APPENDIX II

NOTICE OF RESEARCH PROJECT
SCIENCE INFORMATION EXCHANGE
SMITHSONIAN INSTITUTION
NATIONAL SCIENCE FOUNDATION
PROJECT SUMMARY

PROJECT NO. (Do not use this space)

NSF AWARD NO.

1. NAME OF INSTITUTION (INCLUDE BRANCH/CAMPUS & SCHOOL OR DIVISION)

School of Forestry

2. MAILING ADDRESS

School of Forestry, Oregon State University, Corvallis, Oregon 97331

3. PRINCIPAL INVESTIGATOR AND FIELD OF SCIENCE/SPECIALTY

R. H. Waring, Forest Ecologist

4. TITLE OF PROJECT

Long-term Ecological Research on the H. J. Andrews Experimental Forest

5. SUMMARY OF PROPOSED WORK (LIMIT TO 22 PICA OR 18 ELITE TYPEWRITTEN LINES)

Establishment of a long-term ecological research program is proposed at the H. J. Andrews Experimental Ecological Reserve. The Reserve includes a 6,000-ha experimental forest and six research Natural areas in the Oregon Cascades. These sites have been dedicated exclusively to scientific use and provide superlative examples of northwestern coniferous forests (especially Douglas-fir-hemlock) and stream ecosystems. Extensive on-going research and monitoring programs make establishment of an LTER program appropriate and efficient. Five major components are proposed: (1) changes in composition, structure, and key processes with succession in Douglas-fir-western hemlock forest; (2) nature and importance of forest-stream interactions; (3) population dynamics of young forest stands as affected by density and nutrient regime; (4) long-term impact of nitrogen fixers on forest soils; and (5) patterns and rates of log decomposition. Each LTER component is directly tested by long-term (20 to 100+ year) measurements. Experimental manipulations are included along with observations of pristine natural ecosystems (including 450-year-old Douglas-fir forest). Measurements proposed under LTER components 1 and 2 will provide for a complete set of site long-term baseline measurements as proposed by national workshops when combined with the on-going program at the Andrews. Development of a comprehensive data management system is also proposed in order to insure data are reduced promptly and readily accessible to scientists and collaborating sites. Strong institutional commitments exist from Oregon State University and the U.S. Forest Service.

FOR NSF USE ONLY

DIVISION (OFFICE) AND DIRECTORATE	PROGRAM	
SECTION	PROPOSAL NO.	F.Y.

FOR DGC USE ONLY

START AND END DATES	AMOUNT GRANTED

NSF FORM 4 (7-78) 1. Proposal Folder 2. Program Suspense 3. Division of Grants & Contracts 4. Science Information Exchange 5. Principal Investigator 6. Off. of Govt. & Pub. Progs. 7. Assistant Director

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INTRODUCTION

The new emphasis on long-term ecological research (LTER) by the National Science Foundation is a long overdue and most welcome development. As has been pointed out in several recent reports (Botkin 1977, 1978; The Institute of Ecology 1979) there are numerous hypotheses and questions in biology that can only be addressed, or at least critically tested, through a sustained program of measurements. Such long-term data sets can also be primary sources for development of new hypotheses.

The ecosystem scientists associated with the H. J. Andrews Experimental Ecological Reserve are enthusiastic about the LTER program and this document is our initial proposal for participation. The proposal is focused on this western Oregon Cascade Range reserve which includes six associated Research Natural Areas. The proposal is a collaboration between Oregon State University (OSU) and the U.S. Forest Service (USFS), institutions that are strongly supportive and provide the institutional protection and stability for the research site and assure continuity for the LTER.

The H. J. Andrews Experimental Ecological Reserve (AEER) meets all criteria for a LTER site of the first rank. The quality of the ecosystems and research potential of the site is recognized by its designation as an Experimental Forest, Biosphere Reserve, and Experimental Ecological Reserve. The terrestrial and aquatic systems are diverse and highly representative of the Pacific Northwest coniferous forests. Manipulative research is possible but large undisturbed controls exist. An extensive current program (approximately $1.5 million annually) of research and monitoring is already supported by OSU, USFS, and NSF funds. This activity plus the AEER facility support, presently provided by NSF under the Biological Research Resources program, makes it somewhat easier and cheaper to develop a comprehensive LTER program at H. J. Andrews. Many necessary measurements are already provided and necessary administrative structures exist.

Our LTER goal at the H. J. Andrews will be to build a complete program by adding to on-going research, monitoring, and data management efforts. We propose to add the necessary sampling programs, drastically improve the data management capabilities, and integrate our efforts with other LTER sites across the nation. Key measurements will be picked up from terminating NSF research programs, such as with certain aspects of Watershed 10.

The working maxims of our H. J. Andrews LTER program are as follows:

(1) We will use the program to look at important ecological hypotheses and processes that cannot be examined, or at least definitively resolved, using short-term studies.

(2) We will develop and maintain a complete terrestrial and stream baseline measurement program at AEER as it evolves from eariler proposals (The Institute of Ecology 1979).

(3) We will use sampling strategy that will be statistically adequate to detect change or test hypotheses.

(4) We will emphasize development of capabilities for rapid reduction and analysis of data and convenient, rapid access to the data by interested scientists and collaborating LTER sites.

(5) We will actively seek links with other LTER sites including selection of common equipment or measurement techniques, conduct of common experiments, and data exchange.

SITE DESCRIPTION

The research described in this proposal will be conducted on the H. J. Andrews Experimental Ecological Reserve (AEER), which consists of the H. J. Andrews Experimental Forest and six nearby research natural areas (RNA's). A lengthy description of these sites is contained in the proposal for NSF Grant No. DEB-76-11978, and will be briefly summarized here.

Location and Facilities

The AEER properties are located in the Willamette National Forest on the west slope of the Oregon Cascades (Figure 1). Headquarters for the AEER is currently in the small town of Blue River, approximately 65 kilometers east of Eugene. Construction of centralized facilities on the Andrews Forest itself has been initiated and laboratory, office, and living quarters should be completed in the spring of 1981.

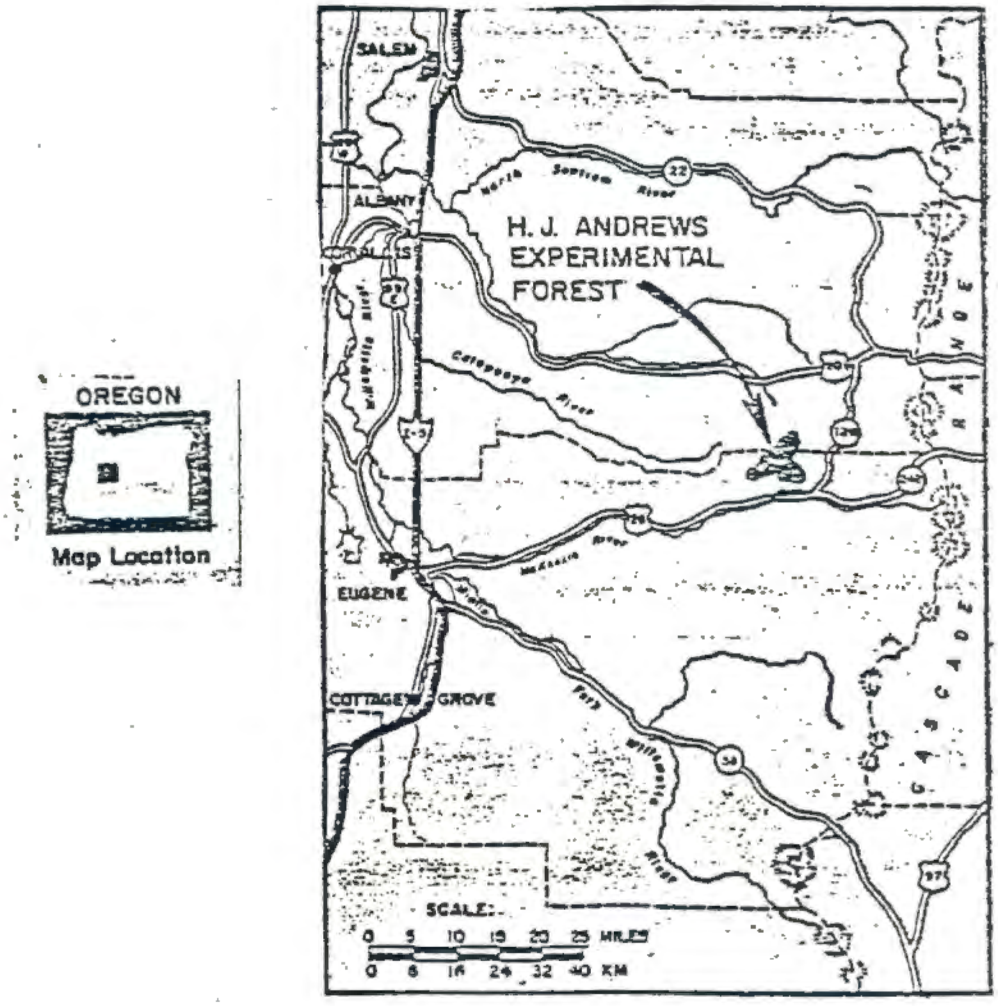
The facilities will be able to accommodate approximately 25 scientists and technicians on a year-round basis, and will have provision for handling an additional 20-25 people during the summer months in a campground. Six mobile homes totaling about 4,000 square feet will provide the living facilities for 24-25 people. Four more mobile homes totaling about 3,000 square feet will contain offices and laboratories. The site plan is designed in such a way that permanent structures can be phased in to replace the mobile units as funds become available.

Current facilities are scattered in several locations and are minimal at best for the present use of the AEER. They consist of three bunkhouse trailers, each of which can accommodate four to six people; two laboratory/office trailers totaling 650 square feet; 250 square feet of laboratory and office space in the Blue River Ranger Station; a 800 square foot unheated warehouse; and a campground with eight tent platforms and wall tents. The severe overcrowding in the summer should be eliminated with the construction of the centralized facilities.

Physical and Biological Features

The Andrews Forest at 6,100 hectares is the largest property comprising the AEER. The RNA's range in size from about 150 to over 1,000 hectares. Four of the RNA's and the Andrews Forest are in the western Cascade geological province; the other two RNA's are in the geologically younger High Cascades. Both provinces are underlain entirely by rocks of volcanic origin. Recent volcanic activity has produced the growth relief of the High Cascades, while erosional processes have shaped the geomorphology of the western Cascades.

Figure 1.--Location of the H. J. Andrews Experimental Forest in western Oregon.



The western Cascades are characterized by steep topography with deeply incised, dendritic drainages. Elevations range from about 400 to 1,000 meters, with bounding ridges generally between 1,000 and 1,400 meters.

A maritime climate prevails over the area, with wet relatively mild winters and dry, cool summers. January means are near 1°C, and July means near 20°C over most of the area. Temperature extremes range from -20°C to 40°C. The precipitation is storngly seasonal with 72 percent occurring in November through March. The 25-year average at a low elevation station is close to 2,300 mm.

Streams, from first to fifth order, are the major aquatic habitat on the AEER, although there are several ponds in one RNA. Streamflow follows the precipitation pattern closely, and winter maximum flow is typically through orders of magnitude greater than the summer minimum. The stream water chemistry is characterized by low concentrations of cations and anions, and a pH near neutral. Summer temperatures approach 15°C, winter temperatures are in the 1°-4°C range.

The first and second order streams are dominated by large amounts of litter and coarse woody debris, which provide the major energy source and create habitats for the aquatic organisms. Larger streams have increasing amounts of net primary productivity, but processed carbon from the small tributaries remains an important part of the energy budget. Aquatic organisms adapted to debris-dominated habitats are particularly well represented. Cutthroat trout (Salmo clarkii) and the Pacific giant salamander (Dicamptodon ensatus) are the top carnivores in the system.

Dense conifer forests cover most of the AEER, although good examples of nonforested ecosystems such as talus slopes, shrub thickets, bogs, ferns, and herbaceous meadows are present. Low elevation (below 1,000 meters) forests are generally dominated by Douglas-fir (Pseudotsuga menziesii), western hemlock (Tsuga heterophylla) and western redcedar (Thuja plicata). Upper elevation forests are typically dominated by true firs (Abies sp.) and intergrade with mountain hemlock (Tsuga mertensiana) stands at the highest elevation.

The natural stands on the AEER generally fall into two age classes--old-growth with dominants in excess of 400 years, and mature with dominants of around 100 years. The Andrews Forest, however, contains a variety of secondary succession communities in areas logged up to 30 years ago. The old-growth stands tend to be massive, with individuals commonly exceeding 60 meters in height and 125 centimeters dbh. Biomass values in excess of 1,000 mt/ha are not uncommon. Leaf areas range up to 20 m^2/m^2 (although 9 to 14 are more common values) and basal areas average 70 to 80 m^2/ha.

The diversity of terrestrial communities found on the AEER provides for a rich fauna which is broadly representative of the Pacific Northwest. Species dependent upon old-growth forests are especially well represented.

History

The H. J. Andrews Experimental Forest was established in 1948 to study timber and watershed management problems associated with the conversion of old-growth Douglas-fir forests to intensively managed stands. As such, the property received permanent dedication to scientific and education objectives. Early research programs were mainly silvicultural and hydrological.

In 1969, the Andrews Forest was selected as an intensive study site by the Coniferous Forest Biome, U.S. International Biological Program. Research became more interdisciplinary, directed toward a more fundamental understanding of coniferous ecosystems using carbon, nutrient and water budgets as integrating mechanisms.

In 1974, the Andrews Forest was designated a UNESCO Biosphere Reserve, representative of the Sierran-Cascade Province. 1977 saw it selected as an Experimental Ecological Reserve along with RNA's. The AEER was chosen in the above two instances for three primary reasons: The properties are designed for research and so managed, ensuring a high site integrity; a diversity of important wide-ranging ecosystems are represented; and the rich research history has provided a large data base.

Research and Monitoring

The scope of the past research on the AEER is reflected in the publication list (Appendix I). Since its establishement, research use of the Andrews Forest has continued to increase. The number of research projects on the AEER has risen especially dramatically following its designation as an EER in 1977. Expenditures now exceed $1.5 million per year for the 43 major research projects being conducted on the AEER. A tabulation of these projects is given in Table 1. Graduate student use has grown equally dramatically with 39 students currently using the AEER.

Much of the current research is oriented around gaged experimental watersheds which provide for water yield and chemistry monitoring under a variety of conditions and allow us to look at land and water interactions. Several of these watersheds will be used in the LTER program, most notably Watershed 10, which represents a recently logged site, and Mack Creek and Watershed 2, which represent a pristine old-growth forest condition.

Permanent sample plots in natural forest and on logged forest sites are a second key research resource. The 36-ha "reference stands" or permanent sample plots established in the natural forests cover the full range of environmental conditions and include several age classes of forest. The plots in cutover areas include a series of 36 10 x 15 m plots on Watershed 10 and 210 successional plots on Watersheds 1 and 3, established prior to logging and now with 14 to 16 years of post-logging vegetative development. The Watershed 10 plots, established and measured for compositional and structural (e.g., biomass and leaf area) changes under an expiring NSF grant, will be adopted under the LTER program.

Many of the current users tell us that the monitoring program conducted under the aegis of the AEER grant from NSF is a major reason for their chosing the site for research. The data sets currently being collected on the AEER are shown in Table 2, which also identifies the agency funding its collection. The list includes many of the measurements recommended in the "Report of a

Table 1.--Major research projects using H. J. Andrews during CY 1978-79 organized by supporting agency.

No.	Project	Principal Investigators	Institution	P.I. Time (FTE) 1/	Graduate Students 2/	Annual Budget ($1000)
NATIONAL SCIENCE FOUNDATION SPONSORED						
1	Accumulation and turnover of soil organic matter	Sollins Spycher	Oreg. State Univ.	0.6	—	70
2	Canopy subsystem structure and function	Carroll Sollins	U. of Oreg. Ore. St. U.	0.5	35,36	175
3	Coniferous Forest Biome	Waring Gessel	Ore. St. U. U. of Wash.	0.1	—	65
4	Dendroclimatic analysis using isotopic ratios	Jacoby White	Columbia U.	n/a	—	n/a
5	Interrelations betw. aquatic invertebrates in woody debris in streams	Anderson Lattin	Oreg. State Univ.	0.6	5,20,37, 38	40
6	Mass soil movement under clearcut and natural conditions	Gray	Univ. of Michigan	n/a	—	n/a
7	Mineralization of woody debris	Triska	Oreg. State Univ.	0.9	—	50
8	Physical and biological responses to forest perturbation	Cromack	Oreg. State Univ.	2.3	1,7,11	110
9	River continuum	Cummins Sedell Vannote Minshall	Ore. St. U. Weyerhaeuser Philadel. Aca. Ida. St. U.	0.2	4,6,15	61
10	Role of ground lichens	Pike	Univ. of Ore.	0.05	—	none
11	Seasonal dynamics of fine roots	Hermann Santantonio	Oregon State Univ.	1.2	24	70
12	Sediment budgets and routing in forested catchments	Swanson	Oregon State Univ.	0.05	—	15

Table 1 (continued)

No.	Project	Principal Investigators	Institution	P.I. Time (FTE)	Graduate Students	Annual Budget ($1000)
24	Tree chemistry and pest interactions	Pitman	Oreg. State Univ.	0.2	21	10
25	Upland game bird populations	Crawford	Oreg. State Univ.	n/a	n/a	n/a
26	Natural fertilization of confier stands	Perry	Oreg. State Univ.	0.3	10	15
DEPARTMENT OF ENERGY SPONSORED						
27	Baseline studies of the effects of energy generation	Hinds	Batelle Northwest	0.3	---	50
28	Thermal regulation of functional groups in streams	Cummins	Oreg. State Univ.	0.1	8,9	50
29	Ecosystem effects of whole-tree harvesting	Sollins	Oreg. State Univ.	0.05	---	6
RESEARCH SPONSORED BY OTHER INSTITUTIONS						
30	Ecological studies of world's spruce forests	LaRoi	Univ. of Alberta (Can. govt.)	1.0	---	25
31	Establishment and operation of ecological reserves	Liu	Taiwan For. Res. Inst. (Nat. Res. Counc. of China)	1.0	---	15
32	Entomological systematics	Lattin	Oreg. State Univ.3/	0.3	3,14,22, 25,27	50
33	Spatial relationships in forest stands	Oliver	Univ. of Wash.	n/a	n/a	n/a
34	Forest influences research experience	Donnely	Univ. of Vermont	0.1	---	5
35	Entomological biosystematics	Schuh	Am. Museum of Natural History	n/a	n/a	n/a

Table 1 (continued)

No.	Project	Principal Investigators	Institution	P.I. Time (FTE)	Graduate Students	Annual Budget ($1000)
13	Function of *Nostoc* in Ore. mountain streams; Ps, N-fixation, and decomposition	Ward Cummins	Oreg. State Univ.	0.8	—	62
U.S. FOREST SERVICE SPONSORED						
14	Early succession biomass and nutrients	Perry Franklin	Ore. St. U. PNW Station	0.1	11,33	15
15	Ecological basis for westside management	Franklin Means	PNW Station	0.8	13,17	100
16	Effects of forest practices on watershed and fisheries habitat	Norris Fredriksen Franklin	PNW Station	2.0	30,31,32	200
17	Genetics of western forest trees	Silen Campbell	PNW Station	0.1	—	10
18	Nitrogen availability of western Cascade soils following harvest	Cromack	Ore. St. U.	0.1	28	19
19	Mineralizable soil N in some Oregon forest types	Cromack	Ore. St. U.	0.1	—	5
20	Impact of forest harvest on surface soils, erosion, and seedling establishment	Swanson McCorrison	PNW Station	0.1	2	16
21	Regeneration after clearcutting and shelterwood cutting	Owsten	PNW Station	0.1	—	10
OREGON STATE UNIVERSITY						
22	Genetic variation in Oregon conifers	Perry	Oreg. St. U.	0.2	—	10
23	Silviculture and ecology of young stands	Perry	Oreg. St. U.	0.3	18,26	15

Table 1 (continued)

No.	Project	Principal Investigators	Institution	P.I. Time (FTE)	Graduate Students	Annual Budget ($1000)
36	Climatic reconstructions from pollen records	Henser	American Geographical Society	n/a	n/a	n/a
37	Anthropod and fungal interactions	Pherson	Northwestern Univ.	n/a	n/a	n/a
38	Nitrogen fixation by native plants	Sylvester	Univ. of Edinburgh	1.0	--	35
39	Role of oxalic acid in soil weathering	Graustein	Yale Univ.	n/a	n/a	n/a
40	Effects of environment and substrate quality on decomposition	Meentmeyer	Univ. of Georgia	n/a	n/a	n/a
41	Population biology of trees	Mack	Wash. State Univ.	n/a	34	n/a
42	Fire history based upon pollen analysis	Gottesfeld	Northwest College	0.1	--	5
43	Habitat and food habits of terrestrial vertebrates	Maser	Bureau of Land Mgt.	0.3	--	15

1/ This is the FTE of commitment by the principal investigators, co-investigators, and senior research associates.

2/ The numbers in this column are keyed to the students listed in table 2 (list of graduate students utilizing the H. J. Andrews).

3/ Support is from a wide variety of sources including NSF, Environmental Protection Agency, the Science Technical Advisory Service, Agency for International Development, and the Pan American Health Organization.

Table 2. Baseline inventories available and measurement programs currently underway for the Andrews and nearby Research Natural Areas, September 1979.

Ecosystems	Funding agency[1]
TERRESTRIAL	
A. Initial conditions	
1. Species lists	AEER
2. Soils descriptions	USFS, NSF
3. Maps*	
a. Topographic	USFS, AEER
b. Soils	USFS, NSF
c. Geologic	NSF
d. Vegetation	AEER
4. Recording of periodic/episodic events	AEER
5. Photopoint system	AEER, USFS
B. Meteorological	
1. Shortwave radiation	AEER
2. Air temperature	AEER, USFS, NSF
3. Soil temperature	AEER, NSF
4. Precipitation (rain and snow depth and duration	AEER
5. Dew point	AEER, NSF
6. Wind speed	AEER
7. Relative humidity	AEER, NSF
C. Chemical composition	
1. Precipitation composition pH, Ca^{++}, mg^{++}, K^{+}, Na^{+}, $SO_4^{=}$, NH_4^{+} $NO_3^{=}$	USFS, AEER
2. Dryfall	AEER
3. Soil nutrients	USFS, AEER, NSF, Univ.
4. Cation exchange capacity**	NSF
5. Soil organic matter	NSF
6. Soil moisture**	AEER
7. Ground water chemistry	USFS, NSF
8. Plant tissues, live and dead	AEER, USFS, NSF, Univ.
9. Throughfall chemistry	Univ.
D. Biology	
1. Vegetation	
a. Composition	AEER, USFS, NSF, Univ.
b. Age class distribution	USFS, AEER, NSF, Univ.
c. Establishment and mortality	USFS, AEER, Univ.
d. Growth rates	USDS, AEER, Univ.
e. Phenology	AEER
f. Spatial pattern	AEER, Univ.
g. Biomass	USFS, AEER, Univ.
h. Litterfall	AEER, NSF, Univ. DOE
i. Plant moisture stress	AEER, Univ.
j. Primary production	NSF, AEER, USFS, Univ.
k. Succession	USFS, AEER, NSF
l. Leaf area	NSF

Table 2 (continued).

2. Invertebrates	
Composition	AEER, NSF, Univ.
3. Vertebrates	
Abundance of selected species, spotted owls, blue and ruffled grouse, mountain quail	USFS, Univ.
E. Watershed and geomorphological variables	
1. Soil creep	USFS, NSF
2. Upland erosion	USFS, NSF, AEER
3. Snowmelt lysimetry	USFS
4. Disturbance history	USFS, AEER
AQUATIC ECOSYSTEMS	
A. Initial conditions	
1. Species lists	NSF
2. Maps	
a. Channel debris	USFS, NSF, AEER
b. Morphology channel cross sections	USFS, AEER, NSF
c. Topography	USFS, NSF
d. Riparian vegetation	AEER
3. Recording of periodic/episodic events	USFS, AEER, NSF
4. Photopoint system	AEER, USFS
B. Physical and chemical	
1. Water temperature	USFS, AEER
2. Stream chemistry total N; $NO_3^=$; total P; $PO_4^=$ dissolved organic C; particulate organic C, P, and N; Ca^{++}, Mg^{++}, K^+, Na^+, pH	USFS, NSF, AEER, Univ.
3. Hydrology	USFS, AEER
4. Solar radiation	NSF
C. Biology	
1. Vegetation	
a. Riparian composition	NSF, AEER
b. Periphyton	
species and biomass	NSF
c. Macrophytes spatial distribution, species, and biomass	NSF
2. Invertebrates	
a. Species	NSF, Univ.
b. Size-frequency	NSF, Univ.
c. Biomass	NSF, Univ.
3. Vertebrates	
a. Species	NSF, Univ.
b. Size-frequency	NSF, Univ.
c. Biomass	NSF, Univ.

[1]AEER refers to measurements funded under the NSF National Field Research Facility grant.

*Completed.

**At frequent intervals.

Second Conference on Long-term Ecological Measurements" held at Woods Hole in February 1978 (Botkin 1978). However, the current program is inadequate with regards to frequency or intensity (or both) of many of these measures and others are carried as part of short-term research efforts. One purpose of this LTER proposal is to correct these deficiencies and fill in missing measurements. Another purpose is to centralize this measurement program so that quality control and continuity is assured.

Data Management

The data collected by AEER support is housed in a central data bank in Corvallis, where it is compiled, edited, and documented. Available data sets are listed in Table 3. We continue to expand the data stored but there is no present means to handle all the data available from the cooperating scientists. All data sets are provided to users at cost. Current costs are covered jointly by the AEER grant and Oregon State University's Forest Science Department.

Library and Collections

Two sets of publications resulting from research on the AEER are maintained--one in Corvallis at the USFS Forestry Sciences Laboratory and one at the AEER Headquarters. Both of these are continuously updated. In addition, a library of materials relevant to current research on the AEER is being collected by AEER staff which is housed with the above. Users of the AEER have open access to this library. Excellent library facilities are available, of course, at the University of Oregon (65 kilometers) and Oregon State University (145 kilometers).

There are four collections of biological specimens from the AEER: vertebrate, invertebrate, fungal, and vascular plant. Only the vascular plant collection is housed in its entirely at the AEER offices. This is because we simply do not have the facilities to handle more than working collections from the other three. The vertebrate collection is housed at the Vertebrate Museum, University of Puget Sound, Tacoma, Washington. A large invertebrate collection is at the Oregon State University Systematic Entomology Laboratory. The fungal collection is at the Herbarium, Botany Department, Oregon State University.

Working collections of important or abundant species, including invertebrates, has been prepared from duplicate material for use on site from the collections housed at the Andrews. These materials will be located with the herbarium in a single room devoted to collections.

The collections have been assembled in a variety of ways. We have budgeted directly for the vascular plant collection which now contains slightly more than 95% of the species known from the area. Other collections are the result of Coniferous Forest Biome research with subsequent curation by museum staff.

Users of the facility provide us with a good assessment of the status of the collections. Their input coupled with the annual review by the National Advisory Committee aids in determining the need for expansion of collections.

Table 3. -- Data Set Listings

TITLE	DATABANK ID CODE	DOCUMENTATION STATUS
AQUATIC LITTERFALL - WS 10 INTENSIVE SITE	AD02	B-2
AQUATIC PARTICULATE EXPORT - WS 10 INTENSIVE SITE	AD04	B-1
AQUATIC STANDING CROP - DETRITUS - WS10 INTENSIVE SITE	AD05	B-1
AQUATIC LATERAL MOVEMENT - LITTER INTO STREAM - WS10	AD03	B-2
AQUATIC LEAF PACK WEIGHT LOSS	AD01	B-1
AQUATIC STANDING CROP RESPIRATION - DETRITUS - WS 10	AD06	B-2
AQUATIC STANDING CROP - INSECTS - WS10 - LEAF PACKS	AS01	B-2
AQUATIC STANDING CROP - INSECTS - COAST STREAMS	AS09	B-2
AQUATIC - STANDING CROP - INSECTS - WS10	AS08	B-2
AQUATIC - INSECT EMERGENCE - WS10; LOOKOUT CK; MACK CK.	AS02	B-2
AQUATIC - STANDING CROP - TROUP - LOOKOUT; MACK	AS07	B-2
GEOPHYSICAL - WS10 STREAM PROFILES	GS01	B-2
GEOPHYSICAL - DEBRIS PULLING EXP - MACK CK.	GS03	B-2
GEOPHYSICAL - INTERFACE - EROSION	IE	B-2
HYDROLOGY - SOIL MOISTURE — NEUTRON PROBE	HMP1	B-1
HYDROLOGY - STREAMFLOW - WE10; WS09	HW01	A-1
HYDROLOGY - SNOWFALL - SNOW ON GROUND - MACKENZIE BR.	HS01	A-1
HYDROLOGY - SNOW SURVEY - ANDREWS	HS02	B-2
METEOROLOGY - ANDREWS CENTRAL MET STATION - DAILY	MO7D	A-1
METEOROLOGY - ANDREWS REF. STAND AIR/SOIL TEMP - DAILY	M20(+)	A-1
METEOROLOGY - ANDREWS STREAM TEMP - DAILY	MH01	B-2
METEOROLOGY - PRECIPITATION NETWORK - ANDREWS - DAILY	MP01	B-2
TERRESTRIAL - DECOMPOSITION - LITTER	TD01	A-1

Table 3 (continued)

TITLE	DATABANK ID CODE	DOCUMEN-TATION STATUS
TERR - DECOMP - LOG STANDING CROP	TD02	A-1
TERR - DECOMP - LOG NUTRIENTS	TD03	B-2
TERR - DECOMP - LARGE ROOT DECOMP; N UPTAKE	TD05	A-1
TERR - DECOMP - LITTER RESPIRATION	TD08	A-1
TERR - ANIMALS - SMALL MAMMALS	TS06	B-1
TERR - ANIMALS - CANOPY INSECTS	TS01	B-2
TERR - ANIMALS - NEMATODE POPULATION - WS10	TS08	A-1
TERR - ANIMALS - SPIDER/MITE POPULATION - WS10	TS09	B-2
TERR - LITTERFALL - ANDREWS NETWORK	TL01	A-1
TERR - LITTERFALL - WS10	TL02	A-1
TERR - INTERFACE - SOIL SOLUTION CHEMISTRY	TN11/IT	A-1
TERR - INTERFACE - STREAM CHEMISTRY - ANDREWS/REGION	IA	A-1
TERR - NUTRIENT CYCLING - TISSUE CONC - WS10	TN09	A-1
TERR - NUT CYC - DESTRUCTIVE NUTRIENT & BIOMASS	TN10	A-2
TERR - NUT CYC - THROUGHFALL NUT & VOL	TN02	A-2
TERR - NUT CYC - STEMFLOW NUT & VOL	TN04	A-2
TERR - NUT CYC - LITTERFALL NUT	TN05	A-2
TERR - PRIMARY PRODUCTION - VEGETATION SURVEY SYSTEM	TP56	A-1
TERR - PP - STEM MAP - ANDREWS REF. STANDS	TP47	A-1
TERR - PP - PRE-LOG SUCCESSION PLOT VEGETATION - WS10	TP42	A-1
TERR - PP - POST-LOG SUCCESSION PLOT VEG. - ANNUAL	TP41	A-1
TERR - PP - CHRONOSEQUENCE VEG. REESTABLISHMENT	TP63	A-1
TERR - PP - DESTRUCTIVE BIOMASS - WS10	TP49	A-1
TERR - PP - STEM MAP - WS10 - (STUMP ANALYSIS)	TP53	B-2

Table 3 (continued)

TITLE	DATABANK ID CODE	DOCUMENTATION STATUS
TERR - STEM MAP - OVERSTORY - WS10	TP06	A-2
TERR - PP STEM MAP - UNDERSTORY - WS10	TP05	B-1
TERR - PP - RIPARIAN VEGETATION - WS10	TP59	A-2
TERR - PP - PHENOLOGY - ANDREWS	TP50	B-2
TERR - PP - STANDING DEAD SURVEYS - ANDREWS	TP51	B-2
TERR - PP - FINE ROOTS - WS10	TP60	A-1
TERR - WATER RELATIONS - LEAF CONDUCTANCE - WS10	TW01	A-1
TERR - WATER RELATIONS - CAMBIAL GROWTH	TP20	A-1

Administrative Structure

The H. J. Andrews EER is administered jointly by the U.S. Forest Service's Pacific Northwest Forest and Range Experiment Station and Oregon State University. These institutions have entered into a long-term (ten-year) agreement on operation and management of the site.

The current administrative structure of the AEER is shown in Figure 2. R. H. Waring and J. F. Franklin are the site co-directors having been delegated the responsibility for developing and operating the AEER by Oregon State University and the U.S. Forest Service's Pacific Northwest Forest and Range Experiment Station, respectively. Arthur McKee is the resident manager and has responsibility for day-to-day operation of the reserve. He is the key individual who sees that the policies and objectives of the site directors and advisory committees are carried out. Key roles include coordination of research projects, supervision of baseline data collection and facilities, construction, and management of the property. McKee supervises two full-time technicians in carrying out the responsibilities.

The local site committee is an advisory body of 8 to 10 people who are intimately involved in research and management activities on the site. This committee is the primary group for: developing the research and management plant for the site; review and approval of research proposals for use of the site; review and approval of timber sale and similar activities; selection of parameters for inventory and monitoring; and decisions on allocation of resources including space, facilities, and national monies.

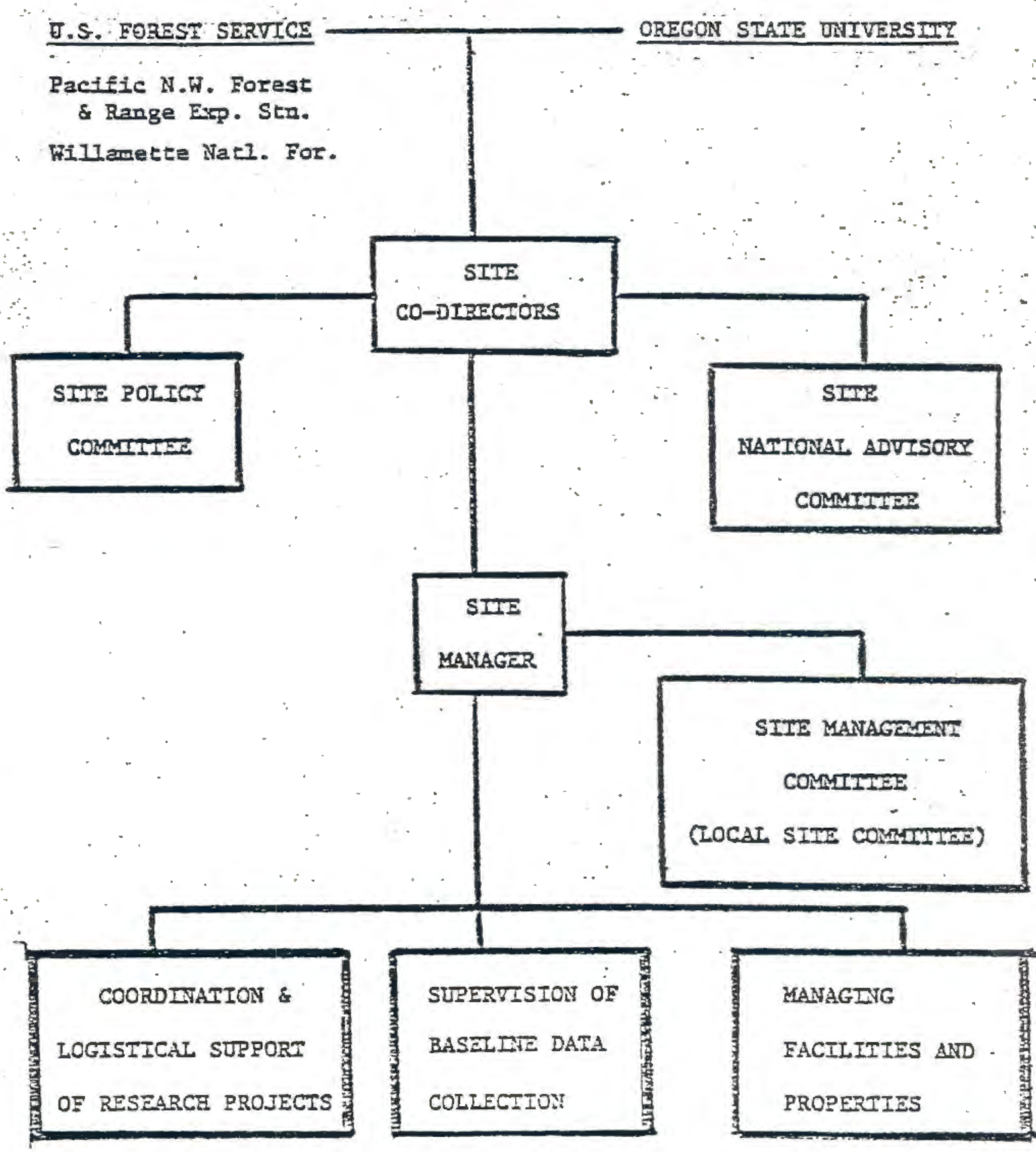
The primary purpose of the National Advisory Committee is to review and advise Oregon State University and the U.S. Forest Service on major decisions regarding the operation and utilization of the H. J. Andrews Experimental Forest and to monitor the performance of the two institutions in fulfilling the goals of a National Field Research Facility. Our purpose is to insure input from an array of qualified scientific personnel less directly involved in the site and broadly representative of institutions and agencies interested in ecological and environmental research. Specific responsibilities include: Reviewing and providing recommendations for action on proposals for research or management which will (a) signficantly alter a substantial area (10 acres or more) of Experimental Reserve or any of the control areas; (b) involve major commitments (10% or the capacity) of the research, living, or working facilities constructed or operated under the EER program; or (c) are otherwise deemed to have a significant impact on the long-term value of the H. J. Andrews as a national facility.

The role of the National Advisory Committee in carrying out its assistance and oversight on operation of the property is similar to that provided by NSF Program Advisory Panels except that we call upon it to play a more active role in formulating overall plans at early stages.

Procedures for approval of a formal research project are the same, regardless of supporting institution:

1. Submission to either site director.

Figure 2. -- Administrative structure of the Andrews Ecological Experimental Reserve.



2. Assignment for review by resident manager and local site committee with special attention to impact on current research projects, facility requirements, and compatibility with the objectives of the H. J. Andrews EER.

3. Assignment to national advisory committee for their recommendation if potential impacts on the Andrews meet the criteria outlined earlier.

4. Local site committee and site manager recommendation to site directors.

5. Review of project by site directors, including determination of adequacy of environmental assessment and hazard analysis.

6. Decision by site directors.

Essentially the same review process would be used in resolving any conflicts which might arise.

The resident manager is a key advisor to both the local site committee and site directors in determining the acceptability of a specific project and in evaluating conflicts since he has the best overview of compatibility with current projects, availability of resources, etc.

It is the policy of the Andrews EER to accommodate all research proposals compatible with the basic objectives of the site. Preference is given to ecosystem-oriented work when conflicts develop in use of facilities and equipment.

Leadership continuity is ensured in two ways. First, the leadership is shared among the three co-investigators (Waring, Franklin and Cummins). All these are committed to research careers in Oregon and it is unlikely that all three would leave. All three are on hard money and have strong institutional support for their LTER participants. The institutions (USFS and OSU) provide additional institutional insurance of continuity. During 30 years of existence, research and management continuity has been provided through six different Forest Service officers. Institutional investment in the contunity of the AEER is very high.

PROPOSED LONG-TERM ECOLOGICAL RESEARCH PROGRAM

Our LTER program consists of two parts. First, there is the LTER itself which includes five components. These components are described in detail in the following section. The second part of our LTER program covers data management. A plan and justification is presented for developing the necessary data storage and retrieval capabilities. The program presentation concludes with short sections on "Information Synthesis and Publication" and "Site Promotion".

Long-term Ecological Research

The proposed LTER at H. J. Andrews Experimental Ecological Reserve includes five components:

1. Changes in composition, structure, and key processess with succession in Douglas-fir-western hemlock forest,

2. Nature and importance of forest-stream interactions;

3. Population dynamics of young forest stands as affected by density and nutrient regime;

4. Long-term impact of nitrogen fixers on forest soils; and

5. Patterns and rates of log decomposition.

Components 1 and 2 basically involve the installation and measurement of a series of plots in terrestrial and riparian/aquatic environments; some minor manipulation, involving removal of debris from reaches of streams is involved. We propose to test a number of hypotheses under components 1 and 2. However, the measurements are also necessary to provide the AEER with an essentially complete set of baseline measurements as proposed by the long-term measurement workshops (Botkin 1978, The Institute of Ecology 1979). We emphasize this because so many measurements are already being taken at AEER and it would be easy to assume that no additional effort is needed. In fact, due to inadequacies in sampling intensity or frequency or to the transient nature of the current funding, LTER support is necessary to provide for a baseline measurement program of sufficient quality and stability.

Components 3 through 5 of our LTER are experimental and involve major manipulations. These components address questions of major scientific interest that can only be directly addressed on the basis of long-term experiments. The LTER on young stand population dynamics (3) will utilize installations replicated in three young Douglas-fir stands. The experiment is a factorial design with five density levels and as well as a single level of nitrogen addition. Longterm impact of nitrogen fixers (LTER component 5) utilizes an experiment where stands of Ceanothus of varying density will be established to determine their long-term effect on soil properties and forest growth. The study of log decomposition (5) involves establishment of a major research project which is intended to last for 100 to 200 years. Logs of appropriate dimensions and species will be cut and placed in both upland forest and at the land-water interface. The large numbers and sizes of logs necessary to allow for periodic replicated, destructive sampling is a significant logistical challenge but the potential benefits merit the effort. (We are particularly hopeful of collaborating with other sites in common log decomposition experiments.)

We have purposely included both undisturbed and manipulated ecosystems in our LTER. The value of long-term resesarch in the natural forests, especially our unique opportunity to study the very old and massive conifer forests, is obvious. We feel that the manipulated ecosystem and experimental installations provides us with further tests and elaborations, increasing the potential understanding from our LTER program.

We propose to time phase the five LTER components for reasons of both finances and personnel. To establish all components simultaneously would require a very large initial grant, strain the capacities of senior personnel, and force hiring of a large number of temporary employees who would than have to be laid off. We propose to establish components 1 and 2 during the first year of the grant, 3 and 4 during the second, and 5 during the third. This also allows more time to develop the experimental designs, select the sites, and create the necessary data handling capabilities before launching the major experiments.

The LTER will be conducted at several sites on the Andrews EER (Fig. 3). This reflects the necessity of studying a variety of ecosystems. The sites where the young stand, nitrogen fixer, and log decomposition experiments will be established have not been finalized so they are not shown.

In the following writeups of each LTER component, we cover hypotheses, justification, methods and measurements (including experimental design), location, interpretation of results, expected duration of the research (total lifespan), and relation to the core research areas of the NSF announcement, "A New Emphasis in Long-term Research". These core research areas are:

1. Pattern and control of primary production,

2. Dynamics of populations of organisms selected to represent trophic structure,

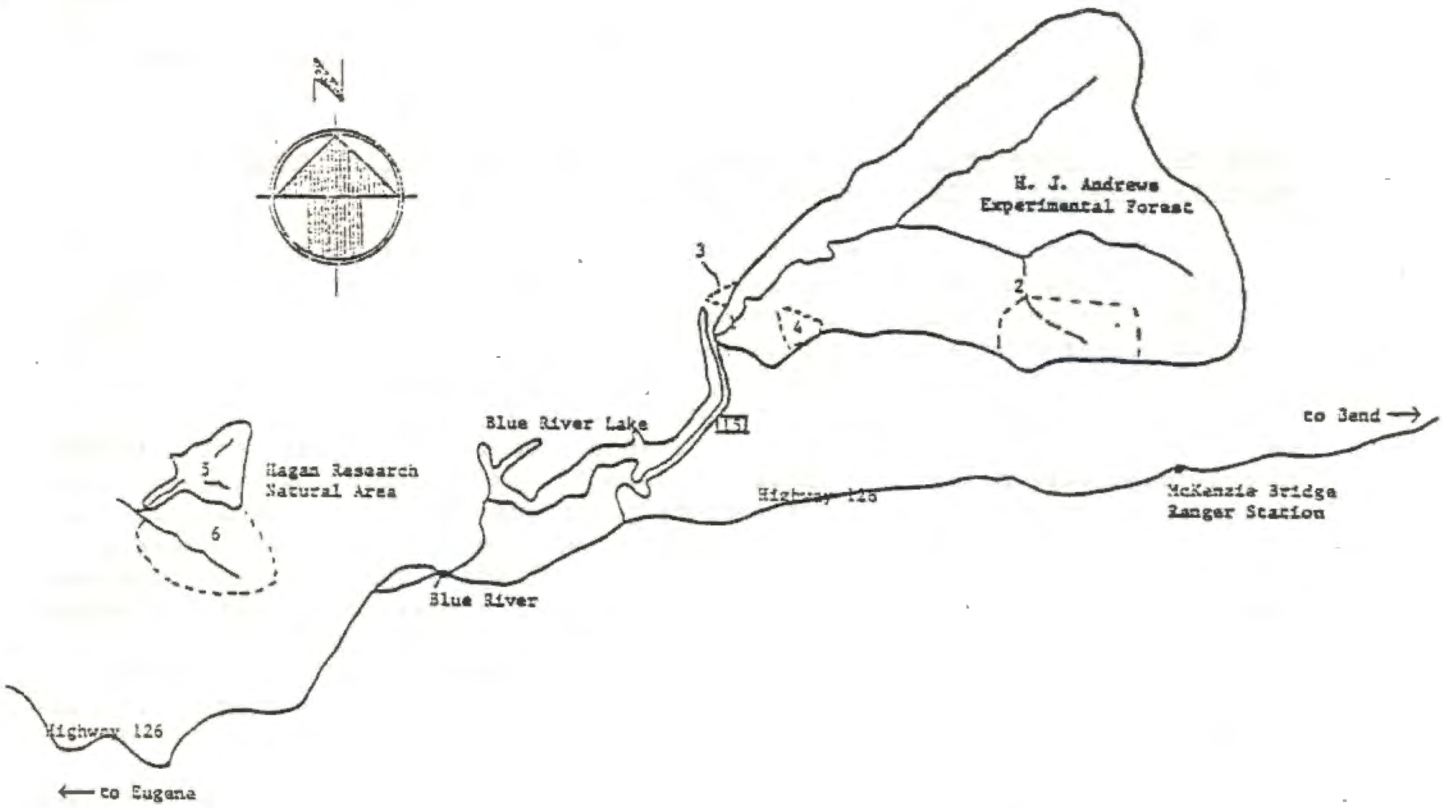
3. Pattern and control of organic matter accumulation in surface layers and sediments,

4. Patterns of inorganic inputs and movements of nutrients through soils, groundwater, and surface waters, and

5. Patterns and frequency of disturbances.

In considering the hypothesis statements, the reviewer should bear in mind that these are the most important hypotheses currently apparent to us. The stated hypotheses are by no means exhaustive and, as the data sets are developed, many more will doubtless occur to investigators, some stimulated by inspections of the data and others completely independently. Also, it should be obvious to the reviewer that the LTER is backstopped by other programs of research and monitoring that provide additional tests (or at least relevant data to test) of the hypotheses.

A final comment on the hypotheses and the need for an LTER program. Many have attempted to test ecological hypotheses using comparative studies of ecosystems of different ages or development states or retrospective studies



1. Central climatic station

2. Mack Creek sampling areas

3. Experimental Watershed No. 10

4. Experimental Watershed No. 2

5. Hagan Research Natural Area (North Fork Hagan Creek)

6. Ordinary management zone (South Fork Hagan Creek)

Figure 3.--Primary LTER study sites in H. J. Andrews Experimental Ecological Reserve.

in which reconstructions are attempted. These are very useful exercises which can produce significant insights. Unfortunately, clear tests of the hypotheses are rarely provided by such efforts due to uncertainities, such as confounding by unknown factors. Long-term observations are often necessary to provide the direct tests. Hence, while many of our stated hypotheses could be examined through other strategies, we believe that the LTER approach is critical.

Component 1. Changes in Composition, Structure, and Key Processes with Succession in Douglas-fir-Western Hemlock Forest.

Many hypotheses have been proposed regarding changes in forest structure, composition, and various ecological processes associated with successional development of the forest. As mentioned earlier, these hypotheses are often based on comparative studies of an age sequence of stands, studies which rarely produce a definitive test of such hypotheses. We proposed to measure aspects of key plant and animal populations, critical processes (growth, litterfall), and structure (spacing, leaf area) in stands representing three very different successional stages, and use these measures to test numerous hypotheses. Some of the most important hypotheses currently obvious to us are outlined in the following section, but it is by no means exhaustive. The potential uses of the proposed data set are extremely large. Each stand represents an important stage in northwestern forest succession: (1) a five-year-old clearcut (Watershed 10), which will allow us to observe developments up to and through the stage of canopy closure which takes 25 to 40 years for completion; (2) a mature (100-year-old) Douglas-fir stand; and (3) an old-growth (450-year-old) Douglas-fir-western hemlock stand.

This component of our LTER proposal relates directly to core research areas 1 (primary production and 2 (population dynamics) of the NSF LTER announcement and marginally to areas 3 (surface organic matter accumulation) and 4 (movement of nutrients).

The initial time perspective of this component is about 40 years. This is based upon the maximum number of years it should take for complete canopy closure (leaf area stabilization) on Watershed 10, the cutover site. This time period should also allow us to observe the effect of several "environmental episodes" (e.g., major windstorms and dry and wet years) in the mature and old-growth forests.

Hypotheses. It is well known that dramatic compositional and population shifts occur in plant and animals when the canopy of the young coniferous forest closes in the developmental sequence following a major disturbance. Incredibly, such shifts have never been systematically observed and documented so that information on patterns and rates do not exist. We propose to collect these data and simultaneously test several hypotheses, including the following:

Decline in number of vascular plant and vertebrate species is directly correlated with development of conifer canopy coverage.

This has important implications since, if true, rate of canopy closure will determine the rate at which species diversity declines.

Bird, mammal, invertebrate, and vascular plant species diversity will reach minimal levels following conifer canopy closure, remain at these levels throughout the ensuing successional stage of dense, rapidly growing forest, and partially recover in mature forests.

Drastic functional shifts in invertebrate communities occur with the shift from herb/shrub communities to coniferous forest including reduced abundance, diversity, and consumption of herbivous invertebrates. Partial recovery will occur in mature forests.

Small mammal populations in the early successional stands will exhibit greater year-to-year fluctuations than in mature forests.

Several hypotheses of special interest involve the population biology of the dominant trees—growth, mortality, and reproductive behanvior. Some aspects of population biology of young even-aged forests will be considered in LTER component 3. In this component, we propose to examine some of the following hypotheses:

Stand development trends toward increasingly even spacing of the dominant trees over time, even to very old (> 450 years) ages.

Forest tree mortality is an episodic process in mature and old-growth stands and a constant (approximating 3/2 rule) in young stands.

Mortality rates of component tree species declines significantly with time and is lowest for the oldest age classes.

Recruitment of replacement trees of a given species into the overstory canopy is more likely to be from recently established seedlings and saplings than from older regeneration present in the understory.

Some hypotheses concern processes at the level of the whole ecosystem rather than simply populations. These include:

Net primary production in northwestern coniferous forests is such that live biomass continues to accumulate up to 250 years or more and that total organic matter continues to accumulate to 750 years or more.

Significant changes in nutrient cycling will occur with the onset of conifer canopy closure following disturbance including: (a) Reduction in quantity and quality of litter; (b) acceleration of litter decomposition; and (c) reduction in nitrogen losses from the rooting zone.

Nutrient losses from a watershed following disturbance decline in direct proportion to the increase in live biomass until the canopy closes and leaf area stabilizes; thereafter, nutrient losses should be essentially constant.

The use of experimental watersheds as our basic sampling units or "stands" allows us to address holistic hypotheses of the previous sort.

Justification. The changes in composition, structure, and key functional processes that occur with succession are, justifiably, a key topic in ecology. Unfortunately, insofar as forested ecosystems are concerned these changes have invariably been based on inferences rather than direct observation. Our LTER project will provide direct observation of key features and processes at the critical stage of tree canopy closure as well as in mature forests. It is important to note that the time scale in these northwestern forests is very different than in the eastern deciduous forests. Crown closure typically takes 25 to 35 years following complete forest disturbance (and can take over 100 years). Similarly, the tree species and forest conditions are very long-lived. This allows us the opportuntiy to look at successional processes over very long time spans, with dominants that can live over 1,000 years, and in ecosystems which have massive accumulations of both live and dead biomass. Observations in such ecosystems are esential to provide end points or boundary conditions for processes of succession, biomass accumulation, etc.

Methods and Measurements. We propose to conduct this research in three different successional stages: (1) seral herb/shrub community; (2) mature forest; and (3) old-growth forest. As mentioned earlier, the seral stand has been selected so that we can observe the dramatic changes associated with conifer crown canopy closure. This sampling we propose to do on Watershed 10 (Fig. 3) where a series of 36 10- x 15-m vegetation/soil sampling plots were established in a stratified random sampling procedure prior to logging in 1975. We will continue to use these plots as a basis for much of the sampling.

The mature forest site is the Hagan Research Natural Area (Fig. 3) and consists of an excellent 100-year-old Douglas-fir forest. The old-growth site is proposed for Watershed 2 (Fig. 3) and consists of a stand of Douglas-fir, western hemlock, and western redcedar in which the dominant firs are 400 to 500 years in age. Both of these sampling sites occupy entire watersheds. A systematic or stratified systematic series of 1/10-ha sample plots is planned for these stands with other measurement programs (e.g., invertebrates) keyed into the same basic design.

The measurement program in abstracted in Table 4. There will be differences in measurement frequency between the seral stand and the mature and old-growth forests because of drastic differences in rates of change.

Standing crop of vascular plants, leaf area, tree growth, and tree mortality are fairly straightforward parameters. They will be based on appropriate linear measurements on the populations within the sample plots combined with existing allometric equations to estimate biomass by components and leaf area. Mortality must be measured annually to test the stated hypotheses but growth and standing crop can be handled at five-year intervals in the older forest.

Litterfall will be collected on a monthly basis from a series of m^2 littertraps. Sampling intensity will be determined by a statistical analysis of existing data.

Inputs of large woody debris (logs, tree tops, and large branches) will be determined on an annual basis by repeat mapping of a random or stratified random sample of the vegetation plots.

Table 4.—Measurement program for study of changes in composition, structure, and key processes with succession in Douglas-fir forests.

Item	Measurement frequency	
	Seral	Mature and Old-growth
Standing crop of vascular plants	Annually	5-year
Growth of trees	Annually	5-year
Mortality of trees	Annually	Annually
Leaf area	Annually	5-year
Litterfall	Monthly	Monthly
Large woody debris inputs	Annually	Annually
Soil Chemistry	5-year	5-year
Invertebrate composition and abundance[1]	Annually	5-year
Mammal composition and abundance[1]	3/year	3/year
Bird composition and abundance[1]	Quarterly	Quarterly
Phenology	Varbiable	Variable

[1]Will include archiving of selected samples.

Soil profiles will be sampled at five-year intervals for chemical and physical analysis. Subsamples will be frozen for archiving. Measurement of the depth, density, and chemistry of the surface organic layers will be a part of this program.

Sampling of the invertebrate communities will be oriented toward determining the relative abundance of various functional groups and include sampling of ground- and plant-dwelling and flying invertebrates. Herbivorous insects will be emphasized because of their direct influence on the primary producers. The seral stand will also receive greater attention than the mature and old-growth stands due to an expected greater importance and yearly variability.

Invertebrate sampling will be intensive during the first two years of study until appropriate host species and key invertebrate species for long-term observation and suitable sampling periodicities have been determined from phenological studies. Standard invertebrate sampling procedures will be used (e.g., DeVac, malaise and black light traps, and Berlese funnel extractions) but we will hold our options open in order to accommodate any national LTER guidelines that are developed. Our sampling procedures will also reflect our special concern with herbivores. Selected invertebrate samples will be archived for possible future chemical analyses.

Small mammal population sampling will utilize standard grid, live-trapping procedures. We expect to trap three times a year. In addition, we will collect 10 adult males of Peromyscus maniculatus once each year at 0.5 km distance from our live trapping grids. Half of these will be archived and the other half analyzed for chemicals, including heavy metals, by Batelle Northwest.

Bird population sampling will use a standardized transect method. Census methods and frequency (annually or quarterly) will be appropriate to the bird group. The bird sampling will include the Mack Creek riparian habitat as a fourth site.

Sampling of owl pellets for elemental analysis (including heavy metals) will be collected from a network of 50 nest boxes. Casts will be collected twice a year with half archived and half analyzed by Batelle Northwest.

Component 2. Nature and Importance of Stream-Forest Interactions

Many of the key interactions between terrestrial and aquatic components of watersheds occur over long time periods or episodically. Therefore, it is particularly important to establish sites for long-term ecological investigations of aquatic and terrestrial interactions. Objectives of LTER research at linked terrestrial/aquatic sites are to examine system-level behavior at pristine, forested control sites, as well as several manipulated sites, in order to test specific hypotheses about the structural and functional relations between forests and streams.

The central premise of the proposed studies is that changes in the structure and composition of streamside terrestrial vegetation control physical features of the stream channel and both these vegetational and physical factors control the composition of aquatic communities and long-term adjustments in the stream ecosystem.

The land/water interaction component of our LTER relates directly to all five of the core research areas listed in the NSF LTER announcement.

The time range on the LTER component is very long. We are dealing here with some types of processes or episodes that, in extreme form, occur once or twice (or even less frequently) during a century. Nevertheless, useful results will be produced during the period of this grant and some hypotheses should be adequately tested within a 20-year period.

Hypotheses. We view composition of the aquatic system as basically regulated by a series of linked factors endogenous and exogenous to the riparian-stream ecosystem (Fig. 4). Our primary hypothesis deals with what we view as two key sets of linkages:

> *Major endogenous linkages between terrestrial and aquatic systems involve factors of habitat control (Fig. 4, A) and food resource control (Fig. 4, B) and these two sets of factors differ in functional relationships and response time.*

To elaborate, terrestrial forest vegetation supplies large woody debris to streams which shapes aquatic habitat and forms structures for retention of detrital food resources and sediment. Streamside vegetation also is the major source of the detrital food resource and controls in-stream primary production through light limitation. Food resource factors operate primarily on annual time scales of litterfall and decomposition rates, while inputs of large woody debris are more episodic and decay periods span decades to a century or more.

Elimination of one or both of the major endogenous linkages (Fig. 4) triggers predictable changes in aquatic ecosystem structure and function. For example, if terrestrial vegetation is removed, detritus inputs are reduced and the stream primary producer-scraper functional component is increased relative to the litter-shredder association. If large wood is removed, the habitat structure is simplified with reduction in pool area. The capacity of the channel to retain detrital inputs is decreased, resulting in support of reduced shredder and collector components and fish and salamander biomass. Food resource limitation does not necessarily affect habitat functions, but removal of habitat can affect availability of food resources by reducing the capacity of the channel to retain detrital inputs for sufficient time to allow processing by aquatic organisms.

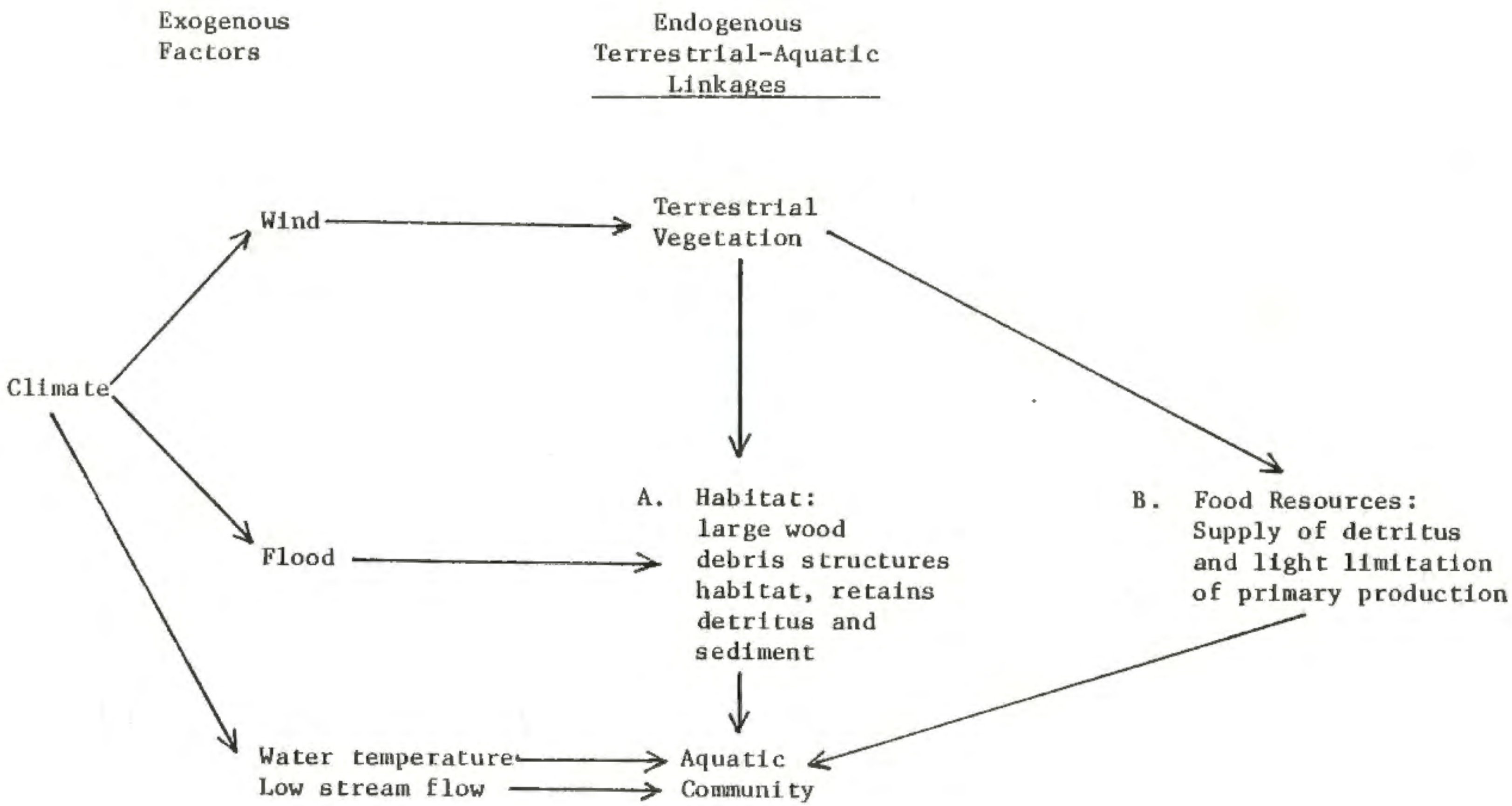


Figure 4.--Comparison of endogenous terrestrial-aquatic linkages and exogenous effects on the linkages. A: habitat control factors; B: food resource control factors.

Our second general hypothesis is that:

Aquatic systems with intact terrestrial vegetation are more resistant to change from major exogenous events (Fig. 4) and recover more rapidly when they occur.

Integrity of the two sets of terrestrial-aquatic linkages buffer the system against change due to exogenous events.

These proposed long-term studies will make it possible to test numerous auxiliary or subordinate hypotheses. Among those we currently recognize and propose to test are the following. We expect many hypotheses will be formulated in the future that will make use of our land/water LTER data set. In the realm of physical processes, auxiliary hypotheses include:

Reductions in sediment storage will result from debris removal.

Rate of sediment release from previously stabilized deposits will be proportional to the length of time that debris has been in place.

This hypothesis rests on the assumption that debris storage time should relate directly to the opportunity for stabilizing root systems of stabilizing vegetation to penetrate the deposits.

Long-term dynamics of large organic debris involves input of debris in time and space but clumping with preexisting accumulation during floods.

This has important implications for long-term dynamics of stream habitats. Finally, with specific reference to the South Fork of Hagen Creek (area 6 in Fig. 3), we hypothesize that:

Road system development and logging will result in increased peak flows and sediment yield on a time scale of 20+ years which will differentially affect control and cleaned stream sections.

We expect pool filling and bank cutting to be more pronounced in the cleaned reach.

In the biological realm, auxiliary hypotheses are related to the control exerted on major functional relationships in the stream community by the composition of the terrestrial vegetation.

In intact ecosystems with food resource control factors operational (Fig. 4), the balance between heterotrophy and autotrophy will vary seasonally and annually with autotrophy exceeding heterotrophy during early summer and heterotrophy dominating the remaining seasons.

General macroinvertebrate species composition and relative functional-group dominance are controlled by terrestrial aquatic linkages. When both sets of control factors operate, species number and biomass by functional group will be shredders ≥ collectors > scrapers.

Fish and salamander densities and age structure are determined by habitat abundance, which is maximal in intact ecosystems, and food resource, which may be greater in the disturbed ecosystems.

The larger food resources in the disturbed system may occur because species of macroinvertebrates with active, short life cycles which are efficiently utililzed by the vertebrate predators, may be favored.

Justification. A long-term perspective is essential to understanding three elements of system behavior. First, high magnitude, low frequency events, such as major wind storms and floods, have prominent roles in alteration of aquatic and terrestrial ecosystems. A long-term record provides a basis to interpret impacts of episodic events relative to more persistent changes in system behavior. Second, some elements of system response or recovery following such events occur on the time scale of decades. Third, systems undergo gradual, inconspicuous, but possibly significant change in response to external factors which vary on long time scales. For example, how do aquatic ecosystems contrast between periods of extended drought (e.g., 1930-1945 in the Pacific Northwest) and sequences of wetter than average years?

In the broader sense of importance, it seems obvious that understanding of terrestrial-aquatic linkages is essential to managing riparian vegetation to protect aquatic resources in areas of intense land use.

Methods and Measurements. Monitoring of physical and vegetational characteristics would consist of repeat surveys of the five components listed in Table 5 and shown schematically in Figure 5. Although the five components are linked, each experiences different types and frequencies of change. As indicated in Table 5, scheduling of repeat surveys of certain parameters would be adjusted depending upon the occurrence of major floods, blowdown, etc. For example, breakup of the crown and the fall of large woody debris into the zone of flooding on the channel can trigger changes in structure and composition of vegetation in and immediately adjacent to the channel. This vegetation is also subject to disturbance by high stream flow events. Fresh additions or high stream flow-induced redistribution of large organic debris in the stream channel can cause changes in vegetation, channel geometry, habitat distribution, and sediment storage.

Terrestrial vegetation will be mapped using standard methods developed during previous establishment of vegetation plots by U.S. Forest Service and Oregon State University personnel (Hawk et al., unpublished manuscript). The plots will extend 50 m away from the stream on both sides and along the stream. During resurveys, points of origin of any large debris entering the stream from more than 50 m upslope will be located and added to the maps. Mapping of large organic debris and habitats in streams will employ procedures developed in previous studies and documented in part by Swanson et al. (1976). Vegetation in channels will be resurveyed annually at marked plots established in different plant communites and in sites of different potential for disturbance by high stream flow events. Channel cross sections will be monumented with steel posts driven into the ground and resurveyed with a transite. All vegetation and survey data and documentation of monument locations will be placed in the data bank of the H. J. Andrews Experiemntal Ecological Reserve.

Table 5.--Physical and vegetational components to be mapped and measured in repeated surveys.

Zone (Fig. 1)	Units mapped/measurements	Frequency
Adjacent to area subjected to flooding	Live and dead standing and down trees	3-5 years[1]
Zone of flooding (including channel	Vegetation and woody debris source located	annual[2]
Channel	Monumented cross section geometry	annual[2]
Channel	Habitats (riffles, runs, pools, alcoves, bedrock)	annual
Channel	Temperature--degree days	seasonal summations

[1]More frequent following major events, e.g., windstorms, mass movements, etc.
[2]Less frequent if flod events do not exceed 1-2 year recurrence interval.

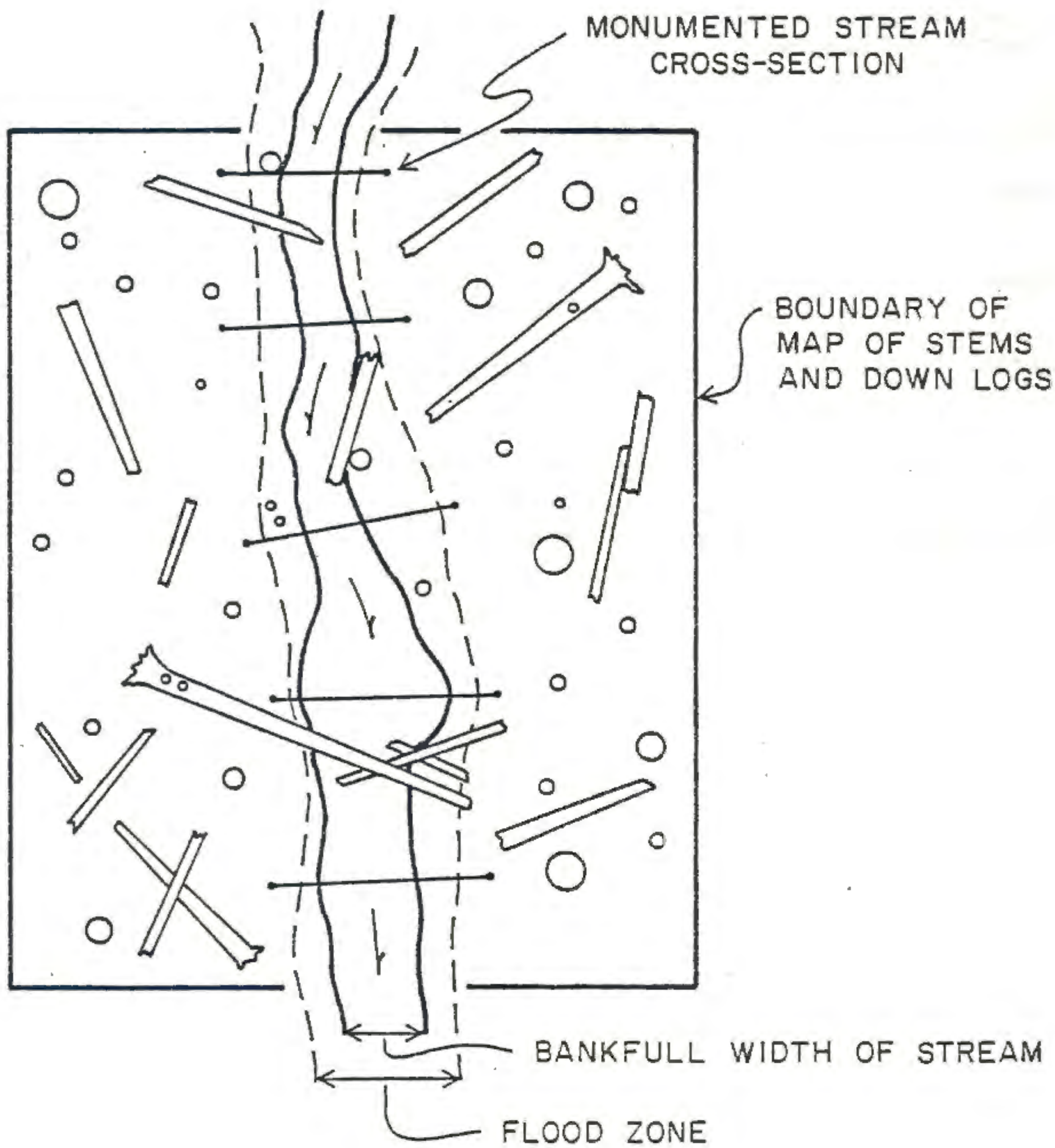


Figure 5.--Schematic example of site of linked terrestrial-aquatic studies. More detailed maps of channel alone will show stream habitats flood zone riparian plant communities. Actual sites will cover larger area relative to tree and stream size.

The in-stream ecological measurements, their frequency and general methods are summarized in Table 6. Recirculating chambers filled with sediments from erosional or depositional habitats will be utilized to evaluate the relative dominance of heterotrophic vs. autotrophic processes in the stream community (Bott et al. 1978). Core (40-cm diam.) samples of sediments (Naiman and Sedell 1979) and hand collections of litter and from wood debris (Anderson et al. 1978) and bed rock (Cummins et al. 1966, foam rubber sampler) would constitute qualitative collections to be analyzed for relative abundance of macroinvertebrate functional groups following the categorizations in Merritt and Cummins (1978). Samples would be archived for more detailed taxonomic separations as the systems become better known. Adult collections, from pyramid-type emergence traps would be used to establish taxonomic catalogues for each site; these would also be analyzed by functional group. Fish and salamanders would be collected by electrofishing using a three successive pass method (e.g., Seber and Whale 1970) for estimating population densities.

Litter input would be measured using direct fall and bank traps of the type previously used in Watershed 10 (Sedell et al. 1974). Because there is wide variation in such trap collections, the intent would be to bracket the range of materials entering over long time periods. Such input data are required in order to evaluate physical stream channel efficiency in conjunction with particulate organic matter (POM) storage measurements. POM would be measured with core samples (Naiman and Sedell (1979) to obtain estimates of coarse (> 1 mm) and fine (< 1 mm > 50 μm) fractions (Table 6). Basic water chemistry parameters (Table 6) would also be monitored with analyses performed by the Central Laboratory Facility of the OSU Watershed Group.

Study Sites. Linked terrestrial-aquatic sites should consist of at least 100-m long stream reaches and the associated terrestrial system extending at least 50 m upslope from the stream's edge (Fig. 5). Three locations within the H. J. Andrews Experimental Forest and a pair of sites in and adjacent to Hagan Research Natural Area (Figs. 3 and 6) are proposed because of control of land use (except one site where normal land use is desired) and the existence of significant amounts of background data in these areas. The five sites include two natural forest control watersheds with no significant man-imposed perturbation, two recently clearcut sites, and a stream reach in natural forest in a basin subject to development typical of National Forest Land managed for timber in this region. Selected site characteristics are listed in Table 7.

Mack Creek has been a principal research site for aquatic, riparian, and large organic debris studies initiated under the IBP and River Continuum programs. The upstream forested section serves as the control for the downstream clearcut reach.

Watershed 10 has also been a principal study site of the IBP/Coniferous Forest Biome Program. The 400- to 500-year-old stand in this watershed was intensively studied before it was clearcut in 1975. Analyses of vegetation succession, aquatic communities, and soil and sediment movement have continued under individual grants to assess watershed/ecosystem response to such severe distubance.

The Hagan Creek study sites are low elevation, moderate gradient streams bordered with about 90-year-old natural stands that probably approximate the

Table 6.--Measurements involving in-stream community processes and inputs.

Measurements	Methods	Frequency	Man days per yr	
			Field	Lab
Heterotrophy: Autotrophy	Measurements of 24 hr O_2 changes in closed recirculating chambers available from the River Continuum Project. (Details in Bott et al. 1978).	Twice Annually (fall-winter, spring-summer)	8	8
Macroinvertebrate functional group composition	Qualitative samples from each of the habitat types mapped (Table 1, Fig. 1; riffle or run, bedrock, pool or alcove, wood debris).	Twice annually (F-W, S-S)	4	4
Adult insect emergence	Taxonomic composition (and functional group ratios) from 5 emergence per terrestrial-aquatic site.	Twice annually (F-W, S-S)	2	10
Fish and salamander population density and age structure	Electrofishing collections from 30-50 m section using a 3 pass successive depletion method.	Annually (summer, stable flow)	4	0
Litter input	Litter inputs from 5 direct fall and bank traps per site.	Every 2 yr	1	5
Particulate organic matter storage (excluding large wood)	3 core (25 cm diam.) samples in erosional and depositional areas. Wet sieved into two particle sizes (>1 mm; < 1 mm > 50 μm) and ashed at 550°C (6 hr). General methods in Naiman and Sedell (1979).	Annually (summer, stable flow)	2	4
Chemical analyses (NO_3, PO_4, DOC, pH, alkalinity, Fe, Ca, etc.)	Standard methods--Watershed Group Chemical Analysis Laboratory	Annual (summer, stable flow)		

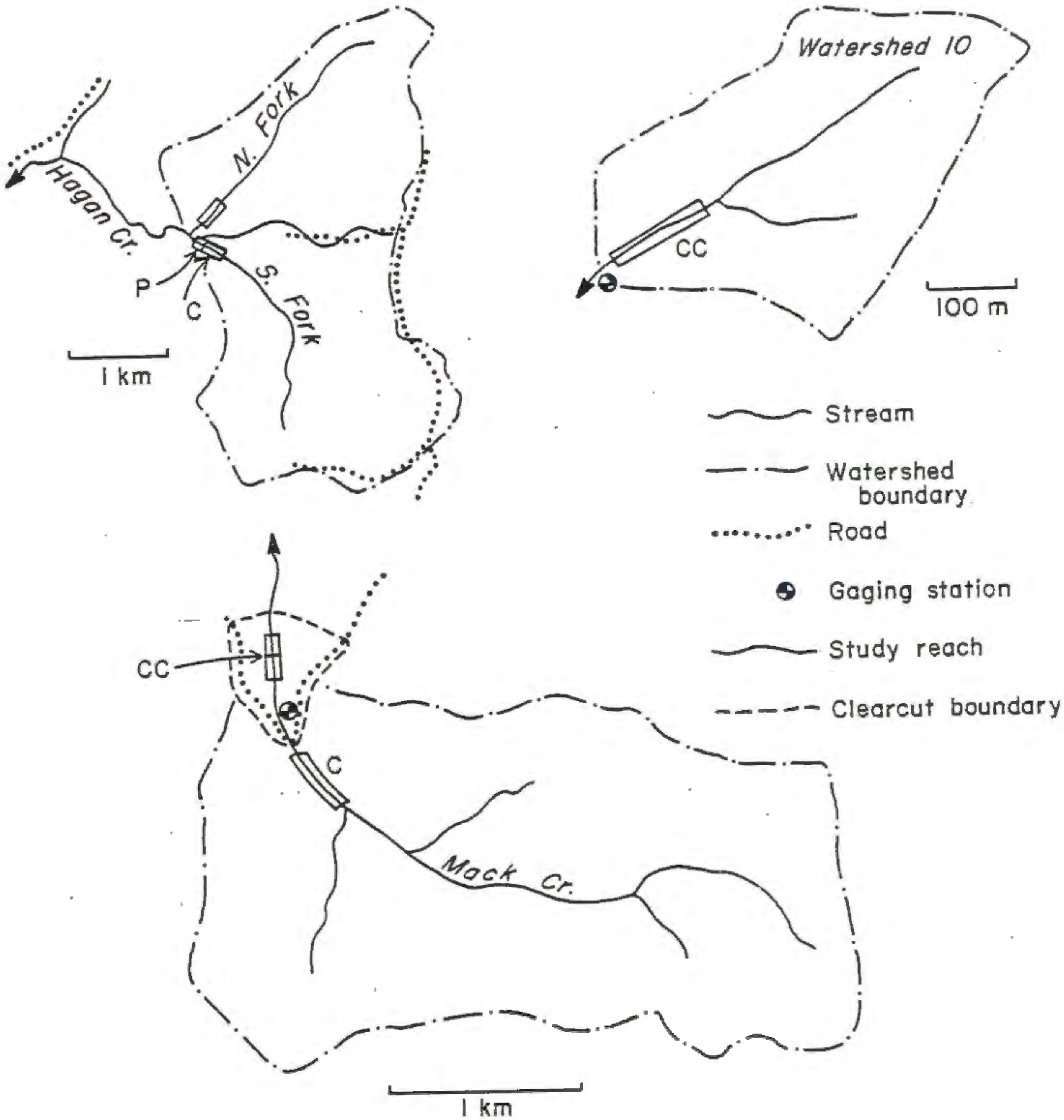


Figure 6.--Locations of linked terrestrial-aquatic study sites. C identifies control sections, P debris pulling sections, and CC post-clearcut recovery sections.

Table 7.--Sites of linked terrestrial-aquatic research.

Site	Vegetation	Watershed area (ha)	Elevation range (m)	Streamflow record	Proposed activity
Mack Creek	400 to 500-yr-old Douglas-fir forest	600	850-1,600	gaged since 1979	300 m natural control
	1964 clearcut shrubs and young conifers	600	Do.	Do.	100 m upstream reach with natural recovery; annually remove debris in 100 m downstream reach
Watershed 10	1975 clearcut shrubs and young conifers	10	425-700	gaged since 1967	150 m reach with natural recovery
N. Fork Hagan Ck.	90-yr-old natural Douglas-fir forest	450	440-1,070	ungaged	300 m natural control
S. Fork Hagan Ck.	Do.	590	440-1,020	Do.	200 m control reach upstream; annually remove debris from 100 m downstream reach.

types of stands to be expected at the end of a management rotation. The North Fork is dedicated to research by its establishment as a Research Natural Area. The South Fork drainage is on ordinary National Forest Land which permits us to (1) manipulate the site by removing large organic debris without compromising other resesarch use of the site and (2) to have a control reach useful for interpretation of the debris removal experiment on the time scale of a decade or so. It will also be a valuable site in determining cumulative downstream impacts of progressive development of the basin with roads and clearcutting which will occur over the next 20 years.

Interpretation. Results of long-term studies of terrestrial-aquatic linkages will be used to test the hypotheses listed previously. The predicted aquatic ecosystem responses to alterations of habitat and food resource links between terrestrial systems will be tested in combined analysis of control, clearcut, and cleaned sites. Both sets of linkages operate in natural, control stream reaches. In the cleaned site (S. Fork Hagan Creek) the large organic debris link between terrestrial and aquatic systems is elimianted, but the food resource link remains intact. Clearcutting reduces the food resource link, but may or may not alter habitat immediately. The Watershed 10 clearcut left much of the large wood-created habitat intact, but the clearcut section of Mack Creek was flushed of large debris by a major flood. Large boulders in Mack Creek moderate the impact of wood removal on the aquatic community by providing habitat and retention sites. Recovery of both habitat and food resource links in these systems will be controlled by patterns and rates of succession of terrestrial vegetation. We expect the food resource link to recover more rapidly than the habitat link. Cleaning of lower clearcut Mack Creek stream section will prevent recovery of the large organic debris function of creating habitat and retention structures.

We have predicted that reduction of the food resource link will result in reduced detritus-based shredder and collector functional components and enhanced primary producer-scraper functional component as the community shifts from heterotrophy toward autotrophy. Where only the habitat link has been broken by removal of large debris, we predict reduction of detritus-based functional components because of reduced retention of detritus. In this case there would be no increase in the primary producer-scraper component, because terrestrial vegetation still limits light. All of these parameters will be measured, permitting a test of the basic hypothesis.

The hypothesis that an aquatic system with intact links is most resistant to change by exogenous events and recovers more rapidly can only be tested by comparing community composition and standing crop and turnover of biomass before and after major disturbances.

The auxiliary hypotheses will be directly tested by proposed measurements, in some cases as parts of the above analyses.

Component 3. Population Dynamics of Young Forest Stands as Affected by Density and Nutrient Regime

Research described here falls under core area 1, primary production, in the NSF announcement. In recent years a number of workers have shown that plant communities follow certain predictable rules in their growth and development. From these efforts, we may infer that some similar adaptations have evolved to permit form to mirror function.

If so, there are genetic as well as environmental components that lie embedded in the observed structural rules by which forests grow.

We propose to initiate an experiment that will initially test our understanding of how environment influences stand structure and growth. The approach, however, permits, by additional replication with differing genetic stock, a full test of the proposed growth and stocking equations.

Theory. In plant populations which are experiencing density related mortality, the relation between individual plant size and stocking density is expressed with high accuracy by the equation

$$B_I = C\rho^{-x} \tag{1}$$

where B_I = individual plant biomass (or volume),
ρ = stocking density,
C, x = constants.

If a linear relationship between diameter and height is assumed, dimensional analysis can be used to calculate a value of 3/2 for the parameter x (Yoda et al. 1963). For this reason, equation (1) is commonly called the "-3/2 power law of self thinning". Studies have found that, in tree populations, x may in fact vary between 1.2 and 1.9 (Harper 1977 reviews the literature, see also Mohler et al. 1978).

In populations which are not self thinning, the relation between mean plant size and density is often written (see the review by Willey and Heath 1969).

$$\frac{1}{B_I} = B\rho^{\phi} \tag{2}$$

Equation (2), the reciprocal yield law, can be derived by substituting equation (1) for K in the integral form of the logistic growth equation (e.g., Shimozaki and Kira 1956).

$$B_I = \frac{K}{1 - e^{-rt} + \frac{K}{B_0} e^{-rt}}$$

where K = asymptotic limit on B_I,
r = intrinsic growth rate,
B_0 = B_I at time 0.

Finally, we introduce the generalized logistic equation (here written in the differential form):

$$\frac{dB_I}{dt} = \frac{rB_I}{\alpha} \left(1 - \frac{B_I^{\alpha}}{K^{\alpha}}\right) \tag{3}$$

The parameter α expresses the degree of symmetry in the equation. If α equals 1, maximum growth occurs when $B_I/K = 1/2$. If α is less than 1, maximum growth occurs when $B_I/K < 1/2$. One interpretation of this is that crowding effects appear earlier. However, the change in growth rate is less sensitive to increasing B_I/K, thus crowding effects, although perhaps appearing earlier, are not as severe. Growth of at least some forest stands follows a logistic curve with $\alpha < 1$ (Perry and Muscato in prep.). It is not clear, however, whether this is due to inherent growth properties of individual trees, or merely reflects a distortion of the growth curve to competition and morality. In other words, is the nonsymmetric growth curve an organismic response to competition or a population phenomenon?

Herein we propose to investigate, within the context of the above theory, processes of population growth in young coniferous populations prior to, and as they are approaching, the self-thinning state. This may be expressed as the period when

$$\frac{B_I}{K} << 1 \rightarrow \frac{B_I}{K} \simeq 1$$

Hypotheses

(1) In a stand which is not self thinning, mean individual tree growth rate is given by:

$$\frac{dB_I}{dt} = \frac{rB_I}{\alpha}\left(1 - \frac{B_I{}^{\alpha}\rho^{\alpha x}}{C^{\alpha}}\right)$$

where parameters are as given before. Values for C and x are obtained from self thinning stands. Values for r and α are to be determined.

(2) In a coniferous population which is not self thinning, the relation between mean tree size (B_I) and stocking density (ρ) should asymptotically approach.

$$\frac{1}{B_I} = \frac{\rho^x}{c}$$

where c, x are parameters of the "-3/2 power law," and can be determined on a site specific basis from self thinning stands.

(3) Following disturbance which reduces stand density, the rate at which B_I approaches the postulated relation of hypotheses (2) is a function of r, the "intrinsic growth rate" and α, the parameter measuring sensitivity to competition. This rate may therefore be modified by changing site quality or species.

Derivation of hypotheses (2) and (3) is given in Appendix 1.

(4) For a given mean tree size, the stocking density producing maximum stand growth rate is:

$$\rho = \left[\frac{1}{1 + x\alpha}\right]^{\frac{1}{\alpha x}} \left[\frac{C}{B_I}\right]^{\frac{1}{x}}$$

(5) For a given density, there is a linear relationship between the mean tree size at which density related mortality begins and the mean tree size at which maximum stand growth occurs.

Thus, at the commencement of mortality:

$$\frac{B_I}{K} = \beta \left[\frac{1}{1 + x\alpha}\right]^{\frac{1}{\alpha}}$$

where β = a constant greater than 1. Other parameters as before.

Derivation of hypotheses (4) and (5) are given in Appendix 1.

Methods and Measurements. In order to test these ideas, we will install in young (15-20 year old) Douglas-fir-hemlock stands, three replications of thinned and fertilized plots. Each replication will contain five density levels (20%, 40%, 60%, 80%, 100% of the original canopy). Each density level will be both fertilized with 200 kg/ha urea prill, and unfertilized. Varying density levels will give a range of values for B_I/K. Fertilization should increase both r and α. We will measure tree size and growth rates at five-year intervals on all plots. One experimental block consists of 15 plots (5 levels of stocking, 3 replications).

Justification. Establishment of a workable model of plant population dynamics which includes genetic and environmental factors will increase the power of population theories considerably. It provides a framework for testing hypotheses regarding the relative roles of genetics and environment in plant population dynamics. Many appropriate hypotheses cannot be tested in an experiment of the size proposed here. However, we intend to obtain funding from other sources to establish similar replications in varying environments and with different species. Because a period of up to 20 years may be required to establish tree growth patterns, a study of this type is particularly appropriate for long-term ecological research.

APPENDIX I

A. Derivation of hypotheses (2) and (3).

From the integral form of the logistic equation

$$B_I = K(1 - e^{-rt} + \frac{K^\alpha}{B_o^\alpha} e^{-rt})^{-\frac{1}{\alpha}}$$

substituting $C\rho^{-x}$ for K

$$B_I = C\rho^{-x}(1 - e^{-rt} + \frac{C^\alpha \rho^{-x\alpha}}{B_o^\alpha} e^{-rt})^{-\frac{1}{\alpha}}$$

Thus

$$\frac{1}{B_I} = \left\{ (\frac{e^{rt}-1}{C^\alpha e^{rt}}) \rho^{\alpha x} + \frac{1}{B_o^\alpha e^{rt}} \right\}^{\frac{1}{\alpha}}$$

Here, t is the time since disturbance (thinning), and B_o is the mean tree size at t = 0. As t becomes larger this equation approaches

$$\frac{1}{B_I} = \frac{\rho^x}{C}$$

B. Derivation of hypotheses (4) and (5).

For a given mean tree size, stand growth rate may be approximated by

$$\frac{dB_s}{dt} = \rho \frac{dB_I}{dt} = \frac{\rho r B_I}{\alpha} (1 - \frac{B_I{}^\alpha}{C^\alpha \rho^{-x\alpha}})$$

differentiating with respect to ρ, setting the resultant equation equal to 0, and solving for ρ, yields the density at which, for a given B_I, maximum stand growth rate occurs

$$\rho = \left[\frac{1}{1 + x\alpha}\right]^{\frac{1}{x\alpha}} \left[\frac{C}{B_I}\right]^{\frac{1}{x}}$$

recalling that $K = C\rho^{-x}$, this may also be written as

$$\left[\frac{B_I}{K}\right]_{\text{max. growth}} = \left[\frac{1}{1 + x\alpha}\right]^{\frac{1}{\alpha}}$$

Hypothesis (5) states that the mean tree size at which density dependent mortality begins is positively related to $\left[\frac{B_I}{K}\right]_{\text{max. growth}}$. Thus

$$\left[\frac{B_I}{K}\right]_{\text{mortality}} = \beta\left[\frac{B_I}{K}\right]_{\text{max. growth}} = \beta\left[\frac{1}{1 + x\alpha}\right]^{\frac{1}{\alpha}}$$

β a constant, greater than 1.

Component 4. Long-term Impact of Nitrogen Fixers on Forest Soils

Woody nitrogen-fixing plants--notably Ceanothus spp. and red alder--are important components of seral forest communities in the Pacific Northwest. Controversy has surrounded their role and importance in the long-term nitrogen balance of forest ecosystems. While considerable work has been conducted on nitrogen fixation over short periods, almost none has examined the long-term effects of such species on soil physical and chemical properties. On managed sites, where these deciduous shrubs and herbs are viewed as conifer competitors, the net effect on tree growth or balance between favorable and unfavorable influence is unresolved. Another question concerns the relative ecological merit of nitrogen-fixing plants as compared to inorganic nitrogen additions in fertilization.

In this LTER component, we propose to examine the long-term effect of Ceanothus velutinus, a native nitrogen-fixing shrub on the chemical and physical properties of the soil (especially C and N status) and on growth of young Douglas-fir. We will establish a series of plots on a freshly cutover area. Treatments will include four densities of Ceanothus, inorgnic nitrogen addition (probably 200 kg/ha aplied twice during the rotation) and untreated controls. A constant density of Douglas-fir (probably 1,000/ha) will be established throughout the experiment and observed for growth response.

The duration of the study is at least 60 years, the earliest possible rotation age for the Douglas-fir. Ideally, observations would extend over several rotations of Douglas-fir. Useful results should begin appearing after about 10 years.

This project addresses the LTER core research areas 1 (primary productivity), 3 (pattern and control of organic matter), and 4 (patterns of inorganic inputs).

Hypotheses. A number of hypotheses concern comparisons of soils on sites with and without nitrogen fixers in early successional communities (Fig. 7). For example:

Soil organic matter and carbon will increase during early succession and gradually decline in middle and late succession when N-fixers are present in early succession and remain unchanged or decrease gradually throughout succession when N-fixers are absent.

Soil N and N availability will increase during early succession due to rapid accretion when N-fixers are present and gradually decline in middle and late succession. Total N capital will remain constant or decline slightly when N-fixers are absent, but N availability may increase early in succession and decline gradually thereafter.

Surface and belowground litter N will decompose at a significantly greater rate early in succession in systems with N-fixers than in those lacking N-fixers due to improved substrate quality and a lower C/N ratio.

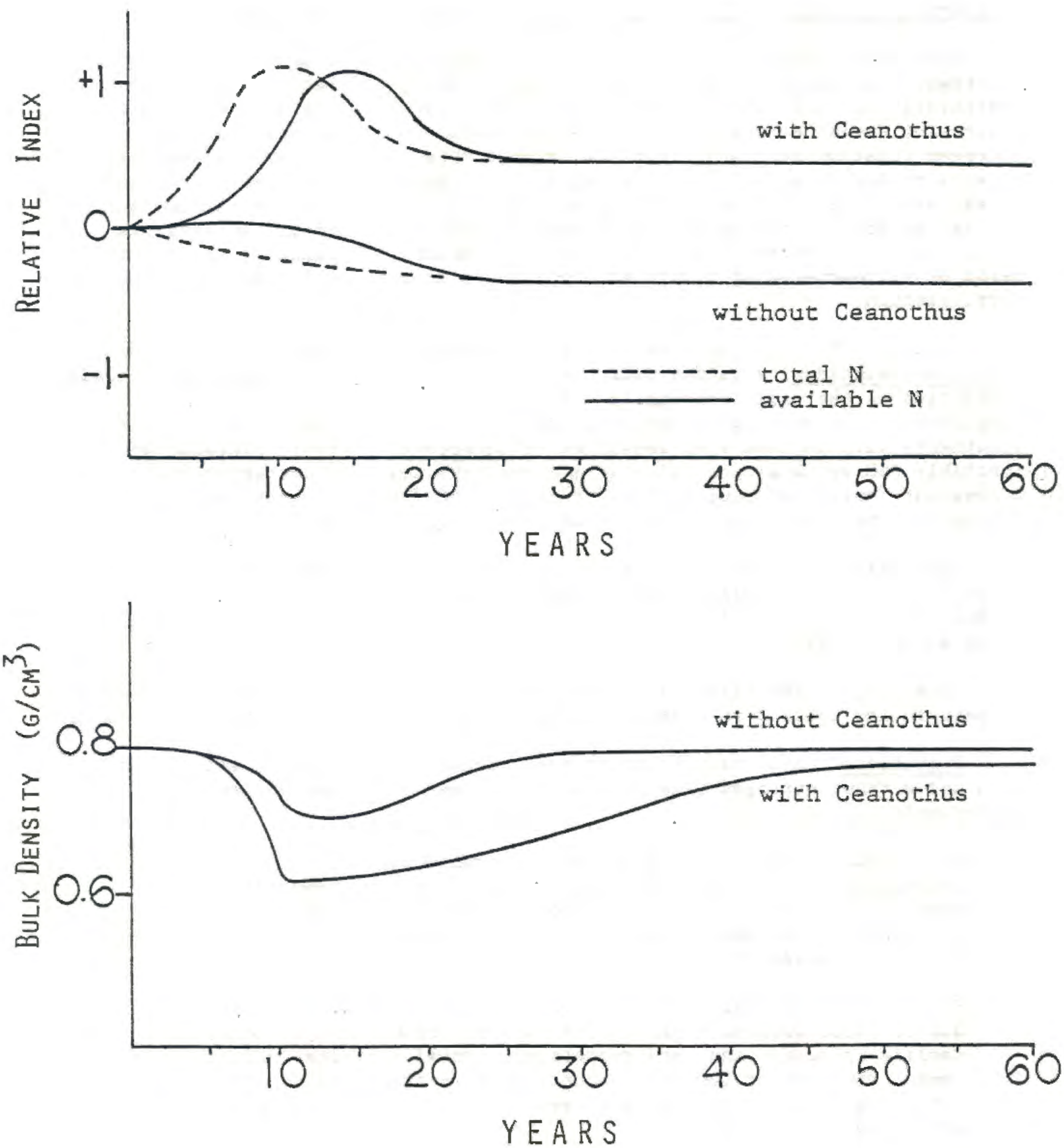


Fig. 7.---Changes in soil properties during 60 years of secondary succession and stand development.

Soil structure will improve during early succession in sites with N-fixers but remain constant or decrease slightly throughout succession on sites lacking N-fixers.

The last hypothesis presumes that the increased soil organic matter and soil animal activity associated with superior litter quality will result in lower soil bulk densities.

Additional hypotheses related directly to the role of Ceanothus in our northwestern ecosystems. For example:

Ceanothus at intermediate density levels is equivalent to inorganic N fertilizer in its effect on growth rate of conifers but not in its long-term effect on soil structure and N availability.

Ceanothus produces increase in both total and available N in the rooting zone and a smaller increase in total C; hence, the C/N ratio narrows during the site occupancy by Ceanothus.

Conifer growth is initially slower when associated with high densities of Ceanothus than at sites where Ceanothus is absent. However, after 15 to 20 years, conifer growth is great when associated with Ceanothus and cumulative yields are greater at the end of a rotation.

Conifer volume at the end of a 60-year rotation increases indirectly with density of Ceanothus.

This is based on the premise that, even at high Ceanothus densities, initial competition between Ceanothus and seedlings produces highly selective, optimal thinning of conifers. This should produce a vigorous stand well-supplied with nitrogen in the long run.

A final hypothesis concerns the durability of Ceanothus' influence on soil properties:

Significant differences in total soil nitrogen and soil organic matter content will persist for at least twice the life span of the Ceanothus or, in this case, for 60 years after the elimination of Ceanothus.

Justification. The results of this study have implications for basic ecological science and forest management. We need to know how natural processes maintain site productivity over repreated seres. We also need to apply these lessons in determining the sustained productive capacity of our forest lands under various management alternatives. One key is maintenance of soil fertility, specifically N availability.

The overall effect of Ceanothus on yield of forest stands is a continuing source of controversy. It presumably competes with conifers for moisture and nutrients and inhibits growth by shading. On the other hand, Ceanothus adds large amounts of nitrogen to the soil which is eventually made available to the trees. The trade-off would appear to be between early conifer growth and higher soil fertility.

Adequate resolution of the competition issue, and the degree to which the effects of such fixers persist, require long-term data. Few data are available and these concern suppression of tree growth early in succession. What ultimately matters are forest yields over a rotation and levels of soil fertility.

In this project we will measure N availability using techniques that should allow us to clearly demonstrate, perhaps in only 10 years, the relationship between Ceanothus density and long-term N availability. From our data on short-term conifer growth at differing Ceanothus levels, we should be able to devise an optimum though perhaps site-specific tradeoff betwen maximizing short-term growth and assuring long-term fertility.

Methods and Measurements. The experimental design of this study involves the creation of a series of plots on a freshly logged site. The six treatments are four densities of Ceanothus velutinus stocking, addition of inorganic nitrogen fertilizer at times and levels calculated as equal to maximum levels from Ceanothus, and a control. Each wll be replicated four times for a total of 24 0.2 ha plots. The study site will be as uniform as possible in slope, aspect, elevation, soil conditions, and Douglas-fir stocking (at < 1,000 stems/ha). The Ceanothus and Douglas-fir will be established by planting. Replacement planting of both will be carried out for the first three years of the study to ensure initial densities are at desired levels.

Planned Ceanothus densities will range from zero (the control) to the maximum typically encountered in natural stands (about 600 plants/ha).

Every five years beginning with plot establishment we will measure biomass of Ceanothus numbers, biomass and current growth rate of Douglas-fir trees, soil N and C status (see below), and summer soil moisture depletion. Biomass regression equations permit us to estimate biomass from simple measurements of clump and stem diameter.

Soil N and C will be measured in bulk soil and in size-density fractions of root-free soil. Preliminary results suggest that these fractions correspond well with turnover time and thus with availability (Spycher and Young 1979, Young and Spycher 1979). Based on our fraction data from a uniform site at the Andrews, four cores sufficed to reduce the standard error (SE) to 10% of the mean. We suspect 10 will be required per treatment in this study. N and C content will be measured in the coarse (> 2 mm) fraction as well as in finer fractions. In some of our soils the coarse fraction constitutes as much as 70% of the total weight and has C contents exceeding 2%.

Another measure of nitrogen availability will be obtained by anaerobic incubation of soil samples in the laboratory (Geist 1977). Preliminary tests on the Andrews Experimental Forest indicate demonstrable differences exist among soils associated with different habitat types (McNabb and Cromack, unpublished).

Leaching losses of anions and cations will be estimated by installing anion and cation exchange columns treated with fungicide below the major root zone. The frequency of collection will be minimized, to once a year if possible. This technique has recently been employed by soil scientists at Washington State University, Pullman and we are consulting with Dr. Stewart Childe, who is now on our faculty (Soils Department) about the procedure.

Denitrification and N-fixation will not be measured because there is no convenient way to measure cumulative effects over several months. Rates must be measured on an instantaneous basis and would therefore have to be carried out at regular intervals throughout an entire year to yield meaningful results. An N-fixation study would be invaluable and could perhaps be carried out as thesis research on some of the plots.

Litter depth, weight and nutrient content will also be measured. In addition substrate quality will be studied using lignin and cellulose content as indices (Cromack 1973, Fogel and Cromack 1977). Sampling the litter layer, Grier and Logan (1977) and Sollins et al. (in press) used a sample of 56 in an exceedingly heterogeneous area (Watershed 1). The SE for the dry weight value was about 10% of the mean, whereas for the nutrient value it was $< 5\%$. Presumably 25 per plot for the dry weight will suffice here where the variability should be much less and perhaps 10 for the nutrient value. For the anion exchange columns we have no experience on which to base a guess; first-year results will be used to determine the necessary sample size.

Soil moisture depletion will be measured gravimetrically four times during the summer dry season. Only the rooting zone will be sampled.

Interpretation. Hypotheses concerning conifer growth can be tested directly by examining data on survival, and height and diameter growth in plots with varying amounts of *Ceanothus*. Results can easily be expressed as density, basal area, biomass, or volume using well-established regression equations (Gholz et al. 1979).

Hypotheses concerning soil status are harder to test. The N availability data should show, if our hypotheses are correct, that N availability increases tremendously as the *Ceanothus* stand occupies the site but then decreases substantially later (Fig. 7). It remains to be seen whether the decrease that occurs when *Ceanothus* occupancy is prevented. Data on other soil variables will be similarly interpreted.

Component 5. Patterns and Rates of Log Decomposition

Coarse woody debris, particularly large down boles, plays critical ecological roles in the forest ecosystems of the Pacific Northwest. Logs provide wildlife habitat, sites for microbial nitrogen fixation, erosional barriers, seedbeds, energy and nutrient sources, and sources of soil organic matter. In streams, debris plays additional roles in creating aquatic habitats, reducing channel erosion, and retaining allochtonous materials. Amounts can be large, averaging 150 mt/ha in natural stands and occasionally exceeding 500 mt/ha.

Relatively little is known about the dynamics of this woody debris, however, when and how it is created and, particularly, the rate at which it is decomposed. Research to date has been based primarily upon retrospective analyses or reconstructions. For example, several studies of decomposition rate have utilized logs dated using scars inflected on living trees when they fell, e.g., was it green or previously dead. This type of study also has serious limitations in comparing various species, sizes of material, or environments since the investigator can only take what nature has provided. At least equally important, it is difficult to study the succession of organisms and processes associated with log decay using this approach.

We propose to establish and conduct the initial phases of a controlled log decay study designed to span in excess of 100 years. Log size and species and environment will be the primary variables with the standard log a 60-cm diameter Douglas-fir. Logs will be placed on the forest floor in a natural forest, a clearcut, and extending from a stream across the interface to an unplanned environment.

Although snags are also important functional components of forest ecosystems, we are not proposing a parallel long-term study due to monetary and technical feasibility problems.

This LTER component relates to core areas 1 (primary production), 3 (organic matter accumulation), and 4 (patterns of inorganic inputs) in the NSF announcement.

Hypotheses. There are many factors that affect decomposition rates of coarse woody debris, most of which can probably be incorporated in the general hypotheses, which does make certain assumptions about the intitial state of the log.

Log decay rate is a function of substrate chemistry, surface area/volume, and environmental conditions.

What we will try to do is isolate as many factors as possible in setting up the long-term experiment so that we can test the following specific hypotheses with regards to northwestern coniferous forest ecosystems:

Decomposition rates will vary with decomposition stage and will be greatest during the first decades of log decomposition.

The greater initial rate is believed due to facilitation of microbial activity by invertebrates.

Wood decomposition rates are a function of substrate quality and C/N ratios and, amoung northwestern species, the speed of decomposition will be red alder > western hemlock > Douglas-fir > western redcedar.

With regards to specific organisms or processes:

Nitrogen fixation rates will be highest during decades of maximal invertebrate and fungal activity.

Invertebrate activity will be greatest during early stages of log decay but will remain important throughout all decay stages.

There is the option to make a specific test of invertebrate effects by including an invertebrate-exclusion treatment. If a separate invertebrate exclusion treatment becomes feasible, an additional hypothesis on the role of invertebrates, as facilitators of fungal activity, would be examined. This is not currently planned, however.

Log colonization by mosses and lichens is initiated after 10 to 20 years of bark conditioning and increases slowly thereafter in all decay stages.

Log colonization by vascular plants increases rapidly in middle and late decay stages.

Other hypotheses concern the effects of size and environment on rate of decay:

A given log will decompose more rapidly in an open environment than on the forest floor.

A given log located at the land x water interface decomposes most rapidly in portions at water line, most slowly in submerged portions, and at intermediate rates in upland segments.

Log decay rate is directly correlated with surface area/volume ratio.

This is believed to be generally true as available data indicates decay is poorly correlated with log volume alone. One reason is the general progression of decay processes (in Douglas-fir in the Pacific Northwest) from the periphery of the log toward its heart.

Some hypotheses regarding vertebrate use are possible but may not be testable in the experimental installation we propose to establish. For example, use by birds will probably peak in early decay stages and use by small mammals in decay stages when abundant fungal bodies are present.

Justification. Information from this project will provide better understanding of physical-chemical and biological changes associated with the process of coarse woody decompositon. More accurate information on rates of log decay of varying types and under varying conditions is needed by both basic and applied scientists as is an improved log decay classification. Such data are necessary for calculating residence times for logs as structural elements in terrestrial and aquatic ecosystems, calculating N-fixation and nutrient release rates, etc. This experiment will provide the clean data essential for determining decomposition rates and for quantitative comparisons of various species, log sizes, and markedly contrasting environments. The alternative is to continue to do opportunistic research on the succession of organisms that utilize logs.

Methods and Measurements. This LTER component will require very careful design because of its large size and expense and the proposed duration of 100 to 200 years. Hence, the design offered below is tentative and would be refined in a series of scientist and statistician workshops following a grant award.

The major aspects of the study are outlined in Table 8. In upland forest, a standard log decay experiment provides the background for comparisons of species and log size and with decomposition rates in a clearcut. The standard log will be a sound Douglas-fir log which is 60 cm at the largest end and 6 m long. These will be cut from green trees, hauled to the site, and carefully placed on the forest floor with a minimum of damage to the bark and stand. Once in place, the logs will be randomly selected for destructive sampling at the appropriate sampling intervals. We considered sequential sampling of fewer, longer logs and concluded that it could not be done without excessively compromising subsequent decay of the remaining log. Consequently, we propose to remove entire logs for destructive sampling, 6 m lengths having been judged the shortest we can use without getting excessive "end" effects.

In the standard log decay study, the proposed sampling periods are 0, 2, 5, 10, 20, 40, 75, 100, and 100+ years. Enough material will be placed to allow addition of a sampling period for a total of 10. Four logs or "replications" will be randomly selected and removed at each sampling period. The measurements to be made are discussed below. We will also plant 10 additional standard logs to allow for extra destructive analyses of invertebrate colonization during the first 10 years of the study (Table 9).

The species and size comparisons will be carried out at the same upland forest site and will incorporate the results from the Douglas-fir (standard log decay) as part of their design. Sound live western hemlock and western redcedar will provide 60 cm x 6 cm logs for the species comparison along with the largest (up to 60 cm) hardwood logs available; red alder, cottonwood, or bigleaf maple will be used. The size comparison will include 30 and 120 cm x 6 m Douglas-fir logs. Only half as many sampling periods (5) are proposed as in the case of the standard log decay study. Their selection is open.

A study of decay rates in a clearcut will utilize a sample of 60 cm x 6 m Douglas-fir logs with five sampling periods (Table 8). The standard log decay data will provide the forest comparison.

The riparian log decay and species comparison study involves anchoring bolts (30 cm x 3m) of Douglas-fir, western redcedar, and red alder so that half of their length is in and half out of a perennial stream. Each bolt is, therefore, functioning in three environments--permanently aquatic, terrestrial, and the interface which is located between high and low flows. Seven sampling periods are proposed (0, 2, 5, 10, 20, 40, and 75 years) with sufficient bolts provided

Table 8.—The major aspects of the LTER log decay study.

Site	Experiment	Sample Periods	Details
Upland forest	Standard log decay	10[1]	60 cm x 6 m Douglas-fir logs at 0, 2, 5, 10, 20, 40, 75, 100, and 100+ years
	Species comparison	5[2]	60 cm x 6 m Douglas-fir, western hemlock, western redcedar, and unknown size hardwood
	Size comparison	5[2]	30 cm, 60 cm, and 120 cm x 6 m Douglas-fir logs
Clearcut	Clearcut log decay	5[2]	60 cm x 6 m Douglas-fir logs
Riparian	Riparian log decay and species comparison	8[1]	30 cm x 3 m Douglas-fir, western redcedar, and red alder sampled at 0, 2, 5, 10, 20, 40, and 75 years

[1]Allows for an unplanned sampling period beside those already designated in details column.
[2]These comparisons will be sampled only half as many times as the "standard log decay" material.

Table 9.--Number of logs by species and size needed at each site for log decay study assuming four log replicates are taken at each sampling period.

Site	Experiment	Sample Periods	Details
Upland forest	Standard log decay	10	40 60 cm x 6 m Douglas-fir
	Species comparison	5	20 60 cm x 6 m western hemlock
			20 60 cm x 6 m western redcedar
			20 ? x 6 m hardwood
	Size comparison	5	20 30 cm x 6 m Douglas-fir
			20 120 cm x 6 m Douglas-fir
	Invertebrate sampling[1]		10 60 cm x 6 m Douglas-fir
Clearcut	Clearcut log decay	5	20 60 cm x 6 m Douglas-fir
Riparian	Riparian log decay	9	32 30 cm x 3 m Douglas-fir
			32 30 cm x 3 m western redcedar
			32 30 cm x 3 m red alder

[1]Extra logs to allow for additional destructive sampling for invertebrates during the first 10 years of the study.

for addition of an eighth sample. The same procedures of randomly assigning logs to their location and randomly selecting four samples of each species at each sampling period will be followed in the riparian as in the upland site.

The sites for installation of the logs have not been selected. The upland site will be placed in essentially undisturbed mature or old-growth forest so as to provide as natural a forested environment as possible. However, the site must be accessible, on gentle topography, sufficiently extensive to provide space for 150 logs (Table 9) and reasonably thrifty so as to minimize damage to the experimental logs from natural windfalls and broken tops. The clearcut installation will be located nearby. The riparian site will be on a second- or third-order stream and may involve some channel modification to accommodate 96 logs in a comparable environment (e.g., depth of water), somewhat protected from flood flows, and with the necessary anchor points.

All logs will be carefully measured and described at the initiation of the study including: diameter at each end, length, branches, damage (e.g., barking or scarring), and age at each end. We do not intend to use logs with rot present. A detailed listing of initial measurements for each log at the time it is placed in the field is given in Table 10.

Logs selected for destructive sampling will first be measured for its dimensions, bark coverage, moss and vascular plant cover, and other appropriate descriptors (Table 11). Physical and chemical analyses will include moisture content, nutrient content, and wood density (Table 11). Subsampling of the log will be done in such a way as to examine redistribution of nutrients within the log.

Invertebrate sampling will be based on both destructive sampling and emergence traps. Numbers, biomass, and distribution of major functional groups will be determined with special attention to carpenter ants and termites. Note that extra logs have been provided for more frequent destructive sampling during the first ten years of the study.

Table 10.--Initial measurements on each permanently tagged and numbered log. Measurements 1 through 5 will be done at both ends of logs.

No.	Measurement
1	Diameter outside bark along four axes.
2	Diameter inside bark along four axes.
3	Diameter of heartwood along four axes.
4	Distance from center ring to wood-bark interface at the top, bottom, and sides of the log.
5	Age.
6	Length of log at top and sides.
7	Location and dimensions of any old scars.
8	Location and diameter of any branch stubs
9	Location and desription of any recent damage (e.g., bark peeling).
10[1]	Density of the sapwood and heartwood.
11[1]	Nutrient content of sapwood, heartwood, and bark (N, P, C, and cations).
12[1]	Lignin, cellulose and acid-detergent soluble fraction[2] concentrations of sapwood, heartwood, and bark.
13[1]	Initial moisture content.
14	Description of initial lichens present.

[1]From thin slice samples taken from each log end. Allowance made to keep each log 3 m or 6 m finished length, depending upon experiment.
[2]Procedures after Van Soest (1963). Acid-detergent soluble fraction includes non-structural C, protein, and hemicelluloses.

Table 11.—General list of measurements made on both terrestrial and aquatic logs selected at each sampling period.

No.	Measurement
1	All relevant dimensional measurements as in Table 10.
2	All relevant physical-chemical[1] data as in Table 10.
3	Invertebrate activity patterns, functional groups and biomass.
4	Fungal colonization patterns, types of wood rot and fungal biomass.[2]
5	N_2 fixation, CO_2 evolution.
6	Epiphytes, including mosses and lichens.
7	Seedling establishment, rooting patterns, and presence of mycorrhizal roots.
8	Evidence of vertebrate use, especially birds.
9	Classification of log decay stage.

[1]Will measure degree of wood lignin degradation and humification of advanced decay following suggestions by Spaulding (1979) and Butler and Buckerfield (1979).

[2]Using fluorescent microscope techniques and fluorescein diacetate hydrolysis fluorescent staining developed by Soderstrom (1977) and G. C. Carroll and A. Todd (personal communication).

Data Analysis, Storage, and Retrieval

From previous Biome studies on the Andrews Forest, we have accumulated a large amount of data (see examples of major data sets in Table 3). Under present Experimental Ecological Reserve program, we are continuing to accumulate information on climate, wet- and dryfall chemistry, vegetation dynamics, stream flow, etc. (see Table 2). Some material is now gathered directly on magnetic tape but most information is still recorded by hand and must be keypunched, edited, and documented before being stored in our EER data bank.

With initiation of long-term research that must involve different personnel over an extended time period, better documentation and access to the data bank is required. We must assure that experimental designs are adequate and efficient. Quality control and standardization need to receive even greater attention. Above all, an overall program is needed to insure continuity in the entire series of baseline measurements.

To accommodate these requirements, we propose to further integrate the Andrews's research program with that of the Forest Science Department. We will do this by adding key personnel to assure integration of data processing and management and constructing a flexible system for handling the data that can be linked to other potential LTER sites.

Integration with Quantitative Services Section of the Department of Forest Science

The present policy involves support of a data base manager (Al Brown) under the EER program and within the Quantitative Services Section of the Department. The Department provides overall coordination through the leadership of Dr. Susan Stafford who is also our statistican. Completing the present staff in the section is Dennis Muscato who is in change of programing and data analysis. The section has keypunching facilities and a remote job entry system (DATA 100) providing high-speed linkage with the central OSU computer and other computer systems.

We propose to utilize the present services provided by the Quantitative Services Section in developing more efficient experimental designs and in standardizing to an even greater extent, the collection, processing, storage, and retrieval of data.

Special Requirements of LTER Program

We propose establishing a Long-term Ecological Research (LTER) data processing network. This is necessary to accommodate the special requirements of a program that is centered 80 miles from campus and which makes commitments for analyzing data in a compatable and efficient manner over extended periods. The network is designed to provide a flexible system that can adjust to technological advancements while providing a sound workable system capable of meeting initial goals. The system will be initiated upon the basis of a proven, stable, but centralized network to one that will be more diverse and accessible.

Two basic approaches to decentralization are possible. The first would involve installing a high-speed, remote job entry system at the field site.

This would provide similar capabilities to what is available on campus but would require a staff for its efficient use and maintenance. It would also be expensive if not heavily used on a continuous basis and occasionally limited by overloads or breakdowns.

Another approach would be to install a number of microcomputers with similar software packages on which small sets of data could be analyzed. The problem here is in developing adequate software and storage capabilities. And, over the short run, many of the major data sets would not be available to researchers while at the field site.

Network Description

As a solution, we propose to combine the best features of both systems and to develop a functional network across campus to our major cooperating departments and to the Andrews.

Microcomputer systems will be installed at: Fisheries and Wildlife Department, OSU (1); Forestry Sciences Lab, US Forest Service (1); Forest Research Lab (1); and H. J. Andrews Experimental Forest (2). Components of each microcomputer system would consist of: 1) Apple microcomputer with Pascal; 2) screen for on-line interactive and graphic functions; 3) hard copy printer; 4) dual diskette drives; and 5) 300 band asynchronous communication mode (Hayes Inc., Atlanta). The H. J. Andrews would have two systems, one to provide for on-line data entry, the other for research program development. All five systems should be supplied by the same vendor to ensure that the systems are fully compatable and that maintenance costs are minimized.

Each microcomputer system will be self-contained with links available, however, to other microcomputer systems within the network for transfer of small files and to the central OSU computer. This linkage capability is essential to allow LTER research to be performed on either the larger OSU computer or on the local microcomputer system. Many larger data sets can only be made accessible in this way.

Network Coordination

To implement the proposed network, some additional staff are required. We propose to create a position for a full-time network coordinator who would be a member of the Quantitative Services Section of the Forest Science Department under the supervision of Dr. Stafford. The Coordinator would have responsibility for the purchase and maintenance of the microcomputer system, for developing microcomputer programing and their documentation, and for establishing standards and providing instruction for total system operation.

Field Data Analyst

To coordinate efforts in the field, we propose a position for a person who is a competent programmer and biologically trained as well. The position would be initially established as equally split between field and computer work. Supervision would be provided by the Site Manager, Art McKee, with close association with the Network Coordinator.

This proposal has the support of all participants and was prepared with the assistance of the Quantitative Services Section. We particularly acknowledge the aid of Dennis Muscato in providing detailed specifications on the micro-computer systems.

The plan outlined above is exactly that--a plan. We are willing to collaborate with other LTER sites in modifying aspects of the data management system to ensure better performance, greater coordination between sites, or cost efficiencies. In summary, our proposal is not set in concrete but open to appropriate modification.

Information Synthesis and Publication

Many of the data sets collected during LTER programs will supplement or compliment AEER baseline data collections. Often times these sets have an intrinsic value which warrants their separate publication. Meteorological station summaries, stand tables, and phenological records are some examples. Such publications would be produced on a periodic basis, at intervals appropriate for the type of data, and the costs shared by U.S. Forest Service Pacific Northwest Experiment Station and the School of Forestry, OSU.

Synthesis and publication of research resulting from LTER funding would, of course, be done by the scientists working on the individual components. As several people are involved in the many aspects of each component, several co-authored papers are to be expected where senior authorship shifts according to the particular point being discussed. The different components are by no means mutually exclusive, and many scientists will be working on more than one component. This kind of structure with several scientists working within and between research projects is one with which we are very familiar, and which has proven very productive. Aside from the assignments made in any given component, collaborations are apt to spring up between scientists as new insights are gained. These would certainly be encouraged.

Collaboration with scientists from off-site would be handled in the manner of the AEER. This takes a variety of forms from someone coming into the program cold and forming a research plan, to current users inviting someone to work on specific problems. The tradition of open data and free collaboration has proven mutually beneficial, and we expect it would continue.

Site Promotion

The site promotion activities of the AEER would be expanded to include LTER aspects not currently being addressed. Since many of the features to be promoted are one and the same, such as a site dedicated to research, or long-term data base availability, the brochures, pamphlets, and slide-tapes developed for the AEER would be very appropriate for the LTER program. Presentations at national meetings which summarize AEER history and research have proven useful in site promotion. Similar presentations for LTER activities would also be made. Brief overviews of certain research components, such as the log decompostion study, would be prepared for distribution. The cost of these publications could be shared by U.S. Forest Service, Pacific Northwest Experiment Station, and the School of Forestry, OSU.

COORDINATION WITH OTHER LTER SITES

The establishment of several LTER sites will provide opportunities to test theories of community structure, diversity, or stability in different ecosystems. We believe that testing these kinds of general theories is a fundamental part of any national LTER program, and are fully committed to intersite coordination and comparability of experimental design. We are ready to participate in any workshop to design and coordinate intersite experiments.

We have budgeted substantial travel funds for both workshops and research coordination. Contacts have been made with the parties writing the proposals for Hubbard Brook Experimental Forest, Coweeta Hydrological Laboratory, Olympic National Park, and the Hanford Reservation. Common data handling systems have been discussed with Hubbard Brook and Coweeta and the system we have proposed is a result. It can be modified as necessary. We have also discussed common experiments with these sites, but the time schedule for this proposal did not allow sufficient development time. If funded, we will definitely pursue common experiments with other sites. Most of our component research programs are designed with intersite comparisons in mind, and can be modified to accommodate other interests or needs.

To ensure the success of intersite coordination and research, we suggest a national administrative structure much like the network management plan proposed in the second Woods Hole report (Botkin 1977). That plan contains provisions for network coordination and central planning and policy. Even in a national coordination effort, much of the research remains very individualistic (a lesson of IBP). The structure proposed would assist in establishing goals, and providing continuity as the individuals change. We believe NSF should take the lead in working with the sites to establish this national administrative structure.

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