CONSTRUCTING A SPECIES DATABASE AND HISTORIC RANGE MAPS FOR NORTH AMERICAN BUMBLEBEES (*Bombus sensu stricto* LATREILLE) TO INFORM CONSERVATION DECISIONS

Kuzey Amerika Bombus Arıları (*Bombus Sensu Stricto* Latreille) Üzerinde Koruma Planları için Tür Veritabanı ve Tarihsel Dağılım Haritaları Oluşturulması

(Genişletilmiş Türkçe Özet Makalenin Sonunda Verilmiştir)

Jonathan B. KOCH[1] and James P. STRANGE[1, 2]

[1] Department of Biology, Utah State University, 5305 Old Main Hill, Logan, UT 84322-5305, USA
[2] USDA-ARS Pollinating Insect Research Unit, Utah State University, 261 BNR, Logan, UT 84322-531, USA
E-mail: James.Strange@ars.udsa.gov

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ABSTRACT: Bumblebees (*Bombus* Latreille 1802) are important native pollinators in North America. However, in the last decade at least six North American *Bombus* have experienced significant range contraction or population declines. A major limitation to studying species declines is the level of knowledge of historic occurrences and abundance. Here we review the current status of a bumblebee subgenus in North America, *Bombus sensu stricto* Latreille 1801*,* and present a method for generating a database and probable historic range maps from multiple museum collections. These databases and range maps can be useful tools when facilitating monitoring programs for at risk species.

INTRODUCTION

Bumblebees (*Bombus* Latreille 1802) are valuable pollinators of wild flowers (reviewed in Milliron 1971, Thorp et al. 1983) and several agricultural crops such as blueberry (*Vaccinium angustifolium* Aiton), cranberry (*Vaccinium macrocarpon* Aiton*)*, greenhouse tomatoes (*Solanum lycopersicum* (Dunal) Spooner, G.J. Anderson & R.K. Jansen) and greenhouse sweet peppers (*Capsicum annuum* Latreille) (Banda & Paxton 1991, Shipp et al. 1994, Javorek et al. 2002, Cane & Schiffauer 2003). Although many bumblebees are generalist foragers, several wild flowers depend exclusively on bumblebees to be pollinated effectively (Macior 1983). In greenhouse settings some bumblebees are better suited and more efficient than commercially reared honey bees (*Apis mellifera* Linneaeus 1758) in facilitating the fruit-set of important crops (Banda & Paxton 1991).Thus, the loss of pollination services provided by bumblebee fauna may have profound impact on the stability of ecosystems and economic markets (Allen-Wardell et al. 1998, Kearns et al. 1998).

To date, several studies have documented range contractions (Fitzpatrick et al. 2007, Williams et al. 2007, Colla & Packer 2008, Goulson et al. 2008); population declines (Thorp 2003, Thorp & Sheppard 2005), decreased community richness (Tommasi et al. 2004, Colla & Packer 2008, Grixti et al. 2009) and localized extirpations of bumblebee fauna (McFrederick & LeBuhn 2006, Kosier et al. 2007). While some studies have identified the probable cause of bumblebee decline (e.g. Grixti et al. 2009), others remain speculative (Thorp 2003, Colla & Packer 2008). A review by Goulson et al. (2008) identifies four prevailing hypotheses contributing to bumblebee decline: global climate change, pathogen pressure, urbanization and agricultural intensification (e.g. Williams 1986, Colla et al. 2006, McFrederick & LeBuhn 2006, Otterstatter & Thomson 2008, Williams et al. 2007). Of the four hypotheses the latter two are the most intensively documented in both Europe and North America; however pathogen pressures from commercially reared congeners is currently receiving more attention (Colla et al. 2006, Otterstatter & Thompson 2008).

Worldwide there are approximately 250 species of bumblebees, of which 50 species occur in North America (Cameron et al. 2007). These species are grouped into subgenera based on behavior, morphology and molecular phylogenies (Stephen 1957, Hobbs 1968, Richards 1968, Milliron 1971, Thorp et al. 1983, Cameron et al. 2007, Williams et al. 2008). Of the species occurring in North America, six species have been identified as potentially declining in abundance and range (Thorp 2005, Colla & Packer 2008, Evans et al. 2008, Goulson 2008, Grixti et al. 2009). Four species belong to the subgenus *Bombus sensu stricto* Latreille 1801*,* whereas the other two species, *Bombus pensylvanicus* (Degeer) 1773 and *Bombus sonorous* Say 1837 belong to the subgenus *Fervidobombus* Skorikov 1922*.* The contractions of the species ranges are not restricted to a single geographic region, but are occurring across the North American continent. Currently the causes of localized extirpations of these six *Bombus* species are unknown. Here we review the current status of four North American bumblebee species of the subgenus *Bombus s. str*. We do not include an investigation of the two North American *Fervidobombus* species.

The decline of North American bumblebees was first observed in the early 1990's (Thorp 2003; 2005, Evans et al. 2008), whereas declines of some European bumblebees has been observed as early as the late 1940's (Williams 1986, Goulson et al. 2008). Although most of the preliminary observations of species decline were anecdotal, recent studies in North America have documented both decreased bumblebee richness and absence of some species where they were once fairly abundant (McFrederick & LeBuhn 2006, Colla & Packer 2008, Grixti et al. 2009). However the full geographic extent of range contractions of North American *Bombus*, particularly those of the subgenus *Bombus s. str.* is not well documented.

A major problem confronting conservation biologists is determining the historic range of a species experiencing range contractions (Shaffer et al. 1999). This appears to be especially true for insects since many are sessile, have patchy distributions across broad geographic scales and display a great deal of phenological variability. Although entomological collections are informative, they rarely have specimen representation of a species across its entire geographic range. This is because insect collectors seldom target a single species, but rather often focus on collecting a large diversity of insects. Second, collectors generally survey near the institution where they deposit their specimens; and when travelling, they are often limited to collecting in areas near major transportation corridors. Third, many institutions have considerable unidentified holdings in their collections or may have specimens that are misidentified. Finally, collection data from determined specimens are usually not incorporated into searchable databases or may be misidentified (reviewed in Soberón et al. 2002, Graham et al. 2004).

Here we demonstrate a model for generating probable historic range maps for a species based on specimens from multiple museum collections. The maps generated from museum collection data can be use to inform conservation work. Range maps generated from species distribution modeling (SDM) techniques can be more effective than the traditional shaded-distribution maps (e.g. Milliron 1971) which provide little information on the probability of finding the species within the distribution. While there are numerous studies that apply SDM techniques to compare and contrast historic and current distribution of species, few studies actually focus on studying the distributions of terrestrial invertebrates (but see Oberhauser & Peterson 2003). SDM techniques provide conservation biologists a tool to determine the likelihood of occurrence using presence, presence/absence or abundance data. Since confirmed absence of bumblebees can be difficult to assess, we utilize SDM techniques that only require presence data. We then demonstrate refinement of mapping through expansion of a database using multiple collections covering a board geographic distribution. We especially focus on *Bombus occidentalis* Greene 1858 as a model for demonstrating the strength of the technique.

MATERIALS AND METHODS

Bombus sensu stricto: Description and Biology

Bombus s. str. is represented by 12 species of bumblebee distributed across Europe, Asia, and North America (Williams 1998, Cameron et al. 2007, Hines 2008). North American *Bombus s. str.* includes *Bombus affinis* Cresson 1863 (rusty patched bumblebee), *Bombus franklini* Frison 1921 (Franklin's bumblebee), *Bombus moderatus* Cresson 1863 (white-tailed bumblebee), *B. occidentalis* (western bumblebee), and *Bombus terricola* Kirby 1837 (yellow banded bumblebee) (Plate 1). *Bombus s. str.* are short tongue bumblebees and have been documented to forage on flowers with short corollas, as well as nectar rob flowers with long corollas. With the exception of *B. moderatus*, for which there is no data to support decline in abundance or range contraction, the North American species of this subgenus are documented to be experiencing decreased abundance in areas they were relatively once common (Thorp et al. 2003, Thorp 2005, Colla et al. 2006, McFrederick & LeBuhn 2006, Rao & Stephen 2007, Grixti et al. 2009).

Bombus affinis, the rusty patch bumblebee

The historic distribution of *B. affinis* spans the eastern half of North America. Historic records are known mostly from the Appalachian Mountain region and the prairies of the Midwest (Medler & Carney 1963, Speight 1967). The northern limit of its historic distribution includes southern Ontario, whereas the southern limit approaches Georgia (Hurd 1978). *B. affinis* is associated with a broad range of habitats including agricultural landscapes, marshes, and forests within its historic range. As a generalist forager, *B. affinis* has been documented to visit at least 65 genera of plant (Macfarlane 1974), and nectar rob several different species of flowering plants with long corollas (Colla & Packer 2008). *B. affinis* have relatively large colony outputs and have been documented to produce a mean of 1081 workers/males and 181 queens in a single reproductive season (Macfarlane et al. 1994).

Bombus franklini, Franklin's bumblebee

B. franklini has the smallest geographic range of all *Bombus s. str.* in North America, and arguably the smallest range of all species of bumblebee (~27,555 km^2) (Thorp et al. 1983, Williams 1998, Thorp 2005). Historically *B. franklini* was found in northern California and the extreme southern end of Oregon, spanning the Pacific coastline into the Sierra-Cascade Crest (Thorp 2005). This narrow range of *B. franklini* may have made it more vulnerable to genetic bottlenecks, although this was never tested since robust populations have not been detected in the past decade. *B. franklini* has been observed visiting 27 genera of plant across five families (Thorp et al. 1983). Although not much is known about the nesting biology of *B. franklini,* it has been observed to produce well over 100 individuals per colony (Plowright & Stephen 1980) and is likely to nest in abandoned rodent holes, both common characteristics of *Bombus s. str.* (Hobbs 1968). Workers and queens of *B. franklini* have also been suggested to be much larger in size relative to other North American *Bombus s. str.* (R. Thorp pers. comm.) Historically, *B. franklini* was treated as conspecific to *B. occidentalis* (Milliron 1971). However Plowright & Stephen (1980) describe significant morphological differences in the male genitalia between *B. franklini* and *B. occidentalis*, as well as differences in wing venation. Molecular data also support separate species designations (Scholl et al. 1992, Cameron et al. 2007).

Bombus occidentalis, the western bumblebee

As both the common and specific name implies, *B. occidentalis* occurs in western North America. Its latitudinal distribution includes Alaska and the Aleutian Archipelago, south to the mountain ranges in Arizona and New Mexico. The species longitudinal distribution is from the Pacific coastline of the United States and Canada east to the plains of central Canada and central Colorado. *B. occidentalis* has also been detected in the Big Horn Mountains, Wyoming and the geographically isolated Black Hills of South Dakota (Milliron 1971). Historic *B. occidentalis* collections are typically associated with sub-alpine meadows, coastlines, and high elevation valleys. Historically, specimens of *B. occidentalis* were not collected in areas receiving little annual rainfall (i.e. the Great Basin Desert and Mojave Desert). Host plants of *B. occidentalis* include 661 different species of plant across 21 families and 54 genera. It is a generalist forager and has also been observed nectar robbing by biting holes in flower corollas such as *Linaria vulgaris* Miller (J. Koch pers. obs.). Like *B. affinis*, *B. occidentalis* has relatively high colony outputs. The species has been observed to produce a mean of 1007 workers/males and 146 queens in a single reproductive season (Macfarlane et al. 1994). At various times in the past *B. occidentalis* was presumed to be a subspecies of *B. terricola* (Milliron 1971). Although recent molecular evidence distinguishes *B. occidentalis* and *B. terricola* as distinct species (Cameron et al. 2007), others continue to treat *B. occidentalis* as a subspecies of *B. terricola* (Williams 2008). In this review we treat *B. occidentalis* as a unique species because of the treatment it has received based on taxonomic designation (Stephen 1957, Thorp et al. 1983) and molecular data (Cameron et al. 2007).

Bombus terricola, **the yellow-banded bumblebee**

Similar to *B. affinis*, the historic distribution of *B. terricola* includes the eastern half of North America and extends north into Canada (Milliron 1971). While the species occurred along the Appalachian Mountain Crest, it was more abundant in the forests and prairies of Canada and far northern United States. In the southeastern extreme of its range *B. terricola* seems to be associated with higher elevations (Speight 1967). The western limit of *B. terricola* includes the eastern portion of Montana, and may overlap with the geographic distribution of its sister species *B. occidentalis* (Milliron 1971, Thorp et al. 1983). It has also been described to be abundant on the northern end of Wisconsin on the Apostle Islands Sea Shore (Medler & Carney 1963). *B. terricola* colonies have been documented to produce a mean of 390 workers/males and 32 queens in a single reproductive season (Macfarlane et al. 1994).

Historic distribution maps

To demonstrate the utility of SDM techniques in predicting the probable historic range of a species, two data sets were applied. The first data set was generated by entering specimen locality records and dates into a database using specimens housed in the museum at the United States Department of Agriculture- Agricultural Research Service (USDA-ARS) National Pollinating Insect Database (NPID) prior to incorporating data from other collections for *B.occidentalis* and *B. franklini*. NPID is located in Logan, Utah, USA, and hosts a comprehensive collection of bees from the western USA. For the eastern species, *B. terricola* and *B. affinis,* we collected locality data made available from the Global Biodiversity Information Facility (GBIF) (http://gbif.org). From GBIF we extracted records from a total of eight different institutions in both the United States and Canada.

Because collections are composed of specimens captured and preserved over a long period of time, data on insect labels are usually not entered into a computer database. Therefore, it was necessary to retroactively capture the data on labels and enter it into a searchable database. In many instances both NPID and GBIF have descriptive locality information associated with specimen labels (e.g. township range and section (TRS), telegraph, geographic coordinates). However, major limitations in applying locality information found on specimen labels to SDMs include inconsistencies when defining localities and the use of broad geographic locality descriptions (Bannerman 1999). To construct the comprehensive potential range map for *B. occidentalis* we first located existing collections housed at universities and government collections in the United States and Canada. For each specimen we recorded all information on the specimen label. To each recorded specimen, a unique identifier number was attached in the form of a small label with a barcode to avoid multiple entries of single specimens. If specific latitude, longitude and elevation data were not included on the label, georeferenced localities were estimated with Google Earth (http://earth.google.com) using any locality data provided by the collector on the specimen label. These data were entered into NPID.

By including the material housed in multiple collections *B. occidentalis* records were increased from 973 specimens to 2958 total specimens. These 2958 specimens represented 1302 unique localities and were utilized to construct the historic distribution map of *B. occidentalis*. To produce the primary species distribution maps, for *B. affinis*, *B. franklini* and *B. terricola*, 90, 11 and 84 unique localities were used, respectively. With the exception of *B. franklini*, the extremely low sample size of *B. affinis* and *B. terricola* is a reflection on the lack of georeferenced locality data available. *B. franklini* on the other hand is narrowly distributed naturally (Thorp 2005), and thus the small sample size of the species is suggested to be a true representation of its known range.

Bombus affinis

Bombus franklini

Bombus occidentalis

Bombus terricola

Plate 1. Representative *Bombus* species of the subgenus *Bombus sensu stricto*

MaxEnt applies entropy to information (data aggregated with a set of constraints) so as to produce a least biased result (model) relative to a probability distribution (Phillips et al. 2006). For a full discussion of the MaxEnt algorithm see Phillips et al. (2004). One limitation to MaxEnt is the need to have a representative sample across a species entire range to determine the most suitable habitat. However, MaxEnt has been tested to produce highly accurate SDMs despite small samples sizes (Wisz et al. 2008; Elith et al. 2007). We evaluated the SDMs of the target *Bombus* using the default parameters as prescribed by Phillips et al. (2006). Unlike algorithms that generate a SDM based on presence/absence or abundance data, MaxEnt requires only presence data. This approach is advantageous for organisms like bumblebees because they can be hard to detect, thus a recorded absence point may not be true absence. To evaluate likelihood of occurrence, MaxEnt calculates a habitat suitability index (HSI); HSI values closer to 0 indicate areas with low habitat suitability, whereas values closer to 1 indicate areas with high habitat suitability (Phillips et al. 2006). These values are visually reflected onto a geographic space using a coloring scheme.

Nineteen bioclimatic variables were applied in the construction of each bumblebee SDM at a spatial resolution of 3.5 arc seconds (Hijmans et al. 2005). These variables were selected because bumblebees display a great deal of phenological variation across latitude, longitude, and elevation. These variables have also been widely used in assessing the geographic distribution of several taxa like other bees (e.g. Hinojosa-Diaz et al. 2005; 2008). Including all variables also limited any potential bias that may be imposed from manually selecting variables based on the known ecology, distribution, and biology of the species in question. ArcGIS 9.2 (ESRI 2006) was utilized to clip all bioclimatic variables to the North American continent, as well as process and visualize results from the SDMs constructed in MaxEnt. Because maximum and minimum HSI vary across the four SDMs, the calculated HSI for each model is re-classed in ArcGIS 9.2 under a 10-fold equal interval.

RESULTS

In total we increased the *Bombus s.str* database from 1006 individuals to 3143 individuals. For *B. affinis* we compiled 67 occurrence records from

GBIF, which include Ohio State University Insect Collection, Canadian Biodiversity Information Facility Bombus of Canada and York University Knerer Collection. Outside of GBIF we include six locality records from Milliron (1971), three records from Washington State University James Museum of Entomology and seven records from the University of Kansas Snow Entomology Museum. For *B. terricola* we compiled 57 records from GBIF, which includes specimens from Ohio State University Insect Collection, University of Kansas Snow Entomology Collection, Illinois Natural History Survey, New Mexico Biodiversity Collections Consortium Database, Borror Laboratory of Bioacoustics, York University Knerer Collection, and a Ph.D. thesis. Outside of GBIF we include 14 records from Milliron (1971) and three from University of Kansas Snow Entomology Collection. For *B. franklini*, we compiled 11 localities from specimens housed at the University of California-Davis Bohart Museum of Entomology. The largest increase has been in *B. occidentalis* where we have added 1955 specimens to our database from eight museum collections (Table 1).

Table 1. Number of *Bombus occidentalis* specimen records compiled to date.

Institution	Number of specimens	Age range of specimens
Brigham Young University	246	1930
Oregon State University	1064	1898-1969
Simon Fraser University	13	1915-1960
Utah State University (NPID)	973	1900-2008
University of Idaho	79	1953-1997
University of Nevada-Reno	4	1957-1958
University of Wisconsin-Madison	153	1921-1979
Washington State University	151	1950-1987
University of California-Davis	120	1923-1992
Publications	125	

For *B. affinis,* two maps of the probable historic range are given in Figure 1a and 1b. Map 1a is generated using data extracted from the GBIF database and shows the probable historic distribution with darker areas representing a higher probability of occurrence based on habitat suitability. Map 1b is the traditional map (Milliron 1971) showing the extremities of the species range. Clear differences in the southern extent of the species distribution occur between the two maps and the habitat suitability map designates several western US locations as suitable habitat.

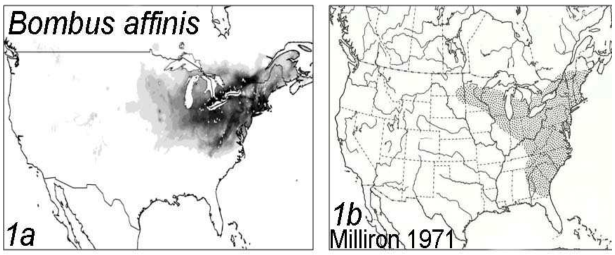

Figure 1. The range maps of *Bombus affinis,* 1a: GBIF database map and 1b: Traditional map

Two maps of the historic distribution of *B. terricola* are also presented. Figure 2a is the habitat suitability map and Figure 2b is the traditional extremity map (Milliron 1971). Both maps show similar probable historic distributions of the species, particularly at the species northern limit. The model shows a probable distribution slightly further south in the Midwest than the traditional shaded map.

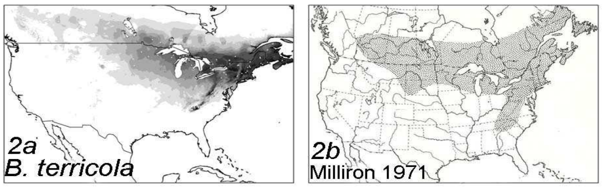

Figure 2. The range maps of *Bombus affinis,* 2a: habitat suitability map and 2b: Traditional extremity map

Three maps of probable historic range of *B. occidentalis* are shown in Figures 3a, 3b, and 3c. Figure 3a shows the historic range map based on NPID prior to addition, Figure 3b shows the historic range map of Milliron (1971), and Figure 3c show the probable historic distribution after addition of

1985 specimens from collections. While map 3b shades only broad geographic areas, the other two maps highlight differences in topography and habitat. The differences in intensity of shading illustrate the relatively higher probability of encountering the species in a given habitat and therefore can inform investigation. The map derived from NPID records before the addition from other institutions has a range significantly smaller than the map of Milliron (1971). However, Figure 3c, which includes data from six institutions more closely resembles the shaded map of Milliron, except that it provides detail especially in the basin and mountain range topography of the inland portion of the species distribution. Figure 4 is a distributional map of *B. franklini* as predicted by 58 specimens representing 11 unique localities. However, the SDM generated from these occurrence records extend far beyond the known distribution of *B. franklini*.

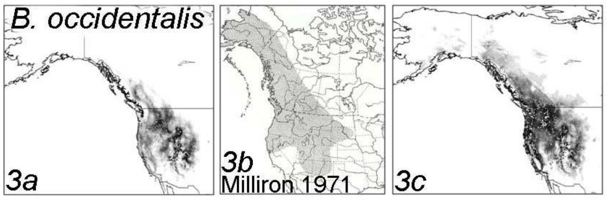

Figure 3. The range maps of *B. occidentalis,* 3a: map based on NPID, 3b: range map of Milliron, 3c: probable historic distribution.

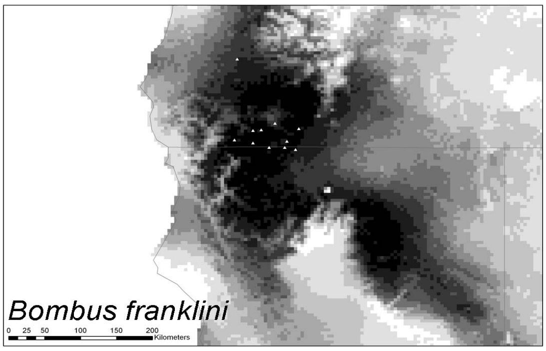

Figure 4. The range map of *B. franklini*

DISCUSSION

Creating a database of historic specimens allows for a broad geographic sample of species occurrence; and may be useful when refining predictive maps using SDM techniques (Graham et al. 2004). While no practical map will fully represent the distribution of a specific bumblebee across a large geographic landscape, it is possible to generate a probable species distribution that is informative to the bee conservationist or collector. Using SDM software to model historic ranges of species is not without problems (Shaffer et al. 1998, Austin 2002); however, considering the information contained in the traditional range maps such as Milliron (1972) several advantages are apparent.

SDMs have the ability to take geographic and climatic variance to account, whereas these characters are usually not reflected in traditional maps. In areas with high environmental variance (e.g. the Great Basin) localities that are unlikely to be inhabited by a species are omitted from the predicted range. The inclusion or exclusion of species across a geographic space is a reflection of the environmental predictors selected when occurrence data is aggregated. This becomes clear when viewing the range map of *B. occidentalis,* where the species is known to occur only on isolated mountain ranges in the Great Basin (Figure 3c). This phenomenon appears elsewhere in the range of the species and is, in fact, seen across the subgenus. *B. affinis*, for example occurs along the crest of the Appalachian Mountains in the eastern United States much further south than it occurs in the lower lying plains. The areas of high elevation in the eastern United States appear as likely habitat in the SDM (Fig 1a). The distribution of *B. terricola* follows a similar pattern to *B affinis*, extending its distribution in southern mountain ranges (Fig 2a).

The intensity of shading provided in the species distribution models also helps to inform the researcher which sites are more likely habitat for the bee. By focusing efforts to locate populations only in areas of high likelihood of occurrence, time and resources can be allocated wisely. However, caution must be placed when defining areas as either ‘suitable’ or ‘unsuitable’ when SDMs are utilized. This is especially true when designing conservation or agricultural zones. It is important to note that SDMs are only as good as the data that is provided to construct them. Thus, SDMs are susceptible to bias by the modeler when predictor variables are selected, as well as the size of the sample used to represent a species known occurrence.

Maps generated by SDMs are dynamic and can be refined with the addition of data. As researchers locate additional specimens, they can be incorporated into the existing database. Once historic data is in a database, it can be accessed easily and made available to a broad community of interested parties. Each subsequent addition of data only serves to refine the distributional map. This refinement is demonstrated clearly with our maps of *B. occidentalis*, especially at the northern extremities of the range. The addition of specimens greatly expanded the predicted range into Canada and Alaska, whereas the first model based on only data from one institutional museum database (NPID) resulted in a more southerly distribution. Interestingly, the distributional maps of *B. terricola* and *B. affinis* that we produced seem to reflect the distribution described by Milliron (1971) more accurately than we observed with *B. occidentalis*. This was despite the use of fewer specimens to generate the maps, indicating that some distributions may require less data to model than others.

Despite the advantages of SDM techniques in generating maps of bumblebee ranges, it is important to remember that, as with all models, the maps are only predictive and do not show with absolute certainty where a species will occur. In some cases the model falsely predicts range for which there is no historical data to support the model. One area of concern for the model of historic distribution is that it predicts the distribution of *B. occidentalis* into the mountains of southern California and northern Mexico. Despite this prediction by the model, there is no historic data to support this distribution. However, NPID does document a single *B. occidentalis* record in San Diego, CA, USA. This record suggests that (1) *B. occidentalis* was found in San Diego, (2) the specimen was incorrectly labeled, or (3) that the specimen was misidentified. It is possible that the southern Sierra Mountains was historically colonized by *B. occidentalis* but that specimens were never collected in the region; however given the intensity of collection in California (Thorp et al. 1983), that seems unlikely. Alternatively, this area may never have been colonized by *B. occidentalis* or colonized in the distant past but the species was extirpated prior to human collection. Either way, the model predicts an area of likely occurrence for which historic records are not available to support the hypothesis. The SDM generated by the *B. franklini* occurrence records also extend well beyond the species known geographic range (Thorp 2005). Although this phenomenon may be an artifact of the small sample size provided, it is likely that the SDM generated for *B. franklini*, like *B. occidentalis* is unable to capture dispersal limitations and natural history of a species (Guisan & Zimmerman 2000). Another type of error that occurs is non-detection of actual habitat as is seen as a result of incomplete data sets with *B. affinis*. In the case of *B. affinis*, the historic data supports a range further south and east. This limitation is best addressed by adding data from a broader array of intuitions, particularly in the missing portion of the historic range.

The generation of the SDMs is useful for not only understanding the habitat occupied in the past, but it also informs research efforts of the future. Comparisons of current distributions to historic distributions help us to understand the effects of landscape and climate changes on bee populations. Predicting future range geometry of species distribution is possible only when a full understanding of the factors affecting past and current distributions is achieved (Shaffer et al. 1998, Scott et al. 2002, Oberhausen & Peterson 2003, Vaughan & Omerod 2005). However, this requires that the datasets used to generate the maps are robust; thus constructing a database of historic records is an essential first step.

CONCLUSION

Of the 467 described genera of bee, *Bombus* are one of the most charismatic and recognizable due to their typically bright, furry and robust appearance (Heinrich 1979, Michener 2007). Thus the decline and range contraction of the genus has been recognized by both the scientific community and the general public. Although baseline data of historic bumblebee communities in North America is sorely lacking, current efforts to retroactively capture records from publications and insect collections (Colla & Packer 2008, Evans et al. 2008, Grixti et al. 2009, Koch & Strange unpub. data) are underway. Here we demonstrated the utility of applying museum records of specimen data across a relatively large sample of institutional collections. As in the case with *B. occidentalis*, increasing institutional databases with specimens from other institutions widens the geographic scope of a species, and has the potential to build more detailed SDMs for determining distribution. This data also provides insight on the phenological variation of a species across its range. While retroactive data capture is time consuming, the benefits are clear.

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GENİŞLETİLMİŞ ÖZET

Amaç: Buradaki derleme ile Kuzey Amerika örneği olan *Bombus s. str.* altcinsine ait bilgi birikiminin aktarılması ve entomoloji koleksiyonlarındaki örnekleri kullanılarak tür veritabanları oluşturma metodunun sunulması amaçlanmıştır. Bombus arıları Kuzey Amerika’da bulunan hem yabani çiçekleri hem de tarımsal ürünleri tozlaştıran balarısı gibi diğer tozlaştırıcıların olmadığı yerlerdeki en önemli tozlaştırıcılardan birisidir. Geçen on yıllık dönemde en azından altı Kuzey Amerika bombus arısı (*Bombus* Latreille 1802) türü önemli anlamda yayılma alanının daralması ya da populasyon azalması ile karşı karşıya bulunmakta ve bunlardan birinin (*Bombus franklini* Franklin 1921) soyu tükenmiş te olabilir.

Gereç ve Yöntem: Müzelerdeki iğnelenmiş arı örneği verileri toplanmış ve veritabanına girilmiştir. Örnek etiketi üzerinden olabilecek tüm veriler, örneğin: toplama tarihi, toplama bölgesi ve toplayıcı bilgileri toplanmıştır. Tarihi örneklerin toplama bölgelerinin enlem, boylam ve rakım verileri coğrafik bilgi yazılımına girilmiştir. Bu veriler kullanılarak birçok entomoloji müzesinde bulunan örnek verileri ile olası tarihi dağılım haritaları oluşturulmuştur.

Bulgular ve Sonuç: Bu çalışmada bir türe yoğunlaşarak, *Bombus occidentalis* Greene 1858, veri miktarının artması vurgulanmıştır. Toplanan veriler 973 den 2928 örnek verilerine çıkınca elde edilen haritanın gerçeğe daha yaklaştığı gösterilmiştir. Örnek sayısının artmasındaki nedenler arasında 9 kuruluştan örnek elde edilmesi, çok sayıda yayına ulaşılması ve türün yayılış alanındaki birçok farklı bölgeden veri elde edilmesi sayılabilir. Genişletilmiş verilerin kullanımı tahmini yayılış alanını genişletmiş ve dağılımı üzerinde bulunma olasılığını değiştirmiştir ki bu da örneğin bir kuruluşta tamamlanmamış verilerden oluşturduğunu görtermektedir. Altcins içerisindeki diğer üç türe *Bombus affinis* Cresson 1863, *B. franklini* and *Bombus terricola* Kirby 1837 ait ön dağılım haritaları veritabanları tam olmamakla beraber bu çalışmada verilmiştir. Bu oluşturulan haritalar tarihte var olan ve kullanılan dağılım haritaları ile karşılaştırılmıştır. Gelecekte tür dağılım değişiklikleri modellemeler ile tahmin edilmekle beraber, bu tahmini dağılım haritaları tehlike altındaki türlerin durumlarının tespitinin başlatılmasında ve korunmasında çok yararlı olabilecektir. Şu an Kuzey Amerika’daki bombus arısı faunasındaki azalmayı açıklayan geçerli hipotezler içerisinde habitat parçalanması ve bozulması, ve ticari anlamda üretilenlerden gelen patojenler yer almaktadır. *Bombus pensylvanicus* (DeGeer) 1773 ve *Bombus sonorous* Say 1837 dışındaki dördü risk altında bulunan türler tek bir altcinse (*Bombus sensu stricto* Latreille 1801) bağlıdır. Her bir tür için, populasyon azalması kaydedilmiş, fakat ne kadar yayılış alan daralması olduğu ve altında yatan sebepler tam anlamıyla anlaşılamamıştır. Bu türlerin yayılış alanlarındaki daralmanın çalışılabilmesindeki en önemli sınırlama Kuzey Amerikadaki geniş dağılım alanındaki tarihsel dağılımın bilinmemesidir. Bu türlerin populasyonlarındaki azalmayı daha detaylı çalışabilmek ve gelecekteki populasyon takiplerini gerçekleştirmek için tarihsel dağılım haritalarına ihtiyaç vardır.