Assessment of Wildlife Vulnerability to Energy Development (AWVED)

2008 Progress Report

September 15, 2008

Douglas Keinath
Senior Zoologist
Wyoming Natural Diversity Database
University of Wyoming
Department 3381
Laramie, Wyoming 82071
307-766-3013, dkeinath@uwyo.edu

Dr. Matthew Kauffman
Assistant Leader
U.S. Geological Survey
Cooperative Fish & Wildlife Research Unit
Department of Zoology and Physiology
University of Wyoming
Laramie, WY 82071
307-766-6404, mkauffm1@uwyo.edu

Dr. Gary Beauvais
Director
Wyoming Natural Diversity Database
University of Wyoming
Department 3381
Laramie, Wyoming 82071
307-766-3027, beauvais@uwyo.edu

Contents

BACKGROUND 1

PROGRESS TO DATE 2

Interagency Logistics *2*
Methodologies *2*
Background Data *4*

NEXT STEPS 5

TABLES AND FIGURES 7

Background

The Assessment of Wildlife Vulnerability (AWVED) was established as a research task to addresses the need to prioritize the management, monitoring, and research needs of Wyoming's long list of Species of Greatest Conservation Need (SGCN; listed in Wyoming's Comprehensive Wildlife Conservation Strategy). AWVED falls under Component 2.1 of the Science Plan, and is a companion effort with WLCI's Comprehensive Assessment (CA). While the CA will guide WLCI's near-term efforts for some key species, we still know next to nothing about how energy development will impact the remainder of the SGCN. AWVED will address this need by developing methods to synthesize existing data into a better understanding of how each species will be affected by proposed energy development. The main goal of AWVED is to help focus conservation attention on the most vulnerable species before they become imperiled to the point that drastic action, such as listing under the Endangered Species Act, becomes necessary.

AWVED is a four-stage analysis aimed at estimating species distributions and assigning preliminary risk ranks (Stage 1), conducting biological sensitivity analyses for potentially at risk species (Stage 2), constructing demographic impact models for those species (Stage 3), and validating results with selected field data (Stage 4). Stage 1 is similar in basic approach to the CA, although broader in scope, while subsequent stages add additional analyses beyond those of the CA.

Progress to Date

We have begun work on the first stage of AWVED, which has primarily focused on three fronts: logistical coordination with key players in this effort, developing the methodological framework for creating range maps and distribution models, and compiling and preparing background data necessary to generate models. Notes on specific progress under each of these fronts are noted below.

Interagency Logistics

There are currently three major parties interested in accurate range and distribution mapping of vertebrate animals in Wyoming:

1. The United States Geological Survey (USGS) regional Gap Analysis Program (reGAP) is updating vegetation and vertebrate maps for the northwestern United States (Idaho, Montana, Oregon, Washington and Wyoming). WYNDD is leading the vertebrate range and distribution mapping portion of this effort.

2. The Wyoming Game and Fish Department (WGFD) is beginning revision of its Comprehensive Wildlife Conservation Strategy (CWCS), which includes refining range maps for its 279 Species of Greatest Conservation Need (SGCN).

3. AWVED, which is funded by the USGS Fort Collins Science Center and the WGFD, is beginning analysis of species distribution relative to energy development in southwestern Wyoming. This is a component of the Wyoming Landscape Conservation Initiative (WLCI).

We organized a meeting with representatives of these entities in May 2008 to discuss synergies in range mapping and modeling (Table 1). As a group, we agreed that it was most valuable to all concerned if we work together on a consistent set of maps, rather than duplicating effort and producing independent products. In general, all parties agreed that methods developed by WYNDD for the NWreGAP analysis would be accepted as the standard for these three efforts and that WYNDD would be the primary producer of these maps. WYNDD agreed to consider CWCS goals when making range maps and distribution models and to keep an open line of communication about methods and progress.

Methodologies

WYNDD staff spent roughly 3 person-months over the last year researching ways to efficiently map occurrence of a large suite of species across Wyoming and an additional 6 person-months developing the computational infrastructure to implement the methods that were ultimately selected. The results of these efforts are encapsulated in the following paragraphs.

Mapping Strategy: Two levels of species biogeographic occurrence were identified as being useful for mapping and analysis for the above-noted projects: range and distribution. ***Range*** is the total areal extent occupied by a given taxon and is usually estimated as the aggregation of all map units thought to be occupied by individuals of the target taxon in the study area. Map units are typically

defined by geographic space only, with little consideration of underlying environmental variation. Because map units are usually coarse, range maps are usually characterized by large, all-encompassing polygons with very little interdigitation of occupied and unoccupied space. In contrast, ***distribution*** is the spatial arrangement of environments suitable for occupation by individuals of a given taxon. It is usually estimated as a subset of all environments in the study area that regularly supports individuals. Whereas units of range are coarse, pre-determined blocks of geographic space that are occupied by individuals, distribution identifies the intersection of multiple environmental gradients that is potentially occupied by individuals. Distribution maps are therefore finer in grain than range maps and exhibit interdigitation of suitable and unsuitable environments. Distribution is effectively a spatial subset of range.

Range Mapping: Because range-mapping considers only known or strongly-suspected occupation of rather coarse map units, it is best pursued with deductive approaches. Expert opinion on the range of most vertebrates has been summarized in various published maps (e.g., Birds of North America, various field guides and species accounts). An initial draft of range maps was created by overlaying such maps and tessellating the output to a common map unit (10-digit HUCs). These "first-round" maps are currently being reviewed by WYNDD staff biologists, who modify the Wyoming range by assigning each HUC an occupational status of "Known to Occur", "Suspected to Occur" or "Likely Absent" based on reported observations and knowledge of local habitat. Once these "second-round" maps are complete, species experts, including staff of the WGFD will be able to review and comment on them via an online tool specifically developed for this purpose (see "Computational Infrastructure below).

Distribution Modeling: For most vertebrates, distribution mapping requires fine-scale consideration of the intersection of multiple environmental gradients. Inductive modeling of geo-referenced species' occurrences is a powerful way to identify suitable environments on continuous and ordinal variables (e.g., elevation, climatic gradients). Inductive modeling of these variables is superior to deductive modeling for at least 2 reasons: (1) inductive analyses can identify variable interactions and other subtleties of multivariate space, whereas expert opinion typically cannot; (2) expert opinion is inaccurate, highly variable, and commonly unavailable in terms of species' relationships with important but obscure variables that are difficult to observe directly in the field (e.g., mean annual precipitation, minimum January temperature). However, deductive selection of suitable classes of categorical variables (e.g., landcover, soil type, ecological land units) is preferable, because opportunistically-collected occurrence data may incompletely represent all suitable categories (thus lessening the power of inductive approaches). Furthermore, most field observers intuitively associate species' observations and behaviors with discrete environments, and thus their experiences represent a good source of categorical relationships. In this context, deductive modeling is probably best performed by having experts review and modify initial lists of suitable categories as identified by mapped occurrence data and previous GAP projects. Therefore, for distribution mapping of most target taxa, we propose overlaying inductive models of continuous and ordinal variables with deductive models of categorical variables, with the final map limited in extent to the maximum range of the taxon. Inductive models will be created assessing environmental attributes from locations of known occurrence (see "Occurrence Layers" below). These attributes will be statistically integrated via algorithms designed to condense multiple input signals into probabilistic models of species presence (e.g., Maximum Entropy or Random Forests). The predictive success of the resulting models will be evaluated, and suitable models will be extrapolated across the state. Species experts, including staff of the WGFD will be able to review and comment on these models an online tool specifically developed for this purpose (see "Computational Infrastructure below).

Computational Infrastructure: As part of NWreGAP, WYNDD collaborated with the Wyoming Geographic Information Science Center (WyGISC) to developed online review tool (e.g., Figure 1). This password-protected tool allows anyone with an internet connection to access our complete set of range maps and suggest specific modifications based on their personal expertise with the species in question. All modifications are attributed to the reviewer and additional information is collected that ranks the expertise of the reviewer with respect to the species and area in question. Modifications from all reviewers will be integrated into a final range map. The accessibility of this tool will enable us to collect and integrate detailed information from a wide variety of sources. It is currently available only to biologists who are generating second-round range maps, but will be made available to a larger audience of experts once the second-round maps are created.

Background Data

Occurrence Layers: Locations of species occurrence are necessary for both the range mapping and modeling. We estimate that we have spent roughly 5 person-months of effort to compile and reconcile known locations of species occurrence from a variety of datasets. To date, we have obtained and processed roughly 1,066,489 occurrence records of 507 species (Table 2). Major sources include WYNDD's Biotics database, WGFD's Wildlife Observation System (WOS), museum specimens drawn from the Conservation Biology Institute (CBI), and bird observations from the Institute for Bird Populations (IBP). All these sources vary in terms of data structure, accuracy, and the type of biological data they contain. This necessitates exhaustive effort reconciling differences to form a single, logically consistent data set.

1. WYNDD's Biotics database was our primary source and set the data standard because it had the most locationally explicit and biologically detailed data, and it required minimal structural manipulation. It consisted of about 170,000 records for non-game species of conservation concern (as of February 28, 2008).

2. In terms of raw data, the WOS dataset was the largest, containing nearly 900,000 occurrence records. This dataset is heavily skewed toward game animals, with 84% of its records (756,000 records) being from 6 major game species (namely elk, mule deer, white-tailed deer, antelope, moose, and sage grouse). For non-game data, the quality of WOS data varies greatly in terms of accuracy, documentation, and biological relevance, making integration into our modeling dataset challenging. When we compared WOS occurrences obtained from WGFD on June 25, 2007 to existing occurrence data in WYNDD's database we eliminated approximately 8,000 records that were duplicates of existing WYNDD records. In the process we also found approximately 15,000 WOS records that appeared to be duplicated *within* WOS. We also modified records to account for changes in taxonomy by cross-walking species names contained in WOS with current standards.

3. There is a wealth of occurrence data contained in museum specimens. Much of this data is already included in the WYNDD database, but we integrated approximately 1,200 additional records from natural history museums that were obtained from CBI on July 6, 2005. Unfortunately, much specimen data has low spatial accuracy and many points in

this data set had no coordinates whatsoever. Thus, we first filtered points to retain only those with usable coordinate information and converted all coordinates into a consistent projection and datum. As with WOS, we then modified taxa names to correspond to those to be used in modeling, including splitting species into subpopulations in some cases.

4. The Institute for Bird Populations collects data from many banding stations throughout Wyoming, much of which WYNDD has already incorporated into its database. Roughly 300 additional records were obtained from IBP on July 2, 2008 and integrated into our modeling dataset. We first remove records that did not provide a species-level identification or which could not be cross-walked to our species list due to uncertainty caused by recent taxonomic reclassification. Then we removed records for species that were not likely breeders at a given station (i.e. migrants and dispersers). Finally, we joined station location data to the IBP records to generate a geospatial dataset containing the filtered data.

Predictor Layers: We obtained a variety of predictor layers for use in developing potential distribution models. All such layers were processed to conform to the standards necessary for modeling, which took roughly 4 person-months of effort. Our current set of predictor layers is shown in Table 3. Thirty two climate variables were originally obtained Dayment Daily Surface Weather and Climatalogical Summaries managed by Oak Ridge National Laboratory (http://www.daymet.org/default.jsp). We performed Principal Components Analysis on this set to isolate a subset of six variables that explain most climatic variation across Wyoming. These layers are likely to be most useful in developing predictive distribution models and will comprise the base set of climate data used to develop those models. Thumbnail images of these data are presented in Figure 2. There are 15 additional environmental datasets, roughly categorized into topography (5 variables), soils (3 variables), water (3 variables), and disturbance (3 variables), images of which are presented in Figures 3 and 4.

Next Steps

Currently, generation of range maps is beginning in earnest. Range maps for all terrestrial vertebrate Species of Greatest Conservation Need should be ready for expert review in the spring of 2009, although a set of 2-4 example maps for use in planning and presenting CWCS updates will be complete by December of this year. Final maps will be available for incorporation into the revised CWCS as they are completed, with all SGCN done by spring 2010. Currently, we expect to present range maps in roughly the format shown in Figure 5a. Maps will also be available electronically and will have supporting documentation that summarizes inputs.

Following completion of the second-round range maps, we will conduct a preliminary GIS-based analysis of potential impacts from energy development for inclusion in the revised CWCS. This analysis will be based on overlaying the range maps with current projections of energy development. A draft report on this analysis will be available by about January of 2010.

In the spring of 2009, we will begin generating potential distribution models for a subset of terrestrial vertebrate SGCN. The subset will consist of 10-50 species selected based on our

initial estimate of what species are most likely to be affected by energy development, although some additional species of particular interest to partners could also be included. Draft models will be available as they are completed, and partners will have the opportunity to review and comment on them. We expect final models to be available for incorporation into planning documents (e.g., the revised CWCS) by late 2009 or early 2010. Currently, we expect to present distribution models in roughly the format shown in Figure 5b. All models will also be available electronically and will have supporting documentation that summarizes inputs, assumptions and validation procedures.

Following completion of range maps and distribution models, we will begin stage two of the AWVED project, evaluating the biological sensitivities of potentially at risk species, which will be discussed in future reports.

Tables and Figures

Table 1: Principle parties attending a mapping coordination meeting on May 30, 2008.

Name	Affiliation
U.S. Geological Survey and University of Wyoming	
Matt Kauffman	Wyoming Cooperative Fish and Wildlife Research Unit
Wyoming Game and Fish Department	
Reg Rothwell	Headquarters – Biological Services
Kirk Nordyke	Headquarters – GIS
Dirk Miller	Headquarters – Fish Division
Dave Zafft	Laramie - Fish Division
Bob Oakleaf (phone)	Lander - Non-game Program
Martin Grenier (phone)	Lander - Non-game Program
Nyssa Whitford (phone)	Lander – GIS
Wyoming Natural Diversity Database	
Doug Keinath	Senior Zoologist
Gary Beauvais	Director

Table 2: Number of occurrence records in the modeling dataset for AWVED as of September 1, 2008, broken down by major taxonomic group.

Taxonomic Group	Number of Occurrences in Modeling Dataset
Ampibians	
Anura	4,961
Caudata	696
Total	5,657
Birds	
Anseriformes	25,447
Apodiformes	708
Caprimulgiforme	1,252
Charadriiformes	11,048
Ciconiiformes	4,851
Columbiformes	3,962
Coraciiformes	687
Cuculiformes	224
Falconiformes	59,213
Galliformes	63,336
Gaviiformes	942
Gruiformes	6,797
Passeriformes	74,027
Pelecaniformes	2,153
Piciformes	3,921
Podicipediforme	1,605
Strigiformes	4,264
Total	264,437
Mammals	
Artiodactyla	729,956
Carnivora	35,480
Chiroptera	1,950
Didelphimorphia	33
Lagomorpha	8,242
Lipotyphla	319
Perissodactyla	5,380
Rodentia	12,189
Total	793,549
Reptiles	
Squamata	1,718
Other	1,128
Total	2,846
Grand Total	***1,066,489***

Table 3: Environmental layers compiled to conduct inductive modeling of species distributions.

Category, Layer	Source	Native Resolution
Topography		
Elevation	National Elevation Dataset (NED; downloaded December 13, 2007)	1 arc-second (approx. 30 m)
Slope	Derived from Elevation dataset above	30 m
Aspect	Derived from Elevation dataset above	30 m
Landform	Derived from Elevation dataset above, using TPI method (following Weiss 2001 and Jenness 2006)	30 m
Topographic Roughness	Derived from Elevation dataset above, using Vector Ruggedness Measure with 10 and 20 cell neighborhoods (Sappington et al. 2007)	30 m
Climate		
Mean Annual Temperature	Daymet	1 km
Wettest Quarter Mean Temperature	Daymet	1 km
Annual Mean Precipitation	Daymet	1 km
Variability (coefficient of variation) of Monthly Precipitation	Daymet	1 km
Annual Frost Days	Daymet	1 km
Interannual Variation in Annual Frost Days	Daymet	1 km
Soils		
Surface Soil Texture	Derived from STATSGO	30m
Soil Depth to Shallowest Restrictive Layer (cm)	Derived from STATSGO	30m
Relative Abundance of Rock Outcrop	Derived from STATSGO	30m
Water		
Distance to Surface Freshwater Feature	Derived from the National Hydrography Dataset	30m
Distance to Permanent Surface Freshwater (m)	Derived from the National Hydrography Dataset	30m
Distance to Permanent Standing Surface Freshwater (m)	Derived from the National Hydrography Dataset	30m
Disturbance		
Distance to Primary Road	Derived from TIGER Data	30m
Distance to Primary or Secondary Road	Derived from TIGER Data	30m
Distance to Any Road	Derived from TIGER Data	30m

Figure 1: Screen-shot of the Northwest Regional Gap Analysis (NWreGAP) Expert Review Tool. This tool will be used to collect and store expert comments on range maps and distribution models developed for both NWreGAP and AWVED.

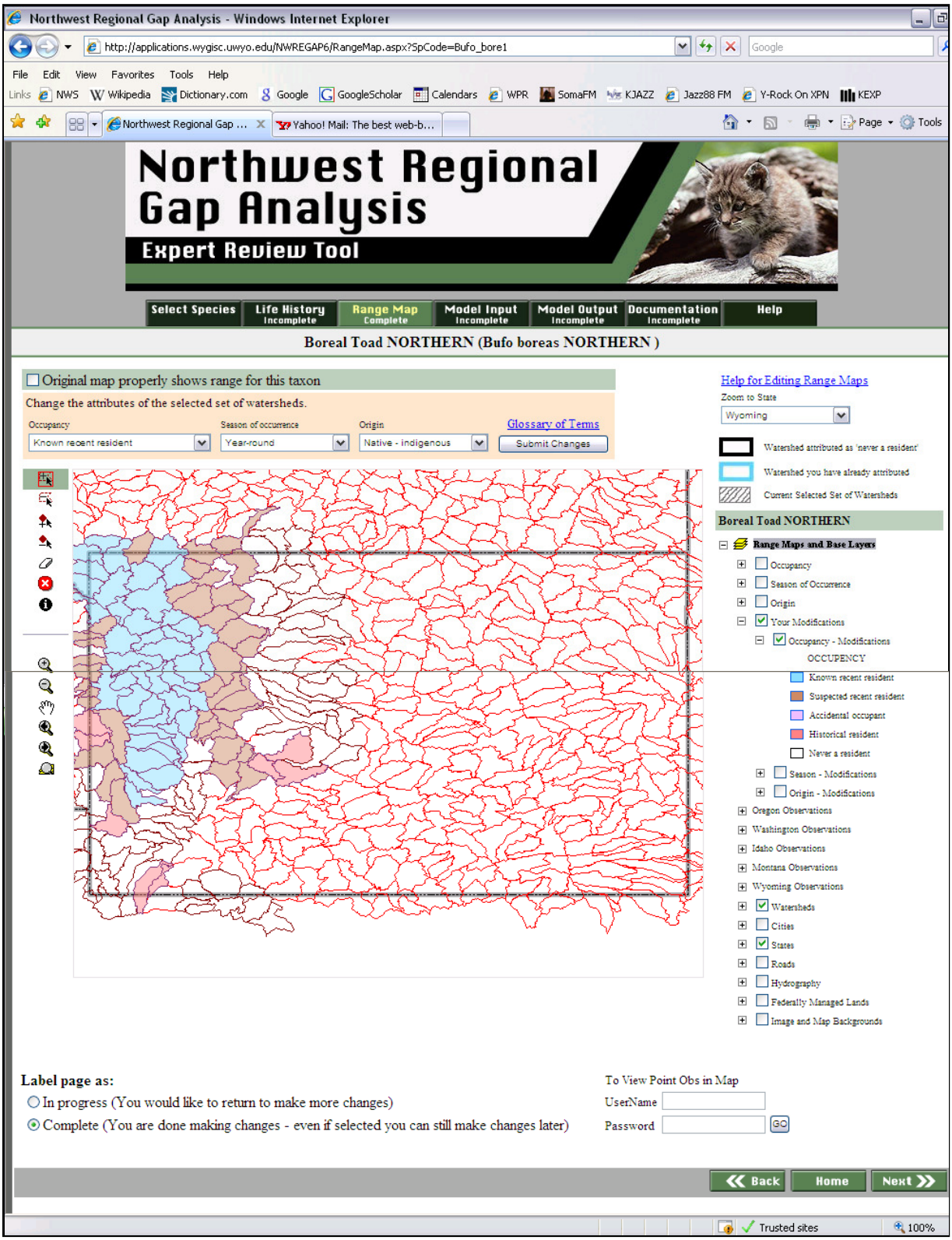


Figure 2: Images of Daymet climate variables for use in developing predictive distribution models of Wyoming's vertebrate fauna.

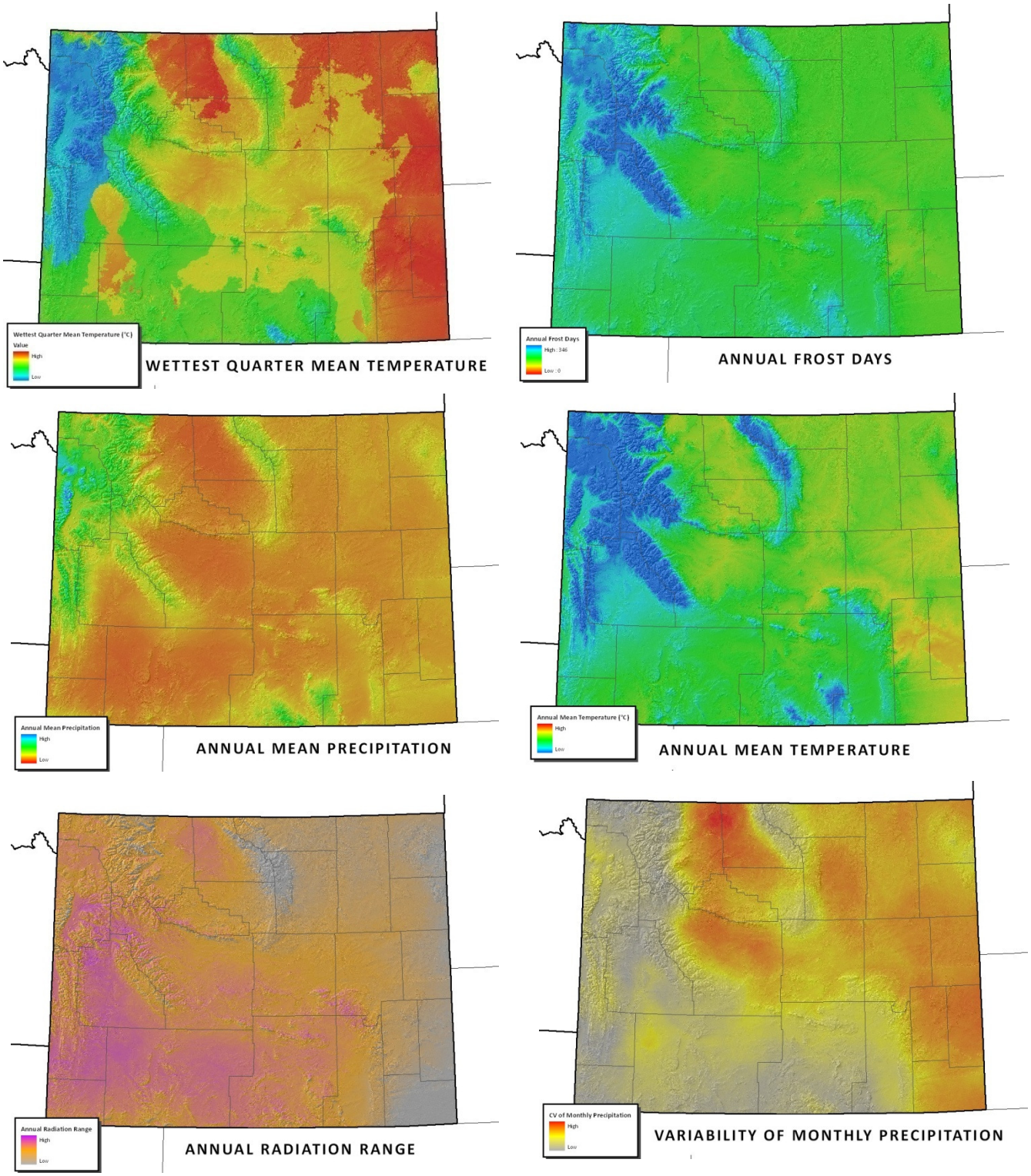


Figure 3: Images of topographic variables for use in developing predictive distribution models of Wyoming's vertebrate fauna.

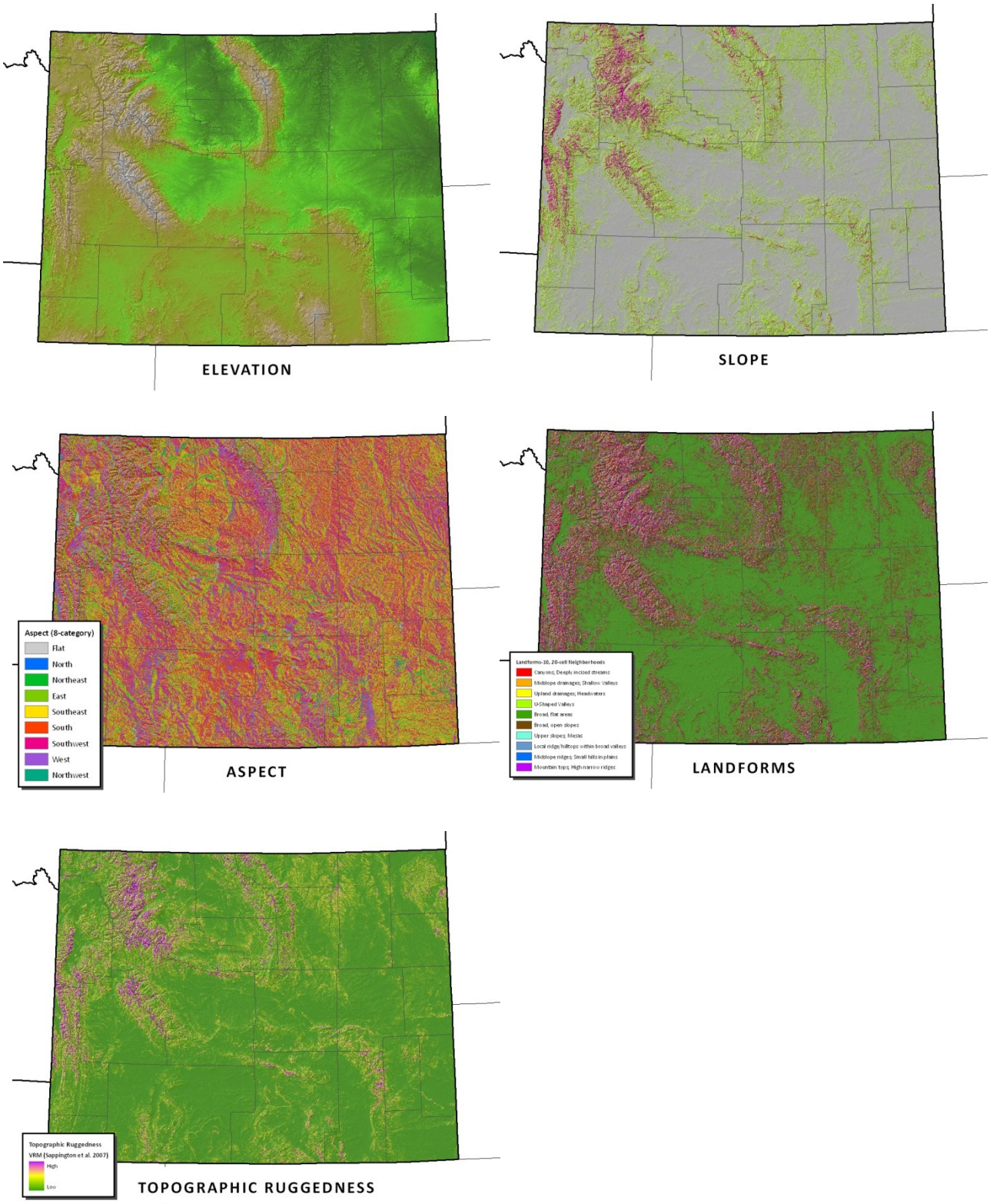


Figure 4: Images of selected hydrography, soils and disturbance variables for use in developing predictive distribution models of Wyoming's vertebrate fauna.

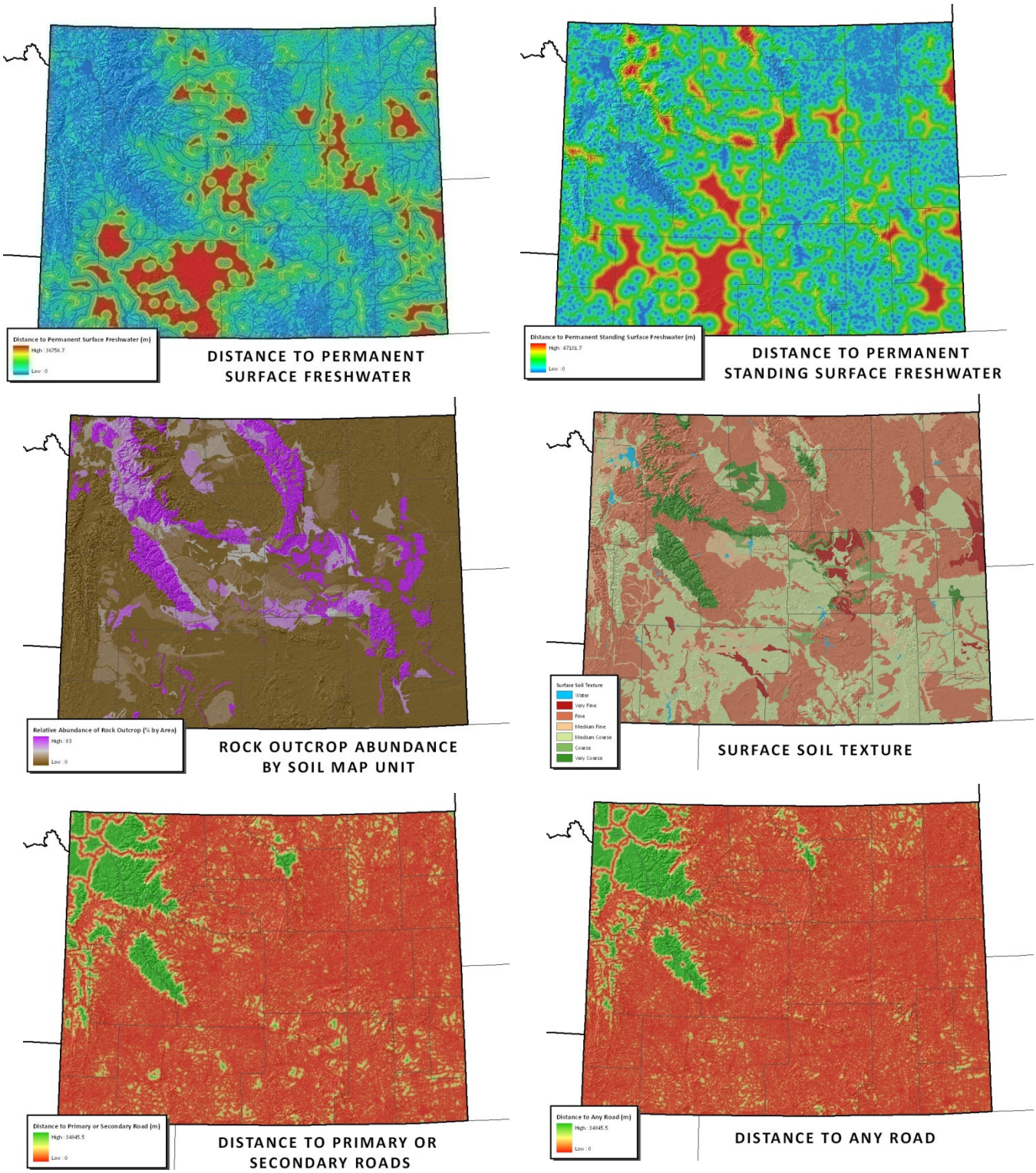
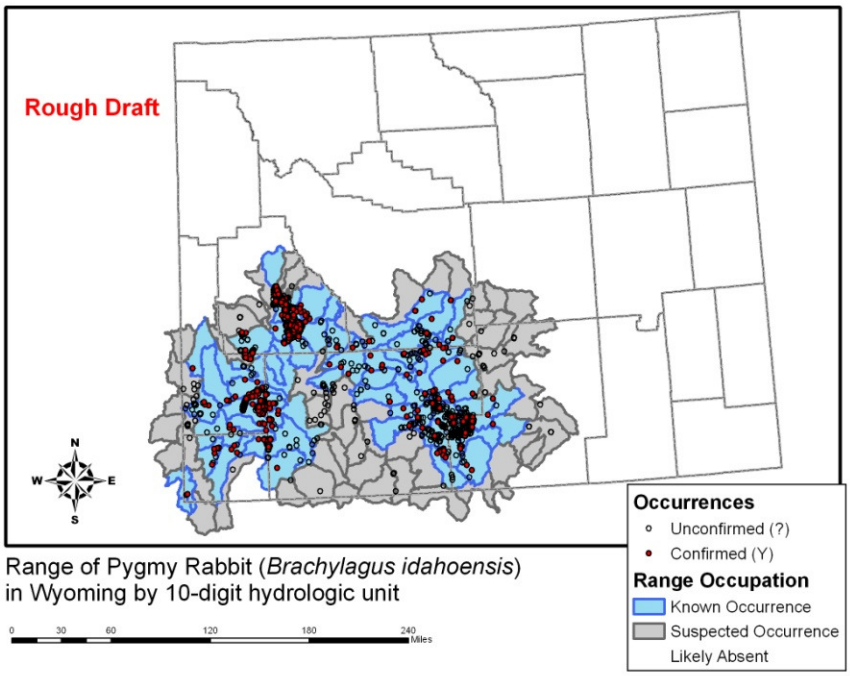
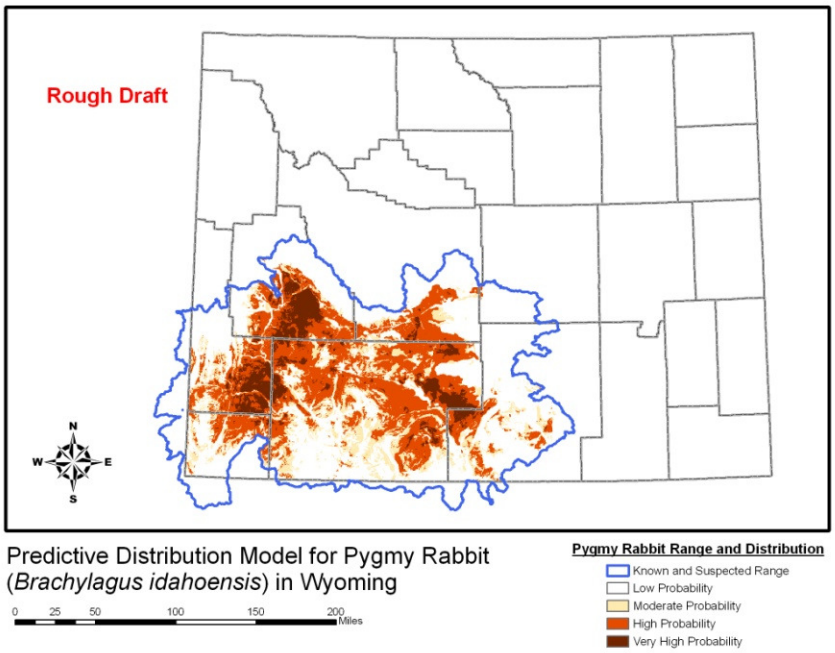


Figure 5: An example of a) range and b) distribution maps that will be produced by AWVED. These are *preliminary* maps generated for pygmy rabbit (*Brachylagus idahoensis*).

a) Example range map for pygmy rabbit (*Brachylagus idahoensis*).



b) Example distribution map for pygmy rabbit (*Brachylagus idahoensis*).