CS486C – Senior Capstone Design in Computer Science

Project Description

Project Title: Wildfire Crisis Strategy Decision Support Tool to Assist Managers with Evaluating Bird Community Response	
Sponsor Information:	Dr. Jamie S. Sanderlin, Quantitative Ecologist (Research Wildlife Biologist) Rocky Mountain Research Station USDA Forest Service jamie.l.sanderlin@usda.gov Dr. Ana Miller-ter Kuile, Postdoctoral Researcher The School of Informatics, Computing, and Cyber Systems Northern Arizona University ana.miller-ter-kuile@nau.edu & Rocky Mountain Research Station USDA Forest Service ana.kuile@usda.gov Dr. Kiona Ogle, Professor & Environmental & Ecological Informatics NRT-T^3 PhD Program Director & Assistant Chair of Informatics The School of Informatics, Computing, and Cyber Systems Northern Arizona University Kiona.Ogle@nau.edu

Project Overview:

Climate change is altering the way fire and other disturbances impact landscapes of the western United States. As a result, ongoing large-scale forest management is aimed at reducing the impacts of large, high severity wildfire to natural resources and human interests (i.e., water sources, air quality, forests for recreation, wildlife species). The USDA Forest Service 10-Year Wildfire Crisis Strategy (WCS) is increasing the scale and intensity at which vegetation-based forest management is enacted across the western United States, including actions in our own "backyard" of National Forests surrounding Flagstaff, Arizona. As this new strategy comes onboard, it is imperative to have effective monitoring in place to measure the impacts of both past and ongoing forest management to forest communities of plants and animals. In this project, we are addressing the monitoring need with large-scale bird community monitoring data from across the western United States, targeting important "firesheds" to understand how past and future management shapes bird communities.

Birds are species of great interest to the public for cultural and aesthetic reasons, as well as the essential roles they play in the functioning of the world's ecosystems (i.e., pest control, plant pollination, seed dispersal). Birds are often selected as indicators of ecological integrity and wildlife conservation resource objectives because of the functional roles they represent in ecosystems. We are using 10+ years of data collected as part of a standardized monitoring protocol across Forest Service Regions 1-4 (encompassing states of Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, and Utah), which captures presence of bird species at locations both with and without forest management actions. We are

incorporating bird community responses into other metrics used to track the outcomes of management that fall under the guidelines of "ecological integrity". These bird data will provide a baseline for future management as well as a glimpse at how past management impacts bird communities and bird community ecological integrity.

The USDA Forest Service is comprised of two main branches, National Forest Systems (NFS) and Research & Development (R&D). USDA Forest Service managers in NFS are responsible for managing habitat for multiple objectives, including provisioning of key wildlife habitat and conservation of viable wildlife populations. Researchers within R&D promote sustainable management of the Nation's diverse forests and rangelands by developing and delivering scientific knowledge and innovative technologies with a focus on informing policy and land-management decisions. There are five Research Stations within R&D, including the Rocky Mountain Research Station (RMRS). RMRS encompasses the Great Basin, Southwest, Rocky Mountains, and parts of the Great Plains. RMRS is further divided by programs with general topic areas. Dr. Sanderlin is a Quantitative Ecologist (Research Wildlife Biologist) within the Wildlife Ecology Program of RMRS. The Wildlife Ecology Program has a mission to provide scientific leadership, reliable ecological understanding, and management tools for the conservation and management of wildlife populations and their habitats. Dr. Sanderlin's research includes evaluating disturbance effects on wildlife communities and improving inference of species for management decisions via modeling and sampling advancements with wildlife monitoring data. Dr. Miller-ter Kuile and Dr. Ogle are collaborators on several agreements between Northern Arizona University (NAU), School of Informatics, Computing, and Cyber Systems (SICCS), and RMRS, USDA Forest Service to complete project research, including the goals described for this project. Dr. Miller-ter Kuile's research includes synthesizing data from long-term population and community datasets to understand how management and anthropogenic change alter populations and biodiversity. Dr. Ogle's research includes developing and applying statistical models to evaluate the impacts of environmental perturbations and climatic variability on plant and ecosystem functions, with a focus on carbon and water fluxes.

The Problem

Integral to project success is the ability to provide results from statistical models of ecological integrity in a user-friendly format for assisting Managers with decisions that consider effects of management activities on bird communities. The project team developed reproducible and scalable workflows for all steps of the process (data wrangling, models, and model output) so that we can scale this approach to capture more landscapes and provide a baseline for future analyses as the 10-year Strategy progresses. This large team (hereafter, 'bird project team') includes members of R&D, NFS, and universities (NAU, University of Arizona) that are further subdivided into subgroups specific to project goals. The Data Visualization and Science Delivery Subgroups sketched out information flow for the project with actors, actions, and products for each step of the process. In the information flow process, one of the draft products identified was a Decision Support tool using model output, but capacity and skills to convert ideas into a tool is limited within the bird project team.

The Solution

We envision a Decision Support Tool addressing the need to provide timely and relevant information that considers effects of management activities on bird communities in a user-friendly format. The solution will be a web application that includes spatial information about the relationships of management actions to bird metrics with current conditions using information generated by the project team.

The web application solution will include the following features (all features encompass a minimum viable product) :

- Maps (raster format) of predicted bird community metrics for all ten priority firesheds at multiple scales (e.g., Region, Unit, priority landscape)
- Ability to visualize bird community trends across multiple scales (regional, rangewide)
- Ability to visualize relationships of bird metrics to management activities and relative importance of covariates
- Ability to identify birds that are positively or negatively impacted by proposed management activities
- Ability to output maps from the web application to load into Graphical Interface Systems
- Ability to output model results (estimates and uncertainty in estimates) in tabular form (CSV) for each priority landscape

Optional advanced features include:

- Visualizations of model uncertainty within web application
- Option of user entering polygons of areas of interest within the application and output maps

- Option of user definiing a raster aggregation of an area of interest to visualize within the application and output maps

The Impact

The increased pace and scale of the Wildfire Crisis Strategy means effective monitoring is needed to measure the impacts of both past and ongoing forest management to plants and animals and communicate these impacts to the public. End-users of this web application include managers across the western United States, researchers, and other stakeholders. A successful Decision Support Tool will allow managers to evaluate responses of bird communities in a timely manner to maintain or increase ecological integrity while reducing overall high severity fire risk in landscapes across the western United States.

Knowledge, skills, and expertise required for this project:

- Experience with professional web development
- Experience with user experience (UI/UX), user design (UD), and accessible web application interfaces
- Experience with programming languages for data visualization (i.e., R, Python, JavaScript, Julia) and principles of data visualization
- Ability to communicate with a large diverse team comprised of researchers and managers
- Familiarity with Graphical Interface Systems is helpful to understand spatially referenced data
- Some familiarity with R would be helpful to understand statistical model output from the pipeline
- Familiarity with data visualization tools (i.e., Tableau, Microsoft Power BI) is helpful, but not necessary

Equipment Requirements:

- There should be no equipment or software required other than a development platform and software/tools freely available online.

Software and other Deliverables:

- A strong as-built report detailing the design and implementation of the product in a complete, clear and professional manner. This document should provide a strong basis for future development of the product.
- Complete professionally-documented codebase, delivered both as a repository in GitHub or some other version control repository; and as a physical archive on a USB drive.