**Western Montana Ecological Forecasting II**

*Enhancing Habitat Suitability Modeling of Mustelid Species and Contaminant Monitoring in Northern Montana using NASA Earth Observations*

**Project Team**

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**Project Overview**

***Project Synopsis:***

American mink (*Neovison vison*) and river otter (*Lontra canadensis*) scat can serve as bioindicators for contaminants in aquatic ecosystems. Working Dogs for Conservation (WD4C) is a Montana-based nonprofit organization that uses detection dogs to locate the scat of these mustelid species for contaminant testing to help assess water quality in western Montana’s rivers. This research uses NASA Earth observations, species occurrence data, and Software for Assisted Habitat Modeling (SAHM) to advance sampling procedures for WD4C and the Virginia Institute of Marine Science (VIMS) by identifying areas of mustelid habitat suitability based on multiple geographic and climatic variables.

***Abstract:***

Environmental contaminants in aquatic ecosystems threaten both human and ecosystem health. Western Montana’s rivers possess great economic and ecological value, yet the status of contaminants in these systems can be unclear. Contaminants such as brominated flame-retardants, heavy metals, and pharmaceuticals negatively affect ecosystem health by traveling through the food chain and bioaccumulating in apex predators. Exposure to these contaminants can result in neurological, endocrine, and reproductive impairments in wildlife and humans. American mink (*Neovison vison*) and North American river otter (*Lontra canadensis*) have a predominantly aquatic diet and serve as reliable indicator species of environmental health. Working Dogs for Conservation (WD4C) uses detection dogs to locate scat samples of these species which are assessed for contaminants by the Virginia Institute of Marine Science (VIMS). With Software for Assisted Habitat Modeling (SAHM), the team generated current (2013-2020) and projected (2021-2040) habitat suitability models for mink and otter utilizing NASA Earth observations from Terra Moderate Resolution Imaging Spectroradiometer (MODIS), Global Precipitation Measurement Integrated Multi-Satellite Retrievals for GPM (GPM IMERG), Shuttle Radar Topography Mission (SRTM), and Soil Moisture Active Passive (SMAP). The habitat suitability maps’ study region encompassed Flathead National Forest and Blackfeet Indian Reservation. Additionally, the team created site accessibility and precipitation anomaly maps that display the viability of survey locations. The current habitat suitability models performed well (AUC-PR=0.88). The most important predictor variables for suitable habitat were distance to rivers, elevation, and land cover. These end products will further inform WD4C survey site selection and contaminant monitoring.

***Key Terms:***

SAHM, ArcGIS Pro, riverine ecosystems, scat sampling, heavy metals, bioaccumulation, Earth observations, remote sensing

***National Application Area(s) Addressed:*** Ecological Forecasting, Water Resources

***Study Location:*** Blackfeet Indian Reservation, Flathead National Forest, MT

***Study Period:*** January 2013 to December 2020; Forecasting to 2040

***Community Concerns:***

* Contaminants such as BFRs, heavy metals, and pharmaceuticals are threatening Montana’s riverine ecosystems. Exposure to these contaminants has the potential to negatively affect neurological, endocrine, and reproductive systems of both humans and animals.
* These chemicals do not break down easily and remain in the environment for extended periods of time, providing the opportunity to travel up the food chain and into the bodies of predators. This issue is concerning because Montana’s river systems supply water to nearby communities, support recreational activities, and provide important habitat for a multitude of species.
* While large-scale mining activities are no longer active, they can still contribute contaminants to waterways. Also, other contaminant sources (wastewater plants, wastewater effluent, increased use of flame-retardants, and runoff from urban areas) are likely to increase as urban areas expand in the study area.
* The lack of knowledge regarding the presence and impact of contaminants on these rich ecosystems hinders the ability of policymakers and land managers to implement appropriate conservation or pollution mitigation strategies.

***Project Objectives:***

* Generate refined habitat suitability models for mink and otter in an expanded study area for 2013–2020
* Refine future habitat suitability models for mink and otter in an expanded study area projected to 2040
* Produce site accessibility maps assessing viability of survey locations based on recreational river use and accessibility factors
* Compose maps displaying precipitation anomalies in relation to topographic characteristics to further aid in monitoring river system contaminants

***Previous Term:***

2021 Spring (GSFC) – Western Montana Ecological Forecasting

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Working Dogs for Conservation** | Dr. Ngaio Richards, Forensics and Field Specialist; Dr. Megan Parker, Founder & Director of Research | End User | No |
| **Virginia Institute of Marine Science** | Dr. Mark LaGuardia, Senior Marine Scientist | Collaborator | No |

***Decision-Making Practices & Policies:***

WD4C uses a field-based approach to locate sampling sites and conduct surveys where mink and otter scat are present in western Montana. These methods rely on local sightings, word of mouth, and random sampling around generally suitable habitat. Surveys and scat collection are also carried out in proximity to known anthropogenic sources of pollution, such as hospitals, car washes, and other sites that may contaminate waterways with polluted runoff. WD4C is expanding their study locations and new surveys are to be conducted on the Blackfeet Indian Reservation, with permission from the Blackfeet Nation. However, no permits are required to collect mustelid scat.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **Terra MODIS** | Land Surface Temperature | Annual, monthly, and seasonal average land surface temperatures (LST) from 2013 to 2020 were used as a predictor variable in the habitat suitability models. |
| **GPM IMERG** | Precipitation | Daily and monthly precipitation accumulation data from 2013 to 2020 were used in the habitat suitability models. Algorithms to predict interpolated values were used as predictor variables in the current and forecasted habitat suitability models and to calculate precipitation anomalies. |
| **SRTM** | Elevation, Slope, Aspect | The topographic variables of elevation, slope, and aspect were used as predictor variables in the habitat suitability models. Topographic variables were also used to generate precipitation anomalies and topographic maps. |
| **SMAP** | Soil Moisture | Soil moisture data from 2015 to 2020 were used as a predictor variable in the current habitat suitability models. |

***Ancillary Datasets:***

* Working Dogs for Conservation American Mink and North American River Otter Species Occurrence data – Historical trapping data related to Mink and Otter presence that were used to train habitat suitability models
* Global Biodiversity Information Facility (GBIF) North American River Otter Species Occurrence data – Mink and Otter presence points compared with Working Dogs for Conservation American Mink and River Otter trapping data. The comparison was used to visually assess final map outputs from SAHM, train habitat suitability models, and aid in the creation of the research site accessibility map.
* Montana National Heritage Program Observational Mink and Otter Data – Used along with GBIF and Working Dogs for Conservation data in current and projected habitat suitability models
* United States Geological Survey (USGS) National Land Cover Database (NLCD) – Land cover classification used for predictor variables in habitat suitability models
* United States Geological Survey (USGS) Conterminous United States Land Cover Projections – A1B scenario current (2021) and projected (2040) land cover data used in projected habitat suitability models
* United States Geological Survey (USGS) National Hydrography Dataset (NHD) – River location data used to calculate distance to river predictor variable for current habitat suitability models
* University of North Carolina Global River Bankfull Width and Depth Database (derived from Shuttle Radar Topography Mission) – River depth and width used as input for SAHM modeling for habitat suitability models
* United States Department of Agriculture (USDA) Forest Service HydroFlow Metrics West – Historical and projected mean annual flow used as predictor variables in projected habitat suitability models
* WorldClim Historical Weather Data – Used to model precipitation and temperature from 2010–2018 for predictor variables in the projected habitat suitability models
* WorldClim Couples Model Intercomparison Project Phase 6 (CMIP 6) Bioclimatic Variables for 2040 – Used to model precipitation and temperature for 2021–2040 for predictor variables in the projected habitat suitability models
* Oregon State University Parameter-elevation Regressions on Independent Slopes Model (PRISM) – Temperature and precipitation data used as predictor variables in current habitat suitability models
* Open Street Map (OSM) – Used to identify potential contaminant sources for the site accessibility maps
* United States Geological Survey (USGS) Digital Elevation Models (DEM) – Used to create a hill shaded topographic feature used in the precipitation anomaly map
* MSDI Transportation Features of Montana – Roads and trails were used to aid partners in safe navigation to surveying sites for site accessibility maps
* Montana Bureau of Mines and Geology (MBMG) Abandoned and Inactive Mines database – Collected from USDA to aid in contamination source acquisition for the site accessibility maps

***Modeling:***

* Software for Assisted Habitat Modeling (SAHM) (POC: Peder Engelstad, Colorado State University) – Modeled present and future habitat suitability analysis of mink and otter in northwestern Montana
* Random Forest (POC: Dr. Allison Howard, University of Georgia) – Model run within SAHM for habitat suitability modeling

***Software & Scripting:***

* ESRI ArcGIS Pro 2.8.2 – Map and visualize habitat suitability results, site accessibility variables, precipitation anomalies and topographic maps
* R Studio 1.4.1717.0 – Create raster stack and calculate mean to incorporate historical climate data into the projected suitable habitat results
* Google Earth Engine – Collect and preprocess data from multiple sensors and satellites
* QGIS 3.2 – Download OSM data via QuickOSM plug-in

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **Refined Habitat Suitability Maps** | Terra MODIS  GPM IMERG  SRTM  SMAP | The Refined Habitat Suitability Maps identify areas likely to have the highest presence of mustelid species, which will help to enhance and standardize the WD4C surveying procedures. This will reduce reliance on mustelid species sightings and expedite the survey site selection process. | I |
| **Refined Future Habitat Suitability Maps** | Terra MODIS  GPM IMERG  SRTM  SMAP | These maps will advance the partner’s understanding of mustelid distribution forecasted to 2040 and will assist in selecting future sites for surveying. | I |
| **Site Accessibility Maps** | N/A | Site accessibility maps will increase the safety and efficiency of partners in reaching survey site locations by outlining public access points within, or in proximity to, suitable habitat. | N/A |
| **Precipitation Anomalies and Topographic Maps** | GPM IMERG  SRTM | Visualization of precipitation anomalies in relation to topography will assist partners in understanding how contaminants move through the ecosystem, therefore helping to determine survey locations. | I |

***Product Benefit to End User:***

WD4C will be able to use the refined habitat suitability maps to select survey locations using multiple NASA Earth observation datasets as modeling inputs. The use of these datasets will standardize the field survey location selection process and may reduce or eliminate the need for information based on locally reported mustelid sightings. Revised maps of future habitat suitability will help partners assess potential impacts of climate change to mustelid habitat. These maps will help WD4C determine future suitable habitat by projecting climatic conditions until the year 2040. Site accessibility maps will provide WD4C with public access points in proximity to suitable mustelid habitat, which promotes the safety of surveyors and the efficiency of their sampling efforts. Precipitation anomaly maps and topographic maps will reveal the geographic characteristics of the landscape in detail and inform how contaminants may move through the ecosystem, giving partners a better idea of viable sampling locations. The end products of this research will enhance surveying procedures for WD4C by using multiple environmental variables to predict the locations with the highest habitat suitability for mustelid species and examine how those locations intersect with contamination sites and precipitation patterns.

**References**

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