

Geographic distribution of American black bears in North America

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Abstract: American black bears (*Ursus americanus*) historically inhabited every province and territory in Canada, all continental states in the United States (U.S.), and northern states of Mexico. We used *BearsWhere?*, an Internet mapping tool, to survey bear biologists in Canada, Mexico, and the U.S. and estimate the current range of black bears using 4 categories: primary range and secondary range (which together comprise total range), bear sighting locations outside range, and no bears reported. Primary and secondary ranges in 12 Canadian provinces and territories, 40 states in the U.S., and 6 states in Mexico totaled 10.5 million km², representing 65–75% of the species' historical range. Total bear range in Canada was 6.9 million km², representing 95–100% of its historical range. Prince Edward Island was the only province with no bear range or sightings. Total range in the U.S. was 3.5 million km², representing 45–60% of U.S. historical range. Respondents reported occasional sightings but no primary or secondary range in 6 U.S. states (IA, KS, NE, ND, OH, and SD), and bears were absent from the District of Columbia and the remaining 4 states (DE, HI, IL, and IN). Only primary range data were available in Mexico, consisting of approximately 99,000 km² across portions of 6 states (Chihuahua, Coahuila, Durango, Nuevo Leon, Sonora, and Tamaulipas). Our ability to detect a change in bear range was limited, but notable expansion of primary range since the mid-1990s was confirmed in Virginia and North Carolina.

Key words: American black bear, bear range, distribution map, geographic distribution, historical range, sightings, survey, *Ursus americanus*

Ursus 25(1):24–33 (2014)

Introduction

Historically, black bears (*Ursus americanus*) were common in forested areas throughout North America (Pelton 2003), a range that extended from northern Canada into central Mexico (Hall 1981:950, Larivière 2001). Their generalist and omnivorous diet, great mobility, and adaptability allowed black bears to exploit a wide variety of habitats and conditions, from swamps to semi-deserts, subtropical to boreal forests, and portions of tundra (Veitch and Harrington 1996). Bears continue to inhabit most of their historical range in Canada, but in the United States (U.S.) overexploitation (e.g., persecution and unregulated harvest) and habitat loss extirpated bears from large portions of their range (Pelton 1987, Servheen 1990, Garshelis et al. 2008). Bear distribution in Mexico is believed to be drastically reduced from its historical extent (Delfin-Alfonso et al. 2012) and it is listed as endangered and considered a Priority Species (Doan-Crider et al. 2010). Both Leopold (1972:412) and

Delfin-Alfonso et al. (2012) implicated overexploitation and habitat loss as factors influencing black bear distribution in Mexico but, of the two, overexploitation may have been more pervasive (D. Doan-Crider, Texas A&M University, personal communication). Since the early 1900s, various laws and policies have been enacted throughout North America to classify bears as game or protected species and to regulate harvest (Miller 1990).

Overall black bear abundance in Canada and the U.S. increased from the 1980s to 2000s, although abundance was stable or decreasing in some areas (Williamson 2002, Garshelis and Hristienko 2006, Hristienko and McDonald 2007, Hristienko et al. 2010), and bears are now common in states where their survival was doubtful (Cowan 1972). Range-wide bear distribution is not documented as often as abundance, but range has expanded in the eastern U.S. since the 1980s (Maehr 1984, Pelton and van Manen 1994) and various reports from western states suggest that recent black bear ranges were stable or expanding (Lackey and Beausoleil 2010).

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Bears have recolonized eastern Oklahoma from Arkansas (Van Den Bussche et al. 2009), western Texas from northern Mexico (Onorato et al. 2004, Van Den Bussche et al. 2009), have begun to recolonize western Oklahoma from Colorado and New Mexico (Kamler et al. 2003), and were thought to be increasing in abundance and expanding their range in parts of Mexico (Doan-Crider et al. 2010). Furthermore, Hoffman et al. (2009) and many news reports throughout the U.S. reported black bear sightings outside areas that the most recently available range-wide distribution map (Garshelis et al. 2008) considered currently occupied bear range. According to D. Garshelis (Minnesota Department of Natural Resources, personal communication), his 2008 distribution map relied on data collected from 1996 (Williamson 2002). Status reports submitted by state biologists to recent Eastern and Western Black Bear Workshops occasionally contained range maps (e.g., Eastridge 2008, Beausoleil and Martorello 2010), but a range-wide, survey-based distribution map has not been developed since 1993 (Pelton and van Manen 1994).

Most widely published range maps for black bears use 2 categories for distribution (present or absent) without defining how presence was determined (e.g., Larivière 2001, Pelton 2003). Several regional range maps for eastern North America, published in workshop proceedings, used 2 presence categories and included methods and definitions (Maehr 1984, Wooding et al. 1994, Darling 1996:137). We sought to update the range-wide, survey-based distribution map at the local scale (Pelton and van Manen 1994), but with 3 presence categories, using geographic information system (GIS) and the Internet to simplify data collection. Secondary goals were to compare our results to past range maps and provide guidance for future mapping efforts of black bear range.

Methods

We worked with the Center for Spatial Analysis of Recreation and Tourism at Michigan State University to develop the Internet-based mapping tool called *BearsWhere?*, which allowed respondents to delineate bear distribution. In 2009, we contacted state and provincial or territorial wildlife agencies within historical bear range to designate a respondent, and we provided them with password access and instructions to the online mapping tool. We

asked respondents in Virginia and Maryland to respond for Washington, DC because it has no wildlife agency. Respondents were asked to complete the survey during the next year and were encouraged to collaborate with others who had knowledge of bears in their jurisdiction, including field biologists, wildlife law-enforcement officers, or university researchers. We did not request that respondents report the total number of collaborators consulted. When using the *BearsWhere?*, respondents chose among Satellite World Images, World Street Maps, or World Topographic Maps base layers (Environmental Systems Research Institute 2010) to orient themselves by roads, cities, rivers and lakes, conservation lands, etc. They could pan and zoom the maps but could only view and edit bear distribution for their respective jurisdiction.

We asked respondents to assign bear data from their jurisdiction into 4 categories: primary range, secondary range, sightings outside range, and no sightings or range; ranges were represented as polygons and sightings as point locations. For range, we overlaid each jurisdiction with hexagonal cells (25 km² for contiguous U.S. and Mexico; 50 km² for Alaska and Canada, due to much larger range areas), and asked respondents to select the category that represented the largest area within that cell.

We defined primary range as areas that respondents considered as breeding range, areas consistently or frequently occupied, areas with high bear density, areas with high-quality habitat, or areas where bears or bear sign were common. Secondary range was occupied by bears but at a lower level than primary range, defined as areas that respondents considered nonbreeding range, areas containing low bear density, areas containing low-quality and often fragmented habitat, or areas where frequency of bears or bear sign were uncommon but not unexpected. Secondary range would also include areas where bear numbers were thought to be sustained by proximity to higher bear density or higher quality habitat, even if isolated breeding occurred. We reported the size of all primary and secondary ranges rounded to the nearest 1,000 km² to acknowledge inherent imprecision.

Bears occurring outside range may be considered vagrants or residents where bear density was too low for respondents to delineate as secondary range. We requested the locations of documented sightings (e.g., roadkills, nuisance complaints, observations)

during 2006–2010 that were outside areas that respondents considered range. To map sightings, respondents placed a marker on the base maps. We suggested that respondents use a single point to represent multiple reports of bears at the same location because the sightings were used to show geographic extent rather than frequency. Ranges and sightings submitted to *BearsWhere?* were stored in a database and mapped using GIS. The broad definitions for the 3 bear-presence categories were intentional because we recognized that one definition (e.g., a specific density or abundance level) would not be equally meaningful for all jurisdictions and we would be relying on the expert knowledge of respondents to interpret opinions and data from various sources. There were differing levels of research and management among and within jurisdictions that resulted in varying types and amounts of data (e.g., harvest data, roadkill, etc.) and empirical data were not available for all areas.

Only one Mexican biologist responded to our survey, so we digitized into GIS a range map drafted in 2005 by attendees of the First Mexican Black Bear Workshop in Saltillo, Mexico (Hewitt and Doan-Crider 2008). We designated all Mexico distribution as primary range because the workshop attendees were asked to map breeding range only (D. Doan-Crider, personal communication). Biologists from all continental U.S. states and Canadian provinces and territories responded to our survey. The majority of respondents used the *BearsWhere?* mapping tool but respondents who did not respond to the survey before December 2010, when our contract with the Center for Spatial Analysis of Recreation and Tourism ended, were given alternate means to submit their information. We edited data sent offline using GIS and merged the results to the *BearsWhere?* database. If the respondent had GIS, we sent a shapefile of the hexagon cells for their state and asked them to edit the cell attributes.

California provided a range map in GIS format that we compared with the cells used in *BearsWhere?*; when cell centers overlapped with their range map, we classified them according to the respondent's directions. Respondents in Oregon and Washington provided maps that we digitized; we then selected the cells when the cell center overlapped their ranges. The respondent in Northwest Territories, Canada, replied to our survey but later sent an updated range that used 6 categories. We collapsed 4 of their categories to the same primary

and secondary range categories used for the other jurisdictions: "Abundant" and "Common" were classified as primary range and "Localized" and "Sparse" were classified as secondary range. Their "Occasional" and "Presence Expected" categories were not included because they matched our definition of bear sightings, which we represented by point locations. We provided a few respondents with paper maps of our hexagon cells on which they drew the range by hand; we then edited the GIS map to match the hand-drawn data. All respondents were contacted after the survey to confirm their response and make additional edits. We sent regional (i.e., multi-state or province) draft range maps to respondents for additional review when bear ranges overlapped state borders but did not align with the ranges reported from neighboring states. Respondents could only edit their own jurisdiction and either submitted edits or confirmed that their map was complete; not all discrepancies were resolved.

To calculate the proportion of current to historical range, we divided the area of our total range (combined primary and secondary ranges) by the area of historical range digitized from Pelton et al. (1999). This historical range used 2 categories of range (present or absent), and we equated their present range to our total range areas and absent to areas with only sightings or unreported. Cowan (1972) stated that central regions of the Great Plains were not originally occupied by black bears, and Schoen (1990) revised the historical range map in Hall and Kelson (1959:866) by excising the central portion of the continent that we interpreted as prairie habitats. Because of the size of the Great Plains and disagreement about its original use by black bears, we removed prairie ecoregions (i.e., Temperate Prairies, West-central Semiarid Prairies, and South-central Semiarid Prairies ecoregions; U.S. Environmental Protection Agency 2010) from both our results and the historical range (Fig. 1) and then recalculated the proportion of total range to historical range. All proportions were rounded to the nearest 5% to acknowledge inherent imprecision.

Results

Primary and secondary ranges were reported in parts of 12 Canadian provinces and territories, 40 states in the U.S., and 6 states in Mexico with an area that extended from approximately 23°14' to 69°29'N and 52°49' to 164°10'W (Fig. 2). The total

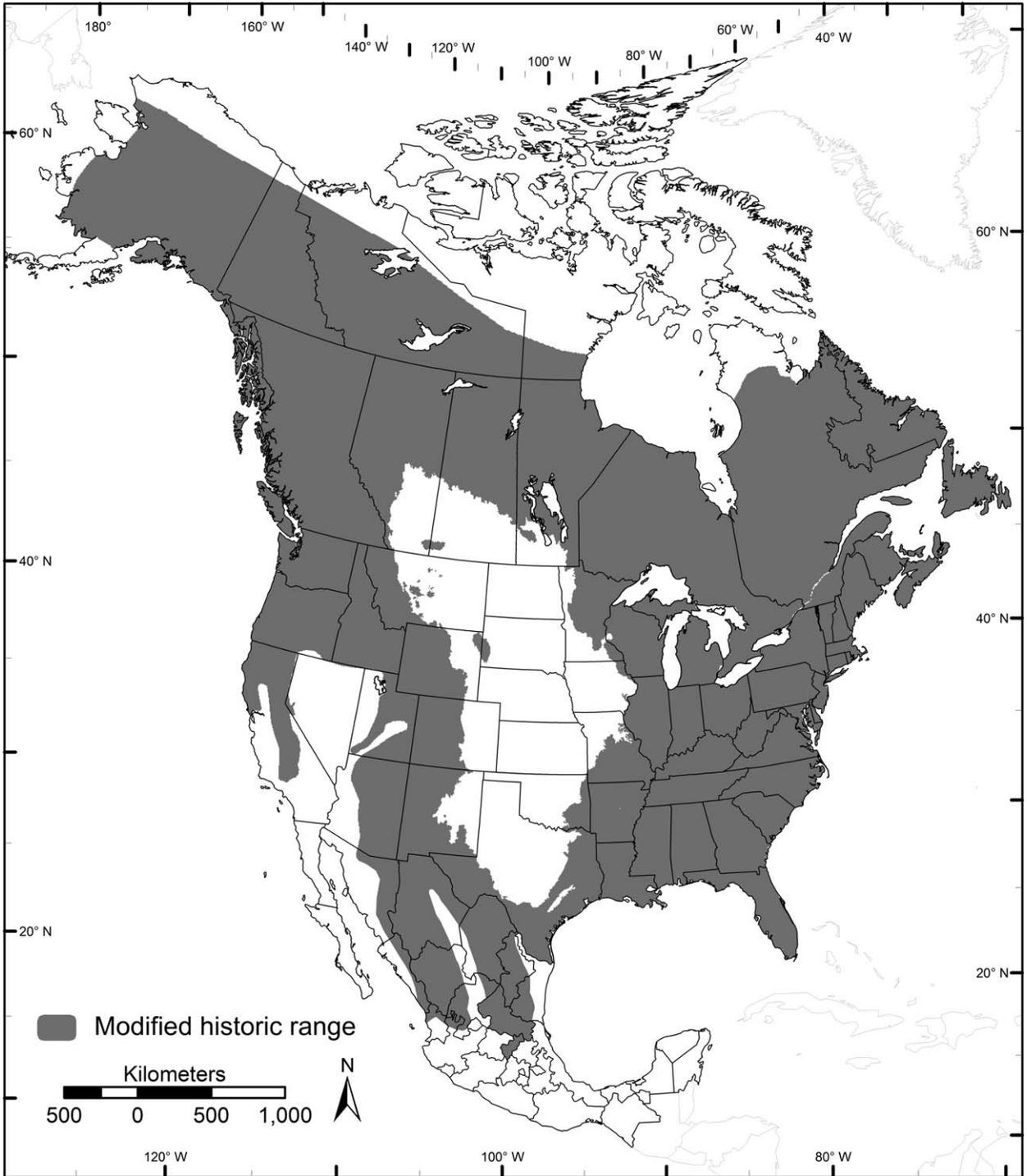


Fig. 1. Historical range of black bears in North America from Pelton et al. (1999), modified to exclude Temperate Prairies, West-central Semiarid Prairies, and South-central Semiarid Prairies ecoregions (U.S. Environmental Protection Agency 2010).

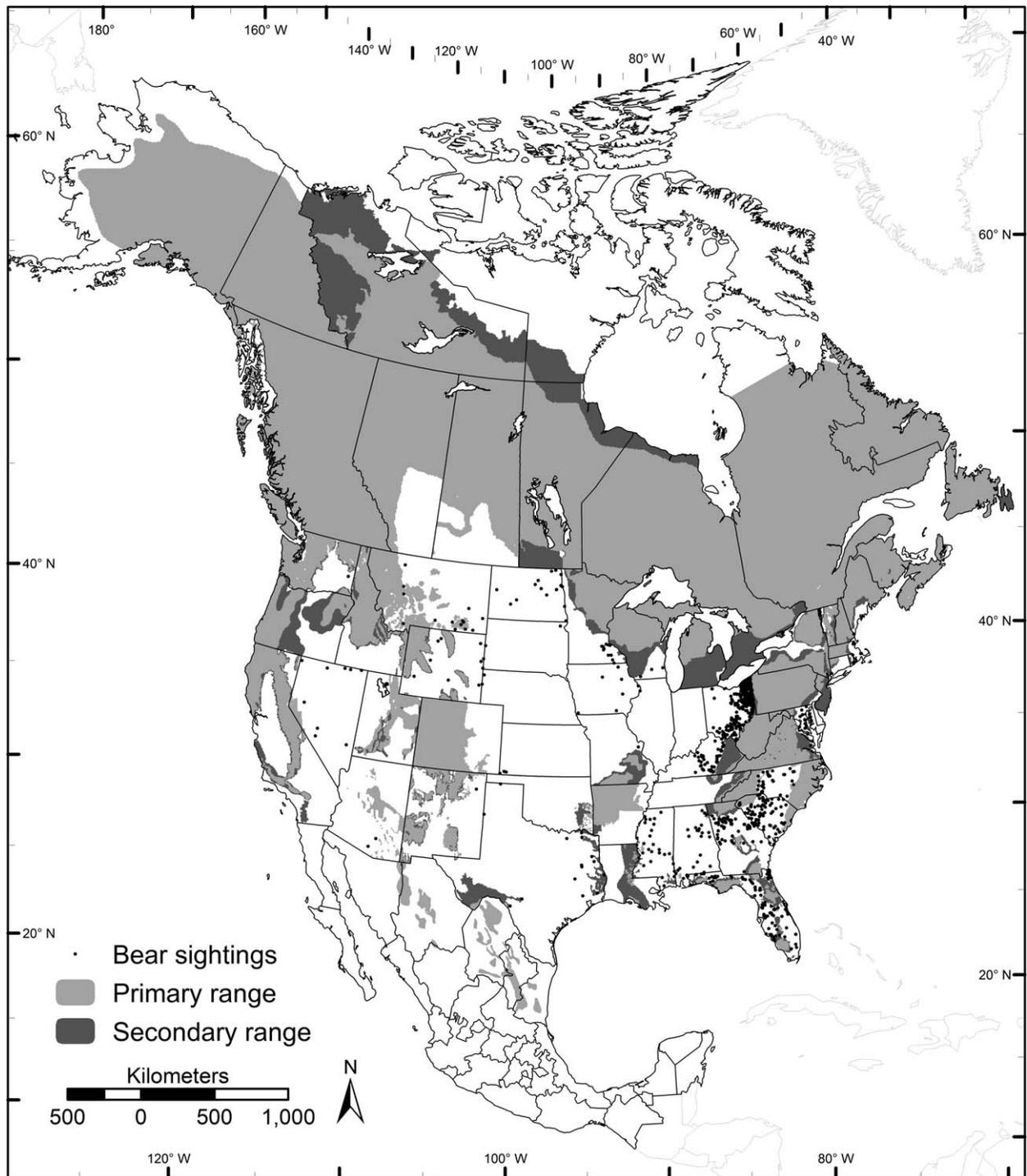


Fig. 2. Estimated primary and secondary range for American black bears in North America, 2009–2012, with sightings reported 2006–2010 outside of range. Only primary range was designated in Mexico. Additional maps representing each country and region are available in Supplemental Material Fig. S1.

black bear range was 10,517,000 km² (50% of the North American continent); 9,187,000 km² (87%) of that was classified as primary range, and the remainder as secondary range. The combined primary and secondary ranges represent 65% of the historical range with prairies included, and 75% of the historical range with prairies excluded.

Canada

Black bear range in Canada totaled 6,880,000 km² (70% of the country); 6,162,000 km² (90%) of that was classified as primary range, and the remainder as secondary range (Fig. 2). Bears inhabit portions of all provinces and territories except Prince Edward Island, where they were extirpated in 1937 (Garshelis et al. 2008). The primary and secondary ranges in Canada represent 95% of the historical range with prairies included and 100% of the historical range excluding prairies.

United States

Total range in the U.S. was 3,560,000 km² (40% of the country); 2,948,000 km² (83%) of that was classified as primary range, and the remainder as secondary range. Bear distribution in the southwestern and southeastern U.S. remains the most fragmented and shows the largest loss from the historical range (Figs. 1 and 2). The total range was 45% of historical range, including prairies and 60% excluding prairies. In the lower 48 states, primary and secondary ranges totaled 2,609,000 km²; 1,998,000 km² (77%) of that was classified as primary range, and the remainder as secondary range. Rhode Island was the only state to report secondary range without any primary range. This total range in the lower 48 states was 40% of the historical range in these states with prairies included and 50% with prairies excluded. With 928,000 km² of primary range, Alaska accounts for 32% of the U.S. primary range and 26% of the U.S. total range. We did not report the proportion of total to historical range for Alaska because the perception of historical ranges (Hall 1981:950, Pelton et al. 1999) differs without explanation and the Alaska respondent considered current range close to 100% of historical range.

Six central and Midwestern states (IA, KS, NE, ND, OH, and SD) reported at least one bear sighting but no primary or secondary range; no bear sightings or range were reported in Delaware, Illinois, Indiana, or Washington, DC (Fig. 2). The number

of sightings on the map is highly variable because of differences in the commonness of sightings, in record-keeping procedures, and differences in reporting among the states. Not all jurisdictions reported the sightings they had, so we do not know how many states truly lack sightings outside their range.

Mexico

The primary bear range digitized from the 2005 Mexican Black Bear Workshop measured 99,000 km², or 5% of the country, in the states of Chihuahua, Coahuila, Durango, Nuevo Leon, Sonora, and Tamaulipas (Fig. 2). No secondary range or sightings were reported. We did not calculate the proportion of current to historical range for Mexico because the current range did not include the secondary range category reported in other jurisdictions and because historical ranges have been speculative and highly variable (Leopold 1972:415, Hall 1981:950, Pelton et al. 1999, Larivière 2001, Garshelis et al. 2008).

Discussion

Among methods used to determine carnivore distribution (Gese 2001), we believe a survey of biologists was the most appropriate to update black bear range because the black bear is a secretive, wide-ranging, but highly managed species (Rondinini and Boitani 2012). Providing a web-based mapping tool provided advantages over previous efforts because data were collected directly into GIS, and scalable base maps provided a variety of geographic details. Range maps using 2 presence categories (e.g., Maehr 1984, Darling 1996:137) show more detail than range maps showing a single presence category (e.g., Larivière 2001) and, we believe, provide more useful information. We added sightings locations as a third category because bears can travel long distances from established populations (Rogers 1987, Maehr et al. 1988, Stratman et al. 2001). Plotting these locations reveals how far outside bear range bears travel, can assist with regional connectivity analysis, and may indicate potential future range expansions.

The use of primary and secondary range and sightings were inconsistent among jurisdictions, suggesting that respondents interpreted our range definitions differently. The use of secondary range seemed the most varied, possibly because the

definition as middle category was the most unclear. Defining range categories that are meaningful for biologists in all jurisdictions is challenging, regardless of the number of categories and definitions used (Maehr 1984, Pelton and van Manen 1994, Wooding et al. 1994, Darling 1996:137). By failing to seek prior consensus among respondents for the range definitions, we increased the variability of responses among jurisdictions. This high response variability prevented us from quantifying changes from previous maps because we could not always determine whether a difference resulted from a real change in bear range, the change in range categories, change in respondents, or past or present confusion in range definitions. However, we made general comparisons, concentrating on jurisdictional-level changes only on our primary range, because we recognized that secondary range was harder to define and measure.

Overall, the list of jurisdictions occupied by bears has only changed since the 1990s for 7 states that contained sightings or only secondary range, an insignificant difference given the uncertainty caused by process variation. These 7 states and the 4 unoccupied states match the 11 that Williamson (2002) listed as having <30 bears (DE, HI, IA, IL, IN, KS, ND, NE, OH, RI, and SD) that were mapped as unoccupied by Pelton et al. (1999); the remaining 39 states with primary range had larger populations and were mapped as occupied. We found 3 states that appeared to have major changes that warranted further investigation. Primary ranges reported to us in Virginia and North Carolina were larger than their distributions in Pelton et al. (1999) and larger than the combined primary, secondary, and potential ranges in Darling (1996:137). Both respondents confirmed these changes to be true range expansions since the 1990s. In contrast, the apparent reduction in Wyoming range compared with Pelton et al. (1999) was not confirmed. The respondent stated that bear range either had not changed or had slightly increased since the 1990s, and thought that Pelton's Wyoming distribution was over-generalized and erroneous in the northeastern corner (the Black Hills have not been occupied by bears since historical times).

Although past range maps used area polygons, we delineated bear range using cells because changes in occupancy would be easier to detect when compared with future range using the same cells and because drawing detailed range polygons on screen can be an arduous task. The cell sizes we used (25 km² and

50 km²) are near the size of individual bear home ranges to minimize the uncertainty in cell selection. Further, we believed that creating a distinct range boundary where data are sparse would be as imprecise as cells.

Bear range remains least understood in Mexico, but Doan-Crider et al. (2010) reported that bears were expanding into previously occupied range and tolerance for them seems to be increasing. In addition to the 6 states we digitized as primary range, bears have been reported in Aguascalientes, Jalisco, San Luis Potosi, and Zacatecas, so our map may underestimate the true occupied range. Jalisco probably has only transient bears (which our definitions would classify as sightings), but some of the other states may have resident bears, which could match our definitions of range (D. Doan-Crider, personal communication). Bears cross the border between Mexico and the U.S. (Onorato et al. 2004, Doan-Crider et al. 2010), but border fencing may reduce the use of this landscape linkage by bears in Arizona, New Mexico, Texas, and Mexico (List 2007, Atwood et al. 2011).

Our proportions of current to historical range are inexact because black bear historical range is not precisely known and because the historical range map was based only on presence or absence of bears. The map in Pelton et al. (1999) was revised from Hall (1981:950). Hall mapped the historical range by delineating distribution throughout the continent at a coarse scale, but he generalized the isolated montane habitats in the American Southwest (Atwood et al. 2011) and missed historical data for Nevada (Lackey et al. 2013). Although black bears have been documented on the prairies historically (Hall 1981:950, Laliberte and Ripple 2003) and recently (Kamler et al. 2003, Hoffman et al. 2009), it seems unlikely that they inhabited the entire prairie region as portrayed in Hall or Pelton et al. (1999) because black bears rely on forested habitats (Cowan 1972, Pelton 2001). We believe black bears most likely occupied the larger forested river systems of the prairies (matching our definitions of either primary or secondary range) with occasional use throughout the rest of the prairies (matching our definition of sightings). Further, Hall's historical range more closely approximates the extent of occurrence, while our current range approximates the area of occupancy (Rondinini and Boitani 2012). By removing the entire prairie habitat, our alternate historical range is likely an underestimate, but the 2

proportions should bracket the actual extent of historical bear range.

To improve future efforts to map black bear distribution across the species' geographic range, we provide several suggestions. First, get consensus that an update is needed and obtain official support, ideally from agency heads of each jurisdiction, so that respondents will be more likely to respond in a timely manner. Second, determine whether the priority is to detect a change in distribution or to map current range as precisely as possible. Detecting a change in range is easier when using the same cells but polygon ranges can be edited to geographic features (e.g., ecotones, tree line, highways, etc.) and are therefore more precise. Third, determine what type of data and abilities each respondent has and whether to use GIS or another mapping system such as the National Feral Swine Mapping System (Southeast Cooperative Wildlife Disease Study 2013). Fourth, provide an opportunity for respondents to discuss details of the methods prior to mapping (i.e., by presenting the range categories and their definitions at regional meetings such as the Eastern and Western Black Bear Workshops). Participants could discuss and resolve their interpretations of the methods, which will improve consistency in survey responses. Discussing category definitions prior to the survey may not eliminate all discrepancies (Darling 1996:137) but should reduce confusion for most respondents and therefore reduce response variation. This discussion should include how respondents should handle areas where bears occur at low densities, where data are sparse, or areas that are only traversed by bears during adverse weather events (e.g., deserts surrounding sky islands of the Southwest). Ideally, respondents could experiment with the mapping system at the workshop and, if respondents are notified in advance, they may be able to update their jurisdiction's range in regional groups during a breakout session. Lastly, ask respondents whether ranges in their jurisdictions had changed since the previous survey, and the reasons for any change, as well as the size and trend in the population. Had we done that in this survey, we would have felt more comfortable reporting more detailed changes in bear range during the past 2 decades. That was an original goal, but it was unachievable because of methodological inconsistencies within and between surveys. We suggest that this range map should be updated at approximately 10-year intervals, following these recommendations,

to better understand the dynamics of black bear range across North America.

Acknowledgments

We owe a special thanks to the biologists who responded to our survey as well as their collaborators. Respondents by state were: N. Webb (AB), K. Titus (AK), M. Sievering (AL), M. Means (AR), R. Thompson (AZ), B. McLellan (BC), M. Kenyon (CA), J. Apker (CO), P. Rego (CT), J. Rogerson (DE), D. Telesco (FL), A. Coley (GA), R. Andrews (IA), C. White (ID), B. Draughan (IL), M. Marcus (IN), M. Peek (KS), S. Dobey (KY), M. Davidson (LA), L. Hajduk (MA), H. Hristienko (MB), G. Guyton (MD), J. Vashon (ME), A. Bump (MI), D. Garshelis (MN), L. Forbes (MO), B. Young (MS), A. Messer (MT), K. Craig (NB), C. Olfenbittel (NC), S. Tucker (ND), S. Wilson (NE), A. Timmins (NH), K. Burgess (NJ), C. Dyke (NL), H. Villalón Moreno (Nuevo Leon, Mexico), R. Winslow (NM), S. Spencer (NS), R. Mulders (NT), G. Szor (NU), C. Lackey (NV), J. Hurst (NY), S. Prange (OH), J. Hemphill (OK), M. Obbard (ON), D. Whittaker (OR), M. Ternent (PA), R. Dibblee (PE), C. Brown (RI), S. Lefort (QC), R. Morton (SC), J. Kanta (SD), T. Trottier (SK), D. Ratajczak (TN), J. Young (TX), J. Dolling (UT), J. Sajecki (VA), F. Hammond (VT), R. Beausoleil (WA), C. Carpenter (WV), L. Olver (WI), D. Bjornlie (WY), and R. Maraj (YT). We are indebted to E. Mahoney, Y. Cui, M. Voldeck, and S. Boshan with Michigan State University's Center for Spatial Analysis of Recreation and Tourism for developing and managing the *BearsWhere?* web mapping tool. We thank K. Okeife and her staff with the Florida Fish and Wildlife Conservation Commission's Center for Spatial Analysis for early GIS planning and putting us in contact with Michigan State University, and also M. Endries and R. Butryn for other GIS assistance. We thank D. Doan-Crider for providing an electronic image of the bear range for Mexico so that our updated distribution could portray the entire species range. We thank D. Garshelis, S. Miller, M. Obbard, M. Pelton, F. van Manen, and M. Vaughan for including us in their discussion of whether black bears historically occupied prairie habitat, which prompted us to add analysis that excluded prairie. We also thank M. Orlando for early project organization, and T. O'Meara and P. Moler for reviewing early drafts. Finally, we thank *Ursus*

Editor J. Belant, Associate Editor D. Etter, D. Garshelis, S. Miller, and an anonymous reviewer for their thorough comments.

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Received: 15 June 2012

Accepted: 15 February 2014

Associate Editor: D. Etter

Supplemental material

Figure S1. Country and regional maps of estimated primary and secondary occupied range for American black bears in North America, 2009–2012, with sightings reported 2006–2010 outside of range.