SUMMARY OF SUSTAINABLE FORESTRY AND OTHER RESEARCH FISCAL YEAR 2015

Forest Resources Division
IC4117 (Rev. 06/03/2016)

MICHIGAN DEPARTMENT OF NATURAL RESOURCES MISSION STATEMENT

"The Michigan Department of Natural Resources is committed to the conservation, protection, management, use and enjoyment of the State's natural and cultural resources for current and future generations."

NATURAL RESOURCES COMMISSION STATEMENT

The Natural Resources Commission, as the governing body for the Michigan Department of Natural Resources, provides a strategic framework for the DNR to effectively manage your resources. The NRC holds monthly, public meetings throughout Michigan, working closely with its constituencies in establishing and improving natural resources management policy.

For information or assistance on this publication, contact the Forest Resources Division, Michigan Department of Natural Resources, P.O. Box 30452, Lansing, MI 48909-7952.

This publication is available in alternative formats upon request.

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Background

The State of Michigan, under the Michigan Department of Natural Resources (DNR), supports research and development projects that contribute to the management of Michigan's forest lands in such a way as to sustain those resources and associated values for future generations. This document is an annual summary of those projects for the DNR's 2015 fiscal year (October 1, 2014 through September 30, 2015).

The DNR is committed to the continuous improvement of forest management in the state on all forest lands, but specifically state forest lands. Forest management in the state is guided by a hierarchy of plans: the Forest Action Plan (currently called the Forest Resource Assessment and Strategy (2010-2020)); the State Forest Management Plan, 2008 (2008-2018); and three regional state forest management plans (2013-2023). The state and regional plans apply to state forest lands, and the Forest Action Plan applies to all forest land in the state.

Research is one of several integral components of a sound forest management program and is one of two critical components of adaptive management (the other being effectiveness monitoring). Together effectiveness monitoring and research (also referred to as validation monitoring) reach their maximum utility, which is diminished if one is done in the absence of the other. Research or validation monitoring is used to identify and validate or verify the assumptions and causal pathways underlying a conceptual model of how we believe a system or part of a system works. It is critically important that the results of research are integrated back into the forest management process or system through the development of tools, techniques, best management practices, guidelines and policy.

Policy Context

Almost all of the state forest land in Michigan is certified under two different sustainable forestry program standards: the Sustainable Forestry Initiative (SFI) and the Forest Stewardship Council (FSC). Implementation of these standards in terms of forest management is interpreted and directed by a suite of 20 work instructions. Work Instruction 5.1 speaks to coordinated natural resource management related research (http://www.michigan.gov/documents/5_133216_7.1.pdf).

The work instruction requires that the DNR, through the division research coordinators, produce a research summary report, report internal and external research funding for the SFI Annual Report and a review of research and implementation needs and opportunities. This research summary report represents partial fulfillment of this work instruction requirement.

Research Summary

To meet the requirements of certification, the required summary focuses on the research that occurs within forested landscapes considering on or more elements of forested ecosystems and/or associated social and economic systems. Because of research's close association with effectiveness monitoring, the forested landscape research is considered within the monitoring framework for sustainable forests: that is, the criteria and indicator framework of the Montreal Process (http://www.montrealprocess.org/). However, since the suite of indicators is more of a moving target than the criteria under which they fall, the research projects are categorized only using the seven criteria. Projects that are related to more than one criterion are listed under the primary criterion with the other linkages being identified.

Research Administration

Research is administered and supported differently in each of the DNR divisions; however, each division has a research coordinator as a point-of-contact. The Wildlife and Fisheries Divisions administer all research activities through their respective research sections. These divisions also have a significant portion of their research efforts funded by a variety of federal grants that have annual reporting requirements. Forest Resources and Parks and Recreation Divisions do not have dedicated research sections and consequently the administration and support of research occurs through each program area.

Research that supports sustainable forestry occurs through a variety of mechanisms. The DNR supports a large number of research projects contracted or partnered with several universities within the state and some beyond its borders. The DNR also supports a Partnership for Ecosystem Research and Management (PERM) program with Michigan State University. The DNR also employs its own research and monitoring staff in Forest Resources, Wildlife and Fisheries Divisions.

Research programs and projects are providing useful information to support improvements in our operations and business practices and each division uses a different array of means to communicate those research findings to staff. Division in-service trainings, specialist meetings and ongoing field and program communications are examples of the means used to convey research information to DNR staff.

For more information about specific research programs or projects, interested parties should contact the research coordinator for the appropriate division. The research coordinator for each division is listed below with their respective contact information.

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RESEARCH RELATED TO SUSTAINABLE FORESTRY – CURRENTLY ON-GOING

Criteria Framework for Sustainable Forestry and Associated Research

Criterion One: Conservation of Biological Diversity

Landscape Diversity:

Partnership for Ecosystem Research and Management – Faculty Support
Primary Contact: Dr. Brent Rudolph, DNR Wildlife Division, East Lansing, Michigan
Email: rudolphb@michigan.gov
Phone: 517-641-4903
DNR Financial Support: $64,370 in FY15, $64,370 total.
Study Area: Statewide.
Time Frame: 10/01/2014-09/30/2015
Abstract: The DNR Wildlife Division is responsible for wildlife population-level management (e.g., harvest regulations, game species designations, invasive species designations), but also play a dominant role in many Forest Resources Division and Parks Division activities, particularly related to habitat. Often times, information on wildlife responses to management activities or the time to evaluate novel approaches to management is lacking within the DNR. With increased emphasis on accountability (e.g., forest certification), DNR stands to benefit from increased expertise on habitat-wildlife relationships, effectiveness monitoring and an understanding of how operational activities (e.g., individual timber harvest proposals, prescribed fire on a recreation area) support statewide wildlife strategies. For DNR Wildlife Division to efficiently implement their Guiding Principles and Strategies, collaboration among internal and external professionals is important. Dr. Gary Roloff possesses considerable expertise on topics that support the DNR mission. As such, Dr. Gary Roloff will advise and consult with Wildlife Division on wildlife-habitat relationships, monitoring the effects of habitat management activities on wildlife populations, study design and sampling and integrating research findings into on-the-ground management.

Critical Silvicultural Research Conducted by PERM Research Forester on Sustainable Regeneration of Northern Hardwood Stands Following Impacts by Invasive Species That Threaten Forest Productivity and Wildlife Habitat
Primary Contact: Dr. Mike Walters, Michigan State University
Email: walte245@msu.edu
Phone: 517-884-4892
DNR Financial Support: $35,000.00
Study Area: The project is located on two sites; one site near Levering on private lands, and one site on state forest lands near Goodhart.

Time Frame: A 5-year project is just drawing to a close in 2016.
Abstract: Dr. Walters initiated the research project funded by Forest Resources Division in FY11 to investigate the effects of Emerald Ash Borer (EAB) motivated harvesting on regeneration in northern hardwood stands in the northern Lower Peninsula (NLP) -- essentially, what comes back, with or without management intervention after ash dies or is removed in northern hardwood stands. The project is located on two sites; one site near Levering on private lands, and one site on state forest lands near Goodhart. Deliverables include data collection and analysis for both sites. The goals of the project are to improve forest structure and the composition of regeneration in ash-heavy northern hardwood stands following EAB-motivated harvests for sustainable timber production in the face of high deer browse pressure. Specifically, the project aims to identify:

- Techniques to steer composition of regeneration away from ash-heavy regeneration and toward a more diverse species mix.
- Factors that can be manipulated using silvicultural techniques to influence natural regeneration composition and density in northern hardwood stands in light of widespread regeneration failures.
- Deer- vs. non-deer causes for differences in regeneration composition and density in northern hardwood stands.
- Information on the performance and success of under-planted hardwood and conifer seedlings, including those that may do better under global warming scenarios, or in the face of deer browse pressure. The project will be completed over a 5 year period, in 2016 (FY16), although funding is required only for the first 4 years during collection of field data. Final analysis of the data and preparation of research synopses will be completed in the 5th year (2016). Deliverables for FY15 include two extension-style bulletins for field foresters on the following topics:
    - "Does gap size influence mortality of residual trees at gaps edges?"
    - "Can we plant species with more southern distributions into northern hardwood stands: being proactive about climate change"

Development of Databases, Classification Systems, and Fisheries Management Tools for Inland Lakes of Michigan
Primary Contact: Kevin Wehrly, DNR Fisheries Division, Institute of Fisheries Research, Ann Arbor, Michigan
Email: wehrlyk@michigan.gov
Phone: 734-663-3554 x 12055
DNR Financial Support: $11,420.00
Study Area: Statewide
Time Frame: Reinstituted and ongoing.
Abstract: The State of Michigan has more than 11,000 lakes that are 5 acres or larger and adequate information is only available for 730 lakes that are "significant public waters". The mission of Fisheries Division, to protect and enhance fish environments, habitat, populations and other forms of aquatic life, requires us to manage all waters to promote the optimum use of lake resources for the benefit of the people of Michigan. The lack of information from the majority of lakes (93%) in the state has hindered our ability to develop adequate fisheries resource sampling designs, to interpret and extrapolate local knowledge regionally or statewide, to develop strategic plans for protecting, enhancing and restoring ecological function and processes for all lakes in Michigan and to evaluate the effects of forest and other land use practices on our lake systems. The study developed a set of inland lake databases and classification systems to provide information and tools for assessing and managing inland lakes in Michigan by:

- Assembling available information on inland lakes into a centralized and standardized database, including water quality, biological community, lake morphology and shoreline development descriptors;
- Delineating buffer, and local and network lake catchment boundaries for all lakes that are five acres or larger;
- Synthesizing natural landscape descriptors for the local and network catchments, including land cover, surficial geology, soil permeability, slope and climate;
- Synthesizing landscape human disturbance descriptors for the buffer and local and network catchment spatial zones, such as agricultural and urban land uses, population, imperviousness, nutrient loading, point source pollution and road density;

- Calculating lake network descriptors, such as lake network position, linkages with river network and groundwater and zoogeographic zone;
- Developing models for predicting parameters that are essential for assessing conditions in lakes where field data are not available;
- Developing a lake classification framework based on variables that are not influenced by human activities;
- Developing lake fisheries classifications based on the suitability for targeted sport fish species;
- Assessing lake health status based on landscape human disturbances. These data provide a baseline for assessing future fisheries and forest management practices.

Status and Trends of Inland Lakes: Methods Development, Program Oversight, and Ecological Assessment
Primary Contact: Kevin Wehrly, DNR Fisheries Division, Institute of Fisheries Research, Ann Arbor, Michigan
Email: wehrlyk@michigan.gov
Phone: 734-663-3554 x 12055
DNR Financial Support: $46,926 Total (25% Game and Fish funds)
Study Area: Statewide
Time Frame: Ongoing
Abstract: The Fisheries Division of DNR initiated the statewide SSTP for inland lakes during the spring of 2002. The division-wide SSTP uses standardized sampling methods in an effort to collect and evaluate data from a statewide perspective. These data include fisheries information from electrofishing, standardized netting, habitat measurements and water quality sampling that will be used to monitor statewide status and trends of inland lake aquatic resources, develop models on key influences and evaluate fisheries and land management activities.

Status and Trends of Fish Populations and Community Structure in Michigan Streams
Primary Contact: Jan-Michael Hessenauer, DNR Fisheries Division, Lake St. Clair Fisheries Research Station, Mt. Clemens, Michigan
Email: hessenauerj1@michigan.gov
Phone: 586-465-4771
DNR Financial Support: $17,401 (25% Game and Fish funds)
Study Area: Statewide
Time Frame: Ongoing
Abstract: The Fisheries Division of DNR initiated the statewide SSTP for streams during the spring of 2002. The division-wide SSTP uses standardized sampling methods in an effort to collect and evaluate data from a statewide perspective. These data include fisheries information from electrofishing, habitat measurements and water quality sampling that will be used to monitor statewide status and trends of streams, develop models on key influences and evaluate fisheries and land management activities.

Evaluation of Returns of Salmonids to Weirs in Michigan's Waters of the Great Lakes
Primary Contact: Randy Claramunt, DNR Fisheries Division, Charlevoix Fisheries Station, Charlevoix, Michigan; and Jory Jonas, DNR Fisheries Division, Traverse City, Michigan
Email: claramuntr@michigan.gov and jonasj@michigan.gov
Phone: 231-547-2914 x 224 and 231-922-5280
DNR Financial Support: $27,262 (25% Game and Fish Funds)
Study Area: Selected tributaries and weirs to lakes Michigan and Huron
Time Frame: Ongoing
Abstract: This project provides annual information on returns of adult stocked and wild salmon and trout to selected Michigan rivers that is used in many Great Lakes management and research efforts. Additionally, biological data on age, growth, condition and fish health are also collected at these sites. Since many of these fish are of wild origin, usually from the watershed on which our weirs are located, the information generated from these locations provides baseline data on the effects of fisheries, land and forest practices on recruitment processes for these species.

Statewide Coded-wire Tagging and Tag Recovery Program
Primary Contact: David Clapp, DNR Fisheries Division, Charlevoix Fisheries Research Station, Charlevoix, Michigan
Email: clappd@michigan.gov
Phone: 231-547-2914 x 237
DNR Financial Support: $113,544 (25% Game and Fish Funds)
Study Area: Statewide
Time Frame: Ongoing
Abstract: This is a support project for all research and assessment projects that use coded-wire tags; the specific results and benefits will vary by study. Coded-wire tags have been used in all Great Lakes to evaluate wild fish production, salmonid stocking methods (e.g., net pens vs. direct stocking), as well as hatchery practices and how these practices influence salmon growth and survival. Coded-wire tag marking has also been an important component of fish restoration projects; e.g., in the case of lake sturgeon marking related to the state lake sturgeon rehabilitation strategy. This study provides information annually that is used to evaluate a broad range of resources issues from the effects of land and forest management practices on wild fish production to better ways to increase salmonid survival following stocking and the feeding ecology and seasonal distribution of Great Lakes fish populations, many of which are dependent on inland streams for recruitment.

Species Diversity:

Lake Sturgeon Population Status in the Cheboygan River Watershed Lakes, Michigan
Primary Contact: Edward Baker, DNR Fisheries Division, Marquette Fisheries Research Station, Marquette, Michigan
Email: bakere1@michigan.gov
Phone: 906-249-1611 x 309
DNR Financial Support: $129,893 (25% Game and Fish Funds)
Study Area: Cheboygan River Watershed
Time Frame: Ongoing
Abstract: This project is focused on Burt, Mullett and Black lakes in the Cheboygan River watershed support one of the largest concentrations of lake sturgeon Acipenser fulvescens in Michigan. The population in Black Lake is the largest of the three lakes and still supports a small harvest fishery and spawns in the Black River in state forest land. Due to the population's size and the large body of knowledge available on the population's demography, spawning behavior, recruitment dynamics and genetics, this population will figure prominently in Michigan's state-wide sturgeon recovery plans. However, this population has been reduced numerically. In contrast, lake sturgeon harvest in Burt and Mullett Lakes has been prohibited since 2000 and there is little known of the status of lake sturgeon in these two lakes which also use rivers in state forest lands for recruitment. Data is being generated by this study on key live history components of lake sturgeon in Black Lake, along with the initial status of the populations in Burt and Mullett Lakes. This would help DNR Fisheries Division in undertaking meaningful management actions directed at restoring lake sturgeon throughout our state and is providing insights on the effects of forest management practices on this state listed threatened species.

Sturgeon Rehabilitation Plan
Primary Contact: Edward Baker, DNR Fisheries Division, Marquette Fisheries Research Station, Marquette, Michigan and Kim Scribner, Michigan State University, East Lansing, Michigan
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Phone: 906-249-1611 x 309 and 517-353-3288
DNR Financial Support: $371,767 (25% Game and Fish Funds)
Study Area: Statewide
Time Frame: Ongoing
Abstract: This study supports Michigan's lake sturgeon rehabilitation activities, as documented in the DNR Lake Sturgeon Recovery Plan and the existing 2005 state Wildlife Action Plan (currently in revision), and in Great Lakes fish community objectives (see www.glfc.org). Lake sturgeon require intact river habitat with clean spawning substrate for spawning, both of which can be affected by forest and land management practices. The study has a number of components including stream rearing of lake sturgeon at multiple restoration sites; developing information on the effects of fish culture practices on egg survival and larval lake sturgeon growth and survival; quantify environmental covariates (temperature and discharge both related to forest and land management practices) and their effects on larval recruitment; developing information on effects of stream

habitat and the species composition and abundance of predators and alternative prey on lake sturgeon larval survival; and determining stage-specific survival of natural and hatchery age-0 and older juvenile lake sturgeon. All of this information is being used to rehabilitate existing lake sturgeon populations and to provide insights on how land use and forest practices affect the habitat of this state-listed species on a statewide basis.

Refinement of the Aquatic Portion of Michigan's Wildlife Action Plan and Development of Tools to Support the Plan
Primary Contact: Kevin Wehrly, DNR Fisheries Division, Inst. of Fisheries Res, Ann Arbor MI
Email: wehrlyk@michigan.gov
Phone: 734-663-3554 x 12055
DNR Financial Support: $197,192 (25% Game and Fish Fund)
Study Area: Statewide
Time Frame: Ongoing
Abstract: This project is developing and will provide implementation tools for the aquatic portion of the Michigan's Wildlife Action Plan (MWAP). This plan will assist the DNR in managing a broad range of aquatic resources and species of greatest conservation need. The products of this project include identifying high priority conservation areas, assessing ecosystem health and identifying key human disturbance factors that are components required by USFWS and MWAP. Additionally, the project is developing the needed GIS spatial framework, databases and decision support tools for carrying out required actions in the plan. Since most of the plan is focused on inland systems, understanding and effectively mitigating the effects of land use and forest management practices will be key components for the successful management of these limited aquatic resources that are critical components of the biodiversity of our forests.

Role of Predators, Winter Weather and Habitat on White-tailed Deer Fawn Survival in Michigan – Phase II
Primary Contact: Dr. Dean Beyer, DNR Wildlife Division, Northern Michigan University, Marquette, Michigan
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Phone: (906) 227-1627
DNR Financial Support: $252,600 in FY15, $1,160,000 total
Study Area: Western Upper Peninsula
Time Frame: 10/1/2011 - 9/30/2017
Abstract: This research project is designed to investigate the role of predators, winter weather, and habitat on white-tailed deer condition and survival across a gradient of ecological conditions (snowfall zones) in the Upper Peninsula. Results from this project will help us understand the interactions among various factors that may limit deer abundance. Specific study components include: 1) estimating pregnancy rates and condition of white-tailed deer; 2) estimating survival and cause-specific mortality of white-tailed deer fawns and does; 3) estimating proportion of fawn mortality attributable to black bear, coyote, bobcat, and wolf predation; and 4) comparing vegetation characteristics at fawn birth sites and kill sites with predator habitat use.

Knowledge of limiting factors is the foundation of wildlife management. This study will provide information on the importance and interactions among several factors that may limit deer abundance. Results from this work are intended to help us formulate appropriate harvest and management recommendations for both deer and predators. Results will also help us address increasing public concerns regarding the impact of predators on deer.

Adaptive Management of Sharp-Tailed Grouse in the Eastern Upper Peninsula of Michigan
Primary Contact: Dr. Dave Luukkonen, DNR Wildlife Division, East Lansing, Michigan
Email: luukkonend@michigan.gov
Phone: (517) 641-4903
DNR Financial Support: $0 in FY15, $86,500 total.
Study Area: Eastern Upper Peninsula.
Time Frame: 10/19/2011-9/30/2016
Abstract: This research aligns directly with the adaptive management principle of the DNR Wildlife Division strategic plan and outcomes will explicitly address goals for population and habitat management for a featured species. Wildlife managers will be able to better use existing monitoring data to evaluate sustainability of sharp-tailed grouse in eastern Upper Peninsula (UP) under alternative harvest and habitat management scenarios. Sharp-tailed grouse hunting has only recently again become legal and there is an opportunity to use new survey methodologies in an explicit manner to help direct future hunting regulations. The question of how much open land to maintain is an ongoing debate within land management agencies and better understanding habitat needs of sharp-tailed grouse may help refine this debate for the eastern UP. There will likely be future

opportunities to conduct habitat management for sharp-tailed grouse and other open land species on private and public lands, so outcomes of an adaptive approach can help justify future grant requests by identifying activities most likely to sustain sharp-tailed grouse. Agency accountability and credibility could be increased by developing this approach in a transparent environment that is inclusive of stakeholders within and outside agencies sharing jurisdiction.

American Woodcock Reproductive Rates In Relation To Forest Structure At Local And Landscape Scales

Primary Contact: Dr. Dave Luukkonen, DNR Wildlife Division, East Lansing, Michigan
Email: LuukkonenD@michigan.gov
Phone: (517) 641-4903
DNR Financial Support: $115,500 in FY15, $319,000 total.
Study Area: Statewide
Time Frame: 05/01/2015-09/30/2018

Abstract: American woodcock (*Scolopax minor*) breeding population indices in Michigan, the Central Management Unit, and range-wide suggest a long-term decline in woodcock abundance since 1968 (Cooper and Rau 2012). Management responses to declining woodcock abundance included restricting harvest opportunities (i.e., reduce season lengths and daily limits: Cooper and Rau 2012) and promoting habitat management to increase early successional forests that benefit woodcock and other wildlife species associated with these habitats (e.g., ruffed grouse: *Bonasa umbellus* and golden-winged warbler: *Vermivora chrysoptera*). Although many biologists believe that loss of breeding habitat quality and quantity was responsible for woodcock population declines (Kelley et al. 2008), there are many uncertainties that may affect woodcock management efficiency and effectiveness; at a continental scale, there is need to "improve understanding of migration, breeding, and wintering habitat quality for American woodcock" (Case and Sanders 2010). Existing habitat models for breeding woodcock rely on correlates between presence/absence or abundance of animals on the landscape, and these models may fail to capture important processes underlying declines in reproductive rates. We believe that the highest priority information needed to improve management of woodcock in the Great Lakes Region is better understanding the relation between woodcock breeding habitat characteristics and reproductive rates; better understanding the relationship between habitat/landscape attributes and reproductive success would assist managers in targeting habitat treatments to improve woodcock reproductive success.

Available demographic information for woodcock supports the idea that declines in reproductive rates associated with changes in landscape-scale habitat characteristics have contributed to declining woodcock abundance. The DNR's volunteer woodcock banding program has provided long-term estimates of woodcock survival with adult and juvenile survival being relatively stable while woodcock abundance was declining (Krementz et. al. 2003, Mayhew and Luukkonen 2010). Woodcock wings from a sample of hunters have been collected by the U.S. Fish and Wildlife Service (USFWS) since 1963 and an index to reproductive success derived from this sample (juveniles per adult females) suggests long-term decline in harvest age ratios (Cooper and Rau 2012). However, the relationship between harvest age ratios and more direct measures of reproductive success (e.g., nesting success and brood survival) have not been tested. Woodcock nest early in spring and survival of nests have generally been high (43-67% nest success) and although survival of nests and young can be affected by weather, most nest losses result from predation (Straw et. al. 1994, McAuley et. al. 1996). The degree to which predation rates and nesting success have changed and are tied to landscape characteristics is relatively unstudied; however, changes in landscape-scale habitat characteristics on breeding areas appear to have affected woodcock demographics as woodcock population trajectories varied among broad ecosystem types (i.e., bird conservation regions: BCR's) with relative population stability in the Boreal Hardwood Transition compared to declines in the Prairie Hardwood Transition and other ecosystems (Sauer et. al. 2008).

Population Dynamics And Management Of Wild Turkeys In Michigan: Linking Monitoring, Assessment, And Harvest-Policy Evaluation

Primary Contact: Dr. Dave Luukkonen, DNR Wildlife Division, East Lansing, Michigan
Email: LuukkonenD@michigan.gov
Phone: (517) 641-4903
DNR Financial Support: $42,849 in FY15, $131,500 total
Study Area: Statewide
Time Frame: 02/01/2015-09/30/2017

Abstract: There are broad public interests and socio-economic benefits associated with sustaining recreational turkey harvests in Michigan and throughout North America. In Michigan, spring turkey hunters increased from around 10,000 hunters in the early 1980s to between 80,000-100,000 hunters over the last decade (Frawley 2013). Likewise, spring gobbler harvest increased from around 5,000 birds per year to between 30,000-40,000 birds over the same period. More broadly, restoration of turkey populations was followed by the resurgence of hunting popularity across the turkey range. By 2006, turkey hunting in the United States (U.S.) was second in popularity only to deer hunting, with an estimated 2.6 million hunters spending greater than 250,000 days afield and generating approximately $4.1 billion in economic output (Harris 2010). However, biologists in many areas are concerned about population declines (Porter et. al. 2011, Tapley et. al. 2011), and it is uncertain that populations can sustain current harvests into the foreseeable future.

Sustaining large recreational turkey harvests will provide societal benefits, and is promoted by clear and specific objectives. Michigan has management goals to provide hunting opportunities while maintaining turkey hunter satisfaction (Frawley 2013). We believe that quantitative evaluation of harvest sustainability would be promoted by augmenting existing goals with explicit descriptions of the types of harvest that are desirable to sustain. For example, ongoing analyses suggest harvest strategies aimed at sustaining large harvests of adult gobblers result in different approaches to management than those attempting to sustain harvests of either sex over both spring and fall seasons (Bryan Stevens, unpublished data). Thus, augmenting existing goals with specific objectives or performance measures related to turkey abundance or harvest by age/sex would allow for a more refined analysis of alternative management strategies. Such analyses would permit proactive evaluation of risks to important harvest metrics associated with specific changes to turkey management regulations.

Although turkey populations in Michigan are thought to be relatively stable, a more refined analysis would provide more detailed information on their population dynamics. Turkey populations in Michigan are currently monitored using raw harvest or number of turkeys harvested per unit of effort (catch-per-unit effort [CPUE]), and this approach is widely used across the U.S. Raw harvest (when effort is stable) or CPUE can provide a reliable population index, but interpretation of CPUE data is complicated by the possibility that the proportion of the population removed per unit effort is not constant (Maunder and Punt 2004). Even if CPUE does index relative abundance, it does not directly provide the biological information necessary to determine sustainable levels of exploitation; this requires more understanding of population drivers and density dependence (Hilborn and Walters 1992, Maunder et. al. 2006). Explicit population assessment models built using both harvest and CPUE data can provide estimates of abundance and sustainable harvest levels. This approach is well developed in commercial fisheries and has been used in terrestrial-wildlife applications (e.g., Conn et. al. 2008). Thus, existing monitoring data should provide a basis for developing assessment models to understand population dynamics and aide management decision making for turkeys in Michigan. Moreover, evaluating the quality of existing monitoring data and the implications of assumption violations for management could be incorporated into model development.

Over the last decade, considerable advancements in computing power and quantitative analyses resulted in development of sophisticated techniques for evaluation of harvest policies for other species (Bence et. al. 2008, Jones and Bence 2009). These techniques use simulation models to forecast the consequences of management decisions while accounting for the uncertainty of both model inputs and projected results. This permits managers to better understand consequences of harvest regulatory policies, and facilitates adaptive approaches that continue to evaluate management as monitoring data are collected through time (Irwin et. al. 2011). Specific regulatory policies to be evaluated for turkeys in Michigan will need to be identified collaboratively with DNR Wildlife Division staff to ensure options are relevant to managers; however, this could include simulation of policies that attempt to meet objectives via harvests that maintain constant levels of hunter effort or harvests through time (i.e., no feedback with monitoring data), harvests that attempt to remove a constant fraction of the population based on regular updating of a population-assessment model, or the status quo framework where harvest regulations are updated at 3-year intervals after evaluating raw CPUE data. Thus, these techniques link monitoring data inputs to management decisions, and are capable of evaluating how both monitoring data type and quality affect our ability to manage turkey harvests effectively. We believe such work would be broadly beneficial to managers making decisions about both monitoring protocols and harvest regulations for turkeys in Michigan.

Analytical Support Refining Black Bear Abundance Estimates In The Northern Lower Peninsula And Addressing Action Items In Michigan's Bear Management

Primary Contact: Dr. Dwayne Etter, DNR Wildlife Division, East Lansing, Michigan
Email: etterd@michigan.gov
Phone: 517-641-4903
DNR Financial Support: $33,855 in FY15, $183,438 total.
Study Area: Northern Lower Peninsula.
Time Frame: 09/13/2013-09/30/2015

Abstract: The goal of Michigan's Bear Management Plan (BMP) is to maintain a sustainable bear population that is within social carrying capacity (MDNR 2009). Bears occur across Michigan's Northern Lower Peninsula (NLP), however, their distribution is not uniform; higher bear densities are likely in areas of preferred habitat (Carter et. al. 2010). The distribution and density of bears across the landscape are important to managers because Bear Management Units (BMUs) are established to effectively distribute hunters and harvest. Additionally, social attitudes towards bears (both positive and negative) may be influenced by localized bear densities.

The DNR presently estimates abundance of bears across the area of the NLP open to bear hunting using a genetic capture-mark-recapture estimator (CMR; Dreher et. al. 2007, Etter and Mayhew 2008). These estimates are produced every few years and are used to evaluate desired population trends and establish annual harvest quotas. While this approach may be effective for achieving broad-scale management objectives, finer resolution estimates of abundance would assist in determining if present BMU boundaries are achieving desired management goals and could be used to address localized bear management issues including evaluating social attitudes towards bears.

Landscape level estimates are also used as an initial population size for a simulated population model that is used in turn to establish annual bear harvest quotas. Although recent trends in estimates and model projections indicate a substantial decline in bear abundance in the NLP, (>20% since 2003) harvest levels remain high even as hunter effort has been reduced (>50% decrease in available licenses since 2008). Additional estimates of bear abundance and model input parameters (i.e., survival and recruitment) would assist in evaluating the impacts of annual harvest on abundance of bears in the NLP.

Data Collection and Analysis to Generate Localized Deer Abundance Estimates and Recommended Future Protocols

Primary Contact: Dr. Brent Rudolph, DNR Wildlife Division, East Lansing, Michigan
Email: rudolphb@michigan.gov
Phone: 517-641-4903
DNR Financial Support: $57,490 in FY15, $250,417 total.
Study Area: southcentral Michigan
Time Frame: 5/01/2014-9/30/2018

Abstract: Monitoring efforts to support decision making for deer management typically occur at county or regional scales. Numerous factors that influence deer management (e.g., hunting access or intensity, land use and cover, predation rates) vary at a much finer scale, but uniformly monitoring such conditions and associated population responses is not generally feasible or necessary. However, events that significantly impact populations or generate substantial public concern periodically create a need to assess deer abundance or population dynamics at a finer scale. This scale mismatch may disrupt an agency's ability to effectively manage social and ecological process and require organizations to evaluate new monitoring frameworks (Cumming et. al. 2006). In particular, the Michigan Surveillance and Response Plan for Chronic Wasting Disease (CWD) requires localized deer abundance estimates to be generated following any documented outbreak of CWD. Furthermore, an increased frequency of outbreaks of Epizootic Hemorrhagic Disease (EHD) in Michigan is attracting substantial concern among deer hunters and other wildlife enthusiasts in affected areas. A particularly significant EHD outbreak in 2012 created considerable public alarm, but may provide a unique and timely opportunity to assess new monitoring frameworks capable of addressing this management dilemma.

The EHD is an acute, infectious, viral disease that is often fatal in Michigan. It was first identified as a viral disease in 1955 following investigations into the death of several hundred white-tailed deer in both New Jersey and Michigan (Shope et. al. 1960). Since the initial 1955 outbreak, additional die-offs in Michigan attributed to EHD occurred in 1974, 2006, 2008, 2009, 2010, 2011, 2012, and 2013. Most die-offs occurred in isolated areas and resulted in estimates of no more than a few thousand deer dying. However, in 2012, EHD was

confirmed in 30 counties and mortalities were reported in 21 other counties where confirmatory laboratory testing of samples was not able to be conducted. In total, EHD was the suspected cause of death in nearly 15,000 reported deer mortalities. To date, these outbreaks do not appear to have had an effect on regional populations. Because of its high mortality rate in Michigan, however, EHD outbreaks are likely producing highly contrasting localized deer abundance. Hunters and other wildlife enthusiasts in affected areas may observe reduced densities of deer for years to come, and these occurrences may influence stakeholder satisfaction. With the greater frequency of EHD outbreaks, such stakeholder experiences are becoming increasingly common.

Monitoring Mast Occurrence And Production Using Citizen Scientists To Inform Wildlife Management In Michigan

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DNR Financial Support: $42,690 in FY15, $123,763 total.
Study Area: southcentral Michigan
Time Frame: 5/01/2014-9/30/2016

Abstract: Hard and soft mast is a critical component of habitat for many wildlife species in Michigan. For example, wild turkeys, bears, and white-tailed deer are known to rely on acorns to build fat reserves for the winter months (e.g., Ostfeld et. al. 1996, Ryan et. al. 2004). Bear damage complaints generally increase when summer crops of soft mast fail (Howe et. al. 2010) and bear hunter success may be inversely correlated with mast production (Malcolm and Van Deelen 2010, Bridges et. al. 2011, S. Mayhew, DNR pers. comm.). Additionally, the productivity of several important furbearers is likely linked to mast production through the population status of small mammal prey species that are known to positively respond to increases in mast production (e.g., Ostfeld et. al. 1996, McShea 2000). Knowledge of the ecological factors that may drive mast occurrence, production, and timing in Michigan are needed to improve current population dynamics models for game species used to for management by DNR Wildlife Division.

Mast occurrence and production are highly variable both spatially and temporally. Hence, direct observation through continuous monitoring is needed to incorporate mast dynamics into DNR population models. For this monitoring to be financially feasible for the Wildlife Division, however, requires a large volunteer workforce. The goal of our proposed research is to evaluate the feasibility and accuracy of using citizen scientists to help collect information on mast production that can be used to inform DNR Wildlife Division population and harvest management decisions. We propose conducting a feasibility study in the northern Lower Peninsula of Michigan.

Analytical Support Refining Wolf Survival Estimates In The Upper Peninsula And Addressing Action Items In Michigan's Wolf Management Plan

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DNR Financial Support: $49,742 in FY15, $135,333 total.
Study Area: Upper Peninsula
Time Frame: 6/01/2014-9/30/2016

Abstract: On January 27, 2012, the U.S. Fish and Wildlife Service (USFWS) removed gray wolves (*Canis lupus*) in the Great Lakes region from the federal list of threatened and endangered species, transferring management authority to the states. Regional wolf populations exceed recovery criteria and there is stakeholder interest in managing wolf abundance to reduce wolf-human conflicts and/or allowing a harvest to manage conflicts or provide recreational opportunities. However, proposals for a public wolf harvest in Michigan are controversial. Because the USFWS removed wolves from the list of federally endangered species only a short time ago, some stakeholders are concerned that any harvest of wolves might cause populations to decline, resulting in reinstatement of federal protection wolves. Decision-makers will request predictions on the effect of various harvest scenarios on Michigan's wolf population. Biologists can use a population modeling approach to develop these predictions. However, population modeling requires inputs of wolf population vital rates. Important inputs needed include estimates of survival rate, mortality factors, and dispersal dynamics. Biologists commonly estimate these rates and factors by monitoring the fates of radio-collared individuals. In Michigan, over 350 wolves were radio-collared and monitored from 1992-2010. These data are more than adequate for developing estimates of survival rate, determining mortality factors, and estimating dispersal. Although preliminary analyses of these data are available, the management need warrants analyses that are

more detailed. In addition, biologists need to understand causes of mortality and dispersal dynamics in order to consider their relative effects and determine which factors management might be able to manipulate to cause desired changes in wolf populations.

Survival & Mortality

Survival rates for wolves have historically been lowest where human influence is high. Annual estimates have ranged from 0.55-0.85 for wolves >1 year old in generally unexploited populations (Fuller et. al. 2003, Adams et. al. 2008, Benhamou and Cornelis 2010). However, studies have shown lower (0.34-0.54) survival estimates for wolves subject to significant annual take (Person and Russell 2008). Hence, reliable survival estimates prior to an annual harvest are essential to the establishment of a baseline rate. While human-caused mortality has been shown to influence adult survival and hence population growth (Person and Russell 2008, Creel and Rotella 2010, Gude et. al. 2012), wolves apparently can sustain some rate of human take (e.g., <30 % human-caused mortality does not appear to influence growth rates; Fuller et. al. 2003, Adams et. al. 2008, Smith et. al. 2010, Gude et. al. 2012). Nonetheless, adult survival is a key vital rate in population growth estimates and it should be monitored closely (Smith et. al. 2010). We anticipate cause-specific mortality effects on survival such as proximity to humans (or road density, as a proxy for conflict), method of capture, and vaccination status of the sampled population. Reliable survival models with valid covariates can provide valuable information to state agencies, especially models constructed in the absence of recreational harvest. Valid estimates of vital rates are important to the understanding of population trends, particularly in a region where state management agencies are implementing wolf harvests and source-sink population dynamics can occur among states.

Dispersal

Dispersal is an important mechanism for wolves. Wolves disperse in order to find new mates, establish new populations, and expand their range, among other factors (Fuller et. al. 2003). Dispersal rates often depend on a number of factors such as prey availability and breeding pack survival. In the Great Lakes region, age was an important determinant of dispersal and dispersal rates for yearlings have ranged from 38-78% (Treves et. al. 2009). Due to habitat fragmentation, human tolerance, and the absence of pack benefits, dispersers may be more vulnerable to natural and human-caused factors that increase the chances of mortality and human-wolf conflict (Fuller et. al. 2003). Understanding dispersal processes within a wolf population is key to providing management recommendations, particularly because these processes can be dependent on many other factors such as pack productivity, habitat fragmentation, prey abundance, and surrounding populations (Fuller et. al. 2003, Treves et. al. 2009). Dispersal may also influence an individual's probability of survival (Boyd and Pletscher 1999, Blanco and Cortes 2007, Smith et. al. 2010). From a management perspective, it is important to consider the potential drivers of individual dispersal from a pack, and the likely consequences of individual survivorship. For example, a unique situation currently exists in the western Great Lakes where, during the wolf hunt season, a dispersing individual might become more or less vulnerable to being killed depending on whether it was moving into or out of a state that permits wolf hunting (i.e. Michigan vs. Minnesota or Wisconsin). Given the circumstances, these effects can influence local or regional populations positively or negatively. Consequently, an understanding of the nature and magnitude of dispersal effects is an important piece of information for wolf population management.

Eastern Massasauga Conservation: Through Refined Modeling, Habitat Management, And Snake Fungal Disease Detection

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DNR Financial Support: $62,190 in FY15, $174,721 total.
Study Area: Lower Peninsula.
Time Frame: 02/01/2015-12/31/2017

Abstract: The eastern massasauga rattlesnake (EMR) is one of three massasauga subspecies in North America and ranges across the Great Lakes region from Iowa to New York and from Ontario to Illinois (Jones et. al. 2012). Today, populations of EMRs have severely declined primarily due to habitat degradation, land development, agriculture, and persecution in fragmented areas, leaving many existing populations isolated and or in decline (Szymanski 1998, Johnson et. al. 2000, Gibbs and Chiucchi 2012). A contributing factor to the decline in habitat quality is that natural processes, such as fires, grazing and flooding events that historically maintained early successional vegetation communities and habitat conditions for EMRs are now beyond their historical range of variability. Today, as with most wildlife species, active habitat management is necessary to maintain habitat quality for the remaining EMR populations.

Effective monitoring of EMR populations is critical for evaluating the success of EMR habitat management practices and to evaluate population trends over time. Because this species inhabits relatively dense vegetation types (e.g., prairies, grasslands with sparse shrub cover, scrub-shrub wetlands) they are often problematic to detect. A greater understanding of the habitat, environmental (e.g., temperature, precipitation) and surveyor (e.g., number, level of training) effects on detection, and the effects of survey methodologies (e.g., transects, random walks) is critical for establishing more standardized population survey techniques, ultimately resulting in increased confidence in the survey results. Additionally, with a standardized, effective, and efficient survey methodology, biologists could more reliably focus on vital rates (e.g., fecundity, juvenile survival) to evaluate the viability of populations. While demographic rates for the EMR, particularly survivorship of adults, have been assessed (Bissell 2006, Bailey 2010, Bailey et. al. 2011, Jones et. al. 2012), rates related to reproduction and reproductive success such as fecundity and neonate survivorship are limited. Research has suggested that demographic rates for EMR can vary greatly among populations (Jones et. al. 2012), yet aside from adult survivorship, little is known of other vital rates for many populations. The fragmentation of this species across its range, in addition to the fact that so little is known of the species' demographic rates, creates difficulty for managers interested in monitoring trends and shifts in populations and modeling population viability. Further, the spread of fungal infection (*Ophidiomyces ophiodiicola*) among free-ranging snakes is considered an important potential threat to the viability of EMR populations (e.g., Allender et. al. 2011). An assessment of the prevalence of *Ophidiomyces* sp. in remaining EMR populations is warranted to determine long-term viability of these populations.

Previous work in Michigan led by Dr. H. Campa has quantified habitat suitability requirements for the EMR in southwestern Michigan (Bissell 2006, Bailey 2010), and resource selection patterns in managed landscapes (Bailey et. al. 2012). From this work, an EMR Habitat Suitability Index (HSI) model was initially developed by Bissell (2006) in southwestern Michigan and later modified by Bailey (2010). The HSI model was developed by quantifying vegetation composition and structural attributes at multiple spatial scales and relating these habitat elements to several EMR population "fitness" performance measures. To appropriately validate this model, a range of habitat conditions across southern Michigan should be assessed. Additionally, with the collection of more data as proposed here, other modeling approaches can be explored (e.g., resource selection functions). Having a validated habitat model would help natural resource managers plan and implement more effective habitat management practices to maintain or enhance populations across the species' range.

Genetic Diversity:

Support for Research on Seedling, Nursery and Tree Development Projects
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DNR Financial Support: $12,000.00 Study Area: Brighton State Forest Nursery
Time Frame: 10/2014 – 9/2015
Abstract: Cooperative research and technical assistance related to nursery improvement and seed orchard management from Michigan State University's Forestry Department. Work in 2014 included continued jack pine seed collection from the best performing families in provenance test sites for use in establishing the next improved jack pine seed orchard. The DNR plans to begin replacement of its current jack pine seed orchard located at the Brighton Tree Improvement Center in a few years. Other work in 2014 included technical assistance in designing the next jack pine seed orchard and evaluation of options for establishing a red pine seed orchard and/or red pine seed production areas out in the forest in the future.

Criterion Two: Maintenance of Productive Capacity of Forest Ecosystems

Seasonal Deer Migration Effects on the Distribution of Nutrients in Forest Ecosystems
Primary Contact: Christopher Webster, Ecosystem Science Center, School of Forest Resources and Environmental Science, Michigan Technological University
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DNR Financial Support: None
Study Area: Ontonagon & Gogebic Counties – Porcupine Mountains Wilderness State Park
Time Frame: 2010 – Present
Abstract: Twenty five pellet plots were sampled during the 2014 season providing nine years of continuous sampling of three hemlock stands within Porcupine Mountains Wilderness State Park (PMWSP). These three stands are part of a larger study encompassing 39 stands distributed across the western Upper Peninsula of

Michigan. Based on the pellet survey, deer use was higher in 2013 than 2012, but lower than the peak levels observed during the winter of 2008. Use was strongly related to stand area. The greatest use occurred in our largest sample stand. No winter deer activity has been recorded in our smallest sample stand. Our results from the broader data set suggest that deer use the same areas within stands through time. The level of overall use during any given winter is strongly influenced by the timing and depth of snow accumulation.

Criterion Three: Maintenance of Forest Ecosystem Health and Vitality

Statewide Beech Bark Disease Monitoring and Impact Analysis Plot Network
Primary Contact: Dr. Deb McCullough, Michigan State University
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DNR Financial Support: None. Conducted partially on state land.
Study Area: State forest lands on the leading edge of the advancing front of Beech Bark Disease the UP and LP
Time Frame: 2012-Ongoing.
Abstract: This project monitored spread and distribution of the exotic beech scale (the advancing front of BBD) and recorded mortality and decline of American Beech trees in long-term impact plots established in 2002-2003. Dynamics of beech scale populations also continue to be assessed annually in 14 Lower Peninsula stands. Beech is a significant species in many northern hardwood stands in Michigan and an important wildlife resource. Data summaries and updated maps illustrating areas impacted by this insect-disease complex were provided to foresters managing affected areas. Since there is no practical control for beech bark disease in forest conditions, having the latest information on the distribution and ongoing impacts of BBD is critical to managing forests to sustain productive sites and avoid unacceptable losses to the disease, as well as unacceptable regeneration. Information from this research is conveyed to DNR Forest Resources Division as it is developed.

Oak Wilt Sample Analysis for Delimitation of Infected Areas
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DNR Financial Support: None. Use of state forest land and data.
Study Area: State and private forest lands statewide
Time Frame: Ongoing
Abstract: Laboratory culturing of samples of oak wood that is thought to be infested with oak wilt is the only concrete way to tell conclusively that this is in fact the case. Confirming the cause of oak mortality is critical to treating oak wilt as several other diseases cause mortality that looks much like oak wilt. These studies make it possible to differentiate causal agents and thus map more accurately the occurrence of oak wilt vs. other diseases that kill oak and are easily confused with oak wilt. Having definitive identification of the causes of oak mortality is critical to sustainable forest management as treatments for the various causes differ and what works for one has no impact on the others. Forest managers need to know what they're fighting to adopt the correct response. These studies are developing ways to detect oak wilt more efficiently, direct suppression efforts and resources more precisely, and manage oak forests more effectively to maintain the species and keep sites productive.

White Ash Survival Following Emerald Ash Borer Invasion; Continuing Research on DNR lands
Primary Contact: Dr. Deborah G. McCullough, Michigan State University, Dept. of Entomology and Department of Forestry
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DNR Financial Support: None
Study Area: DNR lands in southeast Michigan
Time Frame: 2014 – Present

Abstract: (see supplemental reading for more information) Since its discovery in 2002 in Detroit, Michigan, emerald ash borer (EAB) (*Agrilus planipennis Fairmaire*) has been found in 25 additional states and two Canadian provinces. Goals of this project include (1) documenting survival rates of white ash in forested areas in the core of the EAB infestation (e.g., areas where EAB has been present for several years); (2) identification of traits associated with unexpectedly high white ash survival or, conversely, very low white ash survival; and (3) evaluation of two EAB trap/lure combinations. Recent papers in scientific journals have reported >80-99% mortality of green ash, black ash and white ash trees in plots located in forested sites in southeast Michigan and northwest Ohio. We are aware, however, of numerous forest stands in the "core" of the EAB invasion where a high proportion of overstory white ash remain alive and appear relatively healthy, despite several years of EAB presence. Our previous studies, conducted in forests, ash research plantations and the laboratory, have shown vulnerability to EAB varies among ash species. Green ash and black ash are highly preferred EAB hosts, while blue ash is quite resistant to EAB. White ash, the most widely distributed North American ash and the species with the highest timber value, is an intermediate host for EAB. We are conducting field surveys to document condition of white ash and other overstory species and regeneration in 28 locations, trapping to assess presence and relative abundance of EAB, and using GIS analyses to determine if there are characteristics consistently associated with high (or low) survival of white ash trees.

Evaluation of an Integrated Approach to SL.ow A.sh M.ortality (SLAM) Caused by Emerald Ash Borer
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DNR Financial Support: None. Conducted partially on state land.
Study Area: Research data from the SLAM Project (2009-2012)
Time Frame: 2014
Abstract: Emerald ash borer (EAB) has become the most destructive forest insect to invade North America. Unfortunately, tactics to manage EAB are limited and difficult to evaluate, primarily because of the difficulty of detecting and delineating new infestations. A large scale project to slow EAB population growth and the rate of ash mortality was developed, implemented and evaluated in the Upper Peninsula (UP) by collaborators from multiple universities, and state and federal agencies in the SL.ow A.sh M.ortality (SLAM) pilot project. Components of the SLAM pilot project included an extensive inventory of ash abundance across an extensive area of the eastern UP. More than 585 ash trees were treated with a highly effective systemic insecticide, and between 2009 and 2012, more than 2,655 small ash were girdled and debarked to assess EAB distribution and larval density. While only a tiny proportion of ash trees in the project area were treated or girdled, both tactics led to detectable reductions of EAB population growth and protected ash trees in areas surrounding the treatments. The number of treated trees was more important than the size of treated trees. Significant interactions among girdled trees, larval density, and the local abundance of ash phloem indicate girdling trees has a positive, but complex potential as a management tactic. Results have been reported in four papers in scientific journals to date, along with a webinar that can be viewed at http://www.emeraldashborer.info.

Soil Moisture and Nutrient Response to Emerald Ash Borer-induced White Ash Mortality in Michigan
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DNR Financial Support: None. Conducted partially on state land.
Study Area: DNR lands in Southeast Michigan
Time Frame: Ongoing
Abstract: Emerald ash borer (EAB) (Agrilus planipennis Fairmaire) is an invasive species that has proven destructive to forests in 22 states since its discovery in Detroit, MI in 2002. Research has made clear the direct costs and damages associated with EAB, including loss of ecosystem services and damage to plant-based industries. However, less clear are the potential impacts on water resources and nutrient cycling (specifically nitrogen & phosphorus) as a result of EAB related ash die-back; alterations to moisture fluxes and nutrient cycling could have significant effects on impacted watersheds, as well as downstream nutrient limited ecosystems.

The goals for this research are to improve understanding of how EAB related ash die-back alters soil moisture dynamics and soil temperature profiles, changes runoff and infiltration of precipitation, and affects the distribution and speciation of nitrogen and phosphorus in the soils. Ultimately, the goal is to determine if alterations due to EAB related die-back are important on the watershed scale. We plan to develop models that

describe the complex relationships between moisture fluxes, nutrient cycling, vegetation die-back and regrowth. These models will help inform management policy for the control of nutrient loading in EAB impacted watersheds.

Trapping for Detection of Exotic Forest Pests and Evaluation of Native Wood Boring Insect Communities

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DNR Financial Support: None. Conducted partially on state land.
Study Area: Michigan's Upper and Lower Peninsulas
Time Frame: 2013, 2015-2016

Abstract: Our goals are to survey sites at relatively high risk for exotic forest pest introductions via international and domestic invasion pathways. We were especially interested in woodborers and bark beetles, which could potentially cause widespread damage if they became established. These insects can be introduced in solid wood packing material, live nursery trees, unprocessed logs and firewood. We developed risk maps for Michigan's Upper and Lower Peninsulas using GIS technology to overlay variables such as forest cover type, number and origin of state park visitors, sawmill and campground locations, and linear corridors such as railroads, highways and rivers. Spatial data sets and point data were overlaid to identify industrial and recreation sites at risk for specific forest pests. For example, a state park surrounded by maple-dominated forest would be considered a high risk site, if the park hosts visitors from locations where Asian long horned beetle (ALB) has been identified. We selected up to 60-62 sites across Michigan's Upper and Lower Peninsulas to survey each year. An array of traps baited with lures for specific target pests are deployed in each site. Insects captured in the traps are collected, sorted and identified to species to ensure non-native target pests are not present. Selected groups of native woodborers are also identified to assess species composition and diversity of insects in specific forest cover types and locations, and to evaluate efficacy of specific lures.

Emerald Ash Borer Parasitoid Rearing

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DNR Financial Support: None
Study Area: Currently conducted partially on state land in the central and southern Lower Peninsula of Michigan
Time Frame: Ongoing

Abstract: The emerald ash borer (EAB) was likely introduced into Michigan in packing material from China in the 1990s. However, the pest was not detected until 2002, and soon after APHIS and the Forest Service initiated an EAB biological control (biocontrol) effort. Foreign exploration initially identified three biological control agents for EAB; two larval parasitoids - *Spathius agrili* and *Tetrastichus planipennisi*, and one egg parasioid - *Oobius agrili*. The EAB biocontrol agents were first released in 2007 in Michigan. Two years later, APHIS' EAB Program established a dedicated biological control production facility in Brighton Michigan. In 2015, another larval parasitoid, *Spathius galinae*, was approved for field releases and is being mass reared in Brighton. Today, the EAB Program has a strategic goal to release parasitoids in every infested county (over 700 counties) in the United States. At present, 22 of the 25 infested states have received EAB biocontrol, over 3 million parasitoids have been released since 2009, and approximately 25% of the known EAB-infested counties have performed releases.

The rearing facility produces and stockpiles a majority of the parasitoids to be released prior to the initiation of the release season in spring. This approach demands a steady supply of EAB during months that EAB is not present in the field. To maintain a constant supply of off-season adult EAB to produce the necessary egg and larval stage parasitoid hosts, the rearing facility harvests infested, mature ash material during winter months when adult EABs are in diapause. Several hundred ash trees are harvested from private and state lands for this purpose, stored in a cold chamber, and warmed as needed to facilitate adult emergence. These adults are collected and maintained in enclosures with the appropriate resources to encourage reproduction and oviposition. A portion of EAB eggs from these enclosures are provided to *Oobius agrili* to parasitize. The parasitized eggs are then shipped to cooperators to be placed in the field for natural emergence and release.

The remaining EAB eggs are applied to ash bolts and allowed to hatch and develop into 4th instar larvae. Several hundred smaller diameter (2-6 inch) ash trees are harvested from state lands and cut into smaller segments to provide the best EAB host for this stage. Once EAB larvae have developed to the correct stage, they are presented to one of the larval parasitoids. The parasitized larvae within the bolts are then provided to cooperators to be place in the field for natural emergence and release of parasitoids.

Parasitoid recovery efforts are ongoing. However, to date, cooperators in 10 states (Indiana, Illinois, Maryland, Michigan, Minnesota, New York, Ohio, Pennsylvania, Tennessee, and Wisconsin) have successfully recovered the offspring from one or more of the stingless wasps. Because the release sites are continually monitored, we anticipate additional reports of wasp recovery.

Progress in the Classical Biological Control of *Agrilus planipennis* Fairmaire (Coleoptera: Buprestidae) in North America.

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DNR Financial Support: None. Conducted partially on state forest land.
Study Area: EAB infested sites in Michigan
Timeframe: Ongoing
Abstract: First detected in North America in 2002, the EAB (*Agrilus planipennis* Fairmaire; Coleoptera: Buprestidae), an invasive phloem-feeding beetle from Asia, has killed tens of millions of ash (*Fraxinus* Linnaeus; Oleaceae) trees. Although few parasitoids attack EAB in North America, three parasitoid species were found attacking EAB in China: the egg parasitoid *Oobius agrili* Zhang and Huang (Hymenoptera: Encyrtidae) and two larval parasitoids *Tetrastichus planipennisi* Yang (Hymenoptera: Eulophidae) and *Spathius agrili* Yang (Hymenoptera: Braconidae). In 2007, classical biological control of EAB began in the United States after release of these three species was approved. In 2013, release of the larval parasitoids was approved in Canada. Research continues at study sites in Michigan, where the establishment, prevalence, and spread of *O. agrili* and *T. planipennisi* have been monitored since 2008. However, establishment of *S. agrili* remains unconfirmed in northern areas, and its release is now restricted to regions below the 40th parallel. In 2015, approval for release of *Spathius galinae* Belokobylskij (Hymenoptera: Braconidae), an EAB larval parasitoid from the Russian Far East, may be granted in the United States. Researchers are guardedly optimistic that a complex of introduced and native natural enemies will regulate EAB densities below a tolerance threshold for survival of ash species or genotypes in forested ecosystems. Report Available: http://www.nrs.fs.fed.us/pubs/48338.

Portable Field-Based Application Of Non-Destructive Technologies For Rapid, Early Detection Of Emerald Ash Borer

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DNR Financial Support: None. Conducted partially on state land.
Study Area: Two Lower Peninsula plots (Lapeer State Game Area) were resampled in August, 2014
Time Frame: The portion of the project conducted on state land was initiated in summer 2013 and all analyses and report writing is expected to be completed by summer 2016.
Abstract: Field sampling on state land was initiated in summer 2013 and all field sampling was completed in summer of 2014. Field sampling took place in the Lower Peninsula in the summer of 2013. Two Lower Peninsula plots (Lapeer State Game Area) were resampled in August, 2014. Field sampling for the Upper Peninsula took place in the summer of 2014. Sample processing was the focus of fall 2014. In spring 2015, the project moved mainly to data analysis. In summer and fall 2015, a graduate student (Ms. Kaelyn Finely) focused on writing up the two chapters of her thesis and successfully defending her thesis in December 2015. One chapter was focused on dendrochronology of white ash and the other chapter was based on using Near Infrared Spectroscopy (NIR) as an indicator of EAB infestation of white ash stem tissue. Additional analyses and report writing will be completed in summer 2016 and a final report will be submitted to the funding agency (US Forest Service) in fall 2016.

The general objective of the proposed project is to promote the application of three key non-destructive technologies that will allow rapid, early detection of EAB. Acoustic Tomography: This non-destructive technology allows for early detection of insect feeding activity and pattern detection of compromised wood integrity (e.g., insect galleries) based on the measurement of sound velocity through the wood. Multiple sensor probes were inserted in each sample tree into the sapwood of the stem with minimal impact on the tree. Infrared Thermal Imaging: This non-destructive technology allows for early detection of plant stress by measuring changes in heat production of the stem, crown foliage, and surrounding soils of each plot tree. Near Infrared Spectroscopy (NIR): NIR reflectance spectra are known to provide early detection of physiological stress levels in plants induced by plant pests. Foliage, branch segments, bark surface, phloem, sapwood tissue and soil samples were collected for NIR analysis in the laboratory at Michigan State University.

The key expected outcome is that the three technologies will be successfully trained to discriminate between stands affected by EAB and healthy stands and therefore promote forest sustainability. The key benefit is that outlier areas of EAB will be classified along a gradient of potential susceptibility to EAB. This will allow more efficient use of financial resources to target quarantine efforts in areas forecasted to be most impacted by EAB.

Two journal manuscripts have been published so far:

- Finley, K., and Chhin, S. 2016. Forest health management and detection of invasive forest insects. Resources, 5: Article 18 (15 pages).
- Finley, K., Chhin, S., Nzokou, P., and O'Brien, J. 2016. Use of near-infrared spectroscopy as an indicator of emerald ash borer infestation in white ash stem tissue. Forest Ecology and Management, 366: 41-52.

The key findings from the NIR work indicated that NIR spectra of xylem tissue transformed using a Savitzky-Golay smoothing filter with a 1st derivative transformation over the full NIR wavelength range (1134-2190 nm) had the highest classification accuracy (97%) for discriminating between healthy versus EAB infested trees. This component of the study underscores great potential for future research in developing NIR spectroscopy as a cost-effective method of early detection and monitoring of EAB and other stem-boring insects in support of current detection methods.

The key findings from the dendrochronology component of the study indicated that the negative relationship with summer precipitation and moisture index suggested that crown canopies may be damaged by strong winds associated with storm events characteristic of Michigan summers. Increased risk of branch failure due to EAB infestation may further increase ash susceptibility to wind damage. Since moisture levels have also been shown to be important for EAB larval development, it is possible that the negative responses of radial growth to precipitation at the end of the growing season may benefit EAB larval development, thereby reducing radial growth of white ash.

Application of a Seven-Step Effectiveness Monitoring Design to Aspen (*Populus tremuloides*) in Michigan.

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Phone: 517-284-7853
DNR Financial Support: $10,600 in FY15, total $40,600
Study Area: Six state forest management areas – 2 in the WUP, 2 in the EUP and 2 in the NLP.
Time Frame: 01/01/2014 – 08/30/2017.
Abstract: Trembling aspen (*Populus tremuloides*) has great biological, social and economic value in Michigan. It is an important timber species (social and economic value), it provides habitat components for a broad suite of wildlife species (biological value) and it provides for a broad suite of recreational values associated with hunting and wildlife viewing (social and economic value). Management efforts need to be monitored to determine or assess their effectiveness in terms of meeting the goals and objectives for trembling aspen management.

But, trembling aspen is considered to be a loser under the current suite of climate change scenarios and could potentially be confined to a few refugia by the end of the century. There is a very high degree of uncertainty associated with climate change and the response of aspen which underscores the need for effectiveness monitoring, but effectiveness monitoring remains an elusive goal: there are no examples of effectiveness

monitoring programs at an operational scale and responsible agencies have little hope of finding new resources for effectiveness monitoring in an era of highly stressed budgets.

However, this project proposes to show how a seven-step design process can be used in conjunction with Bayesian networks to develop an effectiveness monitoring program for trembling aspen that uses existing data, accounts for the uncertainty in the system (including climate change), links the monitoring efforts to the aspen decision process, thereby permitting adaptive management and that identifies research priorities and permits the immediate use of research results into the monitoring framework. This will provide for an early warning to impending change and will permit managers to evaluate and decide upon a course of action related to the three broad climate change adaptation strategies: resistance, resilience and response.

Population Dynamics And Movements Of Mute Swans In Michigan
Primary Contact: Dr. Dave Luukkonen, DNR Wildlife Division, East Lansing, Michigan
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Phone: 517-641-4903
DNR Financial Support: $116,500 in FY15, $317,500 total.
Study Area: Statewide.
Time Frame: 10/01/2014-09/30/2015
Abstract: Mute swans (*Cygnus olor*) are not native to North America and distribution and abundance of this invasive species has increased significantly throughout the lower Great Lakes since their introduction in the mid-twentieth century. There is much concern about negative impacts of mute swans on native waterfowl, waterbirds, submerged aquatic vegetation, and wetland habitats (USDA 2012). Given that the species is non-native, and projected ecological and social impacts could be large, the Mississippi Flyway Council and DNR established control policies and associated population reduction goals in the mid-1990s.

Swan abundance in Michigan has been monitored via DNR's spring waterfowl survey, but despite initiation of control efforts focused on public lands, the mute swan population continued to grow rapidly through 2010 (i.e., with a long-term 9.3% annual growth rate: $\lambda = 1.093$; DNR unpublished data). The DNR reviewed existing policies and control programs in 2010 in consultation with Federal agencies, local governmental units, animal welfare groups, waterfowl hunting groups, conservation organizations, and other stakeholders. Part of the evaluation included critical review of population dynamics and levels of control needed to meet a short-term goal of population stabilization and long-term population goal of no more than 2,000 mute swans in Michigan by 2030.

Recent efforts to control mute swan population growth in Michigan were guided by a model predicting population response to natural and management-induced mortality (Luukkonen 2010: unpublished). This model was based on available literature and mute swan models developed for other regions (Ellis and Elphick 2007) with the primary management alternatives being lethal take of different age classes or reproductive classes (i.e., experienced and inexperienced breeders), and nest/egg destruction. There is considerable uncertainty about reproductive parameter estimates, the subadult life cycle of mute swans, and the potential for age-varying breeding propensity in relation to breeding densities and management strategies. Inaccurate estimates of vital rates can translate into unrealistic predictions about take of adult mute swans or levels of nest destruction required to meet objectives and this could result in delayed achievement of population goals, causing prolonged impacts to natural resources. Similarly, management efficiency may be compromised by a poorly parameterized model and as mute swan numbers are reduced, it will be increasingly important to efficiently target cohorts that are contributing to reoccupation of breeding sites (e.g., 1-, 2-, and 3-year olds).

Understanding Habitat, Breeding Ecology and Diseases of Feral Swine in Michigan to Inform Effective Management
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Phone: 517-641-4903
DNR Financial Support: $145,881 in FY15, $541,629 total.
Study Area: central Michigan
Time Frame: 12/01/2013-9/30/2018
Abstract: Feral swine (*Sus scrofa*), specifically the Russian boar breed, pose significant threats to habitat, wildlife, human health, and the agricultural industry in Michigan. Free-ranging feral swine occur in 76 of 83 Michigan counties as of 2012. The occurrence of feral swine is projected to negatively affect the $1 billion wildlife value (USFWS and US Department of Commerce 2006) and $300 million domestic swine industry in Michigan. Additionally, feral swine affect agricultural crop production with potential ramifications that extend to

the entire agricultural industry. Furthermore, researchers are just beginning to understand the indirect impacts of feral swine on naturally occurring plant and animal communities.

Feral-swine are opportunistic omnivores known to consume almost any organic material including vegetation, invertebrates, and vertebrates (Schley and Roper 2003). Feral swine affect plants and animals through direct consumption and by habitat modification and degradation, competition, and invasive species propagation. For example, feral swine can negatively affect forest regeneration through consumption of vegetation and seeds (particularly during low mast periods; Sanguinetti and Kitzberger 2010) and secondarily through soil disturbance and stream bank erosion associated with rooting behavior (Hone 1995). In addition, feral swine compete directly with wildlife for food and water resources (Ilse and Hellgren 1995, Laurance 1997) and can prey on some wildlife species. Direct predation on wildlife is poorly documented in the scientific literature, but ground nesting birds and altricial young are likely susceptible to feral swine predation (Tolleseon et. al. 2003). The scale of ecological damage caused by feral swine has not yet been spatially delineated nor economically assessed for Michigan. An understanding of feral swine space use and activity budgets is needed to help assess and predict risks to plant and animal communities and to help prioritize targeted management actions. Unfortunately, little is known about feral swine ecology in northern climates that can be used to better inform control strategies in Michigan.

Feral swine are reservoirs and potentially amplifiers for >30 viral (i.e. pseudorabies, hog cholera, and foot-and-mouth disease [FMD]) and bacterial (i.e. bovine tuberculosis and brucellosis; e.g., Aranaz et al. 2004) diseases and at least 37 known parasites that can affect humans, livestock, and wildlife (Forrester 1991, Davidson and Nettles 1997, Samuel et. al. 2001, Williams and Barker 2001, Hutton et. al. 2006, Wyckoff et al. 2009). These factors, along with the tendency for feral swine to move throughout landscapes, coupled with their low susceptibility to capture, make it difficult or impossible to eradicate swine diseases. The presence of feral swine in Michigan threatens to compromise the disease-free status of the domestic livestock herds and complicates eradication of bovine tuberculosis (bTB) in free- ranging deer. Bovine tuberculosis is established in portions of Michigan's deer herd, and feral swine are a primary reservoir of bTB in many countries around the world. If Michigan's feral swine population became infected with bTB, it could have substantial negative consequences for the cattle industry. Additionally, over the past 17 years, the U.S. has spent about $200-250 million to achieve a pseudorabies free status for the domestic livestock herd (Hutton et. al. 2006). Feral swine have also been implicated in three outbreaks of swine brucellosis in domestic herds (Feral Swine Subcommittee on Brucellosis and Pseudorabies 2005). Presently, pseudorabies has been reported in 11 states and brucellosis documented in 14 states where feral swine are found (USDA-APHIS 2005). In Michigan, preliminary testing by the DNR of 133 feral swine samples indicated ~10% were positive for pseudorabies; toxoplasmosis has also been confirmed. Feral swine can also transmit some common zoonotic diseases to humans such as leptospirosis, salmonellosis, and trichinosis (Tegt et. al. 2011). Collectively, the potential of feral swine as a disease reservoir and vector makes disease monitoring and control a top priority for Michigan's agricultural community.

Feral swine are possibly the most prolific large mammal on earth reaching sexual maturity at a young age, capable of farrowing several times a year, have large litters, and high natural survival. In good habitat, population growth and subsequent colonization through dispersal can occur rapidly resulting in irruptive population growth (Waithman et. al. 1999, Bieber and Ruf 2005). Natural predators have little impact on feral swine populations (Sweeney et. al. 2003) and in good habitat; feral swine can endure extremely high rates of hunting harvest with little impact on the overall population (Barrett and Pine 1990). Thus, if Michigan has any chance to locally control and potentially eradicate feral swine, action must be taken swiftly using all available control techniques.

Feral swine trapping in Michigan has been implemented by United States Department of Agriculture (USDA)-Wildlife Services, with support from the Michigan Department of Agriculture (MDA), to control localized populations. However, little is known about the effectiveness of these trapping efforts to reduce or eradicate local populations. Additionally, there is an absence of spatial ecology information (i.e., dispersal capabilities, daily movements, seasonal movements, proximity to domestic swine, and feeding behavior) that can be used to inform stakeholders about risk, educate landowners, and ultimately better inform population management strategies, including lethal removal. The goal of this project is to quantify feral swine space and resource use, disease status and potential for disease transmission, and develop and evaluate effective lethal removal techniques and strategies.

Criterion Four: Conservation and Maintenance of Soil and Water Resources

Protecting Instream Habitat By Development And Support Of A Water Withdrawal Decision-Support Tool In Michigan

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DNR Financial Support: $ 78,622 (25% Game and Fish Funds)
Study Area: Statewide
Time Frame: Ongoing

Abstract: Land use practices are well known to influence water yields to stream systems that in turn directly influence fish habitat. Michigan's Water Withdrawal Assessment Tool (WWAT; http://www.miwwat.org/) is designed to estimate the likely ecological impact of a proposed water withdrawal and potentially land use on nearby streams and rivers. The foundation of the WWAT is the Michigan Rivers Inventory Project that produced statewide models of landscapes, river habitats, and fish distributions; an initial ecological rivers segment classification; a statewide model of potential groundwater influx to rivers; a regional classification of riparian ecosystems; and a method for regional assessment of stream condition. This project continues the refinement and improvement of this key regulatory tool.

Assessment of Nearshore Fish Communities in Northern Lake Michigan and Lake Superior

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DNR Financial Support: $81,647 (25% Game and Fish Funds)
Study Area: Northern Lake Michigan
Time Frame: Ongoing

Abstract: Inshore areas of the Great Lakes can be affected by riparian land and fisheries management actions and many of the species found in these areas use tributary streams for recruitment which exposes them to the effects of land use actions. This study is providing key information on the population trends in Bays de Noc fish populations that include adult abundance, year class strength, sex and age structure of walleye and yellow perch in northern Lake Michigan. Additionally, the study is developing a database on fish community composition for under-sampled nearshore areas of northern Lake Michigan. These data provide a key baseline to evaluate current and future fisheries, land use and forest management actions.

Criterion Five: Maintenance of Forest Contribution to Global Carbon Cycles

Michigan Gradient Study on Nitrogen Gradients to Understand the Mechanisms Controlling Carbon and Nitrogen Cycling in the Face of Chronic Nitrogen Deposition and the Long-term Consequences of Nitrogen Saturation

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Phone: 906-487-3470
DNR Financial Support: None. Use of state forest land and state data.
Study Area: There are two study areas -- One is primarily in the SE 1/4 NW 1/4 NW 1/4 Sec 33 T52N R36W, but a small portion is in the SW 1/4 NE 1/4 NW 1/4 Sec 33 T52N R36W. The other is located in the SW 1/4 NE 1/4 Sec 1 T36N R5W, with a small part of one research plot in the SE 1/4 NE 1/4 Sec 1 T36N R5W.
Time Frame: Ongoing

Abstract: Over the next century, ecosystems in the Northern Hemisphere will be exposed to elevated rates of atmospheric nitrogen (N) deposition, which could theoretically strengthen the terrestrial carbon sink (C) in this region, potentially helping to mitigate the rate of atmospheric CO_2 increase. However, the degree to which anthropogenic N deposition could foster greater forest productivity and C storage remains uncertain. Ecologists at the University of Michigan, Michigan Technological University, and the University of Idaho have conducted a long-term, regional, field experiment located in Michigan. To simulate rates of elevated atmospheric N deposition, four sugar maple (*Acer saccharum*)-dominated northern hardwood study sites have received annual additions of 3 g NO_3--N/m^2 since 1994. All four study sites rapidly approached N saturation, evidenced by substantial leaching of both inorganic and organic N. Although simulated atmospheric N deposition increased net primary productivity over the 21-year experiment, soil respiration and litter decay have

significantly declined; these responses have rapidly increased C storage in the organic horizons and surface mineral soil. Greater C in these pools results from a decline in lignolytic microbial activity and a corresponding change in microbial community composition. Given these responses, we hypothesize that: i) simulated atmospheric N deposition will continue to accelerate tree growth, tree mortality, and coarse woody debris production, further increasing C storage in woody biomass and soil organic matter; ii) surface soil C will continue to accumulate at a faster rate under experimental atmospheric N deposition; iii) warmer temperatures will accelerate net primary productivity across the climatic gradient encompassed by the study sites; and, iv) climate warming will eventually interact with simulated atmospheric N deposition to differentially increase ecosystem C storage among sites. A series of established core long-term measurements (some stretching back to 1988) enable us to test these long-term hypotheses and to understand how elevated N deposition and climatic variation might affect forest composition and productivity in the long-term.

Development of Management Scenarios for Lake and Stream Habitat and Fisheries Under Current and Future Land-use and Climate Conditions

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DNR Financial Support: $137,492.00 (25% Game and Fish Funds)
Study Area: Statewide
Time Frame: Reinstituted and ongoing.

Abstract: This project assessed habitat conditions for all lakes and streams statewide under current land-use and climate conditions and provided insights on how current habitat conditions influence sport fish populations and fish community structure in lakes and streams. Boosted regression tree models were developed that predicted abundance and growth of fish species in 6,500 lakes. Nutrient loading models and a new temperature model were developed for use in predicting habitat changes in lakes. Recently developed predictions from 14 downscaled climate data were obtained and summarized for all lakes and stream reach catchments in Michigan. Changes in thermal regime and fish species suitability were estimated for all lakes greater than or equal to 10 acres. Maps identifying lakes vulnerable to species changes were developed for 14 different climate scenarios for mid-century and late century time steps. These data are key baseline and predictive information for the effects of land use and forest practice changes on fisheries resources.

Criterion Six: Maintenance and Enhancement of Long-term Multiple Socio-economic Benefits to Meet the Needs of Societies

Comprehensive Analysis and Improvement of Michigan Statewide Angler Survey Data

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DNR Financial Support: $52,764.00 (25% Game and Fish Funds)
Study Area: Statewide
Time Frame: Ongoing

Abstract: This study examines and improves the catch and effort estimates generated by the Statewide Angler Survey Program by developing methods that will improve the spatial and temporal efficiency of estimates and data use and conceptual and quantitative models that describe fishery dynamics and aid in management decision-making. These data provide key baseline harvest and economic benefits across the state that is required to properly evaluate fisheries management and land use practices.

Partnership for Ecosystem Research and Management – Faculty Support

Primary Contact: Dr. Brent Rudolph, DNR Wildlife Division, East Lansing, Michigan
Email: rudolphb@michigan.gov
Phone: 517-641-4903
DNR Financial Support: $271,187 in FY15, $271,187 total.
Study Area: Statewide.
Time Frame: 10/01/2014 – 09/30/2015

Abstract: The DNR Wildlife Division continues to be a national leader in supporting social science relevant to applied wildlife management. More important than the generation of knowledge is the integrated consideration of social science along with biological science when directing wildlife management programs and providing technical advice to policy makers. These efforts require a range of expertise and constant consideration of the best available information plus evaluation and adaption of programs to make use of this information. This is

best performed by close collaboration of professionals possessing diverse expertise, both within and outside of Wildlife Division.

Dan Kramer – social, economic, and policy aspects of wildlife management. Dr. Dan Kramer possesses considerable expertise to advise and consult with Wildlife Division on data collection, study design, and application of findings regarding the social, economic, and policy aspects of wildlife management, particularly regarding conservation of biodiversity and changing land use.

Frank Lupi – economic aspects of wildlife management. Dr. Frank Lupi possesses considerable expertise to advise and consult with Wildlife Division on data collection, study design, and application of findings regarding the economic aspects of wildlife management.

Jordan Burroughs – wildlife outreach. Jordan Burroughs possesses considerable experience to draw upon to advise and consult with Wildlife Division on efforts to engage and improve upon relationships with diverse stakeholders. This project will provide support for program and operations evaluation, diffusion of techniques to integrate human dimensions of wildlife into programs, improve agency engagement, and improve information transfer and professional development for Wildlife Division personnel.

Shawn Riley – human dimensions aspects of wildlife management. Topics requiring particular attention in this regard include human dimensions of wildlife health; hunter recruitment and retention; antecedents to and consequences of varying levels of public trust and confidence in DNR Wildlife Division; human-wildlife interactions; how individuals and communities develop capacity for living with wildlife; application of systems thinking to natural resource policy; and decision-making processes. Dr. Shawn Riley possesses considerable experience, expertise, and a history of consulting with agency staff on improving capacity to make effective decisions informed by these broad perspectives. This project will provide support for professional development for Wildlife Division personnel, program evaluation, and diffusion of techniques to integrate human dimensions into programs, improve public trust and confidence in the agency, and maintain relevance of application of the public trust doctrine to wildlife management.

Geographic Analysis of Age-Period-Cohort Dimensions in Michigan Hunter Participation
Primary Contact: Brent Rudolph, DNR Wildlife Division, East Lansing, Michigan
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DNR Financial Support: $44,502 in FY15, $64,230 total.
Study Area: Statewide.
Time Frame: 7/01/2014-9/30/2016
Abstract: Michigan's hunting population is declining with important implications for wildlife and forest management, conservation funding, restoration efforts, social relationships with nature, and social and cultural ways of life. For recruitment and retention efforts to respond to this decline, it is vital that wildlife planners, policy-makers, and managers understand the nuanced social, cultural, and demographic issues behind it. Moreover, adaptations to smaller future numbers of hunters and different types of hunters (i.e. older) will be necessary. Planners need a solid projection of how the future hunting population will change with a realistic accounting of what to expect under different scenarios. The proposed project focuses on picking apart the demographic issues related to recent hunting decline by estimating the independent effects of age, period, and cohort on hunting participation rates.

Age has long been recognized as an important variable affecting hunting participation. The true effects of age, however, are complicated by the fact that they are easily confounded by period changes that occur over time and differences among birth cohorts. Cohort effects play a vital role in shaping hunter participation (Winkler and Warnke 2012, Chase 2012, Frawley 2006), but again they are difficult to disentangle from age and period effects. Frawley's (2006) report suggests that cohort effects are affecting participation among Michigan's small game hunters and provides some indication that more recent cohorts are not hunting deer at younger ages to the same extent that prior cohorts did. The age-period-cohort (APC) analysis proposed here would go further to statistically test the independent effects of age, period, and cohort in explaining recent hunter decline, do this by single year of age to specify important cohort groups, and incorporate results into a proven model for projecting the future hunting population.

Moreover, age-period-cohort patterns likely vary across space with environmental, social, and cultural contexts. In order to better direct recruitment/retention efforts, it is vital to understand differences in how these patterns work between more urban and more rural areas of the state and from north to south. For instance, if geographic analysis indicates that the Detroit Metro Area is experiencing particular declines among the heavy-

hunting Baby Boom generation, then this could be a cohort within a particular geography that deserves special attention in retention efforts. Are more rural areas continuing to recruit newer cohorts into hunting at the same rates as past generations? To what extent are cohort effects driving participation declines in rural vs. urban areas?

It is important to independently estimate age, period, and cohort because each has different implications for recruitment and retention efforts. Age can be addressed to some extent by improving accessibility. Period changes can be analyzed for relationships with policy changes, deer population changes, weather, economic change, and other factors to better understand how these factors contribute to hunting participation across all age and cohort groups. Cohort effects require further social analysis of how and why different cohorts develop differential likelihoods to hunt. But social analyses of cohort effects need to be closely integrated with demographic analysis to inform study design (i.e. which cohorts should be sampled and grouped together for analysis and from what parts of the state); to analyze survey results (modeling for cohort effects, independently of age and period); and so that social findings can inform assumptions that are integrated into demographic hunter population projection scenarios.

Boone and Crocket Graduate Student Fellowship: regional analysis of antlered white-tailed deer buck harvest and trophy deer records

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DNR Financial Support: $38,100 in FY15, $38,100 total.
Study Area: Statewide.
Time Frame: 06/01/2015-09/30/2015

Abstract: The Wildlife Division has collaborated with the Boone and Crockett Chair of Wildlife Conservation to provide a graduate student fellowship to support a research project to address unmet Division research priorities. A project to be newly initiated in FY 2015 involves a regional analysis of antlered white-tailed deer buck harvest and trophy deer records in the Midwest and potentially the Northeastern region of the US. This work will examine spatial and temporal patterns that influence the distribution of older age class and trophy bucks harvested within these states. The study area will encompass Great Lake States with an emphasis on Michigan. Exact methods of analyses will be developed as cooperating states commit to participation and available data and metadata are acquired. Results from this research will be used to inform managers regarding the influence of habitat conditions, harvest regulations, and hunting traditions on characteristics of harvested deer. The Division will support the graduate fellowship associated with this research project for the entire FY 2015.

Elk Responses to Recreational Use and Habitat Potential in Michigan

Primary Contact: Dr. Dean Beyer, DNR Wildlife Division, Marquette, Michigan
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DNR Financial Support: $31,500 in FY15, $542,000 total.
Study Area: Northcentral Lower Peninsula.
Time Frame: 05/01/2015-09/30/2019

Abstract: Michigan's elk management plan commits to managing for a sustainable elk population in balance with the habitat and supporting quality hunting and viewing opportunities. Over the past 20 years, elk use of areas outside the historic elk range has increased, leading to reduced public viewing opportunities, challenges to continued use of hunting to manage elk, and increasing human-elk conflict. Greater elk use of these outlying areas may be a result of seeking refuge from disturbance from off-road recreational use or better habitat. Research is needed to support management decisions capable of focusing habitat management efforts where benefits will be greatest (elk management plan strategy 1.1), using hunting to control elk numbers, herd composition, and distribution (elk management plan goal 2), addressing private landowner conflicts with elk (elk management plan action 2.1.1), and providing public viewing opportunities (elk management plan action 3.1.1).

Issues resulting from wildlife–off-road recreational user interactions on public lands are a growing problem throughout North America (Taylor and Knight 2003, Naylor et. al. 2009), as well as in Michigan. Forest and wildlife managers in Michigan are concerned about the potential impacts horseback and mountain bike riding may be having on elk behavior and distribution (S. Whitcomb, B. Mastenbrook, personal communications).

The Michigan Elk Management Advisory Team recommended the DNR "study and monitor disturbance factors (including recreational users) that cause elk to move to and from public land into private land where disturbance level is lower…" (Elk Management Advisory Team 2010:9). We propose quantifying the number and relative intensity, frequency, and geographic scope of recreational users and assessing their influence on elk movement, habitat selection, and subsequent hunting and viewing opportunities. This information will be critical for planning the spatial arrangement of habitat management activities and riding trails, and help justify land use regulations for recreational users.

To help plan and evaluate the effects of habitat management designed to benefit elk (and other species), we propose developing a landscape-scale habitat potential model. The elk habitat potential model would help DNR biologists use an "…objective measurement system to plan and monitor the actual status of the elk…range, habitat…" (Elk Management Advisory Team 2010:7) to identify the location of potential vegetation types needed to meet elk habitat management objectives over time. Focusing habitat management practices in these selected areas may also help minimize elk dispersal reducing agricultural damage and facilitating hunting and viewing.

Exploring Causal Factors And Effects Of Declining Hunter Participation In Michigan
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DNR Financial Support: $40,615 in FY15, $267,310 total.
Study Area: Statewide.
Time Frame: 05/01/2015-09/30/2019
Abstract: Hunters are key constituents in state wildlife conservation in Michigan and the US. Hunting, as a form of outdoor recreation, is a valuable part of Michigan's nature-based economy and remains an important element of Michigan's culture and heritage. Activities associated with hunting engage Michiganders with wildlife, and connect them to nature and one another. Nonetheless, participation in hunting is declining. The trends are persistent and widespread (Heberlein and Thomson 1996; Duda et. al. 2010). If current declines in Michigan hunter participation are to be countered, better knowledge of underlying socio-demographic causes of the decline are needed. Insights about how macro social factors (e.g., percent of one-parent households), as well as more local meso (e.g., employment) and micro (e.g., personal) factors are affecting hunter recruitment and retention will help focus management efforts tailored toward sustained hunter participation. Similarly, understanding how internal and external migration affect initiation and participation in hunting will allow the DNR to anticipate and adjust to the changing socio-demographic environment of Michigan, which is experiencing increased urbanization. Assessments of opportunities and challenges for retaining involvement in other forms of wildlife-related recreation are also needed to evaluate potential of stakeholders with broader interest in engaging with wildlife supporting conservation. Little is known about this important population of stakeholders in Michigan. Scientifically based insights are needed into alternative or complimentary models of maintaining conservation-minded publics in Michigan and elsewhere. This proposal fully supports Goal 4 of the DNR Wildlife Division's strategic plan (MDNR 2010).

Improving Efficacy of Furbearer Management in Michigan through Assessment of the Nature and Extent of Illegal Fur Harvesting
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DNR Financial Support: $20,630 in FY15, $244,538 total.
Study Area: Statewide.
Time Frame: 06/01/2015-09/30/2019
Abstract: State wildlife agencies regulate harvest of game species to meet dual objectives of allowing recreational take while ensuring sustainability of populations. Compliance with harvest regulations and cooperation with accurate reporting of effort and harvest success are important for meeting these objectives. The remote locations and often secretive manner in which hunting and trapping occurs (even when conducted legally) makes patrolling and detecting violations difficult, and the secretive nature and elusive behavior of many wildlife species – especially furbearers – makes population dynamics or abundance trends difficult to monitor. Adjustments in harvest regulations (e.g., annual bag limits, season length) and reporting and registration requirements for furbearers including bobcat, fisher, American marten, and otter are common in

Michigan (Frawley 2013a and b, Hiller et. al. 2011). Advancements in statistical modeling of age-at-harvest data now allow for furbearer population abundance estimates, which were historically difficult to obtain (Skalski et. al. 2011). Recent population modeling of marten and fisher abundance in the Upper Peninsula (UP) of Michigan indicate substantial population declines over the past decade. These declines have been attributed to decreased survival of adults of both species (Skalski et. al. 2011, Skalski unpublished data). Managers possess long-term harvest datasets (e.g., reported adult mortality) for marten and fisher, however, little is known about reliability of these reports and other mortality sources including illegal take by furharvesters.

Unlike with many other North American game species, the existence of a legal commercial market for fur means harvest of furbearers is partially motivated by economic gain. Participation in trapping is known to increase with fur prices, which may also increase motivation for users to engage in illegal harvest. Trappers may exceed restrictive bag limits by making use of licenses purchased by non-trappers (with success and potentially effort then being falsely reported by individuals that did not actually trap), take furbearers within closed areas or during closed seasons (with harvest location and dates then being falsely reported), or engage in "high grading" by discarding inferior quality fur or smaller-sized animals in favor of higher quality or larger-sized animals. A lack of compliance with legal harvest rules may not only place populations at risk of overexploitation, but also promote generation of falsified data, interfering with assessment of harvest regulation and evaluation of impacts of regulated harvest on population dynamics and viability.

Incorporating knowledge about the nature and extent of illegal take of furbearers can improve enforcement efforts and aid calibration of population models and effectiveness of regulations developed and implemented by the state to ensure the furbearer resource remains sustainable. Information about illegal furharvesting activities can also aid in discussions with stakeholders, many of whom feel illegal take results in significant negative impacts to the resource. To date, methods for assessing illegal take of furbearers have been limited. Theoretical and methodological developments in conservation criminology (Gibbs et al. 2010) provide an ideal opportunity to address gaps in understanding about illegal take of furbearers and the relationship between illegal take and management. To this end, the goal of this proposed project is to improve our understanding of the factors that significantly affect furbearer management in regards to four limited take species in Michigan: bobcat, fisher, American marten, and river otter. Our focus will be to increase knowledge and understanding of the extent and nature of illegal take to inform more effective furbearer management in Michigan (e.g., Gore 2011).

Facilitating Urban-Suburban Deer Management in Michigan: Social, Spatial and Population Considerations

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DNR Financial Support: $64,974 in FY15, $583,202 total.
Study Area: southeastern Michigan
Time Frame: 10/18/2011-9/30/2016
Abstract: The number of urban and suburban communities consulting with Wildlife Division staff or requesting direct assistance for addressing conflicts with deer has increased in recent years, and this trend is expected to continue. It is unclear whether the rising concerns are a consequence of increasing frequency and intensity of conflicts between deer and human populations in these settings or if tolerance for impacts of deer is decreasing. As a result, there is a need for the Wildlife Division to gain an understanding of factors affecting tolerance levels – ranging from how different segments of the public perceive impacts to characteristics of the composition and use of the landscape by deer – and to discover new ways of achieving societal goals through deer management at geographic scales to which management might be effectively applied. A comprehensive analysis is needed to compare characteristics of communities that are and are not experiencing conflicts. Our goal is to provide Wildlife Division staff with better knowledge and understanding of causal factors in Michigan's urban-suburban deer problems, increase Division capacity for assisting communities resolve deer issues, and to help the Division anticipate the most effective locations and means to prevent or resolve problems within the scope of influence and authority of the Division.

An Evaluation of Moving to a Learning Organization in the Wildlife Division: Measuring Collaboration, Trust, Performance and Effectiveness of Decisions

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DNR Financial Support: $55,465 in FY15, $436,389 total.
Study Area: Statewide
Time Frame: 11/1/2011-9/30/2016
Abstract: The DNR Wildlife Division strategic plan for 2010-2015 sets ambitious objectives for becoming an adaptive (thus learning) organization with improved performance arising from, among other activities, collaborative governance, and greater accountability to the Division's external stakeholders. Although some of the objectives laid out in the strategic plan – especially the biologically oriented objectives related to habitat and wildlife populations – are straightforward to measure, other objectives relevant to becoming a learning organization are less tangible or easy to measure. To evaluate progress in achieving the desired outcomes of the strategic planning effort relevant to becoming a more adaptive and learning organization, research is needed to clarify measures of success (such as greater trust in the Division among stakeholders and more sustainable, effective decisions), collect baseline information and measure progress.

Increasingly, organizations strive to keep up with environmental changes and philosophies of continuous improvement. A key mechanism for dealing with these issues is to optimize the use of human resources and strengthen collaborative relationships with external stakeholders. In wildlife management, this undertaking has to be accomplished within a "messy world" with constantly changing environments and a high level of uncertainty. In the face of uncertainty, trust (we assume trust to include credibility) in the agency on the part of stakeholders becomes crucial to moving forward with decisions, yet systems that accelerate learning must be in place to keep pace with change in physical and social-economic environments. Organizational learning – that is, being adaptive – is a major determinant of sustainably high organizational performance. To thrive, organizations need to learn and change at an increasingly rapid rate. Improving service delivery and effectiveness calls for continual evaluation of the current state of the organization and consideration of future possibilities. A principal way any organization learns and changes is through rigorous assessment, monitoring, and evaluation.

Assessing The Viability Of Game Meat Sharing As A Strategy To Increase Support For Hunting And Wildlife Conservation

Primary Contact: Brent Rudolph, DNR Wildlife Division, East Lansing, Michigan
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Phone: 517-641-4903
DNR Financial Support: $5,591 in FY15, $53,335 total.
Study Area: Statewide.
Time Frame: 7/01/2014-9/30/2016
Abstract: Hunters are key stakeholders in state wildlife conservation. Hunting is a valuable part of Michigan heritage and tradition, engaging Michiganders with wildlife, and connecting them to nature and to one another. Large societal transformations (e.g., increasing affluence and urbanization) are decoupling humans from nature (Heberlein and Ericsson 2005). If declining attitudes and support for hunting are to be countered, and participation increased, insights are needed about how to enhance the relevance, legitimacy, and value of hunting to society (Peterson 2004). Evidence exists that sharing and consumption of game meat may function in several ways as a "coupler" that links humans and natural systems (Ljung et. al. 2012). Yet, specific knowledge is lacking about how social networks operate in distribution and sharing of game meat, what effect game meat sharing has on societal views of legitimacy and relevancy of hunting, and whether support for hunting (and more broadly, nature) may be derived from experiences associated with meat sharing and consumption. An estimated 15 million pounds of venison are harvested annually in Michigan, providing > 60 million quarter pound servings of venison (>6 servings per Michigan resident annually if distributed equally). The extent to which this meat is shared and any positive impacts associated with this sharing are unstudied benefits of wildlife management. Knowledge and insights regarding game meat sharing's social impact are expected to enable the DNR to facilitate partnerships that will increase the reach and impact of game meat in promoting positive attitudes towards and support for hunting.

Mass Media Coverage Of Michigan's 2014 Wolf Referenda

Primary Contact: Dr. Dean Beyer, DNR Wildlife Division, Marquette, Michigan
Email: beyerd@michigan.gov
Phone: 906-228-6561
DNR Financial Support: $31,745 in FY15, $31,745 total.
Study Area: Statewide.
Time Frame: 02/01/2015-03/30/2016

Abstract: The purpose of this study is to examine how wolves and wolf management were framed in the media during and around the time of 2 wolf-related ballot initiatives in Michigan. Framing refers to the way a piece of information is presented. It is a technique used to make certain information about an issue is "more noticeable, meaningful, or memorable to audiences" (Entman 1993). Proposal 14-1 was a, "Referendum of Public Act 520 of 2012, establishing a hunting season for wolves and authorizing annual wolf hunting seasons." The proposal, which designated wolves as a game species for hunting purposes and allowed the Natural Resources Commission to schedule annual hunting seasons, was rejected. Proposal 14-2 was a "Referendum of Public Act 21 of 2013, granting the Natural Resources Commission the power to designate wolves and certain other animals as game without legislative action." The proposal, which primarily granted the National Resources Commission the authority to designate wolves and other animals as game without the input of the state Legislature, as well as giving the Legislature the sole authority to remove an animal from that list, was rejected.

Criterion Seven: Legal, Institutional and Economic Framework for Forest Conservation and Sustainable Management

There is currently no research going on in relation to this criterion.

Surveillance Projects:

Conduct Forest Inventory and Assessment (FIA) Re-Measurements
Primary Contact: Scott A. Pugh, US Forest Service, Houghton, Michigan.
Email: spugh@fs.fed.us
Phone: 906-482-6303 x 17
DNR financial support: $40,200.00
Study Area: Forested Landscapes nationwide including Michigan
Time Frame: Long-Term, On-going.
Web Site: http://www.fia.fs.fed.us
Abstract: The FIA program has been the nation's continual forest census since 1930. We collect and analyze data collected from permanent sample plots to enable reporting information on the status and trends of America's forests: how much forest exists, where it exists, who owns it, how it is changing, and also how the trees and other forest vegetation are growing, how much has died or been removed and how the harvested trees have been used in recent years. This information can be used in many ways, such as in evaluating wildlife habitat conditions, assessing sustainability of current ecosystem management practices, monitoring forest health, supporting planning and decision making activities undertaken by public and private enterprises and predicting the effects of climate change. The FIA program combines this information with related data on insects, diseases and other types of forest damage to assess the current health and potential risks to forests. These data are also used to project how forests are likely to appear in 10 to 50 years under various scenarios to evaluate whether current forest management practices are sustainable in the long run and to assess whether current policies will enable our grandchildren and their grandchildren to enjoy America's forests as we do today. Although this is a national program, the results can be and are summarized for regions and individual states.

The data from this program can also be used to inform the species diversity indicators and Criterion Two: Maintenance of Productive Capacity and Forest Ecosystems.

A Statewide Survey of Michigan's Licensed Anglers
Primary Contact: Dr. Frank Lupi, Michigan State University, East Lansing, Michigan
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Phone: 517-432-3883
DNR Financial Support: $66,909.00 (25% Game and Fish Funds)
Study Area: Statewide
Time Frame: Ongoing
Abstract: This project provides additional fishing effort, catch and catch composition to supplement the direct census information from other surveys through a mail survey of licensed anglers. This study provides information about anglers and their fishing behavior and the ability to track the behaviors over time to assess the status and trends of angling behavior in Michigan. These data provide key baseline harvest and economic benefits across the state that is required to properly evaluate fisheries management and land use practices.

Charter Boat Catch and Effort from the Michigan Waters of the Great Lakes
Primary Contact: Donna Wesander, DNR Fisheries Division, Charlevoix Fisheries Research Station, Charlevoix, Michigan
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DNR Financial Support: $98,510 (25% Game and Fish Funds)
Study Area: Statewide – Great Lakes
Time Frame: Ongoing
Abstract: Fisheries biologists cannot effectively manage sport fish in the Great Lakes without knowledge of the relationship between fish stocks and the fisheries that exploit them. Additionally, some of these stocks are dependent for recruitment on inland streams that can be affected by forest and land management practices. Charter angling is one type of fishery on the Great Lakes. The Michigan charter industry consists of approximately 530 businesses operating 570 boats that catch and harvest a measurable amount of sport fish from the Great Lakes. Charter catch and effort data are generated continuously by this project for a broad range of purposes including wild fish production. Fisheries trends from this group of users provides key insights on how well wild fish are recruiting to our fisheries, and these fish can be traced back to inland streams along the land practices that influence them.

Michigan Statewide Angler Survey Program
Primary Contact: Tracy Kolb, DNR Fisheries Division, Lansing, MI and Zhenming Su, DNR Fisheries Division, Institute of Fisheries Research, Lansing, Michigan
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Phone: 517-284-5828 and 734-663-3554 x 12355
DNR Financial Support: $2,035,498 (25% Game and Fish Funds)
Study Area: Statewide
Time Frame: Ongoing
Abstract: The most fundamental requirements for sound management of recreational fisheries are knowledge of the response of fish stocks to fishing and of the contributions of various fish stocks to the fisheries. This knowledge can be obtained only if there is a long-term record of fishing effort, catch, and catch composition available for analysis. This project is designed to obtain a continuous record of sport fishing effort, catch and harvest, catch and harvest rates and catch composition for important Great Lakes, tributary and inland fisheries of the State of Michigan using consistent protocols and data collection and analysis methods. These data provide key baseline harvest and economic benefits across the state that is required to properly evaluate fisheries management and land use practices.

Technology Development Projects

Development of a GIS-Based Inventory System for the Michigan State Forest – Michigan Forest Inventory (MiFI)
Primary Contact: Jason Stephens, DNR Forest Resources Division
Email: stephensj@michigan.gov
Phone: 989-732-3541
DNR Financial Support: No specific cost – these were rolled into the new timber sale computer tracking program (VMS).
Study Area: Statewide
Time Frame: Long-Term, On-going.
Abstract: This project is moving the former inventory system – Integrated Forest Mapping Assessment and Prescription - to a new operating platform and reinventing the system to provide greater utility while simplifying input and output methodologies. The MiFI system will provide a more user-friendly environment for both power and casual users, thus enhancing the utility of the system overall for collecting, storing, processing, and providing data and information to inform resource management decisions.

Develop and Implement a Computerized Timber Sale Treatment Tracking System
Primary Contact: Douglas Heym, Timber Sales Specialist, Forest Resources Division
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Phone: 517-284-5867
DNR Financial Support: $2,200,000
Study Area: State forest land statewide
Time Frame: Ongoing

Abstract: We are currently developing our timber sale computer program, Vegetative Management System (VMS) to work with our forest wide inventory system (MiFI) to better track forest treatments over time. This will help to better monitor our sustainable forest management. We are researching and then implementing a method whereby treatments are tracked from when they are first proposed to when they are fully implemented. After an area of State Forest land is inventoried, areas are designated for treatment. These areas go through a review process and a final treatment boundary and prescription is approved. Field work begins, the boundary is designated on the ground, the area is mapped using GPS points and the inventory system is updated. The pre-contract paperwork is developed into a timber sale contract proposal. When the proposal is approved, the system is again updated with the final boundary and the approval status. The VMS tracks work as the timber sale progresses. When units of the contract are completed, VMS updates the inventory system. The MiFI is then used to schedule and track any other activities needed to complete the treatment.

Over time, and at any point in time, the system will better reflect the condition of the forest. This is complicated technology to sort through and implement, but the final product will be a model for any land management organization.

Design and Develop Specialized Equipment for Forest Fire Fighting
Primary Contact: Dan Munn, Forest Resources Division.
Email: munnd@michigan.gov
Phone: 989-275-5211
DNR Financial Support: $173,716.00
Study Area: Roscommon Equipment Center and DNR forest lands
Time Frame: Ongoing since March 2007
Abstract: An example of the type of project that is developed entirely from scratch is DNR's flamethrower. Its ability to project burning matter while creating a high intensity sustained heat some distance away from the wildland firefighter is beneficial to reach remote pockets of fuels regardless of whether those fuels are wetland fuels or sparse vegetation that are intended to be consumed during a prescribed burn. Again, this work involves considerable engineering, mechanical, and machining knowledge, skill and ingenuity.

RECENTLY COMPLETED RESEARCH RELATED TO SUSTAINABLE FORESTRY

Improving the Effectiveness of Wolf Management Approaches in Michigan
Primary Contact: Dr. Pat Lederle, DNR Wildlife Division, Lansing, Michigan
Email: lederlep@michigan.gov
Phone: 517-243-0700
DNR Financial Support: $42,943 in FY14, $168,012 total.
Study Area: Upper Peninsula
Time Frame: 1/15/2012-9/30/2015
Abstract: Until recently, wolf management in Michigan was restricted to recovery efforts. Today, managers must contend with range expansion and post-recovery issues including policy changes (e.g., federal delisting, compensation schemes, regulated hunting seasons); public responses to policy change (e.g., lawsuits, ballot initiatives, media coverage, poaching); and balancing preferences, tolerance, and behaviors of traditional and non-traditional wildlife stakeholders both within and outside Michigan. Previous studies have characterized management stakes, stakeholders, and associated attitudes and preferences about wolf management in Michigan. Others have explored the role of hunters as wolf stewards and the relationship between wolf tolerance and compensation. These studies have provided critical information on the human dimensions of wolf management, particularly about stakeholders' fear, experience, and knowledge about wolves and wolf management. Additional social science research needs identified by previous work, the 2007 Michigan Wolf Management Roundtable, and the 2008 Michigan Wolf Management Plan, as being essential to accompany ecological, social, and regulatory changes include: (1) investigating social factors critical to wolf management, especially hunting (e.g., risk perception, value orientations, media coverage); (2) designing, implementing, and evaluating tools to educate key stakeholders about, reconcile competing stakeholder opinions for, and reduce stakeholder conflict vis à vis wolves and wolf management (e.g., hunting, compensation schemes); and (3) evaluating and improving perceived legitimacy of institutional arrangements for wolf management. Current events in Michigan (e.g., the potential for changing management authorities and regulations) provide an ideal time to address gaps in understanding and provide new insight for improving the current and future effectiveness of wolf management in Michigan. Findings from this project will inform other current DNR wildlife management priority areas, including human-wildlife conflict, urban deer management, and policy evaluation.

Walleye Dynamics in Michigan's Inland Waterway: the Burt-Mullett-Pickerel-Crooked Lake System
Primary Contact: Dr. Daniel Hayes, Michigan State University, East Lansing, Michigan
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Phone: 517-432-3781
DNR Financial Support: $102,556.00 (25% Game and Fish Funds)
Study Area: Cheboygan River system
Time Frame: Completed in FY2014
Abstract: Forest practices have the potential to directly affect the quality of aquatic habitat for key fish species. This project quantified the timing and rates of movement among lakes in the large Cheboygan River system, in order to better understand potential source-sink dynamics of walleye in these lakes. The study identified important spawning locations within Mullett Lake and provided insights into dynamics of larval and early juvenile walleye, with an emphasis on determining factors potentially limiting their growth and survival which has application to other lakes in Michigan. The last major element was an analysis of the diet of post-young-of-the-year walleye in all of the lakes within the Inland Waterway, comparing food web structure among these lakes, and the potential shift in food webs as the limnology of these lakes change over time partly in response to land use changes.

Design, Develop and Build Prototype and Operational Equipment Units for Mechanized Forest Fire Fighting
Primary Contact: Dan Munn, Forest Resources Division
Email: munnd@michigan.gov
Phone: 989-275-5211
DNR Financial Support: $716,290.00
Study Area: DNR Forest Fire Experiment Station and DNR forest lands
Time Frame: Completed on May 23, 2014
Abstract: Research done under this project involves design and development of customized firefighting equipment involving considerable engineering, mechanical, and machining knowledge, skill, and ingenuity to meet needs for wildland firefighting equipment. This equipment is not available commercially and is often developed entirely from scratch to meet a need (see the project below). At other times, the equipment development requires building customized parts to link two existing units. In 2014, a primary project was to build, fit and install a Michigan Fireline Plow onto a U.S. Forest Service (USFS) D4K2 Crawler-Tractor. Project was successful and was tested at the Forest Fire Experiment Station in Roscommon, Michigan prior to a USFS representative collecting it from the DNR. This firefighting unit is currently in service at the USFS Mio, Michigan location.

Influence of Lotic and Nearshore Habitats on Fish Populations in Great Lakes and Inland Lake Ecosystems, with Emphasis on Walleye
Primary Contact: Troy Zorn, DNR Fisheries Division, Marquette Fisheries Research Station, Marquette, Michigan
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DNR Financial Support: $81,647 (25% Game and Fish Funds)
Study Area: Bays De Noc
Time Frame: Completed in FY2014
Abstract: This study provided insights into the extent of natural reproduction of walleye in the Michigan waters of Green Bay via marking stocked fish with oxytetracycline (OTC) and described their contribution to walleye year classes; and assessed the relative influence of river spawning habitat, estuary conditions, juvenile-adult growth habitat, and supplemental stocking on spawning runs of walleye (and estimates of percent natural reproduction) in various river-influenced systems in Michigan. These data have implications for assessing the effects of land management practices on a key sportfish species.

Factors Influencing Snowshoe Hare Occupancy and Abundance
Primary Contact: Dr. Dwayne Etter, DNR Wildlife Division, East Lansing, Michigan
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Phone: 517-641-4903
DNR Financial Support: $90,193 in FY14, $176,352 total
Study Area: Northern Lower and Upper Peninsulas
Time Frame: 10/1/2011-9/30/2014

Abstract: Snowshoe hares are an important ecological and cultural species in Michigan. Ecologically, hares are prey for numerous meso-carnivores (e.g., bobcat, fisher, marten, coyote) and raptors. Culturally, hares are part of Michigan's hunting heritage. A broad-scale habitat assessment corresponding to the late 1990s and early 2000s indicated that hare habitat quality in Michigan's Upper Peninsula ranged from poor to marginal with only small, isolated areas of higher quality habitat. Additionally, small-game hunter surveys indicated that snowshoe hare harvest and presumably abundance has declined statewide over the past few decades. The decline in snowshoe hare harvest and presumably abundance is likely associated with multiple factors in Michigan including changes to forest management practices, carnivore abundance and spatial distribution, land use patterns, and/or climate. Because of the ecological and cultural importance of this species in Michigan, there is a need to better understand how these factors influence the abundance of hare and occupancy of particular habitats.

Downscaling Climate Predictions for Michigan & the Great Lakes
Primary Contact: Christopher Hoving, DNR Wildlife Division, Lansing, Michigan
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Phone: 517-284-6192
DNR Financial Support: $2,613 in FY14, $326,936 in total (all federal GLRI funds).
Study Area: Statewide, work conducted in offices and labs
Time Frame: 9/1/2010-1/1/20104
Abstract: This research project is designed to provide downscaled climate data to fish and wildlife managers in Michigan and to provide insight into the effects climate change will have on water levels of the Great Lakes. Climate in Michigan is warming, and global models predict warming will continue. However, global models do not capture local climate variation such as lake effect, nor do global models provide managers with measures of the certainty or uncertainty of predictions. Global models provide averages and poorly capture the intensity and frequency of extreme events, which affect natural systems as much or more than changes in average temperature or precipitation. Finally, future water levels on the Great Lakes are a critical unknown in conserving coastal wetlands, which are critical habitat for fish and wildlife. Future water levels will also impact coastal communities, infrastructure, and international trade.

Climate predictions that incorporate local conditions, uncertainty, extreme events, and lake level dynamics are a critical step in managing fish and wildlife to prepare for a changing climate. Predictions that incorporate local weather patterns, such as lake effect, will allow managers and decision-makers to visualize how the climate has changed and will continue to change. Changes in lake-effect snow are a good example of the utility of downscaled predictions. Lake-effect snow continued to increase as lake ice decreases. At some level of warming that increase will cease, and then reverse, as ever more lake effect precipitation falls as rain. The timing of the change will occur differently along Lake Michigan than Lake Superior, and the timing of the change has important implications to wildlife affected by snow, such as deer, moose, wolves, bobcats, and pine marten. Important fisheries in Michigan are affected directly by temperature, but also indirectly via snowfall, ice cover, and algae growth. Downscaled data will also help foresters model forest growth and health, as required in forest certification. Although focused on Great Lakes ecosystems, downscaling and lake level research will be used by a broad segment of society, including public health and transportation decision-makers.

Statistical Catch-At-Age Assessment of Michigan Black Bear Population Dynamics
Primary Contact: Sarah Mayhew, DNR Wildlife Division, East Lansing, Michigan
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Phone: 517-336-5036
DNR Financial Support: $30,211 in FY14, $102,200 total.
Study Area: Northern Lower and Upper Peninsulas
Time Frame: 10/1/2011-9/30-2015
Abstract: The DNR has adopted black bear management goals to maximize recreational opportunities for hunters while maintaining a stable bear population. To accomplish this goal, the DNR uses a quota system to allocate hunting licenses. To make science-based management decisions, managers must have estimates of population abundance and change over time. The DNR has used capture-mark-recapture (CMR) surveys to estimate black bear abundance in the state, but costs and staffing requirements prevent the DNR from conducting these surveys annually. Statistical catch-at-age (SCAA) models provide an objective statistical approach to obtain annual estimates of black bear population abundances, recruitment, and mortality rates using long-term sex and age-at-harvest data sets and a wealth of auxiliary information that the DNR already has and continues to collect for minimal cost.

Boone and Crockett Chair Graduate Student Fellowship
Primary Contact: Dr. Brent Rudolph, DNR Wildlife Division, East Lansing, Michigan
Email: rudolphb@michigan.gov
Phone: 517-641-4903
DNR Financial Support: $30,000.
Study Area: Statewide.
Time Frame: FY14
Abstract: Wildlife Division has collaborated with the Boone and Crockett Chair of Wildlife Conservation to provide a graduate student fellowship to support a research project to address unmet Division research priorities. The current project involves a regional analysis of deer-vehicle collision (DVC) occurrence in the Midwest region. This work is examining broad-scale factors that influence the likelihood of DVC in Illinois, Iowa, Michigan, and Wisconsin. Results from this research will be used to inform strategies for reducing DVCs and examine whether factors that influence the rate of DVCs can be accounted for in order to use standard available data in each state to generate an index to deer abundance at the regional, state or county scale. The Division will support the graduate fellowship associated with this research project for the entire FY 2014.

Impacts of Harvest and Habitat Conditions on Breeding Mallard Abundance in the Great Lakes Region
Primary Contact: Dr. Dave Luukkonen, DNR Wildlife Division, East Lansing, Michigan
Email: LuukkonenD@michigan.gov
Phone: 517-641-4903
DNR Financial Support: $139,500 total.
Study Area: Statewide.
Time Frame: 10/19/2011-09/30/2015
Abstract: This research addressed priority information needs for mallards that are relevant to state, regional, and national management plans. Mallard management and associated goals for wetland protection, restoration, and enhancement are predicated on expected responses of mallard and other wildlife populations to wetland management. Likewise, Adaptive Harvest Management for mallards predicts changes in broad-scale mallard abundance and harvest potential based on expected responses to harvest regulations and wetland conditions. Outcomes of this research have applications to population and habitat management at multiple management scales. This study aligned directly with the adaptive management principle of the DNR Wildlife Division strategic plan and outcomes explicitly addressed goals for population and habitat management for a featured species. Wildlife managers are better able to use existing monitoring data to evaluate sustainability of mallards in the Great Lakes Region under alternative harvest and habitat management scenarios.

Forest Fuels and Vegetation in Wildfire-Regenerated Jack Pine Forests: Informing Ecological Forestry in the Lake States Region
Primary Contact: Jessica R. Miesel, Michigan State University, East Lansing, Michigan
Email: jrmiesel@gmail.com
Phone: NA
DNR Financial Support: None. Conducted partially on state forest land.
Study Area: Wildfire sites with natural jack pine regeneration on state and federal land in northern Lower Michigan
Time Frame: Fieldwork has been completed. Data analysis is in progress. DNR sites are no longer actively being used for this project.
Abstract: Managing forests according to ecological principles requires an understanding of disturbance effects and stand development processes characteristic of a given ecosystem. In ecosystems dominated by jack pine (*Pinus banksiana* Lamb.) in northern Michigan, stand-replacing wildfires historically created extensive areas of young, even-aged jack pine stands that provided breeding habitat for the Endangered Kirtland's warbler (*Setophaga kirtlandii* Baird). Kirtland's warbler (KW) habitat is currently managed intensively as jack pine plantations, but the success of KW recovery efforts has increased interest in managing jack pine ecosystems for a broader suite of ecological components. This project was part of a larger investigation focused on understanding the natural range of variability in jack pine forest structure and composition. Our goal was to quantify forest fuel loads and to evaluate tree species composition in young (2-4 years post-fire, pre-KW occupancy) and mature (22-38 years post-fire, post-KW occupancy) wildfire-regenerated jack pine stands in Michigan. This project provides information that helps to improve current understanding of structural and compositional heterogeneity in jack pine ecosystems following wildfire in the northern lower peninsula of Michigan. Data from this project will be relevant for ecological forest management decisions that aim to

incorporate natural stand characteristics into habitat treatments, both during preparation for establishing new plantations and for creating more natural patterns in mature, post-KW occupancy plantations

Effects of Sediment Traps on Michigan River Channels

Primary Contact: Todd Wills, DNR Fisheries Division, Lake St. Clair Research Station, Mt. Clemens, MI
Email: willst@michigan.gov
Phone: 586-465-4771
DNR Financial Support: $2,836 (25% Game and Fish Funds)
Study Area: Statewide
Time Frame: Completion in FY2014

Abstract: Sediment traps are a commonly used mitigation measure to influence sediment transport dynamics in stream systems and evaluate their effectiveness in this role. The data from this study show that excavation of sediment traps generally had only small effects on mean channel depth and substrate in the streams studied, with changes occurring both upstream and downstream of the trap. The lateral position of the channels examined remained constant, indicating little side cutting had occurred. Changes in channel area remain variable and appear as likely to occur at transects proximal to the sediment traps as at transects located further upstream or downstream. These results suggest that sediment trap maintenance has not achieved the desired goals of increased down-cutting and exposure of coarse substrates downstream of the sediment traps studied.