

A Joint Meeting

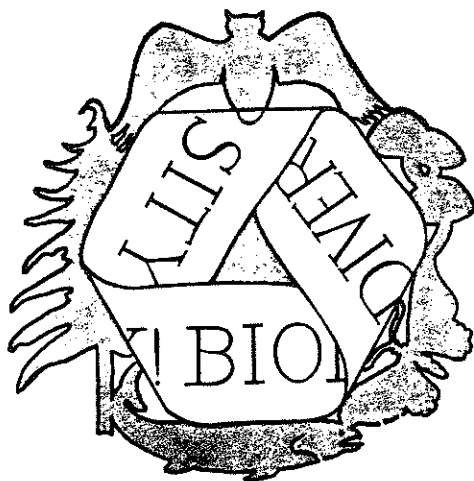
Northwest Scientific Association

— 65th Annual Meeting —

Society for Northwestern
Vertebrate Biology

Northwest Lichen Guild

American Fisheries Society *



March 24-28, 1992
Western Washington University
Bellingham, Washington

PROGRAM and ABSTRACTS

*Program printed separately

SCHEDULE OF EVENTS

Tuesday, March 24

7:00 P.M. - 9:00 P.M.	Reception/ Registration	Canada House
8:00 P.M. - 10:00 P.M.	NWSA Board Meeting	Bond Hall 151

Wednesday, March 25

8:00 A.M. - 12:00 noon	Registration	OM Reg. Center
8:30 A.M. - 12:00 noon	Biodiversity Symposium	Lecture Hall 2
10:20 A.M. - 12:00 noon	Marine Biol	Bond Hall 103
12:00 noon - 1:30 P.M.	Luncheon	Viking Commons
1:30 P.M. - 5:00 P.M.	Biodiversity Symposium	Lecture Hall 2
1:30 P.M. - 5:00 P.M.	NWSA Sessions Marine Biol Geol/Biol	Bond Hall 103 Bond Hall 111
7:00 P.M. - 9:00 P.M.	Nature Seminar	Bond Hall 109

Thursday, March 26

8:00 A.M. - 12:00 noon	Registration	OM Reg. Center
8:30 A.M. - 12:00 noon	NWSA Sessions Botany Forestry Zoo/Aquatic	Bond Hall 106 Bond Hall 112 Bond Hall 111
12:00 noon - 1:30 P.M.	Luncheon and Business mtng	Viking Commons
1:30 P.M. - 5:00 P.M.	NWSA Sessions Forestry Lichens Vert. Zool	Bond Hall 112 - Bond Hall 103 Bond Hall 106

SCHEDULE OF EVENTS continued

Thursday, March 26

5:30 P.M. - 6:30 P.M.	Reception	Viking Lounge
6:30 P.M. - 9:00 P.M.	Banquet	Viking Lounge

Friday, March 27

8:00 A.M. - 12:00 noon	NWSA Sessions	
	Botany	Bond Hall 106
	Lichens	Bond Hall 103
	Vert. Zool	Bond Hall 112
12:00 noon - 1:30 P.M.	Luncheon	Yer on yer own
1:30 P.M. - 5:00 P.M.	Hypogymnia Workshop	Haggard Hall 331
1:30 P.M. - 5:00 P.M.	Wetlands Symposium	Lecture Hall 2

Saturday, March 28

	Field Trips	Haggard Hall
Skagit wetlands/ Padilla Bay		9:00 A.M.-4:00 P.M.
Sulfur Creek - Lichens & Mosses		8:00 A.M.-5:00 P.M.
Noisy Creek - Old growth forest		8:00 A.M.-5:00 P.M.

BIODIVERSITY SYMPOSIUM
March 25, 1992, Lecture Hall 2

- Moderator: **John Miles**, Dean
Huxley College of Environmental Studies
Western Washington University
- 8:30 - 9:00 **Elliot Marks**. Biodiversity at risk:
saving all the pieces. (abstract #)
- 9:00 - 9:40 **David L. Peterson**. Landscape management
in a changing environment. (1)
- 9:40 - 10:20 **Ross Kiester**. Biological diversity and
forest management: a look to the future. (2)
- 10:00 - 10:40 Coffee break
- 10:40 - 11:20 **Jim Lichatowich**. Status and importance of
stocks in the Pacific salmon resource. (3)
- 11:20 - 12:00 **James W. Vincent**. Economics of
biodiversity: market values. (4)
- 12:00 noon - 1:30 Luncheon, Viking Union Commons
- 1:30 - 2:10 **Daniel A. Hagen**. The economics of
biodiversity: non-market values. (5)
- 2:10 - 2:50 **Ed Schreiner**. A National Park Service
perspective on biodiversity. (6)
- 2:50 - 3:10 Coffee break
- 3:10 - 3:50 **Mark Sheehan**. Washington Department of
Natural Resources' strategy for the
protection of biodiversity. (7)
- 3:50 - 4:30 **Peter T. Haug**. Conserving biodiversity at
the landscape level: choices in the
managed forest. (8)
- 4:30 - 5:00 Overall questions and answers

WETLANDS SYMPOSIUM

March 27, 1992. 1:30 - 5:00 P.M.

Moderator: **David T. Mason**
Fairhaven College
Western Washington University

There is a growing need for effective **indexes of wetlands functions**. Available tools are expensive, cumbersome, and consequently, exclude direct citizen involvement. This symposium will explore new and traditional techniques for assessing wetlands functions, techniques that probe the complex interactive wetland environment within relative ease, moderate-to-low expense, and which may provide meaningful site-specific data for decision-makers.

PARTICIPANTS - Panelists will informally discuss their own works as well as comment on each others' ideas in a search for effective indicators of wetlands functions.

Jay Zedler: Saltmarsh ecologist and restorationist.
California State University at San Diego.

Gary Williams: Wetlands functions and values.
Consultant, Vancouver B.C.

Ron Thom: Northwest saline wetlands functions.
Battell Marine Science Labs, Sequim, WA.

Charles Simenstad: Wetlands classification. Fisheries
Research Institute, Univ. of Washington.

Buddy Clairain, Jr.: Wetlands function modeling. Army
Corps of Engineers, Waterways Experiment
Station, Vicksburg, MS.

David Mason: Stress-strain models of saltmarsh,
plankton, and benthic community
functions in arctic saltmarshes and San
Francisco Bay. Fairhaven College, WWU.

GEOLOGY/GENERAL BIOLOGY

Wednesday afternoon, 25 March, Bond Hall 111
Presiding: **Gerald Kraft**, Western Washington University

- 1:30 MARS AFTER VIKING: POSSIBILITIES FOR LIFE. **David J. Thomas**, Central Washington University and **Joshua P. Schimel**, Institute of Arctic Biology. (9)
- 1:50 THE NOAA NATIONAL BENTHIC SURVEILLANCE PROGRAM DATA BASE. **John T. Landahl**, Environmental Conservation Division, NMFS, NOAA, Seattle, WA. (110)
- 2:10 THE DISPOSAL OF HOUSEHOLD HAZARDOUS WASTE: RESULTS FROM A SURVEY OF PIERCE COUNTY, WASHINGTON. **David A. Swanson**, Center for Social Research, Pacific Lutheran University, Tacoma, WA. (10)
- 2:30 ALKALI LAKE, OR: GEOLOGY OF A TOXIC WASTE SITE. **Kenneth A. Cameron**, Geologist, Oregon Department of Environmental Quality. (11)
- 2:50 - 3:20 Coffee break
- 3:20 PRELIMINARY INVESTIGATION OF GARDNER CAVE, PEND OREILLE COUNTY, WASHINGTON. **Eugene P. Kiver**, **John P. Buchanan**, **Brenda R. Gibson**, **William A. Graham**, **Iain A. Olness**, and **Richard Severn**, Eastern Washington University. (12)
- 3:40 THE NOVEMBER 1990 FLOOD IN SOUTH WESTERN BRITISH COLUMBIA, AN OVERVIEW OF THE RESTORATION PROCESS. **C. Robert Bland** and **P. Eng**. (13)
- 4:00 HYDROLOGIC SIMULATION OF THE LAKE WHATCOM WATERSHED. **Steven J. Walker**, Institute for Watershed Studies, Huxley College, Western Washington University, (14)
- 4:20 EFFECTS OF CYST DENSITY AND AGE ON THE SEDIMENTATION OF GIARDIA CYSTS. **Eniko A. Kramar**, Central Washington University. (15)

MARINE BIOLOGY

Session 1 - Wednesday morning, 25 March, Bond Hall 103
Presiding: **Steve Sulkin**, Shannon Point Marine Center

10:20 ENVIRONMENTAL CUES AND THE REPRODUCTIVE CYCLES OF
THREE TEMPERATE ASCIDIAN SPECIES. **Brian L. Bingham**,
Shannon Point Marine Center, Anacortes, WA. (16)

10:40 THE DEVELOPMENT AND PHYSIOLOGICAL RESPONSE OF
CANCER MAGISTER MEGALOPAE TO DUEL CYCLES OF
TEMPERATURE AND SALINITY. **Matthew W. Johnson**,
Western Washington University. (17)

11:00 NUTRITIONAL ANALYSIS AND EFFECT OF CRUDE OIL ON THE
LARVAL DEVELOPMENT OF HEMIGRAPUS OREGONENSIS. **Mary
Jo Hartmen**, Western Washington University. (18)

11:20 GROWTH OF THE RED TIDE ALGA HETEROSIGMA AKASHIWO.
Chris N. Fairbanks, Western Washington University. (19)

11:40 CLAM SPECIES AND VERTICAL DISTRIBUTION ON A
COARSE AND FINE SEDIMENT BEACH IN PUGET SOUND,
WASHINGTON. **Douglas P. Hanson**, Central Washington
University. (20)

12:00 noon - 1:30 Luncheon, Viking Union Commons

Session 2 - Wednesday afternoon, March 25, Bond Hall 103
Presiding: **Steve Sulkin**, Shannon Point Marine Center

1:30 THE SPAWNING DYNAMICS OF WALLEYE POLLOCK, THERAGRA
CHALCOGRAMMA IN SHELIKOF STRAIT, GULF OF ALASKA.
Nazuka Merati, NOAA-Fisheries, Seattle, WA. (21)

1:50 RNA/DNA RATIOS AS INDICATORS OF NUTRITIONAL
CONDITION OF LARVAL WALLEYE POLLOCK, THERAGRA
CHALCOGRAMMA. **Michael F. Canino** and **Kevin M.
Bailey**, Alaska Fisheries Science Center, NOAA,
Seattle. (22)

- 2:10 MANAGEMENT ADVICE FROM A SIMPLE DYNAMIC POOL MODEL
WHEN STOCK-RECRUITMENT PARAMETERS ARE UNCERTAIN.
Grant Thompson, National Marine Fisheries Service,
Seattle, WA. (23)
- 2:30 EFFECTS OF UVBR ON SURVIVAL OF MEDAKA EMBRYOS.
Andrea J. La Tier and **Jack Hardy**. Huxley College,
Western Washington University. (24)
- 2:50 - 3:20 Coffee break
- 3:20 DISTRIBUTION AND SUMMER STANDING CROP OF SEAGRASSES
AND MACROALGAE IN PADILLA BAY, WASHINGTON, 1989.
Douglas A. Bulthuis, Padilla Bay National
Estuarine Research Reserve, Washington Dept.
Ecology, Mount Vernon, WA. (25)
- 3:40 Title to be announced - **Bill Gardiner**
- 4:00 HOW DIFFERENT ARE SAND DOLLARS? AN EXAMINATION OF
THE ORAL-SURFACE PODIA AND SIEVE HYPOTHESES IN
DENDRASTER EXCENTRICUS. **Don C. Williams**, Western
Washington University. (26)
- 4:20 DELAYED HATCHING OF SQUID AS A RESULT OF REDUCED
LIGHT LEVEL. **William C. Summers**, Western
Washington University. (27)

UNDERSTANDING NATURE THROUGH ART
Wednesday evening presentation, March 25, 7-9 P.M.
by **Tony Angell**

ZOOLOGY/AQUATIC BIOLOGY

- Thursday morning, 26 March, Bond Hall 111
Presiding: **Gerald Kraft**, Western Washington University
- 8:30 PHONOTACTIC RESPONSE IN ORTHOPTERANS: SYLLABLE
DISCRIMINATION OF FEMALES IN THE CALLING SONG OF
MALE HOUSE CRICKETS, ACHETA DOMESTICUS. **Gary D.**
Lorenson, Central Washington University. (28)

- 8:50 AN EVALUATION OF ASSOCIATIONS BETWEEN
MACROINVERTEBRATES AND MACROPHYTES IN CANNERY
POND. **Jenifer K. Parsons**, Western Washington
University. (29)
- 9:10 JUVENILE ONCORHYNCHUS KISUTCH DIETS IN CREEK AND
ADJACENT POND POPULATIONS. **Noboru Minakawa** and
Gerald Kraft, Western Washington University. (30)
- 9:30 COMPARISON OF FOOD HABITS OF WILD AND HATCHERY
ONCORHYNCHUS MYKISS IN THE YAKIMA RIVER BASIN.
Scott Urakawa, **Stamford Smith** and **Paul James**,
Central Washington University. (31)
- 9:50 SIMULATING MONOGENIC INHERITANCE IN DROSOPHILA WITH
HYPERCARD. **Thomas H. Thelen**, Central Washington
University. (32)
- 10:10 - 10:30 Coffee break
- 10:30 MORPHOLOGICAL DIFFERENCES OF FERRUGINOUS HAWKS IN
ALBERTA AND IDAHO. **Daniel N. Gossett** and **M. J.**
Bechard, Raptor Research Center, Boise State
University. (33)
- 10:50 AGE DETERMINATION AND AGE AT COMPLETION OF
METAMORPHOSIS OF THE TAILED FROG, ASCAPHUS TRUEI,
Lucie A. Gray, Central Washington University. (34)
- 11:10 RED FOX USE OF THE INTERTIDAL ZONE. **Ronald E.**
Holmes, Western Washington University. (35)
- 11:30 NODULE AND MYCORRHIZAE FORMATION IN ALNUS RUBRA BY
IRRIGATION WITH A STREAM WATER IN THE FOREST. **C.Y.**
Li and **Iwan Ho**. USDA Forest Sciences Lab.
Corvallis, OR. (36)

FORESTRY

Session 1. Thursday morning, 26 March, Bond Hall 112
Presiding: **Brady Green**, U. S. Forest Service

- 8:30 DORMANCY, COLD HARDINESS, AND STRESS RESISTANCE IN
LODGEPOLE PINE (PINUS CONTORTA DOUGL.) SEEDLINGS.
Denis P. Lavender and **Salim N. Silim**, University of
British Columbia. (37)
- 8:50 DORMANCY, COLD HARDINESS, AND STRESS RESISTANCE IN
WHITE SPRUCE (PICEA GLAUCA (MOENCH) LAMB.)
SEEDLINGS. **Denis P. Lavender** and **Salim N. Silim**,
University of British Columbia. (38)
- 9:10 GENETIC VARIATION OF FROST HARDINESS IN WESTERN
RED CEDAR (THUJA PLICATA DONN) SEEDLINGS. **Marilyn**
Cherry, University of British Columbia. (39)
- 9:30 GENETIC EFFECTS ON WOOD SHRINKAGE IN DOUGLAS FIR
(PSEUDOTSUGA MENZIESII (MIRB.) FRANCO). **Matthew P.**
Koshy and **Donald T. Lester**, University of British
Columbia. (40)
- 9:50 GROWTH RESPONSE SPECIFICITY OF SPRUCE INOCULATED
WITH RHIZOSPHERE BACTERIA. **C. P. Chanway** and **B. A.**
O'Neill, Forest Sciences, University of British
Columbia. (41)
- 10:10 - 10:40 Coffee break
- 10:40 EFFECT OF SALAL REMOVAL ON TREE HEIGHT GROWTH AND
FOLIAGE N: A PRELIMINARY STUDY. **C. M. Preston**,
Pacific Forestry Center, Victoria; and **X. C. Chang**
and **G. F. Weetman**, University of British Columbia.
(42)
- 11:00 RAPID REPEATABLE DETERMINATION OF SOIL MOISTURE
IN FOREST CANOPY GAPS USING TIME DOMAIN
REFLECTOMETRY (TDR). **Andrew N. Gray**, Oregon State
University. (43)

- 11:20 INFLUENCE OF RIPARIAN VEGETATION ON MICROBIAL
DEGRADATION OF HERBICIDES IN SOIL. **J. A. Entry** and
W. H. Emmingham, Forest Science Dept. Oregon State
University. (44)
- 11:40 OZONE IN WESTERN WASHINGTON FORESTS. **Felix A.
Basabe**, Huxley College, Western Washington
University. (45)
- 12:00 noon - 1:30 Luncheon, Viking Union Commons
- Session 2. Thursday afternoon, 26 March, Bond Hall 112
Presiding: **Brady Green**, U. S. Forest Service
- 1:30 CLOUDWATER CHEMISTRY AT STAMPEDE PASS AND THE
ALPINE LAKES WILDERNESS AREA. **Linda Cuykendall** and
Felix A. Basabe, Huxley College, Western
Washington University. (46)
- 1:50 WINDFALLS IN THE SIOUXON DRAINAGE, SOUTHWESTERN
WASHINGTON. **Charlotte Pyle**, University of
Washington. (47)
- 2:10 ECOZONES OF THE NORTHWESTERN CASCADES. **Jan A.
Henderson**, **Robin D. Leshner**, and **David H. Peter**, Mt.
Baker-Snoqualmie and Olympic National Forest. (48)
- 2:30 PREDICTING THE LOCATION OF RECREATIONAL-CAUSED
FIRES IN SLAVE LAKE PROVINCIAL FOREST, ALBERTA.
Cristina Vega Garcia and **P. M. Woodard**, University
of Alberta; and **B. S. Lee**, NoFC Forestry Canada,
Edmonton. (49)
- 2:50 - 3:10 Coffee break
- 3:10 ENHANCING VEGETATION AND STRUCTURAL DIVERSITY BY
MANIPULATING FOREST STANDS. **Ted B. Thomas** and
Andrew B. Carey, USDA, Pacific Northwest Research
Station, Olympia, WA.
- 3:30 PRIMARY CAVITY EXCAVATORS IN MANAGED ABIES GRANDIS
FOREST HABITATS IN WASHINGTON'S EAST CASCADES.
Kenneth R. Bevis, Central Washington University. (51)

3:50 BARKING DAMAGE OF LODGEPOLE PINE. **K. Anre**
Friedmann, University of Alberta. (52)

4:10 WINTER FOOD CACHING BY MOUNTAIN BEAVERS (APLODONTIA
RUFA) IN A GIRDLED DOUGLAS FIR STAND. **J. P. Farley**
and **D. L. Campbell**, USDA Animal and Plant Health
Inspection Service, Olympia. (53)

4:30 EFFECTS OF GRAZING ON HIGH ELEVATION SENSITIVE
PLANT HABITATS IN THE OKANOGAN NATIONAL FOREST.
Felix A. Basabe, Huxley College, Western
Washington University. (54)

BOTANY

Session 1. Thursday morning, March 26, Bond Hall 106
Presiding: **Rich Fonda**, Western Washington University

8:20 SETTING PLANT COMMUNITY PRESERVATION PRIORITIES:
RESULTS OF A 16-YEAR CONSERVATION EFFORT IN
WASHINGTON. **Rex C. Crawford** and **Susan Trinh**,
Washington Natural Heritage Program, DNR, Olympia. (55)

8:40 TAXONOMY AND CONSERVATION OF THE GRAPE FERNS AND
MOONWORTS (GENUS BOTRYCHIUM) IN THE PACIFIC NW.
David H. Wagner, University of Oregon. (56)

9:00 STATUS OF RARE PLANT INVENTORY AND PROTECTION
EFFORTS IN WASHINGTON STATE. **John G. Gamon**,
Washington Natural Heritage Program, DNR, Olympia. (57)

9:20 ENDANGERED, THREATENED AND SENSITIVE PLANTS OF
FORT LEWIS MILITARY RESERVATION. **Ted B. Thomas** and
Andrew B. Carey, USDA, PNW Research Station,
Olympia. (50)

9:40 VEGETATION OF THE NOISY CREED WATERSHED. **Richy J.**
Harrod and **Ronald J. Taylor**, Western Washington
University. (58)

10:00 - 10:20 Coffee break

- 10:20 RARE PLANTS OF THE WENATCHEE MOUNTAINS, WASHINGTON.
Richy J. Harrod, USDA, Forest Service, Leavenworth,
 WA. (59)
- 10:40 RE-CLASSIFICATION OF FOREST AND HIGH ELEVATION
 RANGE HABITATS IN THE EASTERN NORTH CASCADES OF
 WASHINGTON. **Therese Bielak** and **Felix A. Basabe**,
 Western Washington University. (60)
- 11:00 PLANT SURVIVAL BENEATH 1980 TEPHRA FROM MOUNT ST.
 HELENS. **D. B. Zobel** and **J. A. Antos**, University of
 Victoria. (61)
- 11:20 INVASION OF INDIGOBUSH (AMMORPHA FRUTICOSA L.)
 ALONG THE COLUMBIA AND SNAKE RIVERS, WASHINGTON
 AND OREGON. **Richard R. Halse**, Oregon State
 University, and **Judith B. Glad**, Portland OR. (62)
- 11:40 STUDYING THE EFFECTS OF MUSHROOM HARVESTING ON
 CHANTERELLE PRODUCTIVITY IN OREGON'S MT. HOOD
 NATIONAL FOREST. **Lorelei L. Norvell**, University of
 Washington. (63)

Session 2. Friday morning, March 27, Bond Hall 106
 Presiding: **Rich Fonda**, Western Washington University

- 8:30 VARIATION AND RELATIONSHIPS OF PLANT COMMUNITIES
 IN THE NORTH CASCADES. **George Wooten** and **Peter**
Morrison, USDA, Forest Service, Winthrop WA. (64)
- 8:50 CLIMATE CHANGE AND SUBALPINE TREE GROWTH. **David W,**
Peterson and **David L. Peterson**, National Park
 Service, CPSU, University of Washington. (65)
- 9:10 EFFECTS OF CLIMATE AND OTHER ENVIRONMENTAL FACTORS
 ON TREE ESTABLISHMENT IN SUBALPINE MEADOWS. **Regina**
M. Rochefort and **David L. Peterson**, National Park
 Service, CPSU, University of Washington. (66)
- 9:30 EFFECTS OF CLIMATE ON REGENERATION OF SUBALPINE
 FORESTS FOLLOWING WILDFIRE. **Ronda L. Little** and
David L. Peterson, National Park Service, CPSU,
 University of Washington. (67)

9:50 UNGULATE/FOREST RELATIONSHIPS IN OLYMPIC NATIONAL PARK: RETROSPECTIVE EXCLOSURE STUDIES. **Andrea Woodward, Douglas B. Houston, Edward G. Schreiner, and Bruce B. Moorhead**, Olympic National Park. (68)

10:10 - 10:40 Coffee break

10:40 EFFECTS OF MINERAL DEFICIENCIES ON PHOTOSYNTHESIS OF SITKA SPRUCE SEEDLINGS. **R. H. Wagner**, University of Washington. (69)

11:00 IN VITRO PROPAGATION, CALLUS INDUCTION, AND PROTOPLAST ISOLATION OF MELALEUCA ALTERNIFOLIA. **Tze-Huey Wah and Hubertus Kohn**, Western Washington University. (70)

11:20 PLANT SPACE BEHAVIOR CONFIRMS W-WAVE HYPOTHESIS. **O. E. Wagner**, Wagner Research Lab., Rogue River, OR. (71)

11:40 OTHER HARMONICS IN PLANT SPACING. **O. E. Wagner**, Wagner Research Lab., Rogue River, OR. (72)

VERTEBRATE BIOLOGY

Session 1: Taxonomy, Distribution, and status of Terrestrial Vertebrates in the Pacific Northwest. Thursday afternoon, 26 March, Bond Hall 106

Presiding: **John J. Lehmkuhl**, USDA, Forest Service

1:30 THE DISTRIBUTION AND STATUS OF POND TURTLES IN WESTERN WASHINGTON. **Harriet Allen**, Washington Department of Wildlife, Olympia. (73)

1:50 THE PAST DISTRIBUTION AND CURRENT STATUS OF THE SPOTTED FROG (RANA PRETIOSA) IN WESTERN WASHINGTON. **William P. Leonard**, Washington Department of Ecology. (74)

2:10 DISTRIBUTION AND STATUS OF THE FISHER IN WASHINGTON. **Keith B. Aubry**, USDA, Forest Service, Olympia, and **Douglas B. Houston**, National Park Service, Olympic National Park. (75)

- 2:30 DISTRIBUTION OF PYGMY RABBIT (BRACHYLAGUS IDAHOENSIS) BURROWS IN SAGEBRUSH FLATS, WASHINGTON. **Megan L. Gahr**, University of Washington. (76)
- 2:50 DISTRIBUTION AND SPECIATION PROBLEMS WITH POCKET GOPHERS (THOMOMYS SPP.) IN OREGON AND WASHINGTON. **Gary Witmer**, USDA Animal and Plant Health Inspection Service, Olympia. (77)
- 3:10 - 3:30 Coffee break
- 3:30 DISTRIBUTION AND STATUS OF SEALS IN PUGET SOUND. **Stephen Jeffries**, Washington State Department of Wildlife, Tacoma. (78)
- 3:50 WASHINGTON STATE SHRUB STEPPE ECOSYSTEM STUDIES; WITH EMPHASIS ON AVIAN SPECIES OCCURRENCE, DENSITIES AND DIVERSITY. **Frederick C. Dobler**, Washington State Department of Wildlife. (79)
- 4:10 STATUS AND DISTRIBUTION OF BALD EAGLES IN WASHINGTON. **James W. Watson**, Washington Department of Wildlife, Mill Creek. (80)
- 4:30 STATUS OF GREAT BLUE HERON NESTING COLONIES IN KING COUNTY WASHINGTON. **Henning Stabins** and **Kenneth Raedeke**, Raedeke Associates Inc., Seattle. (81)
- 4:50 SPECIES COMPOSITION OF TWO OREGON CENTRAL COAST GULL (LARUS SP.) FLOCKS. **Kathy Merrifield**, Oregon State University. (82)

Session 2: General Vertebrate Biology. Friday morning, 27 March, Bond 112

Presiding: **John F. Lehmkuhl**, USDA, Forest Service

- 8:00 PRELIMINARY OBSERVATIONS OF NESTING RAVENS (CORVUS CORAX) ON SAN JUAN ISLAND, WASHINGTON. **Linda T. Campbell**, Friday Harbor, WA. (83)
- 8:20 STUDIES OF THREE TRANSLOCATED POPULATIONS OF THE WESTERN FENCE LIZARD IN NORTHERN PUGET SOUND. **H. A. Brown**, Western Washington University. (84)

- 8:40 SENSITIVITY OF POPULATION GROWTH RATES TO LIFE HISTORY COMPONENTS FOR MEDIUM-SIZED MAMMALS. **James B. Hallett**, Washington State University, and **Margaret A. O'Connell**, Eastern Washington University. (85)
- 9:00 EDGE EFFECTS ON SMALL MAMMALS IN FOREST REMNANTS OF SW OREGON. **L. Scott Mills**, University of Calif., Santa Cruz. (86)
- 9:20 LOG USE BY CALIFORNIA RED-BACKED VOLES. **David A. Tallmon** and **L. Scott Mills**, University of Calif., Santa Cruz. (87)
- 9:40 HYPOGEOUS SPOROCARPS IN MANAGED AND UNMANAGED FORESTS OF SOUTHWESTERN OREGON: COARSE WOODY DEBRIS-FUNGAL-SMALL MAMMAL INTERRELATIONSHIPS. **David A. Clarkson**, Marlboro College, Vermont; and **L. Scott Mills**, **Michael P. Amaranthus**, and **Jennifer Ramstetter**, University of Calif., Santa Cruz. (88)
- 10:00 - 10:20 Coffee break
- 10:20 ABUNDANCES OF SMALL MAMMALS IN OLD AND YOUNG FORESTS ON THE OLYMPIC PENINSULA. **Andrew B. Carey**, Pacific Research Station, Olympia. (89)
- 10:40 EXPERIMENTAL MANIPULATION OF MANAGED STANDS TO PROVIDE HABITAT FOR SPOTTED OWL AND TO ENHANCE PLANT AND ANIMAL DIVERSITY. **William L. Kerschke** and **Andy B. Carey**, USDA, PNW Research Sta. Olympia. (90)
- 11:00 ECOLOGY OF THE WESTERN GRAY SQUIRREL (SCIURIUS GRISEUS) ON FORT LEWIS MILITARY BASE. **Lori A. Ryan** and **Andrew B. Carey**, USDA, PNW Research Station, Olympia. (91)
- 11:20 NEST SITES OF NORTHERN FLYING SQUIRRELS IN MANAGED SECOND-GROWTH FORESTS. **Todd M. Wilson** and **Andrew B. Carey**, USDA, PNW Research Station, Olympia. (92)
- 11:40 USING BIOTELEMETRY TO MEASURE MORTALITY SOURCES IN ELK. **Jack L. Smith**, **Warren A. Michaelis**, and **Kreg Sloan**, Washington Dept. of Wildlife, Olympia. (93)

LICHENS AND MOSSES

Session 1. Thursday afternoon, 26 March, Bond Hall 103
Presiding: **Fred Rhoades**, Western Washington University

- 2:20 GLOBAL PERSPECTIVE ON ENDANGERED BRYOPHYTES. **John A. Christy**, Oregon Natural Heritage Program, Portland. (94)
- 2:40 DISTRIBUTION OF SOME COMMON FOREST LICHENS ON THE OLYMPIC NATIONAL FOREST. **Robin D. Leshner** and **Jan A. Henderson**, Mt. Baker-Snoqualmie and Olympic National Forest, USDA, Forest Service. (95)
- 3:00 USE OF LICHENS BY WILDLIFE IN NORTH AMERICA. **Stephen Sharnoff**, Missouri Botanical Garden. (96)
- 3:20 - 3:40 Coffee break
- 3:40 LICHEN REGENERATION FOLLOWING LOGGING IN CARIBOU WINTER HABITAT IN WEST CENTRAL ALBERTA. **J. M. Snyder** and **P. M. Woodard**, Univ. of Alberta. (97)
- 4:00 ECOLOGY AND SUCCESSIONAL STATUS OF TERRESTRIAL AND ARBOREAL LICHENS ON THE WINTER RANGE OF THE ITCHA/ILGACHUZ CARIBOU. **A. R. Brulisauer** and **M. D. Pitt**, University of British Columbia. (98)
- 4:20 LICHENS OF THE FREMONT NATIONAL FOREST, SOUTH-CENTRAL OREGON. **Bruce Ryan**, Smithsonian Institute. (99)
- 4:40 A GUIDE TO NORTH AMERICAN LICHENS. PREVIEW OF ILLUSTRATIONS FOR THE FORTHCOMING HANDBOOK BY IRWIN BRODO. **Silvia Duran Sharnoff** and **Stephen Sharnoff**, Missouri Botanical Garden.

Session 2. Friday morning, 27 March, Bond Hall 103
Presiding: **Fred Rhoades**, Western Washington University

- 8:40 CHANGES IN RELATIVE FREQUENCY OF EPIPHYTIC LICHEN SPECIES ON OAK AND ASH TWIGS IN WESTERN OREGON, 1971 TO 1991. **Jan Palmer-Muller, Francisco J. Camacho, Stephen C. Sillett, and William C. Denison**, Oregon State University. (101)
- 9:00 DISTRIBUTIONS OF BRYOPHYTES AND LICHENS ON GARRY OAK TRUNKS. **Michael W. Ryan**, University of Victoria. (102)
- 9:20 NEW TRANSPLANT METHODS FOR EPIPHYTIC LICHENS. **Chiska C. Derr and Bruce McCune**, Oregon State University. (103)
- 9:40 BIODIVERSITY OF THE SPECIES USNEA LONGISSIMA; TESTING FOR CHEMOTYPES AND DYE CHARACTERISTICS. **Sherman G. Brough**, University of British Columbia. (104)
- 10:00 - 10:20 Coffee break
- 10:20 LIST OF NAMES IN CURRENT USE (NCU) IN CLADONIACEAE: A PROJECT TO AID IN STABILIZATION OF NOMENCLATURE. **Teuvo T. Ahti**, Univ. of Helsinki, Finland. (105)
- 10:40 MULTIVARIATE ANALYSES OF ELEMENTAL CONTENT IN LICHENS OF OLYMPIC NATIONAL PARK, WASHINGTON. **Fred Rhoades**, Western Washington University. (106)
- 11:00 A FLORISTIC SURVEY OF THE EPIPHYTE COMMUNITIES INHABITING THE CROWNS OF TWO OLD-GROWTH CONIFERS IN REDWOOD NATIONAL PARK, CALIFORNIA. **Stephen C. Sillett**, Oregon State University, and **T. Scott Sillett**, Louisiana State University. (107)
- 11:20 VERTICAL SUCCESSION OF EPIPHYTES IN DOUGLAS FIR - HEMLOCK FORESTS. **Bruce McCune**, Oregon State University. (108)
- 11:40 PRELIMINARY OBSERVATIONS ON "ANTIQUE" FORESTS AND EPIPHYTIC MACROLICHEN DIVERSITY IN BRITISH COLUMBIA. **Trevor Goward**, University of British Columbia. (109)

HYPOGYMNIA WORKSHOP

Friday afternoon, 1:30-5:00, 27 March, Haggard Hall 315

FIELD TRIPS

Saturday, 28 March. All field trips will leave from the Haggard Hall Parking Ramp, on High Street at the time indicated below. Return time is an estimation. Lunches are provided.

Skagit Wetlands/Padilla Bay - Departure time: 9:00 A.M., return time: ca. 3:00 P.M.

Sulfur Creek lava flow - SE side of Mt. Baker, about a 1 1/2 hour bus ride from Bellingham; emphasis on mosses and lichens. Departure time: 9:00 A.M., return time: ca. 4:00 P.M.

Noisy Creek old-growth forest - Above (SE) Baker Lake, about a 1 1/2 hour bus ride from Bellingham to Shannon Creek Camp Ground plus a boat trip across the lake. Departure time: 8:30 A.M. return time: ca. 4:00 P.M.

LANDSCAPE MANAGEMENT IN A CHANGING ENVIRONMENT. David L. Peterson, National Park Service Cooperative Park Studies Unit, University of Washington, Seattle.

The preservation of protected areas may become more difficult in the future if there are rapid changes in the atmospheric environment of the earth. Climate change could result in future ecosystems that are quite different than those that exist today. Recent changes in the growth and distribution of subalpine tree species in western North America suggest that some changes may have already occurred. Ecosystem dynamics are complex and rarely in temporal or spatial equilibrium with the physical environment. A management strategy that focuses on landscapes is preferable to one that attempts to protect ecosystems from change. Protecting a diverse landscape with multiple landforms will insure a maximum number of habitats, refugia, and sources for plant and animal species. This strategy can be complemented by mitigation that enhances survival of individual species.

STATUS AND IMPORTANCE OF STOCKS IN THE PACIFIC SALMON RESOURCE. Jim Lichatowich, Consultant, Sequim, WA.

Species of Pacific salmon are comprised of locally adapted stocks. The American Fisheries Society has identified at least 106 stocks that have become extinct. In addition, 101 stocks are at high risk and 58 stocks are at moderate risk of extinction. Another 54 stocks are of special concern. Habitat damage is the most important cause of the decline.

BIOLOGICAL DIVERSITY AND FOREST MANAGEMENT: A LOOK TO THE FUTURE. Ross Kiester, USDA Forest Service, PNW, Corvallis.

Biological diversity issues pose enormous challenges to forested land management. Meeting these challenges requires understanding the goals for managing for biological diversity, the scientific and technological basis for the management methods, and the trade-offs of managing for biological diversity in the context of other management goals. Deciding on the goals of management for biological diversity must come first and are to be derived from considerations of the use and appreciation of biological diversity. Use may be seen from a human viewpoint or from the viewpoint of the functioning of an ecosystem. Appreciation is largely an aesthetic issue. Possible goals based on use and appreciation and the scenarios of forest management derived from them give insight into the future of forest management.

ECONOMICS OF BIODIVERSITY: MARKET VALUES

James W. Vincent

University of St. Thomas, St. Paul, MN

There is wide concern that plant and animal diversity is threatened by overexploitation and by destruction of habitat. Of the many concerns relating to this loss is the prospect that the economic value of our biological "capital" is eroding at an excessive rate. The economic value of species diversity manifests itself in many ways. Fisheries, for example, depend on the maintenance of economically viable populations of aquatic species. Recreational value derives from the demand for hunting, fishing, wildlife-watching and a host of other activities. Genetic resources are used for medical purposes, to develop new strains of crops, and for genetic engineering. The question thus arises regarding the aspects of existing economic institutions which promote inefficiently rapid dissipation of biodiversity. The pervasive absence of well-defined and enforceable property rights for naturally occurring biological resources precludes the use of economic incentives to conserve these assets. It is argued that the assignment of a more complete structure of property rights for biological resources would promote the functioning of markets which owe their existence to biological diversity. By permitting the capture of the economic benefits of biodiversity, economic incentives are employed in the protection of this diversity. Although there are many cases for which an economically viable set of property rights is not feasible, such measures can, along with a broad range of other policies, provide a mechanism for the conservation of biological diversity.

MARS AFTER VIKING: POSSIBILITIES FOR LIFE. David J. Thomas, Central Washington University, and Joshua P. Schimel, Institute of Arctic Biology.

The results of the Viking biology and organic chemistry experiments seemed to rule out the possibility of life on Mars. We present a hypothetical model of Martian ecology based on the premises that Martian life could be endolithic, and that it could undergo long periods of dormancy. We also review new evidence which supports the possibility of life in hostile environments similar to that of Mars.

Alkali Lake, OR: Geology of a Toxic Waste Site. Kenneth A. Cameron, Geologist, Oregon Department of Environmental Quality

Between 1969 and 1971 25,000 barrels of herbicide waste were stored on the edge of Alkali Lake playa in south-central Oregon. In 1976 the State of Oregon ordered the barrels pushed into trenches, crushed, and covered. The rationale was that this was a closed basin in a semi-desert environment and contaminants would not travel far. In actuality, the basin is part of Basin and Range physiography and is cut by numerous faults traceable on infrared photographs by vegetation variations. An artesian aquifer which feeds springs along the fault traces forms in Pliocene volcanics underlying lacustrine sediments of the playa. Hutton Spring, 3 miles north of the site, is inhabited by the endangered Tui chub. Strong groundwater flow driven by fault directed artesian water is pushing the contamination in the opposite direction than anticipated and the plume has now reached and come to the surface at West Alkali Lake, a distance of $\frac{1}{2}$ mile.

THE DISPOSAL OF HOUSEHOLD HAZARDOUS WASTE: RESULTS FROM A SURVEY OF PIERCE COUNTY, WASHINGTON
David A. Swanson, Center for Social Research, Pacific Lutheran University, Tacoma, WA

This study examines disposal practices involving five types of household hazardous waste using data from a 1989 survey of 804 randomly selected households in Pierce county, Washington. The association between unsafe disposal practices and each of three sociodemographic variables is also examined. The findings indicate that many households usually use unsafe disposal methods for the three hazardous wastes covered in the survey that are directly related to households: cleaning agents; paints/solvents; and pesticides/herbicides. Far fewer use unsafe disposal practices for the two types of hazardous waste directly related to personal transportation: antifreeze; and used automobile oil. An inverse relationship is found between age and unsafe disposal practices but no relationship is found between gender and unsafe disposal practices. The third sociodemographic variable is a proxy for the level of social integration a person has with his or her community. An inverse relationship, which was hypothesized for the level of social integration and unsafe disposal practices, is found to exist between the proxy variable (Whether or not a person plans to be in the same community in five years) and unsafe disposal of each of the five types of household hazardous waste. It is argued that similar findings are likely to be found in metropolitan areas throughout the U.S. Further, the findings lend support to Cassel's observation that state governments must face the need to find alternatives to cost-ineffective Household Hazardous Waste disposal programs in spite of their perceived public support.

PRELIMINARY INVESTIGATION OF GARDNER CAVE, PEND OREILLE COUNTY, WASHINGTON. Eugene P. Kiver, John P. Buchanan, Brenda R. Gibson, William A. Graham, Iain A. Olness, and Richard Severn Eastern Washington University.

A university class surveyed and studied a recently discovered extension of Gardner Cave. The cave system has 490 m of passage and follows the 21° SW dip of the Middle Cambrian Metalline Limestone. Evidence suggests that a coarse fill of outwash(?) gravel was followed by speleothem formation, partial removal of fill, and a later fill by fine-grained sediment. A ceiling channel was cut atop the sediment fill and the present episode of speleothem deposition followed partial removal of fill material. Coarse and fine fills may have occurred more than once. Radiometric dates (Martin 1989) are compatible with cave formation during the last interglacial and Holocene deposition and removal of the fine cave fill. More detailed study of the cave sediment and geomorphic features will improve our understanding of the influence of Pleistocene glaciers, topographic factors, and groundwater hydrology on speleogenesis.

The November 1990 Flood
in South Western British
Columbia,
An Overview of the Restoration
Process

C. Robert Bland, P. Eng.

The November 1990 flood caused widespread damage to rivers in southwestern British Columbia. Restoration works were assessed on a site by site basis by a team of engineers and environmentalists.

While a "people versus fish" conflict was evident, the team approach ensured that the restoration work was carried out with minimal environmental damage.

Hydrologic Simulation of the Lake Whatcom watershed. Steven J. Walker, Institute for Watershed Studies, Huxley College, Western Washington University, Bellingham Washington.

The Hydrologic Simulation Program - FORTRAN (HSPF) was adapted for use in the Lake Whatcom watershed. The watershed was divided into hydrologically homogenous land areas based upon watershed soils and land use/cover data layers. Utilizing the ODYSSEY geographic information system, land surface attributes were overlain and contributing areas ascertained. The set of HSPF model parameters were estimated based upon the matrix of watershed physical conditions and sub-basin boundaries. The model was driven by continuous daily precipitation and potential evapotranspiration time series. Model output was calibrated to two years of continuous historical streamflow data for three creeks within the watershed. The calibrated model was utilized for prediction of the 1990-1991 water budget for the watershed.

EFFECTS OF CYST DENSITY AND AGE ON
THE SEDIMENTATION OF GIARDIA CYSTS.
Enikő A. Kramár, Central Washington University

Currently, to recovery *Giardia* cysts from water a reference procedure is used which requires a centrifugation step of 600 x g for 5 minutes to concentrate the cysts. Findings in our lab indicate that a significant proportion of *Giardia* cysts do not sediment under these conditions and would be discarded using the reference method. The first objective in this present study is to determine the centrifugation conditions needed to pellet the majority of *Giardia* cysts in an aqueous solution. Sedimentation of *Giardia* cysts at different centrifuged forces and at different centrifugation times is being investigated. The number of *Giardia* cysts in both the sediment and supernatant fractions is determined using a membrane filtration staining procedure. Results obtained indicate that centrifugal forces and/or centrifugation times greater than those used in the reference method are needed to sediment all of the *Giardia* cysts from an aqueous suspension. The effects of cyst density and cyst age on sedimentation are being investigated. A second objective of this study is to determine the density of *Giardia lamblia* cysts using a Percoll gradient and density marker beads. These studies are in progress.

ENVIRONMENTAL CUES AND THE
REPRODUCTIVE CYCLES OF THREE
TEMPERATE ASCIDIAN SPECIES. Brian L. Bingham Shannon Point Marine Center, Anacortes, WA.

The reproductive cycles of three ascidian species (*Boltenia villosa*, *Chelyosoma productum*, and *Styela gibbsii*) were studied for 12 months to determine what environmental factors are responsible for long-term reproductive synchrony. Neither seawater properties (i.e. temperature, salinity) nor phytoplankton abundance were strongly correlated with gonad growth or maturation. However, the observed patterns of gonad maturation were related to photoperiod and day length. We manipulated light cycles in the laboratory and compared gonad indices (% wet body weight) and oogenesis in animals exposed to a natural light cycle and those in a reversed light treatment. Significant differences were found between the two groups with the gametogenic cycles of the reversed-light animals being thrown out of phase in seasonally spawning species. These results indicate that day length, in addition to serving as a proximal spawning cue in some ascidians, may also play an important role in longer-term reproductive synchronization.

THE DEVELOPMENTAL AND PHYSIOLOGICAL RESPONSE OF CANCER MAGISTER MEGALOPAE TO DIEL CYCLES OF TEMPERATURE AND SALINITY. MATTHEW W. JOHNSON. WESTERN WASHINGTON UNIVERSITY.

In Washington, the Dungeness crab, Cancer magister is separated into at least two populations, those found on the outer coast and those in the waters of the Puget Sound basin, including Georgia Strait. Previous studies have identified distinct developmental differences in the megalopae. Because of the potential for gene flow between the two areas, larval differences are likely to be phenotypic. The amount of mixing and freshwater runoff in the two areas results in very different surface salinities and temperatures. Because of the vertical migration, the megalopae in the two areas will experience different temperature and salinity cycles. The experiment exposed the megalopal larvae to three diel cycles of salinity and temperature to determine its effects on time to molting, survival, growth, and respiration. Initial analysis suggests that the cycles do effect respiration and time to molting. Trends indicate a delay in the time until molting of the 9-18C temperature cycle as compared to both the 9-18C cycle with a salinity cycle and the 10-13C temperature cycle.

GROWTH OF THE RED TIDE ALGA HETEROSIGMA AKASHIWO. Chris N. Fairbanks. Western Washington University.

Blooms of this single celled alga have recently caused severe loss of fish in net pen fish farms. Blooms result from rapid growth of phytoplankton under ideal conditions of nutrients, temperature, and light. Growth requirements of this alga are not well understood. This work investigates the effect of temperature and light on the growth rate of laboratory cultures of H. akashiwo. Growth was measured over five temperatures (10-20°C) and four light intensities (0.8 - 235.5 μ E). Preliminary results suggest that growth rate is dependent on temperature, increasing with temperature. Doubling time was 6.2 days at 10°C, and 0.7 days at 20°C. Light intensity is less important. These results suggest that the growth of H. akashiwo in the inland waters of Washington State is limited primarily by temperature and somewhat by light intensity.

NUTRITIONAL ANALYSIS AND EFFECT OF CRUDE OIL ON THE LARVAL DEVELOPMENT OF HEMIGRAPUS OREGONENSIS. Mary Jo Hartman. Western Washington University.

Hemigrapsus oregonensis is a brachyuran shore crab whose habitat extends from Alaska to California. This study examined the nutritional requirements and the effect of oil pollution on the development of the zoeae. Individual larvae were raised in the laboratory on one of three diets; the rotifer Brachionus plicatilis, cultured on the green alga Dunaliella tertiolecta; Brachionus plicatilis, cultured on the golden brown alga Isochrysis galbana; and freshly-hatched nauplii of the brine shrimp Artemia sp. Starvation resistance of larvae was also examined. Preliminary results show no differences in the zoeae due to oil contamination of the pre-ovigerous females. Larvae raised on the Isochrysis galbana-fed rotifers appear to have the highest survival rates, highest megalopae dry weights and lowest mean day to molt. Molt frequency was affected by the starvation regime.

CLAM SPECIES AND VERTICAL DISTRIBUTION ON A COARSE AND FINE SEDIMENT BEACH IN PUGET SOUND WASHINGTON. DOUGLAS P. HANSON. CENTRAL WASHINGTON UNIVERSITY

A transect study of clam species distribution and substrate composition was undertaken on two beaches in the Puget Sound region. Clam species were classified according to the type of substrate they inhabited and their position on the beach. General correlations were observed between clam species and sediment size. The study investigated possible reasons each specie preferred a type of substrate for a habitat. Application of this study could lead to the development of guidelines for providing suitable habitat for each clam specie.

THE SPAWNING DYNAMICS OF
WALLEYE POLLOCK, Theragra
Chalcogramma, IN SHELKOF
STRAIT, GULF OF ALASKA

Nazila Merati
NOAA-Fisheries
Seattle, Washington

The spawning dynamics of female walleye pollock, Theragra chalcogramma, in the Shelikof Strait, Gulf of Alaska were studied in 1990. The purpose of this study was threefold; first, to characterize spawning dynamics of this fishery. Secondly, to determine the age at first maturity in female fish. Lastly, to develop an immunochemical assay to assess reproductive condition and to test this assay against other more established methods to determine sexual maturity stage. At this time, an antibody to egg-yolk protein has been developed, native egg proteins have been characterized and an assay has been developed. The assay may be useful in distinguishing between immature and spent/recovering maturity stage. These stages are difficult to determine by visual inspection.

MANAGEMENT ADVICE FROM A SIMPLE
DYNAMIC POOL MODEL WHEN STOCK-
RECRUITMENT PARAMETERS ARE
UNCERTAIN.

Grant G. Thompson, National Marine
Fisheries Service, Seattle, WA

A simple dynamic pool model is used to examine the problem of stock-recruitment parameter uncertainty from a Bayesian perspective. Probabilities associated with different parameter values are used to weight the losses (i.e., opportunity costs to society) associated with any given fishing mortality rate. By choosing appropriate forms for the loss and probability density functions, the model is shown to result in an analytic solution. Because this solution gives the fishing mortality rate that maximizes the expected value of the logarithm of sustainable yield, it is denoted F_{MELSY} . The solution is a monotone decreasing function of parameter uncertainty, converging on the fishing mortality rate corresponding to maximum sustainable yield as the degree of uncertainty approaches zero. As an empirical illustration, the model is applied to the eastern Bering Sea stock of rock sole (Lepidopsetta bilineata).

RNA/DNA RATIOS AS INDICATORS
OF NUTRITIONAL CONDITION OF
LARVAL WALLEYE POLLOCK,
Theragra Chalcogramma.
MICHAEL F. CANINO AND KEVIN M.
BAILEY, Alaska Fisheries
Science Center, NOAA,
Seattle.

Food consumption and nucleic acid ratios of first-feeding pollock larvae in the Gulf of Alaska were sampled during early spring and mid-spring, 1989. A large patch of larvae was detected. Mean prey abundance, gut contents (prey larva¹) and RNA/DNA values of larvae were higher within the patch than in areas outside the patch during early spring. By mid-spring, microzooplankton densities, feeding intensity and RNA/DNA of larvae both inside and outside of the patch had increased. The results indicate a linkage between food availability, feeding, and growth during early periods of larval development.

EFFECTS OF UVBR ON SURVIVAL OF MEDAKA
EMBRYOS. Andrea J La Tier and Jack
Hardy, Huxley College, Western
Washington University, Bellingham.

Medaka embryos were exposed to ultraviolet radiation (280-320 nm) UVBR, predicted to result from 13%, 25% and >25% (+/- 5%) reductions in stratospheric ozone (Oe3). Doses approximated those for clear skies at the water surface in July at 40N (Green et al., 1980). UVBR and photosynthetically active radiation (PAR) were generated using UV-B 313 and Gro-Lux bulbs. Exposure was electronically modulated using a sinusoidal dimming ballast linked to a controller designed to simulate a natural diurnal spectral curve. Wavelength-specific irradiances were converted to total dose, weighted by a DNA action spectrum (Setlow, 1974) and normalized to 300 nm (UVBR DNA 300). A dose rate (2,436 J/M2/day) equivalent to a 13% reduction in stratospheric O3 was sufficient to cause complete mortality of medaka embryos after 10 days of exposure.

DISTRIBUTION AND SUMMER STANDING CROP OF SEAGRASSES AND MACROALGAE IN PADILLA BAY, WASHINGTON, 1989. Douglas A. Bulthuis, Padilla Bay National Estuarine Research Reserve, Washington Dept Ecology, Mount Vernon, WA

The channels, seagrass and macroalgal beds and intertidal flats in Padilla Bay, Washington were mapped during summer, 1989. Seagrasses, principally Zostera marina L., covered about 3000 hectares in Padilla Bay. Zostera japonica Aschers. & Graebn. was distributed higher in the intertidal than Z. marina and covered about 300 hectares. The seagrass, Ruppia maritima, reported from Padilla Bay for the first time, is widely distributed at a very sparse density over about 140 hectares. Large accumulations of Ulva and Enteromorpha covered about 220 hectares in the southern part of Padilla Bay. Density of Zostera marina ranged up to 441 shoots m^{-2} and for Z. japonica up to 1095 shoots m^{-2} . Standing crop of seagrasses ranged from 12 to 103 g dry weight m^{-2} at 13 seagrass covered sites at which macroalgae biomass ranged from less than 1 to 190 g dry weight m^{-2} . The seagrass beds in Padilla Bay are one of the largest contiguous beds of seagrass in Washington and along the Pacific Coast of North America.

DELAYED HATCHING OF SQUID AS A RESULT OF REDUCED LIGHT LEVEL. William C. Summers, Western Washington University, Bellingham, WA 98225.

Eggs of the sepiolid squid, Rossia pacifica, were hatched at near-surface, light levels and cycles, and in nearly continuous darkness to simulate shallow and deep conditions. Six clutches of trawled and aquarium laid eggs were divided into each treatment and hatching monitored over one-half year in running seawater. In cultivation, hatching extends no more than 3 months (98%), but it can be twice that long. It is keyed to the lunar cycle, which is maintained in the dark, and is delayed about one month in the dark treatment.

Because this species is known to occur at a wide depth range and lacks a planktonic juvenile stage, hatching of eggs laid far below the photic zone would be out of synchrony with those laid at shallow depths based on light effects alone. At all simulated depths, hatching near the time of the new moon assures minimal opportunity for visual predators and dispersal of newly hatched squid.

This result is of importance when compared with other known cephalopods.

HOW DIFFERENT ARE SAND DOLLARS? AN EXAMINATION OF THE ORAL-SURFACE PODIA AND SIEVE HYPOTHESES IN DENDRASTER EXCENTRICUS. D.C. Williams, Western Washington University, Bellingham,

Oral and aboral surface hydrolases (amylase, cellulase and protease) were measured in the sand dollar (Dendroaster excentricus), seastar (Pisaster ochraceus) and sea urchin (Strongylocentrotus droebachiensis). Measurement provided no evidence for the uniqueness of the sand dollar oral and aboral surface in contributing to pre-ingestion digestive events of macro- or micronutrients. In addition, relative concentrations of the indicated digestive hydrolases were determined in the small and large intestines of the sand dollar. The small intestine is the site of major digestive hydrolase activity.

PHONOTACTIC RESPONSE IN ORTHOPTERANS: SYLLABLE DISCRIMINATION OF FEMALES IN THE CALLING SONG OF MALE HOUSE CRICKETS - ACHETA DOMESTICUS. Gary D. Lorenson, Central Washington University, Ellensburg.

This study, experimental in design, strives to discover the relationship of number of syllables per chirp of a stridulating male Acheta domesticus to the phonotactic response of a conspecific female. The response of the female to synthetically presented typical and atypical syllable numbers in an otherwise normal calling song were compared to control groups with no sound. The results seem to strengthen previous work done in this field on the typical number of syllables per chirp (3) found in the natural calling song. The data does, however, suggest that this population of house crickets will also respond significantly to atypical numbers of syllables per chirp (5) which has previously not been established. This study investigates this anomaly and recommends future exploration of this parameter to establish a more definitive conclusion.

AN EVALUATION OF ASSOCIATIONS
BETWEEN MACROINVERTEBRATES AND
MACROPHYTES IN CANNERY POND.
Jenifer K. Parsons Western Washington
University.

Samples from six species of emergent, floating leaved, and submerged macrophytes were collected from a shallow freshwater pond during the summer of 1990. All macroinvertebrates collected with the plant material were counted; macroinvertebrate subsamples were dried and weighed. Macroinvertebrate abundances and biomass were greatest on submerged plants and highest in midsummer. Many of the macroinvertebrate taxa such as damselflies, chironomid flies, and various species of snails were common on all plants. However, some macrofauna were associated with specific plants. For example, all lepidopteran larvae were found on *Polygonum hydropiperoides*, and the greatest abundance of crustaceans were collected on *Potamogeton natans*. Macroinvertebrate biomass and abundances were not consistently related to available plant surface area or leaf morphology.

COMPARISON OF FOOD HABITS OF WILD AND
HATCHERY *ONCORHYNCHUS MYKISS* IN THE
YAKIMA RIVER BASIN. Scott Urakawa,
Stamford Smith and Paul James Central
Washington University

Proposed supplementation of native anadromous *Oncorhynchus mykiss* in the Yakima Basin has led to questions regarding the potential competition between hatchery-reared fish and both wild resident *O. mykiss* and wild anadromous *O. mykiss* populations. A two year study began in the spring of 1991 in an attempt to answer some of these questions. Samples of wild *O. mykiss* and hatchery *O. mykiss* were obtained at four different periods during 1991. Gut contents were analyzed to determine the similarity of diets between wild and hatchery *O. mykiss*. Preliminary results show some subtle, but important differences in diet between the hatchery and the wild fish.

JUVENILE *ONCORHYNCHUS KISUTCH*
DIETS IN CREEK AND ADJACENT POND
POPULATIONS. Noboru Minakawa and
Gerald Kraft Western Washington
University.

Juvenile coho salmon reside in fresh water for at least one year. The diet of a coho population residing in Baker Creek, WA was compared with the diet of a population in a nearby man-made pond on four different dates in November, 1988 through January, 1989. Both populations ate larger numbers of prey when there was high rainfall prior to the sampling dates in November and December. Terrestrial invertebrates were equally abundant in diets of both populations on three of the four sampling dates. Both populations fed heavily on *Collembola* during late fall and early winter; taeniopterigids and simuliids (stream) and chironomids (pond) were prevalent in January. Temperature, and rainfall seemed to influence diet.

SIMULATING MONOGENIC INHERITANCE
IN *DROSOPHILA* WITH HYPERCARD.
Thomas H. Thelen Central Washington
University, Ellensburg.

Crossing fruit flies and observing the resulting phenotypic ratios is an excellent way for students to learn that Mendelian genetics has a basis in reality. Unfortunately the process of generating several generations of flies is so time consuming that a student can seldom study the inheritance of more than a single trait. HyperCard simulations were developed to reduce the time commitment and thereby provide a way to expose students to a variety of traits. Two such simulations which have been used effectively in biology and genetics courses will be demonstrated. The one simulates matings involving any of 45 strains of flies and includes 4 patterns of inheritance, and the other with the same number of strains includes 16 patterns of inheritance.

MORPHOLOGICAL DIFFERENCES OF FERRUGINOUS HAWKS IN ALBERTA AND IDAHO. Daniel N. Gossett and M. J. Bechard Raptor Research Center, Department of Biology, Boise State University, Boise, ID 83725.

Twelve female and eleven male adult Ferruginous Hawks (*Buteo regalis*) were trapped, measured and banded during the 1991 nesting season in southeast Alberta, southcentral and southwest Idaho during the first year of a morphometric study. These birds were trapped using dho-gaza or modified dho-gaza nets placed near the nest sites with an owl or other lure bird placed near the net. Thirty measurements were taken on captured birds. Differences were analyzed by sex and study area. Mass was greater for both sexes of Alberta birds than for Idaho birds. Except for differences in mass, Alberta females were most similar to southwestern Idaho females for several characters including wing length, grasp and bill chord. Birds in dark plumage phase morphology were found to be increased in southcentral Idaho compared to previous studies, with 16.3 percent of adults, and 23.7 percent of nestlings occurring in melanistic plumage. Results are preliminary due to small sample sizes.

RED FOX USE OF THE INTERTIDAL ZONE. Ronald E. Holmes, Western Washington University, Bellingham, Washington.

The objective of this study is to document red fox (*Vulpes vulpes*) use of the intertidal zone as a foraging area, and show the effects of the tide cycle on the activity pattern of the red fox. Observations were taken during daylight hours when fox activity is normally low. A % sighting time was calculated as a measurement of fox activity. The arcsine transformation of % sighting time was regressed against the habitat variable tide amplitude. Red fox use of the intertidal zone during daylight hours, when the tide level is descending, was positively correlated with tide amplitude, $r^2 = 0.41$, $p = .003$. A comparison (ANOVA) of fox use of the intertidal zone during ascending vs. descending tides showed a significantly higher use during descending tides, 4.1% vs 29.6%, $p = 0.008$. The correlation of % fox sighting time to tide amplitude increased over the summer (May-July) then dropped in August when a non-intertidal forage item (blackberries) became available. In the study area, in early-mid summer, the tide cycle has the effect of increasing red fox use of daylight hours for foraging when tide amplitude is high and tide level descending during daylight hours.

AGE DETERMINATION AND AGE AT COMPLETION OF METAMORPHOSIS OF THE TAILED FROG, ASCAPHUS TRUEI. LUCIE A. GRAY, CENTRAL WASHINGTON UNIVERSITY

Past studies have shown that there is variation in the time of metamorphosis among different populations of Ascaphus truei. Coastal populations complete metamorphosis at 2 years of age, many inland populations take 3 years, and recently a population in the northern Cascades has been shown to take 4 years. This study examines the age class structure of eastern Cascade populations of Ascaphus larvae in central Washington. A size-frequency analysis on 495 larvae, collected over a period of 7 months, suggests that they metamorphose at three years of age. An examination of morphological characteristics is currently in progress to determine if there are any discrete larval characteristics that coincide with the size classes, or if any of these size classes may represent more than one age class.

NODULE AND MYCORRHIZAE FORMATION IN ALNUS RUBRA BY IRRIGATION WITH A STREAM WATER IN THE FOREST. C. Y. Li and Iwan Ho USDA Forest Service, Pacific Northwest Research Station, Forestry Sciences Laboratory, Corvallis, Oregon 97331

This study was initiated to determine if Frankia and mycorrhizal inocula can be disseminated by the stream water in the forest. Young seedlings of A. rubra in the greenhouse were irrigated with water collected from a creek in the forest. After three months, entire root systems were examined for nodules and mycorrhizae. Seedlings irrigated with the stream water developed nodules and ecto-mycorrhizae while seedlings irrigated with filtered stream water developed no nodules and mycorrhizae and showed stunted growth. Thus the stream water in the forest is the good source of Frankia and mycorrhizal inocula for A. rubra and contributes to natural regeneration of A. rubra along stream bank and beyond.

DORMANCY, COLD HARDINESS, AND STRESS RESISTANCE IN LODGEPOLE PINE (*PINUS CONTORTA* DOUGL.) SEEDLINGS. Denis P. Lavender and Salim N. Silim, University of British Columbia, Vancouver.

The above seedling parameters were studied during the winter of 1991-92. Cold hardiness developed more slowly than it did in white spruce and the maximum hardiness attained (-45°C .) was significantly less than that of spruce ($> -60^{\circ}\text{C}$.) Further, unlike spruce seedlings, the pine seedlings commenced dehardening under natural conditions in January. Release of cold hardiness and bud dormancy were both correlated strongly with duration of exposure of seedlings to temperatures of 5°C ., but stress resistance, as measured by the plants' ability to initiate and elongate new roots after a crushing stress, was independent of both cold hardiness and bud dormancy. Stress resistance reached a maximum between late November and early February. Root growth of the control seedlings varied during the experiment but was not generally related to the length of exposure of seedlings to 5°C . temperature.

GENETIC VARIATION OF FROST HARDINESS IN WESTERN RED CEDAR (*THUJA PLICATA* DONN) SEEDLINGS Marilyn Cherry, University Of British Columbia, Vancouver.

Frost hardiness testing was conducted for two seasons on one-year-old and two-year-old western red cedar (*Thuja plicata* Donn) seedlings which were grown in Vancouver. Eight provenances were sampled with four provenances having family structure (three families per provenance).

Genetic differences occurred on ten test dates per winter between coastal and interior populations, between provenances within populations, and between families within provenances. The rate of hardening and dehardening differed between populations and between provenances.

During the second winter, seedlings became hardy to lower minimum temperatures than in the previous season, but provenance and family rankings were similar for the two years.

DORMANCY, COLD HARDINESS, AND STRESS RESISTANCE IN WHITE SPRUCE (*PICEA GLAUCA* (MOENCH) LAMB.) SEEDLINGS. Denis P. Lavender & Salim N. Silim, University of British Columbia, Vancouver.

The above parameters of white spruce were studied during the winters of 1990-91 and 1991-92. Both the release of dormancy and the development of stress resistance were delayed by the very mild temperatures obtaining during the winter of 1991-92, but the development and degree of cold hardiness were not affected. The release of cold hardiness and of bud dormancy are both strongly correlated ($R^2 > .90$) with the number of degree hours at 5°C . to which the seedlings were exposed and both were initiated after an exposure of about six hundred hours. Seedling resistance to a crushing stress, as measured by the plants' ability to initiate and grow new roots after treatment was not related to cold hardiness but appeared to be influenced by exposure to 5°C . temperature. Maximum stress resistance occurred between late November and early February. Although root growth of the control seedlings varied throughout the experimental period, there was no correlation between total root elongation and duration of seedling exposure to 5°C . temperature.

GENETICS EFFECTS ON WOOD SHRINKAGE IN DOUGLAS-FIR (*PSEUDOTSUGA MENZIESII* (MIRB.) FRANCO). Mathew P. Koshv & Donald T. Lester, University of British Columbia, Vancouver.

416 trees belonging to 48 full-sib families were sampled from a 18-yr-old progeny trial (Ministry of Forests, B.C.). Wood shrinkage in three dimensions, longitudinal, transverse and radial, were assessed at different age intervals within the tree, using samples prepared from a bolt taken at breast height of the tree. Shrinkage changed rapidly as a function of age from the pith. Longitudinal shrinkage decreased whereas radial and transverse shrinkage increased. Variation among trees within family was the largest single source of variation. Estimates of proportion of variation that would be transmitted to the progeny (heritability) varied at different age intervals.

Growth Response Specificity of Spruce Inoculated with Rhizosphere Bacteria. C.P. Chanway and G.A. O'Neill, Forest Sciences, University of British Columbia.

The influence of rhizosphere bacteria on hybrid spruce (*Picea glauca* x *engelmannii*) seedling growth was investigated by isolating bacteria from the rhizosphere of naturally-regenerating spruce seedlings collected from two ecologically distinct zones of British Columbia. After an initial spruce growth screening experiment, the six most effective seedling growth promoting rhizosphere bacteria were re-tested using a factorial design in which seed, soil, and bacteria from both locations were examined in all possible treatment combinations, including pasteurized soil. Depending on the treatment combination, seedling biomass accumulation was stimulated by up to 59% in response to bacterial inoculation. Seedling biomass was greater when spruce seed, soil and rhizosphere bacteria originated from the same geographic site in comparison with treatments in which at least one factor (seed, soil and/or bacteria) originated from the other site. Soil pasteurization negated this effect. However, seedling growth promotion relative to uninoculated controls did not depend on the use of conifer seed, soil, and rhizosphere bacteria collected from the same area.

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RAPID, REPEATABLE DETERMINATION OF SOIL MOISTURE IN FOREST CANOPY GAPS USING TIME DOMAIN REFLECTOMETRY (TDR). Andrew N. Gray Oregon State University, Corvallis.

The accuracy of TDR for determining volumetric water content was evaluated for soils from four forest stands. The TDR system operates by measuring the dielectric constant within waveguides defined by parallel steel probes, making it a rapid, non-destructive, and repeatable method. Proven effective in agricultural soils, TDR has rarely been applied to heterogeneous forest substrates. Regressions developed from TDR measurement of gravimetric soil samples were accurate within .03 cm³/cm³ volumetric water. Some soil types required separate regressions. The TDR technique was able to detect differences in soil moisture patterns within and among canopy gaps of different sizes.

EFFECT OF SALAL REMOVAL ON TREE HEIGHT GROWTH AND FOLIAGE N: A PRELIMINARY STUDY. C.M. Preston*, X.C. Chang**, and G.F. Weetman** *Pacific Forestry Center, Victoria; **University of British Columbia, Vancouver.

Salal (*Gaultheria shallon* Pursh.) competes with young conifer regeneration for N on old growth cedar/hemlock cutovers on northern Vancouver Island. To study the effect of salal competition on fertilizer N distribution and recovery in trees, microplots (1 m radius) isolated to 50 cm depth using plastic barriers were planted to western hemlock, western red cedar and sitka spruce. In half of these plots salal was removed by repeated clipping (treated) and in the other half salal was present as understory (control). (¹⁵NH₄)₂SO₄ was applied at 200 Kg N ha⁻¹ in April 1991. Results obtained show that salal removal caused a significant increase in tree height growth. The greatest increase was observed for western hemlock. Non-salal understory foliage (taken from control plots) had higher N concentration than salal foliage in July, 1991. This was reversed in November due to the evergreenness of salal, which takes up N throughout the year. Salal removal did not significantly affect first year tree foliage N concentration in June, August and November. N-15 enrichment in tree foliage appeared to be greater in control than in treated plots. We think this is a dilution effect and expect N-15 content in biomass to be greater in treated plots.

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INFLUENCE OF RIPARIAN VEGETATION ON MICROBIAL DEGRADATION OF HERBICIDES IN SOIL. J.A. Entry, W.H. Emmingham, Forest Science Department, Oregon State University, Corvallis, OR USA

The persistence of aromatic herbicides in the environment has generated much concern because of their tendency to bioaccumulate and because of their potential effects on human health.

The type of vegetation growing on a site has profound effects on the soil microbial community. Forest vegetation, through litter deposition provides a favorable environment for the development of a rich soil fungal community. The establishment of forest vegetation in riparian areas adjacent to agricultural fields has been suggested as a method to control nonpoint source pollution. Riparian areas growing forest vegetation have a soil ecosystem with higher microbial biomass than riparian areas that are currently used as pasture. Forested riparian areas have a soil ecosystem that resulted in higher atrazine and 2,4-D degradation than riparian areas in pasture. This study indicates that the alternative agricultural practice of forest ecosystems in riparian areas may substantially reduce the input of toxic herbicides applied to agricultural fields to lakes and streams.

OZONE IN WESTERN WASHINGTON FORESTS. Felix A. Basabe, Huxley College, Western Washington University, Bellingham.

Ozone data from 16 ground sites and from 31 hours of aircraft measurements will be presented. Ozone measurements in forested areas from 1985 to 1988 were consistently higher compared to the upwind urban area. Phytotoxic ozone episodes were measured on several occasions at different sites during this period. Aircraft measurements taken in 1988 showed high ozone levels over several thousand square kilometers in western Washington and southwestern British Columbia.

WINDFALLS IN THE SIOUXON DRAINAGE, SOUTHWESTERN WASHINGTON, USA. Charlotte Pyle. University of Washington, Seattle.

In an extensive survey for forest blowdown in the Siouxon drainage, uprooted trees were more typically found along clearcut edges than along naturally occurring edges or in large blocks of uncut forest. High contrast edges (old growth/recent clearcut) were intensively sampled to determine the number and direction of windfalls relative to edge aspect and topographic position within the watershed. For each windfallen (uprooted) tree, species, crown class, distance from clearcut boundary, and root and soil conditions were noted. Edges facing southwest toward the prevailing winds had the greatest number of windfallen trees per decameter of edge. However, east-facing edges also had a high number of windfalls reflecting the intensity of winter storm winds from the east. True firs (*Abies* sp.) were uprooted in greater proportion than they occurred in the stands next to the clearcuts. A disproportionately low number of uprooted dominant and codominant trees may be attributable to the high proportion of true fir in the intermediate and suppressed crown classes. In general, blowdowns did not extend beyond 30 m from the clearcut edge. Where they did surpass 30 m, the forest edge was heavily dominated by silver fir (*A. amabilis*), and the topographic position was conducive to blowdown as well. Overall, the interaction of both landscape and stand level factors is important for the placement of windfirm edges.

CLOUDWATER CHEMISTRY AT STAMPEDE PASS AND THE ALPINE LAKES WILDERNESS AREA. Linda Cuykendall and Tony Basabe, Huxley College, Western Washington University, Bellingham.

Cloudwater samples were collected at Stampede Pass and in the Class I Alpine Lakes Wilderness Area to determine if cloudwater chemistry at Stampede Pass was representative of cloudwater collected at Granite Mountain. A passive collector was used at both sites. All samples were analyzed for hydrogen, sulfate, nitrate, chloride, ammonium, calcium, magnesium, potassium and sodium concentrations. A total of 156 samples were collected from July-September, 1991. Sample pH ranged from 3.5-6.7. Nitrate and sulfate were the dominant anions. Events were not collected simultaneously at both sites however, the chemical composition of cloudwater at Stampede Pass was similar to that found in the Alpine Lakes Wilderness Area.

ECOZONES OF THE NORTHWESTERN CASCADES. Jan A. Henderson, Robin D. Leshner, and David H. Peter. Mt. Baker-Snoqualmie and Olympic National Forest.

Gradient modeling approaches were used to develop a landscape-level environmental gradient model for the Mt. Baker-Snoqualmie National Forest. The model depicts a meso-scale moisture gradient across the Forest. This gradient is affected by prevailing storm tracks from the Pacific, modified by orographic effects related to topography. The model uses the elevation and aspect of the lower boundary of the Silver Fir Zone in this area to generate a map of "ecozones" where the Silver Fir Zone boundary falls within ± 150 ft (~ 46 m) of zonal limits. Once depicted as a map, the ecozone model can be used to describe and analyze the distribution pattern of species and Plant Associations across the landscape. It can also be used as a layer in a Geographic Information System to help map Vegetation Zones and Plant Association Groups.

PREDICTING THE LOCATION OF RECREATIONAL-CAUSED FIRES IN SLAVE LAKE PROVINCIAL FOREST, ALBERTA. Cristina Vega Garcia, P.M. Woodard, University of Alberta, Edmonton, B.S. Lee, NoFC Forestry Canada, Edmonton.

Recreation-caused wildfires are common in Alberta. This is particularly true in Slave Lake Provincial Forest, where an average of \$ 500,000 per year is spent on forest fires caused by people. In this presentation, we discuss how choice behaviour theory and site attribute information can be used to predict occurrence. We will outline statistical procedures to be used and show how neural net software may be applied to solve this problem. The approach represents a significant deviation from approaches currently being used.

PRIMARY CAVITY EXCAVATORS IN MANAGED ABIES GRANDIS FOREST HABITATS IN WASHINGTON'S EAST CASCADES. Kenneth R. Bevis Central Washington University, Ellensburg.

Cavity excavating bird species are important components of forest ecosystems. We examined how these species responded to timber management in one forest type under three management regimes: unmanaged, partial cut (shelterwood) and minimal retention (seed tree). We measured relative abundances of primary cavity excavators, snag densities and canopy closure. First year results (1991) suggest a relationship between snag densities and primary cavity excavator abundance and diversity.

ENDANGERED, THREATENED AND SENSITIVE PLANTS OF FORT LEWIS MILITARY RESERVATION Ted B. Thomas and Andrew B. Carey USDA, PNW Research Station Olympia, Washington 98502

The occurrence of rare plants and their habitats have not been well-studied in the southern Puget Sound region. Fort Lewis Military Reservation covers 86,000 acres in southern Puget Sound province, of which 24,000 acres are non-forested, prairie and wetland sites. The objective of this study is to identify and delineate the location of rare plants and associated species, and describe and map their habitat. The Natural Heritage Program of the Washington State DNR have identified 19 sensitive plants and 1 endangered plant suspected to be found at Fort Lewis. Two of these rare plant species (Aster curtus and Trillium parviflorum) have been located at Fort Lewis, we will attempt to determine the occurrence of the remaining species. Information from this study will assist the Army in the protection and management of rare plants and their habitat.

BARKING DAMAGE OF LODGEPOLE PINE K. Arké Friedmann University of Alberta, Edmonton, Alberta, Canada.

Damage to lodgepole pine (*Pinus contorta*) by the removal of bark by small animals is having a severe impact on the survival and productivity of stands near Hinton, Alberta. The objectives of this study are: to determine when during the year barking damage occurs, to determine the primary damaging agent (red squirrel [*Tamiasciurus hudsonicus*] or snowshoe hare [*Lepus americanus*]), to determine if trees with previous damage are more susceptible to future damage and to determine if damaged areas have predictive physical or vegetative characteristics. Sixty-three plots were visited bi-weekly, and checked for new damage from the end of May until the end of August. Damage began in early June and continued through July. Eighteen percent of the trees surveyed were subject to new damage, while 49% of previously damaged trees were re-damaged. Contrary to previous beliefs the snowshoe hare is not the primary cause of this damage the red squirrel is. Timing, location, appearance and diameter of trees attacked need to be studied in order to correctly identify the cause of this type of damage. Analysis of tree and plot data is currently under way to find predictive characteristics.

WINTER FOOD CACHING BY MOUNTAIN BEAVERS (*Aplodontia rufa*) IN A GIRDLED DOUGLAS-FIR STAND. J.P. Farley and D.L. Campbell. USDA, Animal and Plant Health Inspection Service, Olympia, WA.

Girdling of basal stems and roots of Douglas-fir (*Pseudotsuga menziesii*) causes excessive tree mortality in managed plantations. Vegetation used by mountain beavers is being determined in a 15-year old stand with basal stem diameters of about 18 cm and canopy coverage of about 72% (SD 30%) near burrow systems prior to tree thinning. To locate food caches, 6 g radio transmitters were attached to sword fern bundles taken by mountain beavers. Cached vegetation recovered in February 1991 was compared with available surface plants within about 9 m of food caches of six burrow systems. Sword fern (*Polystichum munitum*), salal (*Gaultheria shallon*) and Oregon grape (*Berberis nervosa*) were the three major species of thirteen species recovered from food caches and were the dominant surface species. Respective percentages of food cache plants by weight vs ground coverage were: sword fern 34.9% (SD 25.4%) vs 36.4% (SD 20.0%); salal 32.4% (SD 20.0%) vs 47.7% (SD 29.6%), and Oregon grape 8.5% (SD 9.5%) vs 31.8% (SD 35.0%). Percentages of sword fern and salal cached appeared closely related to their availability.

SETTING PLANT COMMUNITY PRESERVATION PRIORITIES: RESULTS OF A 16-YEAR CONSERVATION EFFORT IN WASHINGTON. Rex C. Crawford and Susan Trinh. Washington Natural Heritage Program, DNR, Olympia.

This paper discusses changes in protection priorities of plant communities listed in the Washington Natural Heritage Plan (WNHP). Plant community types indicate terrestrial ecosystems and used to assess the protection of and threats to common, native plant species in their natural habitats. Biennial updates of the WNHP from 1983 to 1991 are compared with the initial conservation needs assessment in the 1975 federal "Yellowbook". Protection priorities of and preserves with plant communities are compared by province and zone within province. The increasing numbers of plant community types listed in WNHP reflects additional studies and the location of natural landscapes in the state.

EFFECTS OF GRAZING ON HIGH ELEVATION SENSITIVE PLANT HABITATS IN THE OKANOGAN NATIONAL FOREST. Felix A. Basabe, Huxley College, Western Washington University, Bellingham.

Rare plant meadow habitats were surveyed after 90 years of being grazed and again after six years of not being grazed. There has been an apparent increase in the occurrence of sensitive species in these habitats since grazing was halted. However, it appears that grazing was responsible for preventing forest encroachment on some of the sensitive plant meadow habitats. Light grazing may be required to maintain some of the sensitive species occurrences on rangelands.

TAXONOMY AND CONSERVATION OF THE GRAPE FERNS AND MOONWORTS (GENUS *BOTRYCHIUM*) IN THE PACIFIC NORTHWEST. David H. Wagner University of Oregon, Eugene.

At present there are at least sixteen species of *Botrychium* in the Pacific Northwest, making it the largest genus of ferns in the region. Several have been named only in the past ten years and a few are still undescribed. Some are very rare and present challenging conservation problems, in part because of the difficulty in telling the species apart. Ongoing field research is helping to clarify the boundaries between the species, characterize their ecology, and add to our knowledge of the species' distribution. It is now possible to provide a pictorial summary of the genus and discuss the critical features which are used to distinguish the species. Research based guidelines for ethical, non-damaging specimen collecting are being developed. Specialized pressing methods, which assure the greatest amount of morphological data are preserved, are recommended.

STATUS OF RARE PLANT INVENTORY
AND PROTECTION EFFORTS IN
WASHINGTON STATE. John G. Gamon.
Washington Natural Heritage Program,
DNR, Olympia.

Inventory efforts coordinated by the Washington Natural Heritage Program have resulted in the classification of over 250 native vascular plant taxa as Endangered, Threatened or Sensitive. More than 2500 occurrence records exist for these taxa. Federal lands have been more systematically inventoried than either state or private lands. Protection has been provided through agency policies, establishment of natural areas and voluntary landowner protection. However, most taxa occurring on private lands remain essentially unprotected. Future Washington Natural Heritage Program inventory and protection efforts should focus on taxa occurring primarily on state and private lands. Voluntary landowner protection is likely to be increasingly important for rare plant conservation.

RARE PLANTS OF THE WENATCHEE
MOUNTAINS, WASHINGTON. Richy J. Harrod, U.S.D.A Forest Service,
Leavenworth, WA.

There are 51 plants which occur in the Wenatchee Mountains that are listed by the Washington Natural Heritage Program (DNR) as either Endangered, Threatened or Sensitive (ETS), and all listed as sensitive by the U.S.F.S Regional Forester. Many of these plants, such as Delphinium viridescens, Petrophytum cinerascens, Sidalcea oregana var. calva, Silene seelyi and Trifolium thompsonii, are strict endemics. Many known populations of these species and other ETS plants occur on National Forest lands. A general lack of information concerning the biology and ecology of these species makes it difficult for land managers to make appropriate decisions when timber sales or other projects occur within the vicinity of rare plant populations. Research and management must work closely in order to protect ETS plants by designing studies which meet management needs.

VEGETATION OF THE NOISY CREEK
WATERSHED. Richy J. Harrod and
Ronald J. Taylor, Western
Washington Univ., Bellingham.

The vegetation in the Noisy Creek watershed, near Baker Lake, Washington, was described as part of a Endangered, Threatened and Sensitive (ETS) plant survey. A systematic search method was used to locate ETS plant species, to compile a species list and to qualitatively describe plant communities. Platanthera sparsiflora was the only ETS species found. However, 257 species of plants and 12 distinct plant communities were identified throughout the watershed. Plant communities were distributed in three major forest zones: Tsuga mertensiana/Abies amabilis, Tsuga heterophylla/Abies amabilis and Tsuga heterophylla/Thuja plicata. These forest types can be considered climax, or "old growth", based on age (ca. 750 years) and diversity of forest stands (multi-layered), species richness and soil composition.

RE-CLASSIFICATION OF FOREST AND
HIGH ELEVATION RANGE HABITATS IN
THE EASTERN NORTH CASCADES OF
WASHINGTON. Therese Bielak and Tony Basabe Western Washington
University, Bellingham.

The objective of this study was to develop vegetation classification methods for rangelands in the Winthrop Ranger District, Okanogan National Forest. Three methods were compared; a 0.75 inch hoop line-intercept method and two methods (plot and transect) using a 20 X 50 cm quadrat. Variability in habitat classification resulted from the use of these different methods. The hoop method tended to over estimate the importance of grasses and sedges.

PLANT SURVIVAL BENEATH 1980 TEPHRA FROM MOUNT ST. HELENS. D. B. Zobel, Oregon State University, Corvallis, and J. A. Antos, University of Victoria, Victoria.

Some subalpine forest understory shrubs, herbs and mosses survived at least eight growing seasons of burial in 15 cm deep volcanic tephra, deposited beneath intact forest in May, 1980. Tephra was removed from 50 m² of forest floor in 1980 and 1982, and 40 m² in 1987, to determine the size and number of buried surviving plants. Following 4, 28, and 87 months of burial, respectively, 6, 3, and 2 shrub species; 23, 16, and 1 herb species; and 12, 10, and 2 bryophyte species survived. Surviving after 87 months were Vaccinium membranaceum, V. ovalifolium, Erythronium montanum, Dicranum pallidisetum, and Rhizomnium glabrescens. Only V. membranaceum emerged from unexcavated tephra; in 1989, some recently emerged shoots were unattached to other shoots, and thus had survived burial for 5-9 growing seasons. Surviving buried plants may be an important but hidden source for delayed revegetation of some disturbed sites.

STUDYING THE EFFECTS OF MUSHROOM HARVESTING ON CHANTERELLE PRODUCTIVITY IN OREGON'S MT. HOOD NATIONAL FOREST. Lorelei L. Norvell University of Washington, Seattle.

The choice edible *Cantharellus cibarius*, ectomycorrhizal with various forest trees, is an economically significant secondary forest product. In 1986 the Oregon Mycological Society (helped by the USDA Forest Service) initiated a ten-year study on whether or not chanterelle harvesting would adversely affect productivity or the growth of the mycorrhizal partners. Ten study plots were established in a 100-year old Hemlock-Douglas Fir stand in the buffer zone of Mt. Hood's Bull Run watershed. Since 1986, new chanterelles have been flagged by numbered skewers and mapped by triangulation with the dimensions of each fruiting body recorded every two weeks throughout the fruiting season. Since 1989 six of the ten plots have been harvested with chanterelles removed by cutting (3 plots) or pulling (3 plots). Four plots (in which no chanterelle removal is permitted) serve as controls.

Three years of harvesting data indicate that picking chanterelles does not have an adverse impact on subsequent chanterelle productivity over the short term. Additional observations suggest that canopy closure, annual mean temperature, precipitation, and the presence of coarse woody debris may be more significant in the productivity of a given chanterelle site.

INVASION OF INDIGOBUSH (AMMORPHA FRUTICOSA L.) ALONG THE COLUMBIA AND SNAKE RIVERS, WASHINGTON AND OREGON. Richard R. Halse, Oregon State University, Corvallis, OR, and Judith B. Glad, Portland, OR.

Indigobush is a common component of riparian communities throughout much of the United States, but was not reported in the Northwest until the 1980s. It occurs along the Columbia River from the Hanford Reach to the mouth of the Willamette River on the Oregon shore and to Wahkiakum County on the Washington shore. On the Snake River, it has been found as far upstream as Garfield County, Washington, and Malheur County, Oregon. It has also been reported on the Umatilla River. It occupies the upper fluctuation zone of run-of-the-river reservoirs and the upper drawdown zone of storage reservoirs. The usual substrates are rock (including riprap) and sand. The species may have been introduced for erosion control or as wildlife food and cover. Fruits of indigobush are reportedly dispersed by wildlife, but there are indications that they can be transported by water as well.

VARIATION AND RELATIONSHIPS OF PLANT COMMUNITIES IN THE NORTH CASCADES. George Wooten and Peter Morrison.

Plant communities in the North Cascades Mountain Range of Washington respond dynamically to an extreme range of environmental factors. Vegetation types encompassing maximum spectral and geographic representation across the North Cascades were sampled and 1432 detailed plots were then selected to construct 261 composite samples. Detrended correspondence analysis on this data successively reduced by the elimination of outliers and obvious clusters resulted in a classification of minimally variant data sets. These data sets reveal details of plant community structure and facilitate environmental gradient analysis.

CLIMATE CHANGE AND SUBALPINE TREE GROWTH. David W. Peterson and David L. Peterson. National Park Service, C.P.S.U., University of Washington, Seattle.

Relationships between climate and annual growth were studied for Abies lasiocarpa, Picea engelmannii, and Larix lyallii growing near treeline in the North Cascades. Mixed- and single-species stands were sampled from ridgetop, midslope, and valley sites. Methods of dendroecology were used to relate variations in annual ring widths to seasonal climatic variables. Cold November temperatures negatively affect the following year's growth for all three species. A. lasiocarpa and P. engelmannii growth is promoted by cool, wet springs and low snowpacks. Growth of L. lyallii and P. engelmannii is positively correlated with early summer temperatures. The deleterious influence of snowpack is accentuated for trees growing on north-facing sites and in topographic depressions.

EFFECTS OF CLIMATE ON REGENERATION OF SUBALPINE FORESTS FOLLOWING WILDFIRE. Ronda L. Little and David L. Peterson. National Park Service, C.P.S.U., University of Washington, Seattle.

The influence of climate on subalpine conifer regeneration was examined on two large 90-year old burns northeast of Mount Rainier, Washington. We sampled 520 trees for age determination, and recorded microsite characteristics, soil type, herbaceous vegetation, and tree dimensions. Discrete peaks of tree establishment in the late 1950's, 1983, and 1989 were positively correlated with warm spring temperatures, and high summer precipitation, but were negatively correlated with high summer and fall temperatures. Establishment after wildfire may be faster and less periodic if springs become warmer, but these patterns may be offset by warmer and drier summers.

EFFECTS OF CLIMATE AND OTHER ENVIRONMENTAL FACTORS ON TREE ESTABLISHMENT IN SUBALPINE MEADOWS. Regina M. Rochefort and David L. Peterson, National Park Service, C.P.S.U., University of Washington, Seattle, WA.

Tree invasions in subalpine meadows of the Cascade Range occurred in the late 1800s and 1930s during periods of reduced snowpack and warmer temperatures. We studied spatial and temporal patterns of tree establishment in six subalpine meadows of Mount Rainier National Park and found distinct periods of invasion of Abies lasiocarpa in the mid-1980s. Spatial distribution is associated with herbaceous cover and topography. Temporal establishment is related to snowpack and warm temperatures. A warmer, drier future climate could allow more frequent periods of tree invasion and a directional change in the forest-meadow ecotone.

UNGULATE/FOREST RELATIONSHIPS IN OLYMPIC NATIONAL PARK: RETROSPECTIVE EXCLOSURE STUDIES. Andrea Woodward, Douglas B. Houston, Edward G. Schreiner, Bruce B. Moorhead Olympic National Park.

The effect of Roosevelt elk (Cervus elaphus roosevelti) on stand structure of old-growth Sitka spruce (Picea sitchensis) forests was evaluated by revisiting the sites of elk exclosures established ca. 1935 and ca. 1955 in Olympic National Park. Cover, morphology, growth and establishment of herbaceous, shrub and tree species were evaluated inside and outside of exclosures. Elk were seen to effect the growth and morphology of shrubs (e.g. Vaccinium spp., Rubus spectabilis), understory trees (e.g. Acer circinatum), and establishment of overstory trees (e.g. Tsuga mertensiana). We conclude that elk substantially influence the structure, and therefore function, of old-growth forests of the western Olympic Peninsula.

EFFECTS OF MINERAL DEFICIENCIES
ON PHOTOSYNTHESIS OF SITKA
SPRUCE SEEDLINGS. R.H. WAGNER
UNIV. OF WASHINGTON, SEATTLE

Sitka Spruce seedlings were grown in sand culture in a greenhouse. Nutrients were supplied at three levels: low, medium, and "complete" (1/4 strength Hoagland-type solution). The low level was designed to induce "hidden hunger", a nutrient supply above the appearance of visible symptoms, but mild symptoms were visible at the low levels. During winter, artificial photoperiod and supplemental irradiance were used. Changes in the partial processes of photosynthesis were inferred from open gas-exchange system measurements. Light-response curves were used to obtain the net photosynthetic rate at light saturation and the photochemical efficiency from the slope at limiting light levels. Dark respiration was measured, and total leaf resistance to CO₂-transfer was calculated.

PLANT SPACE BEHAVIOR CONFIRMS W-
WAVE HYPOTHESIS. O.E. Wagner. Wagner
Research Lab., Rogue River, OR 97537

My work confirms that W-waves are important to plant organization (e.g. Nothw. Sci. 64:28-38). In space experiments (e.g. Ann. Revs. of Plant Physiol. 38:317-345) disorganization of growth of cells and other structures appears to be a typical effect of the microgravity environment. See book "W-Waves and A Wave Universe". From my experiments it appears that certain W-wave effects depend on the presence of a strong gravitational field and thus shapes, sizes, and spacings might be effected because of the lack of the appropriate W-wave patterns. Microscopic structures in cell components might also be changed. Long term stays in space might be impossible for any type of cell, including animal, without the presence of the hypothesized W-wave supporting gravitational field. Another possibility is that the space environment just disturbs the organization of the W-wave field without a gravity dependence and the microscopic structures of plants do not necessarily require a large g.

IN VITRO PROPAGATION, CALLUS
INDUCTION, AND PROTOPLAST
ISOLATION OF MELALEUCA
ALTERNIFOLIA. Tze-Huey Wah and
Hubertus Kohn. Western Washington
University, Bellingham, WA.

The tissue culture potential of the woody Australian plant Melaleuca alternifolia was investigated. Shoot micropropagation with substantial bud proliferation was achieved on a soft (0.4% Agar) Shipton medium supplemented with 1 mg/l BAP. Rooting of propagated shoots was initiated on soft Shipton medium without hormones. Callus induction was attained only with shoot tip explants from in vitro grown plantlets on Shipton medium solidified with 0.15% Gelrite and supplemented with BAP (1mg/l), 2,4-D (0.2 mg/l), gibberellic acid (2mg/l) and three amino acids: 87 g/l glutamine, 26.6 g/l aspartic acid, 17.4 g/l arginine. Callus maintenance and growth was not successful on this or other media. Protoplast isolation from leaf mesophyll was only possible after extensive etiolation of leaves with gibberellic acid and dark treatments. Culture of protoplasts was not successful.

OTHER HARMONICS IN PLANT SPACINGS.
O.E. Wagner. Wagner Research Lab.,
Rogue River, OR 97537.

I previously reported that many plant spacings represent harmonics of 1.6 Hz with other harmonics unidentified (Northw. Sci. 64:28-38). Apparently the 1.6 Hz harmonics are more associated with horizontal spacings while vertical spacings like distances between joints on Zea mays (2.4 Hz) represent harmonics of 0.6 Hz the reciprocal of 1.6. This was found for other plants with distances between 164 branch whorls of approx. 14 m ponderosa pines peaking at exactly 0.6 Hz with some minor peaks. Similarly 471 vertical spacings from Equisetum arvense revealed the most major peak at 8.4 Hz the 14th harmonic of 0.6 Hz while 315 spacings from Equisetum hyemale gave the most major peak at 5.4 Hz the 9th harmonic of 0.6 Hz. Plants like Lonicera hispidula vacillans give major peaks at harmonics of both 1.6 and 0.6 Hz like 8, 9.6, 12, 13.8, 16, 19.2, 32, and 48 Hz with a few peaks at, for example, 5 and 26.7 which are as yet unidentified with a definite harmonic series. See book "W-Waves and A Wave Universe".

THE PAST DISTRIBUTION AND CURRENT STATUS OF THE SPOTTED FROG (*Rana pretiosa*) IN WESTERN WASHINGTON. William P. Leonard Washington Department of Ecology.

Herpetologists in the Pacific Northwest noticed the decline of the spotted frog over 25 years ago. Spotted frogs once inhabited large areas of Western Washington. Today, they can be found in good numbers in the North Cascades and the northern portion of Eastern Washington. The cause of the decline is unknown, but introduced bullfrogs (*R. catesbeiana*) spiny ray fishes, as well as habitat loss, are among the leading theories. Western Washington museum specimens were examined to establish the historic range in Western Washington, and extensive field surveys were conducted between 1989-1991 to establish the species' current range. Whatever the reason, the spotted frog appears to be gone from most formerly known localities in Western Washington. In fact, there have been few verified sightings of the species in Western Washington since 1940. In 1990, a single spotted frog was found near Olympia. Attempts to find others there have so far failed. However this discovery renews hope that wild populations still exist in Western Washington.

DISTRIBUTION OF PYGMY RABBIT (*BRACHYLAGUS IDAHOENSIS*) BURROWS IN SAGEBRUSH FLATS, WASHINGTON. Megan L. Gahr WACFWRU, University of Washington, Seattle.

In September 1991, a pygmy rabbit burrow survey was conducted in Sagebrush Flats, yielding a complete distribution and total count of burrow systems. Sagebrush Flats is the largest area where pygmy rabbits are known to occur in Washington State, and 75% of the area is leased for grazing. Active burrows were located in 1-ha units using a coordinate system. A total of 588 burrow systems were counted. The distribution of the burrows corresponded to three main drainage systems. The mean number of burrow systems per 1-ha plot was 1.6 in the grazed and 1.8 in the ungrazed portions. The total number was larger than known for the area based on a previous survey. The location of the burrows indicates that microtopography plays a key role in site selection. Burrows per unit area was similar between the grazed and ungrazed sections. This survey was the first step in a larger project to assess habitat use and population characteristics of pygmy rabbits in Eastern Washington.

DISTRIBUTION AND STATUS OF THE FISHER IN WASHINGTON. Keith B. Aubry U.S. Forest Service, Pacific Northwest Research Station, Olympia, Washington and Douglas B. Houston National Park Service, Olympic National Park, Port Angeles, Washington.

Our objectives were to determine the distribution of fishers (*Martes pennanti*) in Washington using sighting and trapping records, and evaluate their occurrence in relation to major vegetation and elevation zones. We obtained a total of 137 records from 1894-1991. Fishers still occur in the Cascade and Olympic Mountains and in portions of the Okanogan Highlands. They appear to be absent from the eastern edge of Puget Sound, the Kitsap Peninsula, the Willapa Hills, and the Blue Mountains. Fishers occupy different elevation zones east and west of the Crest. Western records were strongly skewed toward low to mid-elevations; 87% were at < 1000 m and the remainder were at < 1800 m. Only 30% of eastern records were at < 1000 m, and 18% were from 1800-2200 m. Most western records (54%) were from the Douglas-fir forest zone; remaining records were from the Pacific silver fir zone (26%) and the Sitka spruce zone (20%). Most eastern records (53%) were from the subalpine fir zone; others were from the Grand fir/Douglas-fir (37%) and alpine zones (10%).

DISTRIBUTION AND SPECIATION PROBLEMS WITH POCKET GOPHERS (*Thomomys* spp.) IN OREGON AND WASHINGTON. Gary Witmer USDA Animal and Plant Health Inspection Service, Olympia, WA.

Pocket gophers are a distinct, specialized, subterranean mammal occupying much of western North America. In many areas, populations are controlled because of damage caused by feeding and burrowing activities. About 5 species and 20 subspecies are recognized in Oregon and Washington. Many small, disjunct populations are considered subspecies and some of these are being considered for federal protection by the USFWS. Distributions of these subspecies is poorly known with reliance on old records. Considerable intergrading occurs. Speciation has been in a state of flux partly due to the variation in morphological characters and poor understanding of the genetics and breeding relationships between species and subspecies. An effort is needed to delineate the range of species and subspecies and to provide criteria for reliable identification of live specimens in the field.

WASHINGTON STATE SHRUB STEPPE ECOSYSTEM STUDIES; WITH EMPHASIS ON AVIAN SPECIES OCCURRENCE, DENSITIES AND DIVERSITY. Frederick C. Dobler Washington State Department of Wildlife

Fifty five randomly selected sites in eastern Washington shrub steppe were surveyed in April and May, to determine the bird species composition of shrub steppe habitats. Three years of study with a total of 8,727 observations, recorded 94 species of birds. Four species, the western meadowlark, the horned lark, Brewer's sparrow and the vesper sparrow together made up over two thirds of the total observations. By contrast, 47 species were seen on three or fewer sample sites, and 38 of these species had three or fewer observations. Density was calculated for 18 species, including Brewer's sparrow, sage sparrow and sage thrasher, which had mean densities for all years combined of 0.63, 0.17, and 0.24 birds per hectare respectively, for the sites where they occurred. Comparisons of bird counts and plant species cover values showed a significant correlation between Shannon-Weaver indices of diversity.

STATUS OF GREAT BLUE HERON NESTING COLONIES IN KING COUNTY WASHINGTON. Henning Stabins and Kenneth Raedeke, Raedeke Associates Inc., 5711 NE 63rd. Street, Seattle, WA. 98115

Field surveys and review of historical data were used to determine the current number of great blue heron nesting colonies and nests, and history of individual colonies. The number of heron colonies has increased from 4 in 1983 to 12 in 1990, with number of nests increased from 40 to 161. The number of nests was increasing in 6 colonies, and was stable in 2. No trend could be established in 3 colonies. One colony of 39 nests was destroyed by eagles in 1991. Average disturbance free buffer area around the colonies was 49.8m (range 17 to 91m). Previous colony inventories noted loss due to direct harassment and shooting of herons. Colonies of less than 8 nests were most vulnerable to disturbance. Heron colonies are now increasing numbers and size, even with urbanization of their habitat, but face threats from the recovering bald eagle population in the region.

STATUS AND DISTRIBUTION OF BALD EAGLES IN WASHINGTON. James W. Watson Washington Department of Wildlife, Mill Creek.

About half of the breeding and wintering bald eagles (Haliaeetus leucocephalus) in the 7-state Pacific Recovery Area reside in Washington state. Most productivity and winter population goals for the state have been met; as of 1991 there are 444 nesting pairs, producing an average of 0.99 young per occupied territory, and stable to increasing wintering populations. Four of 11 sub-recovery zones within the state have not met recovery.

Habitat security remains the key to delisting the species. The majority of nests are on private land so efforts to protect habitat must be balanced with landowner rights, resulting in various degrees of protection. Goals for habitat security need to be established.

SPECIES COMPOSITION OF TWO OREGON CENTRAL COAST GULL (LARUS SP.) FLOCKS. Kathy Merrifield, Department of Botany and Plant Pathology, 2082 Cordley Hall, Oregon State University, Corvallis, Oregon. 97331-2902.

Western, Glaucous-winged, California, and Mew Gulls (Larus occidentalis, L. glaucescens, L. californicus, and L. canus, respectively) were the major component species of gull flocks in the Yachats River mouth in 1990 and 1991 and at Ona Beach in 1990. Western Gulls were present in all months and usually constituted over 75% of each flock from December through September. Glaucous-winged Gulls were well-represented in all months and were most numerous from December through April, usually constituting less than 20% of total gulls. Mew Gulls reached maxima in December or January, usually constituting less than 20% of total gulls, and were absent from June through September. California Gulls were absent from Ona Beach but sporadic at Yachats from January through March. California Gull numbers increased gradually through the summer and sharply in the fall, reaching maxima constituting from 75 to 89% of the each flock total in October. Total gull numbers peaked in October, coinciding with California Gull maxima. More minor component species occurred at Yachats than at Ona Beach. Monthly average flock totals were similar in size and fluctuation between the two sites.

PRELIMINARY OBSERVATIONS OF NESTING RAVENS (*CORVUS CORAX*) ON SAN JUAN ISLAND, WASHINGTON. Linda T. Campbell, P.O. Box 1502, Friday Harbor, WA 98250.

A census of common ravens nesting on the 56 square mile island of San Juan, in the San Juan archipelago of northwestern Washington, was begun in the spring of 1990 and continued in 1991. Raven territorial behavior led the author to most nests, all of which were in coniferous trees. Data were collected regarding the forest habitat and the nest tree characteristics as well as on the behavior of the nesting ravens. Ten nests, seven of them active, were discovered in 1990, and ten active nests were observed in 1991. Further study will be necessary to determine the total nesting population of the island.

SENSITIVITY OF POPULATION GROWTH RATES TO LIFE HISTORY COMPONENTS FOR MEDIUM-SIZED MAMMALS. James G. Hallett, Washington State University, Pullman, Margaret A. O'Connell, Eastern Washington University, Cheney.

Identification of the demographic components that most strongly influence animal population dynamics is essential for understanding life-history evolution and for conservation and management. We compared aspects of the population dynamics of two species with similar food requirements, but very different life histories: Virginia opossum (*Didelphis virginiana*) and raccoon (*Procyon lotor*). These species were studied by monthly live-trapping and radio-tracking from June 1980 to December 1984 in a small watershed at the Conservation and Research Center, National Zoological Park, Front Royal, Virginia. Population structure and dynamics were examined by constructing age- and stage-classified matrix models for each species. The elements of these matrices were the fertilities and survival probabilities of females in each age or stage class. The matrices were analyzed to determine the relative importance of fertility versus survival on population growth. For opossums, first year survival and reproduction had the greatest effect on population growth. Survival of adults was generally most important for raccoons. Changes in demography were attributable to a rabies epidemic that affected only raccoons.

STUDIES OF THREE TRANSLOCATED POPULATIONS OF THE WESTERN FENCE LIZARD IN NORTHERN PUGET SOUND. H.A. Brown, Western Washington University, Bellingham.

Sceloporus occidentalis is the most common and widespread lizard in the western United States, but there are no studies on populations living in northwestern Washington. This study provides data on body size and growth in three introduced populations at beach habitats where this species does not occur naturally, and it is part of an ongoing study of population dynamics of the species in northern Puget Sound. The parent population (15 miles north of Everett, WA) was surveyed from May 1986 to October 1991 by mark and recapture techniques. In September of 1986 I transplanted 10 adults, 15 subadults, and 25 hatchlings to Clayton Beach (along Chuckanut Drive in Skagit County), but I did not find the lizards here again until May of 1990. With this discovery I made further experimental transplants of juveniles during May/June of 1990 to Clayton Beach and two other beach sites (Oyster Creek and Cherry Point). Clayton is successful, and the last two populations also produced hatchlings in October of 1991.

EDGE EFFECTS ON SMALL MAMMALS IN FOREST REMNANTS OF SW OREGON.

L. Scott Mills, Biology Dept., Univ. of CA, Santa Cruz, CA.

Edge effects operate in a species-specific fashion on a system of 16 small (0.5-10ha) forest remnants surrounded entirely by clearcuts. The abundance of Townsends chipmunks (*Eutamias townsendii*) and Trowbridge shrews (*Sorex trowbridgii*) show no spatial trends across these forest remnants. However, capture rate of red-backed voles (*Clethrionomys californicus*) decreases from the interior to the forest/clearcut edge, while deer mice (*Peromyscus spp.*) show the opposite trend. While neither log volume, log abundance, soil moisture, or light levels relate to distance from the edge, soil temperatures do correlate with the vole and deer mouse edge effects. This abiotic factor, in conjunction with changing food abundances, may explain differences in species responses to forest edge.

LOG USE BY CALIFORNIA RED-BACKED VOLES.

David A. Tallmon and L. Scott Mills

Biology Dept., University of California, Santa Cruz.

Although trapping data have associated the California red-backed vole (Clethrionomys californicus) with downed logs, no radiotelemetry work has examined this relationship. On a forest island in Southwest Oregon we radiotracked four voles and mapped the locations of logs within the home ranges of each vole. On average, 97.8% of vole locations coincided with logs even though logs covered only 11% of the estimated home range area. This high use of logs during both resting and activity periods suggests that downed logs are important for foraging and nesting activities.

ABUNDANCES OF SMALL MAMMALS IN OLD AND YOUNG FORESTS ON THE OLYMPIC PENINSULA. Anne-Marie Gillesberg and Andrew B. Carey, Pacific Northwest Research Station, Olympia, WA.

We compared the abundance and diversity of small mammals occurring in old and young forests. Of particular interest were the patterns of abundance of Peromyscus and Clethrionomys, prey species of the spotted owl. Indices to summer abundances were obtained during 1987-1989 using snap trap transects in 6 old, and 8 young, stands. We caught 2596 mammals of 14 species; Peromyscus oreas, Clethrionomys gapperi, and Sorex trowbridgii were most abundant. Number of species did not differ between old and young forest. Neurotrichus gibbsii, S. monticolus, and P. oreas were the only species consistently more abundant in old forest than in young forest. Abundance of P. maniculatus did not differ among stand types. C. gapperi fluctuated in total abundance, and relative abundance between forest types, among years.

HYPOGEOUS SPOROCARPS IN MANAGED AND UNMANAGED FORESTS OF SOUTHWESTERN OREGON: COARSE WOODY DEBRIS- FUNGAL- SMALL MAMMAL INTERRELATIONSHIPS. David A. Clarkson, Marlboro College, Vermont. L. Scott Mills, Michael P. Amaranthus, Jennifer Ramstetter. Four old-growth forest fragments and clear-cuts abutting two fragments were sampled to address three questions: 1). does truffle abundance differ between forest fragments and clear-cuts?; 2). do logs increase truffle abundance?; 3). does the presence of truffles increase chances of locating California red-backed voles, Clethrionomys californicus? Two forest fragments had 20-40 times more truffles than clear-cuts. Truffles were four times more abundant under logs. Presence of truffles significantly increased the probability of locating voles. The data corroborate suggestions that coarse woody debris, hypogeous sporocarps, and red-backed voles are highly interdependent in both forest fragments and clear-cuts.

EXPERIMENTAL MANIPULATION OF MANAGED STANDS TO PROVIDE HABITAT FOR SPOTTED OWL AND TO ENHANCE PLANT AND ANIMAL DIVERSITY. William L. Kerschke and Andy B. Carey, U.S. Department of Agriculture, Forestry Sciences Laboratory, 3625 93rd Ave. SW Olympia, WA 98502

Since 1850 mature old-growth forests, of which the Spotted owl (Strix occidentalis caurina) is closely associated with, have been reduced by 70 percent. Through the use of silviculture and establishment of arboreal rodent nesting sites, we plan to accelerate the development of Spotted owl habitat in 50-60 year old second-growth forests by providing roosting and foraging habitat for owls, and to raise owl prey populations, especially flying squirrels. Sixteen study areas (8 ha each) were established in thinned and unthinned stands of timber at Fort Lewis Reservation. Sites were trapped prior to experimental treatments over a four week period during the fall of 1991 resulting in 119 Northern flying squirrels (Glaucomys sabrinus), 12 Douglas' squirrel (Tamiasciurus douglasii), and 3 Townsend chipmunks (Tamias townsendii). Prescribed treatments will take place in 1992. Populations will be sampled again in five years to determine success.

ECOLOGY OF THE WESTERN GRAY SQUIRREL
(SCIURIUS GRISEUS) ON FORT LEWIS
MILITARY BASE

Lori A. Ryan and Andrew B. Carey
USDA, PNW Research Station
Olympia, Washington 98502

The Western gray squirrel is a candidate for threatened status in Washington. Although limited information is available on this species, they have often been sighted in Oregon white oak (Quercus garryana). The range of the W. gray squirrel extends only to the northernmost range of Oregon white oak in Pierce County, Washington. Managers at Fort Lewis want to retain gray squirrel habitat. The objectives of this study are to 1) inventory and map habitat used by W. gray squirrel 2) observe squirrel food habits 3) estimate population densities and 4) explore relationships between Oregon white oak and W. gray squirrels. These findings will help in making management decisions on Fort Lewis.

NEST SITES OF NORTHERN FLYING SQUIRRELS
IN MANAGED SECOND-GROWTH FORESTS. Todd
M. Wilson and Andrew B. Carey, USDA,
Pacific Northwest Research Station, 3625
93rd Ave. SW, Olympia, WA 98502

Northern flying squirrels (Glaucomys sabrinus) are the major prey of the Northern Spotted Owl (Strix occidentalis caurina). A telemetry study was initiated on squirrels to examine nest types and frequency of nest use. Sites consisted of unthinned and doubly-thinned stands of 50-60 year old second-growth forests. Some of the stands contained residual live trees and a high coarse woody debris component. Radio transmitters were attached to 31 squirrels and monitored throughout the winter and spring of 1991/92. Nest structures, height of nest site, nest use frequency, and distances between nests were recorded. Preliminary results showed an apparent high use of Douglas' squirrel stick nests; snag and live tree cavities were also used. In the future, the effect of residual trees and coarse woody debris on squirrel populations will be examined.

USING BIOTELEMETRY TO MEASURE MORTALITY
SOURCES IN ELK. Jack L. Smith, Warren
A. Michaelis, and Kreg Sloan, Washington
Department of Wildlife, Olympia.

Helicopter darting was used to capture over 300 elk in four (4) Washington State elk populations. We used radio-collars and internal mortality sensor equipped radios. Animals were monitored weekly. Once a mortality signal was detected, field necropsies were performed to determine cause of death where possible. Other evidence at the scene including physical evidence, drag trails, parts of the animals removed or not removed, distance to the nearest driveable road was collected and recorded. A metal detector was used to examine each scene for evidence of method of kill (bullets or broadhead). This study is half finished with one and one half years remaining. We have to date captured over 300 animals and have investigated 86 mortalities. There are four (4) major causes of mortality. In order of the frequency of occurrence they are: legal take, poaching, wounding, and natural loss.

GLOBAL PERSPECTIVE ON ENDANGERED
BRYOPHYTES. John A. Christy.
Oregon Natural Heritage Program
Portland.

Seventy-five researchers from 42 countries responded to a survey on global protection of endangered bryophytes, circulated to members of the International Association of Bryologists. Europe and Asia reported the greatest decline in species and ecological groups, with liverworts being more sensitive than mosses. The most endangered habitats are tropical forests. More than 60% of the respondents cited forestry as causing the greatest decline, with epiphytes as the most threatened ecological group. Alteration or loss of wetlands was the second most significant cause for loss of species. Only two countries outside of Europe have national lists of endangered bryophytes, although several provincial and state lists exist. More research is needed in the Pacific Northwest before we can answer these questions with any degree of certainty.

DISTRIBUTION OF SOME COMMON FOREST LICHENS ON THE OLYMPIC NATIONAL FOREST. Robin D. Leshar and Jan A. Henderson. Mt. Baker-Snoqualmie and Olympic National Forest, USDA Forest Service.

Presence and abundance of lichens were recorded on 235 plots as part of an ecological inventory of the Olympic National Forest. The data were analyzed for distribution patterns relating to environmental and vegetative parameters, including elevation, ecozone (a moisture gradient), vegetation series and plant association. Common forest species include *Alectoria sarmentosa*, *Bryoria fuscescens*, *Hypogymnia enteromorpha*, *H. inactiva*, *H. imshaugii*, *H. physodes*, *Lobaria oregana*, *Sphaerophorus globosus*, *Platismatia glauca*, *P. herrei* and *Parmeliopsis hyperopta*. *Lobaria oregana* showed a tendency toward mesic and moist habitats, while other species such as *Bryoria fuscescens* and *Hypogymnia* spp. showed tendencies toward drier habitats.

LICHEN REGENERATION FOLLOWING LOGGING IN CARIBOU WINTER HABITAT IN WEST CENTRAL ALBERTA. L.M. Snyder and P.M. Woodard University of Alberta, Edmonton.

This study investigates the effects of logging on terricolous lichen regeneration. Forty-five different-aged clearcuts, one 20-year-old partially-logged and three unlogged stands were sampled for all terrestrial plant species percent covers, post-logging treatments and environmental variables. Results show that lichens reach peak abundance in 20 to 30 year old cutblocks and remain constant thereafter in subalpine ecoregions, but decline after 20 years at lower elevations. Subalpine areas support more lichen overall. The partially logged stand contained the most lichens. Successional patterns in lichen genera are evident with *Cladonia* and *Cetraria* reaching peak abundance in uncut stands. Although lichen abundance recovers to that of unlogged stands in 20 years, differences in species composition may affect utilization by caribou.

USE OF LICHENS BY WILDLIFE IN NORTH AMERICA. Stephen Sharnoff Missouri Botanical Garden

A literature search was made for studies citing significant use of lichens by wildlife. Caribou (*Rangifer tarandus*) consumption of lichens was well documented. A number of studies judged lichens to be vital food in winter for two subspecies of black-tailed deer (*Odocoileus hemionus sitkensis* and *O.h. columbianus*), northern flying squirrels (*Glaucomys sabrinus*), and red-backed voles (*Clethrionomys californicus* and *C. gapperi*). Utilization by many other large and small mammals was reported to range from slight to seasonally important. In almost all cases, use was highest in winter. Some implications for forest ecosystems are discussed, and lichen use by birds and invertebrates is briefly summarized.

ECOLOGY AND SUCCESSIONAL STATUS OF TERRESTRIAL AND ARBOREAL LICHENS ON THE WINTER RANGE OF THE ITCHA/ILGACHUZ CARIBOU. A. R. Brulisaue and M. D. Pitt. University of British Columbia, Vancouver, B.C.

To assess the importance of recurring forest fires as a possible determinant of the open nature of forests that are rich in terrestrial lichens, we investigated the successional development of such stands. Lichen-rich stands of lodgepole pine (*Pinus contorta*) appeared to be self-perpetuating climax-communities, which in the absence of fire are able to maintain their typical open nature. Arboreal lichens were found to be governed by a combination of age and moisture which in turn influenced light conditions and self-pruning mechanisms. *Cladonia* and *Cladonia* lichens were most abundant on well-drained and light intense stands. *Cladonia* species peaked at a stand age of ca. 150 years, whereas *Cladonia* spp. continuously increased with age.

CHANGES IN RELATIVE FREQUENCY OF EPIPHYTIC LICHEN SPECIES ON OAK AND ASH TWIGS IN WESTERN OREGON, 1971 TO 1991. Jan Palmer-Muller, Francisco J. Camacho, Stephen C. Sillett, and William C. Denison Oregon State University, Corvallis.

In 1991 we collected twig samples from Oregon white oak (Quercus garryana) and Oregon ash (Fraxinus latifolia) at fourteen sites in the Willamette Valley. These sites had been sampled in 1971 by the same methods. We recorded frequency and cover of all epiphytic lichens growing on five five-year-old and five ten-year-old segments at each site. We observed changes in relative frequency of some lichen species between 1971 and 1991. We now speculate that these changes in frequency occurred as a result of an increase in wet season concentrations of atmospheric sulfur oxides at the sampled sites.

NEW TRANSPLANT METHODS FOR EPIPHYTIC LICHENS. Chiska C. Derr and Bruce McCune. Oregon State Univ., Corvallis.

Ecological studies of epiphytic lichens may be enhanced by further development of simple, effective methods of transplant. Alectoria sarmentosa and Usnea longissima, pendulous, fruticose lichens, and the foliose Lobaria pulmonaria, were made into lightweight removable pendants and transplanted to original and new habitats. A 0.5 g tuft of Alectoria, 15 cm strand of Usnea or 0.2-0.4 g lobe of Lobaria was glued with clear silicone sealant to a 5 cm length of nylon monofilament with a 2 cm loop in the other end. Transplants were attached to tree branches using "Goody ponytailers", elastic loops with 1 cm plastic beads at each end and silicone coating the metal crimps. Reference standards for each species were used to correct weights to standard water content, eliminating differences due to humidity at the time of weighing. Standards of 1-5 g were oven dried to end metabolic activity, then equilibrated with ambient air during lichen pendant drying, and reweighed with each pendant weighing. Average growth over 4 months was 31% for Usnea and 4% for Alectoria. Methods are being tested to minimize fragmentation of Alectoria.

DISTRIBUTIONS OF BRYOPHYTES AND LICHENS ON GARRY OAK TRUNKS. Michael W. Ryan University of Victoria, Victoria.

I examined the distributions of bryophytes and lichens on Garry oak trunks and possible factors influencing their distributions. On all trunks bryophytes were most abundant near the base, whereas lichens increased in frequency with height above the ground. Bryophytes occurred predominantly on the upper sides and lichens predominantly on the lower sides of leaning trunks, whereas both were distributed around all sides of straight trunks. Bryophytes and lichens showed no response to differences in the aspect of the trunk surface. Daily light levels, stemflow and direct interception were measured on several trees. Only direct interception showed a relationship to the distributions of bryophytes and lichens, with bryophytes inhabiting locations that intercepted more rain than those occupied by lichens.

BIODIVERSITY OF THE SPECIES USNEA LONGISSIMA; TESTING FOR CHEMOTYPES AND DYE CHARACTERISTICS. Sherman G. Brough University of British Columbia, Vancouver.

Collections of the lichen Usnea longissima made in British Columbia and Washington were used to dye wool. Differences in dye colors were due in part to the dye methods used but that alone could not account for the wide range of colors obtained. Six chemotypes of U. longissima were detected through thin layer chromatography and these were related to the dye colors obtained. Progress on tests for predicting the chemical substances of the lichen and thus inferring their capacity to dye and the dye colors, is being developed for field use and permanent storage.

LIST OF NAMES IN CURRENT
USE (NCU) IN CLADONIAEAE:
A PROJECT TO AID IN
STABILIZATION OF NOMENCLATURE.
Teuvo T. Ahti, University of
Helsinki, Finland

Proposals will be made to the
XV International Botanical
Congress 1993 in order to grant
protection to listed names of
plants and fungi in current use.
Draft lists of generic names and,
in some families, infrageneric
names have been completed. The
infrageneric list of the lichen
family Cladoniaceae includes
several names and typifications
which are not tenable according
to the present Code of
nomenclature, but which can be
maintained in use if the new
proposals are accepted.

A FLORISTIC SURVEY OF THE EPIPHYTE
COMMUNITIES INHABITING THE CROWNS
OF TWO OLD-GROWTH CONIFERS IN
REDWOOD NATIONAL PARK, CALIFORNIA
Stephen C. Sillett Oregon State University, Corvallis
T. Scott Sillett Louisiana State Univ., Baton Rouge

We quantitatively sampled epiphyte communities
inhabiting the crowns of two conifers, a coastal
redwood and a Douglas-fir, in Redwood National
Park. The trees, which were both about 600 years
old and 78 meters tall, grew side by side on a ridge
top within the Little Lost Man Creek Research
Natural Area. We found 5 mosses, 2 liverworts, and
over 20 macrolichens inhabiting their trunks,
branches, and twigs. Canopy epiphyte communities
were dominated by chlorophycophilous lichens and
mosses. Three nitrogen-fixing lichens were
encountered on a few branches in the Douglas-fir.
Total epiphyte cover (%) was much higher on the
trunk (41 vs. 1.5), branches (64 vs. 11), and twigs
(46 vs. 14) of the Douglas-fir. Similarly, epiphyte
species richness was higher on the trunk (15 vs. 4),
branches (23 vs. 13), and twigs (7 vs. 5) of the
Douglas-fir. Major differences in bark character and
crown architecture between the trees probably
contributed to differences in epiphyte communities.
Unlike Douglas-fir, redwood bark exfoliates readily
and consistently, exposing younger layers that are
very smooth and hard. Redwood crowns also tend
to be denser, narrower, and shadier than Douglas-fir.

MULTIVARIATE ANALYSES OF ELEMENTAL CONTENT
IN LICHENS OF OLYMPIC NATIONAL PARK,
WASHINGTON. Fred Rhoades, Western
Washington University, Bellingham, WA.

Thalli from six groups of lichens
(*Alectoria sarmentosa*, *Bryoria* species,
Tuckermannopsis species, *Hypogymnia*
species, *Sphaerophorus tuckermanii* and
Platismatia glauca) from the perimeter of
Olympic National Park were analyzed for
element content by Inductively Coupled
Argon Plasma Spectroscopy. These lichens
are exposed to gradients of atmospheric
elements derived from marine, crustal and
anthropogenic sources. Concentrations of
elements assignable to each of these
sources are highly correlated to others
assignable to the same source. Each
source's elements show different species-
specific patterns across the various
gradients. Factor analyses are used to
summarize the data for groups of
similarly-behaving elements and ordinate
the lichen groups in multidimensional
space. Discriminant functions of element
concentrations correctly assign thalli to
one of the six groups with high success.

VERTICAL SUCCESSION OF EPIPHYTES IN
DOUGLAS FIR - HEMLOCK FORESTS
Bruce McCune, Oregon State University,
Corvallis.

Epiphytes were sampled on branches and
trunks of felled trees in three Douglas-fir-western
hemlock stands in the Cascade Range, ages 95,
145, and 400+ years. Epiphytes were sorted and
weighed in four functional groups: cyanolichens,
alectorioid lichens, other macrolichens, and
bryophytes. Biomass samples from throughout
the crowns were integrated vertically and radially
on individual trees to derive biomass density
functions for each functional group. These
groups colonize the forest in the same sequence
through time as the order of vertical dominance
in old growth, from top to bottom: "other"
macrolichens (mainly *Hypogymnia* and
Platismatia), alectoroid lichens (mainly *Alectoria*
sarmentosa), cyanolichens (mainly *Lobaria*
oregana), and bryophytes. It follows from these
observations that functional groups of epiphytes
migrate upwards in forests through time. For
example, the *Hypogymnia* and *Platismatia* that
dominate throughout young forests are found
primarily in the upper canopies of old forests.
Similarly, bryophytes enter a stand near the forest
floor and gradually expand their dominance
upwards.

PRELIMINARY OBSERVATIONS ON "ANTIQUÉ" FORESTS AND
EPIPHYTIC MACROLICHEN DIVERSITY IN BRITISH COLUMBIA.
Trevor Goward University of British Columbia, Vancouver.

The results of field studies conducted in the Coastal Western Hemlock Zone and Interior Cedar-Hemlock Zone of southern British Columbia during the summer of 1991 suggest that "antique" forests older than 300-350 years support several lichen species absent from adjacent younger forests — including "oldgrowth" forests aged 150-250 years. Such lichens tend to be either rare throughout B.C., or outside their range.

It is tentatively proposed that antique forests favour the establishment of rare lichens in three ways: 1) they offer a maximum number of microsites; 2) they provide a degree of environmental stability not present in most younger forest types, but requisite for colonization by at least some lichens; and 3) their longevity increases the likelihood of successful inoculation by random air-borne and animal-borne diaspores (the petri-dish hypothesis).

It is also proposed that whereas the long-term survival of many rather common lichen species in the Pacific Northwest may depend on the maintenance of oldgrowth forests, the survival of many rare lichens probably depends on the maintenance of antique forests.

Further work on this problem is in progress.

THE NOAA NATIONAL BENTHIC
SURVEILLANCE PROGRAM DATABASE.
John T. Landahl, Environmental Conservation
Division, NMFS, NOAA, Seattle, WA.

Since 1984, NOAA has conducted the National Status and Trends Program to study the environmental health of the coastal marine waters of the U.S. One part of this program is the National Benthic Surveillance Project (NBSP). This project has amassed a large database on levels of trace metals and anthropogenic hydrocarbon compounds in sediment and fish tissue, and on prevalence of disease and indicators of contaminant exposure in bottom-dwelling fish. Although the NBSP is a national program, the presentation will focus on the types of data available for sites on the West Coast. Data have been collected for 8 fish species (fourhorn sculpin, flathead sole, English sole, starry flounder, barred sandbass, hornyhead turbot, white croaker, and black croaker) from more than 40 West Coast sites. These data are available through the National Oceanographic Data Center (NODC).

STOCK IDENTIFICATION USING ELEMENTAL
COMPOSITION OF FISH HARDPARTS
James N. Ianelli, Seattle, WA

Aspects on the methods, biology, applications and problems of using elemental composition of fish hardparts are reviewed. For stock identification purposes, these methods represent an alternative to conventional mark-recapture and genetic studies. The concept is based on the premise of detecting "natural tags" within hardpart structures, which reflect, to some extent, the environmental conditions and genetics of the stock. Such methods hold promise to resolve ambiguities encountered with other more traditional techniques. An international workshop of researchers active in hardpart elemental composition analyses was recently convened to review the limitations and potential of these methods. A summary of these findings are presented. An example application to a salmon stock identification problem is contrasted with results from investigations on the stock structure of a species of tuna.

RNA/DNA RATIOS AS INDICATORS
OF NUTRITIONAL CONDITION OF
LARVAL WALLEYE POLLOCK,
Theragra chalcogramma.
MICHAEL F. CANINO AND KEVIN M.
BAILEY, Alaska Fisheries
Science Center, NOAA,
Seattle.

Food consumption and nucleic acid ratios of first-feeding pollock larvae in the Gulf of Alaska were sampled during early spring and mid-spring, 1989. A large patch of larvae was detected. Mean prey abundance, gut contents (prey larva⁻¹) and RNA/DNA values of larvae were higher within the patch than in areas outside the patch during early spring. By mid-spring, microzooplankton densities, feeding intensity and RNA/DNA of larvae both inside and outside of the patch had increased. The results indicate a linkage between food availability, feeding, and growth during early periods of larval development.

STOCK IDENTIFICATION TECHNIQUES
FOR SALMON ON THE HIGH SEAS.

R.V. Walker and K.W. Myers, Fisheries
Research Institute, School of Fisheries,
University of Washington.

For over 35 years U.S. scientists have used various methods to delineate oceanic distribution of North Pacific salmon and steelhead (*Oncorhynchus* spp.) and estimate intermingling of different stocks. These methods have included direct proof techniques (such as high seas tagging, coded-wire tagging, and freshwater parasites) and indirect estimation (such as scale pattern analysis, age composition, genetic methods, and trace element analysis). Strengths and weaknesses and examples from results of some of the methods will be presented. Tags have been used to define ocean ranges of salmonids from different regions in North America and Asia, while scales, which are available in larger numbers than tag recoveries, have been used for quantitative estimates of mixing of stocks. A parasite (*Nanophyetus salmincola*) acquired in Pacific Northwest freshwater has been used to identify North American steelhead in the North Pacific Ocean as far west as 163°E.

MANAGEMENT ADVICE FROM A SIMPLE
DYNAMIC POOL MODEL WHEN STOCK-
RECRUITMENT PARAMETERS ARE
UNCERTAIN.

Grant G. Thompson, National Marine
Fisheries Service, Seattle, WA

A simple dynamic pool model is used to examine the problem of stock-recruitment parameter uncertainty from a Bayesian perspective. Probabilities associated with different parameter values are used to weight the losses (i.e., opportunity costs to society) associated with any given fishing mortality rate. By choosing appropriate forms for the loss and probability density functions, the model is shown to result in an analytic solution. Because this solution gives the fishing mortality rate that maximizes the expected value of the logarithm of sustainable yield, it is denoted F_{MELSY} . The solution is a monotone decreasing function of parameter uncertainty, converging on the fishing mortality rate corresponding to maximum sustainable yield as the degree of uncertainty approaches zero. As an empirical illustration, the model is applied to the eastern Bering Sea stock of rock sole (*Lepidopsetta bilineata*).

THE SPAWNING DYNAMICS OF
WALLEYE POLLOCK, Theragra
chalcogramma, IN
SHELKOF STRAIT, GULF OF ALASKA

Nazila Merati
NOAA-Fisheries
Seattle, Washington

The spawning dynamics of female walleye pollock, Theragra chalcogramma, in the Shelikof Strait, Gulf of Alaska were studied in 1990. The purpose of this study was threefold; first, to characterize spawning dynamics of this fishery. Secondly, to determine the age at first maturity in female fish. Lastly, to develop an immunochemical assay to assess reproductive condition and to test this assay against other more established methods to determine sexual maturity stage. At this time, an antibody to egg-yolk protein has been developed, native egg proteins have been characterized and an assay has been developed. The assay may be useful in distinguishing between immature and spent/recovering maturity stage. These stages are difficult to determine by visual inspection.

EVALUATING ANADROMOUS SALMON AND
STEELHEAD CO-MANAGEMENT IN
WASHINGTON STATE AFTER *U. S. v*
WASHINGTON. Gilbert B. Pauley. Wash.
Coop. Fish & Wildlife Res. Unit, Univ. of
Washington, Seattle, WA.

A history of the 1974 case, *U.S. v Washington*, is presented. This case set forth guidelines by which anadromous salmon and steelhead from Puget Sound, Strait of Juan de Fuca, and Washington Coastal waters were to be divided between the treaty Indian Tribes and citizens of Washington State. In the early years following the case decision, the tribes and the state were highly adversarial and used different technical evaluation methods and data sets to present their positions in court. The Federal Court appointed a Technical Advisor to assist with this problem and reduce court time. As the tribes and the state began to co-manage the fish runs, the number of adversarial proceedings between them has declined dramatically.

Backman, Thomas. Columbia River
basin salmon production.

A Salmon restoration program to maintain, restore, and enhance Columbia River basin salmon populations above Bonneville Dam by means of supplementation and hatchery reprogramming is described. The program is being developed in accordance with both sound scientific principles of conservation management, and applicable laws and regulations such as Endangered Species Act and the Pacific Salmon Treaty.

Supplementation is the stocking of genetically and ecologically compatible fish into the natural habitat to increase the abundance of naturally reproducing fish populations. Hatchery reprogramming is the changing of operations of existing salmon hatcheries to directly support the maintenance, restoration and enhancement of salmon runs above Bonneville Dam. Habitat restoration and protection are an important components of a salmon production program.

PEOPLE VERSUS FISH: FLOOD CONTROL
ATTITUDES AND POLITICS. Millard S. Deusen
Washington Department of Fisheries.

With increased flood damage occurring as a result of more frequent and larger flood events, a battle is brewing over the protection of fish habitat and the protection of private property. Have weak governmental regulations dealing with growth management finally caught up with us? Have the flood plains of our rivers and streams been encroached upon to the point of no return? Can fish and people co-exist or are the costs of flood control leaving no room for fish habitat? What is the attitude of people, the politics of flood control and how does the future look if flood hazard management does not include concern for instream resources. Washington's King County has taken a step toward addressing this situation through a draft flood hazard reduction plan. The Corps of Engineers has recognized the importance of instream resources and vegetation management. Will these efforts be too little too late or can they change the trend from "people versus fish" to "people and fish"?

WASHINGTON FISHERY ASSESSMENT INITIATIVE. Rich Lincoln, Washington Department of Fisheries; Michael Grayum, Northwest Indian Fisheries Commission; Bob Gibbons, Washington Department of Wildlife.

The management entities in Washington are beginning an initiative to identify and restore the region's depleted wild salmonid stocks. Under a coordinated approach, WDF, WDW and tribal staffs are beginning an effort that will: (1) complete and maintain a resource status review of the region's salmonid stocks; (2) identify stock production problems; (3) review current resource management objectives for wild and hatchery stocks; and (4) develop, implement, and evaluate integrated restoration programs for critical stocks. These restoration programs will provide an alternative to reacting to listing petitions under the Endangered species Act.

VISIONS OF A STOCK STATUS INFORMATION RETRIEVAL SYSTEM (SSIRS) Sandra M. Noble for the Wild Stock Action Team, U.S. Fish and Wildlife Service, Region 1, Portland, OR.

Difficult access to meaningful information concerning wild and naturally-reproducing fish stocks often frustrates the use of current, scientifically sound data in management decisions. The U.S. Fish and Wildlife Service (Service) proposes to bring on line an information system for 1) inventorying the status of wild and natural stocks, 2) identifying information gaps, and 3) expanding monitoring activities to address those "gaps". Use of the system will be shared among Service and non-Service fishery professionals and interested persons. Service personnel will work closely with their cooperators to obtain suggestions on system development, gain accurate data for the database, and develop cooperative monitoring programs. The Service envisions such a system as essential in assessing stock status, identifying and monitoring stock restoration projects, and providing the information needed to gain funding support for wild stock programs.

GLACIOLOGY, FROG FARMING, AND INFORMATION SHARING IN THE COLUMBIA RIVER BASIN.

Phillip B. Roger, Columbia River Inter-Tribal Fish Commission, Portland, OR.

Designing an inter-agency information sharing system presents challenges not described in classical systems analysis literature. An iterative process and flexible time lines are necessary to handle complex inter-agency problems. Conversely, system complexity offers unexpected opportunities for spin-off benefits. Success depends on trust, creativity, patience, and a sense of humor as much as on skilled analysts and programmers.

RIPARIAN COMMUNITIES IN WESTERN OREGON: THEIR STRUCTURE AND MANAGEMENT. Neil B. Armantrout, BLM, Eugene, Oregon

Riparian community composition and structure were recorded during stream and riparian inventories along streams managed by BLM in Lane County, Oregon. The level of intensity of inventory varied, but age and dominant species were recorded in all inventories. Three broad communities can be described, based primarily on past timber management. Unharvested areas are dominated by conifers, while clearcut areas are dominated by hardwoods. Streams where conifers were higraded have a mix of conifers and hardwoods. On some BLM lands, unaltered riparian communities may occupy as little as 3-5% of the total riparian acreage. Buffers, designed to protect fish habitat, do not maintain riparian communities. Proposed BLM riparian and stream management anticipates the restoration of conifer communities, but our observations suggest this will not happen without an active program of vegetation manipulation.

'EFFECT OF HABITAT ENHANCEMENT AND CANOPY'
REMOVAL ON THE FISH COMMUNITY OF A
HEADWATER STREAM R. E. Bilby and B. R. Fransen
Weyerhaeuser Co., Tacoma, WA

The riparian trees along a 2km section of stream in western Oregon were logged in 1985, in violation of forest practice regulations. As part of the judgement against the landowner, wood was placed in the channel to improve habitat in 1988. Fish populations and habitat have been monitored since 1986 at 3 sites: the enhanced area, a non-enhanced reach without a canopy and a non-enhanced reach with a canopy. Pool area increased 20% as a result of the wood addition at the enhanced site. Pool area during summer also increased at the site with the canopy due to beaver activity. Speckled dace (*Rhinichthys osculus*) have exhibited the greatest response, increasing in numbers at all 3 sites, with greatest gains in the enhanced reach. Salmonid density at all three sites also has increased since 1988. Age 0+ steelhead (*Oncorhynchus mykiss*) exhibit an inverse relationship between density and growth. However, no such relationship is evident between 0+ steelhead growth and dace density, suggesting that the two species are not competing for resources. Increased food availability, due to elevated autotrophic production, in the enhanced and non-enhanced, uncanopied reaches, and improved habitat in the enhanced and canopied reaches are the likely causes of the elevated fish populations.

DECLINING SURVIVAL RATES IN BRITISH
COLUMBIA AND COLUMBIA RIVER HATCHERIES.
Ray Hilborn, University of Washington,
Seattle.

We review the hatchery output and adult production of chinook and coho hatcheries in British Columbia in the Columbia River basin. British Columbia chinook hatcheries have experienced very serious declines in survival so that total chinook catch has dropped in half in the last 15 years, despite a 5 fold increase in hatchery production. British Columbia coho hatcheries have seen less decline in survival, but the total catch has remained roughly constant (prior to 1991). Columbia River coho hatcheries have seen long-term declines in survival, but survival rates have stabilized in the last 5 years, likely due to a substantial increase in size at release. Columbia River chinook hatcheries have had highly variable survival, with good survival in the mid-1980s but very poor survival recently.

PATTERNS OF COMMUNITY STRUCTURE AND
MICROHABITAT USE BY STREAM FISHES IN
THREE WASHINGTON STREAMS. David Lonzarich
University of Washington and Center for Streamside
Studies.

Studies on the ecology of streams in the Pacific Northwest focus almost exclusively upon salmonids and have consequently biased our views of how these systems function and respond to land-use disturbances. An approach is advanced here that integrates information on the biology of other stream fishes with knowledge of salmonids to better evaluate the impacts of stream disturbance. Comparisons are made of fish assemblages in different streams examining relationships with habitat structure and flow regime. Further, potential inter-relationships among species are examined through studies of habitat and micro-habitat use. Seasonal electro-shocking and snorkeling surveys conducted in three Washington streams from summer 1990 to the present (including the major floods of winter 1990-91) reveal: (1) extensive spatial variability in assemblage and population dynamics and rapid recovery of assemblages even following major floods and; (2) variable but often strong patterns of habitat partitioning. Results for species associated with cover and pool habitats (i.e., coho salmon, speckled dace) will form the basis of experiments examining the role of habitat structure on inter-specific behavioral interactions.

SURVIVAL AND CONTRIBUTION RATES FROM
PUGET SOUND AND WASHINGTON COASTAL
HATCHERIES. Terry Wright, Northwest
Indian Fisheries Commission, Olympia.

A Coded Wire Tag Retrieval and Analysis System (CRAS) was developed to analyze survival and fishery contribution data from tags released in Western Washington. Survival rates are demonstrated to be highly variable, both within a hatchery, between years, and between hatcheries. Regressions with survival and size or time of release as well as several other analyses available through CRAS explain some of this variability.

THE NOVEMBER 1990 FLOOD IN SOUTHWESTERN BRITISH COLUMBIA, AND OVERVIEW OF THE RESTORATION PROCESS. Robert Bland, C. Robert Bland Consulting Engineers, Vancouver, British Columbia.

The November 1990 flood caused widespread damage to rivers in southwestern British Columbia. Restoration works were assessed on a site-by-site basis by a team of engineers and environmentalists.

While a "people versus fish" conflict was evident, the team approach ensured that the restoration work was carried out with minimal environmental damage.

CHANGES AND IMPROVEMENTS IN WASHINGTON SALMON CULTURE PRACTICES. Larry Peck, Washington Department of Fisheries, Olympia

The use of salmon hatcheries has been an intricate tool for achieving fisheries management goals in Washington State for nearly 100 years. Currently, the Washington Department of Fisheries (WDF) operates 58 hatchery facilities located throughout the state. Changes in WDF hatchery operations demonstrate the evolutionary nature of how, when, and what we do today at WDF hatcheries.

EMERGENCY FLOOD MANAGEMENT - OR THE BLANK CHECK APPROACH TO FISH HABITAT DESTRUCTION: A CASE HISTORY OF THE 1990-91 FIR ISLAND FLOODS. Brian Williams, Washington Department of Fisheries, Everett.

Protecting fish habitat during a flood event is oftentimes a difficult and thankless task. In the rush to relieve the sufferings of the flood victims, emotions, politics, and confusion drive the decision processes. Fish resources are expected to bear whatever burden is necessary to protect flood plain properties. Impacts to fish habitat are taken for granted. Fish resource managers are cast in the role of obstructionists. Regulatory permits that typically serve to protect fish life and fish habitat become paper exercises that translate into blank checks for fish habitat destruction.

We lost valuable fish habitat during the Fir Island floods. In the year following, hopefully we've recovered some of our losses. You be the judge.

SALMONID ENHANCEMENT LESSONS FROM LARGE-SCALE PROGRAMS IN OTHER AREAS. Ken Bruva, Washington Department of Fisheries, Olympia.

In response to a directive from the Washington State Legislature, the Washington Department of Fisheries (WDF) recently developed a framework plan for doubling the state's salmon catch. One aspect of the plan was a review of the success of similar initiatives in Alaska, British Columbia, Japan, and the Great Lakes. There were valuable lessons learned from these initiatives that were incorporated into the plan developed by WDF.

ASSESSMENT OF AQUATIC HAZARDS FOR FROGS AT TULE LAKE AT LOWER KLAMATH NATIONAL WILDLIFE REFUGE USING THE FROG EMBRYO TERATOGENESIS. Robin Boyer, University of Washington, Seattle.

Decreasing overall species diversity at the Tule Lake and Lower Klamath National Wildlife Refuge has prompted a 2-year federally-funded investigation to assess water quality in relation to the indigenous communities. Agricultural fields, on which a variety of agrichemicals are utilized, border the refuge on three sides. These farms use refuge water, which is repeatedly recirculated between field and refuge, throughout the growing season. In the lab, the FETAX (frog embryo teratogenesis assay; Xenopus) model assessed water quality in reference to frog (Xenopus laevis) embryo mortality and malformation. Embryos were exposed to the undiluted field water of weekly samples collected from nine agricultural drainwater input locations at which the temperature, pH, dissolved oxygen, and conductivity were measured. Results indicate significant malformation and no significant mortality.

REPRODUCTION AND EARLY LIFE HISTORY OF WHITE STURGEON IN THE COLUMBIA RIVER BETWEEN BONNEVILLE AND McNARY DAMS. Calvin R. Sprague, U.S. Fish and Wildlife Service, Cook.

From 1987 through 1991, the U.S. Fish and Wildlife Service sampled white sturgeon (Acipenser transmontanus) eggs, larvae, young-of-the-year (YOY), and juveniles with "D" shaped larval nets and trawls in the lower three pools of the Columbia River. Catch per unit effort for all life stages varied among years and pools, and was highest each year in Bonneville Pool. Spawning and rearing locations were identified for each pool. Spawning dates were back-calculated using egg and larval staging techniques. Sturgeon spawned between late May and mid-July at 12-19°C in tailrace areas. Spawning success was highest during high water years. Rearing occurred in deeper areas of pools downriver from tailrace areas. Ages were estimated and food habits examined for YOY, yearling, and juveniles. Principal food item for young white sturgeon was the amphipod Corophium sp. Study results will be used to help identify potential methods for protecting and enhancing white sturgeon populations.

HABITAT USED BY SPAWNING AND REARING WHITE STURGEON IN THE LOWER COLUMBIA RIVER. Allen Miller and Michael J. Parsley, U.S. Fish and Wildlife Service, Cook.

We investigated habitat use by spawning and rearing white sturgeon (Acipenser transmontanus) in the Columbia River downstream from McNary Dam and quantified the available habitat. We measured water depth, mean column water velocity, and substrate at sites where we sampled for white sturgeon eggs, larvae, and juveniles. Spawning habitat was quantified using the Physical Habitat Simulation System and rearing habitat was quantified using a geographic information system. Depths, velocities, and substrates used by spawning and rearing white sturgeon differed markedly. Recruitment was positively related to discharge. The amount of spawning habitat in each area varied among areas and years, and was dependent on discharge. Impoundment has increased the amount of rearing habitat. Results will be used in formulating recommendations to mitigate the effects of hydropower development on white sturgeon populations in the Columbia River.

IMPLEMENTATION OF THE NORTHERN SQUAWFISH SPORT-REWARD FISHERY ON THE COLUMBIA AND SNAKE RIVERS. Craig C. Burley, Washington Department of Wildlife, Vancouver.

The goal of this project is to reduce the predation mortality of juvenile salmonids (Oncorhynchus spp.) out-migrating through the Columbia and Snake River reservoirs. Northern squawfish (Ptychocheilus oregonensis) is a major predator on out-migrating juvenile salmonids. This project is one component of an overall program designed to remove 10-20% of the northern squawfish population annually in reservoirs between Priest Rapids Dam and the mouth of the Columbia River and between Hells Canyon Dam and the mouth of the Snake River. Sport anglers are paid a reward of \$3.00 per northern squawfish 11 inches or longer. During May 24-September 22, 1991, anglers removed 159,162 northern squawfish. The average per unit effort for the season was 1.09 fish * angler⁻¹ hour⁻¹. This project is ongoing and will be implemented in 1992.

THE NOAA NATIONAL BENTHIC SURVEILLANCE PROGRAM DATABASE. John T. Lindahl, National Marine Fisheries Service, Seattle.

Since 1984, NOAA has conducted the National Status and Trends Program to study the environmental health of the coastal marine waters of the U.S. One part of this program is the National Benthic Surveillance Project (NBSP). This project has amassed a large database on levels of trace metals and anthropogenic hydrocarbon compounds in sediment and fish tissue, and on prevalence of disease and indicators of contaminant exposure in bottom-dwelling fish. Although the NBSP is a national program, the presentation will focus on the types of data available for sites on the West Coast. Data have been collected for eight fish species (fourhorn sculpin, flathead sole, English sole, starry flounder, barred sandbass, hornyhead turbot, white croaker, and black croaker) from more than 40 West Coast sites. These data are available through the National Oceanographic Data Center.

SALMON ESCAPEMENT INFORMATION SYSTEM. Greg Konkell, Washington Department of Fisheries, Seattle.

Annual escapement counts of Pacific Salmon and steelhead for more than 1,100 locations throughout the Pacific Northwest and Alaska were organized in a computer database. A common data format and coding system was developed for more than 26,000 escapement records obtained from a variety of published and unpublished sources. Programs were written which provide a means of displaying trends in spawning populations by individual stream, watershed, and by state and regional determinations.

NORTHWEST ENVIRONMENTAL DATA BASE.

Peter J. Paquet, Northwest Power Planning Council, Portland; Thomas E. Pansky, Bonneville Power Administration, Portland.

The Northwest Environmental Data Base (NED) began in 1984 as a cooperative effort by BPA, the Council, the four Northwest states, Indian tribes, and federal land management agencies to assess the significance of the region's rivers for use in the Council's Protect Area designations, System Planning, and BPA's regional hydropower supply estimates. The effort has resulted in seven detailed resource databases - anadromous fish, resident fish, wildlife, natural features, cultural features, recreational, and institutional constraints - and a network of over 1,000 experts in the seven resource categories. The databases cover all four states (comprehensive) and contain the same data elements for each state (consistent structure and content).

EFFECT OF STOCKING DENSITY ON WILD AND HATCHERY-REARED CHINOOK SALMON (ONCORHYNCHUS Tshawytscha). C. F. Mazur and G. K. Iwama, University of British Columbia, Vancouver.

Stocking density is an important parameter when establishing optimal husbandry conditions for salmonids. This study investigated the effect of stocking density on the hematocrit, cortisol response, and survival of wild and hatchery-reared chinook salmon. Hatchery-reared chinook salmon had significantly lower hematocrit and plasma cortisol concentration increases as density was increased, compared to wild chinook. Equally accelerated mortality rates were observed for both groups of fish as density was increased. This study shows that increasing the stocking density of wild and hatchery-reared chinook salmon results in physiological changes and decreased survival.

SCIENCE, POLITICS, AND THE ENDANGERED SPECIES ACT. Philip Howell, Oregon Department of Fish and Wildlife, Portland.

The Endangered Species Act is in many ways the most powerful legislation affecting fish and wildlife. Congress will shortly be considering the act for reauthorization. This paper discusses how well the ESA is working, its strengths and weaknesses, possible scenarios for reauthorization, and the roles of biologists and fisheries management agencies in petitioning species for listing and administering the act.

SACRAMENTO WINTER CHINOOK: PROBLEM AND RECOVERY. Dave Vogel, CH2M Hill.

The Sacramento River supports a unique race of winter-run chinook salmon that has exhibited dramatic changes in spawning range and annual run sizes since the turn of this century. Although the winter-run experienced a large increase in numbers following the construction of dams (due to increased cold-water storage), a recent precipitous decline prompted Federal listing as a threatened species. The suspected reasons for the decline include water development, pollution, predation, loss of suitable spawning gravels, and recent adverse natural environmental conditions. There is some evidence that ocean fishery may also have adversely affected the run. A cooperative, multi-agency salmon restoration program was implemented prior to listing but was not timely or effective in preventing further declines in the winter run. Because of the small numbers of fish now returning each year, it is difficult for biologists to develop a comprehensive working knowledge of the run's biology, habitat, range, and relation to natural and man-made factors to evaluate how these factors may affect future existence of the run. The biological benefits and detriments of listing the winter-run chinook salmon are discussed along with recommended actions.

THE USE OF THE ENDANGERED SPECIES ACT NOW AND IN THE FUTURE. F. Lorraine Bodi, American Rivers, Seattle.

The anadromous of the Pacific Northwest are in serious trouble, due to hydroelectric development, habitat degradation, overharvest, water diversion, and other causes. The Endangered Species Act is an important tool for the protection of these populations where other methods have failed. For example, the ESA is particularly appropriate in the Columbia River Basin where we have spent more than a decade trying to remedy low flows caused by hydroelectric and other development without success.

One challenge is to mesh the ESA with good science and policy so that we do not overload the system. Another challenge is to take action, erring on the side of the fish where data are uncertain. If we are to avoid new ESA petitions, the region will have to come up with an alternative approach that can accomplish the same objectives as the ESA.

HARMFUL EFFECTS OF THE MARINE DIATOM (CHAETOCEROS CONCAVICORNIS) ON NET-PEN AND OTHER FISH IN PUGET SOUND. Jack Rensel, University of Washington, Seattle.

Blooms of phytoplankton have caused major losses in marine fish culture in Puget Sound and world-wide appear to be increasing in severity and geographic range. Although algal-caused mortality of fish is known to occur in net-pens, little is known about effects in natural and hatchery-reared salmon in Puget Sound. This paper focuses on the marine diatom Chaetoceros concavicornis and how it causes gill irritation and suffocation of mucus production that can lead to chronic stress response and death of salmon. Laboratory bioassay of Atlantic salmon showed blood-oxygen partial pressure was significantly reduced and blood-carbon dioxide partial pressure increased even at relatively low concentrations of the diatom. C. concavicornis blooms regularly in the fall in northern Hood Canal and apparently has caused mortality of migrating chinook salmon.

CAPTURE OF GRASS CARP FROM VEGETATED LAKES. S. A. Bonar, C. R. Bennett, G. B. Pauley, and G. L. Thomas, University of Washington, Seattle.

Seven techniques were evaluated for catching grass carp (Ctenopharyngodon idella) in five lakes containing aquatic vegetation. The methods included capturing fish with angling, pop-nets, or traps in baited areas; angling in non-baited areas; attracting fish to heated areas; and capturing fish using Asian methods which included lift nets and herding fish into gill nets. Herding fish into gill nets was the most effective of the techniques ($p < 0.001$), followed by angling baited areas. Herding is effective in lakes containing thick vegetation, submerged logs and other underwater obstructions, and might be effective for removing fish from overstocked waters or to monitor growth.

ENHANCING VEGETATION AND STRUCTURAL DIVERSITY BY MANIPULATING FOREST STANDS
Ted B. Thomas and Andrew B. Carey
USDA, PNW Research Station

The response of forest stands to silvicultural treatments to improve wildlife habitat is poorly understood. To ensure and maintain viable populations of endangered wildlife species it is necessary to provide suitable habitat for these species and their prey populations. The objective of this study is to promote the development of suitable habitat for the Northern Spotted Owl (Strix occidentalis caurina). Young, managed forests at Fort Lewis Military Reservation will be silviculturally manipulated. Treatments will be applied to two 8 ha stands within 4 replicated blocks of 32 ha each. The blocks represent 2 stands with significantly different sizes of live trees (dbh and tree height) and amounts of coarse woody debris. The expected response to silvicultural treatments is to produce spatial heterogeneity among the live trees and promote structural and species diversity in the understory. Forest stands of this age and structure will be intensively managed in future decades and it is important to recognize their potential as wildlife habitat.

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