**Western Montana Ecological Forecasting**

*Modeling Habitat Suitability of Mustelid Species to Guide Detection Dog Surveys for Contaminants Monitoring, via Collected Scats, in River Systems of Western Montana*

**Project Team**

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**Project Overview**

***Project Synopsis:***

The status of contaminants in western Montana’s river systems is largely unknown. However, analysis of mustelid fecal matter can provide valuable information regarding ecosystem health in a noninvasive, nondestructive, and inexpensive manner. Using NASA Earth observations, this project generated current and future habitat suitability models for American mink (*Mustela vison*) and North American river otter (*Lontra canadensis*) using occurrence data from fecal matter sampling sites. These results will guide Working Dogs for Conservation (WD4C) in survey and detection efforts so that they can more effectively locate contaminant samples from these species.

***Abstract:***

Environmental contaminants are becoming increasingly prevalent in riverine ecosystems. The status of contaminants in western Montana’s relatively pristine river systems is largely unknown. Monitoring for heavy metals, brominated flame-retardants (BFRs), and pharmaceuticals is important due to their negative effects on ecosystems. Exposure to these contaminants can have significant endocrine, neurological, and reproductive effects. Contaminants easily travel up the food chain and bioaccumulate in apex predators. As predators with a largely aquatic diet, American mink (*Mustela vison*) and North American river otter (*Lontra canadensis*) serve as reliable indicator species of environmental health and the status of contaminants. Analysis of scat from these species is a noninvasive method to measure contaminant levels, and detection dogs from Working Dogs for Conservation (WD4C) have been used to locate these scat samples. To aid in the search of these samples, habitat suitability models were created for mink and otter for the years 2013-2020 and projected to 2040 using the random forest algorithm in the Software for Assisted Habitat Modeling (SAHM). Predictor variable data were acquired from Landsat 8 Operational Land Imager (OLI), 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). Within these models, the most important variable for mink and otter habitat was distance to river. Suitable habitat also corresponded with emergent herbaceous land cover and deeper river locations. These habitat suitability models will inform sampling site section for further contaminant analysis.

***Key Terms:***

riverine ecosystems, heavy metals, brominated flame-retardants, pharmaceuticals, Earth observations, bioaccumulation, remote sensing, scat samples

***National Application Areas Addressed:*** Ecological Forecasting, Water Resources

***Study Location:*** Blackfoot, Bitterroot, Clark Fork, Madison, and Yellowstone river systems, MT

***Study Period:*** January2013 to December 2020; Forecasting to 2021-2040

***Community Concerns:***

* Contaminants such as heavy metals, BFRs, and pharmaceuticals in western Montana’s river ecosystems threaten the health of humans and wildlife with long-term biological effects.
* Carnivorous mammals such as mink and otter are ecologically important as predators, and exposure to and bioaccumulation of contaminants is a risk to individual and ecosystem health.
* Mustelid species are economically important to hunters and trappers, and negative biological effects can jeopardize their livelihoods.
* With the exception of historical mining activities, contaminant sources (wastewater plants, wastewater effluent, increased use of flame-retardants, and runoff from urban areas) are likely to increase with increased urbanization in western Montana.
* Lack of information about the presence of BFRs, pharmaceuticals, and heavy metals in these rich ecosystems limits the ability of policymakers and land managers to respond to the hazards.

***Project Objectives:***

* Create habitat suitability maps for mink and otter in western Montana for the years 2013-2020
* Generate future habitat suitability maps for mink and otter in western Montana projected to 2040
* Produce maps of suggested survey areas based on habitat suitability and location of potential contaminant sources

**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:***

Currently, WD4C chooses survey locations based on the presence of habitat characteristics favored by mustelid species, survey site accessibility (including access permission, if required), and proximity to contaminant inputs such as urban centers and wastewater treatment plants. Additionally, WD4C relies on information from trappers and hunters about the location of mink and river otter. After selecting areas for survey, field specialists conduct searches with dogs, often employing multiple teams in multiple river systems. The use of dogs increases the likelihood of finding and collecting samples for analysis, as the dogs are highly trained to detect scat. WD4C has used platforms like Google Earth, but has not previously used remote sensing in their decision-making process.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 8 OLI** | Land surface reflectance | Surface reflectance was used to calculate the Normalized Difference Vegetation Index (NDVI). |
| **Terra MODIS** | Surface temperature (land) | Annual, monthly, and seasonal average land surface temperatures were used as a predictor variable in the habitat suitability model. |
| **GPM IMERG** | Precipitation (algorithm to predict interpolated values) | Daily and monthly precipitation accumulation data were used as a predictor variable in the habitat suitability model. |
| **SRTM** | Elevation, slope and aspect | Topographical data served as a predictor variable in the habitat suitability model and were used to determine feasibility of ground-based surveys. |
| **SMAP** | Soil moisture | Soil moisture data served as a predictor variable in the habitat suitability model. |

***Ancillary Datasets:***

* Working Dogs for Conservation American Mink and North American River Otter Species Occurrence data – species presence points recorded by the partners for mink and otter used to train habitat suitability models
* Global Biodiversity Information Facility (GBIF) North American River Otter Species Occurrence data – species presence points for otter used as a comparison to visually assess final map outputs from SAHM and in the creation of the research site feasibility map
* United States Geological Survey (USGS) National Land Cover Database (NLCD) – used for land cover classification predictor variables in habitat suitability models
* University of North Carolina Global River Bank full Width and Depth Database (derived from Shuttle Radar Topography Mission) – used to generate a river depth predictor variable for habitat suitability models
* Multi-Error-Removed Improved-Terrain (MERIT) Hydro Global Hydrography Dataset – used to estimate height above nearest drainage (HAND) for a predictor variable in the habitat suitability models
* Oregon State Parameter-elevation Regressions on Independent Slopes Model (PRISM) Monthly Spatial Climate Dataset– used for climatic predictor variables in habitat suitability models
* WorldClim Historical Weather Data – modeled precipitation and temperature for 2010-2018 for predictor variables in habitat suitability models
* WorldClim Coupled Model Intercomparison Project Phase 6 (CMIP 6) Bioclimatic Variables for 2040 – modeled precipitation and temperature for 2021-2040 used for predictor variables in the future habitat suitability model
* Open Street Map - used to create a distance from river variable and to identify potential contaminant sources for the research site feasibility map

***Modeling:***

* Software for Assisted Habitat Modeling (SAHM) (POC: Peder Engelsted, Colorado State University) – used to run present and future habitat suitability analysis of mustelids in western Montana
* Random Forest (POC: Kristen Dennis, NASA DEVELOP) – used as a model within SAHM for habitat suitability modeling

***Software & Scripting:***

* Esri ArcGIS Pro 2.7 – used to process data and visualize habitat suitability maps and research site feasibility map
* SAHM 2.1.0 – used for mustelid habitat suitability modeling
* VisTrails 2.2.3-x64 – used as an interface and workflow management for SAHM
* Google Earth – used to create an interactive map for exploring potential contaminant sources
* Google Earth Engine – used to script codes to obtain NDVI from Landsat OLI, annual average land surface temperature from Terra MODIS, annual average precipitation data from GPM IMERG, and annual average climatic variables from PRISM

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used**  | **Partner Benefit & Use** | **Software Release Category** |
| **Habitat suitability maps** | Landsat 8 OLI, Terra MODIS, GMP IMERG, SRTM, and SMAP  | Habitat suitability maps demonstrated the distributions of indicator species in order to guide contaminant detection efforts. Partners also received maps of five key river systems. | N/A |
| **Future habitat suitability maps** | Landsat 8 OLI, Terra MODIS, GMP IMERG, SRTM, and SMAP | Future habitat suitability maps provided partners with predicted habitat suitability in the year 2040 given climatic projections for 2040. Partners also received maps of five key river systems. | N/A |
| **Research site feasibility map** | Landsat 8 OLI, Terra MODIS, GMP IMERG, SRTM, and SMAP | An additional layer of dataguided partners in their field site selection and study design based on presence of contaminant sources and observations of otter presence from external sources.  | N/A |
| **Google Earth package** | N/A | Data points in KML format provide an interactive and user friendly method for partners to explore potential contaminant sources.  | N/A |
| **StoryMap** | N/A | The StoryMap gave partners a visual and interactive product to explain their work and engage the community and decision makers. | N/A |

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

WD4C will use the products created by the DEVELOP team to efficiently allocate resources for scat detection searches in order to collect quality contaminant data. Habitat suitability maps will allow partners to prioritize survey areas. The Google Earth package will allow partners to explore potential contaminant sources in locations not previously surveyed. Future habitat suitability maps will help the end user and the Virginia Institute of Marine Science understand how contaminant exposure (suitable habitat range relative to contaminant input sources) may change in the future and how their work to conserve these ecosystems may need to adjust accordingly. The research site feasibility map will inform practical field site selection and study design. A StoryMap will engage the community and decision-makers by providing a platform to communicate the science and collaboration behind the project and its impact. The methodology developed in this project will allow WD4C to incorporate NASA Earth observations in future studies to streamline the sample detection effort using detection dogs.

**References:**

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