IDAHO DEPARTMENT OF FISH AND GAME

Ed Schriever, Director

Project F19AF00805

Modeling Current and Future Distributions of *Bombus* spp.
Cooperative Endangered Species Conservation

Interim Performance Report

Performance Period
July 1, 2019 to December 31, 2021

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ESA TRADITIONAL SECTION 6
INTERIM PERFORMANCE REPORT

1. **State:** Idaho

   Grant number: F19AF00805, Amendment #1

   Grant name: Modeling Current and Future Distributions of *Bombus* spp.

2. **Report Period:** July 1, 2019 – June 30, 2020

   Report due date: September 28, 2020

3. **Location of work:** Idaho

4. **Objectives**

   Our objectives are to:

   1) use recent field surveys and compiled observations to develop fine-scale current distribution models of *Bombus* species in Idaho,
   2) assess potential changes in distributions by mid-century under moderate and severe climate change scenarios, and
   3) assess potential implications for management of Idaho Department of Fish and Game (IDFG) Wildlife Management Areas (WMAs).

5. **If the work in this grant was part of a larger undertaking with other components and funding, present a brief overview of the larger activity and the role of this project.**

   IDFG is currently engaged in 2 broad-scale *Bombus* projects. The first is a 2-state effort funded through the Competitive State Wildlife Grant Program (C-SWG) titled *Identifying and Implementing Conservation Actions for Bumble Bee Species of Greatest Conservation Need in Idaho and Washington*. This C-SWG project is providing the primary mechanism for data collection necessary to develop our modeled distributions, including assistance with compiling existing *Bombus* records, implementing coordinated statewide surveys (summers of 2018-2020), and training Idaho Master Naturalists and other community scientists. The second is in response to a recent request put forth by Graves et al. (2020). Graves and colleagues developed a sampling framework to address information gaps needed for the *Bombus occidentalis* Species Status Assessment, encouraged others to sample priority areas during the summers of 2020-2021 and contribute data to help in the assessment of stressors and inform future analyses. To contribute to this effort, IDFG is using funding through Section 6 (*Bombus occidentalis distribution model data collection*) to target the identified priority survey areas across the state.

   The overall intent of our project is to use the newly collected and compiled observation data through these 2 projects in conjunction with finer-scale climate, topographic, and land cover data to develop species distribution models for multiple *Bombus* species in Idaho, project those models under moderate and severe future climate scenarios, and assess the implications for management on IDFG WMAs.

6. **Describe how the objectives were met.**

Progress on meeting Objective 1:
We are working closely with Xerces personnel to compile all known observations of *Bombus* species in Idaho (including museum specimens, older survey efforts, and incidental observations) from several sources including the Idaho Fish and Wildlife Information System, University of Idaho WF Barr Museum, SCAN (includes several other data sources), iNaturalist, and the Bumble Bee Atlas. As part of the previously mentioned C-SWG project, the Bumble Bee Atlas is the primary source for current survey data. Collaborative training workshops demonstrated how land managers, scientists, and community naturalists could upload their observations to this database ensuring consistency and accuracy. To date, >11,000 observations have been compiled from the various sources. Recently collected survey data from summer 2020 will be verified and added by late October 2020. All data currently available are being evaluated for use in the models to ensure spatial and temporal accuracy. Of the 22 *Bombus* species known to occur in Idaho, sufficient data currently exists to model at least 4 species identified as Idaho Species of Greatest Conservation Need (*B. fervidus*, *huntii*, *morrisoni*, and *occidentalis*) as well as several more common species in the state (Table 1). We will develop distribution models for these more common species as time permits, focusing on those species known or suspected to be associated with higher elevations (e.g., *B. appositus*, *flavifrons*, *mixtus*, and *sylvicola*). Given the reliance of Cuckoo Bumble Bees on their respective hosts, we elected not to develop models for *B. flavidus* (host = *rufocinctus*), *insularis* (multiple hosts), or *suckleyi* (host = *occidentalis*).

Table 1. Number of recent occurrences (2000-2020) compiled for modeling distribution of selected *Bombus* species in Idaho. Species of Greatest Conservation Need are in bold.

Common Name	Scientific Name	# of Occurrences
White-shouldered Bumble Bee	*Bombus appositus*	144
Two-form Bumble Bee	*Bombus bifarius*	1339
Central Bumble Bee	*Bombus centralis*	248
Yellow Bumble Bee	***Bombus fervidus***	**189**
Yellow Head Bumble Bee	*Bombus flavifrons*	392
Brown-belted Bumble Bee	*Bombus griseocollis*	265
Hunt's Bumble Bee	***Bombus huntii***	**518**
Orange-rumped Bumble Bee	*Bombus melanopygus*	99
Fuzzy-horned Bumble Bee	*Bombus mixtus*	214
Morrison's Bumble Bee	***Bombus morrisoni***	**64**
Nevada Bumble Bee	*Bombus nevadensis*	215
Western Bumble Bee	***Bombus occidentalis***	**124**
Red-belted Bumble Bee	*Bombus rufocinctus*	241
Sitka Bumble Bee	*Bombus sitkensis*	30
Forest Bumble Bee	*Bombus sylvicola*	25
Half-black Bumble Bee	*Bombus vagans*	145

Previous distribution modeling efforts for *Bombus* have occurred at continental scales, both in North America (Koch and Strange 2009, Cameron et al. 2011, Williams et al. 2014, Sirois-Delisle and Kerr 2018) and in Europe (Herrera et al. 2014, Pradervand et al 2014, Casey et al. 2015, Prenado et al. 2016, Marshall et al. 2017, Geue and Thomassen 2019, Lecocq et al. 2019), and at regional scales in the western United States (Jackson et al. 2018, Koch et al. 2019, Ghisbain et al. 2020). Learning from and building on these efforts, we compiled and/or developed finer-scale versions of these covariates, as well as those shown to be useful in other pollinator modeling projects (e.g., Svancara et al. 2019). Our goal was to use data at spatial scales most applicable to *Bombus* species and to ensure variables represented ecophysiological processes known to influence bumble bees either directly or indirectly through selected floral resources.

All previous efforts, except for Herrera et al. (2014), relied on measures of temperature and precipitation from WorldClim at 1-5 km spatial resolution. Working closely with climate researchers (at University of Idaho, University of California Merced, and United States Forest Service) to refine modeling covariates to reflect the more local variability in our Idaho-focused approach, we used temperature data (at 250m resolution) developed for the Northern Rockies by Holden et al. (2015) in combination with the precipitation data from the Parameterized Regression on Independent Slopes Model (PRISM Climate Group 2012) (at 800m). Monthly 30-year normals (1981–2010) from both temperature and precipitation datasets were then used to calculate the 19 bioclimatic variables needed.

Even though bumble bees are known to select along elevational gradients, and numerous topographic variables can influence flowering plants used by bumble bees, few previous modeling efforts employed topographic covariates. Using the National Elevation Data (USGS 2016), we developed several topographic variables including elevation, slope, aspect, Compound Topographic Index, roughness, topographic solar-radiation index (TRASP), relative slope position and vector ruggedness measure. All topographic variables were developed using 10m resolution data following methods in Evans et al. (2014) and Sappington et al. (2007) and resampled to 30m resolution for modeling. In addition, we developed other potentially informative landscape-related variables including distance to water, distance to roads, tree canopy cover, distance to dense canopy, tree and shrub height, and percent natural land cover at 2 scales.

We are using maximum entropy methods (Maxent 3.4.1; Phillips et al. 2006, Phillips and Dudik 2008, Phillips et al 2017) to model current species distributions for selected *Bombus* (Table 1). Given the great flexibility and 'art' in developing species distribution models, several model parameters need to be carefully assessed. Following recommended approaches, we are developing current distribution models for these species using species-specific model parameters and assessing the influence of these parameters, particularly with regard to collinearity and regularization multipliers. To address potential intraspecific variability, particularly for more common and broad-ranging species, we are modeling distributions based on 3 broad geographical areas following Bailey's Ecological Sections boundaries in north Idaho (Okanogan Highlands, Flathead Valley, Bitterroot Mountains, and Palouse Prairie sections), central Idaho (Blue Mountains, Idaho Batholith, Challis Volcanics, and Beaverhead Mountains sections), and south Idaho (Owyhee Uplands, Snake River Basalts, Northwestern Basin and Range, Overthrust Mountains, Yellowstone Highlands, and Bear Lake sections).

The work on this objective is in progress. Final data compilation is anticipated by December 2020, covariate development is completed, and final distribution models are anticipated by May 2021. We will continue to work throughout the project duration to further integrate our local results into ongoing regional efforts (e.g., Graves et al. 2020).

Progress on meeting Objective 2:
Species distribution models are increasingly used to assess the current 'climate envelope' for species and project the potential effects of changes in those climate variables under different future scenarios. However, those efforts are often limited due to a mismatch between the scale of climate data available and the scale relevant to the species of interest. Working with climate experts, we are developing models based on the most scale-relevant data available for *Bombus*. As work on the current distribution models progresses, we are working directly with Dr. John Abatzoglou (University of Idaho/University of California Merced) to project mid-century climate effects under both moderate (Representative Concentration Pathways [RCP] 4.5) and severe (RCP8.5) emission scenarios. Assessing potential changes between current and projected future distributions of *Bombus* will be a key first step in investigating potential direct and indirect effects of climate change on bumble bee populations, assessing potential changes in habitat and distributions, identifying priority areas, and directing future research and monitoring efforts.

The work on this objective is in progress and future model projections are anticipated by August 2021.

Progress on meeting Objective 3:
Upon completion of current and future projected species distribution models, we will assess the potential implications for management of IDFG WMAs across Idaho. This final task will be completed by November 2021.

7. **Discuss differences between work anticipated in grant proposal and grant agreement, and that actually carried out with Federal Aid grant funds.**

   There were no differences between work in the project proposal and worked actually performed.

8. **List any publications or in-house reports resulting from this work.**

   No additional publications or reports have yet resulted from this work.

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