northern Rocky Mountain species, insects, disease, regeneration, ecosystem modeling

In addition, this region is surrounded by wildlands being managed by several agencies. Many on-site fire-related experiments are now in existence at field locations such as Lubrecht Forest of the School of Forestry, and the Newman

Ridge studies of the USDA Forest Service. One outstanding resource for purposes of this program is the ready availability of natural and man-produced fire!

Literature compilation objectives. Fire in the coniferous forest ecosystems in the northern Rocky Mountains has functioned as an influential force throughout the history of these biomes. It functions as a selection factor in species evolution, and routinely influences, by its presence or absence, the compositional and structural characteristics of nearly all of the biotic community types in this coniferous region. Fire is of equal importance in this region as a "decomposer" agent, yet contrasts sharply in comparison with other reducers.

The main concern in searching the "fire literature" should be the enhancement of our understanding of fire as an ecosystem process, and as an important influence on ecosystem function in the northern Rocky Mountains. As with other "basic elements" in ecosystems, fire's influence cuts through nearly all other ecosystem relationships, at all levels of organization. Since the information storage, retrieval, and data bank development activities will function in compiling much of the fire/ecosystem details, it is viewed that the literature review will have the function of making an interpretative overview of currently published materials.

Ahlgren and Ahlgren (1960) provided a review of some of the literature (358 papers); this review can be used as a start and be expanded. Some of the same topics outlined by Ahlgren and Ahlgren can be used, but new ones need to be added. Details on fire behavior, pyrolysis, accumulations and combustion features of wildland fuels, chemical aspects of fire and fuels, and others will be added. Historical accounts (qualitative, descriptive) need to be assessed for basic contents. The interrelationships between such topics as gene pool preservation and biotic diversity need special attention in this review. Actually no topic will be eliminated. Aspects dealing with economics and social benefits will also be covered.

The literature interpretation envisioned, as well as abstracts of articles reviewed, will require a specially developed format since several different reviewers will be engaged in this activity. Other Biomes, particularly the Deciduous Biome, will be contacted in order to adapt the format to the IBP information bank. A well-indexed annotated bibliography will be developed for publication, first as a Coniferous Biome internal report, and later synthesized into a formally published review paper.

An annotated inventory of unpublished current research, significant to understanding the role of fire in the coniferous forest, will be prepared. The format of presentation of this inventory will be compatible with the published material review effort. A useful starting point for the present effort is CRIS, the "Current Research Information Service" of the U.S. Department of Agriculture (a computerized information retrieval system), although other sources will also be used. Correspondence will also be established with research projects directly relating to our mission. Besides utilizing standard compilations of research in progress, personal contact will be established with known research programs and researchers whose work might not be covered in those compilations.

The annotated inventory, including progress reports and unpublished results, obtained from all sources will aid in the development of needed research to complete our understanding of the role of fire in a coniferous biome. The Coniferous Biome may be asked to fund some of this needed research, but it is also believed that much of it will be accomplished by the redirection or refocusing of work currently under way and funded by the various cooperating agencies through the development of more definitive conceptual models of the role of fire in coniferous ecosystems as a result of the efforts herein proposed.

Modeling. The major initial efforts of the fire ecology group will be the development of the spirit and concept of the Biome's modeling approach among contributors, as well as keeping them informed of the development of models within the Biome. This goal might be accomplished by: (1) the establishment of close and continuing contact with the Biome's modeling group, not only for liaison but at least initially for orientation and education (this could be done through workshops and seminars, as well as visits to the intensive sites by some contributors); (2) the formation of a fire modeling committee of about six to eight persons representing the major interest groups and the mathematical and computer specialists; and (3) the formation of interest or specialty groups that may have overlapping memberships. In this sort of arrangement, the specialty groups and/or local modeling group would identify problem areas and processes of interest, hopefully culminating in the formation of conceptual, graphic, or flow chart models.

The modeling of fire and fire-influenced systems may present some problems that have not been encountered in other IBP efforts, and may offer some challenge to the Biome's modeling group. The occurrence of fire has a strong probabilistic element, thus simple deterministic models may not be adequate for our purposes. The aftermath of fire is a nonequilibrium system, so dynamic models based on the mechanics of component interactions are a necessity. The alternative is a system of time-dependent models that are mathematically intractable and probably less useful.

There is often a tendency to think of a single model or a big systems model composed of submodels that fit together in hierarchic fashion to form the grand scheme. This may be the ultimate in systems analysis, but we should consider the value of overlapping or alternative systems of models. This refers to a type of universe problem, where models and research designs at the watershed level of organization may be inappropriate at the regional or stand level.

There also should be some middle ground between the requirements and limitations of the modelers and the ability of the scientist to provide data. Sensitive points in this regard include: (1) the identification of critical processes, as their importance may not be proportional to their magnitude; (2) techniques for reducing the time dependence of models; (3) the size of the "black box" components, which may be more a question of personal scientific philosophy since it affects research efforts and expense as well as the precision and stability of parameters in the model; and (4) quality control and the required precision of estimates.

In summary, the modeling program will probably initiate via workshops in 1972, and this initial effort will be educational in nature. In 1973 we expect the contributors to assist in the construction of models of the role of fire to provide a conceptual framework, assemble and establish some known aspects of transfer, process, and control, infer probable relationships, and identify others requiring investigative research.

6.3.12. Missoula, Montana

Coordination of the Coniferous Forest Biome and the Lubrecht Ecosystem Project. University of Montana. Ecosystem studies coordination.

The Lubrecht Ecosystem Project is designed to provide needed ecological information on forest function, a necessary prerequisite to sound planning and management. Furthermore, there is a critical need to integrate this biological and physical information within the socioeconomic framework of the region. This integration can be achieved with a carefully designed, holistic forest management model. In order to develop a model of value to forest management decision-making, the project is necessarily interdisciplinary and multiphased. Although investigators from diverse disciplines will conduct the research, the common objective of each researcher and each study phase will be to ascertain the safe limits of forest manipulation in the northern Rockies.

A team of 20 scientists has been assembled to begin the intensive and extensive ecological research. The intensive research will use the successful techniques currently being used by Bormann and Likens at Hubbard Brook in New Hampshire. The extensive research, which will be conducted throughout the northern Rockies, will involve studies of the biota, water, soils, and geology of selected areas that have undergone known management practices. In both phases, the structure and function of the forest ecosystem in space and time will be determined before and after management practices. The intensive effort will be conducted in Montana on the Lubrecht Experimental Forest. This effort is designed to allow complete control to the researchers and will be used to develop the forest model for the northern Rockies. The Lubrecht Experimental Forest is 56 km northeast of Missoula, Montana, extends over an area of 11,745 ha, and is owned and administered by the Forest and Conservation Experiment Station of the University of Montana. The topography is hilly, with steep upper slopes from 1067 to 2286 m in elevation. One major watershed of 2226 ha is completely within the forest boundaries, as are several minor watersheds and sections of the valley of the Blackfoot River. The vegetation types cover sagebrush-grasslands, grassland--ponderosa pine, ponderosa pine, Douglas-fir, larch, lodgepole pine, cottonwood riparian forests, and Douglas-fir--larch and alpine fir--spruce mixed forests. Approximately 30% of the area is in Douglas-fir and Douglas-fir admixtures, with the remainder more or less evenly divided among the other vegetation types, except for a limited alpine fir--spruce distribution.

6.3.13. Moscow, Idaho

Coordination of the Coniferous Forest Biome and the Cedar--Hemlock Ecosystem Program. Intermountain Forest and Range Experiment Station USDA Forest Service, University of Idaho, and Washington State University. Ecosystem studies coordination.

Location. The Priest Lake--Priest River watershed is located in the southern Selkirk Mountains just south of the Canadian border in northern Idaho. There are some 233,100 ha in the watershed, 155,400 of which drain into Priest Lake and Upper Priest Lake. The entire watershed is potential climax conifer forest. A small percentage of the area, chiefly on the lower Priest River, has been cleared for agriculture and is used mainly for pasture and hay. Most of the drainage is on the Kaniksu National Forest, and the State of Idaho is the second largest owner. The vegetation is generally an extension of Pacific coastal forests into the northern Rocky Mountains, although there are strong boreal influences and numerous plants of Rocky Mountain affinities. Elevations range from 640 to 2164 m. Part of the drainage is in Canada and is not considered in this description.

Terrestrial environment. The primary study area is the Priest River Experimental Forest, a 2577-ha tract (N 48°21'; W 116°47'). It was established in 1911 as the first center of organized forestry research in the northern Rocky Mountains, and is directed by the Intermountain Forest and Range Experiment Station USDA Forest Service specifically for research purposes. The forest is located on the west face of the Selkirk Mountains and is about 85% mountainous terrain with the remainder mountain meadows of the Priest River alluvial plain. Elevations range from 671 m to 1798 m. Soils are principally brown podzolics underlain by gneiss and occasionally granite or schist. The climate is characterized by summers that are hot and dry and winters with heavy snowfall. The latter accounts for much of the 79 cm of average annual precipitation registered at the headquarters site. Mean annual temperature is 6.5°C (-37° to 39°C) with an average frost-free period of 82 days.

The vegetation is varied and well represents most of the forest types found on the Priest River watershed and the northern Rocky Mountains in adjacent Washington and Montana as well as farther south in Idaho. Climax communities range from Rocky Mountain Douglas-fir on lower, drier slopes through western red cedar and western hemlock, to Engelmann spruce and subalpine fir at higher elevations. All eleven of Idaho's commercial timber species are found in the area.

The experimental forest's main research features are: (1) unbroken weather records extending back to 1912; (2) continuous streamflow measurements for a major drainage within the forest since 1938; (3) lodging, office, and other headquarter facilities operated on a year-round basis; (4) a well-developed permanent road system affording ready access to most parts of the forest; (5) superior protection against fire and man-caused disturbance; (6) a 384.5-ha natural area; (7) a set of policies aimed at planned management of the experimental forest's resources to provide an excellent environment for research; and (8) a wealth of relevant data on various climatic factors, stand history and tree development, soils and ecological associations, accumulated during nearly 60 years of research use. As a further complement to the control weather station, there are a fire weather station and several climatological stations located at various elevations in the gaged watershed.

The faunal components of this area are also typical of the northern Rocky Mountains. Whitetail and mule deer, elk, black bear, and cougar are the principal larger mammals. The smaller vertebrates and invertebrates are those typical of large areas of conifer forests in northwestern North America.

Aquatic environment. Priest Lake and Upper Priest Lake are on the Columbia River drainage and have a coniferous forest watershed. Priest Lake is about 30 by 7 km with a surface area of approximately 9720 ha and is 747 m above sea level. Upper Priest Lake is about 1.6 by 4.8 km with a surface area of some 809 ha. Both lakes are oligotrophic and except in limited areas, a depth of 12 m or more is reached within a few meters offshore. Maximum depths of

Priest and Upper Priest Lakes are 108 and 30 m, respectively. The lakes have at least 13 major tributary streams that are used by spawning populations of lake-run cutthroat and Dolly Varden trout, Kokanee (silver) salmon, and Rocky Mountain whitefish. In addition, the lake supports indigenous populations of suckers, squawfish, sculpin, redside shiner, and peamouth. Rainbow and lake trout, largemouth bass, and green sunfish were introduced into the lake and are now self-perpetuating.

Priest Lake is drained by Priest River, a stream about 80 km long that flows into the Pend Oreille River at the town of Priest River. Mean flow is 47 m^3 sec^{-1} (39-year record), with a minimum of 4.7 $m^3 \cdot sec^{-1}$ and a maximum of 297 m^3 sec^{-1}. The river flows past the experimental forest some 40 river kilometers below the lake. Priest River has populations of rainbow and cutthroat trout, whitefish, and largemouth bass, as well as numerous nongame fish such as those listed for Priest Lake. The many tributary streams, including Benton and Canyon Creeks which are on the experimental forest, support resident populations of cutthroat and brook trout and sculpins. Upper Priest River rises at some 1829 m near the Canadian border and flows into Upper Priest Lake some 32 km below its source. Priest Lake and Upper Priest Lake are joined by a 3.2-km navigable thoroughfare.

There are seven small, subalpine lakes located on the Priest Lake drainage; these support planted populations of cutthroat and golden trout. In addition, there are two lower elevation lakes where considerable eutrophication has taken place. One of these supports a resident population composed chiefly of largemouth bass and green sunfish while the other is managed mainly for bass and perch. Numerous dystrophic bogs and beaver ponds also add to the aquatic habitat available for study.

6.3.14. Moscow, Idaho

Influence of plant disease on functional ecosystems of western coniferous biomes: A problem analysis. University of Idaho and Intermountain Forest and Range Experiment Station USDA Forest Service. Disease influence information review and modeling.

No program statement on the problem analysis of the influence of diseases in coniferous forest ecosystems has been assembled to date, except for the statement in subproject 66 (see section 5). Considerable effort will be made by a working group of scientists at the University of Idaho and Washington State University during 1972 to develop such a program statement. To assist these efforts, based mainly on institutional funding, the Coniferous Biome will conduct a workshop to draw on expertise from elsewhere in the Biome region.

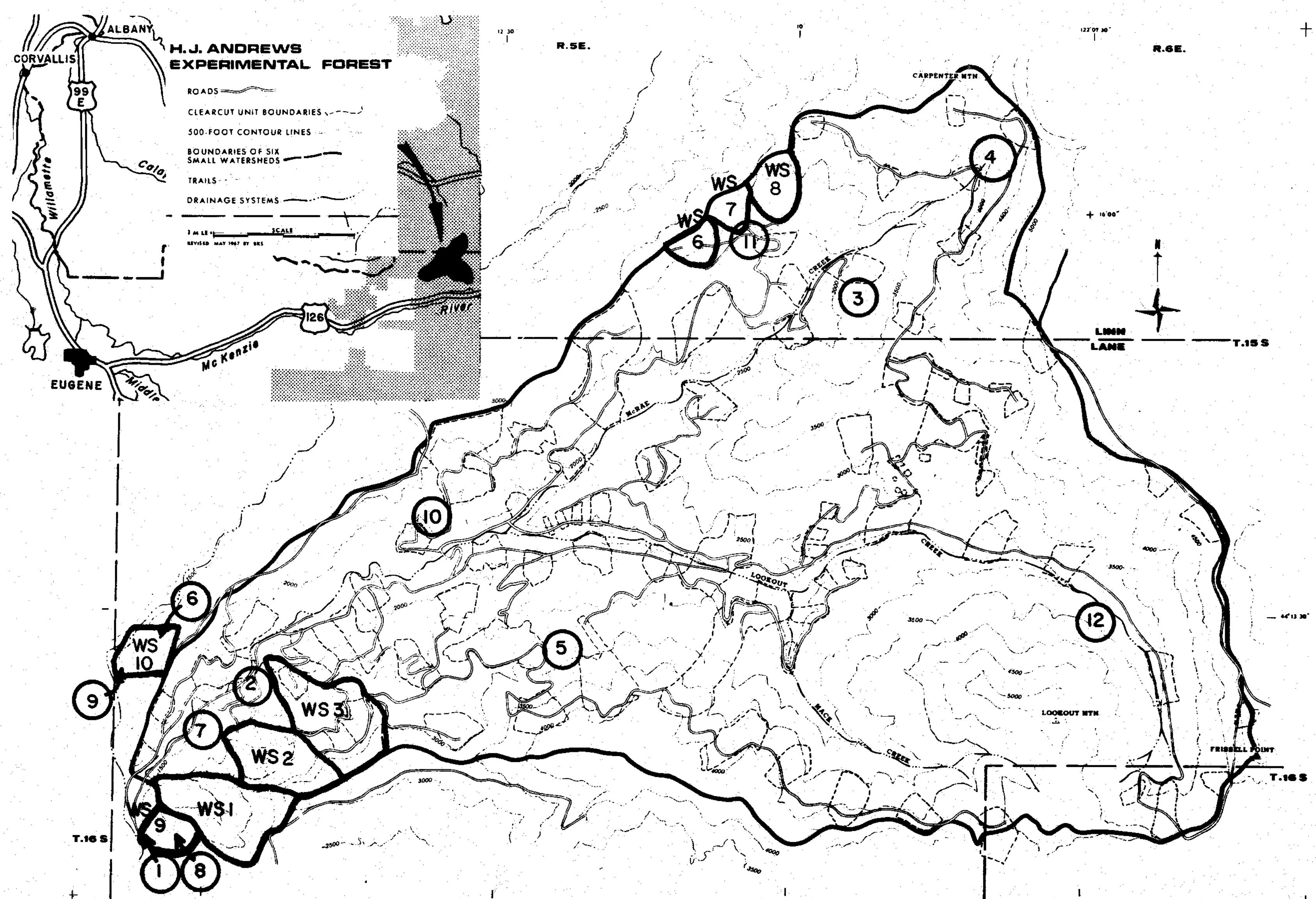

Figure 6.1. Map of the H. J. Andrews Experimental Forest showing the location of the eight gaged unit watersheds, and the reference stands.

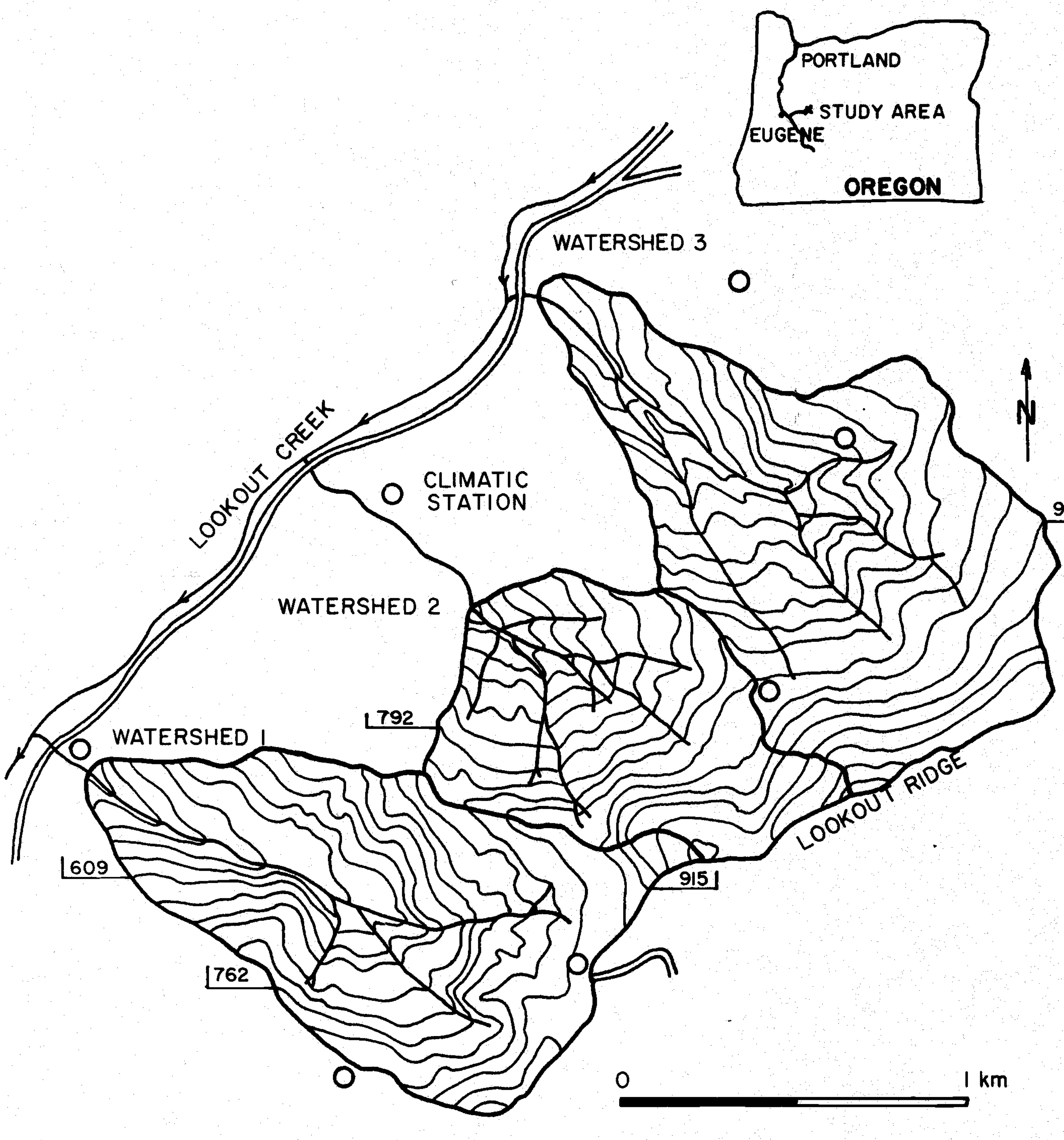

Figure 6.2. Experimental watersheds 1 to 3, H. J. Andrews Experimental Forest. Contour interval = 30 m. ○ indicates location of precipitation gages.

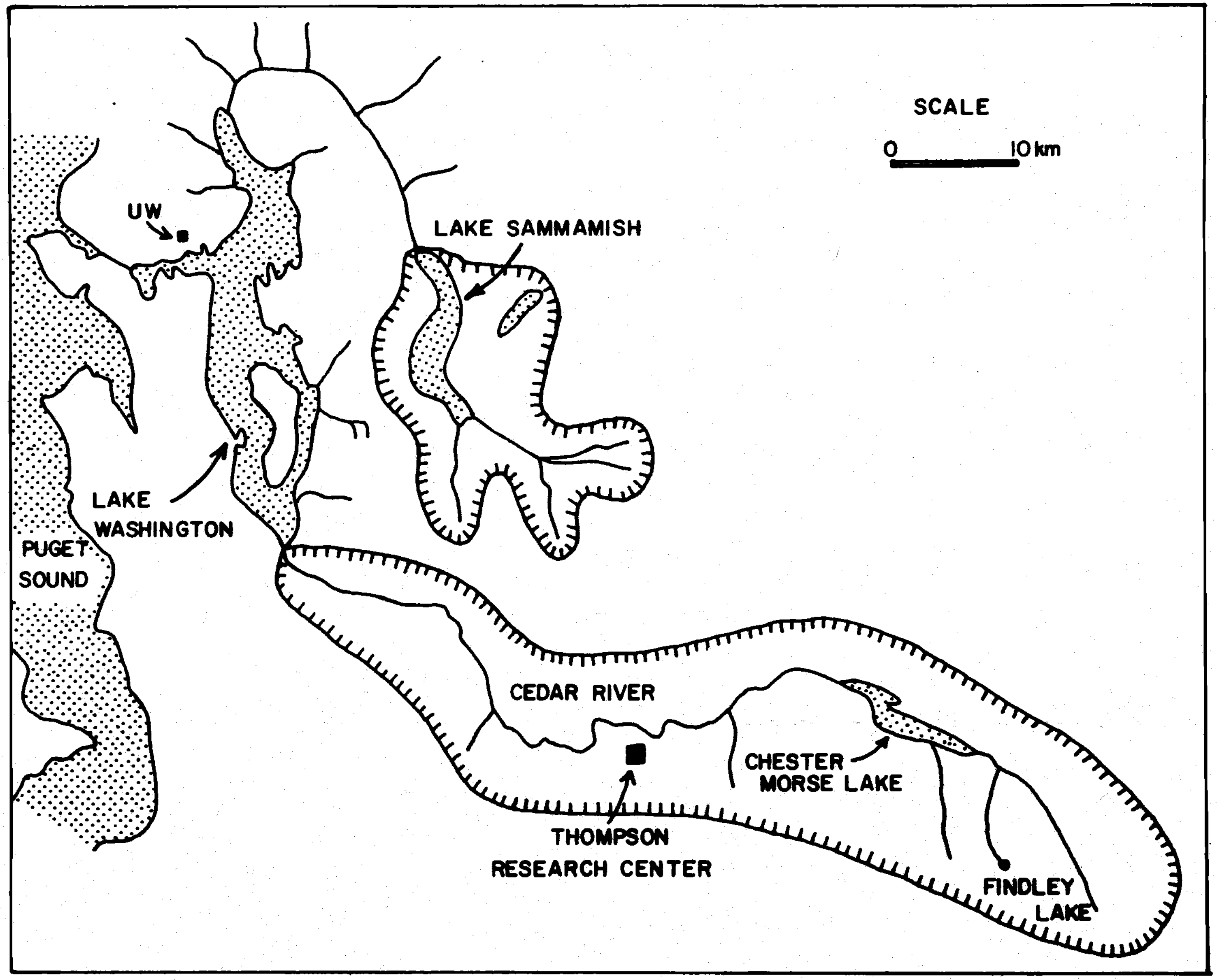

Figure 6.3. Location map, Cedar River--Lake Washington drainage area, southeast of Seattle, Washington.

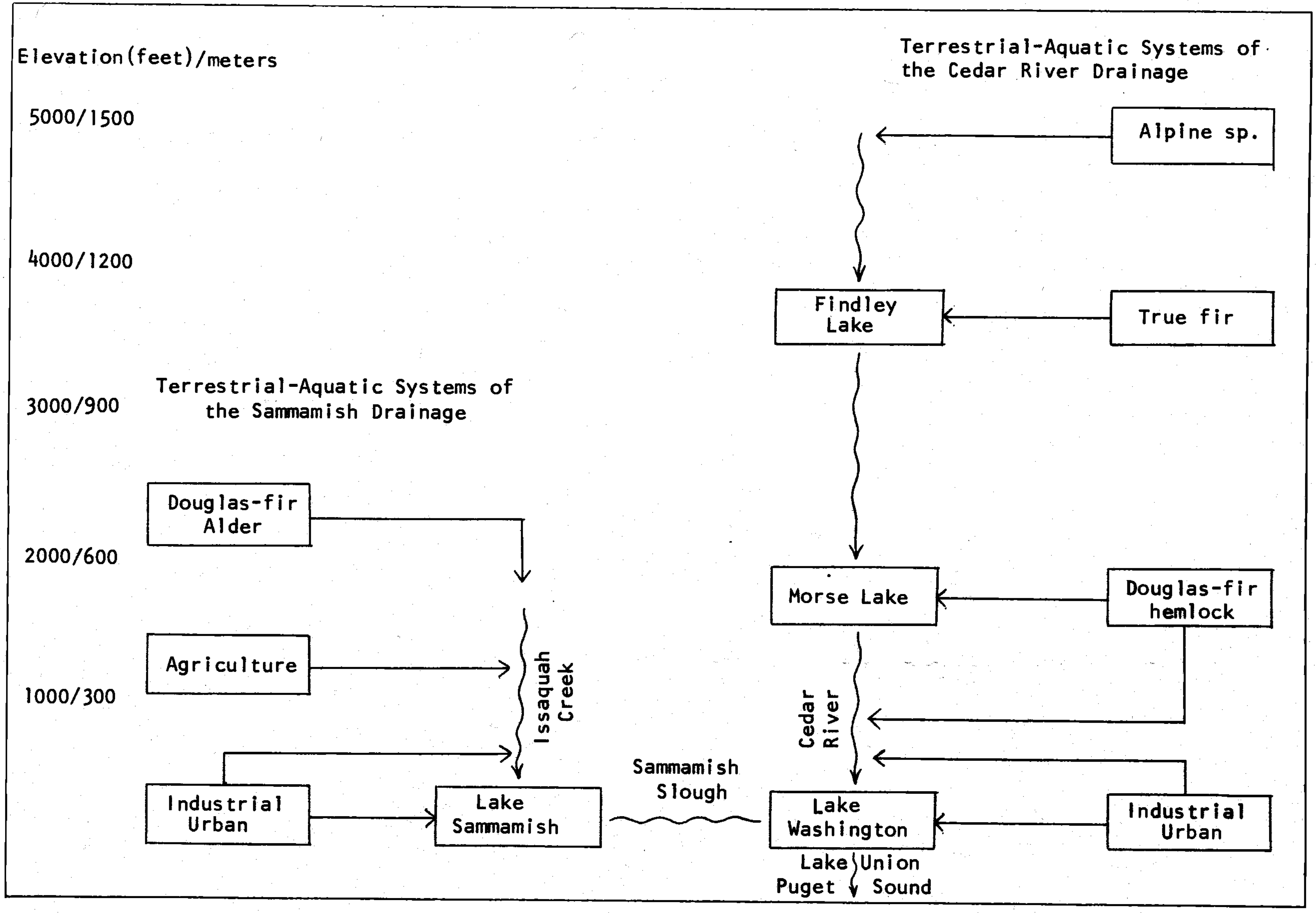

Figure 6.4. Principal components and pathways of transfer in the Lake Washington drainage basin.

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*Some works cited in the text of the proposal are not included in this list because the necessary information was unavailable at the time of publication.

8. PARTICIPANTS

8.1. List of Participants

	Project	
Anderson, N. H.	(60)	Department of Entomology, Oregon State University
Bare, B. B.	(74)	Center for Quantitative Sciences, Univ. Washington
Behan, M. J.	(62)	Department of Botany, University of Montana
Bell, J. F.	(8)	School of Forestry, Oregon State University
Belt, G. H.	(40,43, 44)	College of Forestry, Wildlife and Range Sciences, University of Idaho
Bollinger, J. A.	(46)	Institute for Freshwater Studies, Western Washington State College
Brown, G. W.		School of Forestry, Oregon State University
Brown, H. E.	(71)	USDA Forest Service, Flagstaff, Arizona
Burges, S. J.	(35)	Department of Civil Engineering, University of Washington
Burgner, B. L.	(57)	College of Fisheries, University of Washington
Burgy, R. H.		Department of Water Science and Engineering, University of California, Davis
Carroll, G. C.	(27,28)	Department of Biology, University of Oregon
Chapman, D. G.	(1)	College of Fisheries, University of Washington
Chen, C.-L.	(38)	Department of Civil Engineering, Utah State University
Christman, R. F.	(48)	Department of Civil Engineering, University of Washington
Cole, D. W.	(18,19,75)	College of Forest Resources, University of Washington
Colwell, R.		University of California, Berkeley
Daniel, T. W.	(63)	Department of Forest Science, Utah State University
Daterman, G. E.	(14)	USDA Forest Service, Corvallis, Oregon
Davis, G. E.	(2)	Department of Fisheries and Wildlife, Oregon State University
DeByle, N. V.	(69)	USDA Forest Service, Logan, Utah

DeLacy, A. C.	(58)	College of Fisheries, University of Washington
Del Moral, R.	(11)	Department of Botany, University of Washington
Denison, W. C.	(28,29, 33,60)	Department of Botany,and Plant Pathology, Oregon State University
Dirmhirn, I.	(41)	Department of Soils and Meteorology, Utah State University
Dix, R. L.		Department of Botany and Plant Pathology, Colorado State University
Donaldson, J. R.	(60)	Department of Fisheries and Wildlife, Oregon State University
Driver, C. H.	(27,29)	College of Forest Resources, University of Washington
Dyrness, C. T.	(9,12)	USDA Forest Service, Corvallis; Department of Soils, Orègon State University
Emmingman, W. H.	(6)	School of Forestry, Oregon State University
Fechner, G. H.		Forest and Wood Sciences Department, Colorado State University
Forcier, L. K.	(67)	School of Forestry, University of Montana
Franklin, J. F.	(9,11, 12,76)	USDA Forest Service, Corvallis; School of Forestry, Oregon State University
Fredriksen, R. L.	(20,60)	USDA Forest Service, Corvallis; School of Forestry, Oregon State University
Fritschen, L. J.	(36,43)	College of Forest Resources, University of Washington
Gara, R. I.	(13,52)	College of Forest Resources, University of Washington
Gaufin, A. R.	(61,68)	Department of Biology, University of Utah
Gay, L. W.	(40,43,44)	School of Forestry, Oregon State University
Gessel, S. P.	(18,19,76)	College of Forest Resources, University of Washington
Gilmour, C. M.	(30)	Department of Bacteriology, University of Idaho
Grier, C. E.	(31)	College of Forest Resources, University of Washington
Hall, J. D.	(60)	Department of Fisheries and Wildlife, Oregon State University
Harris, P. W.		USDA Forest Service, Ogden, Utah

Hamerly, Eddie		Center for Quantitative Sciences, University of Washington
Harr, R. D.	(37)	School of Forestry, Oregon State University
Hart, G. E.	(63,64,69)	Department of Forest Science, Utah State University
Hatheway, W. H.	(1)	College of Forest Resources and Center for Quantitative Sciences, University of Washington
Hawkins, R. H.	(38,64)	Department of Forest Science, Utah State University
Haydu, E. P.	(65)	Weyerhaeuser Company, Longview, Washington
Helms, J. A.	(3)	School of Forestry and Conservation, University of California, Berkeley
Hermann, R.	(10)	School of Forestry, Oregon State University
Hett, J.		Oak Ridge National Laboratory
Israelson, E. K.		Department of Civil Engineering, Utah State University
Jensen, H. J.	(32)	Department of Botany and Plant Pathology, Oregon State University
Johnson, F. D.	(70)	University of Idaho
Jordan, C. F.		Argonne National Laboratory
Kays, M. A.	(21)	Department of Geology, University of Oregon
Klein, D. A.		Department of Microbiology, Colorado State University
Kline, J. R.		Argonne National Laboratory
Knox, E.		Department of Soils, Oregon State University
Knudsen, G. M.		School of Forestry, University of Montana
Krantz, G. W.	(32)	Department of Entomology, Oregon State University
Kurmes, E. A.	(71)	School of Forestry, Northern Arizona University
Lavender, D. P.	(8,33)	School of Forestry, Oregon State University
Laycock, W. A.		USDA Forest Service, Logan, Utah
Leaphart, C. D.		USDA Forest Service, Missoula, Montana
Lighthart, B.	(45,46)	Institute for Freshwater Studies, Western Washington State College

Lyford, J. H., Jr.	(60)	Department of Botany and Plant Pathology, Oregon State University
Lyon, J.		USDA Forest Service, Missoula, Montana
McCaughran, D. A.	(17)	Center for Quantitative Sciences, University of Washington
McKee, A.		Oregon State University
Male, L.		Center for Quantitative Sciences, University of Washington
Matches, J. R.	(53)	College of Fisheries, University of Washington
Meiman, J. R.	(72)	Department of Watershed Sciences, Colorado State University
Mogren, E. W.	(72)	Department of Forest and Wood Sciences, Colorado State University
Monahan, J.		Cedar River Watershed, North Bend, Washington
Moore, D. G.	(20)	Department of Soils, Oregon State University; USDA Forest Service, Corvallis
Mullooly, J. P.	(2)	Department of Statistics, Oregon State University
Nagel, W. P.	(14)	Department of Entomology, Oregon State University
Nellis, C. H.		College of Forest Resources, University of Washington
Newton, M.		School of Forestry, Oregon State University
Nussbaum, R.	(15,16)	Department of Zoology, Oregon State University
Olson, P. R.	(51,54)	College of Forest Resources and College of Fisheries, University of Washington
Overton, W. S.	(1,16)	School of Forestry, Oregon State University
Packard, T. T.	(47)	Department of Oceanogrpahy, University of Washington
Pamatmat, M. M.	(55)	Department of Oceanography, University of Washington
Partridge, A. D.	(66)	College of Forestry, Wildlife and Range Sciences, University of Idaho
Paulson, D. R.		Department of Zoology, University of Washington
Philpot, C. W.		USDA Forest Service, Missoula, Montana

Pike, L. H.	(34)	Department of Botany, Oregon State University
Pitman, G. B.	(13)	Boyce Thompson Institute for Plant Research, Grass Valley, California
Porter, S. C.	(22)	Quaternary Research Center, University of Washington
Rains, D. W.		Department of Agronomy and Range Science, University of California, Davis
Reed, K. L.	(4,5)	College of Forest Resources, University of Washington
Reid, C. P. P.		Department of Forest and Wood Sciences, Colorado State University
Riekerk, H.		College of Forest Resources, University of Washington
Riley, J. P.	(38)	Department of Civil Engineering, Utah State University
Rogers, D. E.		College of Fisheries, University of Washington
Rothacher, J.		School of Forestry, Oregon State University; USDA Forest Service, Corvallis.
Scott, D. R. M.	(5,11)	College of Forest Resources, University of Washington
Schubert, G. H.	(71)	USDA Forest Service, Flagstaff, Arizona
Sedell, J. R.	(33,60)	Department of Fisheries and Wildlife, Oregon State University
Singer, M. J.	(25,26)	College of Forest Resources, Universtiy of Washington
Shih, C.-C.	(38)	Utah State University
Spyridakis, D.	(48)	Department of Civil Engineering, University of Washington
Staebler, G. R.		Weyerhaeuser Company, Research Center, Centralia, Washington
Staley, J. T.	(49)	Department of Microbiology, University of Washington
Stark, D. W.		Life Sciences, University of Idaho
Steinhoff, H. W.	(73)	Department of Fishery and Wildlife Biology, Colorado State University
Stettler, R. F.		College of Forest Resources, University of Washington

Stober, Q. J.	(61)	College of Fisheries, University of Washington
Strand, M. A.	(16,23)	Department of Forest Management, Oregon State University
Swanson, F. J.	(21)	University of Oregon
Swanston, D. N.	(24)	USDA Forest Service, Corvallis,
Taber, R. D.	(17)	College of Forest Resources, University of Washington
Taub, F. B.	(49,56)	College of Fisheries, University of Washington
Teller, H. L.		Department of Watershed Sciences, Colorado State University
Thoone, R. E.	(57)	College of Fisheries, University of Washington
Tsukada, M.		Palynology-Botany, University of Washington
Trappe, J. M	(60)	School of Forestry, Oregon State University; USDA Forest Service, Corvallis
Ugolini, F. C.	(25,26)	College of Forest Resources, University of Washington
Van Cleve, K.		Department of Forestry, University of Alaska
Walker, R. B.	(5)	Department of Botany, University of Washington
Wambach, R. F.	(67)	School of Forestry, University of Montana
Waring, R. H.	(6,9,77)	School of Forestry, Oregon State University
Warren, C. E.	(2)	Department of Fisheries and Wildlife, Oregon State University
Webb, W. L.	(7)	School of Forestry, Oregon State University
Weisbrod, A. R.	(17)	College of Forest Resources, University of Washington
Wellner, C. A.	(70)	USDA Forest Service, Moscow, Idaho
Welch, E. B.	(50,51)	Department of Civil Engineering, University of Washington
Whitney, R. R.	(59)	College of Fisheries, University of Washington
Wicker, E. F.		USDA Forest Service, Moscow, Idaho
Wickman, B. E.	(14)	USDA Forest Service, Corvallis, Oregon
Wooldridge, D. D.	(39)	College of Forest Resources, University of Washington

Wootton, D. R.		School of Graduate Studies, Chico State College
Wydoski, R. S.	(59)	College of Fisheries, University of Washington
Youngberg, C. T.	(30)	Department of Soils, Oregon State University
Zinke, P. J.		School of Forestry, University of California, Berkeley
Zobel, D. B.	(12)	Department of Botany, Oregon State University

8.2. Curriculum Vitae

Name: Norman H. Anderson

Title: Associate Professor

Mailing Address: Department of Entomology
Oregon State University
Corvallis, OR 97331

Born: Edam, Saskatchewan, March 17, 1933

Academic Training:

B.S.A.	1955	University of British Columbia
M.S.	1958	Oregon State University
D.I.C., Ph.D.	1961	University of London, Imperial College

Professional Experience:

1955-57	Research Officer, Biological Control Unit, Canada Department of Agriculture
1958-62	Research Officer, Canada Department of Agriculture, Entomology Research Institute, Belleville, Ontario
1962-67	Assistant Professor, Oregon State University
1967-	Associate Professor, Oregon State University

Publications (recent, relevant):

1962. Growth and fecundity of Anthocoris spp. reared on various prey (Heteroptera: Anthocoridae). Entomol. Exp. Appl. 5:40-52.

1966. Depressant effect of moonlight on activity of aquatic insects. Nature (Lond.) 209:319-320.

1968. (with D. M. Lehmkuhl) Catastrophic drift of insects in a woodland stream. Ecology 49:198-206.

1969. (with K. M. Azam) Life history and habits of Sialis rotunda and S. californica in western Oregon. Ann. Entomol. Soc. Am. 62:549-558.

Name: B. Bruce Bare

Title: Assistant Professor

Mailing Address: Center for Quantitative Science
University of Washington AT-10
Seattle, WA 98195

Born: South Bend, Indiana, April 24, 1942

Academic Training:

B.S.	1964	Purdue University
M.S.	1966	University of Minnesota
Ph.D.	1969	Purdue University

Professional Experience:

1968-69	Instructor in Forestry, Purdue University
1969-	Assistant Professor, University of Washington

Publications (recent, relevant):

1965. (with Richard Smith) The systems concept in error checking. Proceedings: Conference on Continuous Forest Inventory, p. 143-150. Michigan Technological University, May 6, 1965.

1968. (with Bob Stone) A computer program for displaying forest survey type information. Research Note NC-45. North Central Forest Experiment Station, St. Paul, Minnesota. 4 p.

1969. (with Eldon L. Norman) An evaluation of integer programming in forest production scheduling problems. Research Bulletin No. 847. Purdue University Agricultural Station, Lafayette, Indiana. 7 p.

1971. Applications of operations research in forest management: A survey. Quantitative Science Paper No. 26. Center for Quantitative Sciences, University of Washington. 57 p. (Mimeo.) (Presented at American Statistical Association Meeting, Fort Collins, Colorado, August 24, 1971.)

1971. Computerized forest resource management game: An assessment and overview. Quantitative Science Paper No. 30. Center for Quantitative Sciences, University of Washington. 17 p. (Mimeo.) (Presented at Computer and Information Systems in Resources Management Decisions Workshop, SAF Annual Convention, September 30, 1971, Cleveland, Ohio.)

-----. The application of simulation in forest management. Proceedings of IV Forestry Symposium, Federal University of Vicosa, Minas Gerais, Brazil, September 1970 (in press).

Name: Mark J. Behan

Title: Associate Professor

Mailing Address: Department of Botany
University of Montana
Missoula, MT 59801

Born: Denver, Colorado, January 17, 1931

Academic Training:

B.A.	1954	University of Denver
M.S.	1958	University of Wyoming
Ph.D.	1963	University of Washington

Professional Experience:

1962- Assistant to Associate Professor, University of Montana

1970- Chairman, Wildlife Biology Program, University of Montana

Publications (recent, relevant):

1968. Diagnosis of mineral deficiency in western larch by visual symptoms. Mont. For. Conserv. Exp. Stn. Bull. 34.

1969. Anatomy and physical properties of two-year western larch seedlings grown in mineral deficient solutions. For. Prod. J. 19:28-31.

1970. Rapid wet ash digestion of coniferous foliage for analysis of potassium, phosphorous, calcium, and magnesium. Mont. For. Conserv. Stn. Bull. 39.

1970. Mineral and energy cycles in forest ecosystems. IN: Role of Fire in the Intermountain West, p. 11-30. Intermountain Fire Research Council, Missoula, Montana.

1971. Ecological compartmentation of airborne cadmium in a grassland ecosystem. Am. J. Bot. 58:476 (Abstract).

Name: John F. Bell

Title: Associate Professor

Mailing Address: Forest Research Laboratory
School of Forestry
Oregon State University
Corvallis, OR 97331

Born: January 7, 1924

Academic Training:

B.S.	1949	Oregon State University
M.S.	1951	Duke University
Ph.D.	1970	University of Michigan

Professional Experience:

1949-59	State Forestry Department, State of Oregon
1959-64	Assistant Professor, Oregon State University
1964-	Associate Professor, Oregon State University

Publications (recent, relevant):

1971. (with W. A. Groman) A field test of the accuracy of the Barr and Stroud optical dendrometer. Forestry Chronicle.

1971. (with J. R. Dilworth) Variable probability sampling. Oregon State Univ. Bookstores, Inc., Corvallis.

Name: George H. Belt

Title: Associate Professor

Mailing Address: College of Forestry, Wildlife, and Range Sciences
University of Idaho
Moscow, ID 83843

Born: Washington, D.C., January 28, 1938

Academic Training:

B.S.	1960	North Carolina State College
M.F.	1962	Yale University
D.F.	1968	Duke University

Professional Experience:

1965- Associate Professor, University of Idaho

Publications (recent, relevant):

1970. Spring evapotranspiration from low sagebrush range in southern Idaho. Water Resource Inst., Univ. Idaho, Tech. Completion Rep. A-014-Ida.

1971. (with I. Dirmhirn) Variation in albedo of selected sagebrush range in the Intermountain Region. Agric. Meteorol. 9:51-61.

Name: John A. Bollinger

Title: Research Associate

Mailing Address: Institute for Freshwater Studies
Western Washington State College
Bellingham, WA 98225

Born: Detroit, Michigan, August 22, 1940

Academic Training:

A.B.	1963	San Diego State College
Ph.D.	1970	University of California, Berkeley

Professional Experience:

1958-62	Laboratory, field, and research assistant in icthyology, San Diego State College
1959	Laboratory and field assistant in field zoology, San Diego State College
1959-64	Research Assistant in ichthyology (variation and systematics of the Achiridae), Scripps Institution of Oceanography.
1966	Teaching assistant in general biology, University of California, Berkeley
1966	Laboratory assistant in industrial toxicology, Diablo Laboratories, Berkeley
1967	Field assistant in pollution biology, Institute of Marine Resources, University of California, Berkeley
1967-69	Reader in cell biology, University of California, Berkeley
1970	Postdoctorate in cell biology, University of California, Berkeley
1970-71	Postdoctorate in ecology, New University of Ulster, Coleraine, Northern Ireland

Name: George W. Brown

Title: Associate Professor

Mailing Address: Forestry Research Laboratory
School of Forestry
Oregon State University
Corvallis, OR 97331

Born Warrensburg, Missouri, January 31, 1939

Academic Training:

B.S.	1960	Colorado State University
M.S.	1962	Colorado State University
Ph.D.	1967	Oregon State University

Professional Experience:

1966- Assistant Professor to Associate Professor, Oregon State University

Publications (recent, relevant):

1962. Piping erosion in Colorado. J. Soil Water Conserv. 17:220-222.

1967. (with J. T. Krygier) Changing water temperatures in small mountain streams. J. Soil Water Conserv. 22:

1969. Predicting temperatures of small streams. Water Resour. Res. 5:

1970. Predicting the effect of clearcutting on stream temperature. J. Soil Water Conserv. 25:11-13.

1970. (with J. T. Krygier) Effects of clearcutting on stream temperature. Water Resour. Res. 6:1133-1140.

1971. (with J. T. Krygier) Clearcut logging and sediment production in the Oregon Coast Range. Water Resour. Res. 7:1189-1199.

Name: Harry E. Brown

Title: Research Forester

Mailing Address: Rocky Mountain Forest and Range Experiment Station
USDA Forest Service
Flagstaff, AZ 86001

Born: July 19, 1924

Academic Training:

B.S.	1947	University of Illinois
M.F.	1950	Colorado State University

Professional Experience:

1950- Research and research administration in watershed and multiple use management

Publications (recent, relevant):

1962. The canopy camera. USDA For. Serv., Rocky Mt. For. Range Exp. Stn. Pap. 72. 22 p.

1965. Characteristics of recession flows from small watersheds in a semiarid region of Arizona. Water Resour. Res. 1:517-522.

1965. Preliminary results of cabling Utah juniper, Beaver Creek watershed evaluation project. Ariz. Watershed Symp. Proc. 9:16-20.

1965. Some applications of the canopy camera in forestry. J. For. 63:674-680.

1969. A combined control-metering section for gaging large streams. Water Resour. Res. 5:888-894.

1970. A system for measuring total sediment yield from small watersheds. Water Resour. Res. 6:818-826.

1970. Status of pilot watershed studies in Arizona. J. Irrig. Drain. Div. ASCE 96(IR1):11-23.

1971. Evaluating watershed management alternatives. J. Irrig. Drain. Div. ASCE 97(IR1):93-108.

Name: Stephen John Burges

Title: Assistant Professor

Mailing Address: Department of Civil Engineering
University of Washington WD-10
WD-10 Seattle, WA 98195

Born: Newcastle, Australia, August 26, 1944

Academic Training:

B.S.	1967	University of Newcastle
B.E.	1967	University of Newcastle
M.S.	1968	Stanford University
Ph.D.	1970	Stanford University

Professional Experience:

1966-67	Assistant Construction Engineer, The Hunter District Water Board, Australia
1967-68	Research Assistant, Hydraulic Laboratory, Stanford University
1968-70	Research Assistant, Department of Civil Engineering, Stanford University
1970-	Assistant Professor of Civil Engineering, University of Washington

Publications (recent, relevant):

1969. (with R. K. Linsley and P. W. Whitford) An evaluation of the decision process in water resources project design. Technical Report 122, Department of Civil Engineering, Stanford University, California.

1970. Use of stochastic hydrology to determine storage requirements of reservoirs--A critical analysis. Report EEP 34, Program on Engineering Economic Planning, Department of Civil Engineering, Stanford University, California.

1971. Use of autoregressive runoff models in reservoir studies. Proc. IASPS Symposium on Statistical Hydrology, Tucson, Arizona. August 29-September 2.

1971. (with R. K. Linsley) Some factors influencing required reservoir storage. J. Hydraul. Div. ASCE 97: 977-991.

Name: Robert L. Burgner

Title: Director, Professor

Mailing Address: Fisheries Research Institute
University of Washington WH-10
Seattle, WA 98195

Born: Yakima, Washington, January 16, 1919

Academic Training:

B.S.	1942	University of Washington
Ph.D.	1958	University of Washington

Professional Experience:

1946-55	Biologist, University of Washington
1948-54	Assistant to Director, FRI, University of Washington
1955-66	Assistant Director, FRI, University of Washington
1955-64	Research Associate Professor, University of Washington
1964-67	Associate Professor, University of Washington
1967-	Director, FRI, University of Washington
1967-	Professor, University of Washington
1967-	Scientific Advisor, U.S. Section International North Pacific Fisheries Commission

Publications (recent, relevant):

1966. Food production in two lake chains of southwestern Alaska. Proc. Int. Soc. Theor. Appl. Limnol. 16:1036-1043.

1968. Further studies on Alaska sockeye salmon (ed.). Univ. Wash. Publ. Fish. New Ser. Vol. 3. 267 p.

1969. (with C. J. Dicostanzo and others) Biological studies and estimates of optimum escapements of sockeye salmon in the major river systems in southwestern Alaska. U.S. Fish. Wildl. Serv. Fish. Bull. 67:405-459.

1972. (with W. L. Hartman) Limnology and fish ecology of sockeye salmon nursery lakes of the world. J. Fish. Res. Board Can. 29: (in press).

Name: George C. Carroll

Title: Assistant Professor

Mailing Address: Department of Biology
University of Oregon
Eugene, OR 97403

Born: Alton, Illinois, February 11, 1940.

Academic Training:

B.A.	1962	Swarthmore College
	1962-63	Copenhagen University
Ph.D.	1966	University of Texas

Professional Experience:

1962-66	NSF Predoctoral Fellow, University of Texas
1966-67	Research Scientist and Assistant Instructor, University of Texas
1967-	Assistant Professor, University of Oregon

Publications (recent, relevant):

1966. (with W. C. Denison) The primitive ascomycete: A new look at an old problem. Mycologia 58:249-269.

1968. (with D. M. Brenner) Fine-structural correlates of growth in hyphae of *Ascodesmis sphaerospora*. J. Bacteriol. 95:658-671.

1971. (with F. E. Carroll) Fine structural studies on poroconidium formation in *Stemphylium botryosum*. Proc. Kananaskis Conf. Nomencl. Taxon. Hyphomycetes (in press).

Name: Doulgas G. Chapman

Title: Professor, Director

Mailing Address: Center for Quantitative Science
University of Washington AT-10
Seattle, WA 98195

Born: Provost, Alberta, March 20, 1920.

Academic Training:

B.A.	1939	University of Saskatchewan
M.A.	1940	University of California, Berkeley
Ph.D.	1949	University of California, Berkeley

Professional Experience:

1946-48	Assistant Professor, University of British Columbia
1948-49	Research Assistant, University of California, Berkeley
1949-53	Assistant Professor, University of Washington
1954-55	Guggenheim Fellow, Oxford University
1953-57	Associate Professor, University of Washington
1958-59	Visiting Professor, Institute of Statistics, North Carolina State College
1963-64	Visiting Research Associate, University of California, San Diego
1957-	Professor, University of Washington
1964-69	Chairman, Biomathematics Group, University of Washington
1965-	Chairman, Scientific Committee, International Whaling Commission
1968-	Director, CQS, University of Washington

Publications (recent, relevant):

1966. (with W. S. Overton) Estimating and testing differences between population levels by the Schnable estimation method. J. Wildl. Manage. 30:173-180.

1967. Stochastic models in animal population ecology. Sixth Symp. Math. Stat. and Probab. 4:147-162.

1969. Statistical problems in the optimum utilization of fisheries resources. Int. Stat. inst. Bull. 42:268-290.

Name: Cheng-lung Chen

Title: Professor

Mailing Address: Utah Water Research Laboratory
Department of Civil Engineering
Utah State University
Logan, UT 84321

Born. Taiwan, Republic of China, November 1, 1931

Academic Training:

B.S.	1954	National Taiwan University
M.S.	1960	Michigan State University
Ph.D.	1962	Michigan State University

Professional Experience:

1955-58	Assistant Engineer, Taiwan Water Conservance Bureau
1958-62	Graduate Research Assistant, Michigan State University
1962-63	Research Associate, Michigan State University
1963-64	Associate Research Engineer, Utah State University
1964-65	Assistant Professor, Utah State University
1965-66	Associate Professor, Utah State University
1966-69	Associate Professor, University of Illinois
1969-	Professor, Utah State University

Publications (recent, relevant):

1970. Surface irrigation using kinematic-wave method. J. Irrig. Drain. Div. ASCE 96(IR1):39-46.

1971. Fate of thermally-polluted surface water in rivers. J. Sanit. Eng. Div. ASCE 97 (SA5):311-331.

1971. Sediment dispersion in flow with moving boundaries. J. Hydraul. Div. ASCE 97 (HY8):1181-1201.

1971. A note on stochastic models for hydraulic systems. Proc. Int. Symp. Stochastic Hydraul., p. 735-738. Univ. of Pittsburg, Pittsburg, Pa.

1971. (with V. T. Chow) Formulation of a mathematical watershed flow model. J. Eng. Mech. Div. ASCE 97 (EM3):809-828.

Name: Russell F. Christman

Title: Associate Professor

Mailing Address: Department of Civil Engineering
University of Washington FV-10
Seattle, WA 98195

Born: Moblie, Alabama, June 30, 1936

Academic Training:

B.S.	1958	University of Florida
M.S.	1960	University of Florida
Ph.D.	1962	University of Florida

Professional Experience:

1960-62	Research Associate, University of Florida
1962-66	Research Assistant Professor, University of Washington
1966-68	Assistant Professor, University of Washington
1968-	Associate Professor, University of Washington
1970-	Special Assistant to the Provost for Environmental Affairs, University of Washington

Publications (recent, relevant):

1966. (with M. Ghassemi) The nature of organic color in water. J. Am. Water Works Assoc. 58:723.

1967. (with R. A. Minear) Fluorometric detection of lignin sulfonates. Eng. 19.

1967. (with R. T. Oglesby) Microbiological degradation of lignin and the formation of humus. IN: K. V. Sarkanen (ed.), Lignins, chemistry and utilization. Interscience, New York.

Name: Dale W. Cole

Title: Associate Professor

Mailing Address: College of Forest Resources
University of Washington AR-10
Seattle, WA 98195

Born: Everett, Washington, May 28, 1931

Academic Training:

B.S.	1955	University of Washington
M.S.	1957	University of Wisconsin
Ph.D.	1963	University of Washington

Professional Experience:

1960-64	Research Associate, University of Washington
1964-65	Acting Instructor and Research Instructor, University of Washington
1965-	Assistant Professor to Associate Professor, University of Washington
1968-	Associate Director of the Organization for Tropical Studies

Publications (recent, relevant):

1967. (with S. P. Gessel, and S. F. Dice) Distribution and cycling of nitrogen, phosphorus, potassium and calcium in a second-growth Douglas-fir ecosystem. IN: Symp. Primary Productivity and Mineral Cycling in Natural Ecosystems, p. 197-233. Am. Assoc. Adv. Sci. Thirteenth Ann. Meet., New York, December 1967. Univ. Maine Press, Orono.

1968. (with S. P. Gessel) Cedar River research--A program for studying pathways, rates, and processes of elemental cycling in a forest ecosystem. Univ. Wash. Coll. For. Resour., For. Resour. Monogr. Contrib. No. 4. 53 p.

1968. (with J. G. McColl) A mechanism of cation transport in a forest soil. Northwest Sci. 42:134-140.

1968. A system for measuring conductivity, acidity, and rate of water flow in a forest soil. Water Resour. Res. 4:1127-1136.

1969. (with S. F. Dice) Biomass and nutrient flux in coniferous forest ecosystems: The development of a quantitative ecological approach. IN: R. D. Taber (ed.), Coniferous Forests of the Northern Rocky Mountains, p. 55-70. Univ. Montana Foundation, Missoula.

Name: T. W. Daniel

Title: Professor of Silviculture

Mailing Address: Department of Forest Science
College of Natural Resources
Utah State University
Logan, UT 84322

Born: San Francisco, California, November 16, 1907

Academic Training:

B.S.	1934	University of California, Berkeley
M.S.	1936	University of California, Berkeley
Ph.D.	1942	University of California, Berkeley

Professional Experience:

1935-41	California Forest and Range Experiment Station, USDA Forest Service, Berkeley, California
1941-44	Washington State Agricultural College, Puyallup, Washington
1944-	Professor, Utah State University

Publications (recent, relevant):

1966. (with R. J. Rivers, H. E. Isaacson, E. J. Eberhard, and A. D. LeBaron) The ecology of the pinyon-juniper type of the Colorado Plateau and the Basin and Range Provinces. Utah St. Agric. Exp. Sta. Pub. 242 p.

1966. Duff--A lethal seedbed for overwinter Engelmann spruce. Proc. Sixth World For. Congr., Madrid 2:1420-1424.

1967. A hypothesis of non-dormancy in seed embryos. Proc. 14th IUFRO Congress, Munich 3:100-118.

1969. Virgin Abieti-Fagetum associations in Yugoslavia. Bull. Torrey Bot. Club 96:235-237.

1969. European vs. American forest practices, J. For. 67:550-553.

1972. (with Josef Schmitt) Lethal and non-lethal effects of the organic horizons of forested soils on the germination of seeds from several associated conifer species of the Rocky Mountains. Can. J. For. Res. (in press).

Name: Gary E. Daterman

Title: Research Entomologist

Mailing Address: USDA Forest Service
Pacific Northwest Forest and Range Experiment Station
Forestry Sciences Laboratory
P.O. Box 887
Corvallis, OR 97330

Born: Freeport, Illinois, June 26, 1939

Academic Training:

B.A.	1962	University of California, Davis
M.S.	1964	Oregon State University
Ph.D.	1969	Oregon State University

Professional Experience:

1965- Research Entomologist, USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, Corvallis

Publications (recent, relevant):

1964. (with J. A. Rudinsky) Field studies on flight patterns and olfactory responses of ambrosia beetles in Douglas-fir forests of western Oregon. Can. Entomol. 96:1339-1352.

1965. (with J. A. Rudinsky and W. P. Nagel) Flight patterns of bark and timber beetles associated with coniferous forests of western Oregon. Oreg. Agr. Exp. Stn. Tech. Bull. 87. 46 p.

1970. (with D. McComb) Female sex attractant for survey trapping European pine shoot moth. J. Econ. Entomol. 63:1406-1409.

Name: Gerald E. Davis

Title: Associate Professor

Mailing Address: Department of Fisheries and Wildlife
Oregon State University
Corvallis, OR 97331

Born:

Academic Training:

B.S.	1956	University of Washington
M.S.	1960	Oregon State University
Ph.D.	1963	Oregon State University

Professional Experience:

1956-58	Research Biologist, Fish Commission of Oregon
1962-63	Instructor in Fisheries, Oregon State University
1963-68	Assistant Professor, Oregon State University
1968-	Associate Professor, Oregon State University

Publications (recent, relevant):

1967. (with C. E. Warren) Laboratory studies of the feeding, bioenergetics and growth of fish. IN: S. D. Gerking (ed.), The biological basis of freshwater fish production, p. 175-214. Blackwell Scientific Publications, Oxford. 510 p.

1968. (with C. E. Warren) Estimation of food consumption rates. IN: W. E. Ricker (ed.), Methods for assessment of fish production in fresh waters. Blackwell Scientific Publications, Oxford. 313 p.

1968. (with R. W. Brocksen and C. E. Warren) Competition, food consumption, and production of sculpins and trout in laboratory stream communities. J. Wildl. Manage. 32:51-75.

1969. (with R. W. Brockson and B. E. Davis) The analyses of trophic processes on the basis of density-dependent functions. IN: Symp. on Marine Food Chains (Aarhus, Denmark). Univ. Calif. Press and Oliver and Boyd, London (in press).

Name: Norbert V. DeByle

Title: Principal Plant Ecologist

Mailing Address: USDA Forest Service
Intermountain Forest and Range Experiment Station
Forestry Sciences Laboratory
860 North 12th East
Logan, UT 84321

Born: Green Bay, Wisconsin, May 1, 1931

Academic Training:

B.S.	1953	University of Wisconsin, Madison
M.S.	1957	University of Wisconsin, Madison
Ph.D.	1962	University of Michigan, Ann Arbor

Professional Experience:

1961-64 Research Forester, Watershed Management, USDA Forest Service, Intermountain Forest and Range Experiment Station, Reno, Nevada

1964- Research Forester, USDA Forest Service, Intermountain Forest and Range Experiment Station, Logan, Utah

Publications (recent, relevant):

1964. Detection of functional intraclonal aspen root connections by tracers and excavation. For. Sci. 10:386-396.

1965. (with Robert Zahner) Effect of pruning the parent root on growth of aspen suckers. Ecology 46:373-375.

1969. Black polyethylene mulch increases survival and growth of a Jeffrey pine plantation. Tree Plant. Notes 19:7-11.

1969. (with Ronald K. Tew and John D. Schultz) Intraclonal root connections among quaking aspen trees. Ecology 50:920-921.

1970. Soil freezing determined with four types of water-filled tubes. USDA For. Serv. Intermt. For. Range Exp. Stn. Res. Note INT-127.

1970. Infiltration in contour trenches in the Sierra Nevada. USDA For. Ser. Internmt. For. Range Exp Stn. Res. Note INT-115.

Name: Allan C. DeLacy

Title: Professor

Mailing Address: College of **Fisheries**
University of Washington WH-10
Seattle, WA 98195

Born: May 21, 1912

Academic Training:

B.S.	1933	University of Washington
M.S.	1933	University of Washington
Ph.D.	1941	University of Washington

Professional Experience:

1937-42	Biologist, USFWS, Seattle
1943-46	Biologist, State of Washington
1946-	Professor, University of Washington

Name: Roger Del Moral

Title: Assistant Professor

Mailing Address: Department of Botany
University of Washington AK-10
Seattle, WA 98195

Born: Detroit, Michigan, September 13, 1943

Academic Training:

B.S.	1965	University of California, Santa Barbara
M.S.	1966	University of California, Santa Barbara
Ph.D.	1968	University of California, Santa Barbara

Professional Experience:

1965-66	NDEA Fellow, University of California
1967-68	NDEA Fellow, University of California
1966-67	Teaching Assistant, University of California
1967	(summer) NSF Summer Trainee, University of California
1968-	Assistant Professor, University of Washington

Publications (recent, relevant):

1966. (with C. H. Muller) Soil toxicity induced by terpenes from _Salvia leucophylla_. Bull. Torrey Bot. Club 93:130-137.

1969. (with C. H. Muller) Fog drip: A mechanism of toxin transport from _Eucalyptus globulus_. Bull. Torrey Bot. Club 96:467-476.

1970. (with C. H. Muller) The allelopathic effects of _Eucalyptus camaldulensis_. Am. Midl. Nat. 83:254-282.

1971. (with R. G. Cates) The allelopathic potential of vegetation of western Washington. Ecology 52:1030-1037.

1971. (with C. H. Muller) Role of animals in suppression of herbs by shrubs. Science 173:462-463.

1972. On the variability of chlorogenic acid concentration. Oecologia (in press).

1972. Diversity patterns in forest vegetation of the Wenatchee Mountains, Washington. Bull. Torrey Bot. Club 99 (in press).

1972. The vegetation of Findley Lake basin. Am. Midl. Nat. (in press).

----. Niche breadth and overlap among tree species in the Wenatchee Mountains, Washington. Submitted to Am. Nat.

Name: William C. Denison

Title: Associate Professor

Mailing Address: Department of Botany and Plant Pathology
Oregon State University
Corvallis, OR 97331

Born: Rochester, New York, June 1, 1928

Academic Training:

A.B.	1950	Oberlin College
M.S.	1952	Oberlin College
Ph.D.	1956	Cornell University

Professional Experience:

1955-60	Assistant to Associate Professor, Swarthmore College
1958-59	Visiting Assistant Professor, University of North Carolina
1960-66	Assistant Professor, Swarthmore College
1966-	Associate Professor, Oregon State University

Publications (recent, relevant):

1972. Delimitation of tribes and genera in the family Sarcoscyphaceae. IN: Taxonomy of operculate discomycetes. Persoonia (in press).

1972. Central American Pezizales. IV. The genera *Sarcoscypha*, *Pithya*, and *Nanoscypha*. Mycologia (in press, scheduled May-June issue).

1972. (with D. M. Tracy, F. M. Rhoades, and M. Sherwood) Direct, non-destructive measurement of biomass and structure in living, old-growth Douglas-fir. Proceedings--Research on coniferous forest ecosystems--A symposium, 23-24 March 1972, Bellingham, Wash. USDA Forest Service, Portland (in press).

1972. (with E. R. Florance and T. C. Allen) Ultrastructure of dormant and germinating conidia of *Aspergillus nidulans*. Mycologia 69:115-123.

Name: Inge Dirmhirn

Title: Professor

Mailing Address: Department of Soils and Meteorology
Utah State University
Logan, UT 84321

Academic Training:

Ph.D. 1950 University of Vienna

Professional Experience:

1948-63	Research Assistant, Research Associate, Research Meteorologist, and Acting Head of Department of Bioclimatology (1959-63) at Zentralanstalt fuer Meteorolgie u. G., Vienna, Austria.
1964	Project Associate Meteorologist, University of Wisconsin and Goddard Space Flight Center, Greenbelt, Maryland
1965-68	Associate Meteorologist, Colorado State University
1968	Professor, Utah State University

Publications (recent, relevant):

1961. Light intensity at different levels. III. IN: Entomological Studies from a High Tower in Mpanga Forest, Uganda. Trans. Entomol. Soc. London 113:270-274.

1964. Das Strahlungsfeld im Lebensraum (Environmental Radiation). Akademische Verlagsgesellschaft, Frankfurt am Main. 426 p.

1968. On the use of silicon cells in meteorological radiation studies. J. Appl. Meteorol. 7:702-707.

1971. (with G. H. Belt) Variation in albedo of selected sagebrush range in the Intermountain Region. Agric. Meteorol. (in press).

Name: Ralph L. Dix

Title: Professor

Mailing Address: Department of Botany and Plant Pathology
Colorado State University
Fort Collins, CO 80521

Born: 1924

Academic Training:

A.B.	1950	Catholic University of America
M.S.	1951	Catholic University of America
Ph.D.	1955	University of Wisconsin

Professional Experience:

1955-60	Assistant Professor, Marquette University
1960-67	Associate Professor, University of Saskatchewan
1967-	Professor, Colorado State University
1968-	Botanical Editor, ECOLOGY

Publications (recent, relevant):

1966. (with J. M. A. Swan) The phytosociological structure of upland forests at Candle Lake, Saskatchewan. J. Ecol. 54:13-42.

1967. (with F. Smeins) The prairie, meadow, and marsh vegetation of Nelson County, North Dakota. Can. J. Bot. 45:21-38.

1968. (with R. D. Newsome) The forests of the Cypress Hills, Alberta and Saskatchewan, Canada. Am. Midl.Nat. 80:118-185.

1969. (with R. G. Beidleman)(eds.) The grassland ecosystem: A preliminary synthesis. Range Science Series No. 2. Colorado State University, Fort Collins. 437 p.

1969. (with J. M. A. Swan and C. F. Wehrhahn) An ordination technique based on the best possible stand defined axes and its application to vegetational analyses. Ecology 50:206-212.

Name: John R. Donaldson

Title: Associate Professor

Mailing Address: Department of Fisheries and Wildlife
Oregon State University
Corvallis, OR 97331

Born: Helena, Montana, January 14, 1929

Academic Training:

B.S.	1951	University of Washington
M.S.	1954	University of Washington
Ph.D.	1966	University of Washington

Professional Experience:

1951-52	Fulbright scholarship, University of Oslo, Norway
1952-53	(summers) Fisheries Biologist, Washington State Department of Fisheries
1954-63	Aquatic Chemist, Washington State Department of Game
1963-66	Predoctoral Associate, University of Washington
1966-71	Assistant Professor, Oregon State University
1971-	Associate Professor, Oregon State University

Publications (recent, relevant):

1966. Hydromechanics of Iliamna Lake, Alaska, 1964 and 1965. Fish. Res. Inst., Coll. Fish. Univ. Wash. Circ. No. 66-10. 18 p.

1968. The status of Oregon lakes. IN: Seminar in Water and Environmental Quality, Water Resour. Res. Inst., Oregon State Univ., Corvallis.

1969. The classification of lakes. IN: Proceedings of the Eutrophication Biostimulation Assessment Workshop, Univ. Calif.

1969. (with Z. Short, F. Palumbo, and P. Olson) The uptake of iodine-131 by the biota of Fern Lake, Washington, in a laboratory and field experiment. Ecology 50:979-989.

1971. (ed.) Proceedings of the Third Sea Grant Conference, March 1970. Oregon State Univ.

1971. (with D. Larson) A compilation of the named lakes in Oregon with bibliography. Water Resour. Res. Inst., OSU, WRRI-8.

Name: Charles H. Driver III

Title: Professor

Mailing Address: College of Forest Resources
University of Washington AR-10
Seattle, WA 98195

Born: Orlando, Florida, October 12, 1921

Academic Training:

B.S.	1947	University of Georgia
M.S.	1950	University of Georgia
Ph.D.	1954	Louisiana State University

Professional Experience:

1952-54	AEC Research Fellow, Louisiana State University
1954-57	Project Leader, Paper Microbiology, Southern Kraft Division Research Department, International Paper Co.
1957-65	Director of Forestry Research, Woodlands Department, Southern Kraft Division, International Paper Co.
1965-	Professor, University of Washington

Publications (recent, relevant):

1967. (with R. T. Oglesby and R. F. Christman) The biotransformation of lignin to humus--Facts and postulates. Adv. Appl. Microbiol. 9:171-184.

1968. (with J. H. Ginns, Jr.) The influence of local environment on infection by _Fomes annosus_. Third Int. Conf. _Fomes annosus_. IUFRO Section 24. Copenhagen, August 1965.

1969. (with J. H. Ginns, Jr.) Annosus root-rot in slash pine plantations four years after thinning and stump treatments. Plant Dis. Rep. 53:23-25.

1969. (with J. H. Ginns, Jr.) Ecology of slash pine stumps fungal colonization and infection by _Fomes annosus_. For. Sci. 15:2-10.

Name: C. Theodore Dyrness

Title: Principal Soil Scientist and Associate Professor

Mailing Address: USDA Forest Service
Pacific Northwest Forest and Range Experiment Station
Forestry Sciences Laboratory
P.O. Box 887
Corvallis, OR 97330

Born: Chicago, Illinois, June 4, 1933

Academic Training:

B.S.	1954	Wheaton College
M.S.	1956	Oregon State University
Ph.D.	1960	Oregon State University

Professional Experience:

1959- Principal Soil Scientist, USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, Corvallis

1969- Associate Professor, Oregon State University

Publications (recent, relevant):

1966. (with C. T. Youngberg) Soil-vegetation relationships within the Ponderosa pine type in the central Oregon pumic region. Ecology 47:122-138.

1967. Erodibility and erosion potential of forest watersheds. IN: W. E. Sopper and H. W. Lull (eds.), Int. Symp. Forest Hydrol., p. 599-611. Pennsylvania State University, August 29-September 10, 1965. Permagon Press, New York. 813 p.

1969. (with J. F. Franklin) Vegetation of Oregon and Washington. USDA For. Serv., Northwest For. Range Exp. Stn. Res. Pap. PNW-80. 216 p.

Name: William H. Emmingham

Title: Research Associate

Mailing Address: School of Forestry
Oregon State Universtiy
Corvallis, OR 97331

Born: Kellogg, Idaho, March 7, 1939

Academic Training:

B.S.	1961	University of Idaho
Grad.	1965	U.S. Air Force Air Intelligence School
M.S.	1971	Oregon State University
Ph.D.	1972	Oregon State University

Professional Experience:

1962-68	Intelligence Officer, U.S. Air Force
1968-	Teaching/Research Assistant, University of Oregon

Publications (recent, relevant):

1972. (with R. H. Waring and K. L. Reed) An environmental grid for classifying coniferous forest ecosystems. Proceedings--Research on Coniferous Forest Ecosystems--A Symposium, 23-24 March 1972, Bellingham, Wash. USDA Forest Service, Portland (in press).

----. (with R. H. Waring) Conifer growth under different light environments in the Siskiyou Mountains of southwest Oregon. (MS submitted to Northwest Science.)

Name: Gilbert H. Fechner

Title: Professor of Forest Genetics

Mailing Address: Forest and Wood Sciences Department
Colorado State University
Fort Collins, CO 80521

Born: Northbrook, Illinois, December 20, 1922

Academic Training:

B.S.	1947	Colorado State University
M.S.	1955	Colorado State University
Ph.D.	1964	University of Minnesota

Professional Experience:

1954- Instructor, Assistant Professor, Associate Professor to Professor, Colorado State University

1964- Project Leader, Genetic characteristics of Rocky Mountain Forest trees, McIntire-Stennis Cooperative Forestry Projects, Colorado Agricultural Experiment Station, Fort Collins

Publications (recent, relevant):

1963. Some ethical concepts for conduct and decision. CSU Forester, vol. 26, 1962-63.

1965. What kind and how much in Dendrology? J. For. 63:466.

1966. (with Robert W. Funsch) Germination of blue spruce and ponderosa pine pollen after eleven years of storage at 0° to 4°C. Silv. Genet. 15:164-166.

1968. Performance of nine northeastern poplar hybrids in Colorado. Proc. Northeast. For. Tree Improv. Conf. (1967) 15:63-71.

1969. (with Roger W. Clark) Preliminary observations on hybridization of Rocky Mountain spruces. Proc. Comm. For. Tree Breed. Can. 11:237-247. Ste. Anne de Bellevue, P.Q., 1968.

1969. (with Robert A. Young) Administrative problems in forestry. J. For. 67:100-103.

1970. Forestry school training--The employer's view. Forest Research Report No. 70-5. Agricultural Experiment Station, Univ. Illinois, Urbana-Champaign. 7 p.

Name: Lawrence K. Forcier

Title: Assistant Professor

Mailing Address: School of Forestry
University of Montana
Missoula, MT 59801

Born: August 17, 1943

Academic Training:

A.B.	1966	Dartmouth College
M.F.S.	1968	Yale School of Forestry
M. Ph.	1970	Yale University
Ph.D.	1972	Yale University (anticipated)

Professional Experience:

1965-70	Research Assistant, Hubbard Brook Project (Dartmouth, Yale)
1970-	Assistant Professor, University of Montana

Publications (recent, relevant):

1969. (with F. H. Bormann) An intraspecific energy flow model for tree populations in mature forests. Bull. Ecol. Soc. Am. 50:92-93.

1971. Research needs for the protection and enhancement of a quality forest environment. IN: Management practices on public lands. Part II, p. 163-166. Portland, Oregon. August 9, 1971. Hearings before Subcommittee on Public Lands of the Committee on Interior and Insular Affairs, U.S. Senate. 92nd Congress.

1971. (with G. M. Knudsen) The Lubrecht ecosystem project: Summer progress report. Mont. For. Cons. Exp. Stn. 36 p.

1972. (with G. M. Blake, R. F. Wambach, R. W. Steele, and G. M. Knudsen) Multidisciplinary research--A means to predict the impacts of forest manipulation in the northern Rocky Mountains. Mont. For. Cons. Exp Stn. (in preparation).

Name: Jerry F. Franklin

Title: Principal Plant Ecologist and Associate Professor

Mailing Address: USDA Forest Service
Pacific Northwest Forest and Range Experiment Station
Forestry Sciences Laboratory
P.O. Box 887
Corvallis, OR 97330

Born: Waldport, Oregon, October 27, 1937

Academic Training:

B.S.	1958	Oregon State University
M.S.	1961	Oregon State University
Ph.D.	1966	Washington State University

Professional Experience:

1957-59	Forestry Aid, USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, Corvallis
1959-63	Research Forester, USDA Forest Service, Corvallis
1963-65	Associate Plant Ecologist, USDA Forest Service, Corvallis
1965-68	Plant Ecologist, USDA Forest Service, Corvallis
1968-	Principal Plant Ecologist, USDA Forest Service, Corvallis Associate Professor, Oregon State University
1970-	Research Associate, Japanese Government Forest Experiment Station, Tokyo

Publications (recent, relevant):

1969. (with C. T. Dyrness) Vegetation of Oregon and Washington. USDA For. Serv., Pac. Northwest For. Range Exp. Stn. Pap. PNW-80. 216 p.

1970. (with C. T. Dyrness and W. H. Moir) A reconnaissance method for forest site classification. Shinrin Rich. 12:1-16 (Japanese summary).

1971. Research natural areas in the Pacific Northwest. Mazama 52:30-34.

1971. (with C. T. Dyrness) A checklist of vascular plants on the H. J. Andrews Experimental Forest. USDA For. Serv., Pac. Northwest For. Range Exp. Stn. Res. Note PNW-138.

1971. (with William H. Moir, George W. Douglas, and Curt Wilberg) Invasion of subalpine meadows by trees in the Cascade Range, Washington and Oregon. Arct. Alp. Res. 3:215-224.

Name: Richard L. Fredriksen

Title: Research Forester and Assistant Professor

Mailing Address: USDA Forest Service
Forestry Sciences Laboratory
P.O. Box 887
Corvallis, OR 97330

Born: Spokane, Washington, February 20, 1930

Academic Training:

B.S.	1954	University of Washington
M.F.	1961	University of Washington

Professional Experience:

1959-60	Technician, Forest Management Research, Weyerhaeuser Forest Research Center, Centralia
1960-64	Research Forester, H. J. Andrews Forest
1964-	Research Forester, USDA Forest Service, Corvallis
1971-	Assistant Professor, Oregon State University

Publications (recent, relevant):

1965. Christmas storm damage on the H. J. Andrews Experimental Forest. USDA For. Serv., Pac. Northwest For. Range Exp. Stn. Res. Note PNW-29, 11 p.

1967. (with J. Rothacher and C. T. Dyrness) Hydrologic and related characteristics of three small watersheds in the Oregon Cascades. USDA For. Serv. Pac. Northwest For. Range Exp. Stn. Misc. Publ. 54 p.

1970. Erosion and sedimentation following road construction and timber harvest on unstable soils in three small western Oregon watersheds. USDA For. Serv., Pac. Northwest For. Range Exp. Stn. Res. Pap. PNW-104. 15 p.

1971. Comparative water quality--natural and disturbed streams following logging and slash burning. Proceedings of Forest Land Uses and Stream Environment, Oregon State University, p. 125-137.

Name: Leo J. Fritschen

Title: Professor

Mailing Address: College of Forest Resources
University of Washington AR-10
Seattle, WA 98195

Born: Salina, Kansas, September 14, 1930

Academic Training:

B.S.	1952	Kansas State University
M.S.	1958	Kansas State University
Ph.D.	1960	Iowa State University

Professional Experience:

1953-56	Weather Officer (forecaster), U.S. Air Force, Okinawa and Texas
1960-62	Soil Scientist, U.S. Water Conservation Laboratory, Phoenix
1962-66	Research Meteorologist, U.S. Water Conservation Laboratory, Phoenix
1966-	Associate Professor to Professor, University of Washington

Publications (recent, relevant):

1967. Net solar radiation relations over irrigated field crops. Agric. Meteorol. 4:55-62.

1967. (with R. Nixon) Microclimate before and after irrigation. Ground level climatology. Am. Assoc. Advan. Sci., Washington, D.C. Publ. 86.

1967. A sensitive cup-type anemometer. J. Appl. Meteorol. 6:695-698.

1969. Evapotranspiration and meteorological methods of estimation as applied to forest. Proc. Third Forest Microclimate Symp. Kananaskis Forest Experiment Station, Seebee, Alberta, September 23-26. p. 8-28.

1970. (with R. Hinshaw) Diodes for temperature measurement. J. Appl. Meteorol. 9:530-532.

Name: Robert I. Gara

Title: Associate Professor

Mailing Address: College of Forest Resources
University of Washington AR-10
Seattle, WA 98195

Born: Santiago, Chile, December 16, 1931

Academic Training:

B.S.	1953	Utah State University
M.S.	1962	Oregon State University
Ph.D.	1964	Oregon State University

Professional Experience:

1957-60	Forester, Kirby Lumber Corp., Houston, Texas
1960-63	Graduate Assistant, Oregon State University
1964-66	Project Leader, Forest Entomology Laboratory, Boyce Thompson Institute, Beaumont, Texas
1966-68	Assistant to Associate Professor, Syracuse University
1968-	Associate Professor, University of Washington

Publications (recent, relevant):

1970. Notes on flight and host selection behavior of the pine engraver *Ips pini* (Coleoptera:Scolytidae) Ann. Entomol. Soc. Am. 63:947-1050.

1970. Studies on the shoot borer *Hypsipyla grandella* Zeller. I. Host selection behavior. Turrialba 20:233-240.

1970. Studies on the shoot borer *Hypsipyla grandella* Zeller. II. Host preference of the larva. Turrialba 20:241-247.

1970. (with S. C. Cade and B. F. Hrutfiord) Identification of a primary attractant for *Gnathotrichus sulcatus*. J. Econ. Entomol. 63:1014-1015.

1971. Influence of some physical and host factors on the behavior of the Sitka spruce weevil, *Pissodes sitchensis*, in southwestern Washington. Ann. Entomol. Soc. Am. 64:467-471.

Name: Arden R. Gaufin

Title: Professor

Mailing Address: Department of Biology
University of Utah
Salt Lake City, UT 84112

Born: Salt Lake City, Utah, December 25, 1911

Academic Training:

B.S.	1935	University of Utah
M.S.	1937	University of Utah
Ph.D.	1951	Iowa State University

Professional Experience:

1943-45	Entomologist, Sanitary Corps, U.S. Army
1946-49	Instructor, University of Utah
1950-53	Aquatic Biologist, Stream Sanitation Research Unit, Environmental Health Center, Cincinnati
1953-54	Assistant Professor, University of Utah
1954-61	Associate Professor, University of Utah
1961-68	Professor, University of Utah
1968-69	Professor and Director of Environmental Biology, University of Montana
1969-	Professor, University of Utah

Publications (recent, relevant):

1966. (with A. W. Knight) Oxygen consumption of several species of stoneflies (Plecoptera). J. Insect Physiol. 12:347-355.

1965. (with A. W. Knight) Function of stonefly gills under reduced dissolved oxygen concentration. Proc. Utah Acad. 42:186-190.

1967. (with A. W. Knight) Stream type selection and associations of stoneflies (Plecoptera) in a Colorado River drainage system. J. Kans. Entomol. Soc. 40:347-352.

1968. (with A. V. Nebeker) The winter stoneflies of the Rocky Mountains (Plecoptera: Capniidae). Trans. Am. Entomol. Soc. 94:1-24.

Name: Lloyd W. Gay

Title: Associate Professor

Mailing Address: Forest Research Laboratory
School of Forestry
Oregon State University
Corvallis, OR 97331

Born: Bryan, Texas, June 26, 1933

Academic Training:

B.S.	1955	Colorado State University
Dip. For.	1959	Australian Forestry School
M.F.	1962	Duke University
Ph.D.	1966	Duke University

Professional Experience:

1960-61	Research Forester and officer-in-charge, USDA Forest Service, Central Sierra Snow Laboratory, Soda Springs, California
1961-66	Research Assistant, Duke University
1966-71	Assistant Professor, Oregon State University
1971-	Associate Professor, Oregon State University

Publications (recent, relevant):

1965. (with K. R. Knoerr) Tree-leaf energy balance. Ecology 46:17-24.

1970. Energy balance estimates of evapotranspiration. IN: Water Studies in Oregon. SEMN WR 012.69, p. 17-39. Oregon Water Resources Research Institute, Corvallis.

1970. (with K. R. Knoerr) The radiation budget of a forest canopy. Arch. Meteorol. Geophys. B 18:187-196.

1970. (with W. P. Lowry) Errors in infrared thermometry and radiometry. J. Appl. Meteorol. 9:929-932.

1971. The regression of net radiation upon solar radiation. Arch. Meteorol. Geophys. Bioklimat. B 19:1-14.

1971. Forest climatology studies at Oregon State University. Proc. Oreg. Acad. Sci. 7:11-23.

1971. (with K. R. Knoerr and M. O. Braaten) Solar radiation variability on the floor of a pine plantation. Agric. Meteorol. 8:39-50.

1971. (with R. L. Stebbins and R. M. Black) The effect of spray irrigation on plum temperatures. Northwest Sci. 45:200-208.

Name: Stanley P. Gessel

Title: Professor and Associate Dean

Mailing Address: College of Forest Resources
University of Washington AR-10
Seattle, WA 98195

Born: Utah, October 14, 1916

Academic Training:

B.S.	1939	Utah State Agriculture College
Ph.D.	1950	University of California, Berkeley

Professional Experience:

1948-	Instructor to Professor, and Associate Dean, University of Washington
1949	(summer) Forest Soils Specialist, U.S. Soil Conservation Service
1950-51	(summers) In charge of Soil Survey, Eastern Rockies Forest Conservation Board, Calgary
1952	(summer) Soils Inventory and Research, Washington State University
1953	(summer) Research, Scott Paper Company, Everett
1955	(spring) Visiting Professor, University of Wisconsin
1955-56	(summers) Research, Weyerhaeuser Company, Centralia
1957-62	(summers) Radiation Biology Laboratory, Rongelap, Marshall Islands
1964	(summer) Eniwetok, Bikini Island Expedition
1966-71	(summers) Research College of Forestry, Costa Rica

Publications (recent, relevant):

1963. (with P. E. Heilman) Nitrogen requirements and the biological cycling of nitrogen in Douglas-fir stands in relationship to the effects of nitrogen fertilization. Plant Soil 18:386-402.

1965. (with D. W. Cole) Movement of elements through a forest soil as influenced by tree removal and fertilizer additions. IN: Forest-soil relationships in North America. Oregon State Univ. Press, Corvallis.

1967. (with D. W. Cole and S. F. Dice) Distribution and cycling of nitrogen, phosphorus, potassium, and calcium in a second growth Douglas-fir ecosystem. IN: Mineral cycling in natural ecosystems, p. 193-197. Proc. AAAS Ann. Meet. (New York). Maine Univ. Press, Orono.

1969. (with T. N. Stoate and J. K. Turnbull) The growth behavior of Douglas-fir with nitrogenous fertilizer in western Washington. Inst. For. Prod. Univ. Wash. Contrib. 7.

Name: C. M. Gilmour

Title: Professor and Head

Mailing Address: Department of Bacteriology
University of Idaho
Moscow, ID 83843

Born: July 2, 1916

Academic Training:

B.S.	1941	University of British Columbia
M.S.	1945	University of British Columbia
Ph.D.	1949	University of Wisconsin

Professional Experience:

1948-49	Instructor, University of Wisconsin
1949-50	Assistant Professor, Oklahoma State University
1950-51	Associate Professor, Oklahoma State University
1951-56	Associate Professor, Oregon State University
1956-67	Professor, Oregon State University
1967-70	Director for Environmental Biology, University of Utah
1970-	Professor, University of Idaho

Publications (recent, relevant):

1964. (with R. P. Bhatt and J. V. Mayeux) Comparative role of nitrate and molecular oxygen in the dissimilation of glucose. Nature 203:55-58.

1966. (with A. G. Wollum and C. T. Youngberg) Characterization of a *Streptomyces* sp. isolated from root nodules of *Ceanothus velutinus*. Soil Sci. Proc. 30:463-467.

1970. (with L. A. Bulla and W. B. Bollen) Nonbiological reduction of nitrate in soil. Nature 225:664.

1965. Microorganisms and Soil Fertility. Oregon State Univ. Press, Corvallis. 164 p.

Name: Charles C. Grier

Title: Research Associate

Mailing Address: Forest Research Laboratory
School of Forestry
Oregon State University
Corvallis, OR 97331

Born: Pasadena, California, September 1, 1938

Academic Training:

B.S.	1968	University of Washington
Ph.D.	1972	University of Washington

Professional Experience:

1966-67	Forest soil survey of Entiat R.D., Wenatchee National Forest
1968-69	Field research in Southern Victoria Land, Antarctica
1969-70	Research and Teaching Assistant, College of Forest Resources, University of Washington
1970-	Research Associate, College of Forest Resources, University of Washington

Publications (recent, relevant):

1969 (with F.C. Ugolini) Biological weathering in Antarctica. Antarc. J. U.S. 4:156-157.

1971. (with D. W. Cole) Influence of slash burning on ion transport in a forest soil. Northwest Sci. 45:100-106.

1971. (with J. G. McColl) Forest floor characteristics within a small plot in Douglas-fir in western Washington. Soil Sci. Soc. Am. Proc. 35:988-991.

Name: James D. Hall

Title: Associate Professor

Mailing Address: Department of Fisheries and Wildlife
Oregon State University
Corvallis, OR 97331

Born: Columbus, Ohio, August 31, 1933

Academic Training:

A.B.	1955	University of California at Berkeley
M.S.	1960	University of Michigan
Ph.D.	1963	University of Michigan

Professional Experience:

1958-62	Graduate Fellow, Michigan Department of Conservation Institute for Fisheries Research
1963-68	Assistant Professor, Oregon State University
1968-	Associate Professor, Oregon State University

Publications (recent, relevant):

1968. (with Homer J. Campbell) The effects of logging on the habitat of coho salmon and cutthroat trout in coastal streams. IN: Logging and Salmon. Am. Inst. Fish. Res. Biol. Forum Proc. Juneau, Alaska.

1969. (with R. L. Lantz) Effects of logging on the habitat of coho salmon and cutthroat trout in coastal streams. IN: T. G. Northcote (ed.), Symp. salmon and trout in streams, p. 355-375. Univ. British Columbia, Vancouver.

1971. (with E. W. Hansmann and C. B. Lane) A direct method of measuring benthic primary production in streams. Limnol. Oceanogr. 16:822-826.

1971. (with J. T. Krygier) (eds.) Forest land uses and stream environment. Oregon State Univ. 252 p.

Name: R. Dennis Harr

Title: Assistant Professor

Mailing Address: Forest Research Laboratory
School of Forestry
Oregon State University
Corvallis, OR 97331

Born: Astoria, Oregon, June 26, 1941

Academic Training:

B.S.	1963	Washington State University
Ph.D.	1967	Colorado State University

Professional Experience:

1969-71	Senior Research Scientist, Battelle-Northwest, Richland, Washington
1971-	Assistant Professor, Oregon State University

Name: George E. Hart

Title: Associate Professor

Mailing Address: Forest Science Department
Utah State University
Logan, UT 84321

Born: February 6, 1929

Academic Training:

B.A.	1951	Yale University
B.S.	1956	University of Michigan
M.S.	1956	University of Michigan
Ph.D.	1966	University of Michigan

Professional Experience:

1956-59	Research Forester, Northeastern Forest Experiment Station, Parsons, West Virginia
1959-66	Associate Hydrologist, Northeastern Forest Experiment Station, Durham, New Hampshire
1966-	Associate Professor, Utah State University

Publications (recent, relevant):

1967. New stream-gaging instruments. IN: W. E. Sopper and H. W. Lull (eds.), Int. Symp. For. Hydrol., p. 787-790. The Pennsylvania State University, August 29-September 10, 1965. Permagon Press, New York. 813 p.

1969. (with J. D. Schultz and G. B. Coltharp) Controlling transpiration in aspen with phenylmercuric acetate. Water Resour. Res. 5:110-113.

1969. A semiautomatic method for reducing streamflow records. J. Soil Water Conserv. 24.

Name: William H. Hatheway

Title: Associate Professor

Mailing Address: College of Forest Resources and Center for Quantitative Science
University of Washington AT-10
Seattle, Washington 98195

Born: Hartford, Connecticut, November 28, 1923

Academic Training:

B.S.	1948	University of Chicago
M.S.	1952	University of Chicago
M.F.	1953	Harvard University
Ph.D.	1956	Harvard University

Professional Experience:

1956-57	Staff Member, the Rockefeller Foundation, assigned to Department of Experimental Statistics, North Carolina State College
1957-61	Assistant Statistician, Field Staff in Agriculture
1961-64	Associate Statistician, The Rockefeller Foundation (Mexico, D.F. Mexico)
1964-65	Executive Director, Organization for Tropical Studies, Inc., San Jose, Costa Rica
1965-66	Botanist, Tropical Science Center, San Jose, Costa Rica
1965-	Collaborator in Botany, the Smithsonian Institution
1967-69	Adjunct Associate Professor, Botany Department, North Carolina State University
1968	Visiting Professor of Botany, Organization for Tropical Studies, Costa Rica (spring and summer)
1969-	Associate Professor, University of Washington

Publications (recent, relevant):

1962. A weighted hybrid index. Evolution 16:1-10.

1963. (with U. J. Grant, D. H. Timothy, C. Cassalett, and L. M. Roberts) Races of maize in Venezuela. Nat. Acad. Sci./Nat. Res. Council Publ. 1136:1-92.

1967. Physiognomic characterizations of three vegetational types at the Guama Ecological Research Area, Belem, Brazil. Consultant's Report to the Smithsonian Institution.

Name: Richard H. Hawkins

Title: Associate Professor

Mailing Address: Department of Forest Science
Utah State University
Logan, UT 84321

Born: St. Louis, Missouri, December 16, 1934

Academic Training:

B.S.	1957	University of Missouri (forestry)
B.S.	1959	University of Missouri (civil engineering)
M.S.	1961	Colorado State University
Ph.D.	1968	Colorado State University

Professional Experience:

1960	Forester, U.S. Forest Service, Denver, Colorado
1961-65	Assistant Civil Engineer, State of California, Department of Water Resources, and Division of Soil Conservation, Sacramento
1965-66	Associate Engineer, State of California, Department of Water Resources, Sacramento, Garberville, and Red Bluff
1967-68	Instructor (Watershed Management), Senior Research Technician, Colorado State University
1968-71	Assistant Director, State University Water Res. Center. SUNY College of Forestry at Syracuse University, Associate Professor (adj.), Forest Engineering
1971-	Associate Professor, Department of Forest Science, Utah State University

Publications (recent, relevant):

1970. Some general comments on the synergistic runoff effect from joint watershed management and weather modification. J. Hydrol. 11:412-420.

----. A note on mixed distributions in hydrology. Proceedings, Symposium on Statistical Hydrology, Tucson, Arizona, August 31-September 2, 1971 (in press).

1972. (with K. P. Singh and R. A. Sinclair) Discussion on "Two distribution methods for flood frequency analysis." (MS submitted and in review to J. Hydraul. Div. ASCE.)

1972. (with others) Preliminary Report, Task Committee on 'Effect of Urbanization on Low Flow, Total Runoff, Infiltration, and Ground Water Recharge. (W. J. Schneider, chairman) ASCE meeting preprint 1620. 30 p.

Name: Eugene P. Haydu

Title: Manager, Environmental Research

Mailing Address: Weyerhaeuser Company
Lab A
Longview, Washington 98632

Born: Cleveland, Ohio, April 11, 1916

Academic Training:

B.S.	1948	Oregon State University
M.S.	1949	Oregon State University

Professional Experience:

1949-52 Principal investigator in studies concerned with environmental factors influencing larval oyster development; conducted toxicity tests with oysters and salmonid fishes; initiated studies to determine the oxygen requirements of salmonid fishes.

1952-56 Conducted intensive long-term oyster bioassays.

1956-62 Intensive studies on the biological treatment of pulp mill wastes in the laboratory and on a pilot plant scale.

1962-72 Initiated and directed a continuing long-term productivity study in three experimental streams constructed on one of the company's tree farms; directed a continuing comprehensive investigation of environmental factors affecting the productivity of the Pacific oyster in Grays Harbor.

Publications (recent, relevant):

1968. Biological concepts in pollution control. Ind. Water Eng.

1970. (with R. N. Thut) Effects of forest chemicals on aquatic life in surface waters. Symposium on Forest Land Uses and Stream Environment, Forest Extension, Oregon State University.

Name: John A. Helms

Title: Associate Professor

Mailing Address: School of Forestry and Conservation
University of California
Berkeley, CA 94720

Born: Esperance, West Australia, September 29, 1931

Academic Training:

B.S.	1953	Australian Forestry School
M.S.	1960	University of Washington
Ph.D.	1963	University of Washington

Professional Experience:

1963-64	Research Associate, University of Washington
1964-65	Acting Assistant Professor, University of California, Berkeley
1965-	Assistant Professor to Associate Professor, University of California, Berkeley

Publications (recent, relevant):

1964. Apparent photosynthesis of mature Douglas-fir in relation to silvicultural treatment. For. Sci. 10:432-442.

1965. Diurnal and seasonal patterns of net assimilation in Douglas-fir (Pseudotsuga menziesii (Mirb. Franco), as influenced by environment. Ecology 46:698-708.

1970. Summer net photosynthesis of ponderosa pine in its natural environment. Photosynthetica 4:243-253.

1971. Environmental control of net photosynthesis in naturally growing Pinus ponderosa Lans. Ecology 53:192.

1971. (with T. W. Cobb, Jr., and H. S. Whitney) Effects of infection by Verticicladiella wagenerii on the physiology of Pinus ponderosa. Phytopathology 61:920-925.

Name: Richard Hermann

Title: Professor

Mailing Address: Forest Research Laboratory
School of Forestry
Oregon State University
Corvallis, OR 97331

Born: Munich, Germany, February 16, 1924

Academic Training:

B.S.	1951	Ludwig-Maximilian University, Munich, Germany
M.S.	1956	Yale University
Ph.D.	1960	Oregon State University

Professional Experience:

1951-54	Forester, Bavarian Forest Service
1958-59	Instructor, Department of Botany, Oregon State University
1959-61	Ecologist, Oregon Protection and Conservation Committee
1961-65	Assistant Professor, Oregon State University
1965-71	Associate Professor, Oregon State University
1971-	Professor, Oregon State University

Publications (recent, relevant):

1969 Root development and height increment of ponderosa pines in pumice soils of central Oregon. For. Sci. 15:226-237.

Name: Harold J. Jensen

Title: Professor

Mailing Address: Department of Botany and Plant Pathology
Oregon State University
Corvallis, OR 97331

Born: September 16, 1921

Academic Training:

B.S. 1947 University of California, Berkeley
Ph.D. 1950 University of California, Berkeley

Professional Experience:

1950- Professor, Oregon State University

Publications:

1967. (with R. H. Mulvey) Monochidae of Nigeria. Can. J. Zool. 45:667-727.

1968. (with R. H. Mulvey) Predaceous nematodes (Monochidae) of Oregon. Oregon State Monographs (Studies in Zoology) No. 12. 57 p.

1970. Survival of Chloroplycae infested by saprozoic nematodes. J. Nematol. 2:351-354.

1971. Protection of *Fusarium* and *Verticillium* propagules from selected biocides following ingestion by *Pristionchus lheritieri*. J. Nematol. 3:23-27.

Name: Carl F. Jordan

Title: Associate Ecologist

Mailing Address: Argonne National Laboratory
Bldg. 181
Argonne, IL 60439

Born: New Brunswick, New Jersey, December 10, 1935

Academic Training:

B.S.	1958	University of Michigan
M.S.	1964	Rutgers University
Ph.D.	1966	Rutgers University

Professional Experience:

1965-66	Research Assistant, Soils Department, Rutgers University
1966-68	Associate Scientist I, Puerto Rico Nuclear Center
1968-69	Associate Scientist II and Acting Project Director, Terrestrial Ecology Project, Puerto Rico Nuclear Center
1969-	Assistant Ecologist to Associate Ecologist, Ecology Project, Argonne National Laboratory

Publications (recent, relevant):

1968. (with J. R. Kline) Tritium movement in soil of a tropical rain forest. Science 160:550-551.

1970. (with J. R. Kline, J. R. Martin, and J. J. Koranda) Measurement of transpiration in tropical trees with tritiated water. Ecology 51:1068-1073.

1970. (with J. J. Koranda, J. R. Kline, and J. R. Martin) Tritium movement in a tropical ecosystem. BioScience 20:807-812.

1970. (with J. R. Martin, J. J. Koranda, and J. R. Kline) Radioecological studies of tritium movement in a tropical rain forest. Symp. Engineering with Nuclear Explosives Proc., p. 422-438.

1971. (with J. R. Kline and R. C. Rose) Transpiration measurement in pines using tritiated water as a tracer. Proceedings of the Third Nat. Symp. on Radioecology. In press.

1971. (with J. R. Kline and D. S. Sasscer) Tritium movement in an old field ecosystem determined experimentally. Ibid.

1971. (with J. R. Kline and D. S. Sasscer) A mathematical model of tritiated and stable water movement in an old field ecosystem. Ibid.

Name: M. Allan Kays

Title: Associate Professor

Mailing Address: Department of Geology
University of Oregon
Eugene, OR 97402

Born: Princeton, Indiana, May 13, 1934

Academic Training:

B.A.	1956	Southern Illinois University
M.S.	1958	Washington University
Ph.D.	1960	Washington University

Professional Experience:

1956-58	Instructor, Washington University
1958-60	Research Assistant, Washington University
1961-65	Assistant Professor, University of Oregon
1965-	Associate Professor, University of Oregon
1970-71	Geologist, Dept. Mineral Resources, Precambrian Division, Province of Saskatchewan, Canada

Publications (recent, relevant):

1964. (with J. L. Bruemmer) Gravity field over zones of major tectonism, southwest Oregon. Ore Bin 26:43-52.

1965. Petrographic and modal relations, Sanford Hill titaniferous magnetite deposit. Econ. Geol. 60:1261-1297.

1965. (with B. H. Helming) Anomalous metamorphism of Jurassic rocks, Klamath Mountains, southwestern Oregon. Geol. Soc. Am. Spec. Pap., p. 85-86.

1968. Zones of alpine tectonism and metamorphism, Klamath Mountains, southwestern Oregon. J. Geol. 76:17-36.

1970. Western Cascades volcanic series, South Umpqua Falls region, Oregon. Ore Bin 32:81-94.

1970. Mesozoic metamorphism, May Creek Schist belt, Klamath Mountains, Oregon. Geol. Soc. Am. Bull. 81:2743-2758.

Name: Donald A. Klein

Title: Assistant Professor

Mailing Address: Department of Microbiology
Colorado State University
Fort Collins, CO 80521

Born: Bridgeport, Connecticut, 1935

Academic Training:

B.S.	1957	University of Vermont
M.S.	1961	University of Vermont
Ph.D.	1966	Pennsylvania State University

Professional Training:

1962	Postgraduate work in bacteriology and languages, Eberhard-Karls Universitat, Tübingen, Germany
1962-66	Research Assistant, Pennsylvania State University
1967-70	Assistant Professor, Oregon State University
1970-	Assistant Professor, Colorado State University

Publications (recent, relevant):

1967. (with L. E. Casida, Jr.) Escherichia coli die-out from normal soil as related to nutrient availability and the indigenous microflora. Can. J. Microbiol 13:1401-1470.

1968. Growth of an aquatic-derived bacterium in the presence of long-chained alkanes. Appl. Microbiol. 16:421-422.

1970. Photomodification processing of biologically recalcitrant pollutants: Control and instrumentation requirements. IEEE Trans. GE-8:139-144.

1970. (with R. C. Rockhill, J. P. Eldridge, and J. E. Park) Photo-fermentation of recalcitrant molecules: Fungal and bacterial responses to lignin sulfonate substrates. Tappi 53:1469-1472.

1971. (with T. C. Loh and R. L. Goulding) A rapid procedure for measuring dehydrogenase activity in soils low in organic matter. Soil Biol. Biochem. 3:385-387.

1972. (with P. A. Mayeux and S. L. Seaman) A symplified unit for evaluation of soil core respirometric activity. Plant Soil (in press).

Name: Jerry R. Kline

Title: Associate Ecologist

Mailing Address: Bldg. 181, Argonne National Laboratory
Argonne, IL 60439

Born: Minneapolis, Minnesota, May 21, 1932

Academic Training:

B.S.	1957	University of Minnesota
M.S.	1960	University of Minnesota
Ph.D.	1964	University of Minnesota

Professional Experience:

1964-65	Postdoctoral Research Associate, Argonne National Laboratory
1965-66	Associate Scientist I, Puerto Rico Nuclear Center
1966-68	Chief Scientist I and Director of Terrestrial Ecology Project, Puerto Rico Nuclear Center
1968-	Associate Ecologist, Argonne National Laboratory

Publications (recent, relevant):

1968. (with C. F. Jordan) Tritium movement in soil of a tropical rain forest. Science 160:550-551.

1970. (with J. R. Martin, C. F. Jordan, and J. J. Koranda) Measurement of transpiration in tropical trees with tritiated water. Ecology 51:1068-1073.

1970. (with J. R. Martin, C. F. Jordan, and J. J. Koranda) Radio-ecological studies of tritium movement in a tropical rain forest. IN: Symposium on engineering with nuclear explosives, Proceedings, p. 422-438.

1970. (with D. F. Jordan, J. J. Koranda, and J. R. Martin) Tritium movement in a tropical ecosystem. BioScience 20:807-812.

Name: Gerhard M. Knudsen

Title: Research Associate

Mailing Address: School of Forestry
University of Montana
Missoula, MT 59801

Born: August 30, 1942

Academic Training:

B.S.	1966	University of Montana
M.S.	1968	University of Montana

Professional Training:

1968-69	Administrative Assistant, University of Montana
1969-	Instructor, Research Associate, University of Montana

Publications (recent, relevant):

1968. (with S. F. Arno, G. M. Blake, and J. R. Habeck) Natural distribution of western larch and subalpine larch. Mont. For. Cons. Exp. Stn. Note 7.

1971. (with L. K. Forcier) The Lubrecht ecosystem project: Summer progress report. Mont. For. Cons. Exp. Stn. 36 p.

1972. (with G. M. Blake, L. K. Forcier, R. F. Wamback, and R. W. Steele) Multidisciplinary research--A means to predict the impacts of forest manipulation in the northern Rocky Mountains. Mont. For. Cons. Exp. Stn. (in preparation).

Name: Gerald W. Krantz

Title: Professor

Mailing Address: Department of Entomology
Oregon State University
Corvallis, OR 97331

Born: Pittsburgh, Pennsylvania, March 12, 1928

Academic Training:

B.S.	1951	University of Pittsburgh
Ph.D.	1955	Cornell University

Professional Experience:

1955-61	Assistant Professor, Oregon State University
1961-66	Associate Professor, Oregon State University
1962-63	National Science Foundation Grantee, Stazione di Entomologia Agraria, Florence, Italy
1965, 68	Deputy Leader and microzoologist, American Quintana Roo Expeditions
1966-	Professor, Oregon State University
1967, 71	Lecturer, Institute of Acarology, Ohio State University
1969-70	Research Professor, Instituto di Biologia del Mare del CNR, Venice, Italy

Publications (recent, relevant):

1965. A new species of Macrocheles (Acarina: Macrochelidae) associated with bark beetles of the general Ips and Dendroctonus. J. Kans. Entomol. Soc. 38:145-153.

1969. The mites of Quintana Roo. 1. A new species of Eutrachytes (Mesostigmata: Uropodidae) from the Yucatan Peninsula with observations on the classification of the genus. Ann. Entomol. Soc. Am. 62:62-70.

1970. Acari (Mesostigmata): Macrochelidae. IN: Brinck and Rudebeck (eds.) South African animal life 14:19-23.

1970. A manual of acarology. Oregon State Univ. Bookstores, Inc. 335 p.

Name: Ernest A. Kurmes

Title: Professor of Forestry

Mailing Address: School of Forestry
Fac. Box 4098
Northern Arizona University
Flagstaff, AZ 86001

Born: January 19, 1931

Academic Training:

B.A.	1953	Lehigh University
M.S.	1957	Yale University
M.F.	1958	Yale School of Forestry
Ph.D.	1961	Yale University

Professional Experience:

1961-67 Assistant Professor, Southern Illinois University, Carbondale
1967- Associate Professor, Northern Arizona University

Name: Denis P. Lavender

Title: Professor

Mailing Address: Forest Research Laboratory
School of Forestry
Oregon State University
Corvallis, OR 97331

Born: Seattle, Washington, October 13, 192

Academic Training:

B.S.	1949	University of Washington
M.S.	1958	Oregon State College
Ph.D.	1962	Oregon State University

Professional Experience:

1950-55	Research Forester, Oregon State Board of Forestry
1955-57	Senior Research Forester, Oregon State Board of Forestry
1957-61	Senior Research Forester, Oregon Conservation and Protection Committee
1961-63	Assistant Professor, Oregon State University
1963-70	Associate Professor, Oregon State University
1970-	Professor, Oregon State University

Publications (recent, relevant):

1970. Foliar analysis and how it is used, a review. School of Forestry, Oregon State Univ. Res. Note 52. 8 p.

1966. Effect of three variables on mineral concentrations in Douglas-fir needles. For. Sci. 12:441-446.

1972. (with Albert Abee) Nutrient cycling within old-growth Douglas-fir stands. Proceedings--Research on Coniferous Forest Ecosystems--A symposium, 23-25 March, Bellingham, Wash. USDA Forest Service, Portland (in press).

Name: William A. Laycock

Title: Range Scientist

Mailing Address: USDA Forest Service
Intermountain Forest and Range Experiment Station
Forestry Sciences Laboratory
860 N. 12th East
Logan, Utah 84321

Born: March 17, 1930

Academic Training:

B.S.	1952	University of Wyoming
M.S.	1953	University of Wyoming
Ph.D.	1958	Rutgers University

Professional Experience:

1955	Range Technician, Wyo. Game and Fish Comm., Wheatland
1955-57	Research Assistant, Pine Region Hydrologic Project, Rutgers University
1957-58	Teaching Assistant, Rutgers University
1958-	Range Scientist, Intermountain Forest Range Experiment Station, USDA Forest Service
1969-70	Senior Research Fellow, New Zealand National Research Advisory Council, with N.Z. Forest Service, Rangiora, N.Z.
1964-	Collaborator at Utah State University (Range Science Department)

Publications (recent, relevant):

1967. How heavy grazing and protection affect sagebrush-grass ranges. J. Range Manage. 20:206-213.

1969. Exclosures and natural areas on rangeland in Utah. USDA For. Serv. Res. Pap. INT-62. 44 p.

1969. (with P. W. Conrad) How time and intensity of clipping affect tall bluebell. J. Range Manage. 22:299-303.

1970. (with D. A. Price) Environmental influences on nutritional value of forage species. IN: Range and wildlife habitat evaluation--A research symposium. USDA For. Serv. Misc. Publ. 1147:37-47.

1970. The effects of spring and fall grazing on sagebrush-grass ranges in eastern Idaho. Proc. XI International Grassland Congress 1970:52-54.

Name: Bruce Lighthart

Title: Assistant Professor

Mailing Address: Institute for Freshwater Studies
Western Washington State College
Bellingham, WA 98225

Born: Evanston, Illinois, April 4, 1934

Academic Training:

B.S.	1959	San Diego State College
M.S.	1961	San Diego State College
Ph.D.	1967	University of Washington

Professional Experience:

1959-61	Diagnostic Medical Bacteriologist, Donald N. Sharp Memorial Community Hospital, San Diego, California
1961	Assistant Instructor in Microbiology, San Diego State College
1961-62	Research Assistant in Marine Microbiology, University of Washington
1963	Teaching Assistant in Fisheries, Microbiology, University of Washington
1963-64	Laboratory Instructor in Microbiology, Seattle University
1965-66	Assistant Microbiologist, University of Washington
1968	Research Assistant Professor, University of Washington
1969	Acting Assistant Professor, University of Washington
1969-	Director, Institute for Freshwater Studies and Assistant Professor, Western Washington State College

Publications (recent, relevant):

1969. Marine planktonic and benthic bacteriovorous protozoa at 11 stations in Puget Sound and adjacent Pacific Ocean. J. Fish. Res. Board Can. 26:299-304.

1969. (with R. T. Oglesby) Bacteriology of an activated sludge waste-water treatment plant--A guide to methodology. J. Water Pollut. Control Fed. 41(8) part 2: R267-281.

1972. (with R. J. Buchanan) Indicator phytoplankton communities: A cluster analysis approach. Syesis (publ. of British Columbia Provincial Museum, in press).

Name: John H. Lyford, Jr.

Title: Assistant Professor

Mailing Address: Department of Botany and Plant Pathology
Oregon State University
Corvallis, OR 97331

Born: Chicago, Illinois

Academic Training:

B.A.	1950	Carleton College
M.S.	1962	Oregon State University
Ph.D.	1966	Oregon State University

Professional Experience:

1963-66	Research Biologist, Oregon State Game Commission
1966-	Assistant Professor, Oregon State University

Publications (recent, relevant):

1968. (with H. K. Phinney) Primary productivity and community structure of an estuarine impoundment. Ecology 49: 854-866.

Name: Donald A. McCaughran

Title: Research Assistant Professor

Mailing Address: Center for Quantitative Science
University of Washington AT-10
Seattle, WA 98195

Born: Vancouver, B.C., July 9, 1932.

Academic Training:

B.S.	1959	University of British Columbia
M.S.	1962	University of British Columbia
Ph.D.	1968	Cornell University

Professional Experience:

1962-65	Wildlife Biologist, British Columbia Government
1969-	Research Assistant Professor, Center for Quantitative Sciences, University of Washington.

Name: Larry M. Male

Title: Senior Research Associate

Mailing Address: Center for Quantitative Sciences
University of Washington AT-10
Seattle, Washington 98195

Born: Fort Worth, Texas, May 26, 1942

Academic Training:

B.S.	1964	Colorado State University
M.S.	1966	University of Maine
Ph.D.	1970	Cornell University

Professional Experience:

1969-70 Statistical Consultant for New York State Project, Department of Human Ecology, Cornell University

1970- Senior Research Associate, University of Washington

Publications (recent, relevant):

1968. (with N. H. Peck and J. W. Rudan) Handling data for growing season weather. New York's Food Life Sci. 1:12-13.

1969. (with D. L. Solomon) A counter example. Biom. Unit Ser. Cornell Univ. Pap. No. BU-187.

Name: Jack R. Matches

Title: Acting Associate Professor

Mailing Address: College of Fisheries
University of Washington WH-10
Seattle, WA 98195

Born: May 20, 1930

Academic Training:

B.S.	1957	Oregon State University
M.S.	1958	Oregon State University
Ph.D.	1963	Iowa State University

Professional Experience:

1957-58	Research Assistant, Oregon State University
1958-63	Research Associate, Iowa State University
1963-65	Senior Microbiologist, University of Washington
1965-68	Research Assistant Professor, University of Washington
1968-69	Research Associate Professor, University of Washington
1969-	Acting Associate Professor, University of Washington

Publications (recent, relevant):

1969. (with J. Liston) Effects of salt on the growth of Salmonella. Bacteriol. Proc. 1969:13.

1969. (with R. DiGirolamo and J. Liston) Uptake, elimination, and effects of irradiation in virus in west coast shellfish. Bacteriol. Proc. 1969:26.

1971. (with J. Liston) Survival of Vibrio parahaemolyticus in fish homogenate during storage at low temperatures. (MS submitted to Food Sci.)

Name: James R. Meiman

Title: Associate Professor

Mailing Address: Department of Watershed Sciences
Colorado State University
Fort Collins, CO 80521

Born: Louisville, Kentucky, December 10, 1933

Academic Training:

B.S.	1955	University of Kentucky
M.S.	1959	University of Kentucky
Ph.D.	1962	Colorado State University

Professional Experience:

1962	Instructor, Watershed Management, Colorado State University
1962-66	Assistant Professor, Colorado State University
1966-	Associate Professor, Colorado State University

Publications (recent, relevant):

1967. (with S. H. Kunkle) Land treatment and water quality control. J. Soil Water Conserv. 22:67-70.

1970. (with W. F. Megahan and B. C. Goodell) The effect of albedo-reducing materials on net radiation at a snow surface. Bull. Int. Assoc. Sci. Hydrol. 15:69-80.

1970. Snow accumulation related to elevation, aspect and forest canopy. National Research Council of Canada, Proceedings of snow hydrology workshop seminar 1968, p. 35-47. Canadian National Committee, Ottawa.

1971. (with David R. Dewalle) Energy exchange and late season snowmelt in a small opening in Colorado Subalpine Forest. Water Resour. Res. 7:184-188.

1971. (with E. Remmenga and H. Keller). Snow distribution in relation to solar radiation on two Swiss pre-Alp watersheds. Water Resour. Res. 7:1636-1640.

Name: Edwin W. Mogren

Title: Professor and Chairman Forest Science Major

Mailing Address: Department of Forest and Wood Sciences
Colorado State University
Fort Collins, CO 80521

Born: Minneapolis, Minnesota, September 16, 1921

Academic Training:

B.S.	1947	University of Minnesota
M.S.	1948	University of Minnesota
Ph.D.	1955	University of Michigan

Professional Experience:

1948-61	Instructor to Assistant Professor to Associate Professor, Colorado State University
1951	Director, Pingree Park Campus
1952-58	Collaborator, Forestry, Rocky Mountain Forest and Range Experiment Station, Fort Collins
1955-68	Director, Pingree Park Campus
1961-	Professor, Colorado State University
1967-	Chairman, Forest Science Major, Colorado State University

Publications (recent, relevant):

1967. Height growth in relation to crown size in juvenile lodgepole pine. College of Forestry and Natural Resources, Colorado State Univ., Res. Note No. 17.

1971. Role of fire in montane ecology IN: C. L. Mahoney (ed.), Manual for natural resources ecology. College of Forestry and Natural Resources, Colorado State Univ.

1971. (with W. D. Striffler) Erosion, soil properties, and revegetation following a severe burn in the Colorado Rockies. Proceedings, Symposium on Fire in the Northern Environment, p. 25-36. Pacific Northwest Forest and Range Experiment Station.

1971. (with S. Sukwong and W. E. Frayer) Generalized comparison of fixed- and variable-radius plots for basal area estimates. For. Sci. 17:263-271.

Name: Duane G. Moore

Title: Soil Scientist and Associate Professor

Mailing Address: USDA Forest Service
Pacific Northwest Forest and Range Experiment Station
Forestry Sciences Laboratory
P.O. Box 887
Corvallis, OR 97330

Born: Barron County, Wisconsin, November 18, 1929

Academic Training:

B.S.	1953	University of Wisconsin
M.S.	1955	University of Wisconsin
Ph.D.	1960	University of Wisconsin

Professional Experience:

1959-62	Project Associate, Department of Botany, University of Washington
1962-65	Assistant Professor, University of Hawaii and Assistant Soil Scientist, Hawaiian Agricultural Experiment Station
1965-	Research Soil Scientist, USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, Corvallis
1965-	Associate Professor, Oregon State University

Publications (recent, relevant):

1965. (with R. L. Fox, J. M. Wang, D. L. Pluckrett, and R. D. Furr) Sulfur in soils, rainwater, and forage plants of Hawaii. Hawaii Farm Sci. 14:9-12.

1966. (with G. C. Gerloff,and J. T. Curtis) Selective adsorption of mineral elements by native plants of Wisconsin. Plant Soil 25:393-405.

1968. (with J. F. Franklin, C. T. Dyrness, and R. F. Tarrant) Chemical soil properties under coastal Oregon stands of alder and conifers. IN: J. M. Trappe, J. F. Franklin, R. F. Tarrant, and G. M. Hansen (eds.), Biology of Alder, p. 157-172. Proc. Fortieth Ann. Meet. Northwest Sci. Assoc. Symp. 1967.

1970. Forest fertilization and water quality in the Pacific Northwest. (Abstract). Am. Soc. Agron. Abstr. p. 160-161.

Name: John P. Mullooly

Title: Assistant Professor

Mailing Address: Department of Statistics
Oregon State University
Corvallis, OR 97331

Born: New York, New York, July 8, 1937

Academic Training:

B.S.	1959	St. Francis College
M.S.	1961	Michigan State University
Ph.D.	1966	Catholic University of America

Professional Experience:

1959-61	Teaching Assistant, Michigan State University
1966-68	Mathematical Statistician, National Heart Institute
1968-	Assistant Professor, Oregon State University
1968-	Part-time Lecturer, Georgetown University

Publications (recent, relevant):

1967. (with J. E. Folks) Mechanism of action of transglutaminase. II, III, IV, V. J. Biol. Chem. 242:1838-1844, 242:2615-2621, 242:4329-4333, 243:418-427, respectively.

1968. A one dimensional random space-filling problem. J. Appl. Probl. 5:427-435.

1971. Maximum likelihood estimation for stochastic first order reactions. Bull. Math. Biophys. v. 33.

1970. (with E. J. Caldwell) Interstitial emphysema: A study of physiologic factors involved in experimental induction of the lesion. Am. Rev. Respir. Dis. 102:516-525.

1972. Maximum likelihood estimation for stochastic rth-order reactions. J. Appl. Probl. 9:508-520.

---- Maximum likelihood estimation for stochastic rth-order reactions. II. (MS submitted to J. Appl. Probl.)

Name: William P. Nagel

Title: Associate Professor

Mailing Address: Department of Entomology
Oregon State University
Corvallis, OR 97331

Born: Brooklyn, New York, July 7, 1929

Academic Training:

B.S.	1953	Syracuse University
M.S.	1957	Syracuse University
Ph.D.	1962	Cornell University

Professional Experience:

1957-59 Forest Entomologist, U.S. Foreet Service, Southeastern USA

1962- Associate Professor, Oregon State University

Publications (recent, relevant)

1965. (with R. L. Johnsey and J. A. Rudinsky) The diptera Medetera aldrichii McAlpine (Lonchaeidea) associated with the Douglas-fir beetle in western Oregon and Washington. Can. Entomol. 97:521-527.

1965. (with G. E. Daterman and J. A. Rudinsky) Flight patterns of bark and timber beetles associated with coniferous forests of western Oregon. Oregon State Univ. Tech. Bull. 87. 46 p.

1965. (with B. D. Cowan) Predators of the Douglas-fir beetle in western Oregon. Oregon State Univ. Tech. Bull. 86. 32 p.

1967. (with J. H. McGhehey) Bark beetle mortality in precommercial herbicide thinnings of western hemlock. (Oregon State Univ. Tech. Paper 2296.) J. Econ. Entomol. 60:1572-1574.

1969. (with J. H. McGhehey) The biologies of Pseudohylesinus tsugae and P. grandis (Coleoptera: Scolytidae) in western hemlock. Can. Entomol. 101:269-279.

Name: Carl H. Nellis

Title: Research Assistant Professor

Mailing Address: College of Forest Resources
University of Washington AR-10
Seattle, WA 98195

Born: Winfield, Kansas, April 1, 1940

Academic Training:

B.S. 1962 University of Idaho
M.S. 1964 University of Montana
Ph.D. (pending) University of Wisconsin

Professional Experience:

1970- Research Assistant Professor, University of Washington

Publications (recent, relevant):

1968. Productivity of mule deer on the National Bison Range, Montana. J. Wildl. Manage. 32:344-349.

1969. Sex and age variation in red squirrel skulls from Missoula County, Montana. Can. Field Natur. 83:324-330.

1969. Productivity of Richardson's ground squirrels near Rochester, Alberta. Can. Field Natur. 83:246-250.

1969. (with R. L. Ross) Changes in mule deer food habits associated with herd reduction. J. Wildl. Manage. 33:191-195.

1972. (with S. P. Wetmore and L. B. Keith) Lynx-prey interactions in central Alberta. J. Wildl. Manage. 36:320-329.

Name: Michael Newton

Title: Associate Professor

Mailing Address: Forestry Research Laboratory
School of Forestry
Oregon State University
Corvallis, OR 97331

Born: Hartford, Connecticut, October 24, 1932

Academic Training:

B.S.	1954	University of Vermont, Dairy and Animal Husbandry
B.S.	1959	Oregon State University, Forest Management
M.S.	1960	Oregon State University
Ph.D.	1964	Oregon State University

Professional Experience:

1960- Instructor, Assistant Professor to Associate Professor, Oregon State University

Publications (recent, relevant):

1968. (with B. A. El Hassan, and J. Zavitkovski) Role of red alder in western Oregon forest succession. IN: J. M. Trappe et al. (eds.), Biology of Alder, p. 73-84. USDA Forest Service, Portland. 292 p.

1968. (with J. Zavitkovski) Ecological importance of snowbrush, *Ceanothus velutinus*, in the Oregon Cascades. Ecology 49: 1134-1145.

1968. (with W. J. Zavitkovski) Effect of organic matter and combined nitrogen on modulation and nitrogen fixation in red alder. IN: J. M. Trappe et al. (eds.), Biology of alder, p. 209-224. USDA Forest Service, Portland. 292 p.

1969. (with J. Zavitkovski and B. A. El Hassan) Effects of snowbrush on growth of some conifers. J. For. 67:242-246.

1970. Environmental evaluation and modification for seedling habitat improvement. Soc. Am. For. Ann. Mtg., Las Vegas.

1971. Resiliency of ecosystems. IN: Pest control, pesticides and safety on forest and range lands. OSU. Div. Cont. Ed. 119-128.

Name: Paul R. Olson

Title: Fisheries Biologist

Mailing Address: College of Fisheries
University of Washington WH-10
Seattle, WA 98195

Born: Seattle, Washington, September 21, 1927

Academic Training:

B.S.	1950	University of Washington
M.S.	1964	University of Washington

Professional Experience:

1950-53	Research assistant, University of Washington
1953-59	Research associate, University of Washington
1959-	Senior Fisheries Biologist, Field Site Coordinator, Fern Lake Research, University of Washington

Publications (recent, relevant):

1966. (with S. Olsen) Limnology of Fern Lake, Washington, USA. Proc. Int. Soc. Theor. Appl. Limnol. 16:58-64.

1967. (with S. Olsen and D. Chakravarti) Analyses of water, bottom deposits, and zooplankton of Fern Lake, Washington. Limnol. Oceanogr. 12:392-404.

1967. (with S. Olsen) Membrane filtration of freshwater. Nature 214:1217-1218.

1969. (with Z. Short, R. F. Palumbo, and J. R. Donaldson) The uptake of I^{131} by the biota of Fern Lake, Washington, in a laboratory and a field experiment. Ecology 50:979-989.

1971. (with L. R. Donaldson, S. Olsen, and Z. F. Short) The Fern Lake studies. Univ. Wash., Coll. Fish. cont. 352. 75 p.

Name: W. Scott Overton

Title: Associate Professor

Mailing Address: Forestry Research Laboratory
School of Forestry
University of Oregon
Corvallis, OR 97331

Born: Farmville, Virginia, October 3, 1925

Academic Training:

B.S.	1948	Virginia Polytechnic Institute
M.S.	1950	Virginia Polytechnic Institute
Ph.D.	1964	North Carolina State University

Professional Experience:

1950-58	Biologist, Project Leader, Surveys and Investigations Project, Florida Game and Fresh Water Fish Commission
1959-63	Assistant Statistician, North Carolina State University
1963-65	Associate Professor, Emory University
1965-	Associate Professor, Oregon State University

Publications (recent, relevant):

1968. Statistical considerations of environmental monitoring. Analysis of Chemicals in the Environment Symp. March 28, 1968.

1969. (with D. E. Davis) Estimating the numbers of animals in wildlife populations. IN: R. G. Giles (ed.), Wildlife Management Techniques. The Wildlife Soc., Washington, D.C.

Name: Theodore T. Packard

Title: Research Associate

Mailing Address: Department of Oceanography
University of Washington WB-10
Seattle, WA 98195

Born: Glen Cove, New York, January 24, 1942

Academic Training:

B.S.	1963	Massachusetts Institute of Technology
M.S.	1967	University of Washington
Ph.D.	1969	University of Washington

Professional Experience:

1964-69 Teaching and Research Assistant, University of Washington
1969- Research Associate, University of Washington

Publications (recent, relevant):

1968. (with M. L. Healy) Electrochemical standardization of dehydrogenase assay used in the estimation of respiratory rates. J. Marine Res. 26:66-74.

1969. (with P. B. Taylor) The relationship between succinate dehydrogenase activity and oxygen consumption in the brine shrimp, Artemia salina. Limnol. Oceanogr. 13:552-555.

1970. (with R. W. Eppley and J. J. MacIsaac) Nitrate reductase in Peru Current phytoplankton. Marine Biol. 6:195-199.

1970. (with O. Holm-Hansen and L. R. Pomeroy) Efficiency of the reverse flow filter technique for concentration of particulate matter. Limnol. Oceanogr. 15:832-835.

1970. (with T. E. Whitledge) Nutrient excretion by anchovies and zooplankton in Pacific upwelling regions. Invest. Pesq. 35:243-250.

1971. The measurement of respiratory electron transport activity in marine phytoplankton. J. Mar. Res. 29:235-244.

1971 (with M. L. Healey and F. A. Richards) Vertical distribution of the respiratory electron transport system in marine plankton. Limnol. Oceangr. 16:60-70.

Name: Mario M. Pamatmat

Title: Senior Research Associate

Mailing Address: Department of Oceanography
University of Washington WB-10
Seattle, WA 98195

Born: Santa Cruz, Philippines, October 17, 1928

Academic Training:

B.S.	1958	Auburn University
M.S.	1960	Auburn University
Ph.D.	1966	University of Washington

Professional Experience:

1952-54	Fish Warden, U.S. Bureau of Fisheries
1954-57	Asst. Fisheries Biologist, U.S. Bureau of Fisheries
1958-60	Research Assistant, Auburn University
1961-63	Research Assistant, University of Washington
1963-66	Predoctoral Fellow, University of Washington
1966-67	Research Associate, University of Washington
1968-	Senior Research Associate, University of Washington

Publications (recent, relavant):

1968 (with D. Fenton) An instrument for measuring subtidal benthic metabolism in situ. Limnol. Oceanogr. 13:537-540.

1969. (with K. Banse) Oxygen consumption by the seabed. II. In situ measurements to 180 m depth. Limmol. Oceanogr. 14:250-259.

1971. Oxygen consumption by the seabed. IV. Shipboard and laboratory experiments. Limnol. Oceanogr. 16:536-550.

1971. Oxygen consumption by the seabed. VI. Seasonal cycle of chemical oxidation and respiration in Puget Sound. Int. Rev. Ges. Hydrobiol. 56:675-699.

Name. Arthur D. Partridge

Title: Professor

Mailing Address: College of Forestry, Wildlife, and Range Sciences
University of Idaho
Moscow, ID 83843

Born: February 17, 1927

Academic Training:

B.S.	1953	University of Maine
M.S.	1955	University of New Hampshire
Ph.D.	1956	University of New Hampshire

Professional Experience:

1950-54	Tree expert, logging, consulting forester
1956	U.S. Forest Service, University of Missouri
1960-	University of Idaho

Publications (recent, relevant):

1967-71. Series of short articles re Idaho's Dutch elm disease. Plant Dis. Rep. 52:46, 53:140-141, 54:701, 55:1064.

1968. Major decays of wood in the inland Northwest. For. Wildl. Range Exp. Stn. Bull. No. 2. 79 p.

1970. The life history and cytology of Rhytisma punctatum on bigleaf maple. Mycologia 61:1085-1095.

Name: Dennis R. Paulson

Title: Assistant Professor

Mailing Address: Department of Zoology
University of Washington NJ-15
Seattle, WA 98195

Born: Chicago, Illinois, November 29, 1937

Academic Training:

B.S.	1958	University of Miami
Ph.D.	1966	University of Miami

Professional Experience:

1964-65	Instructor, University of North Carolina
1966	Research Associate, University of North Carolina
1966-69	Research Associate, University of Washington
1969-	Assistant Professor, University of Washington

Publications (recent, relevant):

1969. Oviposition in the tropical dragonfly genus *Micrathyria* (Odonata, Libellulidae). Tombo 12:12-16.

1970. A list of the Odonata of Washington, with additions to and deletions from the state list. Pan-Pac. Entomol. 46:194-198.

1971. Population structure in overwintering larval Odonata in North Carolina in relation to adult flight season. Ecology 52:96-107.

Name: Lawrence H. Pike

Title: Postdoctoral Research Associate

Mailing Address: Department of Botany
Oregon State University
Corvallis, OR 97331

Born: Livermore Falls, Maine, December 1, 1943

Academic Training:

B.A.	1966	Colby College
M.S.	1969	University of Oregon
Ph.D.	1971	University of Oregon

Professional Experience:

1966-70	Teaching Assistant, University of Oregon
1970-71	Consultant to the Bureau of Land Management, Eugene, Oregon Division
1971-	Research associate, Oregon State University

Publications (recent, relevant):

1971. A method for estimating production of twig-dwelling epiphytes (Abstract). Proc. Oregon Acad. Sci. 7:66.

1971. The role of epiphytic lichens and mosses in production and nutrient cycling of an oak forest. Ph.D. thesis, on file, University of Oregon. 172 p.

1972. Estimates of biomass and fixed nitrogen of epiphytes from old-growth Douglas-fir. IN: Proceedings--Research on Coniferous Forest Ecosystems--A Symposium, 23-24 March 1972, Bellingham, Wash. USDA Forest Service, Portland (in press).

Name: Gary B. Pitman

Title: Project Leader

Mailing Address: Boyce Thompson Institute for Plant Research
Grass Valley, CA 95945

Born: Yreka, California, September 2, 1933

Academic Training:

B.S.	1954	University of California, Davis
M.S.	1963	Oregon State University
Ph.D.	1964	Oregon State University

Professional Experience:

1962-63 USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, Portland

1963- Project Leader, Boyce Thompson Institute for Plant Research

Publications (recent, relevant):

1969. Aggregation behavior of Dendroctonus ponderosae (Coleoptera: Scolytidae) in response to chemical messages. Can. Entomol. 101:143-149.

1969. (with J. P. Vite, G. W. Kinzer, and A. F. Fentiman, Jr.) Specificity of population aggregating pheromones in Dendroctonus. J. Insect Physiol. 15:363-366.

1970. Field response of Dendroctonus pseudotsugae (Coleoptera: Scolytidae) to synthetic frontalin. Ann. Entomol. Soc. Am. 63:661-664.

Name: Stephen C. Porter

Title: Professor

Mailing Address: Quaternary Research Center
University of Washington AK-20
Seattle, WA 98195

Born: Santa Barbara, California, April 18, 1934

Academic Training:

B.S.	1955	Yale University
M.S.	1958	Yale University
Ph.D.	1962	Yale University

Professional Experience:

1962-66	Assistant Professor, University of Washington
1966-71	Associate Professor, University of Washington
1971-	Professor, University of Washington

Publications (recent, relevant):

1970. Quaternary glacial record in Swat Kohistan, West Pakistan. Geol. Soc. Am. Bull. 81:1421-1446.

1970. Quaternary, geologic and climatic history of Swat Kohistan, northern West Pakistan. Am. Philos. Soc. Yearb. 1969, p. 326-327.

1970. (with G. H. Denton) Neoglaciation. Sci. Am. 222:100-110.

1971. Fluctuations of late Pleistocene alpine glaciers in western North America. IN: K. K. Turekian (ed.), The late Cenozoic glacial ages, p. 307-329. New Haven, Yale Univ. Press.

Name: Kenneth L. Reed

Title: Postdoctoral Research Associate

Mailing Address: College of Forest Resources
University of Washington AR-10
Seattle, WA 98195

Born: Boise, Idaho, June 10, 1942

Academic Training:

A.B.	1965	University of Washington
M.S.	1968	University of Washington
Ph.D.	1971	Oregon State University

Professional Experience:

1966-67	Research Assistant, University of Washington
1967	(spring) Teaching Assistant, University of Washington
1967-68	Science Teacher, Evergreen School for Gifted Children, Seattle
1968-71	Research Assistant, Oregon State University
1971-	Postdoctoral Research Associate, University of Washington

Publications (recent, relevant):

1972. (with R. B. Walker, D. R. M. Scott, D. J. Salo) Review of terrestrial process studies. Proceedings--Research on Coniferous Forest Ecosystems--A Symposium, 23-24 March, Bellingham, Wash. USDA Forest Service, Portland (in press).

1972. (with R. H. Waring and W. H. Emmingham) An environmental grid for classifying coniferous forest ecosystems. Proceedings--Research on Coniferous Forest Ecosystems--A Symposium, 23-24 March, Bellingham, Wash. USDA Forest Service, Portland (in press).

1972. (with W. L. Webb) Criteria for selection of an optimal model: Terrestrial photosynthesis. Proceedings--Research on Coniferous Forest Ecosystems--A Symposium, 23-24 March, Bellingham, Wash. USDA Forest Service, Portland (in press).

----. (with P. S. Machno) Age class differences in coniferous stomata (submitted to Forest Science).

----. (with R. H. Waring) Coupling of environment to plant response: A simulation model of transpiration (submitted to Ecology).

Name: Charles P. P. Reid

Title: Assistant Professor

Mailing Address: Department of Forest and Wood Sciences
Colorado State University
Fort Collins, CO 80521

Born: Columbia, Missouri, January 8, 1940

Academic Training:

B.S.	1961	University of Missouri
M.F.	1966	Duke University
Ph.D.	1968	Duke University

Professional Experience:

1965-66	Research Assistant, Duke University School of Forestry
1967-69	Research Plant Physiologist (NAS-NRC Postdoctorate), Plant Sciences Laboratories, Fort Detrick, Frederick, Maryland
1969-	Assistant Professor, Colorado State University

Publications (recent, relevant):

1969. Translocation of C14-labeled compounds in mycorrhizae and its implications in interplant nutrient cycling. Ecology 50: 179-187.

1969. The effects of picloram on transpiration. Plant Physiol. 44, Suppl. No. 118. (Abstract.)

1970. Root permeability as affected by picloram and other chemicals. Physiol. Plant. 23:124-130.

1970. (with W. Hurtt) Root exudation of herbicides by wood plants: Allelopathic implications. Nature 225:291.

1970. (with W. A. Wells and W. Hurtt) Foliar uptake and root exudation of picloram and 2,4,5-T by selected woody species. Proc. Weed Sci. Soc. Am. (Abstract.)

1972. (with W. R. Mark) Lodgepole pine--dwarf mistletoe xylem water potentials. For. Sci. (in press).

Name: Hans Riekerk

Title: Research Assistant Professor

Mailing Address: College of Forest Resources
University of Washington AR-10
Seattle, WA 98195

Born: Ruteng, Indonesia, April 5, 1932

Academic Training:

B.S.	1959	State Agricultural University, Wageningen
M.S.	1961	Auburn University
Ph.D.	1967	University of Washington

Professional Experience:

1961-65	Research Assistant, University of Washington
1965-67	Research Associate, University of Washington
1967-	Research Assistant Professor, University of Washington

Publications (recent, relevant):

1965. Mineral cycling in a Douglas-fir forest stand. Health Physics 11:1363-1369.

1968. The movement of DDT in forest soil solution. Soil Sci. Soc. Am. Proc. 32:595-596.

1971. The mobility of phosphorus, potassium, and calcium in a forest soil. Soil Sci Soc. Am. Proc. 35:350-356.

Name: J. Paul Riley

Title: Professor

Mailing Address: Utah Water Research Laboratory
Department of Civil Engineering
Utah State University
Logan, UT 84321

Born: Celista, B.C., June 27, 1927

Academic Training:

B.A.	1950	University of British Columbia
C.E.	1953	Utah State University
Ph.D.	1967	Utah State University

Professional Experience:

1952-54	Assistant Hydraulic Engineer, B.C. Provincial Government, Victoria, B.C.
1954-57	Instructor, Department of Agricultural Engineering, Oregon State University
1957-62	District Engineer, B.C. Provincial Government, Nelson, B.C.
1962-63	Project Engineer, B. C. Provincial Government, Victoria, B.C.
1963-67	Research Assistant, Utah State University
1967-71	Associate Professor, Utah State University
1971-	Professor, Utah State University

Publications (recent, relevant):

1970. Computer simulation of water resources systems at Utah State University. Occas. Paper 5. Utah Water Research Laboratory, Utah State University, Logan. August.

1970. (with Robert W. Hill, Eugene K. Israelsen, and A. Leon Huber) A hydrologic model of the Bear River basin. Utah Water Research Laboratory, Utah State University, Logan. August.

1970 (with L. Hyatt) Computer simulation of the hydrologic-salinity flow system in an irrigated area. Paper presented at the annual meeting of the Rocky Mountain Region, Am. Soc. Agric. Eng. Fort Collins, Colorado.

1971. (with Keith O. Eggleston and Eugene K. Israelsen) Hybrid computer simulation of the accumulation and melt processes in a snowpack. Utah Water Research Laboratory, Utah State University, Logan. June.

1971. (with Jimmie L. Thomas and Eugene K. Israelsen) A computer model of the quantity and the chemical quality of return flow. Utah Water Research Laboratory, Utah State University, Logan. June.

Name: Donald E. Rogers

Title: Research Assistant Professor

Mailing Address: Fisheries Research Institute
University of Washington WH-10
Seattle, WA 98195

Born: Los Angeles, California, August 27, 1932

Academic Training:

B.S.	1958	California State Polytechnic College
M.S.	1961	University of Washington
Ph.D.	1967	University of Washington

Professional Experience:

1960-68	Fishery Biologist, University of Washington
1969-	Research Assistant Professor, University of Washington

Publications (recent, relevant):

1965. (with R. L. Burgner and J. Reeves) Observations on resident fishes in the Tikchik and Wood River lake systems. Fish. Res. Inst., Univ. Wash. Circ. 229. 14 p.

1968. A comparison of the food of sockeye salmon fry and threespine sticklebacks in the Wood River lakes. Univ. Wash. Publ. Fish. New Ser. 3:1-43.

1970. A summary of climatological observations and water temperatures in the Wood River lake system. Fish. Res. Inst. Univ. Wash. Circ. 70-10. 38 p.

Name: Gilbert H. Schubert

Title: Principal Silviculturist, Research Work Unit Leader

Mailing Address: USDA Forest Service
Rocky Mountain Forest and Range Experiment Station
Forestry Sciences Laboratory
Northern Arizona University
Box 4078
Flagstaff, AZ 86001

Born: November 21, 1915

Academic Training:

B.S.	1942	West Virginia University
M.S.	1950	University of California, Berkeley

Professional Experience:

1946-53	Forester (silviculture), California Forest and Range Experiment Station
1953-62	Research Forester and Project Leader, Sierra Westslope Problem Area, Pacific Southwest Forest and Range Experiment Station
1962-	Principal Silviculturist and Research Work Unit Leader, Rocky Mountain Forest and Range Experiment Station

Publications (recent, relevant):

1970. (with L. J. Heidmann and M. M. Larson) Artificial reforestation practices for the Southwest. USDA For. Serv. Agric. Handb. 370. 25 p.

1970. (with M. M. Larson) Cone crops of ponderosa pine in central Arizona, including the influence of Abert squirrels. USDA For. Serv. Res. Pap. RM-58. 15 p.

1970. (with W. J. Rietveld) Bristlecone pine--Its phenology, cone maturity, and seed production in the San Francisco Peaks, Arizona. USDA For. Serv. Res. Note RM-180. 7 p.

1970. Ponderosa pine regeneration problems in the Southwest. Oregon State Univ., "Regeneration of Ponderosa Pine" Symposium Proc. Sept. 1-4.

1971. The phenology of bristlecone pine on the San Francisco Peaks of Arizona. J. Ariz. Acad. Sci. 6:245-248.

1971. Growth response of even-aged pines related to stand density levels. J. For. 69:857-860.

1971. (with R. S. Adams) Reforestation practices for conifers in California. State of California, Division of Forestry, Sacramento. 359 p.

Name: David R. M. Scott

Title: Professor of Silviculture

Mailing Address: College of Forest Resources
University of Washington AR-10
Seattle, WA 98195

Born: Toronto, Ontario, August 30, 1921

Academic Training:

B.S.	1942	University of Virginia
M.F.	1947	Yale University
Ph.D.	1950	Yale University

Professional Experience:

1950-51	Research Forester, Silviculture, Canada Department of Northern Affairs and Natural Resources
1951-55	Silviculturalist, Research Division, Ontario Department of Lands and Forests
1955-	Assistant Professor to Associate Professor to Professor, College of Forest Resources, University of Washington
1964-68	Associate Dean, University of Washington

Publications (recent, relevant):

1962 The Pacific Northwest region (p. 503-507) and the Alaska region (p. 571-591). IN: J. W. Barrett (ed.), Regional silviculture of the United States. The Ronald Press, New York.

1968. (with J. D. Hodges) Photosynthesis in seedlings of six conifer species under natural environmental conditions. Ecology 49:973-981.

1969. (with G. Ritchie and J. N. Woodman) Some aspects of assimilation and transpiration in forest tree species. Proceedings, Symposium on Coniferous Forests of the Northern Rocky Mountains, p. 43-54. University of Montana.

1971. (with R. C. Dobbs) Distribution of diurnal fluctuations in stem circumference of Douglas-fir. Can. J. For. Res. 1:80-83.

1971. (with Thomas M. Hinckley) Estimates of water loss and its relation to environmental parameters in Douglas-fir saplings. Ecology 52:520-524.

Name: James R. Sedell

Title: Aquatic Biologist

Mailing Address: Department of Fisheries and Wildlife
Oregon State University
Corvallis, OR 97331

Born: Medford, Oregon, July 5, 1944

Academic Training:

B.A. 1966 Willamette University
Ph.D. 1971 University of Pittsburgh

Professional Experience:

1971- Research Associate, IBP Coniferous Forest Biome

Publications: (recent, relevant):

1972. Feeding rates and food utilization of stream caddisfly larvae of the genus Neophylax (Trichoptera: Limnephilidae) using ^{60}Co and ^{14}C. IN: D. J. Nelson (ed.), Symposium on Radioecology: Proceedings of the Third National Symposium at Oak Ridge, Tenn., May 8-10, 1971 (in press).

1972. Studying streams as a biological unit. Proceedings--Research on Coniferous Forest Ecosystems--A Symposium, 23-24 March 1972, Bellingham, Wash. USDA Forest Service, Portland (in press).

Name: Michael J. Singer

Title: Postdoctoral Fellow

Mailing Address: College of Forest Resources
University of Washington AR-10
Seattle, Washington 98195

Born: New York, New York, October 5, 1945

Academic Training:

B.S.	1966	Cornell University
M.S.	1968	University of Minnesota
Ph.D.	1972	University of Minnesota

Professional Experience:

1966-72 Graduate Student, Soil Science Dept., University of Minnesota

Publications (recent, relevant):

1969. Lead accumulation in soils near highways in the Twin Cities metropolitan area. Soil Sci. Soc. Am. Proc. 33:152-153.

Name: Demetrios E. Spyridakis

Title: Research Assistant Professor

Mailing Address: Department of Civil Engineering
University of Washington FV-10
Seattle, WA 98195

Born: Heraklion, Greece, December 6, 1931

Academic Training:

B.S.	1957	Athens Graduate School of Agriculture, Greece
M.S.	1959	University of Wisconsin
Ph.D.	1965	University of Wisconsin

Professional Experience:

1963-64	Research Associate, University of Wisconsin
1964-69	Assistant Professor, University of Wisconsin
1970-	Research Assistant Professor, University of Washington

Publications (recent, relevant):

1967. (with G. Chesters and S. A. Wilde) Kaolinization of biotite as a result of coniferous and deciduous seedling growth. Soil Sci. Soc. Am. Proc. 31:203-210.

1967. (with S. A. Wilde) Hydroponics as a medium for production of tree planting stock. Agron. J. 59:275-278.

1971. (with E. M. Bentley and G. F. Lee) Chemical characterization of marsh discharge waters (accepted for publication).

Name: James T. Staley

Title: Assistant Professor

Mailing Address: Department of Microbiology
University of Washington RD-85
Seattle, WA 98195

Born: Brookings, South Dakota, March 14, 1938

Academic Training:

A.B.	1960	University of Minnesota
M.S.	1963	Ohio State University
Ph.D.	1967	University of California, Davis

Professional Experience:

1967-69	Instructor and Assistant Professor, Michigan State University
1969-71	Assistant Professor, University of North Carolina
1971-	Assistant Professor, University of Washington

Publications (recent, relevant):

1966. (with W. L. Boyd and J. W. Boyd) Ecology of soil microorganisms of Antarctica. IN: Antarctic soils and soil forming processes. Antarct. Res. Ser. 8.

1967. (with W. L. Boyd) L-Serine dehydratase (deaminase) of psychrophiles and mesophiles from polar and temperate habitats. Can. J. Microbiol. 13:1313-1342.

1968. Prosthecomicrobium and Ancalomicrobium: New freshwater prosthecate bacteria. J. Bacteriol. 95:1921-1942.

1969. *In situ* microscopic observation of the growth of algae. Bacteriol. Proc. p. 25 (Abstract).

1970. (with J. A. M. de Bont and H. S. Pankratz) Isolation and description of a non-motile, fuliform, stalked bacterium. a representative of a new genus. Antonie van Leeuwenhoek J. Microbiol. Serol. 36:397-407.

1970. (with J. M. Krul and P. Hirsch) Toxothrix trichogenes (chol.) Berger and Bringmann: The organism and its biology. Antonie van Leeuwenhoek J. Microbiol. Serol. 36:409-420.

1971. Growth rates of algae determined *in situ* using an immersed microscope. J. Phycol. 7:13-17.

James T. Staley (continued)

1971. Incidence of prosthecate bacteria in a polluted stream. Appl. Microbiol. 22:496-502.

1971. (with M. Van Ert) Gas vacuolated strains of <u>Microcyclus aquaticus</u>. J. Bacteriol. 108:236-240.

1971. (with M. Van Ert) A new gas vacuolated heterotrophic rod from freshwaters. Arch. Mikrobiol. 80:70-77.

---- Budding and prosthecate bacteria. IN: H. Lechevalier (ed.), Handbook of microbiology. Chemical Rubber Company, Cleveland, Ohio (in press).

Name: Harold W. Steinhoff

Title: Professor of Wildlife Biology

Mailing Address: Department of Fishery and Wildlife Biology
Colorado State University
Fort Collins, CO 80521

Born: Fort Morgan, Colorado, March 9, 1919

Academic Training:

B.S.	1941	Colorado A & M College
M.S.	1947	State University of New York at Syracuse University
Ph.D.	1957	State University of New York at Syracuse University

Professional Experience:

1947- Associate Professor, Assistant Professor to Professor, Colorado State University

1964- Project leader or coleader on wildlife research projects

Publications (recent, relevant):

1967. Wildlife population dynamics. Proc. 3rd Ann. Short Course Game Fish Manage., Colo. State Univ., p. 40-49. (Mimeo.)

1967. Statistics in wildlife management. Proc. 3rd Ann. Short Course Game Fish Manage., Colo. State Univ., p. 72-74. (Mimeo.)

1968. Wildlife education produces conservation counselors. Trans. N. Am. Wildl. Nat. Resour. Conf. 33:501-508.

1968. (with Morton May and William Brown) Bioeconomic models for big game management. Proc. Ann. Conf. West. Assoc. State Game Fish. Comm. 48:123-218.

1968. (with Albert W. Spencer) An explanation of geographical variation in litter size. J. Mammal. 49:281-286.

1971. Planning study of ecologic effects of artifically increased snow. Proceedings, Symposium on snow and ice in relation to wildlife and recreation. Iowa State Univ., Feb. 11-12, 1971.

1971. Communicating complete wildlife values of Kenai. Trans. N. Am. Wildl. Nat. Resour. Conf. 36:428-438.

Name: Quentin J. Stober

Title: Research Associate Professor

Mailing Address: Fisheries Research Institute
University of Washington WH-10
Seattle, Washington 98195

Born: Billings, Montana, March 25, 1938

Academic Training:

B.S.	1960	Montana State University
M.S.	1962	Montana State University
Ph.D.	1968	Montana State University

Professional Experience:

1958-62 Assistant Fishery Biologist, Montana Fish and Game Department, Great Falls

1962-65 Aquatic Biologist, FWQA, Southeast Water Laboratory, Athens, Georgia

1965-68 Graduate Research Assistant, Montana State University

1969- Research Assistant Professor to Research Associate Professor, University of Washington

Publications (recent, relevant):

1962. Some limnological effects of Tiber Reservoir on the Marias River, Montana. Mont. Acad. Sci. Proc. 23:111-137.

1969. Underwater noise spectra, fish sounds and response to lowfrequencies of cutthroat trout (Salmo clarkii) with reference to orientation and homing in Yellowstone Lake. Am. Fish. Soc. Trans. 98:652-663.

1970. Biological studies of the Kiket Island nuclear power site. Ann. Rep. Fish. Res. Inst. Coll. Fish. Univ. Wash. 114 p.

1971. Biological studies of the proposed Kiket Island nuclear power site. 2nd. Ann. Rep. Fish. Res. Inst. Coll. Fish. Univ. Wash. 197 p.

1972. Distribution and age of Margaritifera margaritifera (L.) in a Madison River mussel bed. Malacologia (in press).

1972. A small bioassay laboratory designed for experimental thermal effects evaluation. Fish. Res. Inst. Coll. Fish. Univ. Wash. Circ. No. 72-1. 12 p.

Name: Mary Ann Strand

Title: Research Assistant

Mailing Address: Department of Forest Management
Oregon State University
Corvallis, OR 97331

Born: Portland, Oregon, December 31, 1945

Academic Training:

B.A.	1967	Whittier College
Ph.D.	1972	Oregon State University

Professional Experience:

1966	Statistical Clerk, USDA Forest Service, Pacific Northwest Forest and Range Experiment Station
1967-70	NDEA Fellow, Oregon State University
1970-	Research Assistant, Oregon State University

Publications (recent, relevant):

1972. Annotated bibliography on the role of foliage-feeding insects in the forest ecosystem. IBP--Coniferous Forest Biome Internal Report 37.

1972. (with W. P. Nagel) Preliminary considerations of the forest canopy consumer subsystem. Proceedings--Research on Coniferous Forest Ecosystems--A symposium, 23-24 March, Bellingham, Wash. USDA Forest Service, Portland (in press).

----. Spruce budworm biomass transfer model. (MS in preparation.)

Name: Douglas N. Swanston

Title: Research Geologist

Mailing Address: USDA Forest Service
Pacific Northwest Forest and Range Experiment Station
Forestry Sciences Laboratory
P.O. Box 887
Corvallis, OR 97330

Born: Pensacola, Florida, June 9, 1938

Academic Training:

B.S.	1960	University of Michigan
M.A.	1962	Bowling Green State University
Ph.D.	1967	Michigan State University

Professional Experience:

1964-71 Research Geologist, USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, Juneau, Alaska

1966- Visiting Scientist and Adjunct Lecturer, Glaciological and Arctic Sciences Institute (Michigan State University) on the Juneau Icefield, Alaska

1971- Research Geologist, USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, Corvallis, Oregon

1971- Geological Consultant, Daniel, Mann, Johnson and Mendenhall, Architects and Engineers, Portland, Oregon - Stability problems in land-use planning

Publications (recent, relevant):

1968. (with J. H. Patric) Hydrology of a slide-prone glacial till soil in southeast Alaska. J. For. 66:62-66.

1969. Mass wasting in coastal Alaska. USDA For. Serv., Pac. Northwest For. Range Exp. Stn. Pap. PNW-83, 15 p.

1970. The mechanics of debris avalanching in shallow till soils of southeast Alaska. USDA For. Serv., Pac. Northwest For. Range Exp. Stn. Pap. PNW-103, 17 p.

1970. (with D. J. Barr) Measurement of creep in a shallow slide-prone till soil. Am. J. Sci. 269:467-480.

1971. Principal soil mass movement processes influenced by logging, roadbuilding, and fire. Proceedings, Symposium on Forest Land Uses and Stream Environment, p. 29-39. Oregon State Univ.

Name: Richard D. Taber

Title: Professor

Mailing Address: College of Forest Resources
University of Washington AR-10
Seattle, WA 98195

Born: San Francisco, California, November 22, 1920

Academic Training:

B.S.	1942	University of California, Berkeley
M.S.	1949	University of Wisconsin
Ph.D.	1951	University of California, Berkeley

Professional Experience:

1946-48	Conservation Aide, Wisconsin Conservation Department
1948-55	Research Zoologist, California Forest and Range Experiment Station
1955-56	Acting Assistant Professor, University of California, Berkeley.
1956-57	Assistant Professor to Professor and Associate Director, Montana Forest and Conservation Experiment Station, University of Montana
1960	American Specialist (Forest-Wildlife Relations), U.S. Department of State, for West Germany, Poland, and Czechoslovakia
1963-64	Fulbright Research Professor, West Pakistan Agricultural University, Lyallpur
1967-68	Professor and Director, Center for Natural Resources, University of Montana
1968-	Professor and Associate Director, Institute of Forest Products, University of Washington

Publications (recent, relevant):

1966. Wildlife in rural and wild America. IN: Wildlife resources in a changing world, p. 20-30, AAAS Symposium.

1967. (with A. H. Sheri and M. S. Ahmad) Mammals of the Lyallpur region, West Pakistan. J. Mammal. 48:392-407.

1967. Forestry and wildlife in northern California. IN: Man's Effect on California Watersheds, p. 168-210. Rep. from the Institute of Ecology, Univ. Calif. Davis to Assembly Comm. on Natural Resources, Planning, and Public Works of the California State Legislature.

Richard D. Taber (continued)

1971. Pest situations involving big game. IN: R. A. McCabe (ed.), The vertebrates that are pests: Problems and control, Chap. VII. Part of a series on principles of plant and animal pest control, Nat. Res. Council (in press).

1971. Population dynamics. IN: R. O. Teague (ed.), A manual of wildlife conservation, p. 60-66. The Wildlife Society. 206 p.

1972. (with J. L. Murphy) Controlled fire in the management of North American deer. Symposium on the management of natural areas, E. Duffey (ed.). British Ecological Society.

Name: Frieda B. Taub

Title: Research Associate Professor

Mailing Address: College of Fisheries
University of Washington WH-10
Seattle, WA 98195

Born: Newark, New Jersey, October 11, 1934

Academic Training:

B.A.	1955	Rutgers University
M.A.	1957	Rutgers University
Ph.D.	1959	Rutgers University

Professional Experience:

1953-55	Undergraduate Teaching Assistant, Rutgers University
1954-55	Associated with Department of Animal Behavior, American Museum Natural History
1959-61	Fisheries Biologist, University of Washington
1961	Research Instructor, University of Washington
1962-65	Research Assistant Professor, University of Washington
1966-71	Research Associate Professor, University of Washington
1971-	Professor, College of Fisheries, University of Washington

Publications (recent, relevant):

1961. The distribution of the red-backed salamander, Plethedon c. cinereus, within the soil. Ecology 42:681-698.

1963. Some ecological aspects of space biology. Am. Biol. Teach. 25:412-421.

1969. A biological model of a freshwater community: gnotobiotic ecosystem. Limnol. Oceanogr. 14:136-142.

1969. Gnotobiotic models of freshwater communities. Proc. Int. Soc. Theor. Appl. Limnol. 17:485-496.

1971. A continuous gnotobiotic (species defined) ecosystem. IN: John Cairns (ed.), The structure and function of freshwater microbial communities, p. 101-120. Virginia Polytechnic Institute and State University.

Name: Hans Leo Teller

Title: Associate Professor

Mailing Address: Department of Watershed Sciences
Colorado State University
Fort Collins, CO 80521

Born: Ceske Budejovice, Czechoslovakia, July 20, 1931

Academic Training:

Dip. For.	1953	Victorian School of Forestry
B.S.	1957	University of Melbourne
M.F.	1960	Yale University
Ph.D.	1963	University of Washington

Professional Experience:

1963-66 Research Officer and Forest Hydrologist, Forests Commission of Victoria, Australia

1967-69 Forestry Officer, Conservation and Land Use Section, Forestry and Forest Industries Division, FAO (Rome)

1969- Associate Professor, Dept. of Watershed Sciences, Colorado State University

Publications (recent, relevant):

1968. Research trends in forest hydrology. Aust. For. 32 111-117.

1968. Review: "International Symposium on Forest Hydrology." Aust. For. 32:179-180.

1970. (with J. D. Ives, H. E. Owen, and H. W. Steinhoff) (eds.) The San Juan Ecology Project, Phase I. A problem analysis and study plan for an evaluation of the ecological impact of weather modification in the Upper Colorado River Basin. Final Report. Dept. of Watershed Sciences, Colorado State University, Fort Collins. 98 p. + appendixes.

1971. Evaluation of weather modification effects on ecology--A Colorado case study. Paper presented at XVth IUFRO Congress, Gainesville, Fla., Mar. 14-20.

1971. (with D. R. Cameron) Preliminary studies in the terrestrial disposition of silver from cloud seeding. Paper presented at 7th American Water Resources Conference, Washington, D.C., Oct. 25-28.

Name: Richard E. Thorne

Title: Senior Research Associate

Mailing Address: Fisheries Research Institute
College of Fisheries
University of Washington WH-10
Seattle, WA 98195

Born: Aberdeen, Washington, April 12, 1943

Academic Training:

B.S.	1965	University of Washington
M.S.	1968	University of Washington
Ph.D.	1970	University of Washington

Professional Experience:

1970 Fisheries Biologist IV, Division of Marine Resources, University of Washington

1970- Senior Research Associate, University of Washington

1971- Program Coordinator, Marine Acoustics Program, Division of Marine Resources, University of Washington

Publications (recent, relevant):

1969. Acoustic techniques of fish population estimation with special reference to echo integration. Fish. Res. Inst., Univ. Wash. Circ. 69-10. 12 p.

1970. (with R. L. Burgner and A. Isaksson) Sea Grant Sockeye Salmon studies. Research in Fisheries, 1969, p. 20. Coll. Fish. Univ. Wash. Contrib. 320.

1970. (with J. Woodey) Stock assessment by echo integration and its application to juvenile sockeye salmon in Lake Washington. Fish. Res. Inst., Univ. Wash. Circ. 702-2. 31 p.

1971. Investigations into the relationship between integrated echo voltage and fish density. J. Fish. Res. Board Can. 28:1269-1273.

1971. (with J. E. Reeves and A. E. Millikan) Estimation of the Pacific hake (Merluccius productus) population in Port Susan, Washington, using an echo integrator. J. Fish. Res. Board Can. 28:1275-1284.

1971. (with P. H. Moose and M. O. Nelson) Hydroacoustic techniques for fishery resource assessment. J. Mar. Technol. Soc. 5:35-37.

Name: James M. Trappe

Title: Project Leader, Principal Mycologist, and Associate Professor

Mailing Address: USDA Forest Service
Pacific Northwest Forest and Range Experiment
Station
P.O. Box 887
Corvallis, OR 97330

Born: Spokane, Washington, August 16, 1931

Academic Training:

B.S.	1953	University of Washington
M.F.	1956	New York State University (Syracuse)
Ph.D.	1962	University of Washington

Professional Experience:

1956- Principal Mycologist, USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, Corvallis

1965- Associate Professor, Oregon State University

Publications (recent, relevant):

1969. Studies on Cenococcum graniforme. I. An efficient method for isolation from sclerotia. Can. J. Bot. 47:1389-1390.

1969. (with H. D. Thiers) Studies in the genus Gastroboletus. Brittonia 21:244-254.

1969. (with C. Y. Li, K. C. Lu, and W. B. Bollen) Effect of phenolic and other compounds on growth of Poria weirii in vitro. Microbios 3:305-311.

1970. (with P. Catalfomo) Ectomycorrhizal fungi: A phytochemical survey. Northwest Sci. 44:19-24.

1970. (with O. Miller) A new Chroogomphus with a loculate hymenium and a revised key to section Floccigomphus. Mycologia 62:831-836.

1971. (with G. Guzman) Notes on some hypogeous fungi of Mexico. Mycologia (in press).

Name: Matsuo Tsukada

Title: Associate Professor

Mailing Address: Department of Botany
University of Washington HA-40
Seattle, WA 98195

Born: Nagano, Japan, January 4, 1930

Academic Training:

B.S.	1953	Shinshu University, Nagano, Japan
M.S.	1957	Osaka City University, Osaka, Japan
Ph.D.	1961	Osaka City University, Osaka, Japan

Professional Experience:

1961-62	Postdoctoral fellow, the Japan Academy
1961-62	Seessel Fellow, Yale University
1962-68	Research Associate, Yale University
1966-68	Lecturer (Biology), Yale University
1969-	Associate Professor, University of Washington

Publications (recent, relevant):

1970. Paleolimnology of Hall Lake, Washington. II. Population growth of fossil desmids: Species diversity and equitability. Pac. Sec. Am. Soc. Limnol. Oceanogr. (abstract):7.

----. Population dynamics of fossil desmids in Hall Lake, Washington. (Submitted for publication.)

----. The history of Lake Nojiri, Japan. Trans. Conn. Acad. Art. Sci. 53: (in press).

Name: Fiorenzo C. Ugolini

Title: Associate Professor

Mailing Address: College of Forest Resources
University of Washington AR-10
Seattle, Washington 98195

Born: Florence, Italy, January 16, 1929

Academic Training:

B.S.	1957	Rutgers University
Ph.D.	1960	Rutgers University

Professional Experience:

1957-60	Hutcheson Memorial Forest Research Fellow, Rutgers University
1960-61	Postdoctoral Fellow, Arctic Institute of North America, Rutgers University
1961-64	Assistant Professor of Soils, Rutgers University
1964-65	Assistant Professor of Soils and Research Associate, Ohio State University
1966-	Associate Professor, University of Washington

Publications (recent, relevant):

1968. Soil development and alder invasion in a recently deglaciated area of Glacier Bay, Alaska. IN: J. M. Trappe, J. F. Franklin, R. F. Tarrant, and G. M. Hansen (eds.), Biology of alder, p. 115-148. Proc. Fortieth Ann. Meeting Northwest Sci. Assoc. Symp.

1970. Antarctic ecology. IN: Dr. Holdgate (ed.), Antarctic soils and their ecology, p. 673-692. Academic Press, London and New York. 998 p.

1972. (with J. G. Bockheim) Soils and parent materials of Findley Lake, Snoqualmie National Forest, Washington. Abstracts of papers presented at the Forty-fifth Annual Meeting of the Northwest Scientific Association, Western Washington State College, March 23-25, p. 2.

1972 (with J. G. Bockheim) Properties and genesis of Humuula Paleosols and modern soils, Mauna Kea, Hawaii. Abstract with programs, Vol. 4, No. 3. p. 252. Cordillera Section, Geological Society of America, Sixty-eighth Annual Meeting, March 29 to April 1, 1972, Honolulu, Hawaii.

1972. (with A. K. Schlichte) Morphology and genesis of adjacent prairie and forest soils of the Puget Sound Lowland. Abstracts of papers presented at the Forty-fifth Annual Meeting of the Northwest Scientific Association, Western Washington State College, March 23-25, p. 12.

Name: Richard B. Walker

Title: Professor

Mailing Address: Department of Botany
University of Washington AK-10
Seattle, WA 98195

Born: Tennessee, Illinois, October 24, 1916

Academic Training:

B.S.	1938	University of Illinois
Ph.D.	1948	University of California, Berkeley

Professional Experience:

1938-40	Teaching Assistant in Botany, University of California
1948-	Successively, Instructor to Professor, University of Washington
1956	Lalor Foundation Faculty Summer Research Fellow
1958-63	Member of four different one-month expeditions to Rongelap Atoll, Marshall Islands
1962-71	Chairman, Department of Botany, University of Washington
1964-65	Guest Investigator, Botanical Institute, The University, Innsbruck, Austria.

Name: Robert F. Wambach

Title: Dean and Professor

Mailing Address: School of Forestry
University of Montana
Missoula, MT 59801

Born: September 30, 1930

Academic Training:

B.S.	1957	University of Montana
M.F.	1959	University of Michigan
Ph.D.	1967	University of Minnesota

Professional Experience:

1959-63	Research Forester (mensurationist), Lake States Forest Experiment Station, USDA Forest Service, Grand Rapids, Minnesota
1963-65	Research Project Leader, Lake States Forest Experiment Station, USDA Forest Service, Cadillac, Michigan
1965-67	Research Project Leader, North Central Forest Experiment Station, USDA Forest Service, Grand Rapids, Minnesota
1967-72	Associate Dean, School of Forestry, University of Montana
1972-	Dean, School of Forestry, University of Montana

Publications (recent, relevant):

1969. Compatibility of mechanization with silviculture. J. For. 67:104-108.

1969. (with John H. Cooley) Fifteen-year growth of a thinned white spruce plantation. USDA For. Serv. Res. Note. NC-72. 4 p.

1970. An economist's view of the environmental crisis. IN: Ecology, Economics and the Environment. Mont. For. Cons. Exp. Stn. 235 p.

1970. (with Arnold W. Bolle and others) A university view of the Forest Service: A Report on the Bitterroot National Forest. Senate Document No. 90-115. 33 p.

1971. Comment on "Impact of fire control practices on ecosystem development." IN: The role of fire in the intermountain West, p. 137-141. Intermountain Fire Research Council. 229 p.

1972. The challenge to forestry in the environmental '70's. IN: Forest land use and the environment. Mont. For. Cons. Exp. Stn. (in press).

Name. Richard H. Waring

Title: Associate Professor

Mailing Address: School of Forestry
Oregon State University
Corvallis, OR 97331

Born: Chicago, Illinois, May 17, 1935

Academic Training:

B.S.	1957	University of Minnesota
M.S.	1959	University of Minnesota
Ph.D.	1963	University of California, Berkeley

Professional Experience:

1963-70	Assistant Professor, Oregon State University
1970	Associate Professor, Oregon State University

Publications (recent, relevant):

1969. Forest plants of the eastern Siskiyous: Their environmental and vegetational distribution. Northwest Sci. 43:1-17.

1970. (with T. Atzet) Selective filtering of light by coniferous forests and minimum light energy requirements for regeneration. Can. J. Bot. 48:2163-2167.

1970. Die Messung des Wasserpotentials mit der Scholander-Methode und ihre Bedeutung fur die Forstwissenschaft. Forstwiss. Centralb. 89:195-200.

1971. Matching species to site. IN: R. K. Hermann (ed.), Regeneration of Ponderosa pine, p. 54-61. Oregon State Univ., School of Forestry.

1972. (with C. T. Youngberg) Evaluating forest sites for potential growth response of trees to fertilizer. Northwest Sci. 46:67-75.

Name: Charles E. Warren

Title: Professor

Mailing Address: Department of Fisheries and Wildlife
Oregon State University
Corvallis, OR 97331

Born: Portland, Oregon, October 26, 1926

Academic Training:

B.S.	1949	Oregon State College
M.S.	1951	Oregon State University
Ph.D.	1961	University of California

Professional Experience:

1953-59	Assistant Professor, Oregon State University
1959-65	Associate Professor, Oregon State University
1965-	Professor, Oregon State University
1957-	General Coordinator, Pacific Cooperative Water Pollution and Fisheries Research Laboratories
1965-66	Associate Editor, The Journal of Wildlife Management
1970-	Sea Grant Coordinating Committee

Publications (recent, relevant):

1967. (with G. E. Davis) Laboratory studies of the feeding, bioenergetics and growth of fish. IN: S. D. Gerking (ed.), The biological basis of fresh-water fish production, p. 175-214. Blackwell Scientific Publications, Oxford and Edinburgh. 510 p.

1968. (with R. W. Brocksen and G. E. Davis) Competition, food consumption and production of sculpins and trout in laboratory stream communities. J. Wildl. Manage. 32:51-75.

1968. (with G. E. Davis) Estimation of food consumption rates. IN: W. E. Ricker (ed.), Methods for assessment of fish production in fresh waters, p. 205-225. Blackwell Scientific Publications, Oxford and Edinburgh. 313 p.

1970. (with R. W. Brocksen and G. E. Davis) The analyses of trophic processes on the basis of density-dependent functions. Symposium on Marine Food Chains, Aarhus, Denmark, p. 468-498. University of California Press and Oliver and Boyd, London.

1971. (in collaboration with P. Doudoroff) Biology and water pollution control. W. B. Saunders Company, Philadelphia. 434 p.

1971. (with G. E. Davis) Laboratory stream research: Objectives, possibilities, and constraints. IN: R. F. Johnston (ed.), Annual review of ecology and systematics, Vol. 2, p. 111-114.

Name: Warren L. Webb

Title: Research Associate

Mailing Address: School of Forestry
Oregon State University
Corvallis, OR 97331

Born: Redmond, Oregon, January 25, 1935

Academic Training:

B.S.	1959	Oregon State University
B.S.	1964	Oregon State University
M.S.	1967	Oregon State University
Ph.D.	1971	Oregon State University

Professional Experience:

1964	Assistant in Forest Management Research, Oregon State University
1964-65	Research Assistant, Oregon State University
1965-68	Research Forester, USDA Forest Service, Berkeley, California
1968-71	Research Assistant, Oregon State University
1971-	Research Associate, Oregon State University

Name: A. R. Weisbrod

Title: Assistant Professor

Mailing Address: College of Forest Resources
University of Washington AR-10
Seattle, WA 98195

Born: Redmond, Oregon, October 14, 1936

Academic Training:

B.A.	1959	University of Minnesota
M.S.	1965	Cornell University
Ph.D.	1970	Cornell University

Professional Experience:

1966-69	Assistant Curator of Birds, Cornell University Bird Collection
1969-70	Associate Curator of Systematic Collections, Cornell University
1970-	Research Biologist, National Park Service, and Assistant Professor, University of Washington

Publications (recent, relevant):

1969. A manual of curatorial instructions and procedures. Cornell Univ. 82 p. (Mimeo.)

1970. Food preferences of a handraised bluejay. Wilson Bull. 82:101-102.

1970. A response of a red-tailed hawk (*Buteo jamacensis*) to mobbing crows. Kingbird 20:70.

1971. Grooming behavior of the bluejay, *Cyanocitta cristata*. Living Bird 10:271-284.

Name: Eugene B. Welch

Title: Associate Professor, Applied Biology

Mailing Address: Department of Civil Engineering
University of Washington FV-10
Seattle, WA 98195

Born: Litchfield, Illinois, December 18, 1932

Academic Training:

B.S.	1958	Michigan State University
M.S.	1959	Michigan State University
Ph.D.	1967	University of Washington

Professional Experience:

1959-62	Fisheries Biologist, Pollution Control Biologist, Montana Fish and Game and Board of Health
1964-67	Aquatic Biologist, U.S. Geological Survey
1967-68	Supervisor, Biology, Water Quality Division, Tennessee Valley Authority
1968-70	Assistant Professor, University of Washington
1970-	Associate Professor, University of Washington

Publications (recent, relevant):

1969. Factors initiating phytoplankton blooms and resulting effects on dissolved oxygen in an enriched estuary. U.S. Geological Survey Water Supply Paper 1873-A. 62 p.

1970. (with W. H. Peltier) Factors affecting growth of rooted aquatics in a reservoir. Weed Sci. 18:7-9.

1972. (with J. A. Buckley and R. M. Bush) Dilution as a control for nuisa algal blooms. J. Water Pollut. Control Fed. (in press).

1972. (with D. E. Spyridakis) Dynamics of nutrient supply and primary production in Lake Samish, Washington. IN: Proceedings--Research on coniferous forest ecosystems--A symposium. Bellingham, Wash., March 23-24. USDA Forest Service, Portland (in press).

Name: Charles August Wellner

Title: Assistant Director, Intermountain Forest and Range Experiment Station, USDA Forest Service

Mailing Address: USDA Forest Service
Intermountain Forest and Range Experiment Station
Forestry Sciences Laboratory
P.O. Box 469
Moscow, ID 83843

Born: January 3, 1911

Academic Training:

B.S.	1933	University of Idaho
M.F.	1938	Yale University
Certificate in Aerology	1944	U.S. Naval Academy

Professional Experience:

1948-58 Leader, Inland Empire Research Center, U.S. Forest Service, Spokane, Washington

1958-65 Chief, Timber Management and Forest Disease Research, Intermountain Forest and Range Experiment Station, U.S. Forest Service, Ogden, Utah

1965- Assistant Director, Intermountain Forest and Range Experiment Station, USDA Forest Service, Ogden, Utah, and Moscow, Idaho

Publications (recent, relevant):

1968. (with David E. Ketcham, and Samuel S. Evans, Jr.) Western white pine management programs realigned on northern Rocky Mountain National Forests. J. For. 66:329-332.

1969. Progress in the development and maintenance of representative natural coniferous forest ecosystems in the northern Rocky Mountains. Symposium on Coniferous Forests of the Northern Rocky Mountains Proc. 1968, p. 131-150. Univ. Montana Foundation.

1970. (with William Worf, Robert H. Cron, Sherwood C. Trotter, Otis L. Copeland, and S. Blair Hutchison) Management practices on the Bitterroot National Forest. A Task Force Appraisal, May 1969-April 1970. USDA Forest Service. 100 p.

1971. Fire history in the northern Rocky Mountains. Symposium on the Role of Fire in the Intermountain West, Intermountain Fire Research Council Proc. 1970, p. 42-64.

Name: Richard R. Whitney

Title: Associate Professor

Mailing Address: College of Fisheries
University of Washington WH-10
Seattle, WA 98195

Born: Salt Lake City, Utah, June 29, 1927

Academic Training:

A.B.	1949	University of Utah
M.S.	1951	University of Utah
Ph.D.	1955	Iowa State University

Professional Experience:

1954-57	Research Biologist, University of California, Los Angeles
1951-60	Project Leader, Susquehanna Fishery Study, Chesapeake Biological Laboratory
1961-67	Fishery Biologist, Chief, BCF Tuna Resources Laboratory, La Jolla, California Research Fellow, Scripps Institute of Oceanography
1967	Acting Assistant Director, BCF Fishery Oceanography Center La Jolla, California
1967-	Unit Leader, Washington Cooperative Fishery Unit and Associate Professor, University of Washington

Publications (recent, relevant):

1961. The orangemouth corvina, Cynoscion xanthulus, Jordan and Gilbert. IN: The Ecology of the Salton Sea, California, in relation to the sportfishery. Calif. Dep. Fish Game, Fish. Bull. 113:165-183.

1961. The Susquehanna fishery study 1957-1960. Maryland Dep. Res. Educ., Contrib. No. 169. 43 p.

1969. Inferences on tuna behavior from data in fishermen's logbooks. Trans. Am. Fish. Soc. 98:27.

1969. Schooling of fishes relative to available light. Trans. Am. Fish. Soc. 98:497-504.

1972. (with William C. Legget) Water temperature and the migrations of American shad. Fishery Bulletin, National Marine Fisheries Service (in press).

Name: Ed F. Wicker

Title: Plant Pathologist

Mailing Address: Intermountain Forest and Range Experiment Station
USDA Forest Service
P.O. Box 469
Moscow, ID 83843

Born: August 21, 1930

Academic Training:

B.S.	1959	Washington State University
Ph.D.	1965	Washington State University

Professional Experience:

1955-72 Plant Pathologist, USDA Forest Service

Publications (recent, relevant):

1969. Differential response of invading _Tuberculina maxima_ to white pine tissues. (Abstr.) Phytopathology 59:16.

1969. Susceptibility of coastal form and central Montana Douglas-fir to _Arceuthobium douglasii_. Plant Dis. Rep. 53:311-314.

1969. Current approach to blister rust control. Proceedings, XI International Botanical Congress, p. 237. (Abstr.)

1969. Dormancy and aecia production by _Cronartium ribicola_. (Abstr.) Phytopathology 59:1057.

1970. Retention of infectivity and pathogenicity by _Tuberculina maxima_ in culture. Mycologia 62:1209-1211.

1970. Incubation period for _Tuberculina maxima_ infecting white pine blister rust cankers. Phytopathology 60:1693.

Name: David D. Wooldridge

Title: Associate Professor

Mailing Address: College of Forest Resources
University of Washington AR-10
Seattle, WA 98195

Born: Seattle, Washington, March 12, 1927

Academic Training:

B.S.	1950	University of Washington
Ph.D.	1961	University of Washington

Professional Experience:

1950-52	Forester, Rayonier, Inc., Hoquiam, Washington
1952-53	Photogrammetrist, Carl M. Berry (part-time)
1953-56	Research Forester, Rayonier, Inc.
1956-68	Research Forester, Forest Hydrology Laboratory, USDA Forest Service
1965-68	Assistant Professor, University of Washington
1968-	Associate Professor, University of Washington
1969-	Assistant Director, Research, Institute of Forest Products, University of Washington

Publications (recent, relevant):

1960. Watershed disturbance from tractor and skyline crane logging. J. For. 58:369-372.

1964. Effects of parent material and vegetation on properties related to soil erosion in central Washington. Soil Sci. Soc. Am. Proc. 28:430-432.

1965. Tracing soil particle movement with Fo^{59}. Soil Sci. Soc. Am. Proc.

1967. Water transport in soils and streams. Transport phenomena in atmospheric and ecological systems, p. 1-20. Am. Soc. Mech. Eng.

Name: Donald M. Wootton

Title: Professor

Mailing Address: Department of Biology
Chico State College
Chico, CA 95926

Born: Paonia, Colorado, April 13, 1916

Academic Training:

A.B.	1941	Santa Barbara State College
M.S.	1943	University of Washington
Ph.D.	1949	Stanford University

Professional Experience:

1941-42	Instructor, Santa Barbara State College
1948	(spring) Visiting Instructor, University of Washington
1949-56	Instructor to Assistant Professor, University of California Santa Barbara
1956-57	Independent Investigator, Marine Biological Laboratories, Woods Hole, Massachusetts
1957-	Assistant Professor to Professor, Chico State College
1964-65	Research Associate, University of Michigan
1966-67	Director, Eagle Lake Field Station, Chico State College
1967-69	Dean, School of Graduate Studies, Chico State College

Publications (recent, relevant):

1965. Digenetic trematodes of North America. Mongr., Student Services, Ann Arbor, Mich. 1-125.

1967. (with E. C. Powell) The identity of *Deropegus* McCauley and Pratt, 1961 and *Parahalipegus,* Wootton and Powell, 1964, genera proposed to receive *Halipegus aspina* Ingles, 1936. J. Parasitol. 53:576.

1967. (with D. Murrel) *Ptyalincola ondatrae,* gen. et sp. n. (Trematoda-Brachylaemidae), a fluke inhabiting the salivary glands of muskrats. J. Parasitol. 53:739-742.

Name: Richard S. Wydoski

Title: Assistant Professor

Mailing Address: College of Fisheries
University of Washington WH-10
Seattle, WA 98195

Born: Nanticoke, Pennsylvania, February 3, 1936

Academic Training:

	1956-57	Wilkes College
B.S.	1960	Bloomsburg State College
M.S.	1962	Pennsylvania State University
Ph.D.	1965	Pennsylvania State University

Professional Experience:

1960-65	Graduate Teaching Assistant, Pennsylvania State University
1965-66	Fishery Biologist, Bureau of Commercial Fisheries, Oregon State University
1966-69	Assistant Leader, Oregon Cooperative Fishery Unit, and Assistant Professor, Oregon State University
1969-	Assistant Leader, Washington Cooperative Fishery Unit, and Assistant Professor, University of Washington

Publications (recent, relevant):

1961. The occurrence of placental scars in mammals. Proc. Penn. Acad. Sci. 35:197-204.

1964. Seasonal changes in the color of starling bills. Auk 81:542-550.

1966. Maturation and fecundity of brook trout from infertile streams. J. Fish. Res. Board Can. 23:623-649.

1968. An improved girthometer for studies of gill net selectivity. Prog. Fish-Cult. 30:62-64.

1969. Occurrence of the spotfin surfperch in Oregon waters. Calif. Fish Game 55:335.

Name: C. T. Youngberg

Title: Professor

Mailing Address: Department of Soils
Oregon State University
Corvallis, OR 97331

Born: Seattle, Washington, March 25, 1917

Academic Training:

B.S.	1941	Wheaton College
M.S.	1947	University of Michigan
Ph.D.	1951	University of Wisconsin

Professional Experience:

1946-47	Teaching Assistant, University of Michigan
1949-50	Instructor, University of Michigan (summer)
1947-51	Research Assistant, University of Wisconsin
1951-52	Forest Soils Specialist, Weyerhaeuser Timber Company
1952-57	Associate Professor, Oregon State College
1958-64	Professor, Oregon State University
1964-65	Sabbatical leave at Harvard Forest, Petersham, Massachusetts
1965-	Professor, Oregon State University.

Publications (recent, relevant):

1966. Forest floors in Douglas-fir forest: I. Dry weight and chemical properties. Soil Sci. Soc. Am. Proc. 30:406-409.

1966. (with A. G. Wollum and C. M. Gilmour) Characterization of a Streptomyces sp. isolated from root nodules of Ceanothus velutinus Dougl. Soil Sci. Soc. Am. Proc. 30:436-467.

1967. (with S. R. Webster and A. G. Wollum) Fixation of nitrogen by bitterbrush, Purshia tridentata (Pursh) D.C. Nature 216:392-393.

1971. (with W. G. Dahms) Soil-vegetation indices for lodgepole pine productivity on pumice soils in Central Oregon. J. For. (in press).

Name: Donald B. Zobel

Title: Assistant Professor

Mailing Address: Department of Botany
Oregon State University
Corvallis, OR 97331

Born: Salinas, California, July 17, 1942

Academic Training:

B.S.	1964	North Carolina State University
M.S.	1966	Duke University
Ph.D.	1968	Duke University

Professional Experience:

1968- Assistant Professor, Oregon State University

Publications (recent, relevant):

1969. Factors affecting the distribution of Pinus pungens, an Appalachian endemic. Ecol. Monogr. 39:303-333.