MINNESOTA COOPERATIVE FISH AND WILDLIFE RESEARCH UNIT

Biennial Report
January 1995 - December 1996

This is the 4th biennial report produced by the MN Coop Unit and summarizes Unit activities during 1995 and 1996. The period from 1995-1996 was again a time of significant change for the MN Coop Unit. After being moved out of the U.S. Fish and Wildlife Service to the National Biological Survey (Service) in 1993, the Unit Program was moved into the U.S. Geological Survey as part of the Biological Resources Division in 1996. This reorganization followed a period of uncertainty regarding the future of the U.S. National Biological Service and the Cooperative Research Units Program. Throughout this period, however, our program at the Minnesota Coop Unit has remained strong, and our ties with Cooperators remain intact. We continue to further our research mission, and were productive in terms of projects and publications over the past 2 years.

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- lakes of Glacier National Park, Montana
- Relating Behavior and Microhabitat Use to Growth in Stream Resident Trout
- Winter Ecology of Ferruginous Hawks in Colorado

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Completed Research
January 1995 - December 1996

Contaminants

Avian Exposure to Agricultural Chemicals in Minnesota

Investigators: David E. Andersen and Pamela F. McInnes
Duration: June 1991 to June 1995
Funding Source: U.S. Fish and Wildlife Service, Region 3 Division of Environmental Contaminants
Project Location: Western Minnesota, Minnesota Cooperative Fish and Wildlife Research Unit

Organophosphorus (OP) and carbamate insecticides are commonly used in agriculture across the United States. In Minnesota, farmers and applicators apply these insecticides to a variety of crops including sugar beets, field corn, sunflowers, potatoes, and wild rice. Because of their widespread use it is likely that non-target organisms in agricultural areas are exposed to these insecticides. OPs and carbamates inhibit cholinesterase in animals; this leads to the accumulation of the neurotransmitter acetylcholine. The build-up of acetylcholine in birds can lead to serious physical effects such as loss of coordination, loss of appetite, convulsions and respiratory collapse. Cholinesterase inhibition in blood and brain tissue can be measured in animals that are exposed to OPs and carbamates. We experimented with drawing blood from nestling birds near fields where OPs or carbamates were applied to evaluate the efficacy of this method as a tool for monitoring the exposure of birds to these insecticides.

In May and June of 1992, we selected four wetland sites near sugar beet fields and one site distant from sugar beet fields. We searched for nests of red-winged blackbirds (*Agelaius phoeniceus*) and other songbirds at these sites and monitored active nests. In addition, we contacted landowners and farmers to gather information regarding type and timing of insecticide applications near these sites. A total of 53 blood samples and 11 carcasses were collected. Serum and carcasses were analyzed for cholinesterase activity and for reactivation of cholinesterase. In addition, intestinal tracts were analyzed for the presence of insecticide residue.

Conclusion: Cholinesterase activity levels were lowest in nestlings at sites near insecticide applications. Plasma acetylcholinesterase reactivation appeared to be the most sensitive indicator of exposure, and provides a non-destructive sampling technique for monitoring exposure of non-target organisms to cholinesterase-inhibiting insecticides.

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Effect of Bioturbation on the Bioavailability of Metals in Sediments: A Test of the Acid Volatile Sulfide Approach for Determining Metal Bioavailability

Investigator: Gerald Ankley and Ira Adelman
Student: Gregory S. Peterson
Duration: January 1993 to December 1995
Funding Source: U.S. Environmental Protection Agency
Project Location: U.S. Environmental Protection Agency, Duluth; Minnesota Cooperative Fish and Wildlife Research Unit

Recent studies have demonstrated the role of acid volatile sulfide (AVS) in controlling the bioavailability of several cationic metals in anoxic sediments. However, metal-sulfide complexes can be relatively labile with respect to oxidation associated with factors such as seasonal changes in rates of oxidation/production of AVS. Another potentially important mechanism of AVS oxidation in surficial sediments is bioturbation. The present study used different densities of the burrowing oligochaete *Lumbriculus variegatus*, in a series of laboratory experiments, to evaluate the effect of bioturbation on oxidation of AVS, and subsequent bioavailability of cadmium and zinc spiked into freshwater sediments. Metal bioavailability was determined directly by

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bioaccumulation in the test organisms and indirectly through analysis of interstitial (pore) water metal concentrations. In these studies, horizon-specific sediment analyses were conducted to assess spatial differences in AVS and pore water metal concentrations specifically related to organism activity.

Conclusion: Burrowing activity of the oligochaete significantly reduced AVS concentrations in surficial sediments in a density dependent manner, and resulted in elevated interstitial water concentrations of cadmium, but not zinc. Concentrations of cadmium in pore water from deeper horizons (below the zone of active burrowing) were consistently lower than those in the surficial sediments. The bioaccumulation of cadmium and zinc by *L. variegatus* was reflective of pore water concentrations of the two metals, i.e., there was significant accumulation of cadmium, but not zinc, by the oligochaetes. Overall, the results indicate that bioturbation can enhance the bioavailability of some cationic metals in surficial sediments, via oxidation of AVS, and demonstrate the importance of analyzing surficial sediments when assessing bioavailability of metals in sediments.

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Impact of Sedimentation and Agricultural Chemicals on Wetlands in the Prairie Pothole Region of the United States

Investigators: Deborah L. Swackhamer and Mary Henry
Student: Carl Herbrandson
Duration: July 1992 to January 1996
Funding Source: U.S. Fish and Wildlife Service, Northern Prairie Wildlife Research Center
U.S. National Biological Service, Northern Prairie Science Center
Project Location: Minnesota Cooperative Fish and Wildlife Research Unit

Wetlands in the Prairie Pothole Region (PPR) are critical to migratory and resident wildlife in the Northern Great Plains. Wetland loss has been extensive in the PPR with remaining wetlands occurring primarily in landscapes dominated by agriculture. Wetland quality has been influenced by agriculture in the PPR, but there is insufficient information available to guide management efforts. Runoff from agricultural fields likely affects wetland fauna and flora, but there are no studies available to guide management efforts. A confounding factor in understanding agricultural impacts on wetlands and wetland biota is potential interaction between effects of agricultural chemicals and sedimentation.

As a component of a larger study to identify how agricultural chemicals and soils from eroded fields impact wetlands, this project involved developing methodology and apparatus capable of isolating effects of sediments on bioavailability or uptake toxicokinetics. A suspended solid testing apparatus was designed and developed as a laboratory model of a contaminated natural environment and studies were conducted to evaluate the toxicodynamic effects of simultaneous exposure of an aquatic intertebrate to suspended solids and carbofuran. These experiments demonstrated a synergism between the combined physical and chemical stressors.

Conclusion: Presence of sediments has an important synergistic effect on toxicokinetics and bioavailability of carbofuran in aquatic macroinvertebrates. Further, sensitivity to toxic chemicals alone or combined with suspended solids can be modulated by adjusting food availability. This study demonstrated the utility and sensitivity of suspended solid testing apparatus in a bioassay discriminating between toxicokinetic and toxicodynamic effects of simultaneous exposure to a chemical and suspended solids.

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Human Activities, Management, and Conservation

An Evaluation of the Indirect Effects of Fluridone (Sonar®) on two Minnesota Lakes

Investigators: Bruce Vondracek and Donald L. Pereira
Student: Steven Pothoven, M.S.
Duration: July 1993 to June 1996
Funding Source: Minnesota Department of Natural Resources - Section of Ecological Services and Section of Fisheries
Project Location: Carver and Hennepin Counties, Minnesota Minnesota Cooperative Fish and Wildlife Research Unit

Eurasian watermilfoil *Myriophyllum spicatum* invaded Minnesota in 1987 and is now found in 65 lakes and rivers. This study was part of a larger project by the Minnesota Department of Natural Resources to investigate using fluridone (tradename SONAR®), a broad spectrum, systemic herbicide to control milfoil. Changes in the fish community structure and predator-prey

interactions due to vegetation removal were investigated as part of a three-year study. Three reference lakes and two treatment lakes were monitored one year prior to treatment (1993) and during two post-treatment years (1994-1995). The fish community was sampled with gill nets, trap nets, beach seines, purse seines, and electrofishing. We examined species composition, relative abundance (CPUE), and diversity of the fish community, and diet of the two major predators largemouth bass (*Micropterus salmoides*) and northern pike (*Esox lucius)*.

In Zumbra Lake (a treatment lake), fish species richness decreased from 23 in 1993 to 16 in 1995. In Parkers Lake, bluegill abundance decreased significantly in 1995 and mean bluegill length increased significantly compared to 1993. Bluegill growth rates increased in both treatment lakes in 1994 compared to the previous 5 years, but remained constant in the three reference lakes.

Largemouth bass feeding efficiency (increased fish per stomach and decreased empty stomachs) increased during the initial treatment year and growth rates were higher in 1994 than the previous 3 years. Northern pike feeding efficiency did not improve, but diet composition related to prey distribution and vulnerability changed following herbicide application.

Conclusion: This study suggests that some species may respond rapidly to plant removal and these changes could influence the long-term composition of the fish community. Lakes with different fish and plant communities should be expected to respond differently to vegetation removal, and these differences should be considered before implementing a plant control program.

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Conservation of the Loggerhead Shrike

Investigator: Francesca J. Cuthbert
Student: Matt Etter
Duration: June 1995 through December 1995
Funding Source: Minnesota Department of Natural Resources
Project Location: Minnesota

Historically the loggerhead shrike (*Lanius ludovicianus*) nested throughout the U.S., southern Canada and northern Mexico. Declines have been recorded in all portions of its breeding range. The most severe decreases have occurred in the upper Midwest and in New England, and it is a threatened species in Minnesota. The purpose of this study was to estimate the distribution and size of the population of loggerhead shrikes in Minnesota in 1995 and to compare these results to data from previous years to evaluate trends in the breeding population in Minnesota. In 1995, surveyors were asked to visit historical loggerhead shrike breeding territories three times each during the breeding season. These visits were planned to correspond to the expected shrike activities of pair-formation, nest-building-incubation, and brood rearing-fledging. Each visit lasted a maximum of two hours. All territories where loggerhead shrikes were known to nest at least once during the last ten years were visited. Additionally, all 1995 reports of shrike sightings were included in surveyors visits from the time of the report. Loggerhead shrikes were observed at 29 locations in Minnesota. Twenty-two shrike nests were discovered and an additional five cases were classified as inferred nesting because more than one shrike was observed on the territory on more than one occasion. We estimate there were 27 nest attempting by loggerhead shrikes in Minnesota in 1995. The 22 confirmed sites were all revisited after the end of the nesting cycle to record vegetation data and other habitat parameters.

Conclusion: This survey suggests that size of Minnesota's breeding population of loggerhead shrikes continues to decline. The 27 nesting attempts documented in 1995 occurred in 14 counties compared to 37 nesting attempts in 12 counties in 1987. In those same counties in 1995, we found 18 nesting attempts, suggesting a decline of 51%. Although our results indicate a decline, we believe there are aspects of shrike breeding behavior that make data interpretation difficult. For example, breeding loggerheads appear to cluster their nesting attempts in certain regions of the state. These clusters may occur in the same area for only a short time (one to several breeding seasons). Therefore, direct comparisons of county estimates may be misleading. Resolution of this survey problem depends on improved knowledge of breeding shrike distribution and habitat preference in Minnesota.

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Virtual Reality Interface for Landscape Visualization

Investigator: C. A. Johnston
Duration: June 1995 to June 1996
Funding Source: U. S. National Biological Service
Project Location: University of Minnesota, Natural Resources Research Institute, Duluth, MN

We developed a software interface that combines the visualization capabilities of virtual reality with the spatial display capabilities of GIS. Landscapes are rendered as perspective views using

actual elevation and land cover data, such that they depicted realistic scenery. The user can specify a vehicle (e.g., airplane, all-terrain machine) and a path for travel, viewing landscape features from different perspectives. We use the term "virtual reality" to denote a system that provides the tools for users to interact with a simulated environment, but not necessarily in real time.

The ultimate goal of the research was to develop a prototype virtual reality interface with data from the Mid-Atlantic Integrated Assessment (MAIA) region, in support of the U.S. Environmental Protection Agency's Environmental Monitoring and Assessment Program (EMAP). The MAIA region falls in the states of PA, VA, WV, DE, NJ, and MD, and the District of Columbia, and includes the entire Chesapeake Bay watershed. Virtual rendering was accomplished with two basic datasets: (1) digital elevation models (DEMs), and (2) land cover data derived from classified satellite imagery.

Accomplishments: (1) interface DEM with virtual reality software, (2) drape classified land cover over DEM, (3) set camera location, elevation, and view angle, and (4) render image, enabling 3-D structures.

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Applied Ecology

Ecology of the Boreal Owl in Northeastern Minnesota

Investigator: David E. Andersen
Student: William H. Lane, M.S.
Duration: 1987-1994
Funding Sources: North Central Forest Experiment Station, U.S. Forest Service, Minnesota Department of Natural Resources Nongame Wildlife Program
Project Location: Lake and Cook Counties, Minnesota Superior National Forest

Studies of boreal owls *(Aegolius funereus)* have been conducted primarily in Europe, the western U.S., and boreal Canada. Little is known about boreal owls in eastern North America, especially at the southern extent of their breeding range. In Minnesota, boreal owls occur during winter irruptions, but had been documented as a nesting species only three times prior to 1987. From 1987 through 1992, nocturnal, auditory surveys were conducted to determine the distribution, status, and habitat associations of boreal owls in northeast Minnesota, primarily within the Superior National Forest. During the six years that surveys were conducted, indices to abundance ranged from 0.059 to 0.219 singing males per km of survey route. Analysis of habitat composition along survey routes indicated that both conifer stands and upland hardwoods were associated with owl presence.

Twenty nest sites were located based on auditory surveys and were subsequently monitored, suggesting that boreal owls are a resident, breeding species in the state. Upland trembling aspen *(Populus tremuloides)* was selected as the substrate tree in 46 (93.9%) of 49 observations of owls at cavities. The average age of cavity trees was over 85 years, and most nest cavities were located in upland hardwood habitats.

Beginning in 1990, 10 male boreal owls were fitted with radio transmitters to document habitat use. Ninety-eight of 107 (91.6%) diurnal roost sites occurred in lowland conifer habitats, with black spruce *(Picea mariana)* identified as the roost tree on 94 (81.7%) of 115 occasions. Minimum Convex Polygon home range size averaged 425 ha prior to nest failure, and increased dramatically after a nesting attempt failed.

Conclusion: Boreal owls consistently occurred as a breeding resident in northeast Minnesota throughout the 6 years of this study. At the landscape level, boreal owls occurred in association with lowland spruce and upland hardwood habitats. Lowland spruce habitats appeared to be important for hunting, and nest cavities occurred in older aspen stands. Current management considerations that focus only on the nest stand likely underestimate the extent of habitats required by breeding boreal owls in northeast Minnesota.

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Population Dynamics of Paddlefish in the Lower Wisconsin River

Investigator: Bruce Vondracek
Student: Ann L. Runstrom, M. S.
Duration: September 1992 to November 1996
Funding Source: U.S. Fish and Wildlife Service, Region 3 Fisheries Wisconsin Department of Natural Resources
Project Location: Lower Wisconsin River, Prairie du Sac, Wisconsin

Minnesota Cooperative Fish and Wildlife Research Unit
U.S. Fish and Wildlife Service, LaCrosse
Fishery Resources Office, Winona, Minnesota

Paddlefish (*Polyodon spathula*) were previously listed as a Category 2 species on the Federal Endangered Species List. Category 2 describes taxa which may be at risk, but for which data on vulnerability and threat are not currently available. Data on the status of paddlefish in the upper Mississippi River basin are particularly lacking. Investigations into the dynamics of this species' populations are necessary to determine the level of endangerment.

A mark-recapture study of paddlefish in the lower Wisconsin River was conducted during 1993 and 1994. Study objectives were to (1) estimate population size, size-structure, age-structure, and mortality rates; and (2) determine the feasibility of transferring adult paddlefish from the study population to an upstream reach of river where immigration is blocked by a hydropower dam and the species has been extirpated.

Paddlefish were sampled in the tailwaters of the Prairie du Sac dam with drifting and deadset trammel nets. Length (body, fork, and total) and weight were recorded for each fish captured. Fish were tagged on the
mandible with a #16 monel band. Age of each fish was estimated indirectly using a regression model of age vs fork length generated with paddlefish sampled from pools 11-13 on the Mississippi River.

Mark-recapture data from 1993 and 1994 were applied to Chapman's modified Schnabel, Schumacher-Eschmeyer, modified Jolly-Seber, and adjusted Petersen models to estimate population size. Estimates of population size ranged from 540 to 1,714 individuals. Size- and age-structure data indicated recruitment between 1993 and 1994 was minimal. Estimates for annual mortality ranged from 29 to 33%. These results suggest the population could be declining at present.

Conclusion: Population estimates in 1993 and 1994 were not significantly different. Comparison of the age-class structure from 1993 to 1994 indicates that no recruitment took place between sampling periods. Instantaneous mortality rate appears high for an unharvested population. However, these fish congregate in an area used heavily by anglers and mortality may be higher as a result of boat-paddlefish collisions.

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Red-Shouldered Hawk Breeding Ecology and Habitat Use in Central Minnesota

Investigator: David E. Andersen
Students: B. Ann Belleman, M.S. and Mary Anne McLeod, M.S.
Duration: April 1994 to June 1996
Funding Source: Minnesota Department of Natural Resources U.S. Forest Service, Chippewa National Forest
Project Location: Camp Ripley National Guard Training Site, Minnesota
Pillsbury State Forest, Minnesota
Chippewa National Forest, Minnesota

Red-shouldered hawk (*Buteo lineatus*) populations have likely declined throughout the Northeast, Midwest, California, and eastern Canada over the past 50 years. Reduction in extent and changes in quality of habitat have been major factors contributing to this decline. In Minnesota, a recent Generic Environmental Impact Statement on Timber Harvesting and Management in Minnesota predicted that the red-shouldered hawk population would decline statewide under all projected timber harvesting scenarios during the next 50 years. This species has not been extensively studied in Minnesota and limited information exists on population status, density, breeding ecology or habitat selection.

In April 1994, we began studying red- shouldered hawks centered at Camp Ripley Army National Guard Training Site (CRANGTS) and the Chippewa National Forest (CNF) in central Minnesota. Our objectives were to: (1) estimate and describe breeding density and reproductive success, breeding chronology and food habits of breeding red-shoulders, (2) describe habitat characteristics and use of red-shoulder nest sites, (3) compare habitat use of breeding red-shoulders across a range of landscapes in central Minnesota, and, (4) evaluate methods for surveying red-shouldered hawks.

Over the 2-year period, 38 red-shoulder nesting attempts were located on or near the CRANGTS and 81% of nesting attempts fledged at least 1 young and in total produced at least 55 young. On the CNF, 20 nests were located, and of the 10 nests were egg-laying was documented, only 2 fledged young. Analysis of survey data suggests that playback of red-shouldered hawk calls illicit more and quicker responses than playback of great horned owl calls. Response rate was highest during incubation. Habitat analyses indicate that red-shoulders nest in older forests interspersed with small wetlands.

Conclusion: Red-shouldered hawks nest at high densities in north central Minnesota, and on CRANGTS had high nesting success. On the CNF, nesting success and productivity were poor, and may be related to food availability. In north central Minnesota, red-shoulders occur in older hardwood habitats and are not restricted to nesting in forested floodplains, as they seem to be in other portions of their breeding range. Evaluation of survey methodology suggests that call-broadcast from roads may be useful in monitoring population trends, and that using red-shouldered hawk calls during incubation would be most effective.

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Spawning Habitat and Summer Microhabitat Use of a Northern Population of Adult Smallmouth Bass

Investigator: Bruce Vondracek
Student: Paul Mavrakis, M.S.
Duration: June 1993 to June 1994
Funding Source: Electric Power Research Institute (EPRI)
Minnesota Power
Project Location: Cloquet River, Minnesota
Minnesota Cooperative Fish and Wildlife Research Unit

Little is known about spawning habitat and summer microhabitat use for adult smallmouth bass (*Micropterus dolomieu*) in the northern part of their range. This study, in a 1.5 km section of the Cloquet River, in northern Minnesota included 3 objectives: (1) Identify sites used for spawning and determine availability of suitable spawning habitat, (2) Determine the availability and use of suitable summer microhabitat, and (3) Test for a relation between adult smallmouth bass and crayfish habitat use.

Habitat availability was quantified by 20 transects (1021 point measurements) distributed throughout the study reach during low flow and high flow conditions. Nine spawning sites were located by snorkeling surveys when water temperature approached 15· C and were monitored throughout the spawning season to determine success of nests. None of the nests were successful, i.e., did not reach fry dispersal stage, during the study due to high water early in the spawning season. Physical characteristics were consistent at all nests: low mean water column velocity (<0.06m/s), intermediate depth (>0.4m), and close proximity to cover.

Adults selected the deepest water available, intermediate mean water column velocities, and course gravel to large boulder substrates. Crayfish were an important part of the adult smallmouth bass diet; 92% of the smallmouth bass that contained food, ingested at least one crayfish. Smallmouth bass used similar mean water column velocities and substrates as crayfish.

Conclusion: Spawning habitat and summer microhabitat for adult smallmouth bass appears to be limited in the Cloquet River. The study reach contained <10% suitable spawning habitat at low flow and 3% at high flow. Less than 7% of the study reach at low flow and 10% at high flow had suitable summer microhabitat.

Ongoing Research
January 1995 - December 1996

Contaminants

PCB Congeners in Marsh Birds in Green Bay Coastal Wetlands

Investigator: Deborah L. Swackhamer
Duration: August 1995 to July 1997
Funding Source: U.S. Fish and Wildlife Service, Green Bay Ecological Services Office
Project Location: Green Bay, Wisconsin; University of Minnesota, Minneapolis

Green Bay has been highly contaminated with PCBs, and is designated as an "Area of Concern" by the International Joint Commission of the Great Lakes. PCBs are persistent, toxic pollutants that bioaccumulate, and have been shown to cause detrimental effects in wildlife and fish-eating bird populations in Green Bay and other locations in the Great Lakes. There has been little work done on the effects of toxic pollutants on passerines or marsh birds. The yellow-headed blackbird (*Xanthocephalus xanthocephalus*) feeds almost exclusively on aquatic insects during its breeding stage, and thus it is during this stage that eggs and nestlings are exposed to PCBs and are potentially subjected to toxic effects.

In conjunction with an ongoing project on yellow-headed blackbirds, the objectives of this project are to determine PCB concentrations in adult and nestling blackbirds from 2 field sites in Green Bay, and to relate observed PCB concentrations with reproductive and population parameters.

PCB concentrations in yellow-headed blackbirds ranged from 20 ng/g to 380 ng/g wet weight, averaging 210 ng/g. Lipid-normalized concentrations ranged from 300 ng/g to 17 ug/g, with an average of 10.7 ug/g. Eggs had less variability in their concentrations, and averaged 390 ng/g wet weight and 10.3 ug/g lipid weight. Despite the variability in the PCB concentrations in the birds, there was no relationship of PCB concentration to the skewed sex ratios found in the exposed population.

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Human Activities, Management, and Conservation

Biodiversity Monitoring: Breeding Productivity, Habitat, and Winter Distribution of Nongame Birds

Investigators: David E. Andersen and Francesca J. Cuthbert
Students: James C. Manolis, M.S./Ph.D. and Ethan F. Perry, M.S.
Duration: September 1991 to May 1997
Funding Sources:U.S. Global Climate Change Research Program
U.S. Fish and Wildlife Service Cooperative Research Units Center
U.S. Fish and Wildlife Service, Region 3 Division of Migratory Birds and Refuge Biology
U.S. National Biological Service, Division of Cooperative Research
Project Location: Chippewa National Forest, Minnesota
Minnesota Cooperative Fish and Wildlife Research Unit

Recent declines in forest songbird populations have received considerable attention, and appear pronounced in some species in eastern North America. These declines have been attributed both to fragmentation/loss of breeding habitat and to deforestation of neotropical wintering habitat, but in many cases it is difficult to discern which factor is most important. Few long-term population studies have been conducted in extensive forest tracts, and even fewer have monitored breeding productivity along with analysis of vegetation. Breeding productivity information will be vital for developing sound management practices.

During May-July of 1992-1996, we monitored nesting success of forest birds in the Chippewa National Forest, Minnesota. We established six 40-50 ha permanent plots in a mature (ca. 80 years post-harvest) maple-basswood forest, and during the 5-year study period located and monitored

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1,423 nests of 46 species. Traditional nesting success estimates were 54% for all species combined, and 38% for open-cup nesting neotropical migrants. In 1993 and 1994, we investigated effects of clearcut edges on reproductive success using artificial and natural nests. In 1993, 61% of artificial nests placed 0-10 m from clearcut edge were depredated, compared to 38% of nests placed 200 m from edge ($P < 0.001$). In 1994, predation rates were higher at the edges (34%) than at distances 25-200 m from edge, (18-22% $P < 0.01$). Beyond 25 m there was no apparent edge effect. These results suggest that edge effects observed in highly fragmented landscapes may also occur in predominantly forested regions.

In addition to monitoring nesting success and evaluating effects of edge on reproduction, we established 72 permanent point count stations (12 on each plot) and conducted 3-4, 100 m fixed-radius counts at each station between 1 June and 15 July of 1992-1996. Vegetation and habitat variables were measured at all nest and point count locations. In 1995, we also began investigating the nesting distribution of least flycatchers (*Empidonax minimus)* on our permanent plots. Several alternative hypothesis related to clumped nesting were tested, including differences in habitat characteristics and potential food resources, predator deterrence, and the potential for extra-pair copulations. We mapped the distribution of territorial male flycatchers through the breeding season, and are evaluating the effect of location within the nesting aggregation on nesting success. Data analyses for this portion of the project are ongoing.

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The Effect of Human Disturbance on the Endangered Great Lakes Piping Plover

Investigator: Francesca J. Cuthbert
Students: Lauren Wemmer, Ph.D., Alice Doolittle, M.S., and Lisa Climo, M.S.
Duration: May 1994 to June 1997
Funding Source: U.S. Fish and Wildlife Service, East Lansing Field Office, Michigan
Project Location: Northern Michigan and Atlantic Gulf Coast

This study addresses several aspects of piping plover (*Charadrius melodus*) biology and management needed for recovery of the endangered Great Lakes population. Work was done on the breeding population in northern Michigan and also on wintering birds along the Atlantic Gulf Coast.

Winter ecology and distribution: Objectives were to locate plovers wintering along the Gulf Coast, determine daily patterns of habitat use, identify plovers from reading leg band combinations and evaluate habitat quality. Although several hundred piping plovers were located, only I was identifiable (banded) from the Great Lakes population. This bird was found on Marco Island, FL and is an individual that has nested at Grand Marais, MI. Based on observation of plovers in winter, analysis of winter habitats was conducted to determine if plovers select wintering sites containing certain configurations of landcover components. A Geographic Information System was used to calculate the areas of landcover types within one km of shorebird sites (both occupied and unoccupied by piping plovers) on the Gulf Coast of Florida. Results of statistical tests indicated a significant difference in three cover types between plover and non-plover sites. Percentage of coastal stand and open water were significantly higher around plover sites than non-plover sites; percentage of marsh was significantly lower around plover sites than non-plover sites. These results indicate that piping plovers are selecting high energy shorelines that are sparsely vegetated. This analysis will be expanded to include an examination of land use, land ownership and human population density to identify conservation concerns and provide additional management guidelines for wintering piping plovers.

Breeding population research: We continued to monitor the breeding population of piping plover in northern Michigan. The number of nesting pairs increased from 21 to 23 from 1995 to 1996. An effort to develop a population model is continuing using recent data. This model incorporates use of captive rearing to enhance the population. Work to identify important habitat features and to evaluate habitat availability in northern Michigan was continued in 1996. All active plover sites and important historical nesting sites in northern Michigan were photographed using aerial videography. Sites were ground truthed and data on human disturbance and prey availability were collected for integration into the evaluation of habitat requirements of plovers during the breeding season.

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Effects of Land Use, Sediment, and Temperature on the Distribution of Benthic Invertebrates and Fish in the Whitewater Watershed

Investigator: Bruce Vondracek
Students: Brian Nerbonne, M.S. and Carson Cox, M.S.
Duration: June 1996 to June 1998
Funding Source: Minnesota Pollution Control Agency
Project Location: Olmstead, Wabasha, and Winona Counties, Minnesota

Minnesota Cooperative Fish and Wildlife Research Unit

Conventional agricultural practices have been shown to have several negative effects on streams. Runoff containing fertilizers, pesticides, or herbicides can result in direct mortality of stream organisms. Conventional agricultural land use also deposits large amounts of sediment in streams, which impacts habitat for aquatic organisms. Best management practices (BMPs) such as vegetated buffer strips or no-till plowing have been purported to reduce sediment delivery rates. The goal of our study is to determine if BMPs are beneficial to instream organisms and stream quality.

The objectives of this study are to: 1) evaluate selected sites to determine effects of stream water temperature, sediment, and substrate particle composition on fish and invertebrate community structure, and 2) evaluate potential changes in substrate composition and the associated aquatic community along streams in parks, wildlife management areas, and where best management practices have been implemented.

In 1996, we sampled sites on the three main branches of the Whitewater Watershed. Agricultural sites were selected to include both conventional and BMPs. We also sampled several sites with natural vegetation to use as references for comparison. By design, we selected conventional and BMP sites along woody or grass buffers in clusters to characterize local effects and minimize larger scale effects. Fish and benthic invertebrates were sampled at each site to determine community composition. Physical habitat assessments were also conducted to examine both instream and riparian conditions.

Significant differences between land use and instream physical habitat were apparent. Conventional sites with woody buffers had larger angles of repose and more exposed soil than other sites. Conventional sites with woody buffers had significantly higher percentages of fine particles in the substrate than along grass-buffered sites or BMP wooded sites. This suggests that woody buffers may have higher sediment delivery rates than other types of land use.

Ongoing analysis will include calculating indices of biotic integrity for both fish and benthic invertebrates to determine whether instream biota responds to differences in instream and riparian habitat. Sampling in 1997 will incorporate methods used in summer 1996, but additional data will be collected in buffer strips.

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Impact of Management Intensive Grazing Practices on the Stream Biota and Stream Habitat of Five Southeastern Minnesota Farms

Investigator: Bruce Vondracek
Students: Julia Frost, M.S. and Laurie Sovell, M.S.
Duration: June 1994 to June 1998
Funding Source: Minnesota Institute for Sustainable Agriculture
Project Location: Dodge, Goodhue, Scott, and Winona Counties, Minnesota
Minnesota Cooperative Fish and Wildlife Research Unit

The National Research Council's 1989 report entitled "Alternative Agriculture" identified a number of environmental and economic problems associated with conventional U.S. agriculture including surface water and groundwater pollution, and soil erosion. Management Intensive Grazing (MIG) is a sustainable farming system increasingly employed by farmers in response to these problems, under which plots of grass are grazed by livestock rotated among numerous small paddocks.

From 1994 to 1996, aquatic biota and stream habitat were monitored as part of a team approach to evaluate the economic, social, and ecological impacts of MIG practices on farms in southeastern Minnesota. Water chemistry, physical habitat, benthic macroinvertebrate, and fish data were collected from five streams on MIG farms and paired conventional farms (continuously-grazed or row cropped) to compare water quality impacts of these farming systems. In addition, the influence of grass and woody riparian buffer zones on stream habitat and biota were evaluated.

Principal Components Analysis distinguished study sites by stream, suggesting the importance of evaluating the influence of farming practices within stream systems. Within stream systems, study sites were distinguished by farming practice for water chemistry, physical habitat, and benthic macroinvertebrate variables. Fecal coliform and turbidity were consistently higher at conventional sites. Physical habitat variables that distinguished sites include degree of shading, sediment levels, exposed streambank soil, and width to depth ratios. Sites with woody riparian buffers had higher levels of fine sediments and substrate embeddedness, more exposed streambank soil, and larger width to depth ratios. On one stream, levels of fine materials and embeddedness were greater at the conventionally-grazed farm than at MIG farms. Hilsenhoff's Family Biotic Index and % Dominance suggested better conditions along woody riparian stations. Fish abundance and diversity varied among all MIG sites and are likely related to inherent differences between streams sampled. Fish abundance levels and species diversity were similar between paired sites and MIG

sites. Based on the results of the monitoring study, research efforts for 1997 will be directed toward: 1) Determination of the mechanisms involved in specific cattle grazing disturbance events to streams, 2) Development of a water quality monitoring toolbox for use by farmers to continue on-farm assessment of management practices.

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Individual-Based Walleye Simulation Model

Investigators: Ira Adelman and Yosef Cohen
Student: Jingyin Li, Ph.D.
Duration: July 1996 - July 1997
Funding Source: Minnesota Department of Natural Resources
Project Location: Department of Fisheries and Wildlife, University of Minnesota

Walleye (*Stizostedion vitreum vitreum*) stocking has been a standard management practice in Minnesota for over half a century. Since the 1950's, more than 7.5 billion young and adult walleye have been stocked in numerous Minnesota waterbodies. This walleye stocking program comprises an important portion of the budget of the Minnesota Department of Natural Resources (MNDNR), Section of Fisheries. Although walleye stocking has been extensively practiced in North America, its effectiveness has not been investigated quantitatively on a broad scale.

In a previous study, we used data from MNDNR lake surveys and stocking records to examine the effects of walleye stocking on the abundance, size of fish, and year-class strength in walleye populations and to determine to what extent and under what conditions these effects occurred. We used 4,470 lake surveys from 1,924 lakes and 20,634 walleye stocking records from 1,716 lakes. These data provided a vast amount of information on the effects of stocking on fish populations, which was not available from site-specific studies reported in the literature. Based on our analysis of these data, we found that stocking increased the abundance of the stocked year class, with a larger increase in lakes without natural walleye reproduction than in lakes with natural walleye reproduction. However, stocking also had negative effects. These were a decrease in the strength of the year classes adjacent to the stocked year class in lakes with natural walleye reproduction and a decrease in the weight of fish in lakes with and without natural walleye reproduction. Walleye stocking is most likely to contribute to walleye population abundance in lakes where walleye reproduction is limited but food is not limiting. This study confirms what fisheries managers have long believed but had not been able to verify on a broad scale, i.e., walleye should not be stocked in lakes where natural reproduction occurs.

To further explore the effects of walleye stocking, we developed an individual-based simulation model for walleye populations based on data from a variety of literature on walleye populations. The model is window and menu based, and has a user friendly interface. The model has the capacity to incorporate information about system carrying capacity, stocking strategy, and fishing pressure, and predicts how stocking and other management strategies will affect the fish population. The current model replicates the empirical findings of the effect of stocking on the abundance and body size of fish in the stocked and adjacent year classes, and indicates that density-dependent competition is one of the important mechanisms in determining these effects. As a useful decision supporting tool, this model can also be used to investigate the effects of other management strategies, such as various fishing regulations, on fish population dynamics.

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Status Assessment for the Great Lakes Population of Common Terns

Investigator: Francesca J. Cuthbert
Student: Kris Timmerman, Ph.D.
Duration: September 1995 to December 1996
Funding Source: U.S. Fish and Wildlife Service
Project Location: University of Minnesota, St. Paul

Common tern (*Sterna hirundo*) population trends for the last two decades (1976-1995) were reviewed for one Canadian province (Ontario) and nine U.S. states to determine status, trends, and general threats to the Great Lakes population of this species. According to the most recent estimates for the Great Lakes, there were approximately 10,000 pairs of common terns nesting in this region during 1989-1990. Historical data do not exist that allow an estimate of the number of common terns in the Great Lakes prior to settlement and during the period of more intensive development during the 1900's. Significant numbers (>1,000 pairs) occur only in Michigan, New York, and Ontario. Minnesota and Wisconsin have typically had smaller numbers over the past several decades. Current estimates are 500-600 pairs for each state. Vermont has maintained approximately 50-150 pairs during the past decade. Four states have 0 to fewer than 50 pairs. Because no consecutive comprehensive international census efforts have been conducted, it is difficult to interpret trends from existing census data. The general consensus is that some populations have declined significantly (e.g., Ohio) and others have increased (e.g., Vermont).

Based on a comparison of data available for Canadian and U.S. waters in the 1970's and 1989-1990, H. Blokpoel and W. Scharf reported a signficant increase in breeding pairs of common terns. However, H. Blokpoel and Tessier reported a 26% decrease in Canada between the 1970's and 1990.

Common terns are affected by a diversity of threats in the Great Lakes region. These include: habitat deterioration and loss, predation, competition for nesting habitat with Ring-billed Gulls (*Larus delawarensis)*, human disturbance and contaminants. Considering population size, number of jurisdictional units and number and remoteness of colony sites, the knowledge of common tern biology, population threats and status at many colonies is extensive. In response to threats, many methods to enhance colony productivity and protection have been developed. Most efforts have focused on: habitat management (including habitat restoration, enhancement or creation), predator control, reduction of competition for nest sites, and prevention of human disturbance. The most critical missing conservation component for the population is a region-wide monitoring and management plan that allows tracking population trends through time.

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Trophic ecology of young-of-the-year Walleye in Minnesota rearing ponds

Investigator: George R. Spangler
Student: Alan McClure, Ph.D.
Duration: June 1991 - June 1998
Funding Source: Minnesota Department of Natural Resources
Project Location: University of Minnesota, St. Paul

Investigation into the factors leading to disparate fingerling production of walleyes (*Stizostedion vitreum*) in winterkill rearing ponds has revealed that differences exist between ponds in the nutrient pathways leading to fish production. Stable isotope analyses to ascertain the trophic pathways leading to walleye production in several rearing ponds have been made for 40 samples from 1992. Of the 40 samples, twenty-two are samples from the Gunclub Pond, sixteen from the Camp Galilee Pond, and two from La Lake. Samples from Gunclub Pond and Camp Galilee Pond include all trophic levels, including primary sources, consumers, and top predators. The relationships between isotope ratios observed in different trophic categories generally conforms to expectations. Consumers have isotope ratios about 3 parts per thousand (3_) heavier for nitrogen and 1 - 2_ heavier for carbon than likely prey or sources of primary production. The isotope ratios of the primary producers that were sampled can be explained well by processes that are known to influence the isotopic composition of source pools and fractionation.

A micro-biochronology of daily otolith growth increments will be coupled with the nutritional pathway analyses to identify significant events in the summer temporal history of rearing-pond fish. Initial attempts to develop the biochronology have failed to produce unambiguous otolith patterns. This is due to allometric growth in the otoliths which must be accounted for in the measurements. Thus far, we have shown that it is necessary to use information from many transects to estimate otolith growth increments. Our procedure is to capture pixel data along five transects within a small part of the growth record at the center of each otolith. The basic idea is to divide each growth increment into a part due to location on the otolith (angle and radius), and a part due to age, past growth, or environment. This allows otolith shape to change as the fish grows. The angle between a given transect and individual growth rings is used to predict this effect at all distances along all the transects. This results in a factor that can be used to expand or contract the spatial scales of each transect so that distance along the transect corresponds to the same time interval on all the transects. When composite descriptions of the temporal history of fish growth within the ponds have been constructed, we will attempt to correlate the nutritional histories with the time series to identify key periods in the early growth of the fish.

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Applied Ecology

Age and Growth of Lake Herring in Lake Superior

Investigators: George R. Spangler and Donald L. Pereira
Student: Stephanie West Todhunter, M.S.
Duration: September 1993 through present
Funding Source: Minnesota Department of Natural Resources
Project Location: Lake Superior, Department of Fisheries and Wildlife

The shallow-water cisco, (*Coregonus artedii*), also known as the "lake herring" has been rebounding in abundance in Lake Superior since 1980, nearly three decades after the collapse of the lake trout (*Salvelinus namaycush*) community. Lake herring in Lake Superior suffered drastic declines in the 1950s and 60s and remained at low abundance through the 70s and early 80s. However, there have been several large year classes recently and it is generally believed that the

lake herring population is recovering lakewide. A comprehensive record of relative growth for this period may lead to a better understanding of the complex dynamics involved in lake herring growth and abundance. Comparisons of growth histories between different geographic regions of the lake should help us to understand whether regional differences between stocks should be taken into account in the lakewide management of this species. To further understand lake herring growth dynamics, we are developing separate biochronologies for four different sites on Lake Superior. The chronologies span a period extending back from the present until the early 1960s and are based on scale sample collections on loan from the Wisconsin DNR, Minnesota DNR and the Ontario Ministry of Natural Resources. Once the chronologies have been established, they will be compared to site specific temperature and abundance time series. Lake herring growth is thought to be density dependent, and thus, should reflect differences in their own densities, as well as the abundance of competing species. If cisco growth is sensitive to annual variations in water temperature, we expect to find some degree of correlation between temperature time series and the lake herring biochronologies.

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Assessing Ecological Structure, Function, And Dynamics Of Undisturbed And Restored Northern Prairie Wetlands

Investigator: John R. Tester
Student: Paul M. Mayer, Ph.D.
Duration: September 1992 - to present
Funding Source: U.S. Bureau of Reclamation
Project Location: Waubay National Wildlife Refuge
University of Minnesota, St. Paul

The inferred goal of restoration is to reestablish ecological structure and function including characteristics such as species diversity, nutrient cycling, decomposition rates, food web structure, and productivity. However, previous studies have revealed that recovery is incomplete or unattainable for at least some of these characteristics. The purpose of our study was to determine if restoration mitigates prairie wetland losses by evaluating whether or not, over time, restored wetlands recover to a state ecologically similar to reference wetlands. We felt that this assessment may be best accomplished by measuring several indicators of structure and function chosen on the basis of current ecological theory. One prediction, for example, is that species diversity will be low in a recovering ecosystem while productivity and community respiration remain high. Therefore, in 1993-1995 we compared indicators in 10 restored and 10 reference prairie wetlands in South Dakota. Indicators included biomass production and respiration, chemical and nutrient levels, diatom species diversity, and decomposition indices. An additional transplant experiment was necessary to interpret the role of dispersal in recovery.

Preliminary data indicate that chemical and nutrient values such as pH and conductivity were highly variable within restored and reference groups but, overall were slightly lower in restored wetlands. Decomposition rates also were highly variable and were not influenced by drainage history. However, biological oxygen demand, one of 3 measures of production and respiration in this study, was higher in restored wetlands. These data support predictions by other researchers regarding the response of ecosystems to disturbance and their subsequent recovery.

Preliminary analysis of diatom communities indicates that a characteristic diatom flora may be identified in reference wetlands, a factor critical in developing useful ecological indicators. Furthermore, diatom species compostition in restored wetlands was dissimilar, indicating that random pioneering events may influence recovery trajectories of restored wetlands.

The diatom transplant experiment also supported the use of diatoms as indicators of recovery. Based on color, texture, and transparency of algae growing on the artificial substrates employed in the experiments, diatom communities apparently differed in reference and restored wetlands indicating that restored wetlands, and perhaps even individual wetlands, may harbor characteristic flora. Furthermore, diatom communities on the transplanted substrates appeared to shift to assemblages like those existing in the wetlands to which the substrates were transferred indicating that environmental conditions (and perhaps competition) and not dispersal events dictate community composition.

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Assessing Wolf Population Structure

Investigators: L. David Mech and David E. Andersen
Student: Thomas J. Meier, M.S.
Duration: January 1994 to December 1996
Funding Source: U.S. Fish and Wildlife Service, Patuxent Wildlife Research Center
U.S. National Biological Service, Alaska Science Center
Project Location: Denali National Park and Preserve, Alaska

Department of Fisheries and Wildlife, University of Minnesota
Department of Biology, University of California at Los Angeles

New techniques of nuclear DNA analysis, using highly variable microsatellite loci, make it possible to determine patterns of relatedness in local populations of animals. When combined with field data on the behavior of these animals, a detailed picture of local population structure may be obtained.

During an eight-year study of a wolf (*Canis lupus*) population in and around Denali National Park and Preserve, Alaska, 150 wolves from 41 packs were captured and radio-collared. Information has been gathered on movements, survival, and dispersal of individual wolves, as well as on patterns of territoriality and interchange of wolves between packs, and the formation and survival of wolf packs. Demographic histories of 34 Denali wolf packs have been compiled for a final project report to the National Park Service and an upcoming book on the park's wolf population.

Genetic samples from 130 Denali wolves have been analyzed for allele patterns at 20 microsatellite loci. Relatedness values have been calculated for each pairwise comparison of sampled wolves. A number of simulations have been performed to test hypotheses about patterns of genetic relatedness in the wolf population. As expected, genetic relatedness is higher for comparisons within packs than for those between packs. Genetic relatedness is also significantly higher between immediately neighboring packs than between more distant packs.

Field observations have shown that the mosaic of wolf packs in Denali is dynamic, with new packs being formed by dispersers, with some older packs dying out, and with interchange of wolves between existing packs. Also complicating the structure of the population are the founding of new packs by more than two wolves, the presence of multiple breeding females within some packs, and the possible exchange of genetic material by breeding between adjacent packs. Genetic comparison of known breeding pairs of wolves based on microsatellite DNA analysis reveals no evidence of intense inbreeding/incest among sampled pairs, suggesting that pack dynamics allow significant genetic mixing within the population.

By comparing specific alleles at each locus between potential parent/offspring pairs, and looking at complementarity alleles between potential mother/father/ offspring sets, assignments of parenthood can be made based on the genetic data. These will be compared with field data and overall patterns of genetic relatedness to get the most accurate picture to date of how the various packs in a wolf population relate to one another.

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Eastern Praire Population Canada Goose Ecology

Investigators: David E. Andersen, Donald H. Rusch (WI Cooperative Wildlife Research Unit)
Mississippi Flyway EPP Technical Committee **Duration:** Ongoing
Funding Sources: U.S. Fish and Wildlife Service
Mississippi Flyway Council (EPP Technical Committee)
Manitoba Department of Natural Resources
Minnesota Department of Natural Resources
Iowa Department of Natural Resources
Missouri Department of Conservation
Arkansas Game and Fish Commission
Canadian Wildlife Service
Project Location: Cape Churchill, Manitoba
Minnesota Cooperative Fish and Wildlife Research Unit
Wisconsin Cooperative Wildlife Research Unit

Eastern Prairie Population (EPP) Canada geese (*Branta canadensis*) breed in the Hudson Bay Lowlands in northeastern Manitoba. This group of birds migrates through southern Manitoba and western Minnesota, and historically wintered in Missouri and Arkansas. Because they nest in the sub-arctic, EPP geese exhibit wide variation in productivity and recruitment, and information regarding breeding ecology and population status is required to effectively manage harvest.

Research on breeding ecology of this population of arctic-nesting geese has continued since the 1960's, and information from these studies has been used to develop management and harvest strategies. Long-term monitoring of breeding density, nesting success, gosling production, and other breeding population parameters has resulted in information useful in modeling this populations. These on-the-ground data collection activities are ongoing annually.

These monitoring efforts occur in close proximity to the La Perouse Bay snow goose (*Anser caerulescens caerulescens)* colony, and over the past 20 years, snow goose use of the study area has increased dramatically. During the same period, breeding densities of Canada geese have dropped dramatically, and snow geese now dominate numerically in historic Canada goose brood-rearing areas. Currently, a research project designed to better understand the relationship

between Canada and snow geese on the breeding grounds is under development.

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Foraging Behavior of California Sea Lions at San Miguel Island, California

Investigator: Donald B. Siniff
Student: Sharon Melin, Ph.D.
Duration: September 1996 March 1997
Funding Source: National Marine Mammal Laboratory
Seattle, Washington
Project Location: University of Minnesota, St. Paul
San Miguel Island, CA

The project was initiated in September 1996 and focuses on describing the annual patterns of foraging behavior, movement and distribution of California sea lions (*Zalophus californianus*) at San Miguel Island, California. The purpose of this study is to better understand the ecological role of California sea lions in the California Current ecosystem.

The foraging behavior will be described through analysis of satellite telemetry and diving data from 20 adult female California sea lions collected over a three year period, 1994-1996. Foraging locations and summary statistics of diving behavior will be used to describe the foraging range of California sea lion females. The movement and distribution of animals along the California coast throughout the year will be determined using sightings of 3,500 animals branded and tagged as pups (representing 9 cohorts). The distribution of sightings by location, age and sex will be used to describe movement and distribution patterns of individuals by age and sex.

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Insects and Anurans as Indicators of Wetland Condition in the Prairie Pothole Region of North Dakota

Investigators: David E. Andersen, Bruce Vondracek, Ralph Holzenthall, Francesca Cuthbert
Duration: January 1995 to December 1997
Students: David J. Anderson, M.S. and Dorothy G. Bowers, M.S.
Funding Source: U.S. National Biological Service, Northern Prairie Science Center
Project Location : Northern Prairie Science Center, North Dakota,
Minnesota Cooperative Fish and Wildlife Research Unit

Wetland complexes in the Prairie Pothole Region (PPR) of North Dakota have been severely impacted by agri-cultural practices. Efforts to evaluate the health of these wetland ecosystems may be hampered by their dynamic nature. A long-term, landscape-based approach may be needed for conservation efforts to succeed. To address this need, potential indicators of wetland condition are being evaluated across three ecoregions within the PPR. Two groups, insects and anurans (frogs and toads), are being assessed for their potential as biological indicators of wetland and landscape condition.

Insects have been useful in monitoringother aquatic habitats, and hold promise for wetland systems. For insects our objectives are to 1) develop an effective sampling strategy, 2) describe insect taxa richness and abundance in sampled areas, and 3) evaluate relationships between regional wetland condition and insect taxa richness and abundance. In spring and summer of 1995 and 1996, 21 sites were visited on three occasions each year. Insects were collected by placing light traps near six seasonal and semi-permanent wetlands within each site. Preliminary analysis indicates abundance and taxonomic richness were highest in the Red River Valley, intermediate in the Drift Plain, and lowest in the Missouri Coteau ecoregion. Sample composition also differed by ecoregion, with the Red River Valley dominated by Coleoptera, Missouri Coteau dominated by Diptera, whereas the Drift Plain had intermediate levels of both groups. These relationships may be important to consider for large-scale monitoring. Further analyses will examine possible relationships between land use and insect taxa richness and abundance.

During 1995 and 1996, we assessed theimpacts of land-use patterns on anuran populations. We conducted nocturnal calling and driving surveys three times each year at 21 sites in the PPR. Additionally, at several sites we used automated recorders to record calling anurans during four 10-minute intervals throughout the night. We detected nine species of anurans and preliminary data suggest that some anuran species are associated with land-use patterns. Relative abundances of the American toad (*Bufo americanus*) and the gray treefrog (*Hyla versicolor/ chrysoscelis)* appeared greater in grasslands than agricultural lands, whereas relative abundance of the Great Plains toad (*B. cognatus*) was greater in agricultural landscapes than in grasslands. Distributions of the gray treefrog and the Plains spadefoot toad (*Spea bambifrons*) were more extensive than previously documented, whereas distributions of the Canadian toad (*B. hemiophrys*) and the

northern leopard frog (*Rana pipiens*) were less extensive. Relative abundance and distribution of some anurans species may be related to land-use patterns at multiple geographic scales.

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Paleolimnology: Reconstructing the Chronology of Fish Residency in Alpine and Subalpine Lakes of Glacier National Park, Montana

Investigators: Dirk Verschuren and Herbert E. Wright
Duration: January 1996 to August 1997
Funding Source: U. S. National Biological Service
Project Location: Glacier National Park
University of Minnesota, Minneapolis

The westslope cutthroat trout (*Oncorhynchus clarki lewisi)* has declined throughout much of its original range in Montana, Idaho, British Columbia, and Alberta due to destructive land-use practices and ecological disturbance caused by the introduction of non-native fishes. Surviving genetically pure populations in headwater lakes of Glacier National Park could play an important role in the managed recovery of cutthroat trout fisheries throughout the region. However, several of these populations occur in lakes above barrier falls or without direct stream access, so that uncertainty exists whether the trout could have naturally invaded these lakes. This project uses paleolimnological techniques to determine whether native trout fisheries in selected lakes are indeed indigenous or became established through undocumented introductions before the establishment of Glacier National Park in 1910. Evidence is derived from examination of the vertical distribution of zooplankton remains preserved in the lakes' profundal sediments. This approach is based on the premise that introduction of planktivorous trout to a previously fishless lake would have caused substantial changes in the local zooplankton community that can be detected in the sediment record.

In a pilot study, we tested the validity of using fossil ephippia (diapause eggs) of the fish-sensitive cladoceran *Daphnia* as an indicator for historical *Daphnia* population densities, and by extension for the presence of a trout fishery. This was done by demonstrating correlation between current *Daphnia* population density and the density of ephippia in surficial sediments of eight headwater lakes with and without fish. In the current project we aim to further validate the technique by analyzing the vertical distributions of zooplankton remains in sediments of lakes with contrasting but documented fishery histories.

In July and August of 1996, sediment cores were collected in six headwater lakes of Glacier National Park. Three of these are warmwater subalpine lakes (mid-summer SWT > 16·C) that are potentially inhabited by two groups of fish-sensitive zooplankton, the cladoceran *Daphnia* and the larvae of phantom midges, *Chaoborus*. The three other lakes are coldwater alpine lakes (mid-summer SWT < 14·C) where *Chaoborus* cannot occur but *Daphnia* does. The group of coldwater lakes includes Arrow Lake, with an indigenous trout fishery; and Poia and Camas Lakes, originally fishless lakes to which cutthroat trout had been introduced. The group of warmwater lakes includes John's Lake, which is too shallow for fish to overwinter; Babbe Lake, where fish do not occur because of its isolated setting; and Swiftcurrent Ridge Lake, an isolated lake to which cutthroat trout and other fish were introduced during the 1920s through 1940s. Preliminary data on fossil zooplankton assemblages in the sediment record of Swiftcurrent Ridge Lake confirm the expected drastic reduction of *Daphnia* population density around the time of trout introduction.

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Relating Behavior and Microhabitat Use to Growth in Stream Resident Trout

Investigator: Bruce Vondracek
Student: Gerold C. Grant. Ph.D.
Duration: September 1992 to June 1997
Funding Sources: Cargill Fellowship
Kalamazoo Chapter of Trout Unlimited
Sigma Xi
Special Projects Foundation of the Big Game Club
Project Location: Valley Creek, Washington County, Minnesota
Minnesota Cooperative Fish and Wildlife Research Unit

It has been suggested that stream trout chose microhabitats that optimize their net energy intake and therefore maximize growth. To maximize energy intake, stream trout likely occupy microhabitats with low water velocity to minimize swimming costs, but close to high velocity water, which supplies more drifting prey. Past studies on microhabitat use have relied upon single observations of fish position to quantify microhabitat use. No studies have successfully related microhabitat use and behavior to growth in natural environments. We are approaching this question using new techniques to quantify microhabitat use, behavior and growth of trout in Valley Creek. Our techniques include using submersible video cameras and a time lapse recorder

to remotely observe trout behavior and microhabitat use. In addition to traditional growth measurements, we are measuring RNA/DNA ratios in muscle tissue biopsies, which we have shown to reflect recent growth rates in adult brown trout. This was the first study in which RNA/DNA ratios were measured from a tissue sample from adult fish without sacrificing the animal.

In 1995 and 1996, we quantified growth rates of sympatric brook (*Salvelinus fontinalis*), brown (*Salmo trutta*) and rainbow (*Oncorhynchus mykiss*) trout in Valley Creek throughout the year. In summer of both years, we collected data on microhabitat use and behavior using time lapse video recordings, and quantified habitat availability. In summer 1996, we quantified availability of drifting prey in Valley Creek, as well as diet composition in the three species of trout, to determine how much these fishes rely on drifting prey items. Hypotheses about trout microhabitat use will be tested by comparing microhabitat use and growth rates to those predicted by models for drift-feeding salmonids.

In addition to the above research, an investigation of reproductive behavior of brook and brown trout was performed during 1995. Spawning trout were monitored over 24-hour periods using time lapse video recordings and submersible video cameras illuminated by infrared lights. Time budgets were estimated from observations of 13 redds (spawning nests) of brook and brown trout. We quantified the percent time redds were occupied by male and female trout of each species, and the percent time females spent excavating the nest, spawning and covering the eggs as well as the number of males present and percent time males spent in agonistic behavior. Further analysis of these recordings will be performed to quantify intraspecific spawning activity in sympatric brook and brown trout.

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Winter Ecology of Ferruginous Hawks in Colorado

Investigator: David E. Andersen
Student: David J. Plumpton, Ph.D.
Duration: July 1992 to June 1997
Funding Sources: U.S. Fish and Wildlife Service
U.S. Army
Rocky Mountain Arsenal National Wildlife Refuge
Project Location: Rocky Mountain Arsenal National Wildlife Refuge, Colorado
Minnesota Cooperative Fish and Wildlife Research Unit

The ferruginous hawk (*Buteo regalis*), North America's largest buteo, was once found in most states west of the Mississippi River and the prairie provinces of Canada. Populations have been declining in recent decades, primarily due to loss of habitats and attendant declines in prey populations. Ferruginous hawks currently occupy one of the smallest breeding range of any North American buteonine hawk. First-year mortality is approximately 66%, yet little information exists regarding habits and habitat use of ferruginous hawks outside the breeding season.

Although Colorado supports a nesting population of ferruginous hawks, it contributes far more to the global population of ferruginous hawks in terms of the number that overwinter there. There is currently much concern for the ferruginous hawk, as large-scale conversion of winter habitat by human development proceeds. The ferruginous hawk was previously listed as a Category 2 species under the Federal Endangered Species Act.

In 1992, we initiated an investigation of the winter ecology of ferruginous hawks in eastern Colorado. Thirty-eight ferruginous hawks were equipped with radio transmitters and monitored for 1,325 hours during 148 complete winter days. Home range size and activity levels were not different between hawks in highly fragmented (urban and suburban) habitats and hawks using the Rocky Mountain Arsenal (single contiguous block of habitat). In the suburban site, ferruginous hawks appeared to modify their behavior to exploit small, isolated colonies of black-tailed prairie dogs *(Cynomys ludovicianus)*, underscoring the importance of this prey resource during winter months. Prairie dog densities declined dramatically between the winters of 1993-94 and 1994-95 on the Rocky Mountain Arsenal, and ferruginous hawks numbers exhibited a concurrent drop on the arsenal, but not the suburban site.

Ferruginous hawks appear to be able to modify their behavior to exploit a variety of landscapes during the winter. As long as suitable prey are available, ferruginous hawks appear capable of exploiting urban and suburban landscapes. Unlike many other raptors that benefit from changes in urban and suburban landscapes, however, ferruginous hawks are dependent upon black-tailed prairie dogs during winter in eastern Colorado, and many human activities negatively impact this prey species.

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Vondracek, B., B.D. Giese, and **M.G. Henry.** 1996. Energy density of three fishes from Lake Superior. *Journal of Great Lakes Research* 22:757-764.

In Press

Kontio, B.D., D.L. Garshelis, E.C. Birney, and **D.E. Andersen.** Resilience of a Minnesota black bear population to heavy hunting: self-sustaining population or population sink? *International Conference on Bear Research and Management* 10.

Smith, D., T. Meier, E. Geffen, L.D. Mech, J.W. Burch, L.G. Adams, and **R.K Wayne.** Is incest common in wolf packs? *Behavioral Ecology*.

Verschuren, D., and **L.F. Marnell.** Fossil zooplankton and the historical status of westslope cutthroat trout in a headwater lake of Glacier National Park, Montana. *Transactions of the American Fisheries Society*.

Technical and Semi-technical

1995

Lane, W.H. and D.E. Andersen. 1995. Habitat requirements for boreal owls in northeastern Minnesota. Final report to the U.S. Forest Service, North Central Forest Experiment Station. 52pp.

Li, J., Y. Cohen, and **I.R. Adelman.** 1995. The effectiveness of walleye stocking in Minnesota. Completion report to the Minnesota Department of Natural Resources. Contract No. MNDNR/M81110-27.

Mavrakis , P.H. 1995. Spawning and summer microhabitat use in a northern population of smallmouth bass. Final Report: Electric Power Research Institute.

Mech, L.D., L.G. Adams, T.J. Meier, and **J.W. Burch.** 1995. Wolf management recommendations, Denali National Park and Preserve. Sampling shad in southern impoundments. Research Manual, Reservoir Committee of the American Fisheries Society, Federal Aid in Fish Restoration under Cooperative Agreement No. 14-16-0002-91-216.

1996

Belleman, B.A. and D.E. Andersen. 1996. Red-shouldered hawk *(Buteo lineatus)* population status and habitat use in the Camp Ripley Training Site. Final Report and Management Recommendations to the Minnesota Department of Natural Resources. 32pp.

McLeod, M.A. and D.E. Andersen. 1996. Status and habitat selection of red-shouldered hawks in the Chippewa National Forest. Final Report to the U.S. Forest Service, Chippewa National Forest. 14pp.

Mech, L.D., T.J. Meier, J.W. Burch, and **L.G. Adams.** 1996. Demography and distribution of wolves, Denali National Park and Preserve, Alaska. Draft final report to the National Park Service.

Pothoven, S.A., B. Vondracek and **D.L. Pereira.** 1996. An evaluation of the indirect effects of flouridone on the fish communities of two Minnesota lakes. Final Report, Minnesota Department of Natural Resources, St. Paul, Minnesota.

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Completed Theses and Dissertations

Completed Theses and Dissertations of Minnesota Coop Unit Students

1995

Mavrakis, Paul H., 1995. Spawning and summer microhabitat use in a northern population of smallmouth bass. M.S. Thesis, University of Minnesota, St. Paul. 119pp.

ABSTRACT

Availability of spawning habitat and summer microhabitat for adult smallmouth bass *Micropterus dolomieu* appears to be limited in a 1.5 km section of the Cloquet River, a controlled river located in northern Minnesota, near the northern edge of the smallmouth bass range. This study included four objectives: (1) Identify sites used for spawning and determine availability of suitable spawning habitat, (2) Estimate the number of males capable of spawning, (3) Determine the availability and use of suitable summer microhabitat, and (4) Establish a relation between adult smallmouth bass and crayfish habitat use. Habitat availability was quantified by 20 transects (1021 point measurements) distributed throughout the study reach during low flow and high flow conditions. A total of nine nests were located and monitored during the 1993 and 1994 spawning seasons. All nests failed, presumably due to flooding. Physical characteristics at the nests included low mean water column velocity (<0.06m/s), intermediate depth (>0.4m), and close proximity to cover. The study reach contained <10% suitable spawning habitat at low flow and 3% at high flow. Ninety-one occupied microhabitat sites were surveyed during 1993 and 1994. At each microhabitat site, a total of eight variables were recorded. A combination of depth and mean water column velocity appeared to be important in the selection of summer microhabitat by adult smallmouth bass. Less than 7% of the study reach at low flow and 10% at high flow had suitable summer microhabitat. Crayfish were determined to be an important part of the adult smallmouth bass diet, 92% of the smallmouth bass that contained food, ingested at least one crayfish. Smallmouth bass used similar mean water column velocities and substrates as crayfish.

McCarthy, William F. 1995. Direct and indirect effects of esfenvalerate on wetland biota. M.S. Thesis, University of Minnesota, St. Paul. 81pp.

ABSTRACT

We investigated the direct and indirect effects of a single aerial application of ASANA® XL, the commercial formulation of esfenvalerate, applied at the maximum rate recommended for grasshopper control (34 g active ingredient/ha) to natural wetland basins located in western Minnesota. Indirect effects were evaluated using free-ranging imprinted mallard (*Anas platyrhynchos*) duckling broods. We compared differences of short-term weight change, and resting, feeding and searching behaviors between broods allowed to forage on reference versus treated wetlands. We observed the greatest treatment effects in broods reared exclusively on treated wetlands. While short-term weight change was variable, birds on treated sites gained consistently less from 5 to 10 days post-treatment. Treatment broods were observed engaging in significantly less feeding ($p < 0.04$) and significantly greater searching ($p < 0.09$) activity than broods on reference wetlands. The probability of daily survival was significantly lower for birds reared on treated sites ($p < 0.1$) from 10 through 15 days post-treatment. Activity traps and emergence traps were used to assess the direct effects of ASANA® XL to endemic macroinvertebrates. We report significant reductions in both abundance and taxonomic richness of nektonic macroinvertebrates and emerging insects following treatment. We conclude that changes in the macroinvertebrate communities that result from direct toxicity of ASANA® XL, can lead to changes in behavior, and reduce both weight gain and survival in waterfowl broods via a food-chain mitigated route.

1996

Herbrandson, Carl. 1996. Toxicological effects of suspended solids and carbofuran on *Daphnia magna*. Ph.D. Thesis, University of Minnesota, St. Paul. 143pp.

ABSTRACT

The introduction of suspended solids into an aquatic system or toxicity test complicates analysis due to the interactions between suspended solids and organic chemicals. Suspended solids can sorb organic chemicals, decreasing their bioavailability. At the same time the physical effect of the solids may change the sensitivity of organisms to chemicals by affecting toxicodynamic interactions. This study presents an apparatus and a methodology capable of isolating toxicodynamic effects from changes in bioavailability or uptake toxicokinetics.

A suspended solid testing apparatus (SSTA) was designed and developed as a laboratory model of a contaminated natural environment to facilitate the toxicodynamic and toxicokinetic studies of chemical stressors in an aquatic system containing suspended solids. The testing apparatus consists of a tank containing multiple chambers designed to expose test organisms to equivalent concentrations of freely-dissolved chemicals, while allowing for varying exposures to suspended particles among chambers. Operating characteristics of the SSTA were determined for use with a non-ionic organic pesticide, carbofuran.

Studies were conducted to evaluate the toxicodynamic effects of simultaneous exposure of an aquatic invertebrate to suspended solids and carbofuran. Acute toxicity data were acquired following 48 hour exposure of *Daphnia magna* (72 - 96 hours-old) to a range of carbofuran concentrations and eight concentrations of suspended solids. These experiments demonstrated a synergism between the combined physical and chemical stressors.

Further experiments were conducted with different mixtures of suspended solids and varying food availability to evaluate possible mechanisms of toxicodynamic interaction. These experiments clearly demonstrated that the sensitivity of *D. magna* exposed to carbofuran alone or a combined exposure to suspended solids and carbofuran can be modulated by adjusting food availability. Increasing food availability decreased *D. magna* sensitivity, as did exposure to suspended solids with increasing fractions of organic carbon (or decreasing specific gravity). The study demonstrated the utility and sensitivity of the SSTA in a bioassay discriminating between toxicokinetic and toxicodynamic effects of simultaneous exposure to a chemical and suspended solids.

Manolis, James C. 1996. Minimizing subjectivity in nesting success estimation: a prototype decision support system and modeling results. M.S. Thesis, University of Minnesota, St. Paul. 64pp.

ABSTRACT

Though often unacknowledged, subjectivity involved in collecting and analyzing nesting success data may introduce bias to and decrease comparability of nesting success estimates. We examine the problem of subjectivity in nesting success studies, using a sample of Least Flycatcher (LEFL) (*Empidonax minimus*) and Ovenbird (OVEN) (*Seiurus aurocapillus)* nests from north-central Minnesota. Classifying nest fate can involve subjective judgment: 40% of our OVEN nests and 30% of our LEFL nests lacked clear empirical cues indicating fate. Nest fate uncertainty is not a problem for Mayfield estimates (Mayfield 1961), but it is problematic for studies comparing characteristics at failed and successful nests ("nest fate studies"). This distinction and how to handle uncertain fates in analyses is not clear in existing literature. As a result, some researchers assume uncertain fates should be excluded from Mayfield calculations. Excluding nests with uncertain fates biased the Mayfield estimate downward by 26% (from 0.45 to 0.33) for our OVEN sample, and 22% (from 0.45 to 0.35) for our LEFL sample. While not a problem for Mayfield estimates if included in analyses, uncertain nest fates are problematic for nest fate studies. Here, uncertain fates cannot be used, and researchers may vary subjectively in how they classify nests as failed, successful, or uncertain. "Rules of thumb" are sometimes used to reduce subjectivity, but these rules are not applied consistently across studies and are not precisely reported in the literature. We formally describe several decision rules, model nesting success outcomes using variations of these rules, and suggest which rule is most appropriate. Finally, we describe a prototype decision-support system that we developed in EXCEL, to consistently estimate nest fates and parameters needed to derive Mayfield estimates of nesting success.

McLeod, Mary Anne. 1996. Red-shouldered hawk habitat use and response to call-playback surveys in north-central Minnesota. M.S. Thesis, University of Minnesota, St. Paul. 78pp.

ABSTRACT

Call-playback surveys were conducted on repeated road transects and transects at active red-shouldered hawk (*Buteo lineatus*) nests in north-central Minnesota to determine the effects of type of call (conspecific or great-horned owl [*Bubo virginianus*]), time of day, and stage of the breeding cycle on red-shoulder response behavior and to evaluate the usefulness of call-playbacks as a population monitoring tool using area occupied/probability of detection techniques. During the breeding seasons of 1994 and 1995, four 10-station road transects were surveyed a total of 59 times and 79 surveys were conducted at 23 active nests. Red-shouldered hawks responded more often and more quickly to conspecific calls than to owl calls, and response rates to conspecific calls were higher prehatch than posthatch. Response rates to both calls were lowest in the middle of the day. Probability of detection using conspecific calls averaged approximately 0.35 and area occupied was around 75%, suggesting call-playbacks may serve as a monitoring tool for red-shoulders in northern Minnesota. Computer simulations are needed to determine the power of this technique in detecting population trends and to evaluate the effects of differing levels of survey effort.

Habitat characteristics were measured at 20 red-shouldered hawk nests and paired random points in northern hardwood stands in the Chippewa National Forest in north-central Minnesota during 1994 and 1995. The nest site was defined as the 0.04 ha circle centered on the nest tree, and random sites were located 75 - 200 m from the nest and centered on a tree _ 23 cm dbh. Compared to random sites, nest sites had larger plot center trees,

taller plot center trees, and taller canopy (paired t-tests, $P < 0.05$). Nest sites where incubation took place had higher basal area, taller canopy, and a higher percentage of trees >37.9 cm dbh (Student's t-test, $P < 0.05$) than nests where the breeding attempt did not reach incubation. Habitat characteristics that were important in distinguishing nest sites from random points in logistic regression models indicate that within a hardwood stand, red-shoulder nest site selection was strongly influenced by the presence of a large tree in which to place the nest.

Peterson, Greg S. 1996. Effect of bioturbation on the bioavailability of sulfide bound metals in freshwater surficial sediments. M.S. Thesis, University of Minnesota, St. Paul. 58pp.

ABSTRACT

Recent studies have demonstrated the role of acid volatile sulfide (AVS) in controlling the bioavailability of several cationic metals in anoxic sediments. However, metal-sulfide complexes can be relatively labile with respect to oxidation associated with factors such as seasonal changes in rates of oxidation/production of AVS. Another potentially important mechanism of AVS oxidation in surficial sediments is bioturbation. The present study used different densities of the burrowing oligochaete *Lumbriculus variegatus*, in a series of laboratory experiments, to evaluate the effect of bioturbation on oxidation of AVS, and subsequent bioavailability of cadmium and zinc spiked into freshwater sediments. Metal bioavailability was determined directly by bioaccumulation in the test organisms and indirectly through analysis of interstitial (pore) water metal concentrations. In these studies, horizon-specific sediment analyses were conducted to assess spatial differences in AVS and pore water metal concentrations specifically related to organism activity. Burrowing activity of the oligochaete significantly reduced AVS concentrations in surficial sediments in a density dependent manner, and resulted in elevated interstitial water concentrations of cadmium, but not zinc. Concentrations of cadmium in pore water from deeper horizons (below the zone of active burrowing) were consistently lower than those in the surficial sediments. The bioaccumulation of cadmium and zinc by *L. variegatus* was reflective of pore water concentrations of the two metals, i.e., there was significant accumulation of cadmium, but not zinc, by the oligochaetes. Overall, the results indicate that bioturbation can enhance the bioavailability of some cationic metals in surficial sediments, via oxidation of AVS, and demonstrate the importance of analyzing surficial sediments when assessing bioavailability of metals in sediments.

Plumpton, David L. 1996. Anthropogenic effects on winter habitat use by ferruginous hawks in Colorado. Ph.D. Thesis, University of Minnesota, St. Paul. 85pp.

ABSTRACT

Habitat loss, fragmentation, and insularization constitute the single biggest threat to global biodiversity. Despite the magnitude of this problem, few studies have examined the response of wildlife to ongoing habitat destruction. I studied the behavior of ferruginous hawks (*Buteo regalis*) wintering in 2 adjacent sites in Colorado that featured low and high anthropogenic influence and habitat fragmentation; the Rocky Mountain Arsenal National Wildlife Refuge (RMANWR), and several Denver suburbs, respectively. Daily home ranges were not different ($P = 0.28$) in size for RMANWR ($N = 25$, $O(x,) = 4.71$ km2, SE = 1.33) and suburban hawks ($N = 13$, $O(x,) = 2.30$ km 2, SE = 0.50). Although hawk activity levels between the sites were not different ($P = 0.146$), RMANWR hawks used more pole and ground perches, of longer sum duration, and comprising a greater proportion of the daily time budget ($P < 0.05$). Conversely, suburban hawks used more tree perches, of longer sum duration, and a greater portion of the daily time budget (P _ 0.001). RMANWR hawks spent less time roosting after daylight began ($O(x,) = 61$ min) than did suburban hawks ($O(x,) =$ 138 min, $P = 0.004$). The principal prey [black-tailed prairie dogs (*Cynomys ludovicianus*)] was procured by killing directly, kleptoparasitizing, and scavenging. Prey acquisition and competitive interactions were not different ($P > 0.05$) between the sites. Relative abundance of ferruginous hawks differed by site and year ($P < 0.0001$), and reflected availability of prairie dogs. Ferruginous hawks modified perch use, time budgets, and roosting habits to exploit fragmented, human-altered habitats, provided some foraging habitats with adequate populations of suitable prey species remained.

Pothoven, Steven A. 1996. An evaluation of the indirect effects of fluridone on the fish community structure of two Minnesota lakes. M.S. Thesis, University of Minnesota, St. Paul. 141pp.

ABSTRACT

I evaluated fish community structure and predator-prey interactions in Parkers and Zumbra Lakes, suburban Minneapolis, Minnesota one year prior and two years following whole-lake herbicide (Sonar®) applications in 1994. In Zumbra Lake, fish species richness decreased

from 23 in 1993 to 16 in 1995. In Parkers Lake, bluegill abundance decreased significantly in 1995 and mean bluegill length increased significantly compared to 1993. Bluegill growth rates increased in both treatment lakes in 1994 compared to the previous 5 years, but remained constant in the three reference lakes. Largemouth bass feeding efficiency (increased fish per stomach and decreased empty stomachs) increased during the initial treatment year and growth rates were higher in 1994 than the previous 3 years. Northern pike feeding efficiency did not improve, but diet composition related to prey distribution and vulnerability changed following herbicide application.

Runstrom, Ann L. 1996. The population dynamics of paddlefish in the lower Wisconsin River. M.S. Thesis, University of Minnesota, St. Paul. 98 pp.

ABSTRACT

Little information exists on the status of paddlefish populations in the upper Mississippi River and its major tributaries. Therefore, management efforts have been limited and insensitive to differences among local populations. I investigated several characteristics of a paddlefish population found in the Wisconsin River, a tributary of the upper Mississippi River. Study objectives were to (1) estimate population size, size-structure, age-structure, and mortality rates; and (2) determine the feasibility of transferring adult paddlefish from the study population to an upstream reach of river where immigration is blocked by a hydropower dam and the species has been extirpated. Mark-recapture data from 1993 and 1994 were applied to Chapman's modified Schnabel, Schumacher- Eschmeyer, modified Jolly-Seber and adjusted Petersen models to estimate population size. Estimates of population size ranged from 540 to 1,714 individuals. Size- and age-structure data indicated recruitment between 1993 and 1994 was minimal. Estimates for annual mortality ranged from 29 to 33%. These results suggest the population could be declining at present. Removal of individuals for a re-introduction effort poses significant risks to the genetic integrity of the Wisconsin River paddlefish population.

Warnke, D. Keith. 1996. A comparison of nesting behavior of bald eagles breeding along Western Lake Superior and adjacent inland Wisconsin. M.S. Thesis, University of Minnestoa, St. Paul. 58pp.

ABSTRACT

Using a remote video recording system and direct observations we constructed quantitative time budgets of adult and nestling bald eagles (*Haliaeetus leucocephalus*) breeding in northern Wisconsin from 7 days post hatch until fledging in 1992 and 1993. Bald eagles breeding in north-central Wisconsin exhibit high productivity (>1.0 young per occupied territory) and low nestling blood contaminant levels. We quantified prey delivery rates, and nestling and adult time activity budgets at the nest on a weekly basis until fledging. Season-long prey delivery rates to Wisconsin bald eagle nests averaged 5.12 items.day-1, and appeared related to number of nestlings in the nest, but not nestling age. Attendance by one or both adults declined rapidly from <90% in weeks 2-4 (8-28 d post hatch) to <20% by week 8 (50-56 d). Nestlings were inactive in weeks 2-4, lying in the nest >90% of the day. Beginning with week 5 (29-35 d), brooding dropped below 3% of the adult time budget and nestlings sought sun and shade in the nest. Nestlings stood or sat in the nest 30% of the time starting in week 6 (36-42 d), began to feed themselves as the amount of time adults spent feeding nestlings declined, and their mobility in the nest increased. During weeks 9-12 (56-83 d post hatch), nestlings stood or sat most of the day (>50%), and the proportion of their time budgets spent at active behaviors (21%) peaked in week 9. Adult attendance at the nest was <10% of the day in weeks 9-12. In addition to quantifying time budgets, we found that the nesting period can be divided into 3 nestling stages for time budget comparison in different regions of the breeding range based on changes in adult and nestling behaviors.

In 1992 and 1993 we conducted behavioral observations at bald eagle (*Haliaeetus leucocephalus*) nests on the Wisconsin Lake Superior shoreline (LSS) where productivity has historically been lower than inland Wisconsin sites. The Lake Superior shoreline breeding bald eagle population was extirpated, most likely due to anthropomorphic contaminant exposure, and has become re-established beginning in the 1980's. We quantified prey delivery rates and time budgets of adults and nestlings at these nests and compared them to the prey delivery rates and time budgets quantified at inland northern Wisconsin nests (Chapter 1). The behavioral differences recorded were most pronounced between inland and LSS nests with 2 nestlings (LSS2). Adults at inland nests delivered an average of 4.79 prey items.day-1, significantly more than the 2.04 items.day-1 delivered to LSS nests. Daily prey delivery rates to nestlings at LSS nests with 1 nestling (LSS1) (2.43 deliveries.nestling-1.day-1) were similar to those recorded at inland nests (3.13 deliveries.nestling-1.day-1), and both were significantly greater than prey delivery rates to LSS2 nests (0.92 deliveries.nestling-1.day-1). Adults at inland nest sites spent significantly more time at the nest (91.7%) than did adults at LSS2 nests (63.7%), and adult attendance at LSS1 nests

(85.7%) was significantly higher than at LSS2 nests, but not different from inland nests during weeks 2-4 post hatch. Adult attendance was higher and nestlings at inland nests spent more time active, feeding, and upright in the nest, and less time lying in the nest compared to nestlings at LSS2 nests in weeks 5-8. During weeks 9-12, LSS2 nestlings spent significantly less time feeding than did nestlings at inland nests. Reduced prey deliveries and behavioral variation are consistent with the hypothesis that bald eagle productivity on the Wisconsin Lake Superior shoreline is primarily influenced by prey availability.

Theses and Dissertations of Unit-Affiliated Students

1996

Li, J., 1996. Data analysis and modeling of walleye stocking in Minnesota. Ph. D. Thesis. University of Minnesota, St. Paul. 143pp.

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Research Project Reports

1995

Lane, W.H. and D.E. Andersen. 1995. Habitat requirements for boreal owls in northeastern Minnesota. Final report to the U.S. Forest Service, North Central Forest Experiment Station. 52pp.

Manolis, J.C., D.E. Andersen, and F.J. Cuthbert. 1995. Biodiversity monitoring: Breeding productivity, habitat, and winter distribution of nongame birds. 1994 Annual Progress Report to U.S. National Biological Service, Division of Cooperative Research. 18pp.

Mavrakis, P.H. and B. Vondracek. 1995. Spawning and summer microhabitat use in a northern population of smallmouth bass. Final Report to Electric Power Research Institute. 119pp.

Plumpton, D.L. and D. E. Andersen. 1995. Anthropogenic effects on winter habitat use by ferruginous hawks in Colorado - Progress report for the period 1 October 1992 to 1 December 1995 to U.S. Fish and Wildlife Service, Rocky Mountain Arsenal National Wildlife Refuge, Commerce City, Colorado. 9pp.

Pothoven, S.A., B. Vondracek, and D.L. Pereira. 1995. An evaluation of the indirect effects of flouridone on the fish communities of two Minnesota lakes. Annual Report to Minnesota Department of Natural Resources, St. Paul, Minnesota. 27pp.

Tester, J.R., D.E. Andersen, and P.M. Mayer. 1995. Assessing ecological structure, function, and dynamics of undisturbed and restored Northern Prairie wetlands. 1994 progress report to U.S. Bureau of Reclamation, Bismark, North Dakota. 14pp.

Vondracek, B., L. Sovell, J.A. Frost and 20 others. 1995. Biological, financial, and social monitoring to develop highly sustainable farming systems. Annual Report to Minnesota Institute for Sustainable Agriculture. 42pp.

1996

Anderson, D.J., D.G. Bowers, D.E. Andersen, F. Cuthbert, and R. Holzenthal. 1996 Anurans and invertebrates as indicators of wetland condition in the North Dakota Prairie Pothole Region. 1995 Annual Progress Report to National Biological Service, Northern Prairie Science Center.

Herbrandson, Carl. 1996. Toxicological effects of suspended solids and carbofuran on *Daphnia magna*. Final report to U.S. National Biological Service, Jamestown, North Dakota.

Mundahl, N.D., B.A. Nerbonne, and B. Vondracek. 1996. Whitewater Watershed Project: 1996 Fish, benthic macroinvertebrate, and habitat assessments. Interim Report to Minnesota Pollution Control Agency. 34pp.

Perry, E.F., J.C. Manolis, D.E. Andersen, and F.J. Cuthbert. 1996. Biodiversity monitoring: Breeding productivity, habitat, and winter distribution of nongame birds. 1995 Annual Progress Report to U.S. National Biological Service, Division of Cooperative Research. 9pp.

Peterson, Greg S. 1996. Effect of bioturbation on the bioavailability of sulfide bound metals in

freshwater surficial sediments. Final report to U.S. Environmental Protection Agency, Duluth, MN.

Tester, J.R., D.E. Andersen, and P.M. Mayer. 1996. Assessing ecological structure, function, and dynamics of undisturbed and restored Northern Prairie wetlands. 1995 Progress Report to U.S. Bureau of Reclamation, Bismark, North Dakota. 8pp.

Vondracek, B., L. Sovell, J.A. Frost and 20 others. 1996. Biological, Financial, and Social Monitoring to develop highly sustainable farming systems. Annual Report, Minnesota Institute for Sustainable Agriculture. 56pp.

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Presentations and Meeting Attendance

Invited Presentations

1995

Andersen, D.E. and **N.A. Stathis**. 1995. Fall movements and foraging of ring-necked ducks in a forested landscape. 1995. Minnesota Chapter of The Wildlife Society Summer Meeting, Grand Rapids, Minnesota.

Manolis, J.C. and **D.E. Andersen.** 1995. Breeding productivity and habitat association of forest songbirds on the Chippewa National Forest. Monitoring forest songbirds in the Upper Midwestern United States. Natural Resources Research Institute, University of Minnesota-Duluth, Duluth, Minnesota.

Pothoven, S.A., B. Vondracek, and **D. Pereira.** 1995. The indirect effects of fluridone (SONAR ®) on the fish communities of Minnesota lakes. Minnesota/Wisconsin Department of Natural Resources workshop on Eurasian watermilfoil, Hudson, Wisconsin.

1996

McLeod, M.A., B. Ann Belleman, and **D. E. Andersen**. 1996. Red-shouldered hawk breeding-season ecology and response to call playback surveys in north-central Minnesota. Midwest Regional Raptor Management Symposium. The Raptor Center, University of Minnesota, St. Paul, Minnesota.

McLeod, M.A. and **D.E. Andersen**. 1996. An evaluation of red-shouldered hawk call-playback surveys in north-central Minnesota: factors affecting detection and detecting population trends. Joint Meeting of The Raptor Research Foundation, Inc., and the American Ornithologists' Union, Boise, Idaho.

Contributed Presentations

1995

Belleman, B. A. and **D. E. Andersen.** 1995. Red-shouldered hawk (*Buteo lineatus*) breeding ecology and habitat use in central Minnesota. Annual Meeting of The Raptor Research Foundation, Inc., Duluth, Minnesota

Flynn, S. M., B. A. Belleman and **D. E. Andersen.** 1995. Red-tailed (*Buteo jamaicensis*) and red-shouldered hawk (*Buteo lineatus*) habitat use in relation to forest fragmentation in central Minnesota (poster). Annual Meeting of The Raptor Research Foundation, Inc., Duluth, Minnesota.

Hove, M.C., R.A. Engelking, M.E. Peteler, E.M. Peterson, A.R. Kapuscinski, L.A. Sovell, and **E.R. Evers.** 1995. Suitable fish hosts for glochidia of four freshwater mussels. 1995 Proceedings of The Conservation and Management of Freshwater Mussels II. Champaign-Urbana, Illinois.

Kontio, B.D., D.L. Garshelis, E.C. Birney and **D.E. Andersen.** 1995. Resilience of a Minnesota black bear population to heavy hunting: self-sustaining population or population sink?. 10th Internat. Conf. on Bear Res. and Manage., Fairbanks, Alaska.

Mavrakis, P. and **B. Vondracek.** 1995. Affects of limited suitable spawning and summer microhabitat on an adult smallmouth bass population. 1995 Joint Meeting of the Iowa/Minnesota chapters of the American Fisheries Society, Okoboji, Iowa.

McLeod, M. A. and **D. E. Andersen.** 1995. Call-playback surveys for red-shouldered hawk (*Buteo lineatus*) in north-central Minnesota. Annual Meeting of The Raptor Research Foundation, Inc., Duluth, Minnesota.

Meier, T. J. 1995. Mortality and dispersal of wolves from Denali National Park and Preserve, Alaska. Wolves and humans 2000: A global perspective for managing conflict, Duluth, Minnesota.

Mumford, K.G., L.A. Sovell, and **B. Vondracek.** 1995. Stream quality following management intensive grazing on southeastern Minnesota streams. Symposium on linkages among farming systems and communities, Association for Farming Systems Research/Extension, Ames, Iowa.

Plumpton, D. L. and **D. E. Andersen**. 1995. Anthropogenic effects on winter habitat use by ferruginous hawks in Colorado. Annual Meeting of The Raptor Research Foundation, Inc., Duluth, Minnesota.

Pothoven, S.A. 1995. The indirect effects of fluridone on fish communities in two Minnesota lakes. North Central Division of American Fisheries Society Centrarchid Technical Committee meeting in Prairie du Chien, Wisconsin.

Pothoven, S.A., B. Vondracek, and **D. Pereira.** 1995. Effects of vegetation removal on the fish community structure and predator-prey relations in two Minnesota lakes. 57th Midwest Fish and Wildlife Conference, Detroit, Michigan.

Pothoven, S.A., B. Vondracek, and **D. Pereira.** 1995. The indirect effects of fluridone (SONAR ®) on the fish communities of Minnesota lakes. 1995 Joint Meeting of the Iowa/Minnesota chapters of the American Fisheries Society, Okoboji, Iowa.

Runstrom, A.L., Bruce Vondracek, and **C.A. Jennings.** 1995. Population dynamics of paddlefish in the lower Wisconsin River. 24th Annual Meeting, Wisconsin Chapter, American Fisheries Society, Madison, Wisconsin.

Sovell, L.A., K.G. Mumford, and **B. Vondracek.** 1995. Stream quality following management intensive grazing on southeastern Minnesota streams. 57th Midwest Fish and Wildlife Conference, Detroit, Michigan

1996

Anderson, D.J. and **B. Vondracek.** 1996**.** Insects as indicators of wetland condition in North Dakota. 58th Midwest Fish and Wildlife Conference, Omaha, Nebraska.

Bowers, D.G., D. E. Andersen, and **N.H. Euliss**. 1996. Associations between land-use patterns and anuran populations in the Prairie Pothole Region of North Dakota. 58th Midwest Fish and Wildlife Conference, Omaha, Nebraska.

Grant, G.C., B. Vondracek, and **P.W. Sorensen.** 1996. Diel spawning activity of brook and brown trout in Valley Creek, Minnesota. 1996 Joint meeting of the Minnesota chapters of the American Fisheries Society, Society of American Foresters, and The Wildlife Society, Brainerd, Minnesota.

Grant, G.C., B. Vondracek, and **P.W. Sorensen.** 1996. Behavior of spawning brook and brown trout in Valley Creek, Minnesota. 58th Midwest Fish and Wildlife Conference, Omaha, Nebraska.

Li, J. , Y. Cohen. 1996. A historical data analysis of the effectiveness of walleye stocking. 126th Annual Meeting of the American Fisheries Society, Dearborn, Michigan.

Mayer, P. M., Tester, J. R., and **S. M. Galatowitsch.** 1996. Developing ecological indicators of structure and function to assess recovery in restored prairie wetlands. 17th Meeting, Society of Wetland Scientists, Kansas City, Missouri.

Mumford, K.G., L.A. Sovell, and **B. Vondracek.** 1996. Impacts of management intensive grazing on streams in southeast Minnesota: Project background, water chemistry, and physical habitat. 1996 Joint meeting of the Minnesota Chapters of the American Fisheries Society, Society of American Foresters, and The Wildlife Society, Brainerd, Minnesota.

Plumpton, D. L. and **D. E. Andersen**. 1996. Anthropogenic effects on winter habitat use by ferruginous hawks in Colorado. U.S. Fish and Wildlife Service, Region 6, Denver, Colorado.

Pothoven, S.A., B. Vondracek, and **D. Pereira.** 1996. Effects of vegetation removal on the fish community structure and predator-prey relations in two Minnesota lakes. 1996 Joint meeting of the Minnesota chapters of the American Fisheries Society, Society of American Foresters, and The Wildlife Society, Brainerd, Minnesota.

Runstrom, A.L., B. Vondracek, and **C.A. Jennings.** 1996. Population dynamics of paddlefish in the lower Wisconsin River. 126th Annual Meeting of the American Fisheries Society, Dearborn, Michigan.

Sovell, L.A., K.G. Mumford, and **B. Vondracek.** 1996. Impacts of management intensive grazing on streams in southeast Minnesota: Fish and benthic macroinvertebrate communities. 1996 Joint meeting of the Minnesota Chapters of the American Fisheries Society, Society of American Foresters, and The Wildlife Society, Brainerd, Minnesota.

Vondracek, B. 1996. Water chemistry, physical habitat, benthic macroinvertebrates, and fish populations in relation to Management Intensive Grazing, Minnesota DNR semi-annual fisheries research meeting, Pequot Lakes, Minnesota.

Scientific Meeting Attendance

1995

24th Annual Meeting, Wisconsin Chapter, American Fisheries Society, Madison, Wisconsin. (*B. Vondracek, A. Runstrom*)

1995 Annual Meeting of The Raptor Research Foundation, Inc., Duluth, Minnesota. *(D.E. Andersen, M.A. McLeod, B.A. Belleman, D.L. Plumpton, S. Flynn)*

Mississippi Flyway Technical Section and Council Meeting, Green Bay, Wisconsin. *(D.E. Andersen)*

Minnesota Chapter of The Wildlife Society Summer Meeting, Grand Rapids, Minnesota. *(D.E. Andersen)*

Monitoring forest songbirds in the Upper Midwestern United States. Natural Resources Research Institute, University of Minnesota-Duluth, Duluth, Minnesota. *(D.E. Andersen and J.C. Manolis)*

Joint Meeting of the Iowa/Minnesota chapters of the American Fisheries Society, Okoboji, Iowa. (*B. Vondracek, S.A. Pothoven, P. Mavrakis, G. Grant, L. Sovell, K. Mumford*).

Minnesota/Wisconsin Department of Natural Resources workshop on Eurasian watermilfoil, Hudson, Wisconsin, 14-15 March. (*B. Vondracek, S.A. Pothoven*)

North Central Division of American Fisheries Society Centrarchid Technical Committee meeting in Prairie du Chien, Wisconsin. 16-17 August. (*B. Vondracek, S.A. Pothoven*)

125th Annual Meeting of the American Fisheries Society, Tampa, Florida, 27-31 August. (*B. Vondracek, B. Nerbonne)*

Nonindigenous Species Panel-Great Lakes Commission in Duluth, Minnesota. (*B. Vondracek*)

Minnesota DNR Semi-Annual Fisheries Research Meeting, Pequot Lakes, Minnesota. *(D.E. Andersen and B. Vondracek*)

Symposium on linkages among farming systems and communities, Association for Farming Systems Research/Extension, Ames, Iowa. (*B. Vondracek, L. Sovell, K. Mumford*).

57th Midwest Fish and Wildlife Conference, Detroit, Michigan. (*B. Vondracek, S.A. Pothoven, G. Grant, B. Nerbonne, L. Sovell*)

1996

Joint meeting of the Minnesota Chapters of the American Fisheries Society, Society of American Foresters, and The Wildlife Society, Brainerd, Minnesota. *(D.E. Andersen, B. Vondracek, S.A. Pothoven, G. Grant, L. Sovell, K. Mumford*)

Nonindigenous Species Panel-Great Lakes Commission in Ann Arbor, Michigan. (*B. Vondracek*)

Nonindigenous Species Panel of the Great Lakes Commission Symposium "Aquatic nuisance species research relevant to the Great lakes basin: enhancing prevention and control efforts" in Ann Arbor, Michigan. (*B. Vondracek*)

Joint Atlantic and Mississippi Flyway Technical Section and Council Meeting, Allentown, Pennsylvania. *(D.E. Andersen)*

Joint Meeting of The Raptor Research Foundation, Inc., and the American Ornithologists' Union, Boise, Idaho. *(D.E. Andersen and M.A. McLeod)*

North American Raptor Monitoring Workshop, Boise, Idaho. *(D.E. Andersen and M.A. McLeod)*

Joint Atlantic, Mississippi, Central, and Pacific Flyway Technical Section and Council Meeting, Kansas City, Missouri. *(D.E. Andersen)*

Midwest Regional Raptor Management Symposium. The Raptor Center, University of Minnesota, St. Paul, MN. *(D.E. Andersen, M.A. McLeod, B.A. Belleman)*

51st Wildlife and Natural Resources Conference, Tulsa, OK. *(D.E. Andersen)*

Annual meeting of the Center for Holistic Management, Rochester, MN. (*B. Vondracek*)

Conference titled "New approaches to rural nonpoint source pollution: what makes them work," participated on a panel discussion "Meeting watershed and farm goals: on-farm monitoring bridges the gap among farmers, resource professionals and researchers," LaCrosse, WI. (*B. Vondracek*)

126th Annual Meeting of the American Fisheries Society, Dearborn, MI. (*B. Vondracek, A.Runstrom, G. Grant, L. Sovell, J. Frost, B. Nerbonne, J. Li, Y. Cohen*)

Sustainable Development Conference, Minneapolis, MN. (*B. Vondracek, L. Sovell*)

58th Midwest Fish and Wildlife Conference, Omaha, NE. *(D.E. Andersen, B. Vondracek, D.G. Bowers, G. Grant, D. Anderson, J. Frost, B. Nerbonne, K. Blann*)

Seventeenth Meeting, Society of Wetland Scientists, Kansas City, MO. (*P. M. Mayer*)

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Honors and Awards

1995

B. Vondracek. 1995. Performance Award, U.S. National Biological Service.

D.E. Andersen. 1995. Performance Award, U.S. National Biological Service.

1996

K.L. Blann. 1996-1997. University of Minnesota Graduate School Fellowship.

L.A. Sovell. 1995-1996. Water Resources Science Fellowship.

B. Vondracek. 1996. Promotion to GS-13 via Research Grade Evaluation, U.S. National Biological Service.

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