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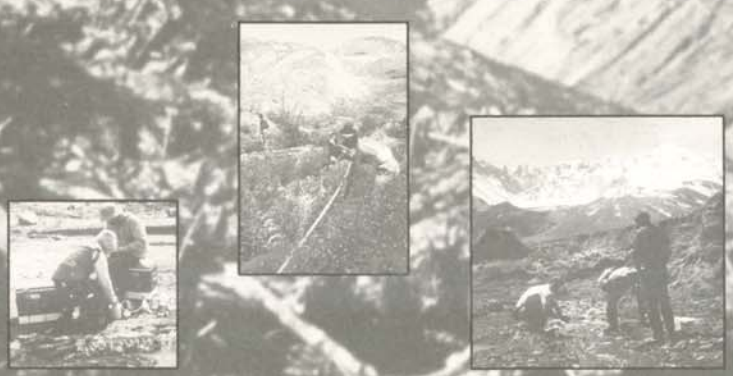
Mount St. Helens, Biological Research Following the 1980 Eruptions: An Indexed Bibliography and Research Abstracts (1980-1993)

Peter M. Frenzen, Anne M. Delano, and Charles M. Crisafulli



Compilers

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MOUNT ST. HELENS:

Biological Research Following the 1980 Eruptions—
An Indexed Bibliography and Research Abstracts (1980-93)

Compilers:
Peter M. Frenzen
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Charles M. Crisafulli

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Abstract

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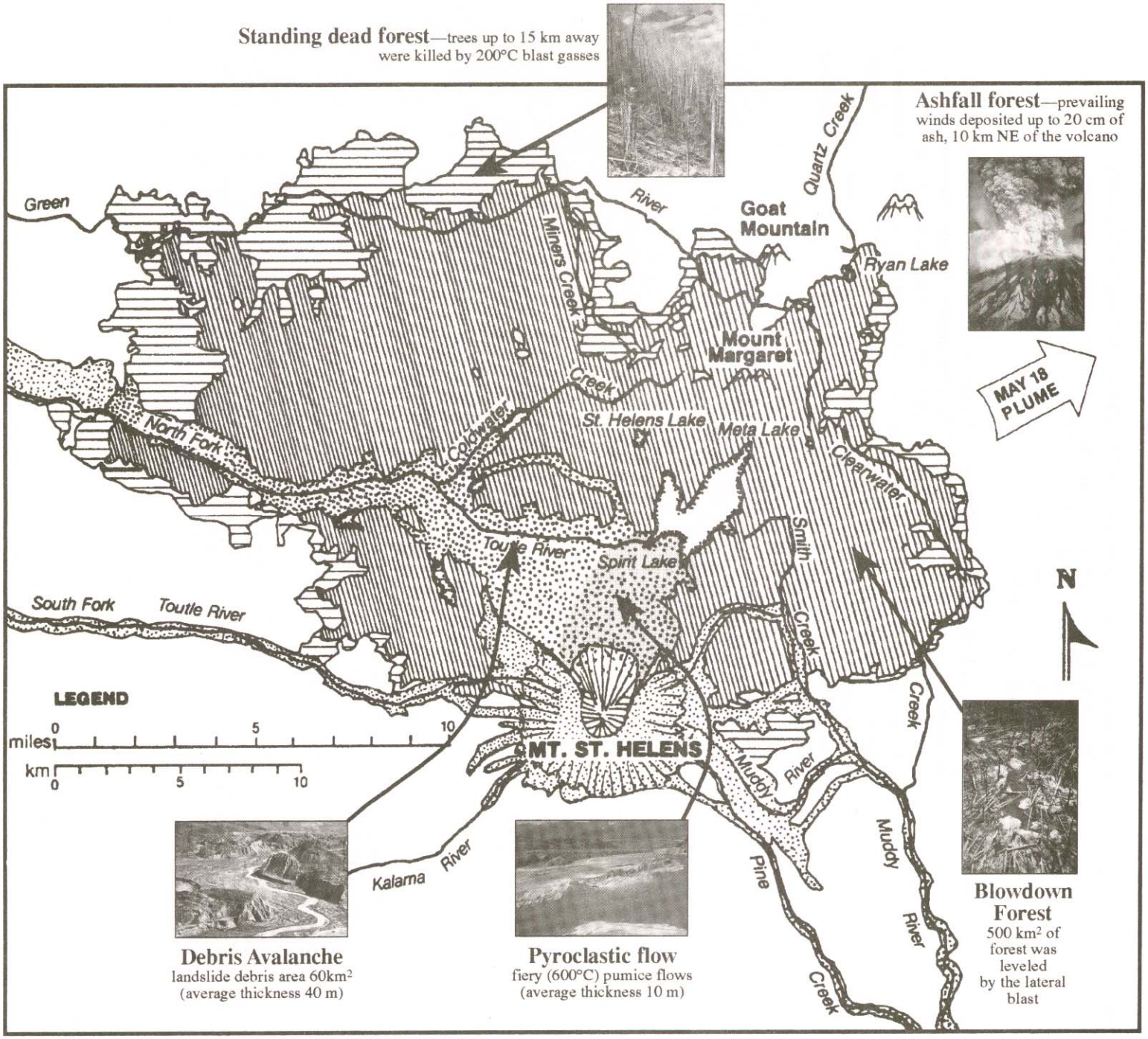
The May 18, 1980, eruption of Mount St. Helens in Washington is possibly the best documented geological event in history. The bibliography displays the results of 13 years of biological and related research in a convenient, indexed format. Our intent is to facilitate collaboration between scientists contemplating new research initiatives and experienced investigators who have conducted baseline studies at the volcano. Prospective investigators are encouraged to contact the Monument Scientist and individual authors listed in the research abstracts to find out more about research opportunities at Mount St. Helens.

Keywords: Bibliography, biological research. Mount St. Helens.


Standing dead forest—trees up to 15 km away were killed by 200°C blast gasses
Ashfall forest—prevailing winds deposited up to 20 cm of ash, 10 km NE of the volcano
Green River
Miners Creek
Goat Mountain
Quartz Creek
Ryan Lake
Mount Margaret
MAY 18 PLUME
Coldwater Creek
St. Helens Lake
Meta Lake
Clearwater
North Fork
Toutle River
Spirit Lake
Smith Creek
South Fork Toutle River
N
LEGEND
0 5 10
miles
km 0 5 10
MT. ST. HELENS
Muddy River
Kalama River
Pine Creek
Muddy River
Debris Avalanche
landslide debris area 60km²
(average thickness 40 m)
Pyroclastic flow
fiery (600°C) pumice flows
(average thickness 10 m)
Blowdown Forest
500 km² of forest was leveled by the lateral blast

Contents

PLEASE NOTE:

The Mount St. Helens National Volcanic Monument is not able to maintain a lending library of these materials. The reader should contact the reference librarian at their local college, university, or municipal library to locate the items listed.

Introduction

The May 18, 1980, eruption of Mount St. Helens, in Washington is possibly the best documented geologic event in history. The proximity of the volcano to major research laboratories has provided an unprecedented opportunity to study geomorphic and biological responses to large-scale disturbance. The more than 500 individual biological, hydrologic, and geologic studies established since the eruption have provided an excellent baseline for tracking ecosystem reassembly at long-time scales.

The following bibliography displays the results of 13 years of biological and related research in a convenient, indexed format. Our intent is to facilitate collaboration between scientists contemplating new research initiatives and experienced investigators who have conducted baseline studies at the volcano. Prospective investigators are encouraged to contact the Monument Scientist and individual authors listed in the Research Abstracts to find out more about research opportunities at Mount St. Helens.

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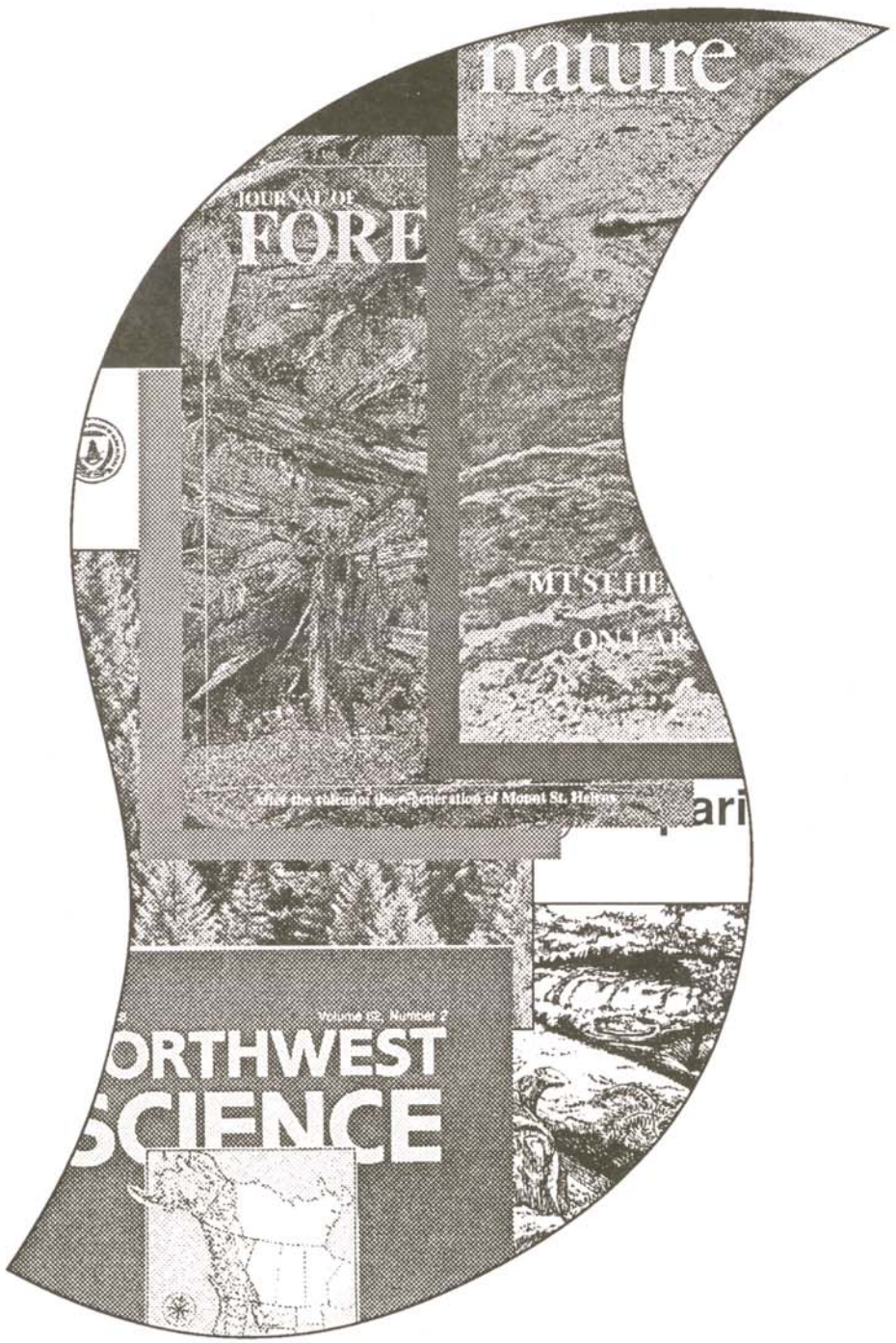
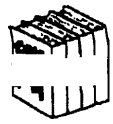
PUBLISHED RESEARCH





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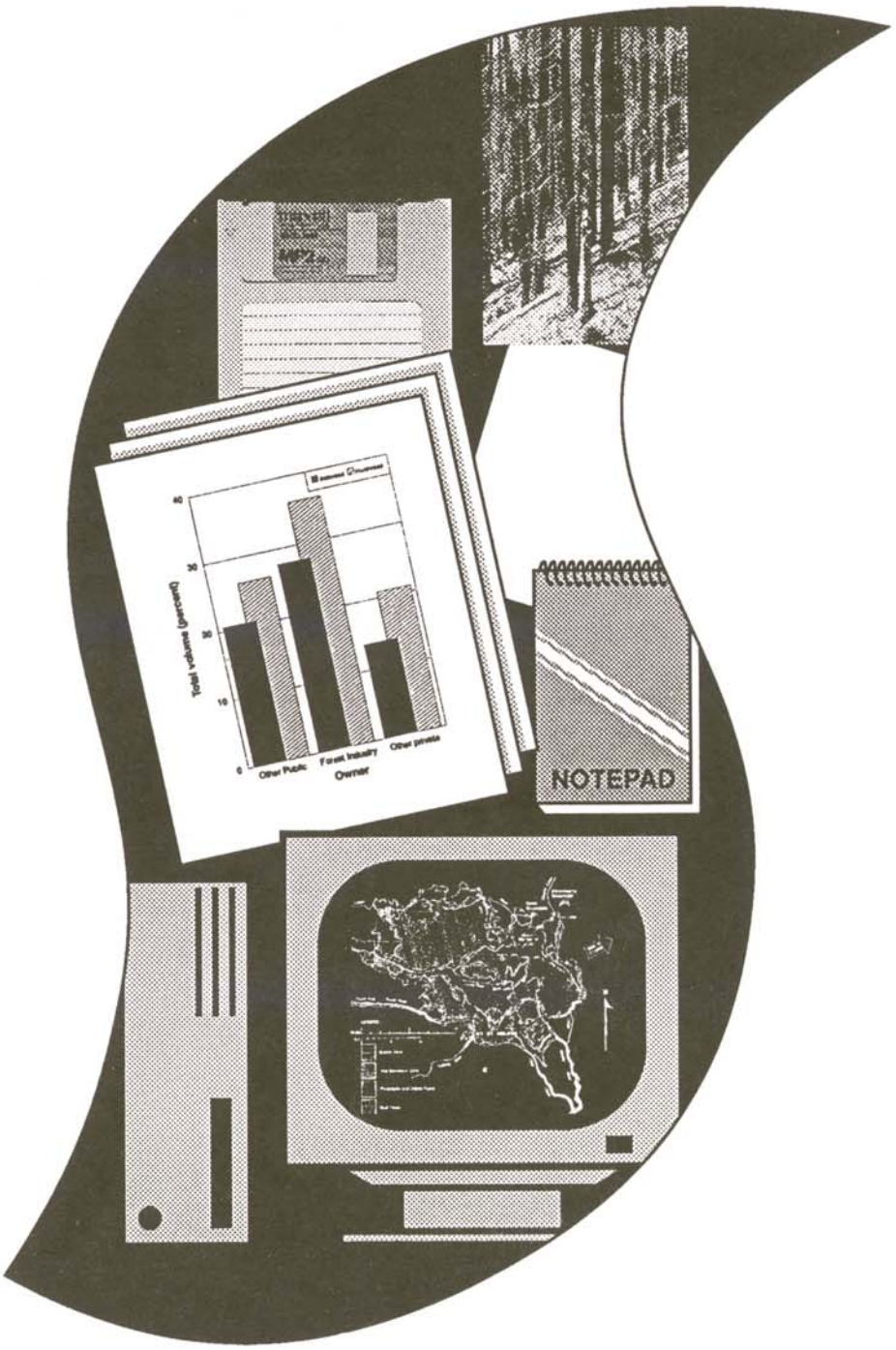
RESEARCH ABSTRACTS



—1A-

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Study Title; Ecosystem recovery on the debris avalanche

Key Words: biological, terrestrial, plant, animal, upland, vegetation, ecosystem, recovery, revegecacion, mammals, insects, debris avalanche

Abstract: The object of this study is to monitor ecosystem recovery on the debris avalanche created by the May 1980 eruption of Mount St. Helens. Vegetation was significantly reduced in the blast area. Plant survival and diversity was apparently related to growth form. Plants with underground dormant buds survived best. Plant recovery has been correlated with moisture rather than physical structure of the substrate.

Mammal recovery is related to plane community structure, particularly important may be the presence of dead organic debris. Migration of deer mice *(Peromyscus mamculatus)* onto the debris avalanche occurred within four years of the May 1980 blast, and significantly more males were sighted than females.

Insect diversity, especially of beetles is largely a result of physical structure of the substrate.

Type of Measurements): Vegetation sampling was performed in 12 plots each 25 meters square; number of species and percent cover for vascular plants was estimated. In August 1981, 31 plots each 250 meters square were established in which all individual plants were marked and number of stems per species counted and soil texture was assessed.

Greenhouse plantings to determine effects of soil moisture were conducted at University of Washington using soil collected from the North Fork Toutle River. Soil moisture measured in mcgapascals (MPa); plant height measured in centimeters; fresh weight and dry weight of plants measured in grams.

Small mammal trapping took place in 1984, and individuals and species were counted and scxcd.

Insects were identified and individuals counted; diversity was measured as number of families and individual taxa per order.

Frequency of Measurements): Annually from 1980; some years several samples were made.

Data Storage: Field notebooks and magnetic computer tapes in personal possession. Data has been published.

Long-term plans, Data available for collaborative efforts: Continuation of monitoring is questionable. Vegetation plots arc permanent. Adams is available for future collaborative efforts, and data is available in publications.

—2A—

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Study Title: Recovery of mycorrhizal associations on Mount St. Helens

Key Words: biological, terrestrial, upland, plant, trees, vegetation, fungi, mycorrhizae, animal, vertebrate, elk, gopher, soils, nutrient, ecosystem, succession

Abstract: This work has studied the recovery of mycorrhizal associations on Mount St. Helens since the eruption in 1980. Mycorrhizal associations are symbioses between plants and fungi localized on the roots of plants. The fungi provide much of the nutrients utilized by the plants and the plants provide carbohydrates to the fungi. The associations on Mount St. Helens range from those plants that form facultative mycorrhizal associations, many herbaceous species including *Lupinus lepidus,* L. *latifolius,* and *Epilobium angustifolium,* to the coniferous trees that are obligacely dependent on mycorrhizae.

Our work has concentrated on the vectors chat move propagules of the mycorrhizal fungi and the ability of those vectors to place inoculum wherein the symbiosis can establish. We have separated the reestablishmcnt dynamics in three zones, the sterile pyroclastic flow with no surviving propagules, the blast zone wherein most of the vegetation was destroyed, and the ashfall zone wherein most of the organisms survived but had to deal with the overlying ash. The recovery rates formed a gradient. Virtually all of the mycorrhizal types that were present before the eruption recovered quickly in the ashfall zones. Pocket gophers and ants facilitated this recovery by returning mycorrhizal fungi to the surface where contact with plant propagules could be made. In the blast zone, gophers and other rodents also survived and initiated mycorrhizal reformation within two to four years. Gophers and other rodents have initiated new mycorrhizal activity on the pumice plain following their arrival ac the particular plant patch. They appear to key on patches of plants rather than individuals for their inoculum dispersal. Wind did not appear to be important for long range dispersal of soil-borne mycorrhizal fungi but may move propagules within a patch. Wind did appear to be important for the long-distance dispersal of the early cccomycorrhizal fungi such as *Thelephora* sp. Together these data indicate that the mycorrhizal fungi arc critical to the recovery of the vegetation on Mount St. Helens and that a variety of animals served as vectors for the dispersal of these important fungi.

Type of Measurements): Presence or absence of mycorrhizal fungal propagules; spore density (number/kg soil); infection presence; species composition (when possible).

Frequency of Measurements): Twice annually in 1982-1986; once annually in 1988 and 1990.

Data Storage: Original data sheets at San Diego State University.

Long-term plans. Data available for collaborative efforts: Plans are to continue monitoring approximately every three to five years within the sample areas into the next century. Collaborative efforts will be considered on a case specific basis.

-3A-

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Study Title: Ecology of the tadpoles of the tailed frog *(Ascaphus truei)*

Key Words: amphibian, ecology, biological, aquatic, animal, vertebrate, tailed frog, tadpole, stream, algae, flow rates, microhabitat

Abstract: Data on the microhabitat parameters, especially pertaining to flow rate and substrate characteristics, of the stream-inhabiting tadpoles of the tailed frog *(Ascaphus truei)* were collected at two tributaries of Clearwatcr Creek at Mount St. Helens, Washington and at Parker Creek on Mary's Peak, Benton County, Oregon. This is the only tadpole in North America that is highly specialized for maintaining position and feeding from algae while attached to rocks via an enlarged oral disc with many rows of labial teeth. Positions of tadpoles in the streams were correlated with oral morphology and associated anatomy. Because of the length of the larval period *of Ascaphus,* there are usually two to three yearly cohorts in the streams at one time. We hypothesized that the interaction of the abilities of the tadpoles to adhere to rocky substrates and the size of the tadpole would result in microhabitat segregation. Whether small or large tadpoles occupied fast versus slow water would depend on the growth pattern of the tadpole (drag) versus the changes of the adhesive abilities with size.

Our data show that none of the parameters that were measured, including flow race at the site of each tadpole, were significantly different between size classes. We concluded that the growth pattern of the body (which is probably isometric based on analyses of tadpoles of other shapes) and of the oral disc are such that tadpoles of all sizes can occupy any usable microhabitat. This commonly includes moving onto usually vertical, wet surfaces out of water at night.

The manuscript that resulted from this study included comparisons of tadpoles *of Ascaphus* and *Heleophryne purcelli,* a morphologically and ecologically similar tadpole from South Africa. Based on differences between selected oral and abdominal musculature and video tapes of the two species moving via their enlarged oral discs, we concluded that the two tadpoles feed in different fashions even though their gross morphology is similar.

Type of Measurements):

- scream slope
- stream flow
- flow at exact site of tadpole
- attached algae at exact site of tadpole

Frequency of Measurements): 2 nights, June 7-8, 1989 at Mount St. Helens.

Data Storage: Data are stored in IBM Lotus 1-2-3 files.

Long-term plans, Data available for collaborative efforts: No long-term research at Mount St. Helens is expected at present. The study site at St. Helens was chosen because previous research showed *Ascaphus* tadpoles common. All data arc available through R. Altig.

—4A—

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Study Title: Effects of pocket gopher *(Thomornys talpoides)* mounds on plant re-establishment processes

Key Words: biological, terrestrial, plant, animal, vertebrate, revegetation, seedling, survival, gopher

Abstract: This study documents that pocket gophers in the blast zone did survive the May 1980 eruption of Mount St. Helens, and they did have an effect on early plant re-establishment within the blast zone. One study site is approximately 20 km northeast of the volcano. This site received a layer of pumice and ash to an average depth of 12 cm in 1980. Vegetation on gopher mounds was compared to that on surrounding un-mounded soil surface. Findings show that species composition is different; there are more residual species on mounds, and seedlings on mounds are more likely to survive and contribute to future local population growth.

A second site, 12 km northeast of the volcano in the blowdown zone, was chosen for additional study. As of 1988 results from sampling this site were not conclusive as to the influence of pocket gophers on plant reestablishment because overall revegetation of the area was still very limited.

Type of Measurements): 20 cm X 50 cm or 25 cm X 50 cm quadrats were centered on each mound and adjacent to each mound, 0.75 meters from it. Plant species identified, individuals counted and growth rate (cm/year) measured for individual plants. In the blowdown zone, all vegetation within randomly located 2 x 2 meter (n=14) permanent plots was tabulated and mapped, as was vegetation within randomly located 25 cm X 50 cm quadrats (n=30); survivorship of marked individuals was noted.

Frequency of Measurements): 54 mounds created in 1980 and 1981 at the tephra fall site were sampled in 1981, 1982, 1983, and 1988. Mounds created in 1982-1984 at the blowdown site were sampled in 1984 and 1988.

Data Storage: Tabulated data are on floppy disks in ABSTAT or Lotus files, and field maps of plots and marked mounds arc in Andersen's personal possession. Maps have been digitized using Intergraph IGDS software and are available on tape for use in a geographical information system to *bona fide* investigators.

Long-term plans, Data available for collaborative efforts: Andersen hopes to continue to monitor blowdown site in the future as revegetation of the area increases; influence of pocket gophers on revegetation may become evident. Future work at this site may also include monitoring changes in small mammal populations. Will pocket gopher population increase as vegetation increases? Opportunity to return and continue investigation depends on funding and schedule (work would have to be conducted independently of current position, probably using vacation or leave time). Andersen is willing to share data or otherwise cooperate with investigators interested in monitoring the permanently marked plots he has established.

—5A

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Study Tide: Population ecology of the aphid *Aphthargelia symphoricarpi* on Mount St. Helens

Key Words: biological, terrestrial, plant, animal, upland, herb, invertebrate, arthropod, insect, aphid, ant, ecology, population ecology

Abstract: I have examined the ecology of the aphid *Aphthargelia symphoricarpi* in terms of its interactions with its host plant *Polygonum newberryi* and its major predator, the ant *Formica fusca.* My approach involves a combination of field experimentation and observation with mathematical modelling.

Interspecific interactions between ants and aphids may be either predatory or mutualistic, depending on the particular species involved, and for some pairs of species, depending on the density of the aphids. The interaction of*Formica* and *Aphthargelia* was overwhelmingly the dominant biotic factor influencing the *A. symphoricarpi* population during both years of this study. Over 30% of the *Polygonum* plants were infested by aphids at the study site. If a plant was infested by aphids, ancs were almost certainly found there as well; the converse was also the case. Analysis of 1985 ant and aphid censuses suggested higher ant counts on plants harboring growing aphid populations than on plants with declining aphid populations.

The strong association of *Formica* with *Aphthargelia* in disturbed communities at Mount St. Helens is a manifestation of predator-prey interaction rather than mutualism. Predation by ants reduced growth rates of aphid populations by 27% and final densities by 64%. I predict that while the current relationship between this ant and aphid is essentially predatory, as the community recovers and other protein sources become more abundant for the ant, the interaction will switch to mutualism.

Type of Measurements):

- Field observations: six 10 m X 10 m plots—mapped every individual *of Polygonum nevsberryi,* recorded presence or absence of ants and aphids; two 10 m X 10 m plots—daily counts of A. *symphoricarpi* populations on individual *Polygonum* plants, counts of age classes of aphids on each plant, number of ants per plant.
- Field experiment: 36 planes in 50 m X 50 m area—naturally present aphid density, number of aphids placed on plants, ants excluded or not excluded.

Frequency of Measurements): 1985 and 1986; frequent population counts during the growing season.

Data Storage:'

Long-term plans, Data available for collaborative efforts: My future plans include continued research on Mount St. Helens. With David M. Wood, I plan to begin a study of the pumice plains area on the north side of the mountain. The basic question of interest will be "How does a barren landscape fill up with species?" The unique environment of the north side of Mount St. Helens provides an unparalleled opportunity to examine the colonization of an ecological "tabula rasa". Our work will include field experiments, sampling of seed rain, mapping of developing vegetation, statistical analysis of spatial data, and mathematical modelling of population spread. The study will encompass aspects of population, community, and landscape ecology simultaneously.

/ Information concerning data storage was unavailable at the time of printing. Contact principal investigator or consult publications for these details.

—6A—

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Study Title: The effects of the eruptions of Mount St. Helens on glaciers, glacier caves, caves and mudflows, etc.

Key Words: crater, topography, avalanche, geomorphology, hydrologic, deposits, caves, biological, mudflow, physical, glaciers

Abstract; The objectives of this project are to study effects of eruptions on glaciers and glacier pseudokarst and to map glacier caves and glacier margin and other caves on Mount St. Helens. In meeting these objectives we will document and photograph: 1) these features, 2) effects ofashfall and mudflows on newly exposed glacier bed and downslopc detritus and erosion produced by melting glaciers, and 3) effects on crater, dome and caves in crater.

Results:

1. Map glacier caves, lava caves and put on topographic map with aerial photos.
2. Speleobiology of glacier caves: specimens were collected of all species observed. Stoneflics (Plecoptera: Perlodidae) *Rtckera sorpta* a penultimate (last stage) nymph of this rare species was found in the Swift Glacier cave. Craneflies (Diptera: Tipulidae) *Omithodes harrimani Coc\\x\\\et* fungus gnats (Diptera: Mycetophilidae) *Boletina* sp.; grylloblattids (Orthoptera: Grylloblattidae); and ice worms (Oligochaeta: Pleiosiopora) *Enchy traeidae* were found in other glacier caves.
3. Mudflows were photographed and put on topographic map^T.
4. Surveys of caves and aerial mapping for topographic maps of cave locations.

Type of Measurements):

- Survey instruments: Brunton compass and survey tape (feet and meters)
- Aerial Photos: Taken by USGS and IGS Members for cave locations and mudflows
- Topographic Maps: USGS topo maps and Army Engineer maps and IGS (feet and meters) Cameras used 35mm, 4x5, process camera, Roberson, Opti copy and Durst enlarger

Frequency of Measurements): Early 1980 to present and monthly in summer at least once a month.

Data Storage: USGS topo, U.S. Army Corps of Engineers maps and IGS files; IGS aerial photo files and NEGS files; IGS maps, files, and cave survey data files.

Long-term plans, Data available for collaborative efforts:

1. Study changes in glacier caves and glacier margin.
2. Map lava and glacier caves.
3. Map and photos of glaciers.
4. Study caves in Spirit Lake basin and crater.
5. Study the effects of the eruptions on glaciers and glacier pseudokarst; effects ofashfall and mudflows on newly exposed glacier bed and downslope detritus.

Baseline data is on file for future use.

Future opportunities may include:

1. Master paper on glacier caves on Mount St. Helens.
2. Study of glacier caves on an active volcanic mountain.
3. Master paper puts forth a model for the evolution of glacier caves, using observations of glacier cave systems and its environs. No one has treated the evolution of glacier caves systems in detail.

—7A—

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Study Title: Recovery of aquatic insect communities in streams near Mount St. Helens

Key Words: biological, aquatic, animal, stream, invertebrate, insect, recovery, secondary, production

Abstract: We have monitored scream insect communities from 1980 to 1988 in Clearwater Creek, Elk Creek, and Ape Canyon. Quantitative and qualitative samples indicate rapid colonization in 1981-1982, and then a gradual increase in richness and diversity. Over 200 taxa have now been collected from Ape or Clearwater Creeks.

The structure and productivity of the benthic community comparing Upper Clearwaccr Creek (affected by the blast and ashfall) with Elk Creek (ashfall only) for 1985 and 1986 was R. Meyerhoffs Ph.D. thesis project.

Type of Measurements): Hess samples (0.02 m) for quantitative benthos collections; kick-net collections and hand washing of wood debris for qualitative collections. Water temperature was monitored from 1985-87 at the Upper Clearwater Bridge with a Datapod.

Frequency of Measurements): In 1981 January, May, July, and October. In 1985 and 1986, 10 to 12 times between March and October for Clearwater and Elk Creeks. In other years only in lace August or early September.

Data Storage: Insects are stored in alcohol. Benthos data are on handwritten data sheets and some on floppy disks (DBASE III format). Temperature data on floppy disks (Lotus 1-2-3).

Long-term plans. Data available for collaborative efforts: We hope to continue to be involved in the aquatic habitat recovery studies with J.R. Sedcll of the USFS. Long-term monitoring of the aquatic insect community will require modest funding.

The Aquatic Entomology Lab at Oregon State University has a large amount of material stored as baseline data. This includes some 1980 pre-eruption collections by the USGS. Funds are needed for identifying, labeling and curating the insects if these collections are to be of much use for other researchers.

—8A—

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Study Title: The evolutionary ecology of *Lupinus lepidus*

Key Words: biology, ecology, terrestrial, plant, upland, subalpine, herbs, seedlings, survival, dispersal

Abstract: A four year study of the evolutionary consequences of colonization was begun in 1990. The objectives of this study are to document the pattern of genetic variation in a colonizing plant species, *Lupinus lepidus,* and investigate the ecological processes which are expected to affect that pattern.

Preliminary genetic data indicate that colonies of *L. lepidus* on the pumice plain of Mount St. Helens are genetically different from each other, probably due to the differing genetic composition of founders. Whether or not differentiation due to founder effects will persist depends on: 1) the rate of population growth, 2) the level of migration between populations, 3) the rate of self-fertilization, and 4) spatial variability in natural selection. Efforts are underway to assess the importance of each of these processes.

Population growth rate and factors affecting it, such as herbivory, are being studied by measuring survivorship, fecundity, seed bank properties, and other demographic parameters for a large number of natural and experimental populations. Genetic studies of these populations arc underway which will allow a comparison of genetic drift with population growth.

Preliminary data shows that *L. lepidus* is self-compatible and that colonizing populations may exhibit a high level of self-fertilization due to the absence of pollinators. This will tend to increase differentiation between populations.

The relationship between fruit set and flowering time was studied in seven populations for two years. This data indicates strong natural selection which varies among populations. However, the observation that selection also varies within populations among years is expected to counteract the among population effects. Much of the variation among populations and years is due to variation in herbivore loads and possibly to pollinator visitation. Reciprocal transplants between populations, started in 1991, will reveal population differentiation and the genetic basis for character differences.

Type of Measurements):

1. Demographic—size, density, fecundity, survivorship, seed germination and survival for individuals in 20 colonizing populations (begun 1991) and 50 small experimental populations (beginning 1992).
2. Phonological—weekly flower and fruit production, pollinator visitation, herbivore damage.
3. Genetic—allozyme variation at eight loci, used for estimating population genotype frequencies and mating systems.

Frequency of Measurements):

1. Demographic—annually beginning in 1991.
2. Phonological—weekly in 1990 and 1991.
3. Genetic—annually beginning in 1990.
4. Mating system—semi-annually.

Data Storage: Data arc stored permanently on field data sheets, and on Macintosh and Unix OS computers in various formats.

Long-term plans, Data available for collaborative efforts: Long term monitoring of demography and genetic variation in a number of permanent plots is planned. Proposals of collaborative efforts are welcome.

—9A-

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Study Title: Recovery of net primary production in subalpine meadows of Mount St. Helens

Key Words: biological, terrestrial, plant, upland, revcgetation, biomass, seedling, survival, tephra, mudflow, net primary production

Abstract: Study sites that received tephra or mudflow deposits during the May 1980 eruption were examined and compared for effects on vegetation. Deposition of 5 to 10 cm of tephra resulted in less species diversity and inhibition of seedling establishment but did not significantly decrease net primary production (NPP); the NPP of these areas did fluctuate dramatically with precipitation rates during seven summers from 1980-1986.

Revcgetation in mudflow areas has been slower; the NPP at these sites has increased but remains below that of the tephra fall sites.

Species composition at both sites is skewed toward those plants that propagate vegetatively. Resprouts from surviving plants are more successful at recolonization than are invading seedlings.

Type of Measurements): Total amount of current year growth/species/quad; number of species/quad; ten 1-meter square quads at Pine Creek; ten 0.1-meter square quads at Lower Butte Camp; nine 0.1-meter square quads at Upper Buttc Camp.

Meteorological data: temperature (°C), precipitation (cm), radiation, soil moisture (percent moisture, megapascals).

Plant nutrient content: nitrogen and phosphorous for dominant species and litter.

Frequency of Measurement(s): 1980-1986; biomass, nitrogen, and phosphorous once at the end of the growing season each year; meteorological data in July and August.

Data Storage: Field notebooks and hard copies on file at University of Washington, Botany Department.

Long-term plans. Data available for collaborative efforts: No future plans to continue this study. Data are available for collaboration.

—10A—

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Study Title: Climate/microclimate measurements over disturbed sites at Mount St. Helens

Key Words: physical, terrestrial, plant, soil, atmosphere, vegetation, weather, climate, microclimate, precipitation

Abstract: Climatic and microclimatic measurements for the summers of 1982 to 1987 were made at three differently disturbed sites around Mount St. Helens. These measurements provided daily information on the physical environment and baseline data for studying the evolution and recolonization of these areas.

Yearly change in the summer conditions greatly influenced soil formation and plant regrowth. Cooler wet summers were more beneficial for seedling establishment and plant growth than the drought periods of the warmer, drier summers.

By 1985, the tcphra covered site ofButte Camp recovered to pre-erupcion conditions. The 5- to 8-cm tephra layer acted as a mulch thus preventing excess evaporation from the original soil profile. The mudflow disturbance at Pine Creek acted similarly though slope and aspect of this site were responsible for higher surface temperatures and drier soil conditions when compared to Butte Camp. Desert like conditions existed on the pyroclastic flow near Spirit Lake. The recovery of vegetation at Spirit Lake showed little progress during the study period. High surface temperatures, greater diurnal temperature fluctuations, low soil moisture, erosion from wind and rain and exposure resulted in an inhospitable environment. Energy balance measurements for Spirit Lake and Butte Camp showed high evaporation rates after precipitation events, while under drought conditions the sensible heat flux became the dominant flux over the dry surface.

Type of Measurenient(s):

- Air temperature at 5, 10, 25, 125 cm above the surface
- Surface temperature
- Soil temperature at -5, -10, -25, -50 and -100 cm below the surface
- Incoming shortwave radiation in W/m2 and Mj/m2/D
- Photosynthecically active radiation in uE/s/m2
- Net radiation **in** W/m2 and Mj/m2/D
- Soil heat flux in W/m2 and Mj/m2/D
- Wind speed in m/s
- Wind direction in degrees
- Soil moisture in percent

Frequency of Measurement(s): Hourly and daily means for summers 1982-1987.

Data Storage: Hourly and daily means from 1982-86 arc stored on magnetic tape in ASCII format. Hourly and daily means for 1987 are stored on 1.2 mb floppy disk in ASCII format IBM compatible.

Long-term plans. Data available for collaborative efforts: As of May 1988 the project was terminated.

Reynolds and his data are available for future collaborative efforts. Some data appears in Reynolds and Bliss, 1986.

—11A—

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Study Title: Physiological and population ecology of lupines colonizing early successional habitats on Mount St. Helens

Key Words: biological, terrestrial, plant, upland, lupines, herbs, revegetation, survival, physiology, temperature, reproduction, rccolonization

Abstract: *Lupinus lepidus* and *Lupinus latifolius* were prominent survivors and among the first colonizers of early succession habitats following the 1980 eruption of Mount St. Helens. Several physiological and morphological properties of seedlings and adults were found to govern the response of these species to the harsh environmental conditions of these habitats.

Morphological, phenological, and demographic studies revealed thatL. *lepidus* was a short-lived wintergreen species (3- to 5-year lifcspan) with low, spreading shoots and small, hairy, solar-tracking leaves. Within the early successional habitats of Mount St. Helens, *L. lepidus* had a high population growth rate, early reproductive maturity and high reproductive allocation. In contrast, L. *lattfolius* was a longer-lived species (estimated 12- to 16-year lifespan), with an erect and densely-branched growth form. L. *lattfolius* had a much lower population growth rate, delayed reproductive maturation and low reproductive allocation.

Comparative analyses of plant water relations showed chat seasonal and diurnal trends of plant water balance were remarkably similar bccwccn species and becwccn age classes wichin a species. Stomacal conductance and leaf water potential were correlated with soil and atmospheric water deficits. Minimal levels of seasonal and diurnal osmotic adjustment were observed in both species. Collectively, these and other traits were indicative ofmesophytic species with leaf tissues that are sensitive to water deficits.

Comparative analyses of photosynthetic responses to temperature and light revealed significant differences between species. The photosynthetic capacity ofL. *lepidus* was higher over a wider range of environmental conditions than *L. lattfolius.* In particular, juvenile and mature plants *of L. lepidus* were able to acclimate to higher temperatures than *L. latifolius.*

By limiting seedling establishment, growth and the reproductive activity ofL. *lepidus* and *L. latifolius,* high temperatures and periodic water deficits are the primary environmental factors

Frequency of Measurements): Measurements throughout growing season, 1983-1988.

Data Storage: Field notebooks, floppy disks in Macintosh Microsoft in personal possession.

Long-term plans, Data available for collaborative efforts: These projects have been completed, and manuscripts arc in the process of publication. Future plans may include studying physiological factors governing species colonization on the pumice plain. Baseline data are not available for future studies.

—12A—

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Study Title: Physiological and population ecology of two subalpine herbs on Mount St. Helens

Key Words: biological, terrestrial, plant, upland, herbs, subalpine, physiology, nutrients, water relations, population ecology, seedling, vegetative

Abstract: This study examined the different adaptive strategics of two subalpine herbs in a stressful environment. The study site received tcphra in the May 1980 eruption. *Polygonum newberryi* and *Eriogonum pyrolifolium* have markedly different morphological characteristics. The former is deciduous and has a large deep root system, the latter is wintergreen and has a shallow root system.

These two species have corresponding differences in physiology and population ecology, as well. Although the large, deep root system *of Polygonum* gives it the ability to avoid drought, *Eriogonum* is more drought tolerant. This does not affect adult mortality rates in cither species but does lead to greater survivorship *of Eriogonum* seedlings. *Eriogonum* is also more tolerant of nutrient stress, an important adaptation in nutrient poor volcanic soils.

Polygonum has below ground meristems making it more tolerant of burial by tephra. Therefore *Polygonum* is more effective at recovery from volcanic disturbance by resprouing from surviving plants, while *Eriogonum* is more effective by seedling re-establishment.

Polygonum is longer-lived and better adapted to the short growing season typical of its habitat. These plants store food **in** their roots over the winter and produce new shoots rapidly in spring. *Eriogonum*, by contrast, depends on current year photosynthesis for early season development of shoots.

Type of Measurements): Individual plants or 1-meter square quads were chosen at random within 10-meter square subplots of a 50-meter square plot.

Measurements: Xylem pressure potential (megapascals, Mpa); leaf conductance (mmole/M^second); soil moisture (MPa); percent seedling survival; number of leaves/plant/season; nitrogen, phosphorous, potassium, and carbohydrate concentrations in roots, stems, leaves; laboratory studies measured seedling growth rates, leaf water conductance, biomass partitioning.

Frequency of Measurement(s): 1982-1984, generally several times per growing season.

Data Storage: Data has been published; floppy disks in Lotus in personal possession.

Long-term plans. Data available for collaborative efforts: No future plans for research. Data are available for collaboration.

—13A—

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Study Title: Observations on the floating log raft in Spirit Lake

Key Words: biological, aquatic, plant, lake, trees, conifers, deforestation, flotation, transport

Abstract: Observations on Spirit Lake and its log raft have been conducted since 1982. Ac that time a significant number (close to 20%) of the stumps (not the broken flotsam) had settled into an upright position in the water. This number included some that had floated into shallow water and had grounded lightly on the bottom (Coffin, 1983).

In 1987 side scan sonar equipment was used to determine what was happening to the trees on the bottom. Based on this research, approximately 19,500 erect stumps are calculated to sit on the lake bottom (Coffin, 1987). Those closer to the south end where screams and significant runoff bring sediments into the lake arc being buried in an upright stance. The south shore is advancing into the lake at 20 to 30 feet per year where streams are building a delta.

Since the lake water level was lowered by the outlet tunnel, some of these upright stumps protruded above water until removed by the floating log mat that moves back and forth over the lake surface.

Wood sampling of the horizontal floating logs indicates that the greater portion are Douglas-fir. Those standing on the bottom arc mostly silver fir, noble fir, and hemlock. Apparently the Douglas-fir is less likely to sink to the bottom. Cedar was found mostly among the broken debris. The brittleness of the wood apparently allowed the cedar trees to be shattered by the eruption.

Type of Measurement(s): Counts of numbers and percentages of upright and horizontal floating stumps and logs.

Frequency of Measurements): Side-scan sonar research was a one shot situation although there is the slight possibility that it could be done again several years in the future.

Data Storage: Sonograph (charts) from side-scan sonar work are stored in the Geoscicnce Research Institute. Also stored here are wood samples from 40+ erect floating trees and 20+ horizontal floating trees.

Long-term plans. Data available for collaborative efforts: Most of Coffin's research has been observational except for the side-scan sonar work and taxonomic studies of the wood samples of floating trees. Coffin wishes to continue to monitor the behavior of the floating log mat in Spirit Lake in the coming years. At this point he doubts if any high-tech or sophisticated research will be involved.

Coffin and his data arc available for future collaborative efforts.

—14A—

Principal Investigators):
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Study Title: Mount St. Helens crater weather station

Key Words: physical, terrestrial, hydrology, upland, atmosphere, crater, telemetry, climate, weather, hydrologic

Abstract: A weather station was established in the crater of Mount St. Helens to continuously monitor precipitation (both rain and snow), temperature, and water equivalence ofsnowpack. The information is gathered to provide baseline data for hydrologic hazards analyses.

Type of Measurements): Precipitation (both rain and snow) in millimeters; water equivalence ofsnowpack in millimeters of head; temperature in degrees Celsius.

Frequency of Measurement(s): Data originally telemetered from the field site to Cascades Volcano Observatory every 15 minutes. However, because of hardware problems, much of the data retrieved was intermittent. Snow pillow and temperature data are approximately complete from time of installation (fall 1987) until mid-January 1989. Precipitation data was highly intermittent over that period. In mid-January 1989, a large snow avalanche in the crater destroyed the site.

Data Storage: Data was telemetered from the field site to Cascades Volcano Observatory and stored on the VAX mainframe computer. Archived data is stored on magnetic tape. Plot of data can be obtained from Bobbie Myers (Opcrations-CVO).

Long-term plans, Data available for collaborative efforts: A large snow avalanche in January 1989 destroyed the weather station. There arc no plans to reestablish it. Data are available from Cascades Volcano Observatory.

—ISA-

Principal Investigator(s):
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Study Title: Spider biogeography at Mount St. Helens

Key Words: biological terrestrial animal invertebrate spiders wind dispersal

Abstract: Spider populations on the pumice plain were sampled and compared to chose at a control sice on the south slope of Mount St. Helens that received only tephra from the May 1980 eruption. All living organisms were either swept away or buried by the eruption at the pumice plain study site; there were no survivors and vegetation was sparse at this location during the years of sampling. Sampling at the control site revealed no significant effects on the spider community. The number of individuals trapped at both sites was nearly the same, but many more species were trapped on the pumice plain than at the control sice. The majority of species arriving on the pumice plain are wind dispersed. They appear to be coming from lowlands approximately twenty miles to the west, transported by prevailing winds through the corridor of the Toutle River Valley. Most spiders perish soon after their arrival, and as of 1985, spiders were not colonizing this location.

Type of Measurements): Collection methods: pitfall traps, barrier flight traps, fallout traps, hand collection, sweeping of vegetation. Species were sorted, individuals counted, samples weighed.

Frequency of Measurements): 1981-1987 traps generally checked every 2 weeks June-October.

Data Storage: Specimens at Burke Museum. Data on cards and floppy disks in Lotus, or Rod Crawford database management system in personal possession.

Long-term plans. Data available for collaborative efforts: Further study depends upon funding. Crawford is willing to collaborate with other investigators with funding. Specimens arc available for loan to legitimate researchers.

—16A

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Study Tide: Animal use of dead and down timber

Key Words: biological, chemical, terrestrial, animal, plant, trees, vertebrates, organic, invertebrates, wood, wildlife, blowdown, decay, standing dead, nutrient

Abstract: Snags and blowdown trees that were killed by the May 1980 eruption were marked for future study. Objectives were to document animal use of snags and down timber and to observe changes in decay stage and wood nutrient status. Sound trees with bark and branches intact were originally marked in several areas of blowdown and standing dead zones.

Intentions to return to these sites and make further observations were not realized, so only initial observations were ever recorded.

Type of Measurements): Visual observations as to soundness of trees chosen; possibly some photographs.

Frequency of Measurements): Initial observations only in September, 1981.

Data Storage: Status of data is uncertain. K. Cromack may have original observation records; other investigators in these areas may have photo records. Study records of marked tree locations are on file at Mount St. Helens National Volcanic Monument, office of the monument scientist.

Long-term plans, Data available for collaborative efforts: K. Cromack has no plans to resuscitate this study. He is willing to help in whatever ways necessary for other investigators to revive this potentially long-term study.

—17A—

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Study Title: Distribution of plant detritus and recovery of plants in deposits of May, 1980 eruption of Mount St. Helens

Key Words: biological, terrestrial, plant, vegetation, recovery, revegetation, blowdown, blast, 1980 deposits, pyroclastic, blast, avalanche, lahar, mudflow, volcanic ash

Abstract: This study seeks to identify types and sizes of plant material and distance and means of deposition in the May 1980 blast of Mount St. Helens. Types of plant material included pieces of moss, leaves, stems, roots, tree branches and trunks. Four types of transport were identified. The debris avalanche deposited plant material 23 km away. Mudflows (lahars) carried material 75 km to the Columbia River. The pressure blast removed vegetation in a 500 km^2 area. Pyroclastic flows in conjunction with the plinian column spread plant debris for at least 75 km in a 110° arc to the north and ease. These results arc being compared with fossilized records of volcanic eruptions worldwide but especially those from Tertiary western United States.

Also studied is recovery of plants in various types and thicknesses of volcanic extrusives. Four types ofextrusives identified were pressure blast, mudflows, hoc gases, and tephra. Recovery is taking the most time where entire removal or burial by several meters occurred. Vegetative recovery was most successful within the first five years in tephra covered sites. In areas of even cover, less than 10 cm of ash did not remarkably affect plant growth. The depth of ash that affected plant recovery was variable and usually greater than 10 cm on hillsides and where cover was uneven such as in the blowdown area.

Type of Measurement(s): Particle type and size in deposits, distance of deposition and speed of deposition for each of the four identified types of transport. Thickness of deposit (cm or meters) within a 1-meter square plot and number of individual plants recolonizing plot were measured in areas of four identified types of burial.

Frequency of Measurements): Sampling conducted in 1985, 1987, 1991(?)

Data Storage: As of November 1990 data exists only in field notebooks and lab notebooks and on maps all on file in Department of Geological Sciences, Michigan State University.

Long-term plans. Data available for collaborative efforts: No permanent plots have been constructed. The sites previously sampled will be sampled again in 1991, and a final report subsequently published.

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Study Title: Lakes and thermal environments in the blast zone of Mount St. Helens

Key Words: biological, chemical, nitrogen, aquatic, ecosystem, thermal, microbial, algae, water quality, lake, bacteria, hot springs, nutrient

Abstract: Approximately 20 lakes exist in the blast zone of Mount St. Helens. The degree to which they were disturbed on May 18, 1980 ranges from slight to a complete physical, chemical, and biological restructuring. Initially, our research focused on the physical, chemical, and microbial conditions within the lakes. Heavily devastated lakes were markedly changed chemically and all plants and animals eliminated. Recovery took the form of dramatic physical and chemical changes within the lakes which were linked to microbial activity. Rapid recovery occurred the first two years. Once the physical and chemical conditions were ameliorated, further biological succession was possible. Presently, we continue to track these changes.

Newly-created thermal areas provided opportunities to study microbial colonization of new environments with temperature playing an important role in which microorganisms were successful. Microbial activity was present from ambient temperature to near the boiling point of water. Some of the thermal areas were transient, but some of them have persisted. Presently, our interest focuses mainly on the Loowit Hot Springs near the dome. The dominant bacterial and algal forms, major processes, and the chemical composition of these waters through time are our major interest.

Type of Measurement(s): Temperature (degrees centigrade), pH, alkalinity (mcq/1), Ca^, Mg^, Na"""", K*, HCOg', CO_3^{-2}, SO_4^{-2}, NO,-, N03-, Si, PO_4^{-3}, Fe, Mn, DON, DOC, DIG, CH,, N^O, Hy CO, *Oy* (mM or mg/1), algal primary production, CH oxidation, nitrification, nitrogen fixation, dcnitrification, chlorophyll a, bacterial number, Mn/S oxidizing bacteria (units of activity per unit volume or area per time). Zooplankton and algal identification and enumeration (numbers/volume).

Frequency of Measurements): Sampling was performed once or twice monthly June through October in 1980; monthly April through September and opportunistically in winter months, 1981-1986; presently yearly or less; this program is currently unfunded.

Data Storage: Lotus-based files—microcomputer; encrgraphics for plots; publications.

Long-term plans, Data available for collaborative efforts: Research presently is minimal, although there is interest in revitalizing the program if funds can be found. A strong set of baseline data is available on both the lakes and thermal springs. Long-term plans include following the chemical and biological patterns within lakes which ranged over a wide variation in total initial disturbance. We are also interested in how temperature structures the biological community over the long-term in newly created thermal environments. In addition, the reintroduction offish into many of the lakes provides an excellent opportunity to follow how the zooplankcon and algal communities respond to the top of the food chain being reestablished.

—19A—

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Study Title: Plant recovery on the debris avalanche

Key Words: biological, terrestrial, plant, upland, shrubs, herbs, grasses, ecology, succession, seeds, dispersal, biomass, seeds, establishment, debris avalanche

Abstract: Seed dispersal and plant establishment have been monitored since 1980 on the debris avalanche created by the eruption of Mount St. Helens. The number of plants on the deposit increased over time to a high of almost two plants per square meter by 1983. The number of species per 250-meter square plot have increased to a mean of 10.3 in 1983 with 76 species being present over the entire deposit. Four years after the eruption only 30 percent of the species present before the eruption had reestablished themselves, and average plant cover was less than 1 percent. By 1989, plant cover had reached 18 percent.

The debris avalanche has been invaded primarily via wind-dispersed seed of early successional species chat survived or have become established in adjacent disturbed areas. Most of the early successional species on the avalanche have plumed seeds that are adapted not only for long distance dispersal, but also for being trapped in wet areas or by spider webs. Fluctuations in the density of seeds dispersed to the deposit was related to variation in precipitation.

Neither seed abundance nor plant density correlated with absolute distance to a seed source or soil texture conditions. Colonization patterns are more influenced by the available biota and prevailing climate conditions than by substrate alterations resulting from the eruption.

This ten-year study of plant recovery on the Mount St. Helens debris avalanche quantifies the resilience of native species in rcvegetating the largest landslide in recorded history. The research cook advantage of the face that some of the 97 permanent plots were invaded by exotic plant species introduced by federal agencies in attempts to enhance vegetation recovery. Comparing the revcgetation patterns of plots with only native plants to plots with the exotic species demonstrated that non-native species actually slow down the rate of natural recovery. Only such a long-term study on a highly disturbed area can document the importance of native species in plant recstablishment. Knowledge of the species and their characteristics which were able to survive the volcanic eruption or to re-invade the area is essential for improved land reclamation programs and for better understanding of plant succession.

Type of **Measurements):** Permanent plots were established along two transeccs on the debris avalanche—one running north-south between Castle and Coldwater Lakes and the other running east-west. The area north of Castle Lake was first surveyed in July 1980. In August 1981, 31 250-meter square circular plots were placed at regular 50-m intervals on a transect between Castle and Coldwater Lakes; the center and 4 radii were marked and numbered; and any plants seen were marked with a stake. In June 1982 when the area was finally accessible by road, an additional 72 plots were established on a transect running east to west on the debris avalanche. The soil texture of each 250-meter square plot was assessed in August 1982. Sticky seed traps were placed in the center of each circular plot, and wind-dispersed propagulcs were measured in 1982 and 1983.

Frequency of Measurements): 1980, 1981, 1982, 1983, 1985, 1989, once annually all years. Seed traps were sampled six times in 1982.

Data Storage: Computer diskettes in Lotus and ASCII.

Long-term plans, Data available for collaborative efforts: Dale desires to continue monitoring the plots every five to ten years. Data is available for future collaborative efforts.

—20A—

Principal Investigator(s):
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Study Title: Long-term succession in subalpine habitats

Key Words: biological, terrestrial, ecology, plant, succession, recovery, uplands, subalpine, survival, lahars, dispersal, seedling, herbs, grasses

Abstract: A long-term study of recovery and primary plant succession in higher elevations was initiated in 1980. **The** objectives included to document recovery and invasion in several distinct habitats (for example, lahars, pumice, blasted ridges, tephra) and to determine the mechanisms of invasion and establishment. In addition, large grids of contiguous 100 m^2 quadrats have been established since 1986 in several habitats.

Recovery patterns vary with the size and intensity of the initial impacts. Tephra impacted sites were completely recovered by 1983 and subsequent vegetation change has not been directional. In contrast, intensively impacted sites have recovered much more slowly. Recovery races differ primarily with the degree of isolation, but the intensity of the impact also governs the recovery rate. For example, lahars surrounded by intact vegetation have acquired as many species as intact vegetation, but community structure remains very different. Total cover after 11 growing seasons remains less than 10% of intact vegetation. Nutrients limit the development ofbiomass and cover, but most species in the immediate vicinity have established on lahars.

On the Plains of Abraham, an isolated site with low fertility and little soil development, cover is barely measurable and composition is strongly dominated by wind-dispersed species such as pearly everlasting and firewecd. Here, as in other locations, initial invaders are confined to "safe-sites", for example, emerging from underneath small rocks or growing along the edges of erosion features. Very few of the locally available species have migrated more than 50 m from pockets of surviving herbs. Spatial analyses of this grid imply that most new plants are derived from outside the plot, that some portions of the grid arc more likely to be invaded than others, and that microtopography is the single most important proximate factor in determining invasion success. Experiments have demonstrated that most sites must first be modified by physical processes such as erosion, frosc-fracturing, or nutrient input from dust, pollen, seeds, dead insects, etc. We have determined that the immediate cause of seedling death is, in most cases, associated with drought, but susceptibility to drought is conditioned by initial growth rates, which is nutrient dependent. Once physical amelioration occurs, it is possible for wind dispersed species, which have a limited ability to establish in unaltered substrates, can establish in a few sites. Once established, the rate of succession appears to accelerate.

One species, Lyall's lupine *(Lupinus lepidus),* is locally important in producing biotic facilitation effects. Individuals of this species contribute nitrogen and carbon to the soil and accumulate fine soil material. However, seedlings of other species generally do not grow under the influence oflupines since living lupines also compete strongly for water. After a lupine dies, invading species strongly prefer the mound created by it, a phenomenon called "delayed nursing".

Most of the devastated habitats on Mount St. Helens remain sparse, but the number of species and individuals is increasing rapidly. As more plants become established and produce seeds, we expect the rate of development to increase, biotic facilitation to become more important, and competitive interactions to intensify.

See Research Abstract from David Wood for relevant study information.

Type of Measurements);

1. Permanent plots—species composition and percent cover.
2. Grids—species presence in 10 X 10 m plots and cover by a scale.
3. Seed traps—number of seeds per year.
4. Manipulation plots—seedling recruitment and survival.

Frequency of Measurements): Annually beginning in 1980.

Data Storage: Data arc scored permanently on field data forms, on print-outs of each stand, and in data files on disk. Many summary data for grids, such as species richness per plot, are also on data files and in graphical arrays. Data for permanent plots and for grids are stored in standard Cornell Condensed format compatible with many programs, including programs that will expand the data to full format for statistical purposes (ASCII). Software includes turbo-pascal data summary routines, COENOSE for rapid clustering, or such FORTRAN programs as DCA, TWINSPAN, etc.

Long-term plans. Data available for collaborative efforts: Baseline data are available to bona-fide investigators. Long-term plans are to continue monitoring permanent plots and permanent grids through 1994, then shifting to a rotating sampling regime.

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Study **Title:** Riparian/wetland classification for streamsidcs

Key Words: biological, plant, vegetation, succession, ecosystem, riparian, scream, ecology, soil, recovery

Abstract: The riparian sampling in the Mount St. Helens vicinity is part of a larger study that extends across the Gifford Pinchot National Forest. Streams sampled on the Mount St. Helens Ranger District are Kalama River, Ease Fork Fossil Creek, and Pin Creek. The purpose of gathering streamside plot data in this project is to produce a classification of strcamsidc vcgetative/geomorphic features. The sampling design is such that plant communities are juxtaposed on their geomorphic surfaces and then related to the stream channel itself. Because this project is being carried out in coordination with a separate Forest Riparian Inventory, we will later be able to relate our riparian information to the aquatic data being collected by the fisheries/hydrology programs.

Once the classification is completed, it will be used in inventories of scream systems, to help understand the dynamics of such systems and how they respond to perturbations, and to help establish reasonable and meaningful objcccives for managing riparian areas. The classificacion will be hierarchical, wich plane community/geomorphic feature clusters, or complexes, probably being the most commonly-used level.

Primary data collected includes percent cover of plants by species and vegetation type; geomorphic features; and topographic site information. Standard floristic clustering techniques will be used to classify plots into community types using plant species, geomorphic surfaces, and environmental attributes as classification criteria.

Type of Measurements):

Plant cover:	by species—percent cover (at sampled area) grouped by plant type—percent cover (at sampled area)
Substrate:	percent cover (of sampled area) of rock, gravel, bare ground
Slope:	percent slope
Aspect:	azimuth
Soil:	depth, color, texture of layers
Slope shape:	convex/flat/concave/undulating
Position:	topographic position, elevation in feet
Timber:	basal area of forested plots, average age of dominants
Snags:	d.b.h., height class, degree of decay
Gcomorphology:	geomorphic surface, valley segment type, width of normal high water and of active channel.
Observations:	wildlife, disease/pathogens

Frequency of Measurements): Streams were sampled once each in 1990-1991.

Data Storage: Primary—ORACLE and IS/CLI data files on main frame computer
Secondary—original field data cards

Long-term plans, Data available for collaborative efforts: Data from this study will be used in inventories of stream systems in order to establish objectives for managing riparian areas. Area Ecology staff and data are available for collaborative efforts.

—22A—

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Study Tide: Riparian/wetland classification for wetlands

Key Words: biological, plant, vegetation, succession, ecosystem, terrestrial, riparian, ecology, revegetation, soil

Abstract: The wetland sampling within the Mount St. Helens National Volcanic Monument is part of a larger study on the Gifford Pinchot National Forest. Information gathered will be used to classify riparian/wetland sites into identifiable ecological units that can be used to understand their environmental characteristics and prescribe appropriate management schemes. Study areas in the Monument arc Coldwatcr Lake, Toutle River debris avalanche, and Goat Marsh Research Natural Area. Sample plots were selected to represent different community types (based on species composition and vegetation structure). Wetlands at Coldwacer Lake and Toutle River debris avalanche were created as a result of the May 1980 eruption of Mount St. Helens, and thus can provide unique insight into the development of wetlands and plant succession.

Primary data collected includes percent cover of plants by species and vegetation type and topographic sice information. Standard floristic clustering techniques will be used to classify plots into community types, using plant species, productivity, and environmental attributes as classification criteria. Coldwater Lake and Toutle River debris avalanche plots will be sampled again in following years to monitor plant succession and re-invasion.

Type of Measurement(s):

Plant cover:	by species—percent cover (at sampled area)
	grouped by plant type—percent cover (at sampled area)
Substrate:	percent cover (of sampled area) of water, rock, gravel, bare ground
Slope:	percent slope
Aspect:	azimuth
Soil:	depth and color and texture of layers
Slope shape:	concave/convex/flat/undulating
Observations:	wildlife, topographic position

Frequency of Measurements): Plots were installed and read in 1988; plots at Coldwater Lake and Toutle River debris avalanche were re-sampled in 1991. Future sampling schedule is to be determined, possibly 3- to 5-year intervals.

Data Storage: Primary—data arc in ORACLE and IS/CLI files on mainframe computer
Secondary—original field notes

Long-term plans. Data available for collaborative efforts: The Coldwater Lake and Toutle Debris wetland areas should be revisited periodically. Wetland plots should be remcasured, photos re-taken and data compared to that collected by Area Ecologists in previous years.

Area Ecology staff and data are available for collaborative efforts.

—23A—

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Study Title: Effects of hillslope erosion on revegetation and sediment influx to the Toutle River

Key Words: geology, streams, rivers, geomorphology, erosion, tcphra, revegetation, sedimentation, watershed

Abstract: The 1980 eruption of Mount St. Helens covered soils with a tephra blanket and killed the forest tree cover in a 550-km^2 area. After the eruption, rates of erosion and plant cover were measured on tephra-covered hill slopes north of the volcano, some of which had been subject to one of three land-management practices. Rill erosion was initially greater than sheetwash, but its importance decreased comparatively quickly. On hill slopes left undisturbed since the eruption, rill erosion and sheetwash underwent a rapid and early decline due to the development of a stable rill network and the exposure and creation of more permeable and less credible substrates. This decline was independent of plant recovery. Logging of trees downed by the eruption and scarification of the surface in preparation for reforestation slowed erosion, although the effect was small because erosion rates had already slowed substantially by the time these two practices were implemented. An experimental grass seeding program gave rise to a plant cover only after erosion had slowed, and then only in a limited range of environments.

The factors controlling erosion, revegecation, and their timing relative to one another at Mount St. Helens are similar to those following explosive volcanic eruptions elsewhere. This suggests that grass seeding is not likely to be effective at slowing erosion following most eruptions, that early mechanical disturbance could be an effective erosion-control measure, and that the persistence of erosion following a future eruption may best be predicted by measurements made soon after the eruption and at several subsequent occasions in order to project the rate of change with time. Annual erosion at our study sites decreased from 26 mm between May 1980 and May 1981 to 1.8 mm between May 1982 and May 1983. Projecting this rate of decline into the future indicated that only about one-sixth of the tephra on hill slopes will be removed by water erosion before soil creep and other forms of mass wasting again dominate hillslope evolution. Thirty-one percent of all sediment eroded from hill slopes in our study area was trapped in lakes impounded by the debris avalanche that filled the North Fork Toutle River valley on May 18, 1980. The remaining sediment entered streams of the Toutle River system. Additional sediment reached these streams from rockslide debris and mudflow material. Net sediment yield to the Main Toutle was 30 to 37 X 10^6 m^3.

Type of Measurernent(s): Erosion stakes; rill and channel cross sections; suspended sediment measurements; scdimentology of fluvial, debris flow, and blast deposits.

Frequency of Measurements): Erosion stake measurements were made in 1980-1983. All other measurements were made in 1980-1981.

Data Storage: Data arc in field notebooks in Dunnc's possession.

Long-term plans, Data available for collaborative efforts: Erosion and sedimentology studies have been suspended. Dunnc has no long term plans for continuing this project. He is available for future collaborative efforts.

—24A—

Principal Investigator(s):
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Study Title: Arthropod recolonization of Mount St. Helens

Key Words: biological terrestrial animal invertebrate insects scavengers predators recolonization

Abstract: Ashfall and blast zone sites have been sampled in order to monitor the recovery of insect and spider populations reduced by the May 1980 eruption. There were many survivors of the eruption in ashfall sites, especially of sedentary species and others that were protected in micro-refugia. Mortality in arthropod populations was correlated with the depth of the ashfall. Using ant colonies as an index, areas with 15 cm or less of ash deposited had species numbers similar to sites outside the devastated area. However in all areas arthropod populations have remained low compared to arthropod population recovery following clearcutting.

At the blast zone sites where all living organisms were killed by the eruption, recolonization began with arthropods. The first arthropod colonists there were predators and scavengers. Several carabid beetle species in the genus *Bembidion* established reproducing populations throughout the Pumice Plain by 1983, long before significant recolonization by plants. These first colonists subsisted on the large amounts of insect prey transported there by wind but unable themselves to survive. The primary colonists of the blast zone include many species that inhabit commonly disturbed locations such as avalanche chutes and river edges. In common with other organisms of unstable habitats, these primary colonists all have a well developed dispersal capacity. By 1986 several spiders as well as perhaps 25 beetle species, mostly carabids, had established populations on the barren grounds of the Pumice Plain. Also by this time, pedestrian species (ones that cannot disperse by flight or on air currents) which had survived in the blowdown area, for example, camel crickets, grylloblattids and phalangids, were found at Pumice Plain sites nearest the blowdown.

As denuded sites become vegetated the arthropod community becomes more complex and trophically varied with different classes of herbivorous species colonizing the vegetation. The early community of predators and scavengers docs not persist in the presence of much vegetation but gives way to species more characteristic of field habitats.

Type of Measurements): Species sorted of select arthropod groups, for example, spiders, the insect families *Carabidae, Form'tddae;* biomass; numbers of individuals. Sampling by pitfall traps, window traps, arthropod fallout collectors and hand collecting.

Frequency of Measurements): Spring to fall 1980-1986, sampling traps two to three times each month throughout snow-free period. From 1987 on, one to several times per season as able.

Data Storage: Field notebooks and lab sorting data sheets; most data entered in IBM computer as Locus 1-2-3 work sheet files. Insect specimens in collection of P.M. Sugg or stored at Burke Museum. Most groups wait on complete identification.

Long-term plans, Data available for collaborative efforts: This in an ongoing study. Edwards and Sugg hope to continue low-level monitoring; future work is dependent upon funding. Data is available for collaboration; insect samples will be available for loan.

—25A—

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Study Title: Plant succession and Pacific silver fir *(Abies amabtlis)* mortality

Key Words: biological, plant, succession, revegetation, soil, terrestrial, upland, recovery, standing dead, volcanic ash

Abstract: The post-eruption remeasurement of ecology reconnaissance plots installed before 1980 is comprised of five distinct parts. The most basic information was collected on 76 plots relocated during the summer of 1981. Photo points and reconnaissance level plots identical to the pre-eruption plots were installed.

Mortality monitoring plots of Pacific silver fir were installed on several sices during the 1981 and 1982 pulses conducted by the Pacific Northwest Forest and Range Experiment Station. All live trees within a 1000-meter square fixed area plot (17-meter radius from plot center) were tagged with tree numbers and species and diameter at breast height in centimeters was recorded. Snags were marked with blue paint.

Additional information was added to the remeasurement effort in 1985. This included the installation oftransects with Daubenmire microplots and fixed area seedling count plots on over 40 of the relocated plots. During the 1989 field season, a more complex seedling plot was installed.

The post-eruption plots were relocated as closely as possible to the location of the original reconnaissance classification plots. Often the plots were exactly relocated with the use of pre-eruption plot photography. When the plot was not exactly relocatable, a replacement plot in the same area with identical site characteristics and plant association was installed. This was noted on the plot cards.

Type of Measurements):

Plant cover:	percent cover of42-ft radius plot by species and vegetation type
	percent cover within a series of Daubenmire microplots
Soil:	depth of 1980 ash layer
	soil layer descriptions
Silver fir mortality:	health (live/dead/declining) of silver fir trees on plot.
Slope/aspect:	percent/azimuth

Frequency of Measurements): About every four years. Last measurement was in 1989.

Data Storage: Data will be stored by Monument Scientist at Mount St. Helens National Volcanic Monument Headquarters.

Long-term plans. Data available for collaborative efforts: Plans are to continue monitoring at the same frequency. Data are available from Mount St. Helens Science Department.

—26A—

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Study Title: SNO'pack Telemetry (SNOTEL)

Key Words: physical, telemetry, runoff, hydrologic, watershed, snow, meteorology, precipitation

Abstract: The SNOTEL system measures snowpack water content—for runoff forecasts, total annual precipitation, and temperature. **We** have six such sites on and adjacent to Mount St. Helens.

Type of Measurements): Ground samples are taken monthly during the snowpack months; electronic measurements arc taken daily.

Frequency of Measurements): The number of measurements arc once a month during the snow pack months; the visits are on a maintenance scheduled frequency.

Data Storage: The data is stored on the Data General at the Soil Conservation Service in Portland, Oregon.

Long-term plans, Data available for collaborative efforts: The snow survey is an on-going program and hasievolved from manual snow courses to the electronic sensors we have today.

—27A—

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Study Title: Natural revegctation of upland portions of the blast zone

Key Words: biological, terrestrial, plant, vegetation, succession, uplands, trees, shrubs, herbs, grasses, blast zone, recovery, revegetation

Abstract: Natural revcgetacion was studied within the northeast sector of the blast zone on Forest Service land. Objectives were: 1) compare revegetation on major disturbance types within the blast zone (pyroclastic flow, blowdown forest and standing dead forest), 2) examine the effects ofpre-cruption plant communities and the presence/absence of snowpack on current vegetation, and 3) establish a system of permanent plots to track ecosystem recovery and describe important processes through time.

The basic sampling unit is five, 250-square-meccr circular plots located at 25-m intervals along a 100-m long transect. Paired transects were installed in adjacent blowdown and pre-eruption clearcut areas (in a few instances transeccs were also located in adjacent patches of standing dead (scorched) trees).

Results indicate that a number of factors contribute to the composition and abundance of vegetation following the eruption. They include: 1) degree of disturbance as influenced by proximity to the volcano, depth of deposit, orientation to blast direction and presence/absence of snowpack at time of eruption), 2) degree of subsequent erosion or deposition of deposits, and 3) pre-eruption community composition (aspect, elevation, serai stage—for clearcuts time of harvest prior to the eruption is important).

Type of Measurement(s):

- Composition and cover to nearest 0.01-meter square for all vascular plant species on whole plot and cover recorded on eight 2-meter squared subplots/plots
- Quantity of large woody debris assessed using line intercept transects in blowdown (1981 only).
- Abundance of small scale surface features (erosion gullies, logs, stumps, rootwads) and plant cover by species recorded for each major surface feature on each 250 meter square plot (1981 only)

Frequency ofMeasurement(s): Annual measurements at period of peak phycomass (late July to end of August) conducted 1980-1984, 1986 and 1989.

After 1982 plots on transects were sub-sampled and only three of five total plots were read (plots located at cndpoints of transects and middle-most plot was sampled (for example, #1, 3, and 5) while intervening plots (#2 and 4) were skipped).

Data Storage: Field notes are stored at the Forestry Sciences Laboratory, Corvallis; copies are stored at the College of Forest Resources, University of Washington.

Electronic data (IBM compatible ASCII files) and accompanying documentation are stored on magnetic tape in the Forest Science Databank at Oregon State University with 5.25" floppy disk copies at the University of Washington (Dr. J. Franklin) and at the Monument Scientist's office, Mount St. Helens National Volcanic Monument.

Long-term plans. Data available for collaborative efforts: Transects will be resurveyed periodically as resources arc available, expect remcasurcment program to continue at three to five year intervals with frequency varying with resource availability. Data are available to *bona fide* investigators for collaborative research.

—28A—

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Study Title: Natural revegetation of debris avalanche and mudflow deposits

Key Words: biological, terrestrial, plant, vegetation, succession, mudflow, trees, shrubs, herbs, grasses, blast zone, recovery, revegetation, debris avalanche

Abstract: Natural revegetation was studied on debris avalanche and mudflow deposits primarily northwest and southeast of Mount St. Helens on Forest Service land. Objectives were: 1) examine patterns of revegetation in response to large and small scale surface changes as deposits are modified by geomorphic processes, 2) characterize revegetation on different types of sites in the devastated area (North Fork Toutle River debris avalanche and Muddy River mudflow), and 3) establish a system of documented permanent plots to track ecosystem recovery and describe important processes through time.

The basic sampling unit was a series of cransects that cross the deposit from valley wall to valley wall. A scries of 250-square-meter circular plots were placed at 50-meter intervals along the transect line. Total number of plots per transect is, thus, determined by total length of transect.

Results indicate that a number of factors contribute to the composition and abundance of vegetation following the eruption. These include degree of initial disturbance (scouring, deposit depth and presence/absence of pre-eruption soil and plane material on the deposit surface following the eruption); degree of subsequent modification of deposits (erosion and/or deposition of material); substrate composition and availability of surface moisture.

Type of Measurements):

- Composition and ground cover recorded to nearest 0.01-square meter for all vascular plants. In 1991 species cover was recorded using a modified Daubenmire cover class and cover on macroplots recorded to nearest percent.
- Composition, cover and number of seedlings recorded on eight, 2-meter square subplots within each plot.
- Plant cover and density was estimated using two 16-meter long line intercept transcccs that bisect each plot along the north/south and east/west microplot radii.
- Small scale surface features (stream channels, terraces, mounds, logs, erosion gullies) were mapped on each plot in 1983 and 1984.

Frequency of Measurements): Annual measurements at period of peak phytomass (late July to end of August) conducted 1980-1984, 1986 and 1989 and a sub-sample of plots in 1990 and 1991.

Data Storage: Field notes are stored at the USFS Forestry Sciences Laboratory, Corvallis, Oregon with copies stored at the College of Forest Resources, University of Washington.

Electronic data (IBM compatible ASCII files) and accompanying documentation arc stored in the Forest Science Databank at Oregon State University with copies at University of Washington (Dr. J. Franklin) and in the Monument Scientist's office, Mount St. Helens National Volcanic Monument, Amboy, Washington.

Long-term plans. Data available for collaborative efforts: Transacts arc permanently marked with steel reinforcing bar at plot centers (centers were originally marked with white plastic PVC pipe although many arc missing). Endpoints are located on adjacent hill slopes (off-deposit), marked with steel fence posts and referenced by three blazed bearing trees or large stumps (in case of pre-eruption clearcuts).

Transect locations have been fixed using a Global Positioning System in 1989 (locations on file at the Monument Scientist's office. Headquarters, Mount St. Helens National Volcanic Monument). Transccts will be resurveyed periodically as resources are available; expect remeasurement program to continue at 3- to 5-year frequency.

Data are available to *bonafide* investigators for collaborative research.

—29A—

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Study Title: Mortality and revegetation of an old-growth forest buried by the Muddy River mudflow

Key Words: biological, terrestrial, plant, vegetation, succession, mudflow, trees, shrubs, herbs, grasses, blast zone, recovery, revegetation, riparian

Abstract: Natural revegetation was studied in an old-growth terrace forest buried by 25 to 150 cm of sand to boulder-sized material from the Muddy River mudflow. Objectives were: 1) examine patterns of mortality, growth and revegetation along a gradient of mudflow deposition, 2) provide baseline data for future estimates of fragmentation and decay of mudflow killed trees and assess the influence of the dead trees on revegetation processes, and 3) establish a 2.5-hectarc grid of stem mapped forest to track ecosystem recovery and describe important processes through time.

Results indicate that 50% ofoverstory trees died within 16 months after burial with 57% and 68% dead two and five years after the eruption, respectively. The principal factor influencing mortality was mudflow thickness. Species differed with respect to susceptibility to burial, with the high rates of mortality observed among red alder and Pacific dogwood (the only common hardwoods). Of the major conifers initial mortality of Pacific silver fir and western hemlock was highest. Five years after disturbance substantial delayed mortality of Douglas-fir and western redcedar brought those species in line with the mortality observed for Pacific silver fir and western hemlock. Small western hemlock saplings that were rooted on floating logs escaped burial and, thus, exhibited little mortality. Total cover of residual shrub and tree species was highest (P=0.05) where deposits were less than 40 cm thick. Total cover of colonizing plant species did not differ significantly with depth (P>0.25).

Type of Measurements): All trees greater than 5 cm d.b.h. (breast height = 1.37 m) were mapped, marked with a numbered tag, measured at d.b.h., and assigned a pro-determined condition class. A total of 20 5 X 5 m vegetation subplots were distributed along the center line of each of the two mapping grids and total vascular plant cover estimated to nearest 0.5%. Total cover of bryophytes, logs, branches and litter was also estimated.

Frequency of Measurements): Trees were measured and locations noted on a stem map in 1981, with each tree checked for mortality in 1982 and 1984. In 1991 mortality was checked and the diameter of all living trees rcmeasured. Vascular plant cover was measured in 1981, 1982 and 1984.

Data Storage: Field notes are stored at the USFS Forestry Sciences Laboratory, Corvallis, Oregon with copies stored at the College of Forest Resources, University of Washington.

Electronic data (IBM compatible ASCII files) and accompanying documentation arc stored in the Forest Science Databank at Oregon State University with copies at the University of Washington (Dr. J. Franklin) and in the Monument Scientist's office, Mount St. Helens National Volcanic Monument, Amboy, Washington.

Long-term plans, Data available for collaborative efforts: Transects will be rcsurveyed periodically as resources are available; frequency of remeasuremcnt is expected to vary with resource availability. Data are available to *bonaftde* investigators for collaborative research.

_30A—

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Study Tide: Disturbance and recovery of soil, microbial, and plant processes

Key Words: biological, chemical, terrestrial, plant, microbial, upland, inorganic, soil, ecosystem, recovery, carbon, nitrogen, lupine, pyroclastic, lahar

Abstract: Our work has focused on disturbance and recovery of soil, microbial, and plant processes following volcanic disturbance. Particular emphasis was placed on spatial relationships involving the carbon and nitrogen cycles. Comparative studies have been conducted at six sites that were disturbed to varying degrees by the May 1980 eruption of Mount St. Helens. These sites include Butte Camp, Upper Pine Creek, the Lahar on the Muddy River, the former Timbcrline parking Area, and Meta Lake.

At large scales of aggregation free-living nitrogen fixation and symbiotic nitrogen fixation are of the same order of magnitude. A lupine patch, however, has more significant effects on recovery as the associated "resource islands" concentrate the flow of resources in both carbon and nitrogen cycles. Lupine patches serve as nodes for ecosystem development on the severely disturbed lahar and pyroclastic flow sites.

Microbial processes and biomass are inversely related to the intensity of disturbance.

Type of Measurements): Principle data sets include estimates of nitrogen fixation by free-living soil microbes and by lupines, estimates of soil microbial biomass, and time series of soil C and N pools.

Frequency of Measurements): Annually since 1980.

Data Storage: Most data has been or will be published. Eldon Franz has specific information about data sets of interest.

Long-term plans, Data available for collaborative efforts: C and N pools will continue to be estimated at regular intervals for the foreseeable future as an indicator of ecosystem development.

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Study Title: Investigation of the effects of Mount St. Helens tcphra on soil gas composition and subsequent effects on root and mycorrhizal growth *of Abies amabilis*

Key Words: biological, terrestrial, plants, upland, trees, soil, gas, tephra

Abstract: It was hypothesized that tcphra from the May 1980 eruption of Mount St. Helens would form an impervious layer, limiting gas exchange (oxygen and carbon dioxide) in the soil. Resulting limited oxygen and excessive carbon dioxide were predicted to affect root and mycorrhizal growth of Pacific silver fir *(Abies amabilis)* causing higher than normal foliage loss.

Experiments were conducted in growth chambers, and observations were made in the field. In growth chambers seedlings were grown under constant light, temperature, and relative humidity approximating mid-growing season. Soil atmosphere and oxygen and carbon dioxide concentrations were controlled. Above ground and root growth were determined after one growing season. Growth was significantly affected by carbon dioxide concentrations in the 10% range and unaffected by oxygen concentrations ranging from 2% to 20%. Observations and measurements in the field at a site with 15 cm of tephra showed premature and extended period of litter fall at three times the normal rate and failed to show soil carbon dioxide concentrations above 5%.

Results achieved in the field did not support the hypothesis. It was concluded that the high rate of foliage loss was not due to inhibition of gas exchange in soil covered by tephra.

Type of Measurements): Growth chamber measurements—basal diameter (millimeter), terminal leader elongation (centimeter/week), fine root biomass (root diameter in millimeter, grams dry weight), mycorrhizal biomass (grams dry weight), total leaf area; oxygen and carbon dioxide were injected into soil at determined rates and occasionally gas chromatography was used to test actual gas in soil.

Field measurements: Existing regressions to determine biomass of stand, core samples to determine fine root and mycorrhizal condition, litter fall collected in 1/4-meter square screens, gas chromatography used to measure carbon dioxide and oxygen concentrations in soil.

Frequency of Measurements): Sampling was performed in 1980-1983/

Data Storage: Hard copies of computer records, field notebooks in personal possession; computer records no longer exist. Data published by Hinckley and others, 1984.

Long-term plans, Data available for collaborative efforts: No future plans for research. The nature of this study called for early investigations and since the hypothesis was not supported by evidence, there would be little purpose to future investigation.

Information concerning the frequency of measurements was unavailable at the time of printing. Contact principal investigator or consult publications for these details.

—32A—

Principal Investigators):
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Study Title: Effects of eruptions and post-eruptive phenomena on caves and pseudokarst of Mount St. Helens

Key Words: physical, terrestrial, inorganic, geology, caves, pseudokarst, eruption, mudflow, runoff, blockage, glaciers, ablation, biological, ecosystem, recovery, caves, physical, geography, volcanic ash

Abstract: Beginning June 1980 systematic observations and measurements arc documenting the effects of the eruption and post-eruptive events on the caves and pseudokarst of Mount St. Helens. Caves of the Cave Basalt Lava Flow were essentially free of physical impacts by the eruptions, but the biota of some was severely impacted by ashfall. Depending on the local physical geography, some of the caves were severely impacted by post-eruption mudflows.

Topography in the Spirit Lake pseudokarsc has been evolving very rapidly. The development and destruction of one cave in pyroclastic material has been documented over a two year period.

Glacier pseudokarst has been the subject of one high elevation study. Surface, subsurface, and aerial studies arc all utilized.

Type of Measurements): Periodic measurements of aggradation and degradation in appropriate caves, selective remapping of impacted caves, systematic photo-documentation.

Frequency of Measurements): Annually, except in Spirit Lake pseudokarst where access was not possible in 1987. Initially more frequent. Future studies are scheduled for 1995.

Data Storage: Reports and publications filed with National Speleological Society and with Gifford Pinchot National Forest. Photo documentation filed in permanent notebooks, currently in Nashville, Tennessee.

Long-term plans. Data available for collaborative efforts: Frequency of studies capered off after 1990 on Cave Basalt Lava Flow, and in Spirit Lake pseudokarst. Future studies in these areas are scheduled for 1995. No further glacier cave studies are planned. Analysis of first decade to be published in Proceedings of 6th International Symposium on Vulcanospelcology and possibly elsewhere. See abstract 6A for additional information.

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Study Title: Contributions by lupines to volcanic soils

Key Words: biological, terrestrial, upland, plant, herb, lupine, carbon, nitrogen, colonization, volcanic soils, microbial activity, nitrogen fixation

Abstract: The effects of colonization of *Lupinus lepidus* and *L. latifolius* on carbon, nitrogen, and microbial activity in volcanically disturbed soils was investigated in several studies. Examination of nitrogen fixation races showed that both species have diurnal and seasonal fluctuations that appear to be associated with environmental factors. Nitrogen fixation rates are highest during daylight and early in the growing season, and the seasonal pattern is reflected in carbon and nitrogen levels; that is, as nitrogen fixation increases, carbon and nitrogen production increases. First year plants of both species fix similar amounts of nitrogen.

Though lupines do contribute a significant amount of nitrogen to the soils where they colonize, their contribution to the overall system is less than that from other sources. The highest rates of nitrogen fixation by lupines among study sites was found on the pumice plain.

Lupine seedlings make the most important contribution in addition of nutrients to soil. Both species begin to fix significant amounts of nitrogen within two weeks of germination; the rate of nitrogen fixation relative to plant biomass is similar for seedlings and adults of both species. Since seedling mortality is generally high in these disturbed areas, a tremendous amount of carbon and nitrogen is released into the soil and made available to other organisms when seedlings die off each growing season.

Comparisons of soil under lupines to bare soil show more total nitrogen in lupine soil. This was the case at all sites studied but was most pronounced on the pumice plain. Studies of soil carbon show that there is more carbon under lupines than in surrounding soil on the pumice plain. In areas of less volcanic disturbance where there is already a high concentration of carbon in soil, there is less carbon under lupines. This is largely due to the priming effect of lupines. Microbial activity is increased under lupines due to addition of nutrients to the soil; with increased activity, microbial respiration increases and carbon is released from the soil in the form of carbon dioxide.

Investigation of the effects of lupines on soil microbial activity compared soil under L. *lattfolius,* living L. *lepidus,* dead *L. lepidus,* and bare soils at various depths. The highest levels of microbial biomass were found under L. *latifolius;* second highest under dead *L. lepidus;* third highest under living L. *lepidus;* and significantly lower levels were found in bare soil. In all instances, most activity occurs in the top 5 cm of the soil profile and decreases as depth increases.

In an experiment in which leaves of the two species were added to samples of each of these soils, interesting patterns of microbial activity were observed. All four types of soil showed the greatest increase in activity when leaves of L. *latifolius* were added; after an initial burst of activity, it tapers off to normal levels for these soils. Addition of *L. lepidus* leaves, by contrast, results in a slower, steady increase in activity that eventually exceeds levels in soils that have been amended with *L. latifolius* leaves. Bare soil shows increased microbial activity with the addition of lupine leaves but not to the level of soils in which lupines have grown.

Type of Measurement(s): Plant measurements for field adults and greenhouse seedlings—biomass (grams); patch density (number ofindividuals/M^2); seed weights; total organic carbon, total Kjeldahl nitrogen, total Kjeldahl phosphorous, inorganic nitrogen, and total soluble carbon; nitrogen fixation (percent); nitrogenasc activity (micromoles/ gram of nodules/time); in addition to all of the above, greenhouse seedlings were measured for leaf area, relative growth rate, net assimilation rate.

Soil measurements (20-day incubation): estimates of carbon and nitrogen mineralization; nitrification potentials; **Ph;** buffering capacity; estimation ofmicrobial biomass via substrate induced respiration.

Frequency of Measurements): Beginning in 1981, annually on the pumice plain. Nitrogen fixation data was collected in summer 1986, once per month for five months at five sites. Soil work conducted in 1987 (four times in summer), June 1988, and September 1990.

Data Storage: Hard copies in spread sheet format in ASCII Quacropro in personal possession.

Long-term plans. Data available for collaborative efforts: Study ongoing to monitor long-term processes especially soil microbes. Hopes to be able to sample soil annually. Available for collaborative efforts, hopes co actively conduct field work in such a situation.

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Study Title: Surface modification of Muddy River laharic deposit, Mount St. Helens National Volcanic Monument, Skamania County, Washington

Key Words: geology upland geomorphology lahar laharic deposit

Abstract: Purpose of the project is to note and describe the extent of modification, since 1980, of the surface of the upper Muddy **River** laharic deposit. Several traverses will involve measurements concerning the density, width, and depth of drainage channels, and changes to interfluvc areas. These will be compared with features recorded on aerial photographs and related to longitudinal gradients of channels and surface. The information is to be summarized in a written report.

A small part of this project was completed in summer 1991. In three traverses laid across the laharic plain in the area just north of road FS 83, six surfaces are recognized. They arc:

1. The surface marginal to the 1980 laharic deposit, consisting of bedrock or older laharic deposits, mantled by cephra, soil, and/or vegetation.

2. A high standing "primary" surface atop the May 18, 1980 lahar, probably that of the morning flow, marked by a hardened surface of fine grains and cobbles, isolated boulders, and wood fragments protruding above the surface, and the beginnings of fresh vegetation.

3. A "boulder pavement" surface, standing about 2 meters in elevation below the "primary" surface, ofunburied boulders from which post-lahar sheet flow and wash has removed fine sediments, lacks abundant new vegetation.

4. A "pumice" surface, marked by a carpet of packed, rounded pumice, almost on level with the "boulder pavement" surface but distinctive to be easily mapped, produced by sheet flow in 1980 carrying abundant pumice, and marked locally by clusters of new trees.

5. Areas of "reworkcd boulders" forming channels of high-water overflow during spring and heavy rain runoff, without vegetation, lying marginally to.

6. "Young channels" of active stream flow, erosion and deposition, at depths 2 tolO meters below the "primary" surface, and lacking vegetation.

The surfaces recognized have not been compared with post-1980 aerial photography.

Type ofMeasurement(s): Tape, pace and compass with aid of a Bruncon compass. Elevation control will be by altimeter.

Frequency of Measurement(s): Traverses will be run at about every 1000 meters. Mapping will stare about July 20, 1991 and continue over the summer. Estimated completion day, allowing field checking, is October 1, 1991.

Data Storage: Information (hard copy) will be filed with headquarters. Mount St. Helens National Volcanic Monument. Another hard copy will be on file in the Department of Geology, Portland State University.

Long-term plans, Data available for collaborative efforts: Philip Gallaway will conduct the study as part of an independent study at Portland State University. Paul E. Hammond will instruct and supervise the work.

No long-term plan is presently being considered in a study of the ongoing surface modification of the Muddy River laharic deposit.

Baseline data will be available for future collaborative efforts.

—35A

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Study Title: Recovery of scream ecosystems following catastrophic disturbances

Key Words: biological, aquatic, animal, stream, vertebrate, invertebrate, organic, wood, ecosystem, recovery, algae, fish, amphibian, sedimentation, watershed

Abstract: This study was conducted in the Clearwater basin of Mount St. Helens. Three projects within the study investigate recovery of trout and sculpin populations, tailed frog populations, and invertebrate populations. Trout were studied in the main channel of Clearwater Creek, and the effects of large woody debris in the stream on fish populations were examined. Trout populations were still low as of 1990, being one-tenth to 20% of that in undisturbed stream systems; this appears largely due to interruption of spawning in years following the blast and to continuing lack of spawning habitat. Trout densities were found to be higher in areas with lots of woody debris. The condition of trout was high throughout the stream in years since 1984 presumably due to rapid recovery of high abundance of invertebrate prey. By 1985 sculpin densities were as high as or higher than in undisturbed screams.

Tailed frogs were studied in the tributaries of Clearwater Creek. Frog population densities in basins that were completely deforested were low or zero apparently due to increase in air and water temperatures above tolerance of frogs. Moderately high densities were recorded in streams in intact forests. In streams for which headwaters are in intact forests but the downstream area was deforested, frog population densities were the highest recorded. These high densities appear due to a combination of conditions optimum for adults and tadpoles. Heavily shaded headwaters are ideal for adults, whereas open downstream reaches provide abundant algae on which the tadpoles feed.

Recovery of invertebrate populations in tributaries of Clearwater Creek was rapid due to scouring of sediments that revealed pre-eruption scream subscrace wichin che firsc cwo years afcer che 1980 erupcion. Invercebrace populacions in chese cribucarics were similar co undisturbed screams cwo years afcer che erupcion. However, densicics in che main seem ofClearwacer Creek are scill significancly lower chan in undiscurbed screams of similar size.

Type of Measurements): Numbers of individuals; mean size of tadpoles of tailed frogs; size of trout; particle size. discharge, and cover; frequency of pools and riffles, volumes of pools, stream temperatures.

Frequency of Measurements): Once per year beginning in 1980, ongoing.

Data Storage: Field notebooks; digital data on floppy disks in Syscac formac in personal possession.

Long-term plans, Data available for collaborative efforts: Projeccs are ongoing. Dace ofcomplccion is indcfinice. Several manuscripcs arc in progress (1991).

Daca arc available as background informacion for seleccivc collaboracions.

—36A—

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Study Title: Survival and growth of native plant species planted in the Mount St. Helens blast area

Key Words: biological, terrestrial, plants, riparian, trees, herbs, grasses, legumes, conifers, Douglas-fir, cottonwood, rcvegetation, hardwoods, fertilizer, erosion control

Abstract: The principal objective of this research was to determine the potential of establishing vegetative cover in areas with deep deposits of volcanic materials from the eruptions of Mount St. Helens in 1980 in order to provide for erosion control. Three sites northeast and northwest of the mountain that received approximately 25 cm or more of volcanic materials were studied—two with largely pumice materials and one with predominately fine ash.

Greenhouse experiments were conducted to determine the influence ofN forms, and N and P races on seedling establishment and growth of grasses and forbs. Many of these species and varieties emerged rather well in the pumice material, but their emergence was severely restricted in the ash.

The field seeding trial contained 28 species and/or varieties of grasses and legumes seeded at three sites. Reasonably good establishment and growth was obtained with several species on the two pumice sites but not at the plots on fine ash. Nine types of seeded grasses performed satisfactorily. Legumes generally performed very poorly in the seeding trials. The survival of planted Douglas-fir varied considerably among sites. Net annual growth and foliar N were significantly improved by fertilizers applied as a supplement to individual trees. The established grasses and legumes did not have any significant effect on growth performance of the trees. The performance of cottonwood on the mudflow of the North Fork of the Toutle River has been disappointingly poor, despite the significant improvement of foliar N levels and net growth of the trees by fertilizer treatments.

Type of Measurements): Laboratory studies: analyses of volcanic soils collected from research sites included particle size, porosity, bulk density, thickness of soil layers, pH, CEC, organic C, exchangeable Ca, Mg, Na, NH.-N, available phosphate; and a fertilizer leaching study.

Greenhouse studies: Seedling emergence, dry matter yield for herbs on three different soil types; dry matter yield, number and fresh weight of nodules on legume roots to determine effects ofN source and N and P rates on herbs in three soil types.

Field studies: number of transplanted individuals survived; flowering and seed maturation, percent germination and emergence for sowed seeds; kg/ha fertilizer, seeding rates (1,000 seeds/kg, kg/ha), density (plants/m^2), percent cover, dry weight of seeded grasses (g/m^2); uptake ofN and P (g/m^2) for seeded herbs; height (cm), annual growth (cm), percent survival, color of Douglas-fir seedlings; fertilizer applications to Douglas-fir; height, growth rate, and nutrient concentration in foliage for cottonwoods.

Frequency of Measurements): Soil analyses were performed in 1981 and 1983.

Greenhouse experiments performed once in 1982.

Field experiments were performed 1981-1983. Herbs were planted in transplanting trials in 1982; survival evaluated each growing season. Herb and grass seed sown and fertilized in field trials in fall 1981 and spring 1982; emergence evaluated twice in fall 1981; other observations made two years after seeding. Additional herb and grass seeding trial conducted in 1983. Douglas-fir seedlings planted and fertilized May 1982; annual growth measured yearly and other observations made two years after planting. Cottonwood stem cuttings planted April 1981; fertilized April 1982, height measured yearly and other observations made in 1982.

Data Storage: Data is on file in SAS software at Washington State University Computing Center.

Long-term plans, Data available for collaborative efforts: Data is available for collaborative efforts. Monitoring of plots will continue, though it will become less frequent.

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Study Title: Effects ofairfall tephra on forests northeast of Mount St. Helens

Key Words: biological, physical, terrestrial, plant, upland, trees, conifers, true firs, forest decline, tephra, survival, foliage, volcanic ash, soil oxygen, physiological, *Abies amabilis*, Pacific silver fir

Abstract: The May 18, 1980 eruption of Mount St. Helens deposited tephra over a very large area of forest land in Southwcst Washington. Tephra affected forest stands primarily by covering the foliage. Most tephra originally deposited is now on the forest floor; however, much of the finest deposits were retained by the foliage and still persist in the crowns of many trees.

Branch and foliage morphology of Pacific silver fir *(Abies amabtlis)* results in its ability to intercept and retain tephra for the longest periods. Significant damage to the pre-1980 eruption foliage occurred after the eruption and continued through the summer. The amount of damage seen on the needles was significantly related to the amount of ash on the foliage. Foliar damage appeared to be related to elevated needle temperatures. The increase in needle temperature was not related to the temperature of the ash when it fell but was related to the ability of the needles to dissipate energy absorbed from the sun.

Seven sites ranging from 15 to 135 km from Mount St Helens were selected to study the impact ofairfall tephra on the growth *of Abies amabilis, A. procera, Pseudotsuga menziesii, Tsuga heterophylla,* and *T. mertensiana.* As tephra depth increased, there was a corresponding increase in visible foliar damage and associated decreases in diameter and height growth. Reduction in diameter growth was greater than reduction in height growth. The reduction in diameter growth approached 50% in both trees and saplings of A. *amabilis.* Growth reduction in true firs was greater than in associated species. This difference was related to their greater capacity for interception and retention ofairfall tephra. Damage to trees, and resulting growth reductions, were due to tephra coverage of both the foliage and the soil. Coverage of the foliage resulted in foliar damage, foliage abscission and reduction of total tree foliar area, and increased fine root mortality. Tephra coverage of the soil had the potential to restrict oxygen diffusion into the soil. However, soil oxygen concentrations less than 10% were measured only once over a 2-year period.

Although Pacific silver fir seedlings and small trees recovered within two years after the eruption, mature and old-growth trees throughout the deposition zone began to show symptoms of advanced decline and mortality in 1986. In late 1988, nine growing seasons after the tephra deposition many mature and old-growth mid-elevation conifer stands within the tephra deposition area are still showing substantial growth losses, decline, and mortality. Preliminary studies of the effects of the tephra deposition have revealed that in some areas virtually all Pacific silver fir trees are succumbing, probably as a result of the effects of tephra deposition, lack of subsequent recovery, or related insect or disease attacks. In other areas, Pacific silver fir recovered to some extent, ranging from slight to complete recovery. Within stands, the recovery of this species also varied widely. Presently, we are assessing the extent of growth loss within the tephra deposition zone. Preliminary results indicate growth losses are limited to Pacific silver fir, but are quite variable within the tephra deposition zone. The ongoing study is investigating the recovery of this species by relating its vigor to stand age, species composition, stand canopy structure, and other sice variables.

Type of Measurements): We have set up 36 clusters of three circular plots each (0.05 hectares) in the areas impacted by ash deposition on the districts ofRandle, Packwood and St. Helens. Measurements taken in each plot consist of: diameters of all trees, radial increments of selected trees, depth of five different textural layers oftephra in the soil, selected tree heights, and visual assessment of the severity of damage to Pacific silver fir trees.

Frequency of Measurement(s): Measurements began in July 1980 and continue through the present. Research plots were set up on a semi-permanent basis and their location has been precisely recorded. For the objectives of our project, repeated yearly measurements will only be taken on some representative sites.

Data Storage: Most of our data is still in the process of being analyzed. Data has been scored into conventional computer ASCII files and is available for analysis with any statistical package. Data concerning the effects ofairfall tcphra on physiological processes in true firs and on growth of sapling and full-size trees and on soil oxygen levels has been published. Data concerning effects ofairfall ccphra on forest decline, especially *Abies amabtlts* is in data files in Lotus 1-2-3 and will be published in Gerardo Segura's Ph.D. dissertation.

Long-term plans. Data available for collaborative efforts: Seeking funding to further investigate effects ofairfall tephra on mature trees in forests northeast of the volcano. We are very interested in maintaining our plot system for future reevaluations of general declining conditions. Our data and plot location information is available for any future collaborative research.

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Study Title: Toutle River off channel habitat enhancement evaluation

Key Words: biological, aquatic, animal, fish, stream, vertebrate, coho salmon, trapping, off channel, riverine, pond, evaluation, over-wintering, habit enhancement

Abstract: Juvenile coho salmon require one year of fresh water bearing before migrating to the ocean. As flows increase and temperatures drop in the fall under-yearling coho tend to migrate from native streams to small tributaries, ponds, swamps and marshes. Because the Mount St. Helens mudflow inundated or made inaccessible this kind of winter habitat, it is considered a limiting factor to salmon production on the Toutle River. This study, which consists of evaluation of enhancement of these winter bearing areas, consists of upstream/downstream trapping of juvenile coho salmon at various sites on the Toucle.

Type of Measurements):

- Flows—cubic feet/second and gallons/minute
- Temps—degrees Fahrenheit
- Salmon counts
- Trout counts
- Fish measurements—length, weight
- Habitat measurements—bearing area in square meters

Frequency of Measurement(s): 2 to 4 times per week, October through July, 1987-1991.

Data Storage: Harvard Graphics; intcr-office memoranda.

Long-term plans, Data available for collaborative efforts: Johnson plans two to three more years of juvenile coho trapping.

Johnson and his data arc available for future collaborative efforts. Data will be in a final report at Washington Department of Fisheries.

—39A—

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Study Title: 1. Ecological factors determining population size *of Aphis varians*
2. Factors causing pattern *of Altica tombacina* population on fireweed

Key Words: biological terrestrial plant animal invertebrate insect ecology herbivory predation competition population dynamics

Abstract: 1. Research is intended to assess the ecological factor(s) of greatest importance in determining the population size of an aphid *(Aphis various)* feeding on fireweed *(Epilobium angustifolium).* **We** manipulated the host plant (by shading, watering, and fertilizing), the size of fireweed patches, the density of a leaf-feeding beetle *(Altica tombacina)* which also utilizes fireweed, and the presence of predators of the aphid (primarily ladybird beetles and syrphid flies) by means of cages.

Preliminary results: Predation is overwhelmingly important in limiting aphid population growth. We found that in the presence of large natural enemy populations, aphids attained their highest densities on small isolated clusters of fireweed. Only in the absence of predators (i.e. in cages) do host plant quality and competing herbivores play a role in aphid population dynamics; aphids were either not affected by fireweed patch size, or were less abundant on small patches of their host plant in the absence of natural enemies. This result points out that the relationship between a herbivore and the geography of host plant islands depends on a larger embedding web of interactions.

2. The leaf-feeding beetle *(Altica tombacina)* tends to be found in large numbers on selected plants of fireweed and absent from nearby fireweed plants. This is largely the result of the habit of several females to lay eggs on one plant and of the general adult population to congregate on one or a few plants. The consequence of this community structure is that as density increases, survivorship decreases due to competition for food. The effect of beetle populations on fireweed is the stripping of foliage from densely inhabited plants.

Type of Measurements): Density of all insects associated with fireweed measured on a per stem basis for 20^0 marked plants, some within experimental cages and others undisturbed; direct observation of movement rates for aphids and ladybugs; rate of growth of aphid colonies.

Frequency of Measurements): Populations censuscd every two weeks during growing seasons of 1985-1989.

Data Storage: ASCII and SYSTAT computer files (5.25" floppy disks formatted for use by an IBM-compatible PC using DOS).

Long-term plans. Data available for collaborative efforts: Part of this project was completed in 1989. Manuscripts concerning completed studies will be published in 1991. Our long-term plans are to return to our original study sites and repeat our experiments in 1992-1995. The point of this will be to evaluate the effects of fireweed patch size as the succession further enriches the community. We hypothesize that pairwise biotic interactions will be weaker because the enriched biota will dilute particular interactions.

We will be glad to cooperate with anyone, especially individuals who could broaden our taxonomic base. Part of our long-term goals include developing mathematical models of invasions and reconstruction of communities. We would be particularly interested in cooperating with other researchers who have spatially structured data.

_40A—

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Study Title: Observation ofrecolonization of amphibians and reptiles in North Fork Toutle River debris avalanche

Key Words: biological, terrestrial, aquatic, animal, ponds, vertebrate, amphibian, reptile, survival, recolonization, migration, debris avalanche

Abstract: Various reports indicate *in situ* survival of, or early migration of, some amphibians into regions of the blast zone following the major eruptions in May of 1980. Investigators observed salamanders, frogs and toads as early as 1980 and 1981 in areas of heavy ashfall northeast of the crater. Survival at higher elevations likely was favored by snow and ice cover and the fact that many animals were in hibernacula.

This study has concentrated on a series of ponds located on the hummocky valley floor of the North Fork between Elk Rock and Spud Mountain, 14 km northwest of the crater. Here the major avalanche debris and lahar flows covered the valley to depths exceeding 75 meters and certainly wiped out existing and presumably active populations.

Continuing monitoring of study sites through 1990 has documented seven species of sixteen predicted for the area (one reptile species) present and breeding. Reproduction rates arc low for most with some reproducing sporadically and others in greater numbers. Some interspecific competition is developing and will be further investigated. A lowland frog species has moved in that may not have previously coexisted with the other species present here.

Type of Measurements): Observations of species present and breeding; approximate numbers of adults; observations of eggs and juveniles.

Frequency of Measurement(s): Annually beginning in 1984 (except 1988), once per month March-September, more often **in** April and **May.**

Data Storage: Field notebooks in personal possession.

Long-term plans. Data available for collaborative efforts: Karlstrom plans an ongoing study for at lease the next ten years. Long range goals of this study include monitoring ofsuccessional stages for amphibians and reptiles in this highly impacted habitat, as well as other aspects of their reproduction, physiology, and behavior.

Karlstrom and his data are available for future collaborative efforts.

—41A—

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Study Title: Post eruption studies of ecological recovery of lakes and rivers in the blast zone of Mount St. Helens

Key Words: biological, chemical, aquatic, organic, inorganic, stream, lake, recovery, bacteria, nutrients, dissolved oxygen, water quality

Abstract: This study concentrates on the effects of the May 1980 eruption on Spirit Lake. During and subsequent to the eruption. Spirit Lake received debris avalanche material, timber and other forest vegetation, pyroclasric flows, mudflows, ashfall, and gcothcrmal waters.

This disturbance increased lake water temperatures and concentrations of inorganic chemicals and organic matter. During summer and fall of 1980 lake bacteria populations increased to a high of 4.2×10^8 cells/ml, dissolved oxygen was completely depleted, and concentrations of iron, manganese, and sulphur increased dramatically.

Chemical and bacterial concentrations began to decrease and dissolved oxygen returned to lake waters in fall 1980. The lake recovered significantly by 1982 with specific regard to dissolved oxygen. The return of dissolved oxygen to lake waters provided for diverse and large communities of aquatic flora and fauna only two years after the eruption. Recovery of Spirit Lake continues. As of 1986 concentrations of most chemical elements have diminished, some reaching close to prc-eruption levels; lake clarity has improved from less than one meter visibility in 1980 to at least 20 meters; the phytoplankton community has recovered to at least 135 species.

Type of Measurement(s): Dissolved oxygen (mg/1) and temperature (°C) were measured at depths throughout the lake profile. Water samples collected at lake surface were tested for concentrations of several chemical elements and compounds (mg/1 or micrograms/1).

Frequency of Measurements): Lake waters were sampled several times per season in 1980, 1981, 1983-1986, and once in September 1989.

Data Storage: All data has been published (Larson and others, 1987). Data is also on floppy disk in ASCII in personal possession.

Long-term plans, Data available for collaborative efforts: No further research is planned by the U.S. Army Corps of Engineers. Douglas Larson is available and willing to assist with future studies.

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Study Title: Microbiology of thermal vents

Key Words: biological, aquatic, animal, plant, stream, bacteria, microbial, thermal springs, bluegreen algae

Abstract: Our objectives are to observe, enrich, isolate, and identify bacteria from hot springs in the Mount St. Helens area. If any previously undescribcd isolates arc found, we will characterize them. In two trips to the area so far, we have observed the following: Cyanobacterial (blue-green algal) mats containing filamentous forms, some with heterocysts; filaments with the appearance of the sulfur oxidizer *Beggiatoa* or *Thiothrix;* and numerous rod shaped and coccus shaped bacteria. From anoxic sediment at 60°C, we obtained an enrichment of methanogenic bacteria that appeared similar to *Methanobacterium thermoautotrophicum.* We also obtained an enrichment of the green non-sulfur photosynthetic bacterium, *Chloroflexus.* **We** observed few organisms in a vent at 85°C.

Type of Measurements): Temperature of water and sediments (°C), microscopic observation of samples.

Frequency of Measurements): Approximately twice yearly, 1989 to present.

Data Storage: Photographic and written descriptions are in lab and field notebooks of individual investigators.

Long-term plans, Data available for collaborative efforts: Plans are to continue our survey of bacteria in thermal areas. We hope to obtain some new isolates, given the novel habitat of the Mount St. Helens area.

Leigh and his data are available for future collaborative efforts.

—43A--

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Study Title: Stream channel adjustments in the Smith-Muddy River drainage after the 1980 Mount St. Helens eruptions

Key Words: geology geomorphology screams erosion watershed sedimentation

Abstract: Stream channel response to the 1980 eruption of Mount St. Helens has varied widely. Stream channels that received only airfall deposits have shown no significant sedimentation following the eruption. In drainage basins that received both blast and airfall deposits, localized channel modification has been observed. However, as the blast/airfall deposits are predominately sand-sized, they have been quickly removed from the steep low-order channels surrounding the mountain with little net effect on pre-eruption channel morphology. Some subsequent channel modification has resulted in lowered gradient reaches downstream as sediment eroded from upstream hill slopes and stream channels has been rcdeposited in these reaches. Long-term effects in blast/airfall affected streams appear limited to channels subjected to debris torrents resulting from shallow-seated landsliding and breakup of in-channel debris jams.

Large woody debris maintains channel complexity in channels inundated with sediment. Friction provided by debris on channels and flood plains promotes deposition of fine-grained sediment on flood plains. Large pieces induce scour of pools and exposure of gravelly substrate and commonly protect banks from erosion.

Type of Measurennent(s): Monumented cross sections and longitudinal profiles; residual depths of pools; pebble counts; photos from monuments.

Frequency of Measurements): Bi-annually, 1980 to present.

Data Storage: Field notebooks and computer files in Data General at USFS Redwood Sciences Lab.

Long-term plans, Data available for collaborative efforts: This study is ongoing. Lisle plans to publish ten year results soon. He is open to collaboration that seeks basic data on stream channel changes.

~44A—

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Study Title: Recovery of riparian vegetation at Mount St. Helens

Key Words: biological, terrestrial, plant, riparian, stream, lake, watershed, revegctation

Abstract: This study documents races and patterns of vegetation recovery at lakes and streams in the blast zone of the May 1980 eruption. Recovery ofstreamside vegetation was dominated by plants that resprouted from below ground parts that survived the blast. Depending upon frequencies and intensity of secondary disturbances, revcgetation from seeds has become increasingly important. Flooding, battering, and deposition ofreworked tephra have extremely important effects on streamside revegctation. Recovery rates arc more rapid at greater distances from the volcano where blast effects were less devastating.

Vegetation at mid-elevation lakes and high-elevation lakes, were sampled also. Recovery has been faster at mid-elevation than at high-elevation lakes. Rate and pattern of recovery depend upon secondary disturbances such as flooding (due to seasonal depth of the water table) and deposition ofreworked tephra.

Type of Measurements): Streams were sampled using line intercept transects of varying lengths (from above floodplain, across stream, to above flood plain). Measurements—percent cover ofgeomorphic surfaces; percent cover of each plant species. Also sampled were 1 m X 5 m plots on each of the various geomorphic surfaces along the transect.

Lakes were sampled with 30-meter transects of 30, 20 cm X 50 cm microplots 1 meter apart. Two or more transects were sampled at each lake; one transect was placed in the emergent zone and one in the scrub, shrub zone. Measurements—percent cover for each species.

Photo points were established at endpoints of each transecc.

Frequency of Measurements): Annually in 1980-1983, 1985, 1987, 1989, and Meta Lake in 1990.

Data Storage: All data stored in the Forest Science Data Bank at Oregon State University. Hard copies in personal possession.

Long-term plans. Data available for collaborative efforts: Future sampling depends upon funding. Investigator is available for future collaborative efforts.

—45A—

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Study Title: Blast zone lakes and organic geochemistry

Key Words: chemical aquatic organic lake geochemistry water quality

Abstract: The objective of the research is to describe the processes controlling dissolved organic material in the lake water following the 1980 eruption of Mt. St. Helens. The concentrations of dissolved organic carbon (DOC) increased 50-fold after the eruption and these increases influenced the chemistry and biology of the lakes for several years. We have shown that most of this DOC was comprised of organic acids classified as either fulvic or hydrophilic acids, similar to those in typical natural waters. We found chat between 1980 and 1983, these organic acid fractions underwent oxidative changes in their chemical characteristics. Similar changes may occur in more typical lakes.

Type of Measurements): DOC (mg C/L); isolation and characterization of organic fractions.

Frequency of Measurements): Infrequent; fall 1980, spring and summer 1981, summer 1983.

Data Storage: Data are in publications and field notebooks.

Long-term plans, Data available for collaborative efforts: We would like to return to obtain humic samples as the vegetation in the watersheds recovers. Data are available for future collaborative efforts.

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Study Title: The hcrpetofauna of Mount St. Helens: survival and colonization following the 1980 eruption

Key Words: biological, terrestrial, aquatic, amphibian, reptile, frog, toad, salamander, newt, snake, lizard, succession, ecology, ecosystem, larvae, lake, stream

Abstract: This study documents the survival and colonization of reptiles and amphibians in areas impacted by the 1980 eruption of Mount St. Helens. Surveys were conducted at 15 locations, with representative sites in three distinct volcanic impact zones: 1) ashfall, 2) blowdown, and 3) blast, during spring and summer from 1980 through 1991. Twelve species ofherptiles (nine amphibians, three reptiles) are considered to have survived volcanic influences ranging from the directed blast to the accumulation of ash in otherwise unaltered habitats. These survivors represent most of a hypothetical list of 16 species considered to have occurred in the area before the eruption. Generally, surviving species were characterized by being more aquatic than those not found and this was attributed to the thermal buffering capacity of cool ice and snow covered aquatic systems where individuals were protected from the hoc volcanic gases.

Colonization for the most part has been from survivors or their progeny which entered areas where suitable habitat had developed since the eruption. Anurans were the first and most widespread colonists, having established breeding populations in virtually all available habitats by the mid 1980s. Snakes became very abundant in the open environment of the blowdown zone by 1991. The less vagile salamanders continue, for the most part, to be restricted to the sites of initial survival. Certain aquatic pond breeding salamanders have, however, experienced rapid population growth and limited colonization.

Type of Measurements): Surveys for presence or absence, relative abundance and breeding activity.

Frequency of Measurements): Schedule of surveys was variable during spring and summer from 1980 to 1991.

Data Storage: Field notebooks on file at Utah State University and at Mount St. Helens National Volcanic Monument Headquarters.

Long-term plans, Data available for collaborative efforts: Continue surveys at least into the mid 1990s. Collaborative efforts will be considered on a case specific basis.

—47A—

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Study Title: Small mammal recolonization on the Mount St. Helens volcano

Key Words: biological, terrestrial, animal, mammal, rodent, habitat, recovery, ecology, ecosystem

Abstract: The purpose of this study was to systematically document the initial survival and the subsequent recolonization of small mammal species into disturbed regions of Mount St. Helens, and to ascertain differences in early succcssional patterns among various habitat types and levels of disturbance. Trapping efforts have documented the re-colonization of small mammals *(Rodentia, Insectivora, Lagomorpha* and *Camivora (Mustelidae))* into representative sites of four broadly defined montane habitats (forests, clearcuts, subalpine meadows and riparian ravines) that were subjected to increasing degrees of volcanic disturbance (undisturbed, ashfall, mud flow, tree blowdown, and pyroclastic/debris flow).

Small mammals were live-trapped on 19 sites (with extensive population studies on 12 sices) from 1980 to 1991. By 1991, of a hypothetical list of 32 resident small mammal species, eight species were captured or observed in the pyroclastic/debris flow zone, 15 species in the tree blowdown zone, and 22 species in the ashfall zone. Small mammal communities in forest and clear-cut habitats, and across different disturbance zones, exhibited little species similarity among sites, even after 11 years of post-eruption recovery. Prc-eruption conditions, such as the patchiness of habitats and small mammal populations, and stochastic events, such as: 1) the initial survival of "small islands" of vegetation and resident mammals, 2) localized habitat alteration by post-eruption erosional processes, and 3) an unusually wet summer (1983) followed by three years of summer drought (1984-1986), had a major influence on small mammal recolonization in this complex mosaic of habitats. The observed differences in species recolonization and establishment success were more attributable to the availability of requisite food and shelter resources than to differences in species-specific dis-persal capabilities.

Type of Measurements): Mark and recapture techniques were employed using Sherman live-traps. Traps were baited with rolled oats and cotton batting was provided for warmth. Mammals were identified to species, marked, weighed, their gender and reproductive condition noted and released at the place of capture. The presence of ectoparasites was also recorded.

Frequency of Measurements): Small mammal trapping was conducted at some subset of the 19 sites between the months of June and September from 1980-1991. Sites were typically trapped for three to five consecutive nights during mid-summer.

Data Storage: Original data sheets, summary forms and ASCII files are housed at Utah State University and at Mount St. Helens National Volcanic Monument Headquarters.

Long-term plans, Data available for collaborative efforts: This is an on-going study which depending on funding sources and technical support will last into the next century. Collaborative efforts will be considered on a case specific basis.

—48A—

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Study Title: Reorganization ofavian communities at Mount St. Helens

Key Words: biological recovery, terrestrial succession, animal ecology, bird ecosystem, habitat

Abstract: This study was initiated to document the reorganization of bird communities on lands disturbed by the cataclysmic eruption of Mount St. Helens. Bird communities were surveyed along a disturbance gradient comprised of four structurally distinct volcanic impact zones and at undisturbed (reference) sites. Forty-two bird species were observed at the eight sites during the survey years. Species richness was inversely related to disturbance intensity. Richness values for the disturbance zones were; Reference (17), Ashfall (16), Blowdown (7), and Pyroclastic (2), respectively. Cluster analyses for community composition and foraging guilds indicate that our sites cluster into 3 groups: 1) sites that were volcanically undisturbed and those that received ashfall, 2) plots that experienced blowdown intensity force, and 3) sites that were subjected to blast force intensity. The reorganization of bird communities is largely determined by the post eruptive habitat components available. As vegetation recovery increases across the landscape we expect to see recruitment of additional species and an eventual convergence of bird species composition among the sites.

Type ofMeasurement(s): Line transects (1 km long) were used to survey birds at our sites. Birds were identified to species. When a bird was located, the perpendicular distance from the line to the bird was estimated with the aid of a range finder. Other data recorded included: 1) an estimate of the bird's height above the ground, 2) the plant species on which the bird was located, 3) substrate type (ground, forb, shrub, tree, [bark, inner-canopy, outer-canopy]), and 4) activity (foraging, nesting, singing, flying, chasing, perching).

Frequency of Measurement(s): Three to five surveys per site during June, July or August from 1981 to 1984 and two surveys per site during July of 1987 and 1991.

Data Storage: Data sheets, summary forms and ASCII files located at Utah State University and at Mount St. Helens National Volcanic Monument Headquarters.

Long-term plans. Data available for collaborative efforts: This is an on-going study that will endure into the next century if funding and technical support continues. Collaborative efforts will be considered on a case specific basis.

49A—

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Study Title: Community reassembly following volcanic disturbance: the ground dwelling beetles *(Coleoptera)*

Key Words: biological, terrestrial, arthropod, insect, beetle, *Coleoptera*, ecology, succession, ecosystem

Abstract: This study documents the recovery of beetles within the volcanically disturbed areas of Mount St. Helens and should provide an index to the rate and stage of ecosystem recovery at various points in time since the eruption. Beetles arc ideal for monitoring ecological recovery following disturbance as they represent a broad trophic array. The ground dwelling beetle fauna of forests and clearcut habitats were sampled using pitfall traps (10 traps/sice) that were open from the time of spring snow melt to early autumn from 1982 to 1984 and again in 1987 and 1990. Sites sampled include undisturbed "reference" areas and three post-eruption habitats (ashfall, blowdown, and pyroclastic/debris flow).

Some specimens remain to be identified and the complete data set needs to be analyzed, nevertheless, preliminary results suggest that there are extreme differences in species composition and abundances among the variously disturbed sites. Notably, the pyroclascic/debris flow site is dominated by ground beetles *(Carabidae)* and tiger beetles *(Cicindelidae),* while the blowdown habitat support large populations of long-horn beetles *(Cerambycidae),* "click" beetles *(Riateridae),* and darkling beetles *(Tenebrionidae).* The undisturbed forests and clearcuts are dominated by a large variety of rove beetles *(Staphylinidae).* The abundances of these beetle groups reflect the relative availabilities of food resources on each of the plots (insect prey, plant materials, fungi, etc.).

Type of Measurement(s): Species composition, richness and abundance are the data recorded.

Frequency of Measurement(s): Pitfall traps were operated from late spring through early autumn for years 1982 through 1984 and again during 1987 and 1990. Contents of traps were gathered on three- or four-week intervals.

Data Storage: Samples, identified specimens, and reference collections will be deposited at the Insect Collection at Oregon State University, University of New Mexico's Museum of Southwestern Biology and at the Mount St. Helens National Volcanic Monument. Data is on summary forms and on ASCII files at the University of New Mexico, Biology Department and at the Mount St. Helens National Volcanic Monument Headquarters.

Long-term plans, Data available for collaborative efforts: Uncertain as to the longevity of this study. Collaborative efforts will be considered on a case specific basis.

—50A—

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Study Title: Demography of *Lupinus leptdus* on the pumice plain and its role in primary and secondary succession.

Key Words: biological, ecology, terrestrial, ecosystem, plant, revegetation, herbs, succession

Abstract: This study details the demography of two populations *of Lupinus lep'idus,* a primary successional plant species growing on the Pumice Plain, and also investigates the role lupine plays in the recruitment of additional species through facilitation. Lupine and other plant species' populations have been censused once or twice each growing season from 1982-1991. Prairie lupine was the first species to colonize the barren deposits of the Pumice Plain and attained extremely high densities in certain portions of our plots during the census years.

Lupine population size, density, and age classes varied considerably through time and appeared to be associated to summer temperatures and precipitation. In one plot, from a population of about eight individuals in 1982, lupine numbers expanded to about 1000 during 1983 and 1984, then burgeoned to 21,923 plants in 1985. This was followed by a sharp decline through density dependent mortality in 1986 to 5,903 individuals. From 1987 through 1991 lupine numbers have slowly declined with population sizes ranging between 1000 and 4000 individuals. Following the high mortality of 1986, numerous wind dispersed weedy species have colonized the sites were lupine had ameliorated the harsh growing conditions of the site. By 1991, 31 species were present on the plot. Once established these early successional forbs and grasses have expanded through sexual and vegetative reproduction and have become dominant features of the plant community. Bryophytes have become very conspicuous components of the flora during 1990 and 1991.

Type of Measurements): Plants were identified to species and individuals were measured and mapped to the nearest centimeter. Flowering and fruiting phenologies were recorded and the presence of phytophagous insects noted, particularly aphids and beetle larvae.

Frequency of Measurements): Lupine and other plant species were censused once or twice annually from 1982 to 1991.

Data Storage: Data are stored on original data sheets, floppy diskettes and on magnetic tapes at Utah State University and at Mount St. Helens National Volcanic Monument Headquarters.

Long-term plans. Data available for collaborative efforts: Plans are to continue monitoring the plant populations growing within these plots into the next century. Collaborative efforts will be considered on a case specific basis.

—51A—

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Study Title: Summer bird populations of upper subalpine zone of Mount St. Helens, Mount Adams, and Mount Rainier

Key Words: biological terrestrial animal upland vertebrate birds abundance diversity

Abstract: Species composition and abundance of summer birds in the upper subalpine zone of Mount St. Helens were compared to those of Mount Adams and Mount Rainier in order to document these populations as well as to examine effects of the May 1980 eruption on bird populations at the volcano.

The majority of birds in this zone at Mount St. Helens were instantly killed by the eruption. Study sites at Mount St. Helens, Pine Creek and Butte Camp, received thin mudflow and tephra deposits, respectively.

Bird species richness was highest at Mount Adams and Pine Creek and lowest at Mount Rainier. Bird abundance was highest at Butte Camp. There was virtually no difference in the number of species found nesting in each study area, but species composition was variable between sites.

Differences in bird species composition and abundance are partly due to different plant community composition between sites. The most marked effect of the volcanic activity was seen at Pine Creek where coniferous trees were killed, eliminating the seeds of these trees as a food source for certain bird species. There appeared to be no long-term impact on bird populations at Mount St. Helens due to the 1980 eruption except at Pine Creek.

Type of Measurements): Bird population measurements: relative abundance—all birds seen or heard at each station; species composition—total species and breeding species; birds classed into foraging guilds.

Vegetation community measurements: species and number of trees per hectare; understory cover estimated using four 1-meter square quads at each station.

Frequency of Measurements): July-August 1982, July-August 1985. Preliminary observations in 1981. Six visits per site, 8 minutes per station, 11 to 22 stations per site.

Data Storage: Field notebooks in personal possession. Data published in Manuwal and others, 1987.

Long-term plans. Data available for collaborative efforts: No future plans for study. Data is available for future collaboration.

—52A—

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Study Title: Soil nitrogen along a disturbance gradient

Key Words: chemical, physical, terrestrial, soil, nitrogen, nutrient, inorganic, upland

Abstract: Soils were studied along a disturbance gradient—Pumice Plain, Timberlinc parking lot, Harmony, Bismark Mountain, Elk Pass, and Fossil Creek Ridge. NOy NH^, N, P, **K,** Ca, Mg, C were assayed. NOg and NH^ were also analyzed from resin bags buried at 15 and 30 cm. Soil samples were collected in 1985. Resin bags were buried for one year—1985-1986, and 1986-1987.

Conclusions: Total nitrogen and nitrogen in soil solution were found in greater concentrations as disturbance decreased along the gradient. Concentrations of other nutrients measured were consistent with this pattern as well. Soil profiles indicate that soils most heavily disturbed and with the thickest deposits from the 1980 eruptions had generally been most heavily disturbed and received thickest deposits from previous eruptions.

Type of Measurements): Total N, total C, extractable: P, K, Ca, Mg, NOg, NH^; and NOg, NH^ on resin bags.

Frequency of Measurement(s): 1985, 1986, 1987—not all each year.

Data Storage: Lab data is in flat ASCII files on floppy disks.

Long-term plans, Data available for collaborative efforts: This study is over. The soil pits are marked with wooden stakes and on maps in the Forestry Sciences Lab in Corvallis. There is certainly an opportunity for others to return later, assay nutrients and look at changes. All data is available on request.

There is a manuscript describing this study in progress (1990).

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Study Title: Seeding habits of upper-slope tree species

Key Words: biological, terrestrial, plant, upland, trees, conifers, ecology, revcgctation, reforestation

Abstract: The Blue Lake noble fir plot is one of 52 plots established in the early and mid 1960s throughout the Washington and Oregon Cascades to do a long-term study of the cone production of upper-slope conifers. Initially the objective was to characterize the size and frequency distribution of cone crops of important upper-slope tree species. Early results indicated that the pattern of cone production varies with geographic location, so a secondary objective to describe this variation was adopted. Another new objective is to describe how climate influences cone production. With the possibility of global warming this objective may become the most important.

Type of Measurement(s): Cones are counted on each tree in the plot from a set viewing point using a spotting scope or binoculars.

Frequency of Measurements): Cones arc counted annually during the cone bearing period.

Data Storage: Foxpro database files at the Oregon State University-CFSL Forestry Data Bank.

Long-term plans. Data available for collaborative efforts: Means plans to collect data from this plot indefinitely.

Baseline data would be available for future collaborative efforts.

—54A--

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Study Title: Population dynamics and habitat ecology of elk in the Mount St. Helens blast zone

Key Words: biological terrestrial animal upland vertebrate elk forage

Abstract: Population dynamics and seasonal patterns of foraging behavior of elk in the northwest portion of the Mount St. Helens bast zone were investigated during the years 1982 through 1985. A combination of rapid vegetation regrowch, mild winters, restricted human access and low harvests allowed a rapid re-invasion and recovery of the elk population.

Eight major plant communities were identified in the Mount St. Helens blast zone. By 1983, plant composition in the blast zone was similar to adjacent lands outside of the blast zone that had been recently logged.

During the winter, elk used low elevacional benches along the major river drainages particularly the seeded debris slide of the North Fork oftheToucle River. In spring, elk moved up in elevation to calve. Early successional fireweed communities and seeps were selected by elk during the summer and fall. Diets of elk were generally higher in forbs during the summer and grasses in the fall and winter than dices of most west coast elk populations. Changes in diet selection were consistent with an energy maximization strategy. Elk selection of plant communities was positively correlated with forage abundance.

Heat flux models indicated that because of large body size, high sweating capabilities, and an increase in wind velocities in afternoon, elk could maintain body temperatures in the open blast zone communities in summer. Model predictions were consistent with our observations that elk did not move to forest cover unless it was readily available.

Type of Measurements):

- Radio telemetry location
- Meteorological/air temp, wind, humidity
- Standing phytomass
- Elk activity
- Forage quality—IVDDM, crude protein
- Fecal analysis—elk food habits
- Animal counts, herd composition
- Elk fetus collections and kidney fat indices

Frequency of Measurements):

- Radio telemetry location: approximately 10 days, January-December, 1983-1985
- Meteorological/air temp, wind, humidity: 24 hr/day, June-November, 1985
- Standing phytomass: monthly, June-November, 1985
- Elk activity: 24 hr/day, 12 days/month, June-November, 1985
- Forage quality: IVDDM, crude protein: June-November, 1985
- Fecal analysis—elk food habits: crude protein—monthly, June-November, 1985; species composition—June-November, 1985
- Animal counts, herd composition: spring and fall, 1983-1985
- Elk fetus collections and kidney fat indices: fall, 1983-1985

Data Storage: Data arc stored on field forms; computer files are in Dec Rainbow CPM Wordstar and Lotus files; Ruscrak recorder tapes. Data have been published in a final report.

Long-term plans, Data available for collaborative efforts: Data are available but no future plans at present. Merrill would like to sec additional data collected on the elk population after the next five years.

—55A—

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Study Title: The Mount St. Helens Data Network

Key Words: physical, weather, runoff, hydrologic, meteorology, precipitation, rain gauges

Abstract: After the eruption of Mount St. Helens, the National Weather Service placed a scries of precipitation and river gauges around the mountain.This data network was put in operation to alert forecasters of heavy precipitation events and/or rapid rises on the Toucle and Cowlitz Rivers or rapid falls in lakes in proximity to the mountain. This paper explains that data network.

Type of Measurement^ s): Wind (speed and direction), precipitation, lake and river levels.

Frequency of Measurements): This is an "event" system.

Data Storage: Columbia River Operational Hydro Meteorological System (CROHMS).

Long-term plans, Data available for collaborative efforts: No long term plans for research. This is a monitoring system.

—56A—

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Study Title: Natural establishment of conifers at Mount St. Helens

Key Words: biology terrestrial plants trees conifers seedlings rccstablishment

Abstract: This study tracks the establishment, survivorship, and growth rate of colonizing tree species on substrates deposited during the 1980 eruption of Mount St. Helens. Two 50 X 50 meter plots were installed at sites on the Pumice Plain (pyroclastic flow deposit) north of the crater and the upper portion of the Muddy River mudflow during 1989 and 1990. Two 50 X 50-meter plots were installed on the debris avalanche near Castle Lake in 1993. In each plot all individual trees are identified to species, measured (total height and stem diameter at ground level), and tagged.

On the Pumice Plain primary succession is taking place on pyroclastic flow deposits with establishment of a variety of tree species along with herbaceous planes and shrubs. Although growing conditions appear to be harsh (coarse pumice with summer surface temperatures exceeding 50°C and drought) recruitment of conifer seedlings is high. Likely seed sources are small, isolated stands of forest located several kilometers away.

On the upper Muddy River mudflow few plants survived the deposition of one meter of boulder to sand size material. Organic materials were incorporated into the flow, but nutrient levels of the deposits remain low. One plot is located approximately 100 meters from the forest edge where an abundant seed source exists. This has resulted in a rapid race ofrecolonization by conifer species, particularly Western white and lodgepole pines. The other plot is located in the middle of the mudflow deposit, about 0.5 kilometers away from the forest edge. The plot in the middle of the mudflow has experienced a much slower rate of tree recruitment than the plot near the edge.

On the debris avalanche establishment of alder, willow and cottonwood is vigorous, especially where groundwater springs provide a moist substrate throughout the growing season. Seasonal browse by elk appears to be influencing the establishment and growth form of some species. The influence of elk and deer on succession is being investigated in the adjacent elk exclosurc study (please sec 57A).

Type of Measurements): Individual trees identified to the species; height(cm); stem diameter at soil level(mm); living or dead.

Frequency of Measurements): Plots were sampled in 1991-1992 and 1993. Plots are sampled at the end of the growing season. Frequency of remeasuremenc is to be determined by resource availability.

Data Storage: Field notes and data sheets are on file in the Monument Scientist's office.

Long-term plans, Data available for collaborative efforts: Frequency of remeasurement to vary depending upon available resources. Additional plots may be established on the debris avalanche and in the blowdown zone in the future. Data and Monument Science staff are available for future collaborative efforts.

—57A—

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Study Title: Effects of elk and deer on early forest succession at Mount St. Helens

Key Words: biology, terrestrial, plants, animals, upland, vegetation, shrubs, herbs, grasses, vertebrate, mammal, elk, deer, succession

Abstract: The objective of this study is to determine the role of elk and deer in the recovery of both natural and managed vegetation following volcanic disturbance. Additionally, we arc interested in documenting the influence of elk and deer on vegetation establishment in areas chat received different levels of volcanic impact. This goal will be achieved through a network of one-half hectare exclosures that will allow cross-site comparisons.

To date elk exclosures have been installed at three locations within the Mount St. Helens National Volcanic Monument. The Coldwatcr exclosure is located in a pre-eruption clearcut site within the blowdown zone. The Castle cxclosure is located on the debris avalanche deposit near Castle Lake. The Clearwater exclosure is located in an area within the blowdown zone that was salvage logged and planted with Douglas-fir following the eruption. Additional exclosures are planned but are dependent upon additional funding.

Adjacent to each exclosure a "control" plot of equal size has been installed. The difference in vegetation attributes between the control plot and that of the exclosure should reflect the influence that elk and deer are having on the returning plant communities at each site. Each exclosure is one-half hectare (70.75 X 70.75 m; 232 X 232 ft) and is surrounded by an eight foot high wire stock fence. An area 60 X 60 m within the fenced exclosure and adjacent, unfenced control will be sub-sampled for vegetation.

Type of Measurements): Two methods of vegetation sampling are used in both the exclosure and adjacent control plot—1-square-meter subplots and 15-meter line intercept transects.

- 125 - 1-square-meter subplots: percent cover by species; total stems of *Epilob'ium angustifolium* taller than 20 cm; number of seems of *E. angustifolium* browsed (control only).
- 15-15 meter line intercept transects: for all shrub and tree species the beginning and ending points of interception with tape is recorded to the nearest centimeter for the length of the tape; height of£. *angustifolium* stems taller than 20 cm; *E. angustifolium* browsed (yes or no; control plot only).

Frequency of Measurements): Exclosure and control plots at Coldwaccr Lake were sampled during September 1991. Castle plots were sampled in August of 1992. Clearwater plots were sampled in August of 1993. All plots will be sampled in 1994 and at three year intervals, thereafter.

Data Storage: Field notes and data sheets are on file in the Monument Scientist's office at the Mount St. Helens National Volcanic Monument Headquarters.

Long-term plans. Data available for collaborative efforts: This is a long term study. Monument Science staff plans on sampling these plots for many decades. Additional exclosures are planned but installation and sampling are dependent upon additional funding. Data are available for future collaborative efforts.

—58A—

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Study Title: Ant-plant interactions at Mount St. Helens

Key Words: biology, terrestrial, plant, animal, upland, herbs, succession, survival, invertebrate, insect, ant

Abstract: Within the blowdown zone of Mount St. Helens, *Formica padfica* is the most common ant species. From studies during the summer of 1991 patterns were observed in the spatial dispersion of *F. padfica* nests and also in the plant species present on the middens of these nests. *Formica padfica* is less active within species rich vegetation patches than in exposed areas. Studies in 1992 will investigate whether *F. padfica* nescs are more common along the edges of vegetation patches. Other studies will investigate the presence of *Hypochaeris radicata* (false dandelion) on the middens of these nests. The wind born seeds of *H. radicata* may have difficulty establishing on the nutrient poor tephra. Ant middens may provide suitable sices for these plants to establish. Soil brought to the surface during nest excavation and the collection of plant and insect parts may add nutrients to the substrate of ant middens. Once established above an ant nest, plants would begin to cause shading of the nest. The resulting decrease in temperature may cause the ants to move their nest location. By moving out away from the shade of a vegetation patch and creating more sices for plant establishment, ants *of F. padfica* may be effecting the expansion of vegetation patches. Since primary succession at Mount St. Helens is a slow process, the seemingly insignificant effect of ants on this process may be relatively important.

Type of Measurements):

Ant activity:	number of ancs per bait per hour
Plants on ant mounds:	frequency of plants on mounds
Colony movement:	number of ant colonies abandoned in three weeks
Shading:	temperature (average) under shade and in sunlight
Germination:	number of seedlings within two weeks
Wind dispersed seeds:	number of seeds per site

Frequency of Measurement(s):

Ant activity:	once per cransect
Plants:	several measurements during growing season
Colony, shading, and germination:	daily for three weeks
Wind:	weekly for four weeks

Data Storage: Data are stored on 3.5", DSHD diskettes in Microsoft Excel software for IBM compatible computers.

Long-term plans, Data available for collaborative efforts: This study is in partial fulfillment of Muscari's Masters degree. He may extend the research to a Ph.D. project in the future. Muscari is willing to collaborate and share any and all data he has collected at Mount St. Helens. Muscari has a good deal of information on the growth offireweed stems containing aphid colonies that may be useful to an appropriate study.

—59A—

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Study Title: Post-eruption species selection and planting trials for reforestation of sites near Mount St. Helens

Key Words: biological, terrestrial, plant, upland, trees, vegetation, planting, conifers, seedling, reforestation, survival

Abstract: This study monitored survival and growth of seven conifer species planted with shading and fertilization treatments on disturbed sites at Mount St. Helens. Seedlings were planted on six low-elevation sites and five high-elevation sites which represented a variety of post-eruption conditions.

First and second year survival and growth results were comparable to plantings on undisturbed sices. Lodgcpole pine survived best, and Douglas-fir exhibited the fastest height growth at elevations below 1100 m (3600 ft). Although western white pine, lodgepole pine, and Engelmann spruce survived equally well on the high elevation sites, lodgcpole pine grew fastest. Lodgepole pine and Engelmann spruce had the highest survival rates on the harshest, exposed sites in the most disturbed areas.

Eight years after planting, all of the species, except Pacific silver fir on the low elevation sites, had greater than 90 percent survival. Douglas-fir and grand fir had the best average growth on the low elevation sites—both species averaged more than 11 feet tall. Lodgepole pine was tallest on high elevation sites, averaging 8 feet in height.

Averaged over all species and sites, the original fertilizer and shading treatments had only small, insignificant effects after eight years. Shading did, however, seem to have lasting, beneficial effects on Pacific silver fir planted on the high elevation sites.

Successful reforestation of disturbed sites at Mount St. Helens is possible with proper species selection and careful handling and planting.

Type of Measurements):

- Survival of planted trees (dead or alive)
- Growth of planted trees (height and diameter in centimeters)
- Competing vegetation (ocular estimate of percent cover)
- Animal damage (yes or no)
- Tree vigor (healthy, weak, damaged)

Frequency of Measurements): 1, 2, 4, and 8 years after planting (now completed).

Data Storage: Permanent database on a Bernoulli cartridge. Entered into IBM microcomputer and analyzed using SAS.

Long-term plans. Data available for collaborative efforts: A manuscript on the eighth-year analysis is being prepared. No further tracking is planned, but the plants are well identified if others want to use them. Long-term monitoring will require stocking control at point of crown closure, which is close to happening on plots in the Clearwatcr drainage.

—60A—

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Study Tide: Limnological monitoring of some lakes of the Mount St. Helens National Volcanic Monument

Key Words: phytoplankton zooplankton nutrients fish water quality biological limnological lakes

Abstract: The monitoring program will sample the phytoplankcon and zooplankton communities of Castle and Coldwater Lake. The sampling program will also include water samples which will be analyzed for soluble reactive phosphorus, total phosphorus, nitrate, major ions, dissolved oxygen, and conductivity. Temperature and water transparency will also be observed. The data will be analyzed to determine the structure of phytoplankton and zooplankton communities in these two lakes and the possible impacts offish introduced into Coldwater Lake.

Type of Measurements): phytoplankton (species and numbcr/ml), zooplankton (species and number/ml) soluble reactive phosphorus (micrograms/liter), total phosphorus (micrograms/liter) nitrate (micrograms/litcr), dissolved oxygen (milligrams/liter), chlorophyll (micrograms/liter), temperature (°C), water transparency (meters).

Frequency of Measurement(s): In 1988-1990 Cascle and Coldwater Lakes were sampled approximately seven times each. In 1988 Spirit Lake was sampled once. In 1991 Castle and Coldwater were sampled four times each; in addition, eleven lakes in the vicinity of Mount St. Helens were sampled once each in 1991.

Data Storage: Data are stored on floppy disk using Quattro on an IBM compatible microcomputer.

Long-term plans. Data available for collaborative efforts: We plan to continue the lake sampling program for a number of years.

Petcrsen and this data arc available for future collaborative efforts. He is particularly interested in collaborating with someone on chemical analyses.

-61A-

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Study Title: Effects of May 1980 eruption on soil arthropods—a preliminary look

Key Words: biological, terrestrial, animal, upland, invertebrate, survival, blowdown, blast zone, soil, arthropods

Abstract: This preliminary investigation sampled soils in the blast area and blowdown zone in September of 1980 for soil arthropods. Predictably, where disruption of pre-eruption ecosystems was most thorough—debris avalanche, pyroclastic flow, blast zone—no soil archropods survived. In the blowdown zone, by contrast, soil arthropod populations were unaffected largely because they were protected by snow cover at the time of the eruption.

Type of Measurements): Soil cores were assayed for species and species density.

Frequency of Measurements): 2-week period in September 1980.

Data Storage: Data has not been published and may be lost. Samples were given to David Walter, New Zealand; he may still have them.

Long-term plans. Data available for collaborative efforts: No future plans for continuing this study; investigators were unable to conduct further sampling after initial work. Since it is unknown if data still exists, future efforts to study the effects of the eruption on and recovery of populations of soil arthropods would have to find other sources for early data. T. Seastcdt is available for questions concerning this preliminary work.

—62A—

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Study Title: Cave biology in the Mount St. Helens Cave Basalt lava flow

Key Words: biological, terrestrial, animal, upland, caves, vertebrates, amphibians, invertebrates, bats, mudflows, tcphra, arthropods, small mammals

Abstract: This study seeks to establish an inventory of species inhabiting and using lava tubes and caves in the Cave Basalt lava flow. Bat populations in caves are dominated by *Plecotus townsendii.* Of small mammal species inhabiting or using caves, deer mice *(Peromyscus maniculatus)* are most wide spread. Few amphibians were observed; the most significant amphibian finding was a population of Larch Mountain salamander *(Plethodon larselli).* 256 invertebrate species of which approximately 100 species are arthropods have been collected in caves.

Observation of deposits from the May 1980 eruption in this area revealed only mudflow and tcphra deposits which for the most part did not threaten life in the caves. Due to the lack of population data for most of these species prior to 1980, it is unclear what the effects of the eruption have been, but they appear not to have been significant.

Secondarily, mudflow and tephra deposits in this area were monitored for movement and re-deposition. Measurements of the depth of deposits using rebar stakes or tree trunks showed little reworking or secondary deposition of mudflow material or tephra in this area.

Type of Measurements): Most species have been described from sighcings and observations. Pitfall traps were used to sample invertebrate populations.

Frequency of Measurements): Bat observations have been made since 1964, once or twice per year. Intensive population studies were made in spring and early summer and autumn of 1983. Post-eruption observations were made in summer of 1980. Fly netting was conducted from 1985 to 1987.

Data Storage: Floppy disks in Wordstar in personal possession. Specimens are stored at the Burke Museum, University of Washington. Data are in an unpublished inventory provided in a contract report by Scnger and Crawford, 1984, at Mount St. Helens, National Volcanic Monument Headquarters.

Long-term plans, Data available for collaborative efforts: The mudflow and tephra deposit study was completed in 1987 and rebar markers were removed. Sengcr is continuing work with fungus flies found in cave entrances. He is willing to collaborate on future cave biology studies.

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Principal Investigators):
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Study Title: Sedimentation and geomorphic changes following the 1980-1983 eruptions of Mount St. Helens

Key Words: geology streams geomorphology watersheds rivers erosion sedimentation

Abstract: Reduced infiltration and burial of surface roughness elements, together with the loss of root strength and reduced cvapotranspiration associated with blast-toppled vegetation have dramatically accelerated erosion ofblast-affcctcd hill slopes. Other investigators have found that rill erosion rates were initially higher than the yearly average, but then declined sharply so that rill erosion rates during the second year were only 5 percent of the average first year rate. Initial races of sheet erosion were substantially higher than the average rate for the year, but the rate of decline was not as pronounced as in the case of rill erosion (Swanson and others, 1983b).

The initial high shcetwash and rill erosion rates profoundly influenced hillslope morphology, and delivered about 6.2×10^4 m^3 of sediment to tributaries of the North Fork Toutle River between June 1980 and May 1981 (Lehre and others, 1983). The resulting sediment yield has created persistent sedimentation and flooding hazards of unprecedented magnitude for downstream urban areas.

Later comparisons between hillslope erosion rates for the second year following the eruption and the total sediment yield of Mount St. Helens-affected streams during the 1982 water year suggest that most sediment is being eroded from in-channel and near-channel sources, primarily stream bank erosion and streamsidc debris slides and avalanches. The frequency of occurrence of muddy floods, debris flows, and debris torrents has decreased. However, active gully systems with strcamside debris slides and avalanches continue to produce highly sediment laden flows, including occasional debris flows, during intense rains. Post-eruption flooding along some lahar-affected channels has caused more erosion and deposition than the initial lahars.

Analysis of the dominant processes and forms inherent to channel adjustment and evolution has found that total mechanical energy is minimized through time. Channel widening has been the dominant geomorphic process.

Type of Measurements): Bed-material particle size and cross-section surveys.

Frequency of Measurements): Annually, June 1980 to present.

Data Storage: PC and Data General computer files at USGS, Vancouver, Washington.

Long-term plans. Data available for collaborative efforts: Future plans are to continue monitoring the North Fork Toutle and Toutle **River** main stem.

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Principal Investigator(s):
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Study Title: Studies of hillslopc erosion in the eastern part of the blast zone

Key Words: physical, terrestrial, geomorphology, erosion, upland, riparian, soil, watersheds

Abstract: We have been measuring tephra/soil erosion rates in the Smith, Bean, Clearwacer, Upper Green River areas of the eastern part of the blast zone. Debris slides and debris flows have been inventoried based on field observations and interpretation of aerial photographs for the 1967 to 1984 period. Sheet and rill erosion was measured with arrays of erosion pins. Repeat photography ofhillslope, channel, and revegetation changes has been done at a variety of locations. The intensity of measurements has been reduced through time, but all sites could be revisited and longer-term trends in erosion rates estimated.

Type of Measurements): (See abstract) Methods and results summarized in American Geomorphological Field Group field trip guidebook.

Frequency of Measurements); Annual or less frequent.

Data Storage: Data in permanent storage in the Forest Science Data Bank, Oregon State University, Forestry Sciences Lab, Corvallis, Oregon.

Long-term plans. Data available for collaborative efforts: Data and field sices are available for use by others.

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Principal Investigator(s):
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Study Title: Forested plant association classification

Key Words: biological, plant, vegetation, succession, ecosystem, terrestrial, ecology, plant, trees, soil

Abstract: This work, which includes sample sites on the Mount St. Helens National Volcanic Monument, extends across forested areas of the entire Gifford Pinchot National Forest.

Vegetation zones are of interest because they generally represent major large-scale climatic differences within a region. A forest zone is the area within which a particular tree species is the stand dominant in the climax plant community. For example, the western hemlock zone encompasses forests where western hemlock would eventually dominate the overstory (assuming no disturbance takes place). Of the forest zones studied, three occur in the Mount St. Helens vicinity: western hemlock zone, Pacific silver fir zone, mountain hemlock zone. The western hemlock zone generally occupies warm moist sites and is found below 3000 ft elevation. The Pacific silver fir zone occupies higher elevation sites (approximately 3000 ft to 4300 ft) where winter snow packs are common. The mountain hemlock zone occupies very cold, moist sites above the Pacific silver fir zone.

Forest zones were subdivided into plant associations, a stable group of plant species capable ofself-perpctuation. By knowing the plant association of a site we can infer a number of climatic attributes and anticipate site response to various treatments. Associations can be used as a basis for inventory of the productive potential of vegetation and other resources which depend upon vegetation for their quality or quantity. Associations also provide a framework for communicating management experiences and research results.

On the Gifford Pinchot National Forest, 17 plant associations have been described in the western hemlock zone, 11 in the silver fir zone, and 12 in the mountain hemlock zone. Plant Association and Management Guides are published according to forest zone and include an overview of the forest zone, dichotomous keys to the plant associations within the zone, and detailed descriptions of each plant association (structure, composition, environment, distribution, productivity, and management).

Sampling schemes involve selecting undisturbed forested stands of at least 60 years of age that represent a range of natural vegetation variation. Data collected includes percent cover of all vascular plants on 500 meter square plots, as well as detailed environmental, timber, snag, down wood, and soils information. Old-growth plots were more heavily weighted as they better reflect the eventual floristic composition which defines associations. Preliminary keys were field-tested and the final classifications modified.

Type of Measurement(s):

Plant cover:	by species—percent cover (at sampled area)
	grouped by plant type—percent cover (at sampled area)
Substrate:	percent cover (of sampled area) of rock, gravel, bare ground, litter.
Slope:	percent slope
Aspect:	azimuth
Slope shape:	convex/flat/concave/undulating
Position:	topographic position, elevation in feet
Soil:	depth, color, texture of layers, rooting depth
Timber:	d.b.h., height, site index, growth basal area, basal area, age
Snags:	d.b.h., height class, degree of decay, number of cavities
Down wood:	size class, length, number of pieces, amounts of fine fuels
Observations:	wildlife, disease/pathogens

Frequency of Measurement's): Study sites within forest zones were sampled once each during years 1979-1987. Plot locations were documented, allowing revisits for subsequent studies and monitoring opportunities.

Data Storage: Primary—Oracle and IS/CLI data files on main frame computer
Secondary—Original field data cards

Long-term plans. Data available for collaborative efforts: Plant Association and Management Guides have been published. Plot locations have been documented, allowing revisits for subsequent studies and monitoring opportunities. Area Ecology staff and data are available for collaborative efforts.

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Study Title: Fungal and mycorrhizal succession in the Mount St. Helens devastation area

Key Words: biological, terrestrial, fungi, mycorrhizae, succession, mudflow, tephra

Abstract: Samples of tephra deposits from the May 1980 eruption showed no mycorrhizal fungi in 1980 to 1985. Samples of buried soils and mudflow soil, however, showed that mycorrhizal fungi did survive the volcanic disturbance. Plant succession patterns in areas of tephra deposits reflect the distribution of mycorrhizae in that plants that resproutcd or germinated from old soils where mycorrhizal fungi were present were much more successful than seedlings that germinated in the tephra that lacked these fungi. Mudflow soils and old soils that were exposed as when tephra eroded were initially much more conducive to revegetation at least partly because these soils contained the mycorrhizal fungi.

Overall fungal succession proceeded from very little present in tephra in 1980 to large amounts of so-called "fireplace" fungi (those that typically fruit on burned organic matter) present in 1981. **As** time progressed, wood decay fungi invaded dead trees in the blast zone.

Type of Measurements): Samples ofpre-eruption soils, ccphra, and plant roots were assayed or microscopically examined for presence or absence of fungal mycelia or propagules.

Frequency of Measurements): 1980-1985, several times during spring and fall.

Data Storage: Field notes in personal possession.

Long-term plans, Data available for collaborative efforts: Trappe hopes to continue to monitor succession of fungi and factors influencing dispersal of fungi in the disturbance zone. He anticipates a possible project with Joe Ammirati of University of Washington. Trappe is available for collaboration.

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Principal Investigators):
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Study **Title:** Distribution of Van Dyke's salamander *(Plethodon vandykei)*

Key Words: biological, terrestrial, animal, upland, vertebrate, amphibian, salamander, plethodon, ecology, habitat, distribution, variation

Abstract: A survey is being conducted to document the distribution *of Plethodon vandykei* and factors correlated with its occurrence. This will entail visiting all known populations in Mount St. Helens National Volcanic Monument, searching for additional populations in the Monument, and recording aspects of the habitat associated with each population visited. By providing a more complete picture of the distribution of the salamander than is presently available, the proposed study will permit monitoring and further study of this species' populations and also enhance understanding of its habitat associations.

Type of Measurement(s): Salamander localities: longitude/latitude, elevation (m), percent overhead canopy with spherical dcnsiometcr, aspect with compass, moisture source associated with site (for example, spring), types of substrates associated with salamanders, number of salamanders, distances of salamanders from moisture sources.

Frequency of Measurements): Field work in the Monument will be performed from late May through November of 1990 and 1991.

Data Storage: Data are in field notebooks and on magnetic computer tapes in Wilson's possession.

Long-term plans. Data available for collaborative efforts: Another study Wilson would eventually like to conduct in the Monument involves an analysis of activity cycles of *P. vandykei* and other salamanders. The above-ground activity season of populations can be established through counts performed during nighttime visits. Counts can be compared to climatic variables to reveal the effect of climate upon activity. This will permit estimation of salamander activity seasons in the Monument and reveal climatic factors that influence appearance above ground. Such information will be useful in interpreting dispersal of salamanders in the impact zone and also permit development of a search profile that will be useful in optimally timing future study of the salamanders.

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Principal Investigators):
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Study Title: Patterns and mechanisms of early plant primary succession on the pumice plain.

Key Words: biological, terrestrial, plant, vegetation, succession, recovery, seeds, seedlings, pumice plain

Abstract: Primary colonists and mechanisms of their arrival to the pumice plain have been monitored since 1986. Measurements of seed rain have shown that the most common wind dispersed species arriving on the pumice plain are *Anaphalis margaritacea, Epilobium angustifolium,* and *E. watsonii.* Of the early colonists *A. margaritacea* is the most wide spread species, but *Lupinus lepidus* is the most abundant species. In addition the *L. lepidus* population is increasing dramatically.

L. lepidus patches have positive and negative effects on other colonists. Positive effects include nitrogen fixation and seed catching growth form. Negative effects include inhibition of other colonists by thriving patches of L. *lepidus* due to competition; this is reduced when patches die off.

The most important conditions affecting overall seedling survival on the pumice plain are moisture and physical structure of the substrate. Seedlings are more successful when moisture is plentiful and in areas of coarse soil surface rather than smooth, even soil surface.

Experiments have shown that A. *margaritacea* seedlings are more hardy than those of £. *angustifolium* possibly partially explaining higher abundance of the former species.

Please **sec** Research Abstract from Roger del Moral for relevant study contributed to by David Wood.

Type of Measurements): Species identification and percent cover were measured in 10 X 10 m plots; experimental plot sizes vary and were sampled for number of individuals surviving and appearing each year and growth rate of individuals (cm/year). Seed rain was measured using 0.1-meter square golf ball craps; species identified and number of seeds per species counted.

Frequency of Measurements): 1600 10 X 10 m plots were established and sampled in 1986, and will be sampled again in 1991. 400 of these arc measured annually. Seed traps were placed in June and collected in October of each year.

Data Storage: Floppy disks in Macintosh software in personal possession.

Long-term plans, Data available for collaborative efforts: Project ongoing until 1993 at least. Investigator is available for future collaborative efforts.

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Principal Investigator(s):
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Study Title: 1. Tree ring dating of prehistoric eruptions of Mount St. Helens
2. Forest succession following the A.D. 1480 eruption

Key Words: biological, terrestrial, plant, trees, vegetation, forest, succession, cephra, prehistoric eruptions, Douglas-fir, tree ring dating

Abstract: This study includes two topics:

1. Dating of prehistoric eruptions of Mount *St.* Helens using tree ring patterns of living trees and of dead, buried trees. Using increment cores of Douglas-fir *(Pseudotsuga menziesii),* three prehistoric eruptions were dated at 1480, 1482, and 1800 A.D.

2. Reconstruction of forest succession northeast of the volcano in the area affected by the 1480 eruption using tree ring dating. This study may provide insight into the rates of forest succession that can be expected following the May 1980 eruption. Tephra fallout from the 1480 eruption killed trees along a corridor northeast of the volcano, leaving scattered survivors among the dead. Douglas-fir reestablished 0 to 2 km from seed sources over a 40- to 60-year period after the 1480 eruption. Douglas-fir reestablished 3 to 4 km from seed sources over a 180 year period after the 1480 eruption. Considering this data, future forest rccstablishmcnc in the 1980 blast area may be expected to take place over a 40 to 180 year period.

Type of Measurements): Tree rings were examined on stump cross sections and increment cores; tree ring widths (mm); ash layer thicknesses (cm).

Frequency of Measurements): 1981-1988; samples collected from several to many trees for each of many plots.

Data Storage: Tree cores and tree ring measurement data on computer disk are stored in Yamaguchi's laboratory at University of Colorado.

Long-term plans, Data available for collaborative efforts: The first study is ongoing, but should be completed by 1993. The latter study was a Ph.D. thesis which was completed and presented in 1986. Yamaguchi is looking forward to returning to the area to work on other projects in the future.

Yamaguchi has many color slides of field conditions at the volcano during 1981-1988, particularly northeast of the volcano. He and his data are available for future collaborative efforts.

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Study Title: Mechanisms of vegetation change following burial by volcanic tephra

Key Words: terrestrial, plant, herbs, upland, shrubs, survival, conifers, 1980, deposits, ecology, recovery, seedling

Abstract: This project continues detailed study of forest understory vegetation change after burial by tephra from Mount St. Helens in 1980. Objectives are to provide a detailed record of pathways of change; to record spatial and temporal variation in soil properties; to determine species characteristics important for recovery from burial; and to use these data to determine the mechanisms of succession. Data will be analyzed to compare responses of different growth forms, species and communities in different conditions of tephra depth, serai age, and time of tephra removal. This study will provide a long-term set of consistent, detailed data about vegetation recovery from an important, widespread disturbance.

Vegetation recovery in many ways has not been predictable from the species' behavior that we observed where plants were not buried or from knowledge of the effects of common forest disturbances in the region. Survival was best for plants with large size or plastic below ground morphology. Vegetation recovery reflected primarily vegetative spread of surviving individuals.

Forest understory species composition is responding to differential ability of plants to survive long-term burial. Major shifts in understory species composition have rarely been observed in this study to date. However, tree seedlings at our study sites have established and survived with high density, which may yet produce a major shift in forest understory structure.

Examination of soil properties has revealed that tephra chemistry changed rapidly with time.

Type of Measurements):

- Vegetation cover and shoot density by species in 1-meter square plots
- Litter cover by category
- Tephra and buried soil chemistry (Ph, organic matter, macronutricnts)
- Tephra texture
- Conifer seedling morphology and size
- Substrate temperature

Frequency of Measurements):

- Vegetation and litter—1980-1983 annually; sporadically since (1984, 1987, 1989, 1990 at some plots)
- Tephra—1980, 1982, 1987
- Seedling morphology—1987-1988 (completed)
- Temperature—1980-1983 (completed)

Data Storage: All data on paper, Oregon State University; selected permanent vegetation plot data (major species, total by growth form) is on computer disks at Oregon State University and University of Victoria.

Long-term plans. Data available for collaborative efforts:

- We hope to resample vegetation on all plots at least once more, and that in deep tephra two to three more times.
- **We** hope to sample cephra chemistry once more.
- **We** hope to do work on autecology of the dominants in recovering vegetation on deep tephra.
- Temperature records have not yet been analyzed.
- Future desired activities are in jeopardy due to our failure to receive funding for further work.
- Our plots are marked with USFS signs, plastic pipe, and stake flags. These were last renewed in 1990.

Data have been published. Ancos and Zobel are interested in future collaboration.

SUBJECT INDEX

AUTHOR INDEX

Frenzen, Peter M.; Delano, Anne M., Crisafulli, Charles M., comps. 1994. Mount St. Helens: biological responses following the 1980 eruptions—an indexed bibliography and research abstracts (1980-93). Gen. Tech. Rep. PNW-GTR-342. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 149 p.

The May 18, 1980, eruption of Mount St. Helens in Washington is possibly the best documented geological event in history. The bibliography displays the results of 13 years of biological and related research in a convenient, indexed format. Our intent is to facilitate collaboration between scientists contemplating new research initiatives and experienced investigators who have conducted baseline studies at the volcano. Prospective investigators are encouraged to contact the Monument Scientist and individual authors listed in the research abstracts to find out more about research opportunities at Mount St. Helens.

Keywords: Bibliography, biological research. Mount St. Helens.

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