United States Department of Agriculture

**Final Report**

| **Title:** | **Influence of human activity upon wildlife behavior and demography** |
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| **Submitted By** | Julie Estrada | **Date Submitted to NIFA** | 01/31/2022 |

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**Performing Department**

Forestry & Natural Resources

**Non-Technical Summary**

Our central goal is to provide rigorous study on the effects of a wide range of human disturbance on wildlife species. This is critical because an ever increasing human population is having greater impacts upon an increasing number of wildlife species. If we wish to have a future that includes the presence of wildlife species and the invaluable ecosystem services they provide we need to better understand how human activities impact those species so that we can make informed decisions about the consequences for wildlife of the range of potential future human activities.

The difficulty in investigating this goal is the spatial scale involved (Boutin and Hebert 2002). For example, many previous studies have looked at the impact of a single forest management technique on a single species. Most of these studies are short in duration and poorly replicated (Miao and Carstenn 2006) and cannot be extrapolated beyond the limits of the specific study. However, the range of human activities affect entire suite of wildlife species in different ways. To address this challenge we need an understanding of not only the response of wildlife to human activity but the mechanism underlying those responses. Gaining such knowledge requires empirical projects involving large spatial scales, long time frames, and multiple study areas are inherently difficult for single investigators to initiate and analyze, therefore collaborative approaches are critical. Additionally, simulation modeling tools can be invaluable because they provide the ability to project how wildlife will respond to a wide range of future that could never be created with empirical experiments. The modeling tools needed to address these challenges are complex enough that great diligence is needed in parameterizing them, running them and analyzing the outputs from them. Thus, the standard approach we employ to make our work with these models most relevant to addressing real applied problems is to collaborate extensively with managers who are interested in the insight our modeling tools can provide. These partnerships with on the ground managers not only help deliver our science but make it more relevant and stronger as we develop it. Ultimately, the combination of relevant empirical studies to parameterize relevant models and application of these approaches to real world management challenges will help identify novel insights and solutions to those pressing challenges that society faces as the extent of human activity continues to expand.

**Accomplishments**

**Major goals of the project**

The overarching goal for this proposal is to improve our understanding of the influence of human activity on wildlife conservation through a combination of empirical and modeling studies.

1. Develop new capabilities into modelling tools we have built to improve the applicability of these tools to a wider range of questions

2. Develop applications of modelling tools we have built to new species in new places and new types of human activities

3. Understand the responses (changes in abundance, survival, reproductive success, foraging behavior, or dispersal patterns) of wildlife species of conservation and management concern to human land-uses such as forest management and outdoor recreation in order to identify effects and mitigate the potential negative effects

**What was accomplished under these goals?**

The impact of this work is to improve our understanding of how human activities influence wildlife species. Such understanding will help inform decisions about the consequences for wildlife of the range of potential future human activities. We advanced this knowledge through a combination of empirical research to parameterize relevant models and application of these approaches to real world management challenges. This combination identified novel insights and solutions to those pressing challenges that society faces as the extent of human activity continues to expand.

The most impactful advancements of this project broadly include the addition of new capabilities to and applications of the SODA and SEARCH simulation frameworks. The capabilities we added to the SODA modeling framework expanded the disciplinary, geographic, and taxonomic scope of applications of this tool. The new capabilities we built into the SEARCH modeling framework made the tool easier to use and applicable to more circumstances. These advancements led to the development of additional applications of SEARCH. More broadly expanding applications of both SODA and SEARCH that were part of this project increased awareness about the utility of individually based modeling as an approach to address challenges of natural resource management. Finally, our empirical research combined the use of techniques such as telemetry and stable isotope studies to investigate how wildlife species typically associated with mature forest habitat use and benefit from landscapes that incorporate early successional elements.

The first objective of this project was to develop new capabilities to improve the applicability of the SODA and SEARCH modeling tools. The first new capability added to SODA was the ability to simulate dynamic behavior of human agents. Previous work with SODA imposed the activities of human agents while providing wildlife agents with the dynamic rules they used to respond to the environment around them and the behaviors of other simulated agents. This new capability of having emergent behavior represented for both human recreationists and wildlife makes the tool more relevant to many circumstances. The second new capability added to the SODA simulation developed code that automates the outputs from one run of SODA as inputs for a follow up run. This turns SODA into a model that not only simulates the behavioral responses of wildlife to human disturbance but also simulates the cumulative population level response providing the ability for SODA to gain insights in the influence of different management actions upon the viability of local populations of wildlife. The third new capability added to the SODA modeling framework was the ability to simultaneously simulate the response of both a predator and prey species to human disturbance. The new capabilities we built into the SEARCH modeling framework include pre and post processing tools written that allow researchers to interpret model runs. The second advancement to SEARCH was the implementing the ability to restart models that are interrupted without losing progress. These advancements greatly enhance the functionality of the SEARCH model and were critical to several of the new applications developed using it.

The second objective of this project was to develop applications of these modelling tools to new species in new places and new types of human activities. These applications have been presented in published papers, as talks at meetings and in thesis and dissertation chapters. For SODA research this is exemplified by a paper published in The Condor in 2018. This paper presented results of models
simulating the response of nesting golden eagles to off highway vehicles in Idaho. Other applications with SODA models include the collaboration developed as part of Daniel Bird's MS thesis with Santa Ana Pueblo that used SODA to help inform the Pueblo about the likely implications of a proposed highway expansion project on local mule deer populations. Similarly, Laura D'Acunto used SODA to simulate the implications of highway expansion projects upon local populations of Indiana bats. Finally, the new dynamic human agent capabilities of SODA were illustrated in chapter 2 of Soraida Garcia's thesis where she replicated previous SODA research regarding the Lawrence Creek Unit of Fort Harrison State Park to distinguish new insights gained from those new capabilities. This project also includes numerous publication documenting applications of SEARCH to new systems and new question in old systems. Collaborations with the Great Lakes Indian Fish and Wildlife Commission in Northern Wisconsin as part of Casey Day's dissertation used SEACH to simulate the interactive effects of different scenarios for forest management with a proposed taconite mine on marten populations. This work is described in papers published in Behavioral Ecology in 2019 and Landscape Ecology in 2020. A similar set of questions about the influence of forest management on dispersal patterns of Prince of Wales Island flying squirrels on the Tongas National Forest was published in Ecological Modeling in 2019. Finally, working with Dr. Shannon Pittman we applied SEARCH to simulate the northward spread of invasive pythons in Florida. This resulted in papers published in Perspectives in Ecology and Conservation in 2017 and in Landscape Ecology in 2018. Collectively these papers describing suitable habitat for this invasive species investigate how variation in snake personality impacts spread. Broadly the set of these examples of applications of SEARCH and SODA illustrate how these kinds of complex questions which are challenging to fully address with empirical research can gain valuable insight through the application of agent-based modeling as an approach.

The third and final objective of this project was to improve understanding of the response of wildlife species of conservation and management concern to human land uses such as forest management. This work focused upon research investigating the reproductive success and post-breeding habitat use by bird species that are typically associated with mature forests.

Results from our field studies investigating breeding success within forests undergoing active forest management are invaluable because they provide important insights regarding the use of early successional forests by bird species that are typically associated with mature forest. These insights were obtained by exploring mechanisms of species response including tracking movements of individual birds as well using stable isotope to understand their diet. This work is described in a 2020 paper published in the Wilson Journal of Ornithology, a 2019 paper published in The Canadian Journal of Zoology as well as 2018 papers published in the Wilson Journal of Ornithology, American Midland Naturalist, and Avian Conservation and Ecology and finally a 2016 paper published in Forest Ecology and Management. We extended these results to consideration of how forest restoration can be jumpstarted by using ecological principles in city parks of Sao Paulo, Brazil (described in a paper published in 2021 in Ecological Engineering) and the tracing of natal origins of migrating owls found in Indiana forests, using stable isotope analysis. This latter study was described in a 2020 paper published in the Wilson Journal of Ornithology. Collectively these studies have expanded our knowledge about applications of new approaches to field studies that can help modify Best Management principles in forested landscapes to improve conditions for wildlife species of interest. The combination of insights from these field and modeling studies have directly addressed our overarching goal of improving understanding of the influence of human activity on wildlife conservation.

**What opportunities for training and professional development has the project provided?**

Training opportunities associated with this project primarily related to the training of four postdoctoral scholars, six PhD students, five MS students and sixteen undergraduate researchers who coauthored peer-reviewed publications. The four postdoctoral scholars trained as part of this project included Dr. Shannon Pittman (2016 - 2017), Dr. Landon Jones (2019 - 2021), Dr. Brandon Quinnby (2020 - 2021) and Dr. Karen Castelli (2019 - 2020). The six PhD students who defended their dissertations and graduated as part of this project include Chia-Chun Tsai (2017), Casey Day (2018), Laura D'Acunto (2018), Patrick Ruhl (2018), Daniel Bampoh (2019) and Jessica Outcalt (2020). The four MS students who defended their theses and graduated as part of this project include Michael Egan (2018), Daniel Bird (2018), Nerisa Taua (2020), Soarida Garcia (2021), and Zach Finn (2021). The sixteen undergraduate researchers who coauthored papers published in peer-reviewed scientific journals as part of this research project included Jasmine Peele, Courtney Nix, Rachel Vanausdall, Miko Moy, Kiara Johnson, Jasmine Abu-Omar, Emily Godollei, Roxy Pourshoushtari, Wes Homoya, John Moore, Landon Neumann, Ashley Higdon, Jamison Pierce, Alexis Proudman, Tabitha Olsen and Amanda Heltzal.

**How have the results been disseminated to communities of interest?**

We disseminate the results from our research via presentations at conferences, publications in peer-reviewed journals, and outreach/extension events to interested stakeholder groups and the general public.

**What do you plan to do during the next reporting period to accomplish the goals?**

{Nothing to report}

**Participants**

**Actual FTE's for this Reporting Period**

| Role | Non-Students or faculty | Students with Staffing Roles | | | Computed Total by Role |
|---|---|---|---|---|---|
| | | Undergraduate | Graduate | Post-Doctorate | |
| Scientist | 1 | 0 | 0 | 0 | 1 |
| Professional | 0 | 0 | 4.2 | 1 | 5.2 |
| Technical | 0 | 0.6 | 0 | 0 | 0.6 |
| Administrative | 0 | 0 | 0 | 0 | 0 |
| Other | 0 | 0 | 0 | 0 | 0 |
| Computed Total | 1 | 0.6 | 4.2 | 1 | 6.8 |

**Student Count by Classification of Instructional Programs (CIP) Code**

| Undergraduate | Graduate | Post-Doctorate | CIP Code |
|---|---|---|---|
| 4 | 7 | 2 | 03.06 Wildlife and Wildlands Science and Management. |

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### Target Audience

The work conducted as part of this project reached all of its target audiences including scientists, natural resource managers, and the general public. Scientists from universities as well as well as state, federal, tribal agencies and NGOs who are researching a wide range of disciplines including conservation biology, ecological modelling, forest ecology, mammalogy, ornithology, landscape ecology, behavioral ecology, population dynamics and those researching human recreation attended presentations at professional meetings about products associated with this project and read the publications resulting from that work. Likewise, natural resource managers who are focused upon wildlife management, forest management and park management benefited from these same publications and presentations. Finally outreach presentations about our work were also made to groups for the general public who are interested in conservation and protection of the natural world.

### Products

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Journal Articles | Published | 2020 | YES |

**Citation**

Neumann, L. K., A. E. Higdon, E. A. Flaherty, B. J. Bumgardner, A. B. Wilms, K. D. Gavenda, C. D. Delancey, and J.B. Dunning. 2020. Delineating the origin of Northern Saw-whet Owls (Aegolius acadicus) in Indiana using stable isotope analysis. Wilson Journal of Ornithology 132:967-977.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Journal Articles | Published | 2021 | YES |

**Citation**

Castelli, K. R., A. M. Silva, and J. B. Dunning. 2021. Improving the biodiversity in urban green spaces: a nature based approach. Ecological Engineering 173:1-8.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Theses/Dissertations | Published | 2021 | NO |

**Citation**

Garcia, S. 2021. Understanding the disturbance of human recreation on wildlife using multiple dynamic agents within an ABM framework. MS Thesis, Purdue University Department of Forestry and Natural Resources. 93 pages.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Journal Articles | Published | 2021 | YES |

**Citation**

Bampoh D., J.E. Earl, and P.A. Zollner. 2021. Simulating the relative effects of movement and sociality on the distribution of animal-transported subsidies. Theoretical Ecology 14:57-70.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Journal Articles | Published | 2021 | YES |

**Citation**

Egan, M.E., C.C. Day, T.E. Katzner, and P.A. Zollner 2021. Dominant coyotes impact gray fox occupancy across the Eastern United States. The Canadian Journal of Zoology 99:63-72.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Journal Articles | Accepted | 2022 | YES |

**Citation**

Day, C.C., J.H. Gilbert, P.J. Manlick, J.A. Grauer, J.N. Pauli, K.T. Scribner, B.W. Williams, and P.A. Zollner. In Press. Evaluating the legacy of multiple introductions of American martens on spatiotemporal patterns of genetic diversity. Accepted in The Journal of Mammalogy May 2021.

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| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Other | Published | 2021 | NO |

**Citation**

Olsen, T.W., A. Heltzel, A. Proudman, and J.B. Dunning Jr. 2021. A Tippecanoe rarity: in-depth analysis of an unlikely inland Brant (Branta bernicla). Indiana Audubon Quarterly 99:6-13.

**Other Products**

**Product Type**

Other

**Description**

Finn, Z. 2021. Restore prairie on your property to protect history, wildlife and humanity. The Woodland Steward 29:8-9, 14.

**Product Type**

Other

**Description**

Outcalt, J. 2020. No room at the inn: suburban backyards and migratory birds. Purdue University Cooperative Extension Publication FNR-593-W.

**Changes/Problems**

{Nothing to report}