Alaska Cooperative Fish and Wildlife Research Unit

Annual Report—2007

April 2008

Alaska Cooperative Fish and Wildlife Research Unit
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Contents

Unit Roster

Federal Scientists

- Brad Griffith: Assistant Leader-Wildlife
- F. Joseph Margraf: Leader
- A. David McGuire: Assistant Leader-Ecology
- Abby Powell: Assistant Leader-Wildlife
- Mark Wipfli: Assistant Leader-Fisheries

University Staff

- Karen Enochs: Fiscal Technician
- Jennifer Miller: Travel Coordinator
- Kathy Pearse: Administrative Assistant

Unit Students

Current

- Chrissy Apodaca, PhD Biology (Wipfli)
- Stacia Backensto, PhD Biology (Powell)
- Elizabeth Benolkin, MS Fisheries (Margraf)
- Emily Benson, MS Biology (Wipfli)
- Rebecca Bentzen, PhD Biology (Powell)
- Matthew Campbell, PhD Biology (Wipfli)
- Jeremy Carlson, MS Fisheries (Margraf)
- Samantha Decker, MS Fisheries (Margraf)
- David Esse, MS Fisheries (Margraf)
- Jonathon Gerken, MS Fisheries (Margraf)
- Laura Gutierrez, MS Biology (Wipfli)
- Christie Hendrich, MS Fisheries (Margraf)
- Meagan (Boltwood) Krupa, PhD Biology (Wipfli)
- Christopher Latty, MS Wildlife (Powell)
- Andra Love, PhD Fisheries (Margraf)
- Elizabeth (Green) Markley, MS Biology (Wipfli)
- Teri McMillan, MS Biology (Powell)
- Jason Neuswanger, MS Fisheries (Wipfli)
- Jonathan O'Donnell, PhD Biology (McGuire)
- Steffen Oppel, PhD Biology (Powell)
- Megan Perry, MS Biology (Wipfli)
- Jeff Perschbacher, MS Fisheries (Margraf)
- Dan Rinella, PhD Biology (Wipfli)
- Jennifer Roach, MS Biology (Griffith)
- Lisa South, MS Fisheries (Wipfli)
- Valerie Steen, MS Biology (Powell)
- Shelly Szepanski, PhD Biology (Griffith)
- Theresa Tanner, MS Fisheries (Margraf)
- Audrey Taylor, PhD Biology (Powell)
- Jason Valliere, MS Fisheries (Margraf)
- Emily Weiser, MS Biology (Powell)
- Brad Wendling, MS Wildlife (Griffith)

Graduated in CY 2007

- Michael Balshi, PhD Biology (McGuire)
- Colin Beier, PhD Biology (McGuire)
- Dave Gregovich, MS Fisheries (Wipfli)
- Aaron Martin, MS Fisheries (Wipfli)
- Bruce Medhurst, MS Biology (Wipfli)
- Lincoln Parrett, MS Biology (Griffith)
- Josh Peirce, MS Wildlife (Wipfli/Follmann)
- Kathy Smikrud, MS Fisheries (Margraf
- Heather Wilson, PhD Biology (Powell)

Post-Doctoral Researchers

- Christopher Binckley (Wipfli)
- Daniel Hayes (McGuire)
- Shuhua Yi (McGuire)

Research Associates

- Eugénie Euskirchen, Institute of Arctic Biology (IAB)

Faculty Cooperators

- Perry Barboza, Department of Biology and Wildlife(DBW)/Institute of Arctic Biology (IAB), UAF
- R. Terry Bowyer, Department of Biological Sciences, Idaho State University, Pocatello
- Loren Buck, School of Fisheries and Ocean Sciences (SFOS), Fisheries Industrial Technology Center, UAF, Kodiak
- Monica Calef, Assistant Professor, State University of New York Albany
- F. Stuart Chapin III, DBW/IAB, UAF
- Erich Follmann, IAB/DBW, UAF
- Tuula Hollmen, SeaLife Center
- Falk Huettmann, DBW/IAB, UAF
- Gordon Kruse, SFOS, UAF
- Mark Lindberg, DBW/IAB, UAF
- Edward Murphy, DBW/IAB, UAF
- Eric Rexstad, University of Edinburgh, Scotland
- Don Spalinger, Department of Biological Sciences, UAA
- James Reynolds, Emeritus UAF

Affiliated Students

Current

- Todd Brinkman, PhD Biology (Chapin)
- Jessica Coltrane, PhD Biology (Barboza)
- Nathan Coutsoubos, PhD Biology (Huettmann)
- Brook Gamble, MS Wildlife (Buck/Murphy)
- David Gustine, PhD Biology (Barboza)
- Aleya Nelson, MS Biology (Lindberg)

Graduated in CY 2007

- Blair French, MS Wildlife (Follmann)

- Kate Martin, MS Wildlife (Lindberg)
- Brandt Meixell, MS Biology (Lindberg)
- Susan Oehlers, MS Wildlife (Bowyer/Huettmann)
- Joy Ritter, MS Wildlife (Rexstad/Huettmann)

Cooperators

- Brian Barnes–Director, Institute of Arctic Biology, University of Alaska Fairbanks
- Robert Davison–Northwest Representative, Wildlife Management Institute
- McKie Campbell–Commissioner, Alaska Department of Fish and Game
- Tom Melius–Director, Region 7, US Fish and Wildlife Service
- Michael Tome-Unit Supervisor, Cooperative Research Units, US Geological Survey

Introduction

This is the Annual Report for the Alaska Cooperative Fish and Wildlife Research Unit, highlighting activities for calendar year 2007. The Unit engages in research on living natural resources for a variety of State and Federal agencies. As an unbiased research organization, the Unit provides information requested and funded by these agencies. When studies are completed, the agencies use the information to assist in their natural resource management efforts. Most of the research is conducted by graduate students, many of whom go on to work for the agencies upon graduation.

The Alaska Unit was established in 1950, providing over half a century of research dedicated to helping conserve and enhance the living natural resources of the State and the Arctic Region. The Unit is part of a larger and even older program, the U.S. Department of the Interior's Cooperative Research Unit Program. Established in 1935, Cooperative Research Units were created to fill the vacuum of wildlife management information and the shortage of trained wildlife biologists. In 1960, the Unit Program was formally sanctioned by Congress with the enactment of the Cooperative Units Act. Each unit is a partnership among the Biological Resources Discipline of the U.S. Geological Survey, a State fish and game agency, a host university, and the Wildlife Management Institute. Staffed by Federal personnel, Cooperative Research Units conduct research on renewable natural resource questions; participate in the education of graduate students destined to become natural resource managers and scientists; provide technical assistance and consultation to parties who have legitimate interests in natural resource issues; and provide continuing education for natural resource professionals. Presently, there are 40 Cooperative Research Units in 38 states, conducting research on virtually every type of North American ecological community. The Program is staffed by more than 100 PhD scientists who advise as many as 675 graduate student researchers per year.

Statement of Direction

The research program of the Unit will be aimed at understanding the ecology of Alaska’s fish and wildlife; evaluating impacts of land use and development on these resources; and relating effects of social and economic needs to production and harvest of natural populations.

In addition to the expected Unit functions of graduate student training/ instruction and technical assistance, research efforts will be directed at problems of productivity, socioeconomic impacts, and perturbation on fish and wildlife populations, their habitats and ecosystems. Fisheries research will emphasize water quality, habitat characteristics, and life history requirements of northern fish populations. Wildlife research will focus on the ecology of northern birds and mammals and their habitats. Unit research will also be directed at integrated studies of fish and wildlife at the ecosystem level.

Unit Cost-Benefit Statements

In-Kind Support

In-kind support, usually operational support of field activities, is critical to the success of the Alaska Cooperative Fish and Wildlife Research Unit. Although the monetary value of this support is not known, a listing of the assistance is provided for each project in this report.

Benefits

Students Graduated: 14
Presentations: 40
Scientific and Technical Publications: 19

Courses Taught

- Independent Study: National Assessment of State Comprehensive Wildlife Conservation Strategies (Griffith and Powell, 3 credit hours, Fall 2007)
- Resilience and Adaptation Program, Ecology Module (McGuire, 1 credit hour, Fall 2007)
- Scientific Writing and Editing (Powell, 3 credit hours, Spring 2007)
- Freshwater Ecosystems Seminar Series (Wipfli, 1 credit hour, Spring 2007)
- Riverine Ecosystems, Special Topics (Wipfli, 2 credit hours, Fall 2007)

Honors and Awards

- Latty, Christopher J. February 2007. Travel grant to attend the 34th Annual Meeting of the Pacific Seabird Association, Asilomar, CA, February 2007, awarded by the Pacific Seabird Group.
- McGuire, A. David. Emil Usibelli 2007 Distinguished Research Award awarded by the University of Alaska Fairbanks.
- Taylor, Audrey M. May 2007. Travel grant to attend the annual meeting of the Association of Field Ornithologists, Orono, ME, July 2007, awarded by the Graduate School, University of Alaska Fairbanks.
- Taylor, Audrey M. Alaska EPSCoR (Experimental Program to Stimulate Competitive Research) 2007/2008 Graduate Fellow in Biology.

Outreach and Info Transfer

Backensto, S., A. Powell, G. Kofinas, C. Gerlach, and E. Follmann. February 2007. The common raven (*Corvus corax*) on the North Slope of Alaska. Coastal Marine Institute Annual Research Review, University of Alaska, Fairbanks, AK.

Brinkman, T. J., G. P. Kofinas, D. K. Person, F. S. Chapin III, K. Hundertmark, and W. P. Smith. 2007. Hunters, logging, feces: Important components of deer

research in Southeast Alaska. February 2: USGS Forest Service Discover Center, Ketchikan, AK; February 12: USDA Forest Service Thorne Bay District Conference Room, Thorne Bay, AK; and February 15: Craig Community Association Building, Craig, AK.

Medhurst, R. B., M. S. Wipfli, C. A. Binckley, J. Y. Kill, and K. P. Polivka. February 2007. Differences in headwater stream invertebrate communities across logging and climatic gradients in the Cascade Range, Washington. Special Workshop, Riparian Management in Headwater Catchments: Translating Science into Management. University of British Columbia, Vancouver, BC, Canada.

Mellon, C. D., M. S. Wipfli, J. L. Li, and D. W. Peterson. February 2007. Effects of forest fire on invertebrate dispersal from headwater streams to riparian and downstream habitats in eastern Washington. Special Workshop, Riparian Management in Headwater Catchments: Translating Science into Management. University of British Columbia, Vancouver, BC, Canada.

Wipfli, M. S. March 2007. Marine-derived nutrients in river ecology in Alaska. Invited Seminar, Salmonid River Observatory Network (SaRON) All-Scientists Meeting, Flathead Lake Biological Station, University of Montana, Polson, MT.

Papers Presented

Balshi, M. S., A. D. McGuire, Q. Zhuang, J. Melillo, D. W. Kicklighter, E. Kasischke, C. Wirth, M. Flannigan, J. Harden, J. S. Clein, T. J. Burnside, J. McAllister, W. A. Kurz, M. Apps, and A. Shvidenko. May 2007. The role of historical fire disturbance in the carbon dynamics of the pan-boreal region: A process-based analysis. Sixth International Conference on Disturbance Dynamics in Boreal Forests, Fairbanks, AK.

Balshi, M. S. and A. D. McGuire. September 2007. The vulnerability of carbon storage in boreal North America during the 21st century in response to increases in wildfire activity. AAAS Arctic Division Meeting, Anchorage, AK.

Balshi, M. S., A. D. McGuire, P. Duffy, M. Flannigan, J. Walsh, D. Kicklighter, and J. Melillo. December 2007. The vulnerability of carbon storage in boreal North America during the 21st century to increases in wildfire activity. Fall Meeting of the American Geophysical Union, San Francisco, CA.

Brinkman, T. J. and D. K. Person. September 2007. Sampling along animal trails: Thinking biologically, increasing power, and maintaining objectivity. The Wildlife Society 14th Annual Conference, Tucson, AZ.

Chapin, F. S. III, J. Randerson, A. D. McGuire, J. Foley, and C. Field. August 2007. Changing feedbacks in the ecosystem-climate system. Annual Meeting of the Ecological Society of America, San Jose, CA. Invited.

Conlin, M. R., M. R. Turetsky, J. W. Harden, and A. D. McGuire. April 2007. Soil climate controls on C cycling in an Alaskan fen: Responses to water table mediated by vegetation. First International Symposium on Carbon in Peatlands, Wageningen, the Netherlands.

Decker, S. K., F. J. Margraf, M. Evenson, A. Rosenberger, and N. F. Hughes. November 2007. Thermal limitations on Chinook salmon spawning habitat. Annual Meeting of the Alaska Chapter of the American Fisheries Society, Ketchikan, AK.

Euskirchen, E. S., A. D. McGuire, F. S. Chapin III, and S. Yi. September 2007. Changes in plant communities in northern Alaska under scenarios of climate change, 2003–2100. AAAS Arctic Division Meeting, Anchorage, AK.

Euskirchen, E. S., A. D. McGuire, F. S. Chapin III, and S. Yi. December 2007. Changes in plant communities in northern Alaska under scenarios of climate

change 2003 to 2100. Fall Meeting of the American Geophysical Union, San Francisco, CA.
Green-Markley, E. C., M. S. Wipfli, and K. M. Polivka. November 2007. Do drifting invertebrates originating from fishless headwater streams affect downstream fish? Annual Meeting of the Alaska Chapter of the American Fisheries Society, Ketchikan, AK.
Griffith, B. February 2007. Heterogeneity in climate warming: Effects on fish, wildlife and habitats. USFWS Climate Change Forum, Anchorage, AK. Invited.
Griffith, B. February 2007. US Climate Change Science Program Synthesis and Assessment Product 4.4. Alaska Forum on the Environment, Anchorage, AK.
Griffith, B. February 2007. US Climate Change Science Program Synthesis and Assessment Product 4.4. USFWS Climate Change Forum, Anchorage, AK.
Griffith, B. June 2007. Climate induced biome shifts and their implications for management of trust species of the National Wildlife Refuge system. Seventy-seventh Annual Meeting, Cooper Ornithological Society, Moscow, ID.
Griffith, B. June 2007. Inconvenient answers: Experiences at the interface of biological research and public policy early in the 21st century. Seventy-seventh Annual Meeting, Cooper Ornithological Society, Moscow, ID.
Griffith, B. May 2007. Potential Implications of Lake Dynamics to Ecosystem Services. USGS Lake Dynamics Symposium, Anchorage, AK. Invited.
Hartman, K. J. and F. J. Margraf. September 2007. Common relationships among proximate composition components in fish. Annual Meeting of the American Fisheries Society, San Francisco, CA.
Kasischke, E., M. R. Turetsky, E. S. Kane, C. Treat, J. W. Harden, K. Manies, R. D. Ottmar, A. D. McGuire, and S. Yi. December 2007. Landscape and climate controls on fire severity in Alaskan black spruce forests. Fall Meeting of the American Geophysical Union, San Francisco, CA. Invited.
Kasischke, E. S., M. R. Turetsky, A. D. McGuire, J. Harden, K. Manies, R. Ottmar, E. S. Kane, and N. H. F. French. May 2007. Recent changes in climate and the fire regime increase depth of burning of the surface organic layer in Alaskan black spruce forests. Sixth International Conference on Disturbance Dynamics in Boreal Forests, Fairbanks, AK.
Latty, C. J., T. E. Hollmen, M. R. Petersen, A. N. Powell, and R. D. Andrews. February 2007. Sublethal effects of implanted satellite transmitters on captive common eider (Somateria mollissima) foraging at a depth of 5 m. Pacific Seabird Group 34th Annual Meeting, Asilomar, CA.
Margraf, F. J., K. J. Hartman, and M. K. Cox. February 2007. Nondestructive field estimation of fat content of Yukon River salmon. Symposium on the Sustainability of the Arctic-Yukon-Kuskokwim Salmon Fisheries, Anchorage, AK.
McGuire, A. D., L. Anderson, T. R. Christensen, S. Dallimore, L. Guo, D. Hayes, M. Heimann, T. Lorenson, R. Macdonald, and N. Roulet. December 2007. Sensitivity of the carbon cycle in the Arctic to climate change. Fall Meeting of the American Geophysical Union, San Francisco, CA.
McGuire, A. D., F. S. Chapin III, J. Walsh, C. Wirth, Q. Zhuang, and E. Euskirchen. February 2007. Arctic feedbacks to the carbon-climate system. AAAS Annual Meeting, San Francisco, CA. Invited.
McGuire, A. D., E. S. Euskirchen, F. S. Chapin III, M. Balshi, Q. Zhuang, J. Melillo, D. Kicklighter, J. Walsh, and C. Wirth. April 2007. Integrated regional changes in arctic climate feedbacks: Implications for the global climate system. CLASSIC Workshop on Land-Atmosphere Interactions in the Arctic, Abisko, Sweden. Invited.
McGuire, A. D., J. Melillo, D. Kicklighter, and L. Joyce. December 2007. The role of nitrogen dynamics in the response of of terrestrial carbon dynamics to changes in

atmospheric carbon dioxide, climate, and land use. Fall Meeting of the American Geophysical Union, San Francisco, CA. Invited.

Medhurst, R. B., M. S. Wipfli, C. A. Binckley, J. Y. Kill, and K. P. Polivka. June 2007. Differences in headwater stream invertebrate communities across logging and climatic gradients in the Cascade Range, Washington. Annual Meeting of the North American Benthological Society, Columbia, SC.

Meka, J. M. and F. J. Margraf. October 2007. Using a bioenergetic model to assess growth reduction from catch-and-release angling and hooking injury in rainbow trout. Wild Trout Symposium IX, West Yellowstone, MT.

Mellon, C. D., M. S. Wipfli, J. L. Li, and D. W. Peterson. February 2007. Effects of forest fire on invertebrate dispersal from headwater streams to riparian and downstream habitats in eastern Washington. Special Workshop, Riparian Management in Headwater Catchments: Translating Science into Management, University of British Columbia, Vancouver, BC, Canada.

Myers-Smith, I., J. Harden, M. Wilmking, C. Fuller, A. D. McGuire, and F. S. Chapin III. April 2007. The influence of disturbance on wetland succession in a permafrost collapse, Fairbanks, Alaska. First International Symposium on Carbon in Peatlands, Wageningen, the Netherlands.

Oppel, S., D. L. Dickson, and A. N. Powell. January 2007. Winter movements of King Eiders in the Bering Sea tracked via satellite telemetry. Alaska Marine Science Symposium, Anchorage, AK.

Oppel, S., D. L. Dickson, and A. N. Powell. February 2007. Factors influencing King Eider winter movements in the Bering Sea. Annual Meeting of the Pacific Seabird Group, Asilomar, CA.

Oppel, S. and F. Huettmann. 2007. January 2007. A modeling method for predicting benthic biomass: using RandomForest to link survey data with environmental data for the Bering Sea region. Alaska Marine Science Symposium, Anchorage, AK.

Scott, J. M., B. Griffith, R. Adamcik, D. Ashe, B. Czech, R. Fischman, P. Gonzales, and A. Pidgorna. June 2007. Managing for change: climate change and the National Wildlife Refuge System. Climate Change Session, 2007 Annual Meeting of the Cooper Ornithological Society, Moscow, ID. Invited.

Scott, J. M., B. Griffith, R. Adamcik, D. Ashe, B. Czech, R. Fischman, P. Gonzales, and A. Pidgorna. July 2007. Managing for change: climate change and the National Wildlife Refuge System. Invited paper presented at the Joint FWS/USGS Executive Leadership Team Meeting, Anchorage, AK.

Taylor, A. R., R. B. Lanctot, and A. N. Powell. July 2007. Use of radiotelemetry to determine tenure times and movement patterns of staging shorebirds on Alaska's North Slope. Annual Meeting of Association of Field Ornithologists, Orono, ME.

Turetsky, M. R., M. Flannigan, J. Harden, E. Kasischke, A. D. McGuire, D. Vitt, and K. Wieder. April 2007. Peatland C responses to changing hydrology and disturbance regimes: Perspectives from boreal North America. First International Symposium on Carbon in Peatlands, Wageningen, the Netherlands.

Turetsky, M., J. Harden, A. D. McGuire, M. Waddington. December 2007. Controls on feedbacks between northern wetlands and the climate system. Fall Meeting of the American Geophysical Union, San Francisco, CA. Invited.

Wipfli, M. S. February 2007. Food resources regulating salmonid populations in fresh water: Variability through time and space. Symposium on the Sustainability of the Arctic-Yukon-Kuskokwim Salmon Fisheries, Anchorage, AK.

Yi, S., A. D. McGuire, J. Harden, and E. Kasischke. September 2007. A dynamic soil layer model for assessing the effects of wildfire on high latitude terrestrial ecosystem dynamics. AAAS Arctic Division Meeting, Anchorage, AK.

Yi, S., A. D. McGuire, J. Harden, E. Kasischke, K. Manies, L. Hinzman, A. Liljedahl, V. Romanovsky, and S. Marchenko. December 2007. A dynamic soil layer model for assessing the effects of wildfire on high latitude terrestrial ecosystems. Fall Meeting of the American Geophysical Union, San Francisco, CA.

Scientific Publications

Balshi, M. S., A. D. McGuire, Q. Zhuang, J. Melillo, D. W. Kicklighter, E. S. Kasischke, C. Wirth, M. Flannigan, J. Harden, J. S. Clein, T. J. Burnside, J. McAllister, W. A. Kurz, M. Apps, and A. Shvidenko. 2007. The role of historical fire disturbance in the carbon dynamics of the pan-boreal region: A process-based analysis. Journal of Geophysical Research, Vol. 112, G02029, doi: 10.1029/2006JG000380, 2007.

Clein, J. S., A. D. McGuire, E. S. Euskirchen, and M. P. Calef. 2007. The effects of different climate input datasets on simulated carbon dynamics in the Western Arctic. Earth Interactions, Vol. 17, Paper 12. 24 pp.

Duffy, P. A., J. Epting, J. M. Graham, T. S. Rupp, and A. D. McGuire. 2007. Analysis of Alaskan burn severity patterns using remotely sensed data. International Journal of Wildland Fire 16:277-284.

Euskirchen, S. E., A. D. McGuire, and F. S. Chapin III. 2007. Energy feedbacks of northern high-latitude ecosystems to the climate system due to reduced snow cover during 20th century warming. *Global Change Biology* 13:2425-2438.

Hartman, K. J. and F. J. Margraf. 2007. Assessing fish populations in remote subarctic lakes using hydroacoustics. Lake and Reservoir Management 23:211-218.

Kane, E. S., E. S. Kasischke, D. W. Valentine, M. R. Turetsky, and A. D. McGuire. 2007. Topographic influences on wildfire consumption of soil organic carbon in interior Alaska: Implications for black carbon accumulation. Journal of Geophysical Research - Biogeosciences 112, G03017, doi:10.1029/2007JG000458.

Kimball, J. S., M. Zhao, A. D. McGuire, F. A. Heinsch, J. Clein, M. Calef, W. M. Jolly, S. Kang, S. E. Euskirchen, K. C. McDonald, and S. W. Running. 2007. Recent climate-driven increases in vegetation productivity for the Western Arctic: Evidence of an acceleration of the northern terrestrial carbon cycle. Earth Interactions 11, Paper 4. 30 pp.

Knoche, M. J., A. N. Powell, L. T. Quakenbush, M. J. Wooller, and L. M. Phillips. 2007. Further evidence for site fidelity to wing molt locations by King Eiders: Integrating stable isotope analyses and satellite telemetry. Waterbirds 30(1):52-57.

McGuire, A. D., F. S. Chapin III, C. Wirth, M. Apps, J. Bhatti, T. Callaghan, T. R. Christensen, J. S. Clein, M. Fukuda, T. Maximov, A. Onuchin, A. Shvidenko, and E. Vaganov. 2007. Responses of high latitude ecosystems to global change: Potential consequences for the climate system. Pages 297-310 in J. G. Canadell, D. E. Pataki, and L. F. Pitelka, eds. Terrestrial Ecosystems in a Changing World. The IGBP Series, Springer-Verlag, Berlin Heidelburg.

Meka, J. M., and F. J. Margraf. 2007. Using a bioenergetic model to assess growth reduction from catch-and-release fishing and hooking injury in rainbow trout, *Oncorhynchus mykiss*. Fisheries Management and Ecology 14:131-139.

Myers-Smith, I., A. D. McGuire, J. W. Harden, and F. S. Chapin III. 2007. The influence of disturbance on carbon exchange in a permafrost collapse and adjacent burned forest. Journal of Geophysical Research - Biogeosciences 112, G04017, doi:10.1029/2007JG000423.

Phillips, L. M., A. N. Powell, E. J. Taylor, and E. A. Rexstad. 2007. Use of the Beaufort Sea by king eiders breeding on the North Slope of Alaska. Journal of Wildlife Management 71(6):1892-1898.

Rupp, T. S., X. Chen, M. Olson, and A. D. McGuire. 2007. Sensitivity of simulated boreal fire dynamics to uncertainties in climate drivers. Earth Interactions 11, Paper 3. 21 pp.

Sitch, S., A. D. McGuire, J. Kimball, N. Gedney, J. Gamon, R. Engstrom, A. Wolf, Q. Zhuang, J. S. Clein, and K. C. McDonald. 2007. Assessing the carbon balance of circumpolar arctic tundra using remote sensing and process modeling. Ecological Applications 17:213-234.

Wilson, H. M., P. L. Flint, and A. N. Powell. 2007. Coupling contaminants with demography: effects of lead and selenium in Pacific common eiders. Environmental Toxicology and Chemistry 26(7):1410-1417.

Wilson, H. M., P. L. Flint, T. L. Moran, and A. N. Powell. 2007. Survival of breeding Pacific common eiders on the Yukon-Kuskokwim Delta, Alaska. Journal of Wildlife Management 71(2):403-410.

Wipfli, M. S., J. S. Richardson, and R. J. Naiman. 2007. Ecological linkages between headwaters and downstream ecosystems: Transport of organic matter, invertebrates, and wood down headwater channels. Journal of the American Water Resources Association 43:72-85.

Wu, W., A. H. Lynch, S. Drobot, J. Maslanik, A. D. McGuire, and U. Hertzfeld. 2007. Comparative analysis of the Western Arctic surface climate among observations and model simulations. Earth Interactions 11(6): 24 pp.

Zhuang, Q., J. M. Melillo, A. D. McGuire, D. W. Kicklighter, R. G. Prinn, P. A. Steudler, B. S. Felzer, and S. Hu. 2007. Net emissions of CH_4 and CO_2 in Alaska: Implications for the region's greenhouse gas budget. Ecological Applications 17:203-212.

Technical Publications of Federal Staff

Hayes, D. J., L. Guo, A. D. McGuire. 2007. A scientific synthesis and assessment of the Arctic carbon cycle. AMAP/CliC/IASC Arctic Carbon Assessment Workshop, Seattle, WA, 27 February-1 March 2007. EOS 88(26):270.

Powell, A. N., and S. Backensto. 2007. Foraging ecology of common ravens (*Corvus corax*) on Alaska's Coastal Plain and its relationship to oil and gas development. Annual Report to the Coastal Marine Institute, University of Alaska Fairbanks.

Powell, A. N. and S. Backensto. 2007. Foraging ecology of common ravens (*Corvus corax*) on Alaska's Coastal Plain and its relationship to oil and gas development. Final Report, CMI, University of Alaska Fairbanks.

Taylor, A. R., A. N. Powell, and R. B. Lanctot. 2007. Pre-migratory movements and physiology of post-breeding shorebirds on Alaska's North Slope. Annual Report to the Coastal Marine Institute, University of Alaska Fairbanks.

Vorosmarty, C. J., A. D. McGuire, L. Hinzman, M. Holland, M. Murray, J. Schimel, W. Warnick, J. Weatherly, H. Wiggins. 2007. New perspectives through data discovery and modeling. Arctic System Synthesis Workshop, Seattle, WA, 2-4 April 2007. Eos 88(27):278.

Theses and Dissertations of Unit-Sponsored Graduate Students

Balshi, Michael S. 2007. The role of carbon dynamics in the boreal forest. PhD Thesis, University of Alaska Fairbanks. 193 pp.

Beier, Colin M. 2007. Regional climate, federal land management, and the social-ecological resilience of southeastern Alaska. PhD Thesis, University of Alaska Fairbanks. 227 pp.

French, H. Blair. 2007. Effects of bear viewers and photographers on brown bears (*Ursus arctos*) at Hallo Bay, Katmai National Park and Preserve, Alaska. MS Thesis, University of Alaska Fairbanks. 73 pp.

Gregovich, Dave. 2007. Landscape modeling of threespine stickleback occurrence in small southeast Alaska lakes. MS Thesis, University of Alaska Fairbanks. 109 pp.

Martin, Aaron E. 2007. Aquatic community responses to stream restoration: Effects of wood and salmon analog additions. MS Thesis, University of Alaska Fairbanks. 54 pp.

Martin, Kate H. 2007. Breeding ecology and fasting tolerance of scaup and other ducks in the boreal forest of Alaska. MS Thesis, University of Alaska Fairbanks. 102 pp.

Medhurst, Robert B. 2007. Headwater stream invertebrate communities: A comparison across ecoregions and logging histories. MS Thesis, University of Alaska Fairbanks. 94 pp.

Meixell, Brandt W. 2007. Population dynamics of tundra swans on the lower Alaska Peninsula. MS Thesis, University of Alaska Fairbanks. 95 pp.

Oehlers, Susan. 2007. Habitat selection and sightability of moose in southeast Alaska. MS Thesis, University of Alaska Fairbanks. 197 pp.

Parrett, Lincoln S. 2007. Summer ecology of the Teshekpuk Caribou Herd. MS Thesis, University of Alaska Fairbanks. 148 pp.

Peirce, Joshua M. 2007. Relationships between brown bears and chum salmon at McNeil River, Alaska. MS Thesis, University of Alaska Fairbanks. 84 pp.

Ritter, Joy. 2007. Species distribution models for Denali National Park and Preserve, Alaska. MS Thesis, University of Alaska Fairbanks. 159 pp.

Smikrud, Kathy M. 2007. A remote sensing-GIS based approach for assessment of Chinook salmon rearing habitat in the Unuk River floodplain. MS Thesis, University of Alaska Fairbanks. 170 pp.

Wilson, Heather. 2007. Population ecology of Common Eiders on the Yukon Kuskokwim Delta, Alaska. PhD Thesis, University of Alaska Fairbanks. 186 pp.

Research Reports

Reports are listed as Completed or Ongoing, in the categories of Aquatic, Terrestrial, or Ecological Studies. The List of Abbreviations appears on the final page of the report.

Completed Aquatic Studies

Landscape Modeling of Threespine Stickleback Occurrence in Small Southeast Alaska Lakes

Student Investigator: Dave Gregovich, MS Fisheries
Advisor: Mark Wipfli
Funding Agency: Sport Fish Division/ADFG (RSA Base Supplement)

Note: Dave Gregovich graduated from the University of Alaska Fairbanks in December 2007. His thesis abstract follows:

Although threespine stickleback (*Gasterosteus aculeatus* L.) are known to inhabit a wide range of habitats, their distribution across lakes in Southeast Alaska is not known. Threespine stickleback are an important prey item for many consumers in freshwater ecosystems. Additionally, isolated populations may be genetically unique and thus important from a conservation perspective. This study focused on identifying landscape factors and models useful in predicting the presence of threespine sticklebacks in small (0.5–5 ha) lakes of Southeast Alaska. Stickleback occurrence was assessed via snorkeling and minnow trapping in 54 lakes, which were divided into calibration (n=36) and prediction (n=18) data sets. A number of models representing four methodologies—generalized linear models, generalized additive models, classification trees, and artificial neural networks—were built based on the calibration set, cross-validated, and evaluated by prediction to the test set of lakes. Lake elevation, distance from saltwater, and slope of lake outlet stream were the most useful predictors of stickleback occurrence. Results suggest that the likelihood of stickleback presence is highest in low elevation lakes near the coast. Human development and recreational activity also tends to be common in these areas, and so land-use planning should account for the high potential of threespine stickleback here.

Aquatic Community Responses to Stream Restoration: Effects of Wood and Salmon Analog Additions

Student Investigator: Aaron Martin, MS Fisheries
Advisor: Mark Wipfli
Funding Agency: Chugach National Forest/USDA

Note: Aaron Martin graduated from the University of Alaska Fairbanks in August 2007. His thesis abstract follows:

Many aquatic ecosystems in the Pacific Northwest have been impacted by land use activities. Often these impacts have resulted in deleterious effects that directly or indirectly limited the capacity of habitat to produce fish. Habitat restoration potentially increases the quantity and quality of resources available to the aquatic communities within these impaired systems, thus increasing biotic integrity and fish procuction. In this study, responses of aquatic communities exposed to woody debris

bundle and salmon analog additions were measured in the year following creation of off-channel, fish habitat in southcentral Alaska. Biofilm, invertebrates and juvenile coho salmon, *Oncorhynchus kisutch*, were sampled in four treatment types (control, wood, analog, and analog+wood). Biofilm significantly increased in analog enriched treatments. No treatment effects were detected in benthic invertebrate responses, however, treatment differences were detected in coho diets. Coho density and standing stock were significantly higher in the wood treatment, and coho in the control treatment showed signs of density-dependent limitations. Condition for fish was highest in the analog enriched treatments after treatment additions. These results suggest salmon analog and woody debris bundle additions may be viable short-term restoration tools, providing a boost in food and shelter for aquatic communities in habitats undergoing restoration.

Headwater Stream Invertebrate Communities: A Comparison Across Ecoregions and Logging Histories

Student Investigator: R. Bruce Medhurst, MS Biology
Advisor: Mark Wipfli
Funding Agency: Bonneville Power Administration/DOE

Note: Bruce Medhurst graduated from the University of Alaska Fairbanks in August 2007. His thesis abstract follows:

Monitoring stream condition is not always conducted with understanding how climate may influence anthropogenic disturbances. Stream monitoring has traditionally been accomplished through sampling benthic invertebrates, while sampling drifting invertebrates as a potential monitoring tool has received little attention, in spite of drift often being easier and less expensive to sample. The objectives of this study were to understand how logging influences stream invertebrate communities (benthic and drift) across two ecoregions in the Cascade Range, central Washington, and to determine whether drift samples might serve as a replacement for benthic samples in assessing headwater stream condition. Benthic and drifting invertebrates were sampled from 24 headwater streams in logged and unlogged watersheds within two ecoregions (wet and dry), and community metrics contrasted. Invertebrate community responses to logging varied with ecoregion (e.g., higher shredder densities in logged watersheds of wet ecoregion only). Differences in benthic community structure were not reflected in the drift, and relationships between benthos and drift were highly variable. Although both sampling types (benthic, drift) revealed ecoregional and land-use (logging) differences in invertebrate communities, lack of consistent relationships between the sampling types suggests drift sampling does not provide more reliable information about stream benthos or headwater stream condition.

A Remote Sensing-GIS Based Approach for Assessment of Chinook Salmon Rearing Habitat in the Unuk River Floodplain

Student Investigator: Kathy Smikrud, MS Fisheries
Advisor: F. Joseph Margraf
Funding Agency: Sport Fish Division/ADFG (RSA Base Supplement)

Note: Kathy Smikrud graduated from the University of Alaska Fairbanks in May 2007. Her thesis abstract follows:

Remote sensing offers an alternative method to managers in mapping and monitoring the habitat within large rivers. Large rivers are not accommodating for traditional (foot) fish habitat surveys due to their size and typically complex habitat. This study investigates the use of digital aerial photos and thermal infrared images acquired in spring 2003-2005 to map and quantify juvenile Chinook salmon (*Oncorhynchus tshawytscha*) habitat in a 12-river km section of the Unuk River floodplain in Southeast Alaska. Images were processed and analyzed to produce a fluvial landscape classification (7 landcover classes with an overall classification accuracy of ~ 84%) using a combination of aerial and thermal images. Change detection of large woody debris (LWD) was also examined and revealed both quantitative and distributional changes during the 3 years. A GIS-based habitat suitability analysis was used to identify potential Chinook salmon rearing habitats including: river channel edges, sloughs, braids, pools associated with LWD and primary river channels. Overall 77.82 hectares of potentially medium/high Chinook rearing habitats were identified. Results from this study provide a promising foundation towards mapping and monitoring salmon habitat in large river systems for purposes of protection, conservation and monitoring to ensure sustainable stocks of salmon.

Ongoing Aquatic Studies

Variation in Age at Maturity Among Sockeye Salmon (*Oncorhynchus nerka)* Spawning Populations from Lake Clark, AK

Student Investigator: Elizabeth Benolkin, MS Fisheries
Advisor: F. Joseph Margraf
Funding Agency: USGS
Other Support: NPS

Poor returns of sockeye salmon to the Kvichak River watershed have been observed since 1996, and this decline is a priority concern for subsistence fishers and resource managers. Although the number of sockeye salmon that return to this system is highly variable, there is a lack of life history information characterizing various component populations of the Kvichak River. This study compared the marine age at maturity of sockeye salmon collected during 2002–2005 from nine Lake Clark, Alaska, spawning locations from three habitat types: rivers, tributary beaches, and main lake beaches. The influence of spawning location and brood year on marine age distribution (2 or 3 years) was estimated for each sex using logistic regression using a major tributary as a reference spawning location. Marine age distribution significantly differed across spawning locations for both sexes. Among females, most spawning locations were more likely to be comprised of younger fish (marine age 2) as compared to the major tributary. Among males, only one spawning location was more likely to be comprised of younger fish, while two spawning locations were more likely to be comprised of older fish (marine age 3) as compared to the major tributary. Sockeye salmon marine age distribution differed significantly across brood years for females, but not for males. These results will be synthesized with other life history information, including length at age, fecundity, and egg size, to develop accurate population models of Lake Clark sockeye salmon.

Assessment of Fish Condition in Arctic Ocean Nearshore Lagoons Using Bioelectrical Impedance Analysis

Student Investigator: Jeremy Carlson, MS Fisheries
Advisor: F. Joseph Margraf
Funding Agency: Fairbanks Fish and Wildlife Field Office/USFWS (RWO 137)
In-Kind Support: Vehicle, bunkhouse and technical assistance provided by Arctic National Wildlife Refuge/USFWS

Arctic nearshore habitats are important for many fish species to feed and grow. Warming trends in the Arctic and the threat of development could directly impact fish populations. Healthy fish populations are important to subsistence users and the arctic ecosystem in general. The objects of this study are to evaluate and calibrate the use of Bioelectrical Impedance Analysis (BIA) for determining fat content of fish as a means of accurately measuring fish condition in the field. Fish examined include immature and mature Arctic cisco, Arctic cod, Arctic flounder and Dolly Varden. Fish were captured in nets set in Jago and Kaktovik lagoons in summer 2005. BIA measurements were taken on sampled fish. These fish were then euthanized, homogenized, and sent to a laboratory to determine fat, protein, water, and ash composition. Preliminary laboratory results show an average increase of 7% crude fat content in Dolly Varden from the early to late season. Laboratory results will be used to calibrate the BIA measurements. It is expected that BIA will provide researchers with a quick, minimally invasive technique to evaluate fish condition in

the field. The prospect of oil development and the increase in Arctic temperatures may cause problems for fish species that use nearshore waters for feeding and growth. Reduction in the ability of fish to forage efficiently may directly affect subsistence users and the many arctic species that utilize them.

Geomorphology and Selection of Spawning Habitat by Inconnu: A Heuristic Model

Student Investigator: Theresa L. Tanner, MS Fisheries
Advisor: F. Joseph Margraf
Funding Agency: Fairbanks Fish and Wildlife Service Field Office/USFWS

Little is known about inconnu (*Stenodus leucichthys*) critical habitat needs. Current studies of inconnu spawning behavior suggest a high level of habitat selectivity. This selectivity implies there are specific habitat characteristics that these fish require for spawning. The purpose of this study was to build a heuristic habitat model that can be used to better understand inconnu spawning site selection within remote Alaskan watersheds. Using readily available, low, or no-cost remote sensing data layers, geographical information systems (GIS) were used in conjunction with multivariate statistics to elucidate relationships between geomorphologic features and spawning site selection. Landscape variables such as stream gradient may be correlated to habitat selection; however, the spatial resolution of the remotely sensed data used in this study did not provide sufficient spatial detail to generate correlations between spawning habitat selection and landscape variables with any certainty.

Thermal Limitations on Chinook Salmon Spawning Habitat in the Northern Extent of Their Range

Student Investigator: Sam Decker, MS Fisheries
Advisor: F. Joseph Margraf
Funding Agency: Sport Fish Division/ADFG (RSA Base Supplement)
In-Kind Support: Vehicle, technical assistance, and equipment provided by ADFG during the field season

Habitat limitations to spawning areas of Chinook salmon are largely unexplored in the northern regions where the runs remain strong and the habitats are generally in a natural state. Understanding the mechanism behind habitat selection will allow for critical habitat to be identified and estimation of the effects of temperature changes on the area of spawning habitat for Chinook salmon in the Chena River. Much research has occurred on upper thermal limits of Chinook salmon on highly modified rivers in California, Oregon, Washington, and British Columbia, but little work has been done on cold, northern rivers with healthy stocks. The object of this study is to use accumulated thermal units to determine the upstream and downstream extents of the Chinook salmon spawning habitat. Temperature loggers were placed at intervals along the Chena River. Accumulated Thermal Units will be compiled and thermal zones mapped with GIS. We predict the results will show a length of the Chena River that reliably achieves the required thermal units for Chinook salmon egg development with marginal areas upstream and downstream that may or may not be suitable habitat on any given year. Although moderately urbanized in its lower reaches, the Chena River has many qualities that make it a typical interior Alaska stream. If the habitat use by Chinook salmon can be better understood here, then this information may be transferable to other more remote systems.

Habitat Assessment of Juvenile Salmonid Populations with the Aid of Aerial Imagery of a Southcentral Alaskan Stream

Student Investigator: Jeff Perschbacher, MS Fisheries
Advisor: F. Joseph Margraf
Funding Agency: Sport Fish Division/ADFG, Region 2 (RSA)
In-Kind Support: Vehicle, technical assistance, and equipment provided by ADFG during field season; Quickbird satellite imagery provided by the Kenai Peninsula Borough

Summer rearing habitat and population distributions of juvenile salmonids have not been identified on the southern Kenai Peninsula. Access to upper sections of watersheds can be logistically difficult and costly. Steelhead trout are a valuable sport fish resource, while Chinook and coho salmon are important to subsistence, sport, and commercial fisheries. Little is known about freshwater habitat quality and quantity essential to sustain healthy populations in areas of increased recreation, residential, and commercial development. The objective of this study is to determine the summer distribution and freshwater habitat use of juvenile salmonids in the South Fork of the Anchor River. A GIS layer with ranked densities of juvenile salmonids (Chinook, coho, rainbow/steelhead) will be layered on top of ranked, in-stream physical habitat data extracted from aerial imagery, to visualize potential areas of high, medium, and low rearing habitat quality. Habitat field measurements from 18 sites throughout the watershed were collected July–September. Available aerial imagery will be used to assess the accuracy of measuring in-stream physical habitat. Snorkel surveys were conducted in summer 2007 to estimate densities of juvenile salmonid populations. A GIS layer of ranked habitat quality collected from aerial imagery will be overlaid on top of a ranked density of each juvenile salmonid layer to create a final layer of high, medium, and low rearing habitat quality. Traditional habitat assessment of juvenile salmonids is logistically challenging and can be costly. The alternative approach of using aerial imagery offers an affordable way to assess habitat characteristics that can be easily repeatable to monitor change. Identification of juvenile salmonid population densities and distribution can be combined with habitat characteristics in a GIS framework to be used by fisheries and land use managers to help sustain healthy salmonid populations.

Alternative Escapement Goals for Unuk River Chinook Salmon (*Oncorhynchus tshawytscha*)

Student Investigator: Christie Hendrich, MS Fisheries
Co-Advisors: Gordon Kruse and F. Joseph Margraf
Funding Agency: Sport Fish Division/ADFG, Region I (RSA)
In-Kind Support: Field accommodations, logistical assistance, and riverboat and other field equipment provided by ADFG

Establishing Chinook salmon (*Oncorhynchus tshawytscha*) escapement goals based on spawner-recruit relationships requires intensive stock assessment over many years and does not address productivity potential or limitation as a function of environmental (i.e. habitat) constraints or changes. Alternative escapement goal methods should be explored and evaluated against established biological escapement goals (BEGs) from quality stock assessment information. Chinook salmon play a key role in marine and freshwater ecosystems while providing for commercial, sport, and

subsistence users throughout the Pacific Northwest. Escapement goals are the tool by which valuable salmon stocks are managed for maximum sustained yield. The intent of this study is to explore habitat-based approaches to setting escapement goals for Chinook salmon on the Unuk River in southeast Alaska. The BEG for this system will serve as the benchmark against which alternative goals are measured. Spatially documented spawner densities on the Unuk River were recorded between 2003 and 2005. These densities and available habitat data are being investigated in three spawning habitat capacity models. The three habitat model approaches are intended to demonstrate variation in simplicity versus performance in contrast to each other and the spawner-recruit approach. Knowledge acquired about using the relationships between habitat and fish production in escapement goal models on the Unuk River may contribute techniques for using these types of models elsewhere in the future.

Reconstructing Salmon Runs Using Marine Derived Nutrients in Freshwater Mussels

Student Investigator: Andra Love, PhD Fisheries
Advisor: F. Joseph Margraf
Funding Agency: NPS to HDR Inc.
In-Kind Support: Field and office equipment provided by HDR Inc.

Alaska's Bristol Bay region supports a world-class salmon fishery that has recently experienced variable returns. An understanding of historical salmon presence in the Bristol Bay drainages would be beneficial in efforts to create responsive management plans to variability in fish returns. In addition, a gold mining project is proposed in a portion of the fishery's headwaters, creating a need to research baseline conditions in the region. Freshwater mussels are an effective tool for water quality monitoring and are being used for several studies in the area. The objectives of this study were to establish a nutrient baseline in the tissue of the mussels and to explore the use of nitrogen and sulfur ($\delta^{34}S$) isotopes (marine derived nutrient indicators) in the annual rings of the mussel shells for reconstruction of historical fluctuations in Bristol Bay salmon escapement. *Anodonta beringiana* mussels were collected from Katmai National Park in 2005 and from Iliamna Lake in 2005 and 2006. Katmai National Park mussel tissues were examined in 2005 to determine whether there are differences in $\delta^{15}N$ ratios between systems that receive MDN and systems that do not. Freshwater mussel shells were examined in 2006 for $\delta^{34}S$. Sample processing is ongoing. There was a statistically significant difference in $\delta^{15}N$ ratios between the systems that receive MDN and ones that do not in Katmai National Park. Samples from sites where salmon were present were generally more enriched in nitrogen isotopes. Sulfur isotope enrichment was detected in the freshwater mussel shells. The next step in the process is to test for individual rings and compare data to anadromous fish stream records. If it is proven that freshwater mussel annuli can be used as a proxy for historical salmon run abundance in a system, a low-cost method of establishing escapement data can be developed where such information does not currently exist. Freshwater mussels can be used as a tool for this purpose when sediment cores and other methods are not appropriate or are not cost effective.

Population Characteristics of Spawning Inconnu in the Sulukna River, Alaska

Student Investigator: David Esse, MS Fisheries
Advisor: F. Joseph Margraf
Funding Agency: Central Yukon Field Office/BLM
Other Support: DIDSON sonar unit and technical assistance provided by USFWS

Inconnu (*Stenodus leucichthys)* are an important subsistence and sport fish within Alaska. However, currently little is known of the abundance, timing, and structure of spawning inconnu populations within the Yukon River watershed. What is currently known is that they spawn in a very few discrete locations within the Yukon River watershed, making gathering of baseline population information in these areas necessary. For upcoming planning purposes it is important to know the abundance, timing, and age and length structure of these spawning populations on BLM lands. The objective of this study will be to document the outmigration timing, abundance, and age and length structure of outmigrating inconnu in the Sulukna River in 2008 and 2009. DIDSON sonar will be used to determine outmigration timing and enumerate outmigrating inconnu, and seine nets will be used to collect fish for biological data sampling. Understanding the population characteristics of spawning inconnu in the Sulukna River will aid managers in making informed decisions in regard to this fishery resource as well as aid in future research on inconnu in the Yukon River watershed.

Identification and Characterization of Inconnu (Sheefish) Spawning Habitat in the Sulukna River

Student Investigator: Jonathon Gerken, MS Fisheries
Advisor: F. Joseph Margraf
Funding Agency: Koyukuk/Nowitna National Wildlife Refuge/USFWS
In-Kind Support: Technical assistance and equipment during field season provided by the Fairbanks Fish and Wildlife Field Office/USFWS and the Northern Field Office/BLM

Sheefish are a highly valued resource by people residing throughout the Yukon River drainage. Subsistence users have voiced concern regarding an increased dependence on sheefish and other whitefish populations due to declining salmon populations. If increases in sheefish harvest are occurring, then the preservation of the spawning areas and their unique habitat features becomes extremely important for the viability of the Yukon River sheefish population. However, spawning habitat site selection of sheefish is largely unknown in the Yukon River drainage. The object of this study is to quantify the habitat features of sheefish spawning sites. Information will be applied to identify other spawning areas in the Yukon River drainage. Fish were sampled by hook and line in September and October 2007 to identify spawning areas. Habitat information was collected when sheefish presence was identified. Spawning sheefish appeared to select areas where upwelling groundwater was occurring. Areas of upwelling are a result of river habitat features such as sinuosity, substrate, geology, and gradient. Management of a fishery for long-term sustainability requires an understanding of the species life history. This understanding does not exist for sheefish in the Yukon River drainage. Results of this project will assist managers in development of management plans and prescriptions.

Fall Chum Spawning Habitat in the Mainstem Tanana River

Student Investigator: Lisa South, MS Fisheries
Co-Advisors: F. Joseph Margraf and Amanda Rosenberger
Funding Agency: Commercial Fisheries Division/ADFG

Chum salmon are extremely important for subsistence and commercial fisheries in Alaska. Increasing development and recreational use along the Tanana River poses possible habitat degradation concerns, and a greater knowledge of this area is needed for better management and research. However, spawning habitat by fall chum salmon is largely unknown in the mainstem area of the Tanana River. The objectives of this study are to determine fall chum spawning in the mainstem Tanana and proximity to upwelling areas, characterize habitat preferences, and create predictive habitat models. Fish are implanted with radio-transmitters and movements will be tracked through two spawning seasons. Upwelling areas are mapped during winter months (ice-free zones) and will be confirmed by aerial thermal imaging. It is currently thought that chum salmon select upwelling sites for spawning habitat due to increased water temperatures throughout winter months to aid in egg incubation. Data collected will be analyzed to determine if there is a correlation and will then be used to create predictive habitat models. This analysis will allow better management decisions and could possibly be applied to other rivers within Alaska to create more cost-effective management and research.

Spatial Subsidies from Headwater Streams to Fish-Bearing Habitats Across Climatic and Disturbance Gradients in the North Cascade Mountains

Investigator: Christopher Binckley, Postdoctoral Fellow
Principal Investigator: Mark Wipfli
Funding Agency: Bonneville Power Administration/DOE
In-Kind Support: Technical assistance and equipment provided by the USDA Forest Service

Headwater streams provide ecosystem services (e.g., energy and nutrients) for downstream consumers (e.g. fish), yet how regional climate and local land-use interact to influence the magnitude of these subsidies is poorly understood. Quantifying how timber harvest surrounding headwater streams differs among larger scale ecological subregions is needed to predict how headwater streams might affect fish populations and downstream riverine ecosystems. The objective of this study was to determine how timber harvest and ecological subregion (climate) affect the downstream transport of invertebrate, organic, and inorganic material. We measured the amount of invertebrate, organic, and inorganic material transported to fish habitats from 60 fishless headwater streams in the Wenatchee River Basin of the North Cascade Range. Streams were categorized into four groups based on ecological subregion (wet or dry), and extent of past timber harvest (high or low). The magnitude of headwater stream resources transported downstream reflect both the smaller scale land-use surrounding headwater streams and the larger scale climatic region in which they occur. Significantly more invertebrates were transported from dry ecoregion streams, while organic and inorganic material transport was significantly higher in high timber harvest sites. Headwater streams dominate the total stream number, channel length, and catchment area of larger drainage networks. Predicting the magnitude of downstream transport from these sites, and the consequences this may have on consumer populations, requires an

understanding of how both local land-use and regional climate influence these subsidies.

Do Drifting Invertebrates Originating from Fishless Headwater Streams Benefit Downstream Fish?

Student Investigator: Elizabeth Markley, MS Biology
Advisor: Mark Wipfli
Funding Agency: Bonneville Power Administration/DOE
In-Kind Support: Pacific Northwest Research Station/USDA Forest Service

It is not clear if and to what extent small, fishless headwater streams affect fish communities downstream, and if the food (invertebrates) transported from these headwater streams is crucial prey for these downstream fish. Often legal protection from resource management activities such as timber harvest applies only to streams bearing fish. Yet the influence of small, fishless streams on fish in areas fed by those fishless headwaters is not understood. In order to understand how management activities in fishless streams affect fish downstream, we must understand trophic connections between organisms in these bodies of water. The objective of this study is to determine how drifting invertebrates from fishless headwater stream reaches affect downstream fish communities. The biomass of drifting invertebrates at the uppermost barrier to fish within several small headwater streams was correlated to fish biomass and growth downstream. Further, invertebrate biomass was manipulated (blocked or supplemented) in several headwater streams to determine the effects of altering food supply on fish. Samples are currently being processed so results are not available yet, but a positive correlation between biomass of drifting invertebrates and biomass of fish is expected. If fishless headwater streams are important food sources for fish downstream, the fish-bearing criterion qualifying a stream for buffer protection may not be sufficient to protect fish and therefore may need to be adjusted to better conserve fish populations and their associated aquatic habitats.

Tracking the Presence and Effects of Marine-Derived Nutrients in Southcentral Alaska Watersheds

Student Investigator: Daniel J. Rinella, PhD Biology
Advisor: Mark Wipfli
Funding Agency: Gulf Ecosystem Monitoring Program/EVOS
In-Kind Support: Bunkhouse and lab space in Homer and Cooper Landing, respectively, provided by Kachemak Bay Research Reserve and USDA Forest Service; thesis preparation support provided by Environment and Natural Resources Institute/UAA

Little is known about the watershed-scale distribution and effects of marine-derived nutrients and carbon (MDN) delivered to streams by spawning salmon. MDN can greatly increase stream productivity and the fitness of stream-rearing fishes, and understanding these effects at broad spatial scales is necessary for sound fisheries management. Our objectives were to track MDN and measure effects in stream and riparian environments at the watershed scale and to understand the relationship between spawner abundance and the fitness of rearing fishes. During 2004 and 2005 our approach was to link stream chemistry, stable isotope, and fatty acid measures along a gradient from headwaters to mouth in nine watershed (six with salmon,

three without) in three regions of the Kenai Peninsula. During 2006 we measured juvenile coho salmon and Dolly Varden fitness parameters during spring and fall in 12 salmon streams representing a large range of spawner densities. Large fluxes of dissolved nutrients (nitrogen and phosphorus) coincided with salmon spawning and increased in a downstream direction. Macroinvertebrates and riparian plants generally showed isotopic enrichment that increased in a downstream direction, but isotope ratios were highly variable and did not appear to be a reliable predictor of MDN inputs. Dolly Varden fatty acids signatures and lipid levels suggest that increased energy storage is associated with MDN consumption and that larger Dolly Varden disproportionately capitalized on MDN. Our data suggest that stream-resident fishes are the most reliable integrators and indicators of MDN at watershed scales. Current effort is focusing on the relationship between spawning salmon abundance and stream-resident fish growth and fitness as a tool for guiding ecologically based salmon escapement goals.

The Role of Marine-Derived Nutrients in the Health and Sustainability of Resident and Anadromous Fishes of the Yukon River Drainage

Student Investigator: Chrissy Apodaca, PhD Biology
Advisor: Mark Wipfli
Funding Agency: Science Support Program/USGS
In-Kind Support: Logistical and equipment support provided by USFWS

Little is known about the presence and role of marine-derived nutrients (MDN) in the Yukon River watershed. MDN from adult salmon may influence the health and sustainability of fish that occur in and near salmon spawning areas. Yukon River salmon support important subsistence and commercial fisheries in both Alaska and Canada. Multi-species and ecosystem-level effects of marine subsidies remain poorly understood, particularly in large, complex river systems like the Yukon drainage. The objectives of this study are to determine (1) the biological extent of MDN in riverine ecosystems (e.g., measure how much MDN are assimilated by resident and anadromous fish), (2) the magnitude of MDN influence across broad geographic scales (Yukon Delta, Yukon Flats, Yukon River headwaters in Canada), (3) if certain fishes benefit from the spawning runs of others (e.g., do Chinook juveniles and resident fishes benefit from chum runs?), and (4) the role and significance of MDN in fish health. Stable isotopes (carbon, nitrogen, and sulfur) and fatty acid analyses were used to track the presence of MDN in fishes. Tissue samples were collected from one anadromous species (Chinook salmon) and two resident species (Arctic grayling and slimy sculpin) at sites representative of geographically distinct regions of the Yukon drainage (Yukon Delta and Yukon Flats National Wildlife Refuges, and Yukon Territory, Canada). Samples for 2006 and 2007 are being processed and analyzed. Incorporating nutrient information into salmon escapement management may enhance current management techniques. Research focused on MDN can provide managers with information about how the magnitude of salmon runs may be linked with habitat quality for fish that rear in freshwater environments.

Interdisciplinary Approaches to River Management in Southcentral Alaska

Student Investigator: Meagan Boltwood Krupa, MS Environmental Science
Advisor: Mark Wipfli and F. Stuart Chapin
Funding Agency: NSF IGERT Fellowship

Managers and decision makers are individually struggling to manage Anchorage's freshwater fisheries as the effects of urban development increase, but many of these efforts have unintentionally undermined other efforts. Streambank stabilization is the most obvious example of this disconnect. Over the last five years, at least two projects on Anchorage's Ship Creek mitigated earlier stream restoration projects conducted by different agencies. Despite years of heavy use, the uniqueness and accessibility of the popular downtown Ship Creek fishery continue to attract attention. This project is important because it will increase decision makers' understanding of complex systems and lessen the impact of urban development on salmon populations through enhanced collaboration. The goals of this work are to (1) identify the strengths and weaknesses of river management in Southcentral Alaska by examining Anchorage's Ship Creek; (2) define the economic, social, and ecological measures of success for restoration efforts, and (3) determine what can be done to increase the overall success of these river restoration efforts. These objectives will be accomplished by (1) assessing the effectiveness of current salmon management policies on Anchorage's Ship Creek through the theoretical application of robustness theory; (2) conducting a review of past river restoration projects in Southcentral Alaska via comparative case study research, and (3) redefining river restoration goals/objectives, techniques and monitoring procedures. The anticipated results of this study include determining how to redefine and implement current river restoration goals/objectives to better address short- and long-term social, economic, and ecological goals. Data from this study will contribute to the long-term goal of conserving Anchorage's creeks and salmon populations for the economic benefit and ecological enjoyment of future generations. The results will be useful to the greater science community, Alaskan communities, funders, statewide managers, and policy makers, including the Municipality of Anchorage, Mat-Su and Kenai Boroughs, Alaska Department of Fish and Game, U.S. Fish and Wildlife Service, and National Marine Fisheries Service.

Ecology and Demographics of Chinook Salmon

Student Investigators: Emily Benson, MS Biology; Matthew Campbell, PhD Biology; Laura Gutierrez, MS Biology; Jason Neuswanger, MS Fisheries; and Megan Perry, MS Biology
Advisor: Mark Wipfli
Funding Agency: Arctic-Yukon-Kuskokwin Sustainable Salmon Initiative
Additional Support: Logistical support provided by Sport Fish Division/ADFG

It remains unclear the extent to which environmental variables such as food, flow, temperature, etc., limit Chinook salmon populations in fresh water. Chinook salmon are a vital economic, subsistence, and cultural resource in Alaska. However, annual productivity is highly variable. The processes that drive population fluctuations are poorly understood. Better predictions of fish production would increase efficiency of the resource utilization and decrease the reliance on in season management techniques. The objectives of this study are to determine which and to what extent environmental variables regulate productivity and variability of the Salcha and Chena Chinook salmon stocks. Initial pilot sampling got underway during the 2007 season,

with 2008 and 2009 expected to be full study seasons. We are sampling a multitude of chemical, physical, and biological variables in the Chena River including stream nutrients (N, P), stream flow, water temperature, discharge, food supplies (aquatic and terrestrial invertebrates), large wood, pool depth and frequency, and other variables. Juvenile salmon population densities will be analyzed against these variables to determine if these variables regulate juvenile Chinook salmon populations, and if so, when and to what extent. Initial observations suggest that several of these variables are playing a role in regulating juvenile Chinook salmon abundance and distribution throughout the Chena drainage. Long-term preservation of Chinook salmon as a resource will have numerous benefits to people in the state of Alaska. Determining which environmental variables are the key drivers in Chinook productivity will improve management of these and other salmonid species throughout Alaska.

Completed Wildlife Studies

Population Ecology of Common Eiders on the Yukon Kuskokwim Delta, Alaska

Student Investigator: Heather Wilson, PhD Biology
Advisor: Abby Powell
Funding Agency: Yukon Delta National Wildlife Refuge/USFWS; Alaska Science Center/USGS; Sea Duck Joint Venture; and Angus Gavin Memorial Bird Research Grant

Note: Heather Wilson graduated from the University of Alaska Fairbanks in May 2007. Her thesis abstract follows:

Knowledge of ecological factors that influence birth, death, immigration, and emigration provide insight into natural selection and population dynamics. Populations of Pacific common eiders (*Somateria mollissima v-nigrum*) on the Yukon-Kuskokwim Delta (YKD) in western Alaska declined by 50-90% from 1957 to 1992 and then stabilized at reduced numbers from the early 1990's to the present. This study investigates the primary underlying processes affecting population dynamics of Pacific common eiders, with the goals of understanding factors that may have led to the observed decline and subsequent stabilization, and providing tools from which conservation, management, and recommendations for future research can be drawn. I examined variation in components of survival and reproduction in order to test hypotheses about the influence of specific ecological factors on life history variables and to investigate their relative contributions to local population dynamics. These analyses include data I collected from 2002 to 2004, in addition to historical data collected from 1991 to 2001. Apparent survival of adult females was high and relatively invariant, while components of reproduction were low and variable, both within and among individuals. Timing of nesting and seasonal declines in clutch size and nest survival indicated that females in the early and mid parts of the breeding season produced the highest numbers of offspring; suggesting directional selection favoring early nesting. Probability of a nest containing ≥ 1 nonviable egg was positively related to blood selenium concentrations in hens, but no other contaminant-related reductions in life history variables were found. All estimates of population growth (λ) indicated that the YKD population was stable to slightly increasing during the years of the study (range λ: 1.02-1.05 (CI: 0.98-1.11)), and would respond most dramatically to changes in adult female survival. However, historical fluctuations in λ were primarily explained by variation in reproductive parameters, particularly duckling survival. Practical options for increasing adult survival may currently be limited. Thus, enhancing productivity, particularly via methods with simultaneous positive effects on adult survival (e.g., predator removal), may offer a more plausible starting point for management aimed at increasing population growth.

Breeding Ecology and Fasting Tolerance of Scaup and Other Ducks in the Lower Boreal Forest of Alaska

Student Investigator: Kate Martin, MS Wildlife
Advisor: Mark Lindberg
Funding Agency: Yukon Flats National Wildlife Refuge (RWO 142)

Note: Kate Martin graduated from the University of Alaska Fairbanks in August 2007. Her thesis abstract follows:

Information on the breeding ecology of boreal forest ducks is lacking, despite management concern for species such as the lesser scaup (*Aythya affinis*), whose population has declined markedly since the 1980s. The mechanisms impacting population growth of scaup, and which component of their population dynamics is most affected, are unknown. Previous investigators hypothesized that food deprivation in the spring may reduce breeding success. My objectives were to: 1) examine reproductive parameters of lesser scaup and other ducks on the Yukon Flats in interior Alaska, and 2) measure the tolerance of captive scaup to fasting, in comparison to sympatric Northern shovelers (*Anas clypeata*) and American wigeon (*Anas americana*). Although breeding probability of paired females was assumed to be 1.0, the breeding probability of paired female scaup was between 0.12 (SE = 0.05, n=67) to 0.68 (SE = 0.08, n=37), and was positively related to body mass. These results suggest that managers may overestimate the productivity of boreal ducks using traditional survey methods. In addition, captive female scaup completely recovered from a loss of 11% body mass in only four days, suggesting that mass loss can be rapidly reversed, and may be able to obtain the body condition required for reproduction, if food supplies are adequate.

Population Dynamics of Tundra Swans on the Lower Alaska Peninsula

Student Investigator: Brandt Meixell, MS Biology
Faculty Advisor: Mark Lindberg
Funding Agencies: Izembek National Wildlife Refuge/USFWS (RWO 143); DBW and IAB/UAF

Note: Brandt Meixell graduated from the University of Alaska Fairbanks in May 2007. His thesis abstract follows:

This study was initiated in response to concerns regarding apparent declines in abundance and breeding pair density of tundra swans on and adjacent to Izembek National Wildlife Refuge (NWR) on the lower Alaska Peninsula. I conducted an analysis of long-term data (1978–1996) to estimate demographic parameters and assess the relationship between survival probabilities and a number of environmental and ecological factors. Rates of productivity (egg, nest, cygnet survival) and annual rates of apparent adult survival were lower and more variable than previously observed for other swan populations and species. A negative relationship between nesting success and brown bear density indicates that depredation by bears is a primary determinant of tundra swan reproductive success. Changes in apparent survival probability were primarily influenced by high and variable rates of permanent emigration. Because of low rates of production and apparent survival, immigration by swans from other breeding areas may be important for sustaining a breeding population of tundra swans on and adjacent to Izembek NWR.

Habitat Selection and Sightability of Moose in Southeast Alaska

Student Investigator: Susan Oehlers, MS Biology
Advisors: Falk Huettmann
Funding Agency: Bureau of Indian Affairs; USDA Forest Service

Note: Susan Oehlers graduated from the University of Alaska Fairbanks in May 2007. Her thesis abstract follows:

We examined the role of scale and sex in habitat selection by radiocollared Alaskan moose (*Alces alces gigas*) on the Yakutat forelands, Alaska, USA. We used conditional logistic regression to quantify differences in habitats selected between sexes and seasons at 3 different spatial scales (250, 500, and and 1000 m), and multi-response permutation procedure (MRPP) to test for differences in spatial distribution between the sexes. Sexes selected for habitats similarly during the mating season, when sexes generally were aggregated, whereas sexes exhibited differential habitat selection during the non-mating season when sexes were segregated. Both sexes selected habitats at the 1000 m scale; models limited to 2 variables, however, demonstrated differences in scales selected by the sexes. There was a significant difference between male and female spatial distribution during all months (MRPP; P <0.0001), and distances between individuals were higher in females than in males, particularly during spring. We also developed a sightability model for moose with logistic regression, and used Distance Sampling to develop sightability correction factors (SCFs). Application of the sightability model and Distance Sampling to a sample data set of 600 moose yielded population estimates of 652–1124 ($\bar{x}$ = 755) and 858–1062 ($\bar{x}$ = 954) moose, respectively.

Summer Ecology of the Teshekpuk Caribou Herd

Student Investigator: Lincoln Parrett, MS Wildlife
Advisor: Brad Griffith
Funding Agencies: Division of Wildlife Conservation/ADFG; Department of Wildlife Management/NSB

Note: Lincoln Parrett graduated from the University of Alaska Fairbanks in May 2007. His thesis abstract follows:

The summer range of the Teshekpuk Caribou (*Rangifer tarandus granti*) Herd is currently undergoing the initial stages of petroleum exploration and development. Pre-development baseline information is necessary to interpret post-development distribution and habitat selection of caribou and to develop mitigation measures. We estimated bi-weekly distributions, diet and habitat selection by caribou during the summers, 2002-2004, based on aerial relocations of 21-49 radio-collared females. Little or no habitat selection was detected when comparing used locations to habitat available within bi-weekly utilization distributions. Habitat selection was much stronger when comparing bi-weekly utilization distributions to the remaining area of summer use. At the latter scale of analysis, there were dynamic temporal patterns in resource selection by caribou. High air temperature was strongly avoided throughout July. Tussock tundra was avoided early in the summer, but selected during August. Wet sedge was selected in June and from late-August through September. Estimates of dietary nitrogen content indicated that high nitrogen concentrations are available only for a short period in early summer, and declined well before forage biomass.

Predicted dietary nitrogen concentration appeared to be much lower for the Teshekpuk Caribou Herd than for the Porcupine Caribou Herd. Successful mitigation measures for petroleum development in NPR-A will need to be spatially and temporally tailored to observed dynamic patterns in caribou resource selection. Future work should estimate the performance of caribou (e.g., survival or weight gain) in relation to habitat quality and use in order to confirm the value of selected habitats and to enhance the robustness of mitigation measures.

Relationships Between Brown Bears and Chum Salmon at McNeil River, Alaska

Student Investigator: Joshua Peirce, MS Wildlife
Co-Advisors: Mark Wipfli and Erich Follmann
Funding Agency: Wildlife Conservation and Commercial Fisheries Divisions/ADFG

Note: Josh Peirce graduated from the University of Alaska Fairbanks in August 2007. His thesis abstract follows:

Since 1967, the McNeil River State Game Sanctuary (MRSGS) has been managed by the Alaska Department of Fish and Game to "provide permanent protection for brown bears." Up to 144 bears have been identified in a summer at MRSGS, and 72 bears at once have been observed in the vicinity of McNeil Falls. In this study, 155 chum salmon were radio tagged as they entered McNeil River and monitored daily. In 2005 and 2006 bears killed 48% of pre-spawning tagged chum salmon and consumed 99% of all tagged chums below McNeil Falls where most of the run occurs. A retrospective analysis of 31 years of run data using a new stream life, and a correction for observer efficiency, revealed that the current escapement goal of 13,750-25,750 actually represents 34,375-64,375 chum salmon. Considering the large removal of pre-spawning chum salmon, I recommend an additional 23,000 chum salmon be added to the escapement goal. Additionally, an annual escapement of 4,000-6,000 chum salmon above McNeil Falls should be set as an objective. These recommendations should encourage increased chum salmon returns, providing both food for McNeil bears, as well as benefiting the commercial fishery with increased harvest opportunities.

Effects of Bear Viewers and Photographers on Brown Bears (Ursus arctos) at Hallo Bay, Katmai National Park and Preserve, Alaska

Student Investigator: H. Blair French, MS Wildlife
Advisor: Erich Follmann
Funding Agency: National Park Service

Note: Blair French graduated from the University of Alaska Fairbanks in May 2007. His thesis abstract follows:

We investigated the effects of bear viewing and photography on brown bears (*Ursus arctos*) that used open habitats at Hallo Bay, Katmai National Park and Preserve (KNPP), Alaska. We also investigated how bear use of the area varied with season, human presence, and time of day. We found that the mean number of bears present varied significantly with season, time of day, and human presence. There were significantly more bears present before the salmon season than during the salmon season; bear numbers increased significantly during the day, and there were

significantly more bears when humans were present. Humans at varying distances least affected activity budgets of sows with spring cubs, but foraging efficiency (bites per minute) of sows with spring cubs was significantly lower with humans <50 m away than with humans absent. Fishing success (chases per catch) of large males and single bears was lower when humans were present, but fishing success of sows with spring and older cubs was higher when humans were present. We conclude that humans are affecting brown bears that use Hallo Bay and therefore the Katmai NPP Bear Management Plan is being violated as well as the act establishing the National Park Service. We recommend that managers at KNPP restrict visitor use at Hallo Bay and enforce existing policy.

Species Distribution Models for Denali National Park and Preserve, Alaska

Student Investigator: Joy Ritter, MS Biology
Co-Advisors: Eric Rexstad and Falk Huettmann
Funding Agency: Denali National Park/NPS (RWO 129)

Note: Joy Ritter graduated from the University of Alaska Fairbanks in May 2007. Her thesis abstract follows:

The objective of this study is to explore the use of existing data to model the distribution of four species in Denali National Park; caribou, moose, grizzly bear, and wolf. Radiolocation data consisting of 1331 locations collected over three years for female caribou, 1329 locations collected over three years for female moose, 6579 locations collected over ten years for grizzly bears, and 2686 locations collected over three years for wolves were obtained from park biologists. A geographic information system was used to derive landscape characteristics associated with the animal locations and random locations placed in the same area. Caribou models were developed at three spatial scales with three different algorithms. Classification tree models showed a high prediction success, correctly classifying 75 to 94 percent of randomly withheld animal locations. Fall models for female caribou had the poorest prediction ability while summer models for female grizzly bears performed best. Topographic landscape characteristics such as elevation and terrain ruggedness were important classifiers for most of my prediction models. Distribution maps were developed for individual and multiple species during different seasons. Areas of moderate elevation along the north side of the Alaska Range are important for all our study animals.

Ongoing Wildlife Studies

Ecology of Staging Shorebirds on Alaska's North Slope Coast

Student Investigator: Audrey Taylor, PhD Biology
Advisor: Abby Powell
Funding Agencies: Coastal Marine Institute, UAF/MMS; Angus Gavin Migratory Bird Research Fund; Quick Response Program, Migratory Bird Management, and Arctic National Wildlife Refuge/USFWS; Arctic Field Office/BLM; BPXA, Inc.; and ConocoPhillips Alaska Inc.
In-Kind Support: Technical assistance and equipment use during the field season

Little information exists on the abundance and distribution, length of stay, or movement patterns of staging shorebirds across the North Slope coast. This information is critical for evaluating the potential impacts of industrial development and climate change, because contamination from oil spills or erosion/inundation of coastal wetlands may impact large numbers of staging birds. Our study objectives were (1) to estimate the abundance and distribution, and (2) to document length of stay (LOS) and movement patterns of post-breeding shorebirds along the North Slope coast. We used a combination of ground camps and aerial surveys to examine abundance and distribution through time and space and to deploy and track radio-transmitters to determine LOS and movement patterns. Hotspots of shorebird abundance occurred at Peard Bay, Elson Lagoon, Dease Inlet, Pogik Bay, and Beaufort Lagoon. We estimated the density of staging shorebirds to be 86 ± 14 individuals (all species combined) per km^2. LOS across all species averaged 6.5 ± 1.5 days, but our second-best model supported species-specific differences. The majority of our data on movement patterns come from Semipalmated Sandpipers, which moved north along the Chukchi Sea and/or east along the Beaufort Sea to the Canning River Delta over the course of 1-4 days. Shorebirds are non-uniformly distributed on the North Slope coast; thus human activity and industrial development during late summer in heavily used areas may affect a disproportionate number of individuals. Because LOS and movement patterns are species-specific, effects of development and climate change should be evaluated at the species level.

Tundra-Nesting Shorebirds in Relation to Landscape Transformation and Climate Change

Student Investigator: Nathan Coutsoubos, PhD Biology
Advisor: Falk Huettmann
Funding Agency: BLM (RWO 155); USFWS
In-Kind Support: USFWS provided technical assistance, housing, and equipment in the field

Many shorebird species worldwide are in decline. Tundra-nesting shorebirds around Barrow, Alaska, are threatened by long-term trends like climate change and short-term trends such as landscape transformation via urbanization. Shorebirds are an important component of the tundra ecosystem. Species composition may be affected at the local level by tundra drying due to climate change; and abundance, timing of breeding, and nesting success may be affected by an increase in Barrow's urban footprint. The objects of this study are first, to determine quantitatively if the abundance of local shorebirds has changed since 1979; and second, to determine if abundance and nesting success are affected by construction of a new municipal landfill. Birds were surveyed using Distance Sampling methods in two general areas:

on survey routes from the 1970s, and in and around the new landfill. Nesting success was determined by monitoring shorebird nests in and around the new landfill using a specific survey design. Analyses are ongoing and will be completed in the next two years. Preliminary results indicate that landfill construction and associated landscape transformation create pockets of habitat that undergo snowmelt about a week earlier than the surrounding tundra, creating important early-season feeding habitat with dense concentrations of birds. Analyses from 1970s comparisons are in progress. Given a warming environment and an increase in the urban footprint all across the Arctic, and given both legal and local interests in protecting wildlife, it is important to understand the impacts on shorebird species as their tundra habitat changes in order to manage proactively. Sustainability of local wildlife resources depends in part on the impacts of local-scale changes such as this study addresses.

Breeding Biology of King Eiders at Teshekpuk Lake and the Kuparuk Oilfields

Student Investigator: Rebecca McGuire Bentzen, PhD Biology
Advisor: Abby Powell
Funding Agencies: Coastal Marine Institute/UAF; ConocoPhillips Alaska, Inc.; BLM; NSB; MMS; and USGS

Little is known about the breeding biology of king eiders (*Somateria spectabilis*) and the potential impacts of development on their breeding grounds. The National Petroleum Reserve-Alaska (NPR-A) northeast planning area has the highest known density of nesting king eiders in Alaska and is being leased for oil and gas exploration. Our objectives were to estimate nest survival, factors influencing nest site choice, and incubation behavior in both an undisturbed and disturbed area. Additionally, we evaluated the nutritional state of incubating females at both sites. Accessible areas around Teshekpuk Lake and Kuparuk were searched for nesting King Eiders from 2002 through 2005. We located and monitored nests (~40/site/year), measured habitat characteristics of nest and random sites, placed data loggers in nests to monitor incubation constancy, and trapped females to take blood samples. Nest success was higher at Kuparuk, when nests were undisturbed by observers, and post-fox control. Incubation constancy was slightly higher at Kuparuk than at Teshekpuk, and females appeared to be primarily reliant on endogenous reserves to maintain high nest attendance rates, but did feed during incubation. The NPR-A is the center of the breeding distribution and the area of greatest nest density of King Eiders in Alaska and is being leased for development, so it is important to have information on the reproductive parameters of King Eiders in both an undisturbed and a disturbed area.

Factors Influencing Winter Movements of King Eiders in the Bering Sea

Student Investigator: Steffen Oppel, PhD Biology
Advisor: Abby Powell
Funding Agencies: USGS OCS Program
In-Kind Support: NSB

Many migratory birds are assumed to remain stationary in a small area during winter. However, recent research indicates that midwinter movements are evident in several bird species, and the factors causing those movements are poorly understood. King Eiders (*Somateria spectabilis*) breeding in Alaska winter in the Bering Sea. Unlike other sea ducks, some King Eiders move long distances during

winter and use several winter sites each year. We examined winter movements of King Eiders to explore whether environmental factors such as day length, sea ice, and food abundance could explain the occurrence of winter movements longer than 50 km. We tracked 95 birds with implanted satellite transmitters for one year and obtained online environmental data for every location during the winter period. We then used a multivariate algorithmic model to identify which factors are important for King Eiders to decide whether to stay at or depart from a winter site. Departure decisions of wintering King Eiders were highly variable among individuals. We conclude that individual strategies exist that interact with environmental conditions to form multiple movement patterns. Only a minor proportion of winter movements may be forced by environmental conditions. We propose that many winter movements may be of an exploratory nature where individuals aim to acquire information about alternative winter sites that may enhance their survival probability at some point in time when environmental fluctuation renders their preferred winter site unsuitable. This variable behavior may enable King Eiders to rapidly adjust to environmental changes resulting from global warming.

Physiological and Dive Performance Effects of Implantable Satellite Transmitters on Common Eiders (*Somateria mollissima*)

Student Investigator: Christopher Latty, MS Biology
Co-Advisors: Abby Powell and Tuula Hollmen
Funding Agencies: Alaska Science Center/USGS; Alaska SeaLife Center; Fairbanks Field Office/USFWS
In-Kind Support: Alaska SeaLife Center

Small surgically implanted satellite transmitters have been used to delineate populations and identify movement patterns of sea ducks. However, little is known about how transmitters may affect their carriers. Implanted transmitters could potentially affect the health of the carrier and/or the validity of collected data. Our objective was to test if clinical condition, biomarkers, mass, or dive performance were affected by surgery and/or the carrying of a transmitter. We trained six captive common eiders to dive 4.9 m for their food and then surgically implanted each with a satellite transmitter. We conducted clinical evaluations and collected biological samples, mass data, and video footage of foraging dives prior to surgery and at staggered intervals post-surgery. Preliminary analysis suggests many biomarkers are altered for the first few weeks after surgery, with most returning to baseline levels by 2 months. Hematocrit, β- and γ-globulins were the only markers deviated 2-3.5 months after transmitter implantation. We found dive speeds were slower for most investigated dates after surgery, with ascent slower for 2 months and descent slower for 3.5 months after implant. Additionally, we found dive duration and foot beat frequency while foraging on bottom were affected. Knowledge of sea duck movement patterns and phenology (including that of threatened species) is increasingly being determined by implanted transmitters. Scientists should consider our results and how they may affect the fitness, condition, and acquired data when designing studies and analyzing information from studies utilizing PTTs in sea ducks. Based on our findings, research on improved implant procedures and transmitter design is warranted.

Large-scale Habitat Requirements of Breeding Black Terns

Student Investigator: Valerie Steen, MS Wildlife
Advisor: Abby Powell
Funding Agency: Region 6/USFWS (RWO 156)
In-Kind Support: Personnel provided by USFWS

Black Terns are a species of concern due to habitat loss on the breeding grounds and population declines. They nest semi-colonially in freshwater wetlands and require a larger foraging area that includes neighboring wetlands and uplands. While the type and quality of foraging area may be critical to nest-site selection and reproductive success, little is known about these large-scale requirements. The objective of this study is to develop a model of black tern occurrence based on large-scale habitat features. Surveys for nesting black terns will be conducted beginning this spring (2008) in participating Wildlife Management Areas and National Wildlife Refuges throughout USFWS Region 6 (ND, SD, UT, KS, CO, MO, WY, NE). Large-scale habitat features such as wetland size, area of neighboring wetland, and upland habitat type (grassland or tilled) are expected to be important predictors of black tern occurrence. The results of this large-scale habitat analysis will help guide regional conservation planning for black terns.

Breeding Ecology of Common Ravens (*Corvus corax*) on Alaska's Coastal Plain in Relation to Oil and Gas Development

Student Investigator: Stacia Backensto, PhD Biology
Advisor: Abby Powell
Funding Agency: Coastal Marine Institute/UAF, BLM, BP Exploration AK Inc., Center for Global Change/UAF, ConocoPhillips Alaska, Inc., USFWS, NSB, Regional Resilience and Adaptation Program/UAF, and Minerals Management Service
In-Kind Support: ConocoPhillips, BPXA, Inc., and NSB

Little is known about the breeding ecology of the common raven on the North Slope of Alaska and how human development affects raven survival and productivity. Ravens appear to be increasing their numbers across the North Slope in response to human development. Ravens are nest predators of tundra-nesting birds, and the extent to which they negatively influence these species is unknown. The objectives of this study were to describe raven breeding and foraging ecology in Alaska's North Slope oil fields. In 2007 we documented nest locations, collected sightings of marked ravens from the public across Alaska and summarized data for nest site characteristics, movements of breeding adult and juvenile ravens, and the diet of breeding ravens. Ravens placed nests primarily on processing facilities and drill sites and maintained smaller territories during the nestling stage, than after chicks fledged. Adults and juveniles were observed mostly in or near the oil fields during winter, but some were also seen in Beaver, Fairbanks, and Anchorage. Raven diet consisted mostly of small mammals and avian remains. Alaska's North Slope oil fields provide structures for nesting and anthropogenic food sources that support a resident breeding population of ravens. Management options for decreasing raven populations include eliminating access to landfills and other food sources, and removing nests.

Title: Glaucous Gulls on Alaska's North Slope: Response to Development and Effects on Other Wildlife

Student Investigator: Emily Weiser, MS Wildlife Biology
Advisor: Abby Powell
Funding Agency: Department of Wildlife Management/NSB
In-Kind Support: ConocoPhillips Alaska, Inc.; BLM

Glaucous Gulls are major predators on the North Slope and may benefit from human development. Currently, their diet and their population response to development are unknown in northern Alaska. Glaucous Gulls may be feeding on birds that are of conservation concern; they also may be feeding on species hunted for subsistence by Native Alaskans. If gull population growth results from continuing oil development on the North Slope, increased gull predation could cause or exacerbate population declines for those species. This study will describe Glaucous Gull diet and reproductive output on the North Slope. Study sites will include undeveloped, residential, and industrial areas to examine the effects of development on gulls. We will collect and analyze pellets and other food samples to describe gull diet. We will also monitor the number of gull eggs and chicks produced to determine whether populations in developed areas may be growing due to enhanced reproductive output. This study will reveal the extent to which gulls rely on human refuse as a food source and their potential population response to an increase in that food source. The study will also identify the gulls' prey species, quantify the extent to which gulls prey on birds of conservation concern, and predict how that may change as development continues. If a detrimental effect is predicted, developers and managers will be able to make informed decisions to limit gull population growth, such as limiting gull access to human refuse.

Smith's Longspur (*Calcarius pictus*) Abundance, Habitat, and Distribution in the Brooks Range, Alaska

Student Investigator: Teri McMillan, MS Wildlife Biology
Advisor: Dr. Abby Powell
Funding Agencies: Arctic National Wildlife Refuge/USFWS; Gates of the Arctic National Park and Preserve/NPS
In-Kind Support: Technical assistance, staff, and equipment provided by USFWS and NPS during field season

Smith's Longspur abundance, habitat preferences, and distribution are largely unknown in Northern Alaska. Smith's Longspur are identified as a species of *high* conservation concern. In order to develop effective conservation measures for this species, it is necessary to understand population abundance, habitat preferences distribution. The objectives of this study are to (1) measure Smith's Longspur abundance, (2) identify habitat preferences and environmental factors that influence the distribution and abundance, and (3) develop a species distribution model to predict the distribution of breeding Smith's Longspurs in the Brooks Range. In June 2008, I will conduct Smith's Longspur point count surveys and collect habitat data at each survey point and combine this data with data collected by the USFWS and NPS from 2003–2007 to generate Smith's Longspur *presence* points that can be used along with environmental predictor variables to construct a Smith's Longspur distribution model. From point count surveys I expect to calculate Smith's Longspur density and plan to compare densities among drainages, habitat types, and along latitudinal gradients. I will compare habitat characteristics of sites where Smith's

Longspur are and are not detected. With presence and absence locations I will be able to create a Smith's Longspur distribution model using environmental variables as predictor. With reliable distribution and quantified abundance information for the Brooks Range, land managers can then move forward with developing a conservation plan and monitoring program for Smith's Longspurs. By understanding habitat preferences we will be able to better assess the how Smith's Longspur populations may be affected by shrub and tree line advancement caused by global warming.

Development of Sampling Techniques for Prince of Wales Spruce Grouse

Student Investigator: Aleya Nelson, MS Wildlife
Advisor: Mark Lindberg
Funding Agencies: ADFG; DBW and IAB/UAF
In-kind Support: Thorne Bay Ranger District/USDA Forest Service provided a technician and logistics

Spruce grouse (*Falcipennis canadensis isleibi)* are infrequently detected on Prince of Wales (POW) Island in the Alexander Archipelago of Southeast Alaska. Infrequent detection may be a testament to the elusive behavior of the bird or a reflection of low abundance or survival. Spruce grouse on POW Island were recently proposed as a distinct subspecies. Consequently, the Forest Service and ADFG are interested in the population ecology of spruce grouse on the island from a management perspective. We conducted research on POW Island from March–August 2007 to develop an effective sampling technique to estimate abundance and survival. Sampling techniques tested for abundance estimation included systematically driving roads, walking habitat transects with dogs, mark-recapture, adaptive sampling, broadcasting recorded vocalizations, investigating relayed/historical sightings, and occupancy modeling. We captured 24 grouse (17 female, 7 male) with a noosing pole and fitted them with necklace-style radio-transmitters weighing 4.5 g. Biological samples and photos were taken for ongoing taxonomic delineation of the subspecies. Radio-marked grouse were monitored weekly for survival and productivity. We used radio-marked birds to estimate survival and compare detection probabilities of various survey techniques. We observed a total of 33 spruce grouse with the majority (22) found in May and June. Ten captures were the result of communicated locations by Forest Service personnel while 14 were detected through sampling techniques. We found two nests and marked six broods. In an occupancy modeling experiment where the known location of a grouse was used to estimate the probability of its observation, detection was 0.25 on 20, 0.25 km x 0.25 km sampling units. The most effective sampling techniques, as determined by the highest detection probabilities, will be implemented in subsequent field seasons on a landscape scale to estimate population abundance.

Developing a Method for Estimating Deer Abundance in Southeast Alaska

Student Investigator: Todd Brinkman, PhD Wildlife
Co-Advisors: F. Stuart Chapin III and Kris Hundertmark
Funding Agency: Wildlife Conservation Division/ADFG (RSA Base Supplement)
In-Kind Support: Vehicle, technical assistance, and equipment provided by ADFG during field season

In recent years, subsistence users on Prince of Wales Island (POW) have expressed concern about the difficulty in harvesting sufficient numbers of deer to meet their

needs. Lack of information about Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) populations has hindered attempts to address subsistence hunting concerns and evaluate management practices. In particular, no reliable estimates of population abundance exist. Abundance is one of the most important population parameters because it serves as the currency by which success of management programs can be judged. Further, a reliable estimate of abundance leads to a better understanding of other variables (e.g., landscape change, cause-specific mortality) influencing the species of interest. Our primary objective is to develop a method to estimate density and population trends for deer in southeast Alaska. We are using pellet-group surveys along transects located on POW to count fecal pellets and collect pellets for DNA extraction. We are using DNA extracted from fecal pellets to identify individual deer. After individual deer can be linked back to a specific place and time, mark and recapture techniques will be used to estimate abundance. Our second of three field seasons was completed in May 2007. We have collected samples from 2,500 pellet groups and counted over 7,000 individual pellet groups. DNA extraction is nearly complete for the first two field seasons, and we are currently genotyping individual deer. An estimate of deer abundance at a watershed scale will be determined by the end of February 2008. In addition, we have had success in developing methods to determine sex from DNA extracted from pellets. With our results, we will provide the first ever estimates of abundance and sex ratio for Sitka black-tailed deer. It is important to monitor deer population levels and trends in Southeast Alaska to help resolve subsistence harvest issues, manage sustainable harvests, and evaluate the effects of habitat change on population.

Heterogeneity in Winter Habitat and Calf Weight Change for Moose in Alaska

Principal Investigator: Brad Griffith
Funding Agency: NPS; USGS
In-Kind Support: Technical assistance and equipment provided by ADFG

Moose are an important sport and subsistence hunting resource in Alaska, and their management is becoming increasingly complex. Habitat capacity, predation risk, consumptive demand, hunter access, and climate change may interact in complex ways to influence moose population levels. Quantifying the relationships between habitat characteristics and moose performance (e.g. weight change, survival, reproduction) would reduce management complexity. The goal of this project is to estimate statewide heterogeneity in winter forage availability and use and overwinter weight change of moose calves and to investigate the relationships between winter habitat characteristics and moose performance. Calf weights and estimates of forage production and utilization, using a stratified random sampling scheme based on moose density and landcover classes, were obtained at Lake Clark National Park and Preserve (LCNPP), Koyukuk National Wildlife Refuge (KNWR), Alaska Peninsula/Becharof National Wildlife Refuge (APNWR), and Game Management Unit 20A (GMU20A) from the winters of 2004-05 through the winters of 2006-07. Fall calf weights were largest at APNWR (209.8 kg) followed by LCNPP (208.0 kg), KNWR (194.5 kg) and GMU20A (175.0 kg). Overwinter weight change of calves averaged-15.0 kg in GMU20A (SE=2.5, n=36; 2006-07),-12.9 kg at KNWR (SE=2.1 kg, n=26; 2005-06), -2.0 kg at APNWR (SE=3.2 kg, n=10; 2005-06), and 8.1 kg at LCNPP (SE=2.2 kg, n=20; 2005-06). Analyses of forage characteristics from LCNPP, KNWR, APNWR, and GMU20A will be used to estimate habitat capacity and to interpret calf weight differences among study areas. Data collection is complete, and analyses are nearing completion.

Monitoring the Body Condition of Caribou in Late Winter: Developing and Evaluating a "Hands Off" Approach

Student Investigator: Dave Gustine, PhD Biology
Advisor: Perry Barboza
Funding Agency: USGS

How does the body condition of caribou affect population dynamics? We are developing and refining a non-invasive technique to assess average body protein loss in caribou herds that will assist management agencies in predicting whether populations are growing or declining. We will examine how diet, demographic (age and reproductive status), and environmental parameters (winter severity and terrain variables) in late winter vary with body protein loss. Protein loss will be evaluated with isotopic measures of nitrogen metabolites in blood, snow urine, and feces. We are using blood samples from 160 adult female caribou of known reproductive status and age in the Denali herd across 12 years (1993-2005) to assess relationships between protein status and demographic or environmental parameters. These analyses will set the context for estimates of protein status using excreta collected from four Alaskan caribou herds from 2006–2008. To date, we have collected 720 excreta samples (feces and snow urine) from the winter ranges of the Western Arctic, Central Arctic, Denali, and Chisana caribou herds. In late winter 2008, we will collect approximately 440 additional samples. We predict that variation in all factors (diet, demography, and environment) will affect the protein status of female caribou. Specifically, we predict that severe winters will limit the resources (body protein) available for production of offspring and this limitation will be evident in our isotopic measure of nutritional status. Climate changes in arctic and subarctic systems may increase the likelihood of more severe winters for caribou by affecting the type and timing of precipitation (e.g., rain on snow events in March and April) and, therefore, altering food availability. Management agencies need non-invasive tools to help predict how caribou populations may change in "warming" northern systems. This research will refine and provide a hands-off method to assess nutritional changes in Alaskan caribou herds.

Winter Nutritional Physiology of North American Porcupines

Student Investigator: Jessica Coltrane, PhD Biology
Co-Advisors: Perry Barboza and Don Spalinger
Funding Agency: Wildlife Conservation Division/ADFG
In-Kind Support: Vehicle, technical assistance, and equipment provided by ADFG during field season

Porcupines are exposed to the full brunt of the arctic winter, because they stay active through winter but subsist on low quality foods, such as spruce needles and cambium. No previous studies have addressed the behavioral and physiological mechanisms that allow porcupines to thrive in such an extreme northern environment. Porcupines are prevalent throughout many areas of Alaska, yet there are little to no data concerning habitat use or physiology of porcupines. During certain winter conditions, they are a significant portion of the food base for many predators. The overall goal of this study is to increase our understanding of behavioral and physiological adaptations of porcupines to the extreme winter environment of Alaska. The project investigates the nutritional physiology,

energetics, and behavior of Alaskan porcupines in winter. Foraging behavior and diet selection are being measured in free-ranging, radio-collared animals in Southcentral Alaska. Captive animals were used to ascertain digestibilities of diet, metabolic rates, body composition, water turnover, and physiological maintenance of nitrogen balance. We will combine the data from captive and free-ranging animals in a predictive model to describe the responses of wintering porcupines to changes in ambient temperature and food quality. This project is ongoing, and results are in progress. Field data indicate that porcupines in the study area forage mainly on white spruce cambium and needles, as well as birch cambium during the winter months. On this diet, porcupines lost up to 35% of their body mass over the duration of the winter. Feeding trial data are preliminary and currently being finalized. Porcupines are prevalent throughout most forested regions of Southcentral Alaska. They provide a prey base for most midsized to large predators. In addition, their foraging activities alter the architecture of mixed deciduous and coniferous forest by impacting tree limb growth and occasionally killing trees or portions of trees. Such activities provide habitat for other species, such as cavity-nesting birds. In addition, in the winter scattered tree branches and needles resulting from porcupine feeding activities provide food for ground foragers, such as snowshoe hares, which are an important prey item for many Alaskan predators.

Completed Ecological Studies

Regional Climate, Federal Land Management, and the Social-Ecological Resilience of Southeastern Alaska

Student Investigator: Colin Beier, PhD Biology
Faculty: A. David McGuire
Funding Agencies: NSF, USDA Forest Service, USDA New Crops, and Center for Global Change, IARC/UAF

Climate change in Southeast Alaska was investigated with respect to impacts on temperate rainforest ecosystems. Findings suggest that warming is linked to emergence of declining cedar forests in the last century. The dynamics of federal management were investigated in several studies concerning the origins and outcomes of national conservation policy, the boom-bust history of the regional timber economy, and the factors contributing to the current "deadlock" in Tongass National Forest management. Synthesis of case study findings suggests both emergent phenomena (yellow-cedar decline) and cyclic dynamics (timber boom-bust) resulting from the convergence of ecological and social drivers of change. Adaptive responses to emergent opportunities appear constrained by inertia in management philosophies. Resilience to timber industry collapse has been variable at local scales, but overall the regional economy has experienced transition while retaining many of its key social-ecological interactions (e.g., subsistence and commercial uses of fish and wildlife). An integrated assessment of regional datasets suggests a high integrity of these interactions but also identifies critical areas of emergent vulnerability. These findings are relevant to policy and management recommendations decisions relevant to supporting regional resilience to future change.

Modeling the Contribution of Belowground Carbon Allocation and Productivity to Net Carbon Storage in the Upper Great Lakes Region

Student Investigator: Eugénie Euskirchen (now a Research Associate, IAB)
Advisor: A. David McGuire
Funding Agency: USDA Forest Service

Recent empirical studies of commercial and widespread tree species, including red pine, and aspen (northern hardwoods) forests, have documented belowground carbon storage and productivity over a range of successional stages. These studies have found differences in belowground productivity between the forest types and over successional stages. Generally, the root-shoot ratios in young coniferous stands are proportionally higher than those in older coniferous stands, with the ratio typically peaking around the time of canopy closure. Furthermore, root-shoot ratios in northern hardwood stands (e.g., mixed hardwood stands comprised of sugar maple, red oak, red maple, and aspen) are thought to be higher than coniferous stands, both in recently disturbed forests and those later in stand development. Consequently, aspen allocates more C to roots relative to pine and stores more C in the mineral soil and roots. Likewise, measured coarse root productivity in mature red pine and northern hardwood stands has been found to comprise approximately one-tenth of total net primary productivity (NPP) and may not be adequately accounted for in ecosystem models. From a modeling perspective, it would be beneficial to incorporate empirical information pertaining to belowground processes into estimates of productivity and C sequestration in the Upper Great Lakes Region. Process-based

forest ecosystem models may not adequately account for these dynamics due to a previous lack of information on belowground allocation and productivity. Consequently, in this study, it was our goal to take a first to step toward implementing a better description of belowground dynamics in a biogeochemistry model. Specifically, we examined how the addition of information on coarse roots, based on newly available data, to parameterizations of the Terrestrial Ecosystem Model (TEM) altered net primary productivity and changes in ecosystem carbon, including both vegetation and soil carbon, in a region of northern Michigan. Overall, NPP was 125-150 g C m^{-2} yr^{-1} greater in model simulations that included a coarse root component than those that did not. This translated into greater ecosystem carbon storage between the years 1980–2000 in the simulations that included a coarse root component compared to those that did not, with a majority of the increase in storage occurring in the vegetation carbon pool in the red pine and the soil carbon pool in the northern hardwoods. These results suggest the importance of including the best available data pertaining to coarse root biogeochemistry in ecosystem models. It also suggests the importance of species selection when managing Upper Great Lakes forests for carbon storage. Future work on the modeling of belowground processes in the Upper Great Lakes region should take into account (1) successional changes in the productivity of coarse roots, and (2) how these successional changes in coarse roots translate into changes in carbon storage over time.

Biocomplexity: Feedbacks Between Ecosystems and the Climate System

Student Investigator: Michael Balshi, PhD Biology (partial support for graduate student programmer)
Advisor: A. David McGuire
Funding Agency: National Science Foundation through Marine Biological Laboratory

The boreal forest contains large reserves of carbon, and across this region, wildfire is a common occurrence. To improve the understanding of how wildfire influences the carbon dynamics of this region, methods were developed to incorporate the spatial and temporal effects of fire into the Terrestrial Ecosystem Model (TEM). The historical role of fire on carbon dynamics of the boreal region was evaluated within the context of ecosystem responses to changing atmospheric CO_2 and climate. These results show that the role of historical fire on boreal carbon dynamics resulted in a net sink of carbon; however, fire plays a major role in the interannual and decadal scale variation of source/sink relationships. To estimate the effects of future fire on boreal carbon dynamics, spatially and temporally explicit empirical relationships between climate and fire were quantified. Fuel moisture, monthly severity rating, and air temperature explained a significant proportion of observed variability in annual area burned. These relationships were used to estimate annual area burned for future scenarios of climate change and were coupled to TEM to evaluate the role of future fire on the carbon dynamics of the North American boreal region for the 21st century. Simulations with TEM indicate that boreal North America is a carbon sink in response to CO_2 fertilization, climate variability, and fire, but an increase in fire leads to a decrease in the sink strength. While this study highlights the importance of fire on carbon dynamics in the boreal region, there are uncertainties in the effects of fire in simulations with TEM. These uncertainties are associated with sparse fire data for northern Eurasia, uncertainty in estimating carbon consumption, and difficulty in verifying assumptions about the representation of fires that occurred prior to the start of the historical fire record. Future studies should incorporate the role of

dynamic vegetation to more accurately represent post-fire successional processes, incorporate fire severity parameters that change in time and space, and integrate the role of other disturbances and their interactions with future fire regime. The results of this study are relevant to climate system policy.

Fire-Mediated Changes in the Arctic System: Interactions of Changing Climate and Human Activities

Student Investigator: Monika P. Calef (former postdoctoral researcher, now Assistant Professor at SUNY Albany)
Advisor: A. David McGuire
Funding Agency: National Science Foundation

Boreal ecosystems in Alaska are responding to climate change in many ways, including changes in fire regime. While large-scale wildfires are an essential part of the boreal forest ecosystem, humans are changing fire regimes through ignition and suppression. We conducted two studies to evaluate interactions between humans and the fire regime in interior Alaska. In the first study we analyzed the impact humans have on fire ignitions and relative area burned with distance into the forest from human access points such as settlements, highways, and major rivers in Alaska from 1988–2005. Additionally, we created a fire prediction model to identify drivers for lightning fires in the boreal forest. Human presence increases the number of ignitions near settlements, roads, and rivers and appears to reduce the area burned within 30–40 km of villages and rivers. In contrast to fires near roads and rivers, human presence may somewhat increase the area burned within 30–40 km of highways. The fire prediction model indicated that the probability of fire increases as distance from human settlements increases. In contrast, the model indicated that the probability of fire decreases as distance from roads increases and that the probability of fire in relation to distance from rivers depends on the year of analysis. While the ecological consequences of these human impacts are still unclear, our research shows that human influences on fire regime clearly affect the pattern of fire within 40 km of settlements, which is an area that represents 31% of Interior Alaska. A key conclusion from this study was that future research should focus on more completely understanding the role of human presence in the suppression of wildfire in Interior Alaska, which was the focus of our second study. To better understand the impact of human fire suppression on fire regime, we analyzed wildfire size and location in different suppression zones from 1988 to 2006 in Interior Alaska at multiple spatial and temporal scales. While wildfires are highly variable in space and time, suppression reduces area burned at a landscape scale over multi-decadal time periods. Lightning strike density and designated suppression effort primarily determined total area burned while vegetation type and topography showed little influence. Regression analyses of percent area burned over time showed increasing trends that are consistent with a warming climate. The high spatial resolution of our analysis provides valuable insights into landscape-level interactions between wildfire and suppression and how these interactions may influence the future fire regime in Alaska.

Impact of Climate Change on Vegetation and Water Supply

Student: Mike Balshi, PhD Biology (partial support for graduate student programmer)
Advisor: A. David McGuire
Funding Agency: USDA Forest Service (RWO 150, completed)

This study has analyzed the carbon dynamics and water yield simulated by the Terrestrial Ecosystem Model (TEM) for both historical and future (1900-2100) climate and forest harvest. This study is part of a USDA Forest RPA Special Study, which has been granted to Dr. Linda Joyce of the USDA Forest Service Rocky Mountain Forest and Range Experiment Station. The simulations indicated that carbon storage in U.S. forests will continue to increase through the 21st century primarily because of increases in vegetation carbon associated with the abandonment of agricultural land in the latter half of the 20th century. Comparisons of water yield simulated by TEM agree with measurements of water yield in the 20th century. Simulations with TEM indicate that water yield increased and became more variable in the last two decades of the 20th compared with earlier decades in the 20th century. The pattern of water yield in the last two decades of the 20th century is maintained throughout the 21st century. The analysis of changes in carbon storage and water yield simulated by TEM is providing information relevant to policy discussions on carbon and water management in the face of climate change. This research will contribute to developing a more comprehensive approach to risk assessment and management in the forest sector relative to climatic change.

Ongoing Ecological Studies

Synthesis of Arctic System Carbon Cycle Research Through Model-Data Fusion Studies Using Atmospheric Inversion and Process-Based Approaches

Postdoctoral Researcher: Daniel Hayes
Faculty: A. David McGuire
Funding Agency: NSF

A large release of carbon dioxide and methane from high latitude terrestrial and marine systems to the atmosphere has the potential to affect the climate system in a way that may accelerate global warming. To improve our ability to predict the dynamics of carbon in high latitudes, this project will comprehensively analyze the carbon cycle of the arctic system, guided by the following two general questions: (1) What are the geographic patterns of fluxes of carbon dioxide and methane over the Pan-Arctic region and how is the balance changing over time; and (2) What processes control the sources and sinks of carbon dioxide and methane over the Pan-Arctic region and how do the controls change with time? To address these general questions, the project is integrating data on carbon dioxide and methane dynamics of the Arctic System using a combination of prognostic and inverse approaches to provide an integrative approach to estimating and understanding the exchanges of carbon dioxide and methane from terrestrial and marine components of the system. This study has brought together diverse regional data sets and understanding in the context of a linked set of numerical model studies and is examining, and attempting to quantify, the fluxes and links between the terrestrial, atmospheric, and oceanic components of the Arctic carbon and methane cycles. A postdoctoral researcher, Dr. Daniel Hayes, has conducted historical simulations with the Terrestrial Ecosystem Model (TEM) and is currently analyzing those results and will provide the results of his simulations to other components of the project. In preparation for this research, McGuire has conducted an international assessment of the current understanding of the carbon cycle in the Arctic. This assessment is currently under review by the scientific community.

Snow Cover and Biology in the Arctic

Research Associate: Eugénie Euskirchen
Faculty: A. David McGuire
Funding Agency: NSF

In terrestrial high-latitude regions, observations indicate recent changes in snow cover, permafrost, and soil freeze-thaw transitions due to climate change. In a previous paper funded by this project (*Euskirchen et al., Global Change Biology, 2006*), we successfully simulated these changes and related them to changes in growing season length, productivity and net carbon uptake in extratropical regions (30–90°N) for the period 1960–2100. We have conducted two follow-up studies in the past year. In the first follow-up study (*Euskirchen et al., Global Change Biology, 2007*) we found that increases in snow cover-climate feedbacks during 1970–2000 were nearly three times larger than during 1910–1940 because the recent snow-cover change occurred in spring, when radiation load is highest, rather than in autumn. These changes in energy exchange warrant careful consideration in studies of climate change, particularly with respect to associated changes in vegetation cover. To better consider changes in vegetation cover, we developed a new version of the Terrestrial Ecosystem Model (TEM, version 7.0) to include a dynamic

vegetation component with competition among plant functional types for nitrogen and light. We performed model simulations for the years 2002–2100 under nine future climate scenarios for a region in northern Alaska extending from the ecotonal boreal forest to the Arctic Ocean. Our analysis indicates that the net primary productivity (NPP) of the dominant plant functional types will increase. The increase is dominated by birch (*Betula*) species in the shrub tundra, which had an increase in NPP that was at least three times greater than any other plant functional type. These increases in NPP resulted in decreases in summer albedo and an overall atmospheric heating effect. However, this heating effect was smaller than that due to changes in the snow season, including both the melting of snow in the spring and the return of snow in the autumn. Changes in the timing of snowmelt in the spring exhibited a large influence on atmospheric heating because the radiation load is higher at this time of year compared to the autumn. Furthermore, those ecosystems with a high seasonal contrast in albedo, such as tundra, showed much larger changes in atmospheric heating than did those with a low seasonal contrast in albedo. This study is generally relevant to climate change policy as it considers multiple ways in which terrestrial ecosystem responses to climate change can influence the climate system.

Carbon Responses along Moisture Gradients in Alaskan Landscapes

Student Investigator: Jon O'Donnell, PhD Biology (effective January 2007)
Advisor: A. David McGuire
Funding Agency: Geologic Division/USGS (RWO 149)

The Alaskan interior contains enormous carbon reserves in vegetation and soils. As a result of changing temperatures, we anticipate enhanced releases of carbon dioxide, methane, and dissolved organics to streams and ocean waters. How carbon responds to changing climate will affect carbon dynamics and will likely depend on interactions with soil moisture and permafrost extent, which is quite variable in Alaskan landscapes. In this project, we are examining physical and biological controls on carbon exchange along soil moisture gradients in the boreal forest of Interior Alaska. Our objective is to develop a set of physical (temperature, moisture, radiation) and biogeochemical (e.g. C flux and quality) data that will facilitate accurate models of C exchange in boreal landscapes. In 2005, study plots were established along a moisture gradient near the Bonanza Creek Experimental Forest, 20 km southwest of Fairbanks, AK. A boardwalk was constructed spanning the entire moisture gradient (approximately 400 m) to minimize trampling of the site. We installed Campbell CR10X dataloggers along the moisture gradient at five locations that varied according to vegetation type and drainage class. Beginning in May 2005, soil temperature, soil moisture, photosynthetically active radiation, and water table height were logged hourly at each site. During summer 2006, we began monitoring electrical conductivity and redox potential at the three wettest sites along the moisture gradient. Data from dataloggers were manually downloaded once a week during the summer field seasons and once per month during the winter. We have also measured a suite of biogeochemical factors in conjunction with the physical parameters at each of the sites along the moisture gradient. These include total C and total N stocks for each organic layer, CO_2 and CH_4 fluxes from the soil to the atmosphere, groundwater solutes, and dissolved gases. Both the physical and biogeochemical data are currently being maintained in databases at UAF and at the USGS in Menlo Park, CA. Preliminary findings from groundwater sampling indicate that dissolved organic carbon concentration is typically greater at the wetter sites

than the dry sites along the moisture gradient, reflecting stronger leaching potential at wetter sites. Other analyses suggest that both vegetation type and moisture are important controls on the chemical composition of DOC. Nitrate and sulfate concentrations decreased with increasing moisture content, which reflects the importance of anaerobic microbial processing (e.g. denitrification, sulfate reduction) under wetter conditions. Additionally, the ratio of dissolved CH4:CO2, which functioned as an index of anaerobic activity, increased with depth from the soil surface. In fall 2007, organic soil horizons were sampled at the black spruce site (BZBS) on the moisture gradient. Samples were collected by hand to preserve bulk density. A laboratory study was conducted to evaluate the influence of moisture and ice content on thermal conductivity across the three horizon types (live/dead feathermoss, fibric, humic). Findings from the laboratory study will be used in conjunction with field measurements of temperature and moisture to predict the vulnerability of permafrost to thaw at this site and other moderately-drained black spruce stands in interior Alaska. The insights from these studies have the potential to inform models of C exchange in boreal landscapes.

Wildfire Consumption of Ground-Layer Organic Matter in North American Boreal Forests and Peatlands: Implications for Atmospheric Trace Gas Emissions and Long-term Soil Carbon Storage

Postdoctoral Researcher: Shuhua Yi
Faculty: A. David McGuire
Funding Agency: NASA through the University of Maryland

One of the greatest uncertainties in modeling carbon cycling in boreal forests is the level of surface fuel consumption (SFC) that occurs during fires. The deep ground-layer of organic matter present in many boreal forests (consisting of litter, lichen, mosses, dead woody debris, and organic soil) frequently burns during fire. The amount of carbon released directly to the atmosphere from SFC ranges between 5 and > 60 t C ha^{-1}. The spatial and temporal factors controlling variations in SFC require additional research. Researchers at the University of Maryland and Michigan State University are conducting field studies to evaluate the role of landscape characteristics (topography, soil texture, and presence/absence of permafrost) and climatic processes (seasonal weather patterns controlling fuel moisture and fire behavior and inter- and intra-annual climate patterns controlling seasonal permafrost thaw and drought) in controlling surface fuel consumption during individual fire events. We are incorporating the improved understanding from the field studies into the Terrestrial Ecosystem Model (TEM) to examine how recent increases in fire activity in Interior Alaska are influencing the terrestrial carbon budget based on variations in assumptions concerning seasonal variations in area burned and surface fuel consumption. A postdoctoral researcher (Shuhua Yi) has modified the structure of TEM to better consider these issues. A dynamic soil layer structure has been implemented into TEM to investigate the effects of organic layer on soil temperature, moisture, and carbon dynamics. The modified version of TEM consists of four modules, i.e. environmental, ecological, disturbance, and dynamic soil layer module. The environmental module calculates the water and radiation fluxes among atmosphere, canopy, snow and soil, and the simultaneous thermal and hydrological dynamics within soil layers. The modified TEM was tested on a tundra burn site and two black spruce fire chronosequences. Results showed that model can reasonably simulate evapotranspiration, soil temperature and soil moisture, and active layer depth was sensitive to the thickness of organic layer. The ecological module of TEM

is currently being validated using data from two black spruce fire chronosequences in Interior Alaska, after which we plan to apply the model over the Yukon River Basin.

Magnitude, Rate, and Heterogeneity of Lake Drying in National Wildlife Refuges in Interior Alaska

Student Investigator: Jennifer Roach, MS Biology
Advisor: Brad Griffith
Funding Agency: Science Support Program/USGS (RWO 152)

Recent studies have identified substantial losses in surface water area in sub-Arctic boreal regions since 1950, and this trend has been coincident with climate warming in these regions. However, the magnitude, heterogeneity, and mechanisms behind climate-induced lake drying in Alaskan National Wildlife Refuges are not known. Changes in the amount of surface water in National Wildlife Refuges could alter critical summer breeding and nesting habitats for migratory waterfowl. The objectives of this study are to (1) identify potential mechanisms behind lake drying and (2) fully characterize the magnitude and rate of lake drying in Alaskan National Wildlife Refuges. Possible mechanisms will be identified by comparing field characteristics at lake sites with differential rates of drying in National Wildlife Refuges. The magnitude of surface water changes in nine National Wildlife Refuges will be estimated by comparing aerial photography, satellite imagery, and SAR imagery from 1950 to present. More extensive floating mat vegetation at drying lakes compared to non-drying lakes in four study areas in Yukon Flats, Innoko, and Tetlin National Wildlife Refuges indicate that terrestrialization is the primary mechanism behind observed rates of drying in these study areas. Greater surface area to volume ratios at drying lakes indicate that lakes with a shallow basin morphometry may be more susceptible to the effects of terrestrialization. Changes in the amount of surface water in National Wildlife Refuges could affect waterfowl breeding and nesting habitats. In addition, the processes of terrestrialization and peatland formation could result in an increase in carbon storage on the landscape.

List of Abbreviations

ADFG	Alaska Department of Fish and Game
AKCFWRU	Alaska Cooperative Fish and Wildlife Research Unit
ARCUS	Arctic Research Consortium of the United States
BLM	Bureau of Land Management
CMI	Coastal Marine Institute, UAF
DBW	Department of Biology and Wildlife, UAF
DOE	Department of Energy
EVOS	Exxon-Valdez Oil Spill
GIS	Geographical Information System
GPS	Global Positioning System
IAB	Institute of Arctic Biology, UAF
IMS	Institute of Marine Science, UAF
MMS	Minerals Management Service
NASA	National Aeronautics and Space Administration
NPR-A	National Petroleum Reserve-Alaska
NPS	National Park Service
NSB	North Slope Borough
NSF	National Science Foundation
NWR	National Wildlife Refuge
PI	Principal Investigator
RSA	Reimbursable Services Agreement
RWO	Research Work Order
SFOS	School of Fisheries and Ocean Sciences, UAF
SSP	Science Support Program
UAF	University of Alaska Fairbanks
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
	BRD Biological Resources Discipline