1998
ANNUAL REPORT TO COOPERATORS

IDAHO COOPERATIVE
FISH & WILDLIFE RESEARCH UNIT

COOPERATORS:

University of Idaho

USGS
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REPORT TO COOPERATORS

1998

Idaho Cooperative Fish and Wildlife Research Unit
Department of Fish and Wildlife Resources
College of Forestry, Wildlife and Range Sciences
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The following College of Forestry, Wildlife and Range Science Faculty and Researchers are cooperating on projects with the Idaho Cooperative Fish and Wildlife Research Unit. They are also involved in teaching and other research projects in their respective departments.

David Bennett - Fishery Resources
Michael Falter - Fishery Resources
Patricia Heglund – Wildlife Resources
Oz Garton - Wildlife Resources
George LaBar – Fishery Resources
Kirk Lohman – Wildlife Resources
Christine Moffitt – Fishery Resources
Dennis Murray – Wildlife Resources
Jim Peek - Wildlife Resources
John Ratti - Wildlife Resources
Kerry Paul Reese - Wildlife Resources
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Billy Connor	Ph.D. Fishery Resources	T. C. Bjornn
Patrick Crist	Ph.D. Wildlife Resources	J. M. Scott
Jesse D'elia	M.S. Wildlife Resources	R. G. Wright
Matt DeMarco	M.S. Fishery Resources	T. C. Bjornn
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Brian Janosik	M.S. Wildlife Resources	R. G. Wright
Jason Karl	M S. Environmental Science	J. M. Scott
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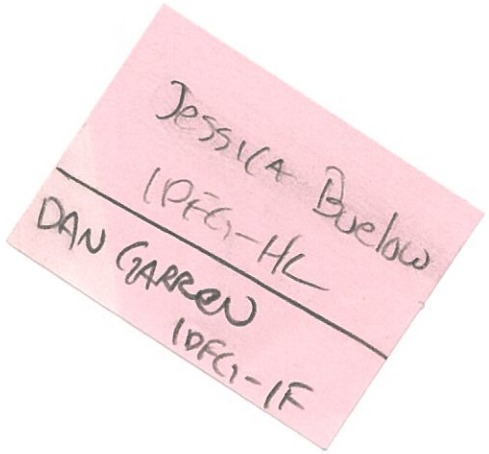
Tom Welker	Ph.D. Fishery Resources	J. L. Congleton
Andrew Yost	M.S. Wildlife Resources	R. G. Wright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Pamela Bell	M.S. Wildlife Resources	E. O. Garton
Chad Bishop	M.S. Wildlife Resources	E. O. Garton
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Matt Davis	M.S. Fishery Resources	D. H. Bennett
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Steve Intelmann	M.S. Fishery Resources	C. M. Moffitt
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Tim Welker	Ph.D. Fishery Resources	D. Scarnecchia
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Introduction

Unit History

The Cooperative Wildlife Research Unit Program began in 1935, when five Wildlife Units were established at land grant universities. Additional Units have been added in many states since that time. In 1961 the Cooperative Fishery Research Unit Program was initiated. Beginning in 1984, Wildlife and Fishery Units were combined into Cooperative Fish and Wildlife Research Units. At the present time, there are 41 Cooperative Research Units. In 1994 the Cooperative Research Units were moved into the National Biological Service under the Division of Cooperative Research. In 1996 the National Biological Service and Cooperative Research Units were moved into the United States Geological Survey under the Biological Resources Division.

The Idaho Cooperative Wildlife Research Unit was established at the University of Idaho September 20, 1947, and the Idaho Cooperative Fishery Research Unit was established in 1963. The two Units were combined into the Idaho Cooperative Fish and Wildlife Research Unit in 1985. The Unit is housed in the Department of Fish and Wildlife Resources in the College of Forestry, Wildlife and Range Sciences. The Unit is staffed, supported, and coordinated by the USGS/Biological Resources Division, U.S. Fish and Wildlife Service, Idaho Department of Fish and Game, University of Idaho, and The Wildlife Management Institute. The U.S. Fish and Wildlife Service supported and coordinated the unit from its founding until 1993.

Program Direction

The Unit works toward the following basic objectives: (1) conduct research on fish and wildlife problems of state, regional, and national interest, (2) train graduate students for careers in the fish and wildlife professions, and (3) provide technical assistance to state and federal managers and researchers. The Unit emphasizes research to (1) help find solutions to problems affecting anadromous fish passage in the Snake River basin; (2) evaluate methods of establishing new animal populations or augmenting existing populations; (3) improve estimators of animal abundance; (4) evaluate effectiveness of existing reserve and management areas in the Pacific Northwest; (5) study the basic biology of aquatic and terrestrial animals; and (6) evaluate factors that regulate carrying capacity in streams and terrestrial habitats.

Unit Research, Expertise, and Interests

Unit personnel maintain close working and professional relationships with University faculty and Idaho Department of Fish and Game personnel. Research studies are conducted primarily within Idaho, although some work is done in adjoining states, as well as Hawaii and Alaska. Excellent laboratory facilities are provided by the University.

Unit research is supported by the State contribution and by contracts from the USGS/Biological Resources Division, the U.S. Fish and Wildlife Service, U. S. Army Corps of Engineers, U.S. Forest Service, Bonneville Power Administration, Northwest Power Planning Council, and other federal, state, and private agencies. In addition to research activities, Unit personnel teach graduate-level courses, serve as thesis advisors for graduate students, and participate in a variety of professional activities. Cooperating faculty at the University of Idaho and Idaho State University serve as thesis advisors for additional graduate students.

J. Michael Scott - Unit Leader and Professor of Wildlife Resources – Recent research activities include studies on the: Distribution, abundance, and limiting factors of Hawaiian birds; limiting factors in endangered species; reserve identification, selection, and design in North America; use of translocation as a tool for establishing or augmenting animal populations; and Gap Analysis. Areas of interest include animal ecology, conservation biology, estimating animal numbers. Specialty course: FW-504 Conservation Biology.

Ted C. Bjornn - Assistant Unit Leader and Professor of Fishery Resources - Recent research activities include studies on: Wild trout ecology and management; effects of small hydro on stream carrying capacity; habitat features that affect carrying capacity; anadromous fish production in the Tucannon River; role of stress and BKD in salmon smolt losses; viability of hatchery versus wild steelhead; survival of salmonid embryos in relation to sediment; supplementation of wild salmon and steelhead; juvenile chinook salmon-brook trout interactions; passage of adult salmon and steelhead at dams. Areas of interest include management and ecology of wild and hatchery salmonids, and radio-telemetry. Specialty course: F510 - Advanced Fish Management.

Jim Congleton - Assistant Unit Leader and Associate Professor of Fishery Resources - Recent research activities include studies on the: Effects of stress, tissue injury, and infection on components of natural disease resistance; stress response of chinook salmon smolts collected and transported from Snake River dams; natural defenses against IHN virus. Areas of interest include mechanisms of disease resistance in fish and stress physiology. Specialty courses: F511 - Fish Physiology, F514 - Fish Population Ecology.

R. Gerald Wright - Research Scientist and Professor of Wildlife Resources - Recent research activities include studies on: Wildlife management in national parks and protected areas; modeling of ecological problems; ungulate ecology and habitat use; natural resource data management and geographic information systems. Specialty courses include Human Dimensions of Wildlife Management.

Ongoing Projects - Fisheries Resources

David H. Bennett - Principal Investigator

Evaluation of adult chinook salmon passage and squawfish distribution at Lower Granite dam during testing of surface bypass and collection prototype-smolt predation

North Fork Coeur d'Alene cutthroat/habitat relationships

Effects of increased winter water levels in Lake Pend Oreille on kokanee survival, predation, food abundance, and aquatic macrophytes

Ted C. Bjornn - Principal Investigator

Studies of fishways modifications and temperature, spill deflectors, and patterns at lower Snake River dams

Monitoring and evaluation of fall chinook salmon supplementation in the Snake River

Synthesis of information on Snake River salmon and wild trout management

Effect of hatchery supplementation on stock productivity and performance

Evaluation of adult salmon, steelhead, and lamprey migration past dams and through reservoirs in the Lower Columbia River and into tributaries

Jim L. Congleton - Principal Investigator

Evaluation of the procedures for collection, transportation, and downstream passage of outmigrating salmonids

Development of methods of control of infectious hematopoietic necrosis virus (IHN) in commercially reared salmonid fishes

Improved nutrition to increase the viability of hatchery smolts

C. Michael Falter – Principal Investigator

Effects of increased winter water levels in lake Pend Oreille on kokanee survival, predation, food abundance, and aquatic macrophytes

Christine Moffitt - Principal Investigator

Understanding of factors affecting the epidemiology of whirling disease in Idaho

FDA Approved Registration of Erythromycin for Treatment of Bacterial Kidney Disease

Dennis Scarnecchia - Principal Investigator

Determination of the effects of contaminants on white sturgeon reproduction in the Kootenai River

Habitat use and population dynamics of benthic fishes along the Missouri River

EVALUATION OF ADULT CHINOOK SALMON PASSAGE AND SQUAWFISH DISTRIBUTION AT LOWER GRANITE DAM DURING TESTING OF SURFACE BYPASS AND COLLECTION PROTOTYPE-SMOLT PREDATION

Principal Investigator: D. H. Bennett
Student Investigator: George Naughton

Funding Agency: U.S. Army Corps of Engineers
Completion Date: 3/31/99

Objectives: 1) To estimate abundance of smallmouth bass and northern squawfish in the trailrace and forebay of Lower Granite Dam during operation of the Surface Bypass and Collection prototype (SBC); and 2) To estimate predation on chinook salmon by northern squawfish and smallmouth bass in the tailrace and forebay of Lower Granite Dam during operation of the SBC.

Progress: We compared the relative and absolute abundance, diet composition, and consumption rates of salmonid fishes by smallmouth bass *Micropterus dolomieu* and the northern pikeminnow *Ptychocheilus oregonensis* in the tailrace and forebay of Lower Granite Dam associated with the surface bypass collector and with those from the Snake and Clearwater river arms of upper Lower Granite Reservoir. We found that the relative abundance of smallmouth bass < 174 mm in length was significantly higher in the Snake and Clearwater river arms than in the tailrace and forebay, while smallmouth bass > 174 mm in length were generally more abundant in the Snake River arm than in other sampling locations during 1996 and 1997. Northern squawfish >349 mm were most abundant in the tailrace boat-restricted zone, while squawfish <200 mm were most abundant in the tailrace in 1996 and 1997. We found no significant differences in the relative abundance of northern squawfish 200-349 mm in length among reservoir locations in both years. Based on a mark-recapture census we found the absolute density (No/m) of smallmouth bass > 174 mm in length was highest in the forebay of Lower Granite Dam. Population density of smallmouth bass > 174 mm in length was highest in the tailrace. Crustaceans and nonsalmonid fishes were the most abundant food items by weight of both smallmouth bass and northern squawfish from April through August 1996 and 1997. Juvenile salmonids were a food item of insignificant importance to smallmouth bass and northern squawfish diets at any location in Lower Granite Reservoir and tailrace. We did not find evidence of consumption of juvenile salmonid fishes by northern squawfish at the four sampling locations in 1996 and 1997. Consumption rates of juvenile salmonid fishes by smallmouth bass were highest in the forebay (0.017 smolts/bass/day) in 1996 and in the tailrace (0.015 smolts/bass/day) in 1997, respectively. We estimate approximately 6,400 and 7,800 juvenile salmonid fishes were consumed by smallmouth bass from April to August 1996 and 1997, respectively. High flows and resulting lower water temperatures and higher turbidity may have contributed to the low levels of predation on juvenile salmonids we observed during 1996 and 1997.

NORTH FORK COEUR D'ALENE CUTTHROAT/HABITAT RELATIONSHIPS

Principal Investigator: D. H. Bennett
Student Investigator: Ann Abbott
Funding Agency: Idaho Department Fish and Game
Completion Date: 12/31/97

Objective: 1) To evaluate the effects of land management activities on westslope cutthroat trout in the Coeur d'Alene River.

Progress: Final report and student thesis is being prepared after one year being in a "holding" pattern.

EFFECTS OF INCREASED WINTER WATER LEVELS IN LAKE PEND OREILLE ON KOKANEE SURVIVAL, PREDATION, FOOD ABUNDANCE, AND AQUATIC MACROPHYTES

Principal Investigator: D. H. Bennett
Student Investigators: Lance Clark
Dimitri Vidergar
Funding Agency: Idaho Department Fish and Game
Completion Date: 12/31/99

Objectives: 1) To evaluate growth and survival of age 0 kokanee in Lake Pend Oreille; 2) to evaluate the spatial and temporal zooplankton abundance in Lake Pend Oreille during the growth season for kokanee; and 3) To evaluate the abundance of potential predators and assess their consumption of kokanee in Lake Pen Oreille.

Progress: We monitored zooplankton abundance, conducted in lake-growth and survival studies, and tagged sampled contents of potential kokanee *Oncorhynchus nerka* predators in Lake Pend Oreille, Idaho through 1997. Growth studies indicated kokanee survived in net pens at low, medium and highest zooplankton abundances although growth was highest in the net pens having the highest abundance of zooplankters. Zooplankton abundance was highest in Ellisport Bay of the four bays and two open-lake sampling sites. Temporal distribution s of zooplankton were generally similar among sampling sites; two dietary important cladocerans, *Bosmina* and *Daphnia* generally increased in August and declined in September or October. Daytime vertical abundance of zooplankton was generally similar at the 5, 10, 15, and 20 m depths. Horizontal abundance of both cladocerans and copepods was generally similar among samples collected at water depths of 1 to 100 m except at Ellisport Bay where zooplankters were most abundant at the 5 and 10 m depths.

We trained volunteers through an extensive public education effort to correctly tag and document recaptures of rainbow trout (kamloops) *Onchorhyncus mykiss*, bull trout Salvelinus confluentus, and lake trout *Salvelinus namacush* > 406 mm. Between April and December 1997 195 kamloops were tagged, 239 bull trout were tagged, and 59 lake trout were tagged. Preliminary population estimates of kamloops and bull trout were 29,282 (+/- 28,604-95% confidence intervals) and 5,880 (+/- 5,586-95% confidence intervals), respectively. Movement of recaptured fish varied from a few miles to approximately 23 km.

Stomach samples were collected from harvested kamloops and lake trout, and northern squawfish. We collected 503 stomach samples in 1997. Results of stomach samples analyzed showed that kamloops and lake trout are feeding primarily on kokanee while northern squawfish are feeding primarily on insects, and other miscellaneous prey items.

STUDIES OF FISHWAYS MODIFICATIONS AND TEMPERATURE, SPILL DEFLECTORS, AND PATTERNS AT LOWER SNAKE RIVER DAMS

Principal Investigator: T. C. Bjornn
Student Investigator: Rich Piaskowski

Funding Agency: U.S. Army Corps of Engineers
Completion Date: 3/31/99

Objectives: 1) Monitor passage of spring chinook salmon through the fishways at Lower Granite, Little Goose, and Ice Harbor dams, with particular reference to north powerhouse entrances and passage through transition pools; 2) Monitor water temperatures in the forebays and fishways at Lower Granite and Ice Harbor dams during summer and early fall to determine if temperatures in fishways can be improved; 3) Monitor the distribution and movement of squawfish and smallmouth bass in the forebay and tailrace of the dam in relation to the SBC, discharges from the SBC, water temperatures, river flow, and spill at the dam; and 4) Relate fish passage rates to flows, spill, powerhouse discharges, and total dissolved gas in the tailrace during the period of passage.

Progress: A prototype surface bypass and collector (SBC) was installed at Lower Granite Dam in winter 1996 to evaluate surface bypass and collection as a means to improve juvenile salmonid passage and survival at Columbia and Snake river dams. To evaluate the potential for increased predation on juvenile salmonids during operation of the SBC, we monitored the distribution and movements of 75 adult northern squawfish *Ptychocheilus oregonensis* and 32 adult smallmouth bass *Micropterus dolomieu* outfitted with radio-transmitters, April to September, 1996-98. Five northern squawfish monitored in the forebay, and 12 and 20 smallmouth bass monitored in the forebay and tailrace consistently inhabited near shore areas. In the tailrace, the distribution of 71 northern squawfish was limited to shorelines and protected low velocity areas when continuous spill was present. Northern squawfish moved into the spillway-stilling basin and downstream from the turbines when river flows decreased and there was no spill.

Losses of juvenile salmonids to predation by northern squawfish and smallmouth bass vary seasonally and depend on river conditions. The potential for predation on juvenile salmonids by northern squawfish in close proximity to the SBC in the forebay, or by smallmouth bass in either the forebay or tailrace, is not very high because of small numbers of predators and they did not congregate near the SBC. In the tailrace, predation by northern squawfish on juvenile salmonids could be significant if river flows are low and there is little or no spill when juvenile salmonids are passing through the SBC and over spillbay 1. At the present time, squawfish abundance is low which will limit predation.

In 1996, a prototype surface bypass collector (SBC), and in 1998 a behavioral guidance structure (BGS) for migrating juvenile salmonids, were installed at Lower Granite Dam. Mobile tracking and fixed receiver sites were used to monitor radio-tagged adult chinook salmon to evaluate the potential effects the SBC and BGS could have on upstream adult migration. The operation of the surface bypass collector could potentially affect upstream adult migration by creating another opening for fish to fallback over the dam and installation of the behavioral guidance structure could alter migration routes.

Adult salmon were tracked by boat or on foot as they exited the fish ladder on the south shore. A fixed antenna and receiver located 2 km upstream recorded fish as they exited the forebay area. In 1997, 192 chinook salmon were tracked; the majority of fish migrated along the south shore (135) while some crossed in front of the dam to the north shore and traveled upstream (14). Sixteen traveled upstream through the middle of the channel and 22 were located in the vicinity of the surface bypass collector. Four fish were tracked twice (fallbacks that reascended) and 90 had been reported as being recaptured in fisheries or at hatcheries or spawning areas. In 1998, 145 chinook salmon were tracked (85 BGS out, 44 BGS in, and 16 BGS in transition). The majority of fish migrated along the south shore (79) while some crossed in front of the dam to the north shore and moved upstream (31). Sixteen fish were located in the vicinity of the

surface bypass collector and 15 were tracked to the behavioral guidance structure. Two fish were tracked twice (fallbacks that reascended) and 43 had been reported as being recaptured in fisheries or at hatcheries or spawning areas.

The SBC and BGS do not appear to have an effect on adult passage. The percentage of fish that crossed to the south and north shore is similar with the BGS in and with the BGS out. Forty-eight percent of fish went up the south shore with the BGS in and 62 percent with the BGS out. Seven percent of the fish crossed to the north shore with the BGS in and 22 percent with the BGS out. The migration route results of 1998 are similar to 1997 (before the BGS was installed 79% south shore and 8% north shore). Fallback rates will be assessed upon completion of the general migration file and compared to previous years.

Spill deflectors or flip lips were not added to the spillbays at Ice Harbor Dam until 1997 due to concerns that deflected spill would create flow patterns that would be detrimental to adult passage and the belief that daytime spill would be minimal at Ice Harbor Dam. In 1996, uncontrolled spill and spill for smolt passage contributed to dissolved gas levels that exceeded current standards. High dissolved gas levels may lead to losses of adults and juveniles due to gas bubble disease. Spill deflectors were added to spillbays four through seven in 1997 and to spillbays two, three, eight, and nine in 1998.

The addition of spill deflectors to spillbays at Ice Harbor Dam appears to have reduced dissolved gas levels at moderate levels of spill but not at levels in excess of 100 kcfs. We monitored entrance use and the time needed for adult chinook salmon to approach and enter fishways to determine if the addition of spill deflectors had any effect on adult migration.

MONITORING AND EVALUATION OF FALL CHINOOK SALMON SUPPLEMENTATION IN THE SNAKE RIVER

Principal Investigator: T. C. Bjornn
Student Investigator: William Connor
Funding Agency: U.S. Fish and Wildlife Service
Completion Date: 12/31/99

Objectives: 1) Assess timing of emergence and migration of natural fall chinook salmon as related to survival to the tailrace at Lower Granite Dam; 2) Assess the residualism of natural and hatchery fall chinook salmon in the Snake and Clearwater rivers; and 3) Assess the attributes of hatchery fall chinook salmon following release into the Snake River and their survival to Lower Granite Dam.

Progress: Fall chinook salmon eggs were obtained for the study and the fish reared at Lyons Ferry Hatchery until release in spring 1998 in the Hells Canyon reach of the Snake River. Samples of hatchery juveniles and wild subyearlings collected from the Snake River were PIT tagged and released back into the river. Their migration downstream in the Snake River was monitored at the dams to assess timing of migration, migration rate, and survival. Adults from releases in prior years returned to the Snake River and were monitored at Lower Granite Dam. Radio transmitters were placed in a sample of the returning adults to determine their distribution in the spawning areas upstream from the dam.

SYNTHESIS OF INFORMATION ON SNAKE RIVER SALMON AND WILD TROUT MANAGEMENT

Principal Investigator: T. C. Bjornn
Funding Agency: USGS/Biological Resources Division
Completion Date: 6/30/99

Objectives: 1) To prepare a book-length manuscript on the biology, management, history of Snake River salmon and steelhead; and, 2) To prepare a book-length manuscript on the biology, population dynamics, and management of wild trout in the Pacific Northwest.

Progress: A large amount of historical information on the salmon and steelhead stocks of the Snake River basin has been accumulated and analyses have been proceeding. Outlines for two possible books have been prepared. Data from our past studies on salmon, steelhead, and wild trout is being accumulated and converted to usable form. Some analyses has been completed for the books, but no writing took place during the year due to the press of work on other projects with more pressing deadlines.

EFFECT OF HATCHERY SUPPLEMENTATION ON STOCK PRODUCTIVITY AND PERFORMANCE

Principal Investigator: T. C. Bjornn
Co-Principal Investigator: S. Rubin
Funding Agency: USGS/Biological Resources Division
Pacific Northwest Natural Science Center
Completion Date: 12/31/98

Objectives: 1) Compare the growth and survival of genetically marked offspring from local wild steelhead and from hatchery steelhead in two tributaries of the Lochsa River; 2) Compare the growth and survival of genetically marked offspring from local wild steelhead and from hatchery steelhead in hatchery ponds at Dworshak NFH and Carson NFH; 3) Compare the growth and survival, in streams and in a hatchery, of juvenile spring chinook salmon from Warm Springs NFH with that from Carson NFH and the Warm Springs River; and 4) Test for selection on genetic marks by comparing the growth and survival of juvenile fish with the different genotypes rearing together in natural streams and in hatcheries.

Progress: Experimental steelhead have been reared in Brushy Fork Creek, Crooked River, Twentymile Creek, North Fork Palouse River, Dworshak National Fish Hatchery, and Clearwater Hatchery. The fish will be used to compare wild and hatchery fish, selective neutrality of genetic marks, and the effects of temperature on development rates. Fish were sampled from all streams and hatcheries, population estimates were made in some streams, and traps were operated in Brushy Fork and Twentymile creeks to monitor downstream migration of juveniles.

EVALUATION OF ADULT SALMON, STEELHEAD, AND LAMPREY MIGRATION PAST DAMS AND THROUGH RESERVOIRS IN THE LOWER COLUMBIA RIVER AND INTO TRIBUTARIES

Principal Investigator: T. C. Bjornn
Student Investigators: Tami Reischel
Michael Craig

Funding Agency: U.S. Army Corps of Engineers
Completion Date: 12/31/2001

Objectives: 1) Prepare final work plan for field work to be conducted in 1996; 2) Complete testing of potential receiver sites and antenna setups at each of the dams to determine how and where adequate transmitter signal reception can be obtained; 3) Complete installation of radio telemetry equipment, as needed, at each of the dams and the mouths of tributary streams; 4) Complete preparation of protocols and computer programs for processing fish movement data downloaded from receivers; 5) Capture, tag, and track adult salmon and steelhead at the lower Columbia and Snake River dams; and 6) Begin processing and analyzing fish movement data and prepare data summaries and a report.

Progress: In 1998, we continued studies of the upstream migration of adult salmon and steelhead past dams, through reservoirs, and into tributaries of the Columbia River basin and placed radio transmitters in 896 spring and summer chinook salmon and in about 1000 fall chinook salmon. We began putting transmitters in spring chinook salmon on 1 April and discontinued tagging summer chinook salmon on 15 July because river temperatures exceeded 70 F. We began tagging fall chinook salmon on 31 August despite continued high river temperatures to avoid missing the main part of the fall run.

As in past years, a high percentage (92%) of the spring and summer chinook salmon released with transmitters downstream from Bonneville Dam in 1998 returned to the dam and proceeded upstream. We were still tagging fall chinook salmon at the time this report was prepared.

Some salmon move back downstream past dams on the Columbia and Snake rivers and are referred to as fallbacks. Fallback rates (number of fallback events/number of fish passing dam) of up to 30% have been reported in past years at Bonneville Dam, particularly when large amounts of water was discharged through the spillways. Based on completed analyses of the 1996 data, 14% of the salmon that passed over Bonneville Dam fell back over the dam, but because some fell back more than once, the fallback rate that would be used to correct counts of salmon passing the dam was 16.7% (133 events/795 salmon that passed dam). Rates of fallback were related to the volume of spill. Our preliminary estimates of fallback rates in 1996, 1997, and 1998 at Bonneville Dam of spring and summer chinook salmon were 17.8%, 19.4%, and 12.9%.

Because of the high incidence of fallback among salmon using the Bradford Island fishway in 1997 and 1998, migration routes of salmon and steelhead that exited the Bradford Island fishway were monitored with radio telemetry equipment to obtain baseline data. Data will be used in consideration of proposals to reduce fallback at the dam.

Spring and summer chinook salmon , sockeye salmon, and steelhead outfitted with radio transmitters and released downstream from Bonneville dam were tracked from the Bradford Island fishway exit upriver approximately two kilometers. A radio receiver and antenna located 4 km upstream from the dam was used to record fish as they exited the study area. In 1997, a total of 251 fish (130 chinook salmon, 111 sockeye salmon, and 10 steelhead) were tracked; eight were tracked twice (fallbacks that reascended), 146 were recorded at the upstream receiver site, and 78 had been reported as being recaptured in fisheries or at hatcheries or spawning areas. In 1998, 131 spring and summer chinook salmon were tracked; two were tracked twice (fallbacks that reascended), 115 were recorded at the upstream receiver site, and 37 had been

reported as being recaptured in fisheries or at hatcheries or spawning areas. Of the chinook and sockeye salmon tracked in the Bonneville forebay in 1997, 19% and 12% were estimated to have fallen back. In 1998, the preliminary fallback estimate of chinook salmon tracked in the forebay is 10 percent.

Studies to evaluate passage of adult Pacific lamprey at Bonneville dam were continued in 1998 with the release of 200 transmitter-tagged lamprey into the tailrace of the dam. Special studies to evaluate their swimming behavior and performance were conducted. Lamprey with transmitters were monitored in the tailrace and as they proceeded up the ladders to determine where they were having difficulty in their attempts to pass the dam. Modifications to the B-branch entrance to the Bradford Island fishway were evaluated. Tributaries downstream and upstream from Bonneville Dam were searched for lamprey with transmitters.

We evaluated the swimming performance of adult Pacific lamprey *Lampetra tridentata* by modifying the hydraulics and design of an experimental PVC pipe fishway and compared the resulting lamprey passage. Testing facilities at the Bonneville Dam Adult Fish Collection and Monitoring Facility (AFF) consisted of 30-ft. sections of PVC pipe (8 or 12 in. diameter) connected to a downstream introduction tank and an upstream collection tank. A total of 77 test trials were conducted involving 805 lamprey (495 naive, 310 re-tested) during June through August 1998. Proportions of lamprey that passed through the pipes and total passage times were similar across lower water velocities tested (0.5, 1.0, and 1.75 fps), but proportions that passed decreased and total passage times increased at water velocities $\geq$ 4.5 fps. Proportions of lamprey that passed were higher during nighttime as compared to day and higher during the earlier period of testing (17-Jun-2Jul98) compared to the later (7Jul-23Jul98). Lamprey had lower passage rates through pipes with 1 ft steps every 10 ft (41%$\pm$16 SE) compared to straight pipes (85.5%$\pm$ 3.8 SE). The lower passage rate was apparently due to high water velocities (6-6.5 fps), low water depth (1-2 in.), and pipe slope (1-on-3 ft.) present within stepped transition sections.

EVALUATION OF THE PROCEDURES FOR COLLECTION, BYPASS, AND DOWNSTREAM PASSAGE OF OUTMIGRATING SALMONIDS

Principal Investigator: J. L. Congleton
Student Investigators: Tom Welker
Lorrie Haley
Funding Agency: U.S. Army Corps of Engineers
Completion Date: 12/31/98

Objectives: 1) Sample spring chinook smolts of wild and hatchery origin to determine and compare physiological responses to barge transportation; 2) Analyze blood and tissue samples; provide blood and tissue samples to other investigators; 3) Determine if significant differences exist between wild and hatchery chinook salmon such that they might have different survivorship following collection, bypass, or transportation; and 4) Determine the cumulative effects of dam passage on stress indices, energy stores, and "tissue damage" enzymes in migrating chinook salmon.

Progress: At present, few field data are available regarding the cumulative physiological responses of juvenile salmonids to passage through multiple dams. This information is needed to determine the effects of passage through the hydropower system on fish condition and viability, to supplement ongoing studies undertaken to determine relative smolt-to-adult survival rates for transported and inriver migrating fish, and to determine if differences in hatchery rearing practices affect post-release survival. In the spring of 1998, a study was initiated using PIT-tag "diversion-by-code" systems at dams on the Snake and Columbia Rivers

to identify and sample groups of migrating spring/summer chinook salmon released from three Snake River hatcheries. Juvenile chinook salmon reared at Dworshak, Rapid River, and McCall hatcheries were sampled at Lower Granite, Little Goose, John Day, and Bonneville dams. Prerelease samples were also taken at the three hatcheries.

Tissue samples were taken for determination of gill Na^+, K^+ ATPase activity; plasma cortisol, glucose, protein, triglyceride, cholesterol, chloride, sodium, potassium, calcium, alanine aminotransferase, aspartate aminotransferase, lactate dehydrogenase, and creatine kinase concentrations; organ size and appearance; erythrocyte vitamin E content; the occurrence of erythrocytic inclusion body syndrome; and carcass and gut water, lipid, protein and ash concentrations. In total, over 6000 samples will be analyzed; about one-third have been analyzed at this time.

Initial evaluation of the data indicates that total lipid reserves, which were initially highest in Dworshak fish and lowest in McCall fish, declined rapidly during downstream migration, falling to about 45% of prerelease values at Little Goose dam and changing little at downstream sampling points. Declining lipid reserves were accompanied by declining plasma triglyceride, cholesterol, and total protein concentrations. At Bonneville dam, the lipid reserves of Dworshak fish were extremely low (2.6% of dry carcass weight), and somewhat higher for McCall (4%) and Rapid River fish (6.7%). These differing lipid levels are of interest because some published literature has indicated that the ability to adapt to seawater may be compromised in smolts with low lipid reserves. Alkaline phosphatase levels, which may reflect the rate of food intake, declined in the lower river. The levels of tissue-damage enzymes did not differ between hatcheries or show an increasing or decreasing trend from Lower Granite to Bonneville dams but were consistently elevated in fish sampled at Little Goose Dam.

Migrating wild and hatchery spring/summer chinook salmon and steelhead were sampled from gatewells at Lower Granite Dam in 1998 for determination of a range of physiological and health indices. These data, which have not yet been fully analyzed, will serve to establish baseline values needed for a comprehensive, multi-year evaluation of physiological data collected in earlier years.

DEVELOPMENT OF METHODS OF CONTROL OF INFECTIOUS HEMATOPOIETIC NECROSIS (IHN) VIRUS IN COMMERCIALLY REARED SALMONID FISHES

Principal Investigator: J. L. Congleton
Funding Agency: Western Regional Aquaculture Consortium
Completion Date: 3/31/99

Objectives: 1) Develop model challenge protocols that mimic the etiology of mixed IHNV/*Flexibacter psychrophilus* infections; 2) Determine effects of IHNV and *F. psychrophilus* on the immune response of rainbow trout; and 3) Determine histopathological changes in various tissues from fish exposed to mixed IHNV/*F. psychrophilus* infections.

Progress: Mixed infections of *Flexibacter psychrophilus*, causative bacterium of bacterial coldwater disease (CWD), and IHNV are often observed in populations of cultured rainbow trout. Fish infected with *F. psychrophilus* may be predisposed to IHNV, and the converse may also be true. Studies concerning the synergism of these two pathogens have not been reported, and little data is available concerning appropriate prevention and treatment methodology for these mixed infections. The development of methods for monitoring the immune response to *Flexibacter psychrophilus* and determination of the effects of *Flexibacter psychrophilus* on the immune response to IHNVare essential preliminary steps toward development of a combined vaccine that would protect fish from the mixed infections by the two agents. In

1998, an enzyme-linked immunosorbent assay (ELISA) was developed to detect and quantify the specific humoral immune response of rainbow trout against *F. psychrophilus*. During the next year, this ELISA will be used to study the ability of IHNV-infected and control fish to mount an antibody response to *Flexibacter psychrophilus* challenge. In future years, the ELISA may be used to monitor the production of protective antibody after innoculation of trout with experimental *Flexibacter psychrophilus* vaccines.

IMPROVED NUTRITION TO INCREASE THE VIABILITY OF HATCHERY SMOLTS

Principal Investigator: J. L. Congleton
Student Investigator: Tom Welker
Funding Agency: Idaho Department of Fish and Game
Completion Date: 7/30/99

Objectives: 1) Organize workshop on fish nutrition; 2) Develop or adapt assays for detection of oxidative stress in fish; 3) Initiate laboratory trial at UI with alternative diets; 4) Initiate sampling of fish from Idaho Department of Fish and Game hatcheries to test antioxidant indices; 5) Carry out feeding trials at state or Federal chinook salmon hatcheries; release marked test groups to determine post-release survival; and 6) Develop BPA funding proposal for expansion of project.

Progress: Objectives 1, 2, and 3 were completed in previous years. In the spring of 1998, spring and summer chinook salmon juveniles were sampled from Rapid River and McCall hatcheries to test antioxidant indices. Juvenile chinook salmon were also sampled from Dworshak National Fish Hatchery, and fish from all three hatcheries were sampled during downstream migration at Lower Granite, Little Goose, John Day, and Bonneville dams. Assays of red blood cell peroxidative resistance (a measure of vitamin E status) indicated that vitamin E status declined to the greatest extent in Dworshak fish and to the least extent in McCall fish during downstream migration. Laboratory assays to determine the extent of oxidation of liver and kidney tissues will not be completed until spring 1999.

EFFECTS OF INCREASED WINTER WATER LEVELS IN LAKE PEND OREILLE ON KOKANEE SURVIVAL, PREDATION, FOOD ABUNDANCE, AND AQUATIC MACROPHYTES

Principal Investigator: C. M. Falter
Student Investigator: Tyler Wagner - Undergraduate
Funding Agency: Idaho Department Fish and Game
Completion Date: 12/31/99

Objectives: 1) To monitor abundance and distribution of aquatic macrophyte to determine if the higher winter pool elevation is a benefit to the establishment of Eurasian water milfoil *Myriophyllum spicatum spicatum.*

Progress: In 1997-98, we sampled Pend Oreille Lake and the Pend Oreille River throughout the summer-fall period. We selected sites (sampling areas) with emphasis on the northern portion of Pend Oreille Lake and the Pend Oreille River outlet arm of the lake, and three sample areas in the mid-and lower sections of the lake. Specific dry weight biomass levels are being determined, but most sites showed common-to-heavy macrophyte growth in the 3.5-7.0 m depth range. There was generally little growth in the shallowest depth strata (0-3.5 m), with indices of rare to sparse plant growth in that shallowest zone. We collected

very few plants in the deepest depth strata of 7-11 m. In this deep sublittoral zone, the substrate consisted mostly of sand, gravel, and rock. No Eurasian water milfoil (*Myriophyllum spicatum spicatum*) was found in 1997 but explosive growth developed at the outlet end of the lake in 1998. Depth distribution of *M. spicatum spicatum* suggests more optimal growing conditions with the higher winter water levels. Over 1,000 plant samples have been collected in the summer-fall of 1997-98, along with water chemistry, transparency, substrate, and water samples.

The results of this study will be used to determine if higher winter water levels permit introduction and spread of water milfoil and to manage water level for increased population size of zooplankton and hence kokanee (land locked sockeye salmon).

UNDERSTANDING OF FACTORS AFFECTING THE EPIDEMIOLOGY OF WHIRLING DISEASE IN IDAHO

Principal Investigator: C. M. Moffitt
Student Investigator Monica Hiner
Funding Agency: Idaho Department of Fish and Game
Completion Date: 6/30/99

Objectives: 1) Provide laboratory analyses for samples of fish from short-term tiactinomyxon exposures using the newly developed in situ hybridization probes for M. cerebralis; 2) Develop a database information on M. cerebralism in Idaho; 3) Evaluate the significance of populational and environmental factors using the information obtained from the data base of field samples and exposures tests in Idaho and in states with known problems; and 4) Prepare final reporting for the project.

Progress: Student Monica Hiner began work on this project fall of 1997. We proposed a conceptual model for factors affecting whirling disease, caused by *Myxobolus cerebralis*. Factors within the conceptual model were identified for which data may be available from cooperative agencies such as USGS, USFWS, Idaho Department of Fish and Game, USFS, and DEQ. Biotic factors include diversity of benthic invertebrates, including density of oligochaete worms, fish species, population age structure, and fish movements. Abiotic factors include river flow regime and type (regulated, spring fed, run-off), water temperature, stream size, substrate type, and barriers to fish migration.

We constructed a database for *M. cerebralis* within Idaho including sampling agency, number and species of fish sampled, site, date, diagnostic technique, and outcome of the testing (positive or negative for *M. cerebralis*). We prepared preliminary maps of the distribution of samples and positive fish. In cases where exposure studies were conducted, prevalence was obtained from histological assessments and in some cases we obtained results of histological scores of samples by level of infection. Data collection for biotic and abiotic factors corresponding for each site where whirling disease status is known is in progress.

Student Hiner presented a paper at the 4th Annual Whirling Disease Symposium in Fort Collins, Colorado in February. This presentation focused on the conceptual model and our efforts to collect data for this. In preliminary studies conducted at the University of Idaho (funded through the Montana Whirling Disease Partnership), we detected positive and negative collections in a reach of the South Fork of the Boise River below Anderson Dam. During the summer of 1998, we expanded study locations and sampling times to four sites and three months (June, July, and August). We reared groups of rainbow trout (*Oncorhynchus mykiss*) and cutthroat trout (*Oncorhynchus clarki*) from fertilized embryos to swimming fry in the FWR wet laboratory. At three intervals in the summer, we transported fry to the South Fork of the Boise for a 10-d exposure and returned the fish to the U of I lab for extended rearing in specific pathogen-free conditions.

Water temperature was monitored throughout the exposures in the river. We detected a 3-4 C° difference between the site at Anderson Dam and the other three downstream sites. Benthic invertebrate samples were collected from each site after the exposure trials were completed in August. The downstream site had a heavy organic load and many oligochaete worms. The fish exposed at this site in June that have been examined by histology appear heavily infected, and fish in the laboratory are showing clinical disease such as black tail and whirling behavior.

During rearing of our exposure fish in the FWR wet laboratory, we had an outbreak of bacterial coldwater disease and were forced to terminate the rainbow trout exposure group from June to contain the infection. We are rearing five experimental units from 10 d-exposed fish from the St. Joe River and North Fork of the Coeur d'Alene. Two tanks of the fish from the North Fork of the Coeur d'Alene developed *Ichthyophthirius* infections, likely brought in the lab on these fish. We were able to contain the infection and save the fish in one of these tanks by repeated formalin treatments.

We are continuing rearing of exposed groups of fish in the wet laboratory, and will continue histological assessments of samples of fish from each group and from the fish from northern Idaho studies. In the coming months, we will collect data for environmental modeling of *M. cerebralis*. We will prepare an abstract and presentation for the 5th Annual Whirling Disease Symposium, held in February in Missoula, Montana. Student Hiner is planning to complete her thesis and final report on the project in the summer of 1999.

FDA APPROVED REGISTAION OF ERYTHROMYCIN FOR TREATMENT OF BACTERIAL KIDNEY DISEASE

Principal Investigator: C. M. Moffitt
Student Investigator: Yasunari Kiryu
Funding Agency: U.S. Fish and Wildlife Service
Completion Date: 12/31/98

Objectives: 1) Analyze data, prepare summaries of analysis of experiments, and submit all necessary data needed to satisfy the requirements of drug registration of erythromycin injectable and feed additive; 2) Follow-up submittals with direct dialog with FDA to clarify necessary elements; 3) Arrange for archival storage of data for the required 5 years post project; and 4) Prepare final reporting for the project.

Progress: This project was funded to assist with completion of the U. S. Food and Drug Administration's requirements for the approval of erythromycin to control bacterial kidney disease in salmonids. Bacterial kidney disease, caused *by Renibacterium salmoninarium*, is a chronic and serious cause of mortality to populations of Pacific salmon, particularly in captive brood or production aquaculture settings. The major funding for this project was provided through Bonneville Power Administration, and these USFWS funds were provided to supplement the initial funding when the progress for registration was slowed by changes in policy interpretation within the Food and Drug Administration. When the project was begun in 1989, the requirements for environmental assessment and for human risks of resistant microorganisms were few. However, 10 years later, the FDA and other sectors are actively concerned about the risks of resistant microorganisms resulting from use of drug is food animals (and also humans). In addition much more attention has been given to the environmental consequences of administration of antibiotics or any chemicals in aquaculture settings.

We have successfully completed all required studies of efficacy, target animal safety and tissue residue depletion. Over 15 submissions of pivotal data have been reviewed by the Center for Veterinary Medicine's Office of New Animal Drug Evaluation. These include non-clinical laboratory studies of

efficacy and studies of target animal safety for two ages of juvenile salmonids. In addition, we coordinated field trials of efficacy at over 120 hatcheries in the Pacific Northwest to generate a large data set used to demonstrate the safety and efficacy of the treatments in a field setting. A positive review of all pivotal field trials conducted during 1991 to 1996 was received this September. These submissions support a label claim for the erythromycin feed additive of 100 mg/kg body weight, administered in the feed each day for 20 to 28 days of therapy. The claim will be supported for water temperatures ranging from 4 to 17°C.

However, we still have not obtained a manufacturing sponsor for this feed additive product, nor have we resolved, to the satisfaction of FDA, the risks to humans of acquiring resistant microorganisms from the use of this drug in salmonids. In addition there are outstanding issues regarding the environmental fate.

We are compiling information on resistant microorganisms in fish with assistance of regional scientists but will not be able to complete outstanding elements for registration before the end of this contract. We are contacting the funding agencies to determine if they want to extend these contracts or close them without all objectives completed. Funding was never provided to handle these unanticipated set backs in the program.

DETERMINATION OF THE EFFECTS OF CONTAMINANTS ON WHITE STURGEON REPRODUCTION IN THE KOOTENAI RIVER

Principal Investigator: D. Scarnecchia
Student Investigator: Gretchen Kruse
Funding Agency: Idaho Department of Fish and Game
Completion Date: 12/31/99

Objective: To determine if contaminants (PCBs, pesticides and heavy metals) in gonad, egg, and larval tissue of Kootenai River white sturgeon are limiting survival of sturgeon eggs and larvae.

Progress: To date, we have collected 20 ovarian tissue samples from Kootenai River white sturgeon. We will be collecting the remaining 7 or more samples during the spring of 1999. Sixteen of these 20 samples have been analyzed for contaminants by AMTEST in Redmond, Washington. Tissues were screened for 9 metals, organophosphates, organonitrates, organochlorines, and carbonates. Seven metals (Arsenic, cadmium, copper, iron, lead, selenium, and zinc) and 5 organochlorines (DDT, DDE, Aldrin, Dieldrin, and Arochlor 1260) were found in ovarian tissues.

Data from these first 16 samples have been entered into a statistical program and preliminary analysis has begun. Concentrations of metals appear to have small variances but the concentrations of Organochlorines have rather large variances.

Due to delayed construction, the Kootenai Tribe was unable to bring the water filtration system on-line this spring. Therefore, we were unable to complete the egg rearing experiment to analyze contaminant uptake, by developing embryos, from water, suspended solids, and sediment. All equipment is prepared and this experiment has been rescheduled for May/June 1999.

HABITAT USE AND POPULATION DYNAMICS OF BENTHIC FISHES ALONG THE MISSOURI RIVER

Principal Investigator: D. Scarnecchia
Student Investigator: Tim Welker
Funding Agency: U.S. Army Corps of Engineers
Completion Date: 12/31/00

Objectives: The goal of the overall study is to gain information to assist in planning a broader study that will help the COE in complying with the Endangered Species Act. 1) Describe and evaluate recruitment, growth, size structure, body condition, and relative abundance of selected benthic fishes in the Missouri River between the Yellowstone River-Missouri River confluence and the headwaters of Lake Sakakawea, North Dakota, and between Garrison Dam and the headwater of Lake Oake; 2) Describe the use of six dominant habitats (main channel, outside bend, inside bend, tributary mouth, connected secondary channel, nonconnected secondary channel), and 3) Measure hydrological (e.g. velocity), physical (e.g. bottom type), and water quality (e.g. turbidity, temperature) features where fish are collected.

Progress:

This project was just initiated, and results are pending completion of field work.

Completed Projects - Fisheries Resources

David H. Bennett - Principal Investigator

Predations of fall chinook by smallmouth bass on salmon in the Hells Canyon reach of the Snake River, ID

Fish interactions in Lower Granite Reservoir, Idaho-Washington

Jim C. Congleton - Principal Investigator

Studies to establish biological design criteria for fish passage facilities: Improved wet separator efficiency

Evaluation of the effects of descaling on short-term survival of migrating juvenile salmonids

George LaBar – Principal Investigator

Fish information website

Dennis Scarnecchia – Principal Investigator

Life history characteristics of key native fish entrainment at Intake Canal, Yellowstone River, MT

PREDATIONS OF FALL CHINOOK SALMON BY SMALLMOUTH BASS IN THE HELLS CANYON REACH OF THE SNAKE RIVER

Principal Investigator: D. H. Bennett
Student Investigator: R. D. Nelle
Funding Agency: USGS/Biological Resources Division
Western Fishery Research Center
Completion Date: 5/31/98

Objectives: 1) Estimate abundance of smallmouth bass in the Hells Canyon reach of the Snake River; 2) Estimate consumption rates of fall chinook salmon by smallmouth bass; and 3) Estimate total loss of fall chinook salmon as a result of predation by smallmouth bass.

Results: The relative abundance of smallmouth bass 150 mm to 249 mm for 1996 and 1997 were significantly higher in the portion of the Snake River upstream of the Salmon River than downstream. Also, smallmouth bass >250 mm were significantly more abundant upstream of the Salmon River but not in 1997. Preliminary estimates of smallmouth bass abundance are about 400/km, similar to the findings of other regional studies.

Preliminary results suggest the diet of smallmouth bass in the Hells Canyon reach of the Snake River is comprised primarily of insects, fish, and crayfish based upon frequency of occurrence. Juvenile fall chinook salmon made a small portion of the diet during 1996 and 1997. We are currently examining scale samples for age determinations for the bioenergetics analysis.

FISH INTERACTIONS IN LOWER GRANITE RESERVOIR, IDAHO-WASHINGTON.

Principal Investigator: D. H. Bennett
Student Investigators: Matt Davis
Steve Anglea
Tom Dresser
Tom Cichosz
Funding Agency: U.S. Army Corps of Engineers
Completion Date: 9/30/97

Objectives: 1) To qualify and quantify the predatory influence of smallmouth bass on juvenile chinook salmon in Lower Granite Reservoir; 2) To determine habitat use, fish species associations and overlap in shallow water habitat in Lower Granite Reservoir; 3) To identify factors affecting the abundance of northern squawfish and smallmouth bass in Lower Granite Reservoir; 4) To evaluate food and feeding guilds for resident and juvenile anadromous salmonid fishes in Lower Granite Reservoir; 5) To determine habitat use and role of crayfish in the Lower Granite Reservoir system; 6) To assess the magnitude and location of predation on subyearling chinook salmon in Lower Granite Reservoir; 7) To evaluation biotic and abiotic factors affecting subyearling chinook salmon abundance in Lower Granite Reservoir; and 8) To assess habitat use of subyearling chinook to estimate the rearing potential of Lower Granite Reservoir.

Results: This study, in part, examined interactions of resident fishes on downstream migrating juvenile salmonid fishes in Lower Granite Reservoir from 1994 through 1995. Smallmouth bass *Micropterus dolomieu*, the most abundant and important resident species, is widely distributed in Lower Granite Reservoir and exhibited the highest catch per effort in the upstream portion of the reservoir. An estimated

20,911 (17,092-26, 197-95% confidence intervals) smallmouth bass >174 mm inhabited the reservoir based on a mark-recapture study. We estimated that 65,400 smallmouth bass >69 mm were found in the reservoir after adjusting for mortality.

Dietary differences of smallmouth bass were found between 1994 and 1995. Crustaceans comprised a large proportion of smallmouth bass diets in both 1994 and 1995, and salmonids comprised a smaller portion in 1995. Salmonids were found in stomachs of smallmouth bass about every month from April through October of both years. We estimated 82,476 juvenile salmonids were consumed by smallmouth bass in Lower Granite Reservoir in 1994 compared to 64,020 in 1995. About 62% of those losses occurred in the upstream portion of the reservoir.

We sampled more than 14,000 fishes representing 20 species during 1994 and spring 1995. Canonical correspondence analysis was used to generate biplots of species distribution relative to habitat attributes. Mean substrate size, biomass of macrophytes, and depth were the predominant habitat variables. Biplots of these variables and habitat use of juvenile salmon *Oncorhynchus* spp. and steelhead *O. mykiss* overlapped with those of several resident species indicating similarities in habitat use. Discriminant analysis was used to predict which habitat variables were significant in predicting the absence/presence or high/low abundances of fishes in Lower Granite Reservoir.

We examined factors limiting the abundance of northern squawfish *Ptychocheilus oregonensis* in Lower Granite Reservoir. We found that density dependence did not regulate mortality of northern squawfish at two life stages, from egg to larval and ages 0+ to 3+, but it was significantly correlated with several habitat attributes. Over 35 competing models were developed for these two life stages with temperature the most significant overall habitat variable.

An index of abundance of juvenile smallmouth bass was related to temperature as was average length. Over-winter survival of juvenile smallmouth bass ranged from 1.9% to 14.3%, although we were unable to demonstrate a significant relationship between water temperature and over-winter survival.

We examined food and feeding guilds of resident and juvenile anadromous salmonid fishes in Lower Granite Reservoir in 1994 and 1995. We found 93 different food items in resident and juvenile anadromous fishes. Numerous prey items were common between resident and juvenile anadromous salmonids especially dipterans, insect parts, and crustaceans. The proportion of dietary items in wild and hatchery salmonids were significantly correlated with several resident fishes including bluegill *Lepomis macrochirus*, pumpkinseed *L. gibbosus*, crappies *Pomoxis* spp., yellow perch *Perca flavescens*, and northern squawfish.

The last two aspects of this study examined the distribution and abundances of crayfish and white sturgeon *Acipenser transmontanus*. Catch per efforts for both species were highest in the upstream section of Lower Granite Reservoir. We found that the experimental drawdown in March 1992 may have contributed to the partial collapse of a year class of crayfish. Overall mean size of white sturgeon and movement that ranged from 0 to 31 km was similar to results from earlier surveys.

Our overall results demonstrate a substantial influence of resident fishes on juvenile anadromous fishes. Predation, diet, and similarities in habitat use were the common elements where overlap occurred. Other than predation losses, we can not identify the effects of the dietary and habitat overlaps on survival of downstream migrating salmonids.

STUDIES TO ESTABLISH DESIGN CRITERIA FOR FISH PASSAGE FACILITIES: IMPROVED WET SEPARATOR EFFICIENCY

Principal Investigator: J. L. Congleton
Funding Agency: U.S. Army Corps of Engineers
Completion Date: 9/30/98

Objectives: 1) Evaluate feasibility of modifying hydraulic conditions in existing two-stage fish to reduce passage time and improve separation; 2) investigate the feasibility of using secondary separators; and evaluate the effect of high-intensity lighting over the upstream section of the two-stage separator at Little Goose Dam.

Results: Juvenile salmonid bypass facilities at hydroelectric dams on the Snake and Columbia Rivers are used to collect juveniles for subsequent transport or release downriver. Because it is believed that juvenile chinook salmon that are confined or transported with juvenile steelhead (which are larger and more aggressive than chinook salmon smolts) experience higher levels of stress than those transported with other chinook salmon, separation of smolts by size has been an objective of juvenile bypass systems for a number of years. Fish separators, arrays of shallowly submerged, parallel plastic bars, are used to segregate smaller smolts such as chinook and sockeye salmon from steelhead smolts. The separators are also used to separate adult salmonids, nonsalmonid incidental species, and debris from the juvenile fish.

In practice, there are several problems with existing wet-separators: small and large fish are incompletely separated, and fish may delay for long periods both above and below the separator bars. Over the past several years, we have performed various on-site studies to determine how fish separator performance might be improved.

The first objective in 1998 was to determine the effectiveness of secondary in-flume separation of large and small smolts. The in-flume separators, positioned near the downstream end of the flume leading from the separator to the east bank of raceways the Lower Granite Dam fish handling facility, were constructed of horizontal 25 mm (O.D.) aluminum bars with 16 mm spacing placed 7-9 cm below the water surface. Two designs were compared, one 2 meters and one 3.5 meters in length. Larger fish that could not pass through the bars were diverted into a raceway by a stop plate at the end of the device; smaller fish passing through the bars traveled on down the flume to another raceway. The performance of the two designs tested in 1998 did not differ significantly, but the results of the 1997 and 1998 tests taken together indicate that separation efficiency increased in proportion to separator length, and was about 80% with the longest design tested (3.5 meters). This simple, inexpensive device separates smaller and larger smolts well, but additional engineering studies are needed to solve the potential problem of debris accumulation.

The second objective in 1998 was to determine if separation of smaller and larger smolts by the fish separator at Little Goose Dam could be improved by increasing light intensities over the separator. An array of halogen lamps was installed above the upstream separator section and operated on a 48-h on/48-h off cycle for 52 days from 11 April to 1 June. The mean separation efficiency for yearling chinook salmon (percentage of fish passing through the upstream section) was 59% with the lights off and 69% with the lights on ($P < 0.01$). However, the percentage of hatchery and wild steelhead passing through the upstream section was also significantly increased, from 12% to 18% ($P = 0.02$) and from 37 to 41% ($P = 0.06$). The result was that the chinook salmon:steelhead ratio for both the upstream and downstream separator sections differed little between the two lighting conditions.

The third objective in 1998 was to determine if partial separation of smaller fish and larger fish could be achieved by providing a "sanctuary" area into which smaller fish would be attracted by a flow of water, while larger fish would be excluded by appropriately spaced bars. This concept was tested in the raceways used to hold "daily sample" fish at McNary Dam. Use of daily sample fish provided a known number of

smolts of known species composition for each trial. The fish were confined to the downstream 3.3 m of a raceway by a blocking screen. After the raceway had been loaded, a bar screen with 13 mm spacing between bars was placed behind the crowding screen and the crowding screen removed. Flow entering from a diffuser plate on the bottom of the upstream end of the raceway provided attraction flow through the separator bar screen. Two flow rates were tested (25 and 100% of the maximum flow available), and 5 trials were completed for each flow rate. After overnight holding, the blocking screen was replaced, the water level lowered, and all fish upstream of the separator bars were lightly anesthetized and counted by hand to determine total number and species composition. The mean separation efficiency for yearling chinook salmon was 80% (9 trials).

EVALUATION OF THE EFFECTS OF DESCALING ON SHORT-TERM SURVIVAL OF MIGRATING JUVENILE SALMONIDS

Principal Investigator: J. L. Congleton
Funding Agency: U.S. Army Corps of Engineers
Completion Date: 9/30/98

Objectives: 1) Evaluate the effects of descaling on short term survival of juvenile salmonids; 2) Evaluate physical damage correlated with descaling; and 3) Evaluate alternative measures of physical damage.

Results: The major objectives for this project were completed in 1994, 1995, and 1996. This earlier work demonstration that: 1) concentrations of "tissue damage" enzymes measured in spring chinook salmon and steelhead smolts sampled at Lower Granite Dam on the Snake River were correlated with extent of descaling and with internal bruising and hemorrhaging; 2) about one-half of grossly evidently descaling injuries observed at Lower Granite Dam had occurred one to three weeks previously, possibly at the time of release from hatcheries; and 3) moderate descaling injuries (10 to 20% of body surface) had little or no effect on disease resistance or osmoregulation.

The work undertaken in 1998 was limited to one field trial to determine baseline levels for various enzymes in migrating smolts. Spring chinook salmon were obtained from the daily sample at Lower Granite dam and held for 6, 12, and 18 days to allow recovery from the effects of collection and handling. Blood samples were taken for determination of plasma cortisol, glucose, protein, triglyceride, cholesterol, chloride, sodium, potassium, calcium, alanine, aminotransferase, aspartate aminotransferase, lactate dehydrogenase, and creatine kinase concentrations. Analyses of these samples will be completed by December, 1998.

FISH INFORMATION WEBSITE

Principal Investigator: G. L. LaBar
Funding Agency: Idaho Department of Fish and Game
Completion Date: 8/15/98

Objectives: 1) To establish a fish information site on the World Wide Web identifying fish species in Idaho and their distribution.

Results: The project was completed in August, 1998. The website focuses on bull trout (*Salvelinus confluentus*), with emphasis on distribution within Idaho. The website consists of 12 sections plus the homepage. Each section is accessed via hyperlink from the homepage. In addition to distribution data, an extensive bibliography, hyperlinks to other sites, legislative history, and current research activities concerning bull trout are provided. The site currently resides on the University of Idaho server in Moscow, Idaho and requires 760 kb of disk storage. The website is registered with several commercial search engines including Alta Vista, Yahoo, and Infoseek. Arrangements for maintenance of the website are in place through December, 1998.

LIFE HISTORY CHARACTERISTICS OF KEY NATIVE FISH ENTRAINMENT AT INTAKE CANAL, YELLOWSTONE RIVER, MT

Principal Investigator: D. Scarnecchia
Funding Agency: Bureau of Reclamation
Completion Date: 4/15/98

Objectives: 1) Determine life history characteristics (length and weights, age and growth, food habits, reproductive condition) of key native species (sturgeon, burbot, flathead chub, stonecat, sauger, and goldeye) collected in sieve nets; and 2) Assist in day and night sieve net sampling.

Results: Results to date have centered on bionomics of flathead chubs. Ages were determined for 250 flathead chubs of which 26 were males, 17 females, and 209 of unknown sex. Ages ranged from one to seven years. No males were found older than age five, although seven females were older than this age. Mean lengths of fish sampled at time of sampling were 108 mm at age 1, 129 mm at age 2, 147 mm at age 3, 164 mm at age 4, 196mm at age 5, 221 mm at age 6, and 246 mm at age 7.

Chub containing eggs had two distinct sizes of eggs. The large eggs averaged 1.11 mm in diameter and the small eggs 0.410 mm. Of 40 fish yet to spawn, 6 had both size classes of eggs and 4 had only one size group. Because flathead chubs have pharygneal (grinding) teeth, stomach content analysis was unsuccessful. Only 3 of 178 stomachs analyzed contained identifiable organisms.

The presence of chubs of all ages indicates that habitat conditions in the lower Yellowstone River fully support this species.

Ongoing Projects - Wildlife Resources

E. O. Garton - Principal Investigator

Mule Deer Ecology

Elk Habitat

Point Reyes National Seashore Tule elk populations

John H. Giudice – Principal Investigator

Waterfowl recruitment and survival on the Desert Wildlife Area, Central Washington.

Patricia Heglund - Principal Investigator

Accuracy of Presence Absence Predictions for Terrestrial Vertebrates: Issues of Scale - with J. Michael Scott.

Kirk Lohman – Principal Investigator

Effects of eliminating livestock grazing on the structure and composition of riparian vegetation on the Little Pend Oreille National Wildlife Refuge.

Dennis Murray – Principal Investigator

Elk condition and reproductive physiology

Bighorn sheep disease

Predator-prey relationship of Canada Lynx and snowshoe hares on the Clearwater National Forest and surrounding areas

John T. Ratti - Principal Investigator

Avian and mammalian population ecology investigations, Lower Snake River, WA.

Assessment of the ecological value of Snake River islands on Deer Flat National Wildlife Refuge to neotropical migrant birds

Feasibility study on the reintroduction of gray wolves to the Olympic Peninsula – with J. Michael Scott

Kerry P. Reese - Principal Investigator

Blue Grouse Ecology

Upper Snake Fire and Sage Grouse

Sage Grouse Survival

Sharp trail grouse

Wildlife habitat tract improvement

Pheasant ecology

J. Michael Scott - Principal Investigator

Aquatic Gap Analysis

Large Area Mapping of Biodiversity

Setting Conservation Priorities: An Evaluation of Theory and Method

Idaho Gap Analysis

R. Gerald Wright

Park road use and vehicle interactions at Denali National Park, Alaska

Identify at risk plant communities in the Western United States

Fire ecology and rehabilitation and restoration strategies

A survey of amphibian activity in ponds in the Palouse grasslands of Idaho

MULE DEER ECOLOGY PROJECT

Principal Investigator: E. O. Garton
Student Investigator: Chad Bishop
Funding Agency: Idaho Department of Fish and Game
Completion Date: 9/30/99

Objectives: 1) To determine and compare mule deer fawn mortality rates among three separate winter ranges in Southwest Idaho; 2) To determine the specific causes of mortality - thus evaluating the impacts of predation, early winter fawn weight, nutrition, and weather on fawn survival; and 3) To develop a mortality model to potentially predict mule deer fawn susceptibility during winter.

Progress: Assessing mule deer (*Odocoileus hemionus heminous*) fawn mortality during winter is an important element of deer population management. In particular, determining fawn survival rates, understanding factors which contribute to mortality, and identifying variables which predict mortality are beneficial to wildlife managers. We radio-monitored 61 fawns during the 1995-1996 winter and 60 fawns during the 1996-97 winter on 3 study areas in southwest Idaho. For the 3 study areas combined, the over-winter fawn survival rate was 0.754 (SE=0.055) during the 1995-96, and 0.447 (SE=0.065) during the 1996-97. Throughout both winters, coyote and mountain loin predation were the dominant proximal causes of mortality. Overall, mean early winter mass of mortalities was significantly lower (P=0.002) than of surviving fawns. Excluding fawns killed by mountain lions, analyses of femur marrow fat indicated that fawns succumbing to mortality were among the weakest in the population. The probability of over-winter mortality was modeled with mass, sex, and habitat use variables using logistic regression analyses. The probability of fawn mortality increased with smaller group sizes, lower mass, being male, and using steeper slopes. Differences in cause-specific mortality across the 3 study areas emphasize the need for research in different areas where limiting factors vary. Reliable predictors of mortality, such as early winter mass, may be applicable to populations across the West and enable wildlife managers to anticipate over-winter survival as early as December.

Nutritional stress is an important mortality factor for wintering mule deer fawns. The rate at which fawns utilize existing fat stores is at least partially dependent upon the quality of available forage during winter. Although numerous studies have determined the nutritive value of various forage species, more research is needed to determine whether individual forage species vary in quality across the landscape. We determined whether differences existed in the nutritional quality of antelope bitterbrush or cheatgrass brome between study areas or among habitats common to each area. In virto dry matter digestibility (IVDMD) of bitterbrush varied among study areas in 1996 and 1997 (P<0.001). The highest IVDMD measured in a study areas was 29.83% in 1997 while the lowest was 15.23% in 1996. Bitterbrush crude protein (CP) was different among habitats in 1997 (P+0.005), with mean CP values ranging from 7.03%. The length and diameter of available bitterbrush leaders varied within and among study areas because of differential utilization. Bitterbrush quality differed in relation to the mean diameter of leaders obtained from each random sampling site (P<0.001). Cheatgrass IVDMD was different between study areas (P<0.001) in 1996, with mean values ranging from 65.79%. Mule deer fawn mortality may have been influenced by differences in forage quality, but no direct relationship was detected.

ELK HABITAT PROJECT

Principal Investigators:	E. O. Garton J. M. Scott
Student Investigator:	Leona Bomar
Funding Agency:	Idaho Department of Fish and Game
Completion Date:	6/30/99

Objectives: 1) Identify and describe patterns in Idaho elk populations using Idaho Department of Fish and Game aerial survey data at various scales; 2) Determine if correlations exist between patterns in elk demographics and independent variables, such as net primary productivity, precipitation, geologic type, and canopy cover; and 3) Develop predictive models of cow density, calf:cow ratios, and bull vulnerability that will identify priority areas and evaluate alternative management strategies.

Progress: Understanding the changes which occur in elk demographics at various spatial and temporal scales and identifying the variables influencing these population characteristics is critical for effective management. The first priority was to examine the population structure of elk herds across the state and determine if any patterns exist. To adjust for human error and model differences, all Idaho Department of Fish and Game survey data files were rerun with the second edition of the program AERIAL SURVEY. Frequency distribution, cluster analysis, and GIS displays will be used to determine the spatial extent of patterns at various scales. Topography, forage quality, and range maps are being used to estimate the most likely locations of animals within each spatial unit.

Analyzing harvest data will provide insight into the effects of various management strategies across the state and the differential vulnerability among age and sex classes. Separate layers of elk vulnerability, harvest season length, and management strategy will be developed and overlaid to compare the effectiveness of different combinations of road densities, hunter densities, and harvest strategies.

Concurrent with the elk data analysis, an extensive search of existing GIS databases revealed over 80 independent data layers that could be used to gain better understanding of the relationship between elk and their environment. Although each layer is statewide, the accuracy of each may vary by geographic region. Recognition of this fact only emphasizes that this analysis is not intended for site-specific applications but for general characterizations of broad scale spatial pattern and trend and for identifying testable hypothesis regarding distributions, size, and trends in populations of elk. While this study is not designed to experimentally test the causes of variation in elk demographics across Idaho, we anticipate the results of this work will provide a platform from which further testing of landscape scale relationships can occur.

POINT REYES NATIONAL SEASHORE TULE ELK POPULATIONS

Principal Investigator: E. O. Garton
Student Investigator: Susan Roberts
Funding Agency: Rocky Mountain Elk Foundation
Completion Date: 5/31/00

Objectives: 1) To identify the plant species tule elk are consuming at Point Reyes National Seashore; 2) To identify areas of vegetation under intense foraging pressure; 3) To identify the abundance and distribution of the plant species occurring on the elk range at Point Reyes; and 4) To quantify the digestibility, protein, and trace minerals content of the forage.

Progress: To ensure the health of an endangered coastal California grassland ecosystem, there is a grave need to document how tule elk are utilizing and affecting the plant communities of Point Reyes National Seashore. Point Reyes contains one of the last tracts of open coastal grasslands that is not developed for agricultural purposes such as cattle grazing. The feeding habits of the tule elk and the nutritional quality of the forage need to be described in order to understand the ecology of tule elk at Point Reyes and their potential impacts on and interactions with the native plant community.

Field research was conducted from May 18-August 15, 1998 at Point Reyes National Seashore on the central California coast. In order to learn how to identify the various plant species occurring on the elk range, we did line transect vegetation surveys at 6 plots that had been randomly chosen and surveyed in 1986. Each transect was 30 meters long and involved 100 sampling points.

One elk was observed at a time while they fed, the exact area where the elk fed was located, and vegetation surveys at each feeding site were completed. We recorded all of the plant species that occurred in the feeding site, defined by a $0.75m^2$ frame. All fresh evidence of feeding by elk on any plant was counted and recorded as bites per plant species. Whenever visibility conditions were good, we recorded the number of bites each observed elk took while they were feeding. In July, we did a preliminary analyses on the feeding data and established the most dominant plants in the diet and the most abundance plants on the range. Three of the most preferred diet items and two of the most abundant plants were collected at six different locations.

We also collected fecal samples form 15-30 males and 15-30 females during the second week of each month. These samples were oven dried and each individual sample labeled and separately stored.

By the end of the first field season, the totals sum:

Number of female elk observed	69 elk
Number of feeding surveys completed	69 sites
Number of fecal samples collected	90 elk
Number of bites observed	~3000 bites
Number of vegetation plots completed	6 plots and 1800 data points
Amount of vegetation collected	15 Kg (wet wt.)
Number of hours spent in the field	615 hours

WATERFOWL RECRUITMENT AND SURVIVAL ON THE DESERT WILDLIFE AREA, CENTRAL WASHINGTON

Principal Investigator: J. Giudice
Advisors: J. T. Ratti and E. O. Garton
Funding Agency: Washington Department of Fish and Wildlife
Completion Date: 12/31/00

Objectives: 1) Evaluate the feasibility of using sightability models to estimate brood visibility and calculate correction factors; 2) Estimate dabbling duck recruitment and its critical determinants; 3) Use the mallard productivity model and estimates of critical population parameters to model population dynamics on the Desert Wildlife Area; and 4) Evaluate the population response of dabbling ducks to wetland enhancements on the Desert Wildlife Area

Progress: The study was initiated in April 1997 and a continuation of the pilot study. Our 2nd field season was completed in September 1998. Data analysis is currently in progress. One-hundred-ten duck nests were located in 1997-98. Mallard (*Anas platyrhynchos*), teal spp. (*A. discors, A. cyanoptera, A. crecca*), and gadwall (*A. strepera*) accounted for 87% of total nests found. Nest success was 13.4 and 20.0% in 1997 and 1998, respectively. Predation accounted for 66% of nest failure. Most egg predation appeared to be avian. Twenty-three hens (12 mallards, 5 gadwall, 6 teal) were nest trapped and marked with an 8-g prong-and-suture radio transmitter. Brood survival (30 day) in 1997 was 0.50 and duckling survival was 0.29. Analysis of 1998 brood-survival data has not been completed, although preliminary analysis suggests survival in 1998 was similar to 1997. Estimated recruitment rate in 1997 was 0.33 female ducklings/adult female. Population modeling indicated a declining population ($\lambda = 0.742$ to 0.946). Data for 1998 have not been analyzed and were not included in model projections. Logistic-regression analysis of simulated-brood data (1997 only) indicated brood dispersion, dominant obstructing vegetation, % visual obstruction, and sighting distance significantly affected brood visibility. In 1998, we used wild, radio-tagged brood hens to evaluate compatibility of brood-survey procedures with sightability-model methods. Short-duration point-counts appear to be the most statistically compatible and logistically feasible method for conducting brood surveys and estimating sighting probabilities. However, small sample sizes precluded development of a precise sightability model. A larger sample of radio-tagged hens is needed to adequately evaluate the application of sightability-model and mark-recapture methods to brood surveys. Thus, we hope to expand the brood-visibility research in 1999 to include study sites in the Canadian Prairies.

ACCURACY OF PRESENCE ABSENCE PREDICTIONS FOR TERRESTRIAL VERTEBRATES: ISSUES OF SCALE

Principal Investigators: P. Heglund
J. M. Scott
Student Investigator: Jason Karl

Funding Agency: USGS/Biological Resources Division
Completion Date: 9/30/99

Objective: 1) To test the accuracy of Gap Analysis project predictions of species occurrence at landscape (Gamma level diversity) and site specific (Alpha level diversity) levels of spatial organization for northern Idaho.

Progress: The usefulness of wildlife habitat relationship (WHR) models for adequately predicting the presence or absence of wildlife species varies considerably. This difference frequently stems from a failure to recognize the effects of spatial scale to which the models are applied. In conjunction with scientists working on an associated project, we examined scale effects on wildlife habitat relationship (WHR) models by looking at data availability for habitat modeling, collecting bird occurrence data for model development and testing, constructing WHR models for North Idaho birds and testing the model output at different model complexities, spatial data resolutions and levels of analysis (e.g., site versus cover type). We observed that game species and species of political interest frequently were the only species with adequate habitat information in the published literature to create WHR models using more than vegetation cover type information. We put our results and observations together in a cooperatively written manuscript that has recently been accepted for publication.

To increase our data set, we conducted breeding bird surveys on the Craig Mountain Wildlife Management Area (WMA), Idaho in 1993, 1994 and 1997 where over 100 bird species were detected. This represented 45.82% of Idaho's avifauna. Using this data we constructed and tested WHR models for 60 birds species. The models varied by 3 levels of model complexity (amount of habitat information) and 3 spatial data resolutions (0.09 ha, 4 ha, 10 ha). We tested these models at 2 levels of analyses, the site level and cover type level. We observed that total area of habitat predicted for a species decreased as model complexity increased or when we decreased the spatial resolution. Model performance tended to increase as models became more complex at site levels of analysis and coarse spatial data resolutions. However, at the cover type level, increasing model complexity did not significantly change model performance. At the cover type level of analysis, simple models with high spatial data resolution performed best. Based on our results, we would expect models designed for landscape level analyses with coarse spatial data resolution (e.g., 100ha) to perform well with simple models. Our results suggest that specific objectives need to be defined prior to modeling wildlife habitats and that WHR models developed at one scale may not apply well in other situations. When developing models, any future use of the models should also be considered.

This work has resulted in the preparation of one master of science thesis and two additional publication. One additional publication is currently in preparation and will be submitted to the appropriate journal upon revision.

Karl, J.W. 1998. Wildlife Habitat Relations Models: theory and application. M.S. thesis, University of Idaho, Moscow, ID. 129pp.

Karl, J.W., Heglund, P.J., E.O. Garton, J.M. Scott, N.M. Wright, and R. Hutto. 1998. Sensitivity analysis of wildlife habitat relationship model performance. For submission to Ecological Applications.

EFFECTS OF ELIMINATING LIVESTOCK GRAZING ON THE STRUCTURE AND COMPOSITION OF RIPARIAN VEGETATION ON THE LITTLE PEND OREILLE NATIONAL WILDLIFE REFUGE

Principal Investigator: K. Lohman
Student Investigator: Marilyn K. Nielson
Funding Agency: USGS/Biological Resources Division
Western Regional Office
Completion Date: 3/30/99

Objective: 1) Document the early effects of livestock exclusion on the structure and composition of streamside vegetation.

Progress: The structure and composition of riparian vegetation in grazed and ungrazed pastures along Bear Creek and the Little Pend Oreille River were sampled during the summer of 1998 before livestock were turned out. Eleven 50 m study reaches were established with 10 circular plots per reach designed to determine vegetative cover, plant species composition, and vertical structure. A second round of sampling was done at the end of the grazing season. Data are currently being analyzed to determine if there are differences in cover, hydrophilic species, and woody species recruitment between grazed and ungrazed pastures, both before and after the grazing period. This study is designed to assess the initial recovery of riparian pastures which have been heavily grazed in the past and from which livestock have only recently been excluded. It will also provide a sampling framework for long-term monitoring of riparian vegetation on the Little Pend Oreille NWR.

ELK CONDITION AND REPRODUCTIVE PHYSIOLOGY

Principal Investigator: D. Murray
Student Investigator: Rachel Ash
Funding Agency: Idaho Department of Fish and Game
Completion Date: 6/30/99

Objectives: To evaluate the role of nutritional state of captive female elk on 1) reproductive physiology and 2) body condition and nutritional assays.

Progress: We have completed the collection of elk feces and analysis of reproductive steroids among captive animals subject to varying nutritional regimens. Preliminary results suggest that hormonal profiles and pregnancy rates of elk differ substantially according to nutritional state of animals. A manuscript describing this work is in preparation.

We have recently initiated whole-body homogenization of 15 elks carcasses and subsequent determination of body composition. Numerous indices of nutrition and condition have been collected from these same animals and will be correlated to body fat composition. Up to thirty additional carcasses will be homogenized in December and March.

BIGHORN SHEEP DISEASE

Principal Investigator: D. Murray
Funding Agency: Idaho Department of Fish and Game
Completion Date: 6/30/99

Objective: To examine environmental factors potentially correlated to bighorn sheep dieoffs in North America.

Progress: We have gathered population trend and herd composition information from >150 bighorn sheep herds across North America. Analyses are currently in progress to evaluate the relationship between several weather attributes and the magnitude and intensity of bighorn population dieoffs. Our hypothesis is that environmental factors trigger pneumonia outbreaks in bighorn sheep. Analyses will be completed and a manuscript prepared in the next 10 months.

PREDATOR-PREY RELATIONSHIP OF CANADA LYNX AND SNOWSHORE HARES ON THE CLEARWATER NATIONAL FOREST AND SURROUNDING AREAS

Principal Investigator: D. Murray
Graduate Investigators: Todd Steury
Aaron Wirsing
Funding Agency: Idaho Department of Fish and Game
Completion Date: 6/30/99

Objectives: 1) To evaluate the likelihood of a successful release of lynx in Idaho using mathematical models of lynx-snowshoe hare population dynamics; 2) To estimate the biomass of snowshoe hare and red squirrels available on the Clearwater National Forest; and 3) To describe the population dynamics of hares and squirrels in Idaho.

Progress: Graduate researchers started in January 1998 to study hares and squirrels. Todd recently completed the first draft of a manuscript exploring the potential outcome of lynx release in Idaho. Both students initiated field activities in June, and since that time, over 150 animals on the Clearwater have been captured, marked, and monitored. Students have also initiated the estimation of hare and squirrel numbers across the Clearwater. Preliminary results suggest that hare numbers are low, but squirrels are abundant on the Clearwater. Coyotes seem to play an important role in the limitation of hare numbers, whereas few red squirrels are taken by predators and their survival appears to be quite high.

AVIAN AND MAMMALIAN POPULATION ECOLOGY INVESTIGATIONS

Principal Investigator: J. T. Ratti
Funding Agency: US Army Corps of Engineers
Completion Date: 7/6/99

Objectives: 1) To conduct an inventory of riparian and drainage habitats along Snake River reservoirs between Clarkston, WA, and Ice Harbor Dam; 2) To map locations of selected riparian and drainage habitats, estimate size, and provide a general description of habitat types; 3) To conduct studies of relative abundance of wildlife resources within the riparian and drainage habitats and closely associate upland habitats; and 4) For each species present, to document phenological patterns of use, ecological dependence, estimates of abundance, relative estimates of production, and observations of young.

Progress: In 1975, the U. S. Army Corps of Engineers (Corps) initiated the Lower Snake River Fish and Wildlife Compensation Plan to analyze and mitigate impacts to fish and wildlife resulting from lower Snake dams. As a result, the Corps acquired and/or designated 4,254 acres for wildlife habitat (Corps, 1991). Approximately 1,100 of these acres have been developed as ten intensively managed and irrigated Habitat Management Units (HMUs). Management activities at irrigated HMUs included planting of trees, shrubs, and wildlife crops (e.g., corn and sunflower), haying, and noxious-weed control. The objective of this study was to evaluate the value of irrigated HMUs to selected bird species and small mammals relative to naturally occurring riparian habitats along the lower Snake River.

Twenty-seven study sites were selected for bird censuses in 1997 and 1998 on the lower Snake River, from Ice Harbor Dam upriver to Clarkston, Washington. The study area included four reservoirs: Ice Harbor, Lower Monumental, Little Goose, and Lower Granite. Study sites were divided into three habitat types: seven irrigated HMUs, eight non-irrigated sites, and twelve drainages. Irrigated HMUs and non-irrigated sites were bars or benches along the Snake River that supported woody riparian vegetation, although non-irrigated sites were not intensively managed. Drainages entered the Snake River, and ranged in size from the relatively large Tucannon River to small, narrow canyons with ephemeral streams. All drainages had woody vegetation. Forty-four bird census stations were located on irrigated HMUs, 43 on non-irrigated sites, and 46 in drainages. Small mammals were trapped at nine of these study sites: one irrigated HMU, one non-irrigated site, and one drainage in each of Ice Harbor, Lower Monumental, and Little Goose reservoirs. Six sites were also selected for bird censuses in the lower section of Hell's Canyon.

Variable Circular Plot (VCP) methodology was used to census bird populations in three seasons along the lower Snake River. Breeding-bird censuses took place from mid-May through mid-July 1997. Fall birds were censused during September and October of 1997. The Spring bird population was censused from mid-March through April 1998. Each VCP census station was visited four times during the breeding season and three times in fall and spring. Since fall birds were often less vocal and more cryptic than breeding or spring birds, observers also conducted an area search at each site during fall. The area-search method was also used to census birds in Hell's Canyon in summer and fall.

Density estimates were calculated for common bird species in each season. Birds that flew over the sampling area were deleted from density-estimate calculations. A randomized-block Analysis of Variance (ANOVA) was used to test for differences in species' densities among irrigated HMUs, non-irrigated sites, and drainages. A Bonferroni adjustment for pairwise comparisons was used on significant tests. Data from area searches were not subjected to statistical tests.

Ninety-two species were detected **during the breeding season** on the lower Snake River. Observers detected 9,787 individual birds in four visits to each census station, for an average of 2,447 birds per visit. At irrigated HMUs, 3,777 individuals were detected, 3,074 at non-irrigated sites, and 2,936 in drainages.

Including flyovers, the five most frequently detected species were, in descending order, bank swallow, cliff swallow, red-winged blackbird, western meadowlark, and northern oriole. Absolute densities were calculated for 30 species and relative abundance was calculated for three swallow species. Northern oriole and red-winged blackbird had the highest densities. Nine species had higher densities at irrigated HMUs than at either drainages or non-irrigated sites. These were American robin, bank swallow, black-billed magpie, California quail, Canada goose, lazuli bunting, mourning dove, ring-necked pheasant, and western meadowlark. Three species, house wren, northern flicker, and northern oriole had higher densities in drainages. Killdeer and spotted sandpiper had higher densities at non-irrigated sites.
Observers detected 605 individual birds and 45 species during two visits to Hell's Canyon in the breeding season. Lazuli bunting was the most-abundant species. The next-most-abundant species were cliff swallow, American goldfinch, wild turkey, and California quail. Wild turkey was not detected on the lower Snake River study area.

During fall 114 species were detected using both the VCP and area-search methods. Observers detected 9,071 individual birds in three visits to each station with the VCP method, for an average of 3,024 birds per visit. At irrigated HMUs, 4,316 individuals were detected, 2,878 at non-irrigated sites, and 1,947 in drainages. Including flyovers, red-winged blackbird was the most frequently detected species, followed by white-crowned sparrow, American goldfinch, Canada goose, and European starling. Densities were calculated for 17 species. White-crowned and song sparrows had the highest densities. There was an average of 156 white-crowned sparrows per 10 hectares at irrigated HMUs. American robin and white-crowned sparrow had higher densities at irrigated HMUs. Savannah sparrow had higher densities at non-irrigated sites, and rock wren had higher densities in drainages.

Observers detected 25 species during the fall visit to Hell's Canyon. California quail was the most abundant species. The next-most-abundant species were American goldfinch, song sparrow, cedar waxwing, and yellow-rumped warbler. Again the wild turkey was the only species detected in Hell's Canyon that was not observed along the lower Snake River.

During spring observers detected 91 species and 7,921 individual birds in three visits to each station, for an average of 2,640 birds per visit. At irrigated HMUs 3,488 individuals were detected, 2,390 were detected at non-irrigated sites, and 2,043 in drainages. Including flyovers, the five most frequently detected species were, in descending order, white-crowned sparrow, American goldfinch, red-winged blackbird, western meadowlark, and Canada goose. Densities were calculated for 21 species. White-crowned sparrow and American robin had the highest densities. American goldfinch, American robin, Canada goose, killdeer, mourning dove, ring-necked pheasant and white-crowned sparrow had higher densities at irrigated HMUs. Northern flicker and red-tailed hawk had higher densities in drainages.

The average number of each species at each site was used to calculate species richness and diversity in each season. Differences in species richness and diversity among irrigated HMUs, non-irrigated sites, and drainages and among the four reservoirs were tested with ANOVA. Species richness was consistently higher at irrigated HMUs and non-irrigated sites than in drainages for all three seasons. Species diversity did not differ among habitat types in any season. Species richness was different among the four reservoirs only during the breeding season. Species diversity differed among reservoirs in the breeding season and during spring.

Small mammals were trapped in late-July and August 1997 using two methods. Four drift-fence/pit-fall traps and 112 baited live-traps were open for five nights at each of the nine sites. A total of 374 small mammals were captured. Of these, 122 were recaptures, for a total of 251 individuals. Six small-mammal species were captured. Deer mouse was the most-abundant species, with 186 individuals captured, followed by 22 montane voles and 18 western harvest mice. A slightly higher number of animals were captured at irrigated HMUs when both trap types were combined. At irrigated HMUs 0.054 individuals per

trap night were captured. At non-irrigated sites 0.042 individuals and in drainages 0.047 individuals per trap night were captured.

Observers visually estimated percent cover of vegetation in six categories within a 30-meter circle surrounding each VCP station during September 1997. The categories were grasses, forbs, shrubs from 0.0 to 0.5 meters tall, shrubs from 0.5 to 1.0 meters, shrubs from 1.0 to 3.0 meters, and trees greater than 3.0 meters tall. Differences in vegetative cover among irrigated HMUs, non-irrigated sites, and drainages were tested with a randomized-block ANOVA. Irrigated HMUs had a higher percent cover of grass, 0.5 to 1.0 meter shrubs, and 1.0 to 3.0 meter shrubs than non-irrigated sites, but not compared to drainages. Overall, irrigated HMUs and drainages had similar coverages of grass and woody vegetation, and had consistently higher coverages of grass and woody vegetation than non-irrigated sites. In contrast, non-irrigated sites had higher forb cover.

Even though irrigated HMUs and drainages were more similar in vegetative structure than non-irrigated sites, bird-species densities did not always respond accordingly. Birds may have responded to specific habitat features that varied between irrigated HMUs and drainages, regardless of their overall structural similarities. In addition, irrigated HMUs and non-irrigated sites were more alike physiographically than drainages. Therefore, some species may have responded to available habitat on the landscape level, rather than to microhabitat features, such as floristic structure.

Irrigated HMUs provided quality-avian habitat along the lower Snake River. However, all lower Snake River riparian habitats, including irrigated HMUs, non-irrigated sites, and larger drainages, may have a higher ecological value as migratory habitat than breeding habitat. Furthermore, more bird species were using lower Snake River riparian habitats in 1997-1998 than in 1974. Birds appeared to have responded positively to the increase in habitats offered at irrigated HMUs and to the evolution of palustrine emergent and palustrine shrub-scrub habitat. Future changes in reservoir levels will undoubtedly affect bird communities along the lower Snake River in all seasons. If the lower Snake River is allowed to return to pre-impoundment levels, these effects will be influenced by a complicated interaction among natural and management responses.

Additional years of data would strengthen current results significantly. An increase in sample size would increase the number of species for which density could be calculated and would raise statistical power. New species-use patterns may be revealed and would, thus, provide more confidence for the ecological assessment of the value of irrigated HMUs. A more-detailed-habitat study could provide specific data on species use of irrigated HMUs, non-irrigated sites, and drainages. Further information is needed on bird use of riparian habitats during the winter. It is recommended that bird populations be monitored in all seasons if significant changes in water levels are anticipated along the lower Snake River. More information is also needed on small mammal and raptor use of riparian habitats along the lower Snake River.

ASSESSMENT OF THE ECOLOGICAL VALUE OF SNAKE RIVER ISLANDS ON DEER FLAT NATIONAL WILDLIFE REFUGE TO NEOTROPICAL MIGRANT BIRDS

Principal Investigator: J. T. Ratti
Funding Agency: US Fish and Wildlife Service
Completion Date: 7/6/99

Objectives: 1) To measure avian abundance, richness, and diversity for island riparian habitats on the Snake River portion of Deer Flat NWR and adjacent mainland riparian habitats; 2) To monitor avian nest success on islands and adjacent mainlands, and assess physiographic and ecological factors related to success rates; 3) To determine actual and potential nest predators of nesting birds; and 4) To compare mainland nesting populations with island nesting populations to assess the relative importance of island habitats.

Progress: Scientists and wildlife managers have demonstrated that waterfowl often have a higher nest success on islands; however, this pattern has not been investigated for nesting songbirds. In April 1998 we initiated a project to examine the importance of islands in the Snake River to nesting songbirds. The study area encompassed the Snake River portion of Deer Flat National Wildlife Refuge in Idaho and the adjacent mainland. We systematically selected 44 islands for sampling, half of which were studied in 1998. Each island was paired with a mainland site. Mainland sites were located within 1-river mile of its island pair and were in riparian vegetation.

The Variable Circular Plot method was used to calculate species densities on island and mainland sites. Censuses took place from mid-May through mid-July 1998. With these data, we will test for differences in species abundance, richness, and diversity between island and mainland sites.

Sixteen of the island/mainland pairs were selected for nest searching and monitoring. We found approximately 500 nests. Common nesting species were Mourning Dove, American Robin, Yellow Warbler, Song Sparrow, Red-winged Blackbird, and Northern Oriole. Nests were checked every 3-4 days to determine nest status (i.e., incubating, feeding chicks, etc.). Nests were monitored with as little disturbance as possible; however, nests were monitored closely near fledging to observe if chicks fledged successfully. We estimated causes of nest failure (desertion, weather, mammalian or avian predation, and parasitism) by examining remaining evidence. We will use the Mayfield method to calculate nest success on each island and mainland site for each species. Nest success will be expressed in daily mortality rates, and mortality will be partitioned into losses due to predation, desertion, and parasitism. Differences in daily mortality rates between islands and mainland sites will be tested with paired t-tests.

We also used remote-triggered cameras on artificial nests to examine the predator community on island and mainland sites. We used both Trailmaster© infrared-triggered units and mechanical-trip cameras. Cameras identified four nest predators, Black-billed Magpie, Deer Mouse, Fox Squirrel, and Garter Snake.

FEASIBILITY STUDY ON THE REINTRODUCTION OF GRAY WOLVES TO THE OLYMPIC PENINSULA

Principal Investigators: J. T. Ratti
J. M. Scott
Funding Agency: US Fish and Wildlife Service
Completion Date: 12/1/98

Objectives: To compile information on 1) current and historical status of wolves on the Olympic Peninsula; 2) determine habitat suitability of federal, state, and private lands for supporting a viable self-sustaining wolf population; 3) distribution, density, trends, and mortality factors of primary prey species; 4) adequacy of habitat and prey base for supporting a viable self-sustaining wolf population; 5) future projections for an established wolf population on the peninsula; and 6) socio-economic impacts of wolf introduction.

Progress: A draft report has been submitted. However, all report data are confidential at this time and report results have not been released to the public by the U.S. Fish and Wildlife Service.

SAGE GROUSE SURVIVAL

Principal Investigator: K. P. Reese
Student Investigator: Matthew B. Lucia
Funding Agency: Idaho Department of Fish and Game
Completion Date: 6/30/99

Objective: To determine cause- and age-specific mortality of chick and juvenile sage grouse.

Progress: Between 2 August and late October, 1997, 26 juvenile sage grouse (13 male and 13 female) and 4 adult female sage grouse were radio-marked in the Edie Creek Ranch and Table Butte areas of southeastern Idaho. In addition, 9 birds, 8 adult males and 1 adult female, were leg-banded. We collected over 400 locations on these birds until 15 March 1998. Twenty-three percent of these radioed birds died from August-march. Mortality factors have been powerline strikes, coyote predation, avian predation, and unknown causes.

In 1998, 32 juvenile birds have been radio-marked since July, 12 on Edie Bench and 20 around Table Butte. One bird has been shot by hunters, as were 3 leg-banded adult males. Monitoring will continue through March 1999.

BLUE GROUSE ECOLOGY

Principal Investigator: K. P. Reese
Student Investigator: Hollie Miyasaki
Funding Agency: Idaho Department of Fish and Game
Completion Date: 6/30/99

Objectives: 1) To determine the productivity of blue grouse populations on grazed and lightly grazed sites using clutch size, nest success, and chick survival as measures of productivity; 2) to determine the age ratio of the fall harvest and compare it with observed pre-harvest age ratios; 3) to determine survival rates of radio-marked hens and chicks during brooding, post-brooding, and wintering periods; 4) to formulate an elasticity model and substitute data from this study for specific life stages in the model.

Progress: In 1996 there was a total of 45 blue grouse captured, 26 of these were radio-marked. The harvest ratio on opening weekend was 3.7:1 (juvenile:hens) from the Andrus Wildlife Management Area (AWMA) study area. The ratio of juveniles to hens observed prior to the hunting season was 3.6:1 which is not significantly different from the harvest ratio (P=0.05). From 6 June 1996 to 31 May 1997 blue grouse survival rate was 40.7%.

In 1997, nesting information was collected from females radio-marked the previous year. There were 8 nest observed with clutch size ranging from 6 to 10 eggs, averaging 8.25 eggs per nest. There was a total of 51 blue grouse captured on the AWMA study area during the 1997 field season. Of these, 39 chicks and females (yearling and adult) were radio marked. Additionally adult and yearling females were recaptured and fitted with new transmitters. The ratio of juveniles to adult and yearling females in the opening day harvest was 4.4:1. This was not significantly different (P=0.05) than the observed chick to hen ratio of 4.9:1. Blue grouse survival rate from 1 June 1997 to 28 May 1998 was 54.3%. This was not significantly different than the 1996-97 survival rate (X^2=1.162,d.f.=1, P=0.281).
Data analysis of blue grouse movements and vegetation use is on going. In addition, a literature search for parameters which will be used in a life-stage analysis is being conducted.

UPPER SNAKE FIRE AND SAGE GROUSE

Principal Investigator: K. P. Reese
Student Investigator: Pamela Bell
Funding Agency: Idaho Department Fish and Game
Completion Date: 6/30/99

Objective: To investigate the effects of prescribed fire and wildfire on sage grouse nesting habitat and brood rearing habitat in the Upper Snake River Plain.

Progress: This is the first study to examine the long-term impacts of wildfire and prescribed fire on sage grouse nesting and brood-rearing habitat on the Upper Snake River Plain in southeast Idaho. Fieldwork was carried out from May through August in 1996 and 1997 in Clark and Fremont counties in sagebrush-grassland. A total of 20 different-aged burns were sampled, ranging in age from wildfires which burned in the 1960's to prescribe fires set in 1996. The mosaic of burned and unburned habitat was sampled using the line intercept method for shrubs canopy cover, Daubennire frames for forb and grass cover, and pitfall

gaps to determine insect abundance. Plots were searched for signs of use by sage grouse.
No long-term benefit was detected as a result of burning. Long-term negative impacts from fire were found in nesting habitat, as 14 years post-burn sagebrush had not returned to preburn conditions. Mean sagebrush cover was 8% in 6-14 year old burns, compared to 18% in unburned vegetation. Mean sagebrush shrub height was 49cm tall in 6-14 year-old burns, compared to 71 cm tall in unburned vegetation. Forb abundance was similar among different-aged burns. There was a short-lived response in insect abundance as there were more ants and beetles in the 1 year-old burn. This effect was not apparent in 3-5 year-old burns. No difference was found in the extent to which sage grouse used different-aged burns. Thesis completion is expected in November, 1998.

SHARP TAILED GROUSE

Principal Investigator: K. P. Reese
Funding Agency: Idaho Department Fish and Game
Completion Date: 6/30/99

Objective: To determine reproductive success of newly released and formerly released Columbian sharp-tailed grouse translocated into the Shoshone Basin.

Progress: Thirty-four males attended two leks in the Shoshone Basin prior to the 1998 release of newly translocated birds. Thirty-two females and 31 males were released in Spring 1998. Seventeen of these hens were radio-marked and two hens released in 1997 retained functioning transmitters. Between April and 11 July, three hens died for a mortality rate of 16%. All 16 remaining hens nested, but at varying distances from the leks (range 0.1-13.4 km, mean = 5.7 km). No renests were documented. Next success was estimated to exceed 40% while hen success of the radioed birds was 56%. Seven nests were lost; two to magpies or ravens, one to cattle, and four to mammalian predators.

WILDLIFE HABITAT TRACT IMPROVEMENT

Principal Investigator: K. P. Reese
Funding Agency: Idaho Department of Fish and Game
Completion Date: 6/30/99

Objective: 1) To develop a method of prioritizing the various wildlife tracts that are managed in partnership by BLM and IDFG.

Progress: We tested the prioritization methods proposed in this project using 69 BLM wildlife tracts within the Snake River Resource Area of southcentral Idaho. Seven weighted criteria were rated on each tract: 1) size in ac; 2) distance to other tracts; 3) ease of access; 4) fenced; 5) canopy; 6) understory; and 7) research potential. Tract values were further refined by considering subjective non-weighted factors such as past investments such as gophers, nesting structures, presence of wetlands or specific species of wildlife, and professional judgment. Each tract was finally rated as 1) retain in wildlife tract program; 2) retain for other purposes, e.g., research, etc.; or 3) disposal or retirement from the program. Recommendations for each tract are presented in the report entitled, "Prioritization Criteria for BLM, Wildlife Tracts in South-central Idaho," by Makela, Apa, Klot, and Nohrenberg, May 1998.

PHEASANT ECOLOGY

Principal Investigator: K. P. Reese
Graduate Student: Gary A. Nohrenberg
Funding Agency: Idaho Department of Fish and Game
Completion Date: 6/30/99

Objectives: To determine what effects limited predator removal has on pheasant populations in southern Idaho. Specific objectives are: 1) Is survival and productivity of hen pheasants greater in areas of limited predator removal? and 2) Do pheasant populations and targeted predator populations differ between predator-removal and non-removal areas?

Progress: Gary A. Nohrenberg has completed a draft of his M.S. Thesis. The final thesis should be defended by the end of December, 1998.

AQUATIC GAP ANALYSIS

Principal Investigator: J. M. Scott
Funding Agency: USGS/Biological Resources Division
Completion Date: 12/01/98

Objectives: 1) Identify areas of high species richness within major ecoregions for aquatic species that are: a. rare species, b. endangered and threatened species, c. declining bird species, d. sensitive species; 2) Determine what percent of each vegetation type by ecoregion occurs within existing preserves; 3) Determine what percent of each area of species richness falls within existing preserve areas; 4) Determine location of areas of high species richness for each vegetation type; 5) Identify areas of potential conflict for areas of species richness; 6) Prepare map with preserves selected as to protect areas of biodiversity into the 22nd century; and 7) Coordinate research activities on Gap Analysis project throughout the U.S.

Progress: We prepared draft guidelines for conducting aquatic Gap Analysis. Aquatic Gap Analysis projects were initiated in Missouri and New York.

LARGE AREA MAPPING OF BIODIVERSITY

Principal Investigator: J. M. Scott
Funding Agency: USGS/Biological Resources Division
Completion Date: 12/31/02

Objectives: 1) Test three basic tenets of reserve design. a. Capturing 12% of a species range captures the full geographical and ecological expression of the species; b. Protecting umbrella species across the full range of their ecological and geographical expression captures 90% of all biodiversity; and c. The current set of conservation areas in the western United States captures the full spectrum of vegetation types. 2) Translate research protocols for Gap Analysis into Spanish; and 3) Create thematically seamless land cover and land use maps for the 10 western states.

Progress: Three manuscripts have been completed. Findings from an assessment of the occurrence of bioreserves by elevation and soil productivity were presented at the annual meeting of The Society for Conservation Biology in Sydney, Australia and the Gap Analysis meeting in Santa Barbara, California. Preliminary findings indicate that areas of high elevation and low soil productivity are over represented in bioreserves and the low elevation, high soil productivity areas very under represented. The majority of lands in the low elevation areas are privately owned.

Scott, J. M. and M. D. Jennings. 1998. Large-area mapping of biodiversity. Pp34.47 *In* Annals of the Missouri Botanical Garden 85(1), Missouri Botanical Garden.

Scott, J. M., M. Murray, R. G. Wright, B. Csuti, and R. L. Pressey. Representation of natural vegetation in protected areas: Capturing the geographic range. Submitted.

SETTING CONSERVATION PRIORITIES: AN EVALUATION OF THEORY AND METHOD

Principal Investigator: J. M. Scott
Funding Agency: USGS/Biological Resources Division
Completion Date: 12/31/98

Objectives: 1) Categorize the conservation status of major ecosystems in the Northwestern U.S. using Kuchler's potential natural vegetation and ownership and management status; 2) Categorize the conservation status of major ecosystems in the Northwestern U.S. using the existing vegetation and ownership and management status maps; 3) Evaluate whether areas identified as under-represented in conservation areas by both approaches should be given higher priority in future conservation planning; and 4) Compile a bibliography of relevant literature.

Progress: A review of the occurrences of 106 mapped vegetation types in the 10 western states found that 35% of them had 10% or less of their area in bioreserves. This 35% figure for under representation of vegetation types is very similar to values obtained for areas that were mapped in much more detail than we were able to accomplish.

IDAHO GAP ANALYSIS

Principal Investigator: J. M. Scott
Funding Agency: USGS/Biological Resources Division
Completion Date: 12/31/98

Objectives: 1) Map vegetation of Idaho at a scale of 1:100,000 and a minimum mapping unit of 2 hectares; 2) Identify underprotected vegetation types; 3) Model presence or absence of terrestrial vertebrates at 1:100,000 and a mmu of 2 hectares; 4) Determine occurrence of unprotected species in special management areas; and 5) Conduct accuracy assessment tests of vertebrate models through field studies.

Progress: Hosted Annual Gap Analysis Meeting. Research efforts have focused on assessing occurrence of species and dominant cover types in reserves and addressing questions of reserve identification and selection in the western United States. Current strategies for selecting nature reserves rarely address the need to capture genetic or ecological variation within target species or ecosystems. We used latitude and longitude to stratify the distribution of 4 widespread vegetation cover types in the western United States into 16 cells, each of which was further stratified by up to 5 elevation classes. While protection of some vegetation types was high in parts of their range, it was minimal to nonexistent in other parts. Our results suggest that natural area systems need to consider representation of internal species and ecosystem variation to succeed in their objective of maintaining biological diversity. A second generation land cover map (2 ha mmu) of northern Idaho has been completed. The map for the southern half of the state will be completed by December 1998. Second generation models of species distributions in Idaho have been completed and sent out for review.

PARK ROAD USE AND VEHICLE INTERACTIONS AT DENALI NATIONAL PARK, ALASKA

Principal Investigator: R. G. Wright
Student Investigator: Andy Yost
Funding Agency: National Park Service
Completion Date: 12/31/98

Objectives: 1) Measure various components of wildlife behavior; 2) Develop consistent techniques which can be incorporated into a long-term plan to monitor wildlife behavior in response to visitor road use; and 3) Examine factors related to habitat security, visibility, topography, and quality which influence wildlife behavioral responses to bus tour stimuli.

Progress: Because traffic volume (primarily bus tours) decreases progressively west to east along the road. We defined four sampling strata along the 130 km corridor to take this into account. We established 19 viewsheds (large plots) within these four strata. Each viewshed encompassed part of the road corridor. We also established 9 viewsheds that were off-road, i.e., did not include the road corridor. All viewsheds were sampled using a two-hour scan sample protocol 11 times in 1996 and 1997 respectively. All animal sightings, including sex and age, when possible, were documented at each sampling and their specific locations were mapped. The actual area of each viewshed was quantified using DEM data to delineate all area visible from the observation point established in each viewshed. We calculated the distance of each sighting from the observation point and used the program "Distance" to obtain density estimates for each strata. We buffered the road corridor into 300 m intervals on either side and examined the proportion of sightings in each of four zones.

We found that moose, grizzly bear, and caribou (the three species studied) numbers along the park road and their distance from the road were linked more to habitat and elevation than to traffic volume. Moose were more abundant in the dense willow communities on the western portion of the road, caribou in the higher elevation tundra on the eastern end of the road, and grizzly bear primarily occupied the mixed sedge and low shrub communities east of the Toklat River. Although many of the animals are probably habituated to park road traffic, we found the present management of the road system and the restrictions in place seem to be adequate in protecting wildlife and preserving the viewing opportunities for visitors. We feel the non-invasive objective monitoring system developed for this study can be a useful and relatively easily used tool to evaluate if future management changes influence wildlife numbers and distribution along the road.

All field work has been completed, data analysis is completed and final report and thesis will be done by 12/98.

IDENTIFYING AT RISK PLANT COMMUNITIES IN THE WESTERN US

Principal Investigator: R. G. Wright
Student Investigator: Shannon Mann
Funding Agency: USGS/Biological Resources Division
Completion Date: 12/31/99

Objectives: 1) Develop a common vegetation classification for the GAP vegetation maps for the 12 state region west of the continental divide; 2) Calculate the spatial area occupied by each plant community type and measures of the spatial distribution and average patch size for each community; 3)Using GAP land owndership and land stewardship maps, identify those plant communities that lack sufficient protection according to s tandard conservation criteria; 4) Using county scale census data and measures of distribution and patch size, identify those communities selected in objective 3 as being inadequately protected that may be at the greatest risk for land conversion; and 5) Examine the correspondence between our findings and those of other studies which have identified threatened plant communities or ecosystems.

Progress: Data analysis completed. We mapped 106 plants communities over a 12-state region of the western U. S. We calculated the spatial area occupied by each plant community and the extent to which each was found on protected lands, unprotected public lands, and private lands. There were 42 plant communities that had <10% of the respective area in protected lands. These types occupied 35% of the study area. Using the exact proportion of lands protected, the total land area occupied by each type, the geographic range (number of states) of the type, the number of patches it occupied and the average patch size, we reduced this list to 26 types considered to be most vulnerable. We identified changes in human population for each of the 287 counties in the study area and identified the specific county locations for all unprotected patches >2,500 ha for each of the 26 types considered to be most at risk. This analysis allows us to target specific conservation efforts in counties with the high population growth rate and presumably the highest risk of habitat conversion. Preliminary results presented in paper at the Society of Conservation Biology Meetings in July; paper in preparation.

FIRE ECOLOGY AND REHABILITATION AND RESTORATION STRATEGIES

Principal Investigator: R. G. Wright
Student Investigator: Jesse D'elia
Funding Agency: National Park Service; Bureau of Land Management
Completion Date: 12/30/98

Objectives: 1) Describe and map both natural and introduced plant communities according to recognized and accepted classification systems; 2) Group plant communities according to common fire regimes and response to fire; 3) For each plant community a) describe the characteristic frequency; b) identify the associated vertebrate species; c) discuss management implications of fire use and exclusion; d) identify communities where sufficient data are lacking to derive the above conclusions; 4) Develop conceptual models of post fire succession for different plant communities; and 5) Compile data base.

Progress: Using GAP analysis vegetation maps for the U. S., we have identified and mapped by ecoregion all semi-arid and arid land vegetation communities. Using BLM data we have mapped the timing, extent, and origin of all recorded fires. From these data and extensive literature surveys, we have developed fire risk models (for both human caused and lightening cause fires) for each vegetation type in each ecoregion at two week intervals over the burning season. The mapped results of these models are now being compared to human settlement patterns based on census data and other sources to determine areas that would be of highest risk of wildfire. Papers on preliminary results of the project were presented at the Society of Conservation Biology Meetings and the GAP Analysis meetings in July. The final report and thesis will be done by 12/98.

A SURVEY OF AMPHIBIAN ACTIVITY IN PONDS IN THE PALOUSE GRASSLANDS OF IDAHO

Principal Investigator: R. G. Wright
Funding Agency: National Park Service
Completion Date: 12/15/01

Objectives: 1) To describe and map amphibian species occurrences and abundance in ponds of the Idaho Palouse. 2) To characterize these ponds as to age, depth, surrounding habitat, and other ecological characteristics.

Progress: This is a new project that is a continuation of an earlier study.

Completed Projects - Wildlife Resources

Pat Heglund - Principal Investigator

Accuracy of Presence Absence Predictions for Terrestrial Vertebrates: Issues of Behavior, Demographics, and Habitat Selection – with J. Michael Scott

Kirk Lohman - Principal Investigator

An inventory of amphibians and reptiles in riparian habitats along the Lower Snake River.

John T. Ratti - Principal Investigator

The Impact of Land-Use Practices on Vertebrates of Western States.

Ronald Robberecht - Principal Investigator

Juvenile salmon migration feasibility study, Lower Snake River, WA: Vegetation regeneration analysis.

J. Michael Scott - Principal Investigator

Development of a Bioinformation Node in Wyoming

Gap Analysis: A Guide to Protecting Biodiversity in the United States.

GIS Mapping/Field Verification.

R. Gerald Wright – Principal Investigator

Development of methods to measure and monitor exotic plant infestation in National Park Service areas in the Northwest

A survey of amphibian activity in ponds in the Palouse grasslands of Idaho

Examinations of the ecoregion as the appropriate level for ecological analysis

ACCURACY OF PRESENCE ABSENCE PREDICTIONS FOR TERRESTRIAL VERTEBRATES: ISSUES OF BEHAVIOR, DEMOGRAPHICS, AND HABITAT SELECTION

Principal Investigators: P. Heglund
J. M. Scott
Graduate Student: Jason Karl

Funding Agency: USGS/Biological Resources Division
Completion Date: 9/30/98

Objective: 1) To test the accuracy of Gap Analysis project predictions of species occurrence at landscape (Gamma level diversity) and site specific (Alpha level diversity) for northern Idaho.

Results: The usefulness of wildlife habitat relationship (WHR) models for adequately predicting the occurrence or abundance of wildlife species varies considerably. This variation frequently stems from our failure to recognize the effects of behavior, population demographics, and habitat use and dispersion on the development of wildlife habitat models. More importantly we have found that simple measures of accuracy based on presence or absence of a species have application at broad geographic scales but serve little purpose when used at increasingly finer resolutions. We began our efforts by working toward the development of a reliable process by which we could predict the distributions of a variety of species and assign a probably of occurrence to each cell on a map. We examined data from two studies on neotropical migratory birds (i.e., Craig Mountain Wildlife Management Area, Idaho and North Rocky Mountain Region, Idaho and Montana) to determine their value in an examination of the influence of behavior, population demographics, and habitat selection on wildlife habitat relationship (WHR) models. We conducted breeding bird surveys on the Craig Mountain Wildlife Management Area (WMA), Idaho in 1993, 1994 and 1997 and detected 107 species of birds. In addition, point count data collected in 1995 and 1996 were obtained from a broad geographic region covering forested regions of northern Idaho and western Montana. When we restricted the data to north Idaho the data covered 92 of 132 species of birds. We concluded that data from studies of diurnal species or species within a single order alone are not useful in examining the effects of behavior (e.g. diurnal vs. nocturnal). Due to the bias inherent in sampling diurnal birds there are no nocturnal species with enough data represented to make viable comparisons. The same holds true for models based on population demographics. Few studies have been done that provide information on a variety of species to examine the general application of wildlife habitat relation models based on demographic data. In addition, demographic data were not included in the data sets we had available. There was however, a reasonable amount of information available to explore wildlife habitat relation models based on spatially available habitat data. We are currently in the process of preparing a manuscript that summarizes the results of our efforts. We fully expect to submit this manuscript for external review in December 1998.

Karl, J.W., N.M. Wright, P.J. Heglund, and J.M. Scott. 1998. Obtaining environmental measures to facilitate vertebrate habitat modeling. Wildl. Soc. Bull. In press.

Heglund, P.J., N.M. Wright, E.O. Garton, J.W. Karl, and J.M. Scott. In prep. Development of probability models for use in wildlife habitat modeling using geographic information systems. For submission to Journal of Wildlife Management.

AN INVENTORY OF AMPHIBIANS AND REPTILES IN RIPARIAN HABITATS ALONG THE LOWER SNAKE RIVER

Principal Investigator: K. Lohman
Student Investigator: Susan Loper
Funding Agency: U.S. Army Corps of Engineers
Completion Date: 1/30/98

Objectives: 1) To determine amphibian and reptile species richness in riparian habitats along the Lower Snake River; and 2) To determine the relative abundance of amphibian and reptiles in riparian habitats along the Lower Snake River.

Results: We investigated the distribution and abundance of amphibians and reptiles along the lower Snake River in southeastern Washington during 1996 and 1997. Our objective was to determine if either relative abundance or species richness differed between riparian and upland habitats. We also compared the effectiveness of several sampling techniques (pitfall traps, funnel traps, and visual encounter surveys). Based on number of animals caught per trap night, amphibian and reptile abundance was slightly, but not significantly greater in upland than in riparian habitats. In contrast, based on number of individuals seen per hour visually surveyed, amphibian and reptile abundance was greater in riparian than upland habitat, although this difference was also not statistically significant. Species richness was similar in both habitats, regardless of survey method. The generally poor quality of riparian habitats along the lower Snake River may explain the absence of significant differences in species richness and relative abundance between riparian and upland habitats. The number of species detected by different sampling techniques was similar; however, each technique detected species that the others did not and a combination of techniques maximized the number of species detected. We also studied the effects of egg desiccation on the hatching success of two amphibian species (*Hyla regilla* and *Ambystoma macrodactylum*) in the laboratory. Up to 8 hours of desiccation had no effect on the hatching success of either species. *Hyla regilla* eggs were also exposed to 18 and 30 hour desiccation periods. Only those eggs exposed to 30 hours of desiccation had significantly lower hatching success than controls.

THE IMPACT OF LAND-USE PRACTICES ON VERTEBRATES OF WESTERN STATES

Principal Investigator: J. T. Ratti
Funding Agency: USGS/Biological Resources Division
Completion Date: 9/30/97

Objective: 1) To construct a matrix for western vertebrate species of land-use practices that potentially impact population abundance and distribution and to write an interpretive report from the data.

Results:.

Methods:

1. Construct list of vertebrate species to be included in the analysis.
2. Construct list of vertebrate species to be excluded from the analysis.
3. Obtain peer-review of species list.
4. Conduct literature review of habitat losses on each species.

5. Contact each state fish and game agency for information on non-game and games species habitat losses.
6. Contact each state Heritage Program and State Museum of Natural History for information on vertebrate species habitat losses.
7. From available data, construct land-use practices "list of categories."
8. Construct matrix and write interpretive report
9. Obtain review comments and prepare manuscript for preparation.

Work completed/attempted and problems encountered:

1. Construct Species List
   A. **Mammals** - based on Whitaker (1996). We constructed an Excel database that contained mammal species listed as occurring (presence/absence) in the 11 western states (WA, OR, ID, CA, NV, MO, WY, CO, AZ, NM, and UT). Species were organized by taxonomic groups (class, order, and species) to facilitate the anticipated need for random-stratified sampling from the completed list.

      Problems - The species list was too exhaustive given the budget and personnel available to review/gather literature on each species. Because emphasis was on species of concern, we decided to take a slightly different approach to constructing the species list. Rather than listing all species, the revised/reduced list would be based on data from each state's Fish and Game and Heritage office.

   B. **Heritage Databases.** We used the Natural Heritage Program's (NHP) web site to download Species of Concern lists and/or to identify each state's database manager. We received or downloaded vertebrate "tracking lists" (NHP databases) from AZ, CO, ID, MO, NV, NM, OR, WA, and UT. We also contacted Audrey Godell (Director, Western Conservation Information Management, TNC) about NHP databases and documentation of the "reasons for listing." Audrey provided a regional tracking list of species of concern. Wyoming was in the process of updating their tracking list and did not want to provide data until the new list was completed.

      We used EGR and ESR databases (hardcopies or downloaded files) to build an Excel database that contained Global Rank information and GREASONS (field containing "reasons for listing") for amphibians, reptiles, birds, and mammals found in the 11 western states. Taxonomic information was included to facilitate possible random sampling of species from the list. Because each state's EGR list was extensive and had slightly different formats, a significant portion of our time was spent entering and/or transferring data into the Excel database.

      Problems - Audrey Godell provided (e-mail, 9 Jan 1997) the following information regarding NHP databases and data inconsistencies:

      (1) There are two databases that are part of the BCD (the computer system used to track heritage information within each state): Element Global Ranking (EGR) and Element State Ranking (ESR). These databases have fields in them that would have answers we wanted (i.e., reasons for listing). **However,** the data fields have been inconsistently filled out, i.e., some species will have a record in one or both of these databases and some won't.

(2) There is a field in the Element Tracking database that describes the estimated number of occurrences for each species in that state. This is often an important factor in determining a species state rank. Again, Audrey was not sure how many heritage programs fill out this field (i.e., the data are inconsistent).

Chuck Harris of IDFG also cautioned (e-mail, 8 Jan 97) that the "reasons for listing" are not always well documented. Many NHP "species of concern" are listed because of "expert opinion" without having that opinion or supporting data documented.

C. **BNA species accounts x NHP list.** After reviewing the extensive size and associated problems with the NHP data, we decided to use the BNA species accounts to reduce the list of potential species. I compiled a potential bird-species list by cross-referencing BNA data (list of completed accounts) with ESR data for the 9 western states (excluding WY and CA). There were 240 species with completed BNA's in 1996. Of these 202 species appeared in ≥ 1 ESR databases. The 202 species represented 17 orders and 44 families.

Problems - We did not gain much by using the combined ESR database and BNA list to reduce the number of potential species to include in the analysis (i.e., only 38 species were removed from consideration). We did not have the necessary funds or personnel to review all the identified bird species. Furthermore, there are a number of inherent problems with the ESR databases that could affect the validity of our conclusions. Finally, by using the BNA list we also were making an implicit assumption that species with completed BNA accounts were similar to other North American bird species (i.e., in terms of the extent and quality of information available on those species).

Summary

The major reasons why we could not complete the project as planned was that the NHP databases did not provide adequate documentation to critically evaluate the reasons for species declines (i.e., we could not document the effect of land-use practices on population or species trends). Of course, the alternative was to conduct intensive literature reviews of species of concern. However, data on non-game species often are limited, lacking, or found mostly in gray literature. We did not have sufficient funding or personnel to conduct intensive and extensive literature reviews. Furthermore, previous research has already described/discussed the difficulty of using trend data to determine if population declines were real and if apparent declines were related to land-use practices (e.g., Jerry Deal 1994, and several chapters in Martin et al. 1995).

Literature Cited

Deal, J. W. 1994. An analysis of breeding bird population trends in the Western United States, 1968-1991. M.S. Thesis, University of Idaho, Moscow, Idaho, USA.

Martin, T. E., and D. M. Finch. 1995. Ecology and management of neotropical migratory birds: a synthesis and review of critical issues. Oxford University Press, New York, New York, USA.

Whitaker, J. 0. 1996. National Audubon Society field guide to North American mammals. Alfred Knopf, New York, New York, USA.

Alternative Analysis

As an alternative to our original project plan, we asked the question "how many species lack adequate study

needed for basic ecological knowledge and conservation management?" To assess this question, we chose to analyze the number of peer-reviewed publications for all North American avian species. Our objectives, methods, and results are provided in the attached draft manuscript.

VEGETATION REGENERATION ANALYSIS

Principal Investigator: R. Robberecht
Funding Agency: U.S. Army Corps of Engineers
Completion Date: 10/31/97

Objectives: 1) To conduct an inventory of sediment seed sources in the lower Snake; 2) To analyze published studies; and 3) To predict successional trends, potential communities, and management recommendations.

Results: Summary of findings: 1) River sediments do form a seed bank; 2) A large portion of seeds in the sediment are viable seed (47%); 3) Sediments near shore, i.e., in the shallower areas, have the highest seed number; 4) The majority of seeds in the sediments are native herbaceous plant species (64%); 5) The sediment seed bank contained exotic species (29%); and 6) Active restoration of newly exposed shorelines is recommended to avoid communities dominated by exotic plant species.

Recommendations: It is highly recommended that an interactive multimedia expert system be developed for the restoration and management of shorelines along the Snake River region. Computer-based expert systems, which simulate the human expertise on a particular subject, can be an important and powerful tool for the restoration and management of shorelines along the Snake River. Rather than simply an information database, expert systems simulate human decision-making thought processes. Although the development of expert systems is highly complex and specialized, this new technology has been successfully used in a variety of fields. Such an expert system should include the following attributes: 1) Built-in expertise of scientists experienced in restoration and ecology; 2) Interactive multimedia interface; 3) Combined CD-ROM/internet use; 4) Pertinent literature; 5) Interactive and predictive interface for methodology and management; and 6) GIS, photographs, scientific graphics.

DEVELOPMENT OF A BIOINFORMATION NODE IN WYOMING

Principal Investigator: J. M. Scott
Funding Agency: USGS/Biological Resources Division
Completion Date: 9/1/98

Objectives: 1) Establish an NBII "bioinformation node" with the State of Wyoming; and 2) Develop a prototype state bioinfomation node design that can be ported to other states.

Results: A decision support system for land use planners (county, state, and federal) was developed for Teton County, Wyoming. Beta testing of the system demonstrated the usefulness of this user friendly graphic rich software. Reviews by agency, corporate, and county personnel has been very positive. Several other states and counties have expressed interest in using the system.

GAP ANALYSIS: A GUIDE TO PROTECTING BIODIVERSITY IN THE UNITED STATES

Principal Investigator: J. M. Scott
Funding Agency: USGS/Biological Resources Division
Completion Date: 3/31/98

Objectives: 1) Identify areas of high species richness for unprotected species by major ecoregion for: a. rare species, b. neotropical migrants, c. endangered and threatened species, d. declining bird species, e. endemic species; 2) Determine what percent of each vegetation type by ecoregion occurs within existing preserves; 3) Determine what percent of each area of species richness falls within existing reserve areas; 4) Determine location of areas of high species richness for each vegetation type; 5) Identify areas of potential conflict for areas of species richness; 6) Prepare map with preserves selected as to protect areas of biodiversity into the 22nd century; and 7) Coordinate research activities on Gap Analysis project throughout the US.

Results: The refereed journal articles, monographs, or book chapters listed below were completed under this project and may be consulted for details on work accomplished.

Butterfield, B. R., B. Csuti, J. M. Scott. 1994. Modeling vertebrate distributions for Gap Analysis. Pp53-68 (Chapter 4) In Miller, R. I. (Ed.) Mapping the Diversity of Nature. Chapman & Hall, Great Britain.

Csuti, B., L. A. Graham, and J. M. Scott. 1995. Gap analysis: A spatial approach to identifying representative areas for maintaining biodiversity. pp. 537-541 *In* J.A. Bissonette and P.R. Krausman (eds.), Integrating People and Wildlife for a Sustainable Future. The Wildlife Society, Bethesda, MD.

Csuti, B., S. Polasky, P. H. Williams, R. L. Pressey, et al. 1996. A comparison of reserve selection algorithms using data on terrestrial vertebrates in Oregon. Biological Conservation 00:1-15.

Csuti, B., A. J. Kimerling, T. A. O'Neil, M. M. Shaughnessy, E. P. Gaines, and M. M. P. Huso. 1997. Atlas of Oregon Wildlife: Distribution, habitat, and natural history. Oregon State University Press. 492pp.

Defenders of Wildlife. 1998. Oregon's Living Landscape: Strategies and opportunities to conserve biodiversity. Defenders of Wildlife, Portland, Oregon. 218pp.

Engelking, L.D. (Editor). 1994. A preliminary vegetation classification of the Western United States. Unpublished report prepared by the Western Heritage Task Force for The Nature Conservancy, Boulder, CO.

Grossman, D. H., (Editor). 1994. Rare plant communities of the conterminous United States. The Nature Conservancy. 620pp.

Sneddon, L., M. Anderson, and K. Metzler. 1994. A classification and description of terrestrial community alliances in The Nature Conservancy's Eastern Region: First approximation. A report prepared for the National Gap Analysis Program.

Weakley, A., K. Patterson, S. Landaal, M. Pyne, M. Gallyoun, D. Faber Langendoen, and J. Drake. 1997. An alliance level classification of the vegetation of the Southeastern United States. A report by The Nature Conservancy Southeast Conservation Science Department to the University of Idaho Cooperative Fish and Wildlife Research Unit and National Gap Analysis Program.

Drake, J., and D. Faber-Langendoen. 1997. An alliance level classification of the vegetation of the Midwestern United States. A report by The Nature Conservancy Midwest Conservation Science Department to the University of Idaho Cooperative Fish and Wildlife Research Unit and National Gap Analysis Program.

Jennings, M. D., B. Csuti, J. M. Scott. 1997. Wildlife habitat relationship models: Distribution and abundance. Cons. Biol. 11:1271-1272.

Jennings, M. D. and J. M. Scott. 1993. Building a macroscope: How well do places for biodiversity match reality? Renewable Resources Journal. Summer:16-20.

Jennings, M. D. and J. M. Scott. 1993. Gap Analysis: Information for conserving biodiversity. Idaho Forester:40-41.

Jennings, M. D. 1995. Gap Analysis today: A confluence of biology, ecology, and geography for management of biological resources. Wildlife Society Bulletin 23(4):658-662.

Kiester, R, J.M. Scott, B. Csuti, R.F. Noss, B. Butterfield, K. Shar, D. White. 1996. Conservation prioritization using GAP data. Conservation Biology 10(5):1332-1342.

Machlis, G. E., J. M. Scott, D. J. Forester, and C. B. Cogan. 1994. The application of Gap Analysis to decision making in the U.S. National Wildlife Refuge System. Pp 66-74 *In* Transactions of the 59th North American Wildlife and Natural Resources Conference.

Noss, R. F. and B. Csuti. 1994. Habitat fragmentation. Pp 237-264 *In* Meffe, G. K. and C. R. Carroll (Eds.). Principles of Conservation Biology. Sinauer Associates, Inc., Sunderland, MA.

Noss, R. F., T. E. LaRoe III, and J. M. Scott. 1995. Endangered Ecosystems of the United States: A preliminary assessment of loss and degradation. Biological Report 28. U.S. Department of Interior, National Biological Service, Washington, DC.

Scott, J. M. et al. 1994. A handbook for Gap Analysis. Idaho Cooperative Fish and Wildlife Research Unit. National Biological Service.

Scott, J. M., and B. Csuti. 1997. Gap Analysis for biodiversity survey and maintenance. Pp 321-340 *In* Reaka-Kudla, M. L., D. E. Wilson, and E. O. Wilson (Eds.), Biodiversity II. Joseph Henry Press, Washington, DC.

Scott, J.M., B. Csuti. 1996. Noah Worked Two Jobs. Cons. Biol. 11:1255-1257.

Scott, J. M., B Csuti, and F. W. Davis. 1993. An application of geographical information systems for wildlife species. Challenges in the Conservation of Biological Resources. Pp 167-180 *In* Decker, D. J., M. E. Krasny, G. R. Goff, C. R. Smith, and D. W. Gross (Eds.), A Practitioners' Guide. Westview Special Studies in Natural Resources and Energy Management, Boulder, Colorado.

Scott, J. M., E. T. LaRoe, and M. D. Jennings. 1995. Gap Analysis: A geographic approach to planning for biological diversity. P462 *In* E. T. LaRoe (Ed.), Our Living Resources. U.S. Department of Interior, National Biological Service, Washington, DC.

Scott, J. M., F. Davis, B. Csuti, et al. 1993. Gap Analysis: A geographic approach to protection of biodiversity. Wildlife Monographs 123:1-41.

Scott, J.M., E.D. Ables, T.C. Edwards, R.L. Eng, T.A. Gain, L.D. Harris, J.B. Haufler, W.M. Healy, F.L. Knopf, O. Torgerson, and H.P. Weeks, Jr. 1996. Conservation of biological diversity: Perspectives and the future for the wildlife profession. Wildlife Society Bulletin 23(4):646-657.

Scott, J. M., M. Jennings, R. G. Wright, and B. Csuti. 1996. Landscape approaches to mapping biodiversity. *BioScience* 46(2):77-78.

Scott, J. M., S. A. Temple, D. L. Harlow, and M. L. Shaffer. 1994. Restoration and management of endangered species. Pages 531-539 *In* T.A. Bookhout (ed.), Research and Management Techniques for Wildlife Habitats, 5th Edition.

Scott, J.M., T.H. Tear, and L.S. Mills. 1995. Socioeconomics and the recovery of endangered species: Biological assessment in a political world. Conservation Biology 9:214-216.

Scott, J. M. and B. Csuti. 1997. Gap Analysis: Assessing landscape trends in diversity. Pp409-410 *In* G. K. Meffe and C. R. Carroll (Eds.), Principles of Conservation Biology, Second Edition, Sinauer Associates, Inc. Sunderland, MA.

Shaw, D. M. and M. Jennings. 1995. Federal data bases of land characteristics. Pp 467-468 *In* E. T. LaRoe (Ed.), Our Living Resources. U.S. Department of Interior, National Biological Service, Washington, DC.

Stine, P.A., F.W. Davis, B. Csuti, and J.M. Scott. 1996. Comparative utility of vegetation maps of different resolutions for conservation planning. Pp. 210-220 *In* R.C. Szaro and D.W. Johnston (eds). Biodiversity in Managed Landscapes: Theory and Practice. Oxford University Press. New York.

Wright, R. G., M. P. Murray, and T Merrill. 1998. Ecoregions as a level of ecological analysis. Biological Conservation 1:1-7.

Wright, R. G., M. Murray, and T. Merrill. 1994. An ecological evaluation of proposed new conservation areas in Idaho: Evaluating proposed Idaho National Parks. Biological Conservation 8:207-216.

Wright, R. G., J. G. McCracken, and J. Hall. 1994. An ecological evaluation of proposed new conservation areas in Idaho. Evaluating proposed Idaho National Parks. Conservation Biology 8:207-216.

Wright, R.G., J.M. Scott. 1996. Evaluating the ecological suitability of lands for parks and protected areas using gap analysis databases. Pp. 121-130 *In* National Parks and Protected Areas: Their role in Environmental Protection. Blackwell Science, Cambridge, Massachusetts.

GIS MAPPING AND FIELD VERIFICATION

Principal Investigator: J. M. Scott
Funding Agency: Bureau of Land Management
Completion Date: 12/1/97

Objective: To assess accuracy of predicted bird species occurrences.

Results: The vegetation map for 140,000 acres on Craig Mountain was revised based on intensive field sampling. Resultant vegetation map had a minimum mapping unit of 2 hectares and was used to predict pattern of species occurrence at 2, 4, 10, and 100 hectares. Models with differing complexity were used to predict occurrences. The simplest model habitat types plus range captured most occurrences, however improvement in model accuracy and power were obtained when other variables (e.g. canopy cover, elevation, etc.) were added. For the 65 species tested model accuracy was usually greater than 80% accurate.

DEVELOPMENT OF METHODS TO MEASURE AND MONITOR EXOTIC PLANT INFESTATION IN NATIONAL PARK SERVICE AREAS IN THE NORTHWEST

Principal Investigator: R. G. Wright
Student Investigator: Ryan Monello
Funding Agency: National Park Service
Completion Date: 9/30/98

Objectives: 1) Describe and map both natural and introduced plant communities according to recognized and accepted classification systems; 2) Group plant communities according to common fire regimes and response to fire; 3) For each plant community – a) describe the characteristic frequency; b) identify the associated vertebrate species; c) discuss management implications of fire use and exclusion; 4) identify communities where sufficient data are lacking to derive the above conclusions; 4) Develop conceptual models of post fire succession for different plant communities; and 5) Compile data base.

Results: We surveyed and mapped exotic noxious weed infestations using GPS/GIS in four NPS areas in Idaho and Washington; Nez Perce National Historic Site, City of Rocks National Reserve, Hagerman Fossil Beds National Monument, and Whitman Mission Historic Site. We examined the intensity of the infestations, risk of spread to other areas, and logistical constraints and based on these criteria developed recommended control options for all major infestations.

We established transects for sampling small mammals and breeding birds in each of the four areas both within and outside the weed infestations. In general, because of the limited area surveyed, the number of mammal species trapped was small. We captured 12 small mammal species during 3250 trap nights. The number of captures and species caught differed significantly between weed areas and non-weed areas only at Hagerman. A total of 97 species of birds were observed in all park units. Because of the small range of noxious weed infestations, none of the bird surveys could discern a difference between noxious weed infestations and native habitat. Final report to the NPS published.

A SURVEY OF AMPHIBIAN ACTIVITY IN PONDS IN THE PALOUSE GRASSLANDS OF IDAHO

Principal Investigator: R. G. Wright
Student Investigator: Ryan Monello
Funding Agency: National Park Service
Completion Date: 12/30/97

Objectives: 1) To describe and map amphibian species occurrences and abundance in ponds of the Idaho Palouse. 2) To characterize these ponds as to age, depth, surrounding habitat, and other ecological characteristics.

Results: Amphibian presence and reproduction were determined in 37 ponds to investigate ecological requirements for their persistence in the Palouse. Ponds were located in four habitat classes: forests, agriculture, grassland, and residential. Four anuran and three caudate species were found with *Hyla regilla*, *Rana luteiventris*, and *Ambystoma macrodactylum* being the dominant pond inhabitants; and *Bufo boreas*, *Rana catesbeiana*, *Taricha granulosa*, and *Ambystoma trigrinum* occupying ponds to a lesser extent. Ten habitat variables were included in a discriminant function analysis for each species distribution and reproduction which effectively discriminated between used and unused sites. The distribution of amphibians was found to be most adversely affected by the presence of fish. Older ponds and presence of emergent vegetation positively influenced reproduction.

In a separate study, a population of H regilla was re-evaluated over a 2-year period to examine differences in population sizes compared to 20 years ago. Total 1996 captures were very low and indicated a substantial reduction in treefrog abundance relative to 1976-77. Captures in 1997 exceeded all years for which capture data were available. The differences suggest that anuran survey results can vary greatly depending upon environmental conditions.

EXAMINATIONS OF THE ECOREGION AS THE APPROPRIATE LEVEL FOR ECOLOGICAL ANALYSIS

Principal Investigator: R. G. Wright
Funding Agency: USGS/Biological Resources Division
Completion Date: 12/30/97

Objectives: 1) To examine whether the ecoregion scale of analysis is both useful and appropriate. 2) To determine how well the boundaries of ecoregions, as proposed by both Bailey and Omernick approximate the boundaries of existing mapped vegetation. 3) To determine the influence that the hierarchical level of vegetation classification has on the concurrence of the boundaries of the vegetation classes with the boundaries of ecoregions.

Results: Study completed, paper in press, Biological Conservation. Because of the many attempts to classify geographic areas into zones such as ecoregions of similar characteristics, we examined how well the boundaries of the most commonly used ecoregion classifications for the U. S. matched the boundaries of existing vegetation cover mapped at three levels of classification, fine, mid, and coarse scale. We analyzed the ecoregions defined by Bailey and Omernik for Idaho, Oregon, and Washington. We found

similar resource among the two ecoregion classifications. For both ecoregion delineations and all three vegetation classifications, the patterns of existing vegetation did not correspond well with the patterns of ecoregions. Most vegetation types had a small proportion of their total area in a given ecoregion. There was also no dominance by one or more vegetation types in any ecoregion and contrary to our hypothesis, the level of congruence of vegetation patterns with ecoregion boundaries decreased as the level of classification became more general.

Wright, R.G., M.P. Murray, and T. Merrill. 1998. Ecoregions as a level of ecological analysis. Biological Conservation 86:207-213.

Honors and Awards Received by Unit Staff and Students.

Andrew Lindbloom received the Ted Trueblood Communications Award for the best student paper at the 35th Annual Meeting of the Idaho Chapter of The Wildlife Society, March 1998. His presentation was "Habitat use, reproduction, movements, and survival of chukar partridge in west-central Idaho.

Dr. J. Michael Scott received the Outstanding Researcher Award for the College of Forestry, Wildlife and Range Sciences, University of Idaho.

Dr. J. Michael Scott received the Edward T. LaRoe III Award from the Society for Conservation Biology.

Dr. J. Michael Scott elected Fellow of the American Association for the Advancement of Science.

Publications and Professional Papers presented - Unit Staff and Students

Scientific Papers:

Congleton, J. L. 1998. Book review: "Fish Stress and Health in Aquaculture" (G. K. Iwana, et al., eds.). Northwest Science 72(1):70-71.

Congleton, J. L., W. J. LaVoie, C. B. Schreck, L. E. Davis, M. S. Fitzpatrick, and D. G. Elliott. 1998. Blood chemistry and performance indices for juvenile chinook salmon and steelhead descaled experimentally and during passage through fish bypasses at dams on the Snake River, Washington. Pp. 71-75 In Stress in Fish Symposium Proceedings, Third International Congress on the Biology of Fishes, Baltimore, Maryland.

Ostergren. M. and R. G. Wright. 1998. Creating a bibliographic database for a widely distributed collection. J. Special Libraries Association:Information Outlook 2:27-30.

Wright. R. G. and P. D. Tanimoto. 1998. Using GIS to prioritize land conservation actions: Integrating factors of habitat diversity, land ownership, and development risk. Natural Areas Journal 18: 38-44.

Jennings. M. D., B. Csuti, and J. M. Scott. 1997. Wildlife habitat relationship models: distribution and abundance. Conservation Biology 11(6):1271-1272.

Scott. J. M. and M. D. Jennings. 1998. Large area mapping of biodiversity. Annals of The Missouri Botanical Garden 85(1):34-47.

Scott. J. M. and D. S. Wilcove. 1998. Improving the future for endangered species. Bioscience 48(8):579-580.

Technical and Semi-technical papers:

Bjornn, T. C., C. A. Peery, and L. Garmann. 1998. Deposition of fine sediments in substrates and their effects on survival of trout embryos. Technical Report 98-1, Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow, Idaho. 36pp.

Bjornn, T. C., K. R. Tolotti, J. P. Hunt, P. J. Keniry, R. R. Ringe, and C. A. Peery. 1998. Passage of chinook salmon through the lower Snake River and distribution in the tributaries, 1991-1993. Part I of final report for Migration of adult chinook salmon and steelhead past dams and through reservoirs in the lower Snake River and into tributaries. U.S. Army Corps of Engineers, Walla Walla, Washington. 95pp.

Bjornn, T.C., J. P. Hunt, K. R. Tolotti, P. J. Keniry, and R. R. Ringe. 1998. Entrances used and passage through fishways for adult chinook salmon and steelhead. Part III of final report for Migration of adult chinook salmon and steelhead past dams and through reservoirs in the lower Snake River and into tributaries. U.S. Army Corps of Engineers, Walla Walla, Washington. 99pp.

Bjornn, T.C., J. P. Hunt, K. R. Tolotti, P. J. Keniry, and R. R. Ringe. 1998. Turbine priority and its effects on passage of steelhead at Snake River dams. Part IV of final report for Migration of adult chinook salmon and steelhead past dams and through reservoirs in the lower Snake River and into tributaries. U.S. Army Corps of Engineers, Walla Walla, Washington. 73pp.

Bjornn, T.C., J. P. Hunt, K. R. Tolotti, P. J. Keniry, and R. R. Ringe. 1998. Movements of steelhead in fishways in relation to transition pools. Part V of final report for Migration of adult chinook salmon and steelhead past dams and through reservoirs in the lower Snake River and into tributaries. U.S. Army Corps of Engineers, Walla Walla, Washington. 44pp.

Bjornn, T.C., J. P. Hunt, K. R. Tolotti, P. J. Keniry, and R. R. Ringe. 1998. Effects of zero versus normal flow at night on passage of steelhead in summer and fall. Part VII of final report for Migration of adult chinook salmon and steelhead past dams and through reservoirs in the lower Snake River and into tributaries. U.S. Army Corps of Engineers, Walla Walla, Washington. 62pp.

Congleton, J. L., W. J. LaVoie, C. B. Schreck, L. E. Davis, H. Lorz, and M. Beck. 1998. Evaluation of procedures for collection, bypass, and downstream passage of outmigrating chinook salmon, Objectives 2, 3, and 4. Annual Report to U.S. Army Corps of Engineers, Walla Walla District, 1995. 34pp.

Congleton, J. L., W. J. LaVoie, C. B. Schreck, L. E. Davis, H. Lorz, and C. Slater. 1998. Evaluation of procedures for collection, bypass, and downstream passage of outmigrating chinook salmon, Objectives 2, 3, and 4. Annual Report to U.S. Army Corps of Engineers, Walla Walla District, 1996. 53pp.

Connor, W. P., T. C. Bjornn, H. L. Burge, R. Waitt, and T. Anderson. 1997. Early life history and survival of Snake River natural subyearling fall chinook salmon in 1996. Chapter. Annual Report 1995. U.S. Fish and Wildlife Service. 23pp.

Miller, C. A. and R. G. Wright. 1998. Visitor satisfaction with transportation services and wildlife viewing opportunities in Denali National Park and Preserve. Idaho Cooperative Fish and Wildlife Research Unit Technical Report. 35pp.

Ostergren, M. and R. G. Wright. 1998. Natural resource bibliography (NRBIB) for National Park Service Units in California and Nevada. Final Report NPS/CCSOUI/NRTR-98/18. Idaho Cooperative Fish and Wildlife Research Unit. 43pp.

Peery, C. A, T. C. Bjornn, and K. R. Tolotti. 1998. Evaluation of adult chinook and sockeye salmon passage at Priest Rapids and Wanapum 1997. Technical Report 98-5, Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow, Idaho.

Schreck, C. B., L. E. Davis, D. Kelsey, J. L. Congleton, W. J. LaVoie. 1998. Evaluation of facilities for collection, bypass, and transportation of outmigrating chinook salmon. Annual Report to U.S. Army Corps of Engineers, Walla Walla District, 1995. 64pp.

Theses and Dissertations:

Karl, J. W. 1998. Assessment of wildlife habitat relationship models: Theory and application. M.S. Thesis, University of Idaho, Moscow, Idaho. 137pp.

Monello, R. J. 1998. Amphibian habitat preferences and population dynamics in the Palouse region of Northern Idaho. M.S. Thesis, University of Idaho, Moscow, Idaho. 68pp.

Papers Presented:

Bjornn, T. C., C. A. Peery, P. J. Keniry, K. R. Tolotti, R. R. Ringe, Tami Reischel. October 1997. Migration patterns and passage at dams of salmon and steelhead in the Columbia and Snake rivers. Corps of Engineers Annual Review.

Wright, R. G. October 1997. A graduate student perspective of the International Biological Program. 30th Anniversary Symposium of the Natural Resource Ecology Lab., Ft. Collins, Colorado.

Bjornn, T. C. and P. J. Keniry. November 1997. Temperature in fishways and forebays of dams in the Snake River and passage of adult salmon and steelhead. Columbia/Snake River Mainstem Water Temperature Workshop.

Congleton, J. L. November 1997. Blood chemistry indices in juvenile chinook salmon and steelhead before and after barge transportation. 19th Annual Smolt Workshop, Hood River, Oregon.

Bjornn, T. C. February 1998. Passage of adult chinook salmon at dams and migration into tributaries, an update. Annual meeting, Idaho Chapter of American Fisheries Society, Idaho Falls, Idaho.

Keefer, M., and T. C. Bjornn. February 1998. Fishway entrance use and passage by adult chinook salmon in 1996 at Bonneville, McNary, Ice Harbor, and Lower Granite dams. Annual meeting, Idaho Chapter of American Fisheries Society, Idaho Falls, Idaho.

Reischel, T., and T. C. Bjornn. February 1998. Salmon and steelhead migration routes in the forebays of Ice Harbor, Lower Granite, and Bonneville dams. Annual meeting, Idaho Chapter of American Fisheries Society, Idaho Falls, Idaho.

Peery, C. A. and T. C. Bjornn. February 1998. Evaluation of adult chinook and sockeye salmon passage at Priest Rapids and Wanapum dams with orifice gates closed and with an experimental fishway fence-1 997. Annual meeting, Idaho Chapter of American Fisheries Society, Idaho Falls, Idaho.

Keniry, P. J., T. C. Bjornn, K. . Tolotti, and R. R. Ringe. February 1998. Timing of migration and distribution of adult steelhead with radio transmitters in the Snake River drainage. Annual meeting, Idaho Chapter of American Fisheries Society, Idaho Falls, Idaho.

Porter, P. February 1998. Interactions between cutthroat and coho salmon juveniles in an artificial stream. Annual meeting, Idaho Chapter of American Fisheries Society, Idaho Falls, Idaho.

Bjornn, T. C. March 1998. Migration behavior of adult steelhead in the Columbia and Snake Rivers. Coastwide Steelhead Workshop, Port Townsend, Washington..

Scott, J. M. March 1998. Avian monitoring program: An assessment of observer training and taxonomic coverage. Idaho Chapter The Wildlife Society Annual Meeting, Moscow, Idaho.

Elliott, D. C. M. Aiwohi, and J. L. Congleton. June, 1998. Effect of temperature on healing of descaling injuries in chinook salmon Oncorhynchus tshawytscha (Poster). Western Fish Disease Workshop, Parksville, British Columbia.

Congleton, J. L., W. LaVoie, C. B. Schreck, L. Davis, M. Fitzpatrick, and D. Elliott. July, 1998. Blood chemistry and performance indices for juvenile chinook salmon and steelhead descaled experimentally and during passage through fish bypasses at dams on the Snake River, Washington. Third International Congress on the Biology of Fishes, Baltimore, Maryland.

Schreck, C. B., L. Davis, C. Seals, T. Stahl, J. L. Congleton, R. Pascho, and G. Oosterhout. July, 1998. Migration of juvenile chinook salmon and effects of development, stress, and pathogens. Third International Congress on the Biology of Fishes, Baltimore, Maryland.

Scott, J. M. July 1998. Rocks and ice revisted: An assessment of the geographical and ecological distribution of bioreserves in the contiguous 48 states. Society of Conservation Annual Meeting, Sydney, Australia.

Wright, R. G. July 1998. Identifying unprotected and at risk plant communities in the western US. Society of Conservation Annual Meeting, Sydney, Australia.

Elliott, D., C. Aiwohi, and J. L. Congleton. August, 1998. Effect of temperature and exposure to Reinbacterium salmoninarum on healing of descaling injuries in chinook salmon Oncorhynchus tshawytscha smolts. Third International Symposium on Aquatic Animal Health, Baltimore, Maryland.

Scott, J. M. September 1998. Ecosystem restoration: Where to start? The Wildlife Society Annual Meeting, Buffalo, New York.

Wright, R. G. September 1998. The fuzzy logic of National Park Service resource management. The Wildlife Society Annual Meeting, Buffalo, New York.

Publications and Professional Papers presented - Unit Cooperators

Scientific Papers:

Bennett, D. H. 1997. Food abundance linked to survival of downstream migrating fish. Hydro-Review 16 (7):87-88.

Connelly, J. W., M. W. Gratson, and K. P. Reese. 1998. Sharp-tailed grouse (Tymanuchus phasianellus). In The Birds of North America, No. 354 (A. Poole and F. Gill, eds.). The Birds of North American, Inc., Philadelphia, PA. 20pp.

McDonald, M. W., and K. P. Reese. 1998. Landscape changes within the historical distribution of Columbian sharp-tailed grouse in Eastern Washington: Is there hope? Northwest Science 72(1):34-41.

Reese, K. P. and J. W. Connelly. 1997. Translocations of sage grouse Centrocerus urophasianus in North America. Wildlife Biology 3(3/4):235-241.

Technical and Semi-technical papers:

Bennett, D. H., T. Dresser, Jr., and M A. Madsen. 1998. Habitat use, abundance, timing and factors related to the abundance of subyearling chinook salmon rearing along the shorelines of Lower Snake River reservoirs. Completion Report. US. Army Corps of Engineers, Walla Walla Washington. 91pp.

Edelmann, F. B., M. J. Ulliman, M. J. Wisdom, K. P. Reese, and J. W. Connelly. 1998. Assessing habitat quality using population fitness parameters: A remote sensing/GIS based habitat-explicit model for sage grouse Centrocerus urophasianus. Idaho Forest, Wildlife, and Range Experiment Station Tech. Report 25, University of Idaho, Moscow, Idaho. 33pp.

Theses and Dissertations:

McDonald, M. W. 1998. Ecology of columbian sharp-tailed grouse in Eastern Washington. M.S. Thesis, University of Idaho, Moscow, Idaho. 125pp.

Papers Presented:

Lindbloom, A., K. P. Reese, and P Zager. March 1998. Habitat use, reproduction, movements, and survival of chukar partridge in west-central Idaho. 35th Annual Meeting of the Idaho Chapter of The Wildlife Society, Moscow, Idaho.

Schneider, J. W. and K. P. Reese. April 1998. Hypertrophic fluctuations in digestive organs of Columbian sharp-tailed grouse. North American Ornithological Conference, St. Louis, Missouri.

Reese, K. P. April 1998. Sage grouse reintroductions: Habitat and other considerations. Washington Department of Fish and Wildlife Sage Grouse Reintroduction Meeting, Moxee, Washington.

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