BEHAVIORAL RESPONSES OF AMERICAN BLACK BEARS TO REDUCED NATURAL FOODS: MIGRATION PATTERNS AND DIET

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SUMMARY OF FINDINGS

Our previous work found that the fleshy fruits and nuts that constitute the main natural foods for American black bears (*Ursus americanus*) declined greatly in the Chippewa National Forest (CNF) study site in north-central Minnesota, from the 1980s to mid-2010s. So far, we have not been able to detect differences in sex-age-specific winter weights of bears between these 2 time periods, nor any difference in reproduction. Here we explored some potential reasons for why weights have not changed despite the lower availability of natural foods. We investigated whether bears more frequently left the CNF to find richer foraging areas during the 2010s than they had previously. During the 1980s, a portion of the radiocollared bears made fall migrations, mainly southward to better foraging areas, each year. Data from GPS-collared bears during 2016–2018 suggest that such migrations may be more frequent now. We used stable isotope analysis of segmented hair samples to investigate whether bears that migrated enhanced their diet with corn, which has an amplified $\delta^{13}C$ signature. One male bear that fed in a cornfield had greatly enhanced $\delta^{13}C$ values for the hair segments representing the fall diet. Other male bears, whether they migrated or not, showed a less dramatic increase in dietary corn in the fall, possibly from hunters' baits. Many male bears also apparently found corn products around people's houses during the summer. Females, on average, had lower $\delta^{13}C$ values, but also showed evidence of feeding on corn products during the summer. Bears appear to be using human-related foods to make up for reduced natural foods.

INTRODUCTION

American black bears (*Ursus americanus*) in Minnesota forage on carbohydrate-rich fleshy fruits in summer, and then seek out fat-rich nuts (oaks [*Quercus* sp.] and hazelnuts [*Corylus* sp.]) in fall to gain necessary fat reserves for hibernation. However, within the Chippewa National Forest (CNF) study area, near the center of Minnesota's bear range, there has been a significant decline in availability of natural bear foods since we started studying bears there in the early 1980s (Rettler et al. 2018). The aim of this study is to understand how bears are responding to this reduced availability of food. Does it affect their weight, body condition, growth rate, reproduction, and survival? Or have they found adaptive ways to compensate? Our data so far indicate that bears in winter dens have similar sex- and age-specific weights and reproduction as in the 1980s, suggesting that they may have found alternate food sources to compensate for the reduction in fruits and nuts. Here we investigate whether migration out of the CNF to better food-producing areas could explain the normal winter weights and reproduction, despite the decline in the CNF food base.

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During the 1980s, a portion of bears (averaging 44% of males and 39% of females) from the CNF migrated each year in late summer and fall, generally southward, to better food-producing areas, specifically areas richer in oaks or agricultural crops (Noyce and Garshelis 2011). Counter to expectations, that research found that migrations were more common during years with high food production, and less frequent during poor years, suggesting that bears perceived that in poor food years, their travel might not yield a compensatory food reward (in other words, that poor food conditions would occur across the broad landscape, and not just local to the CNF). Here we examined whether such migrations have become more or less frequent in response to diminished food on the CNF and whether bears that made migrations during the recent period (2010s) benefited in terms of one particular food reward—corn. This dietary item is easily discernible from stable isotope analysis of hair, which assimilates the different dietary components as it grows, so some aspects of the diet can be reconstructed through time by dividing the hair in segments (Ben-David and Flaherty 2012, Ditmer et al. 2016).

OBJECTIVES

1. Compare the proportion of bears on the CNF that migrated to fall feeding areas during the mid-2010s to that during the 1980s.
2. Determine whether bears make use of human-related foods as a dietary supplement.

STUDY AREA

Located in northcentral Minnesota, the CNF study area falls in the transition zone between the boreal forests to the northeast and the temperate forests in the central part of the state. Our 620-km^2 study area was dominated (42% of area) by the eastern extent of the CNF; the remainder included part of the George Washington State Forest and other state-owned land (11%), county land (6%), private land (18%), commercial timber industry (8%), and open water (15%). The eastern two-thirds of the study area was upland forests dominated by various combinations of aspen (*Populus tremuloides, P. grandidentata*), maple (*Acer spp.*), red pine (*Pinus resinosa*), paper birch (*Betula papyfiera*), and balsam fir (*Abies balsamea*). The western third was largely lowlands dominated by speckled alder (*Alnus incana*), black spruce (*Picea marina),* tamarack (*Larix laricina*), black ash (*Fraxinus nigra*), northern white-cedar (*Thuja occidentalis*), quaking aspen, and balsam poplar (*Populus balsamifera*). Many lakes, forest roads, and recreational trails occur throughout the public land. This area was heavily hunted for bears due to the large extent of easily-accessible public land. Larger oak stands and agricultural landscapes do not exist on the study area but can be found to the south and west.

METHODS

We fit bears with GPS radiocollars and monitored them during 2016–2018. GPS locations were obtained at 2-hour intervals during the non-denning period (April–November). We classified migrations as significant movements (>5 km) outside the summer home range during mid-July to October. We excluded bears shot during the September hunting season because we could not discern whether they would have migrated.

To quantify the amount of corn in the diet, we used stable isotope analysis of bear hair samples collected from GPS-collared bears in winter dens. Bears molt and grow new hair each spring, so hair samples represented a bear's diet from mid-June/early-July until hibernation (when hair growth ceases). For each bear, we cut approximately 30 hairs into 8 equal-length segments (Figure 1), making the assumption that differing hair lengths among bears was due to differing growth rates; thus, each segment of each bear would correspond to diet assimilation during approximately the same 2-week period over the 4-month span from start of hair growth to

hibernation (e.g., segment 1 at the distal end represents the diet in early July, and segments 7–8, closest to the root, represent the fall diet).

Hair samples were analyzed in a Thermo Delta V isotope ratio mass spectrometer interfaced to a NC2500 elemental analyzer at the Cornell Isotope Laboratory. Isotope results are expressed with a "δ" notation to indicate the change in isotope ratios relative to an international standard. Higher $\delta^{13}C$ values indicate a larger contribution of C_4 plants (corn or sugarcane) in a bear's diet, whereas lower values indicate more natural vegetation (Ditmer et al. 2016). Higher $\delta^{15}N$ values identified food from a higher trophic level or contained higher amounts of protein (not discussed in this report).

RESULTS

We observed fall migrations for 57% (*n*=27) of 47 bear-years during 2016–2018. Migrations occurred for 53%, 50% and 61% of bears in 2016, 2017, and 2018, respectively (Figures 2–4). Among all 3 years, migrations occurred for 59% of female (*n*=17) and 57% of male (*n*=30) bear-years. Most migrations were directed to the south or southwest of the study area. Males traveled up to 130 km and spent up to 8–9 months away from their summer home ranges (because some overwintered in the area where they had migrated to).

Hair sample segments representing the fall showed a pulse of enriched carbon for males, especially those that did not migrate (Figure 5). We excluded 1 migratory bear which, based on GPS locations, spent most of the fall (in all years) in a cornfield and had a very carbon-enriched hair signature in fall (Figure 6). In contrast, for females, whether migrating or not, peak $\delta^{13}C$ values occurred in hair segments representing the summer (Figure 5). Carbon values for non-migrating males were higher than for females for all hair segments.

DISCUSSION

Preliminary results suggest that the direction and extent of fall migrations from the CNF were on par with those observed in the 1980s. The most migrations occurred in 2018, when food conditions on the CNF were much higher than in 2016 and 2017, a pattern consistent with the 1980s (Noyce and Garshelis 2011). However, the proportion of bears migrating during the years with low food (2016 and 2017) was higher than observed during the 1980s, possibly suggesting that more frequent migrations to areas with richer foods was one way that CNF bears were able to increase body weights in fall.

Another way that bears may have filled in the gap of low natural fall foods was through greater reliance on hunters' baits, which are available to bears from mid-August to mid-October. These baits generally include sugar or corn-based products (e.g., high-fructose corn syrup), so should show up as enriched $\delta^{13}C$ in fall hair segments. We will explore the possibility that bears increased their use of baits over the decades by comparing $\delta^{13}C$ values for bear hair samples collected during 2016–2020 versus those collected in the 1980s–early 1990s.

We have records (GPS points or camera trap photos from hunters) of some of the current GPS-collared bears visiting hunters' baits, and their carbon signatures are enhanced in fall hair segments. However, sometimes the $\delta^{13}C$ signature is not distinct, possibly because the bear did not consume a significant amount of bait or because a large proportion of the consumed bait was not sugar- or corn-based. We surveyed hunters in the CNF area to find out what mixture of bait products they used, and we will be examining the carbon and nitrogen signature for these (Kirby et al. 2017).

Stable isotope signatures also indicated that some bears obtained corn-based products at other times of year. The $\delta^{13}C$ signature for males is generally higher than for females throughout the year (Figure 5), and some of the males in the sample were known to consume human-related

sources of food, near people's homes. These foods likely include birdseed, which we should be able to detect with a nitrogen signature (Ditmer et al. 2016). We also have direct evidence, from scat samples, of bears obtaining corn in summer (Figure 7), presumably from deer (*Odocoileus virginianus*) feeders. It appears that one reason that bears are able to maintain weights comparable to the 1980s in the face of reduced natural foods is through the use of human-related foods.

ACKNOWLEDGMENTS

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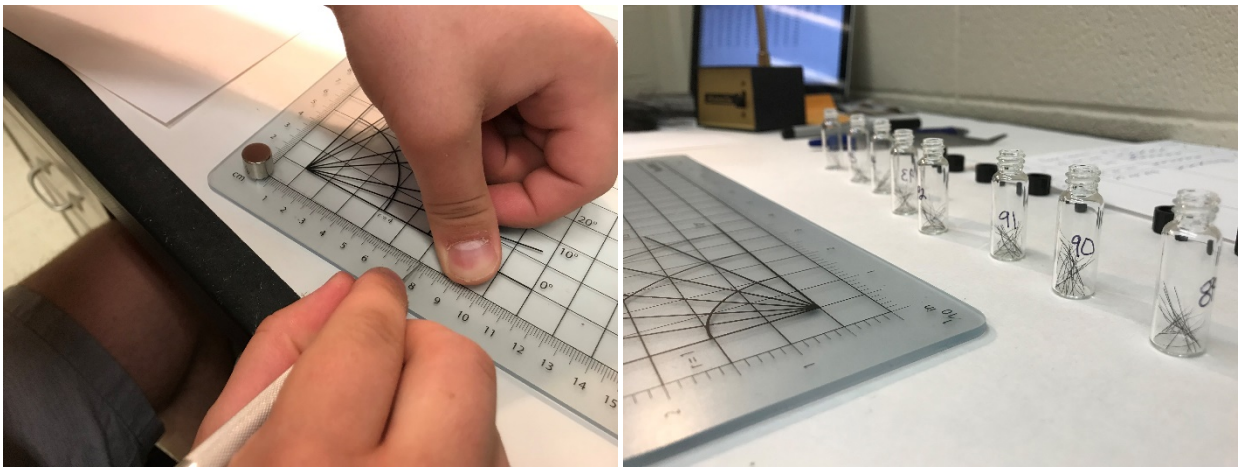

Figure 1. Hairs were collected from GPS-collared bears in winter dens, then cut in 8 equal lengths, representing approximately 2 weeks of growth. Approximately 30 hairs from each bear were segmentally cut to obtain a sufficient sample of each portion of hair for stable isotope analysis.

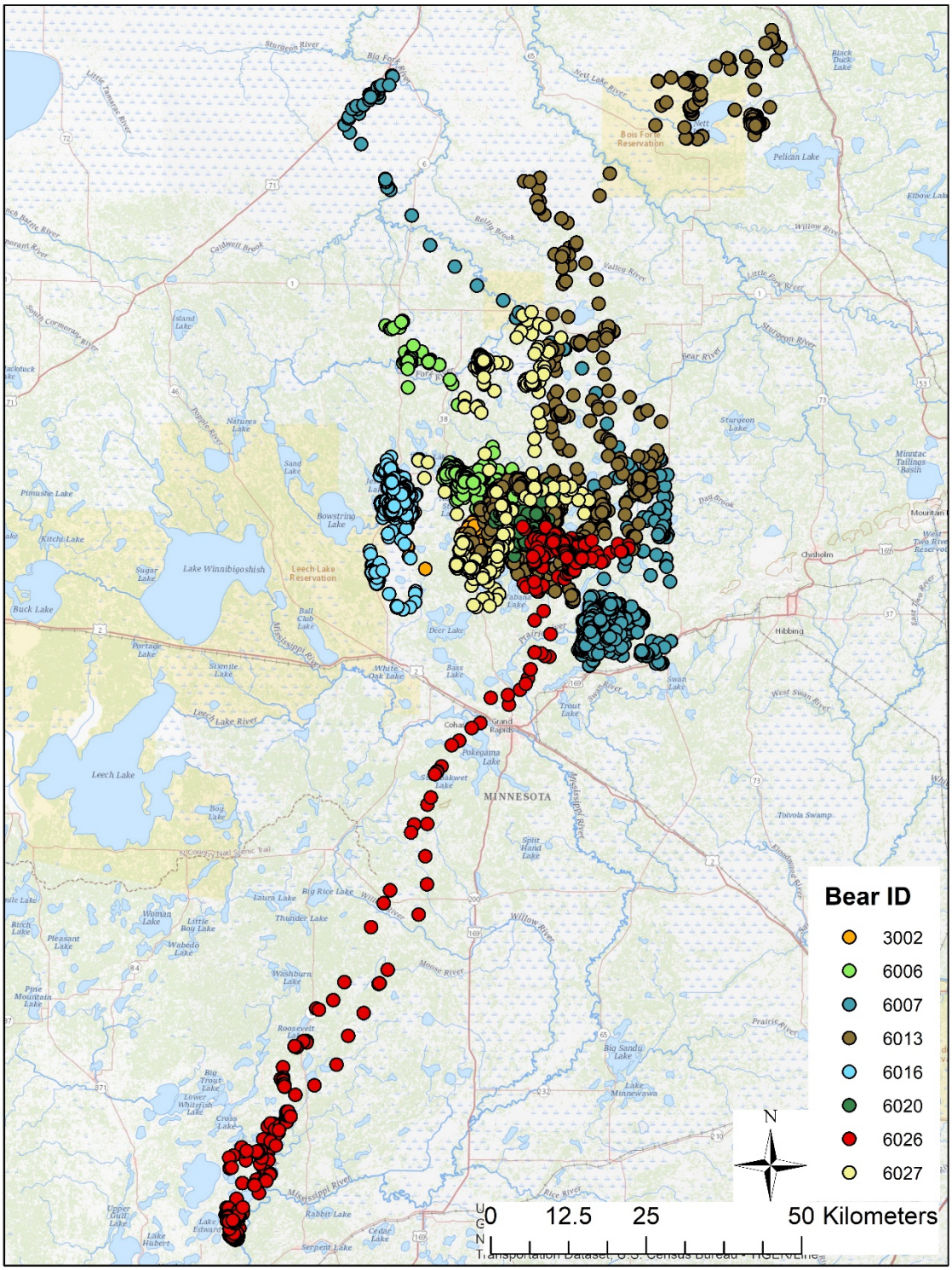

Figure 2. Fall migration movements of 8 GPS-collared bears (3 male, 5 female) from the CNF in 2016 in Minnesota.

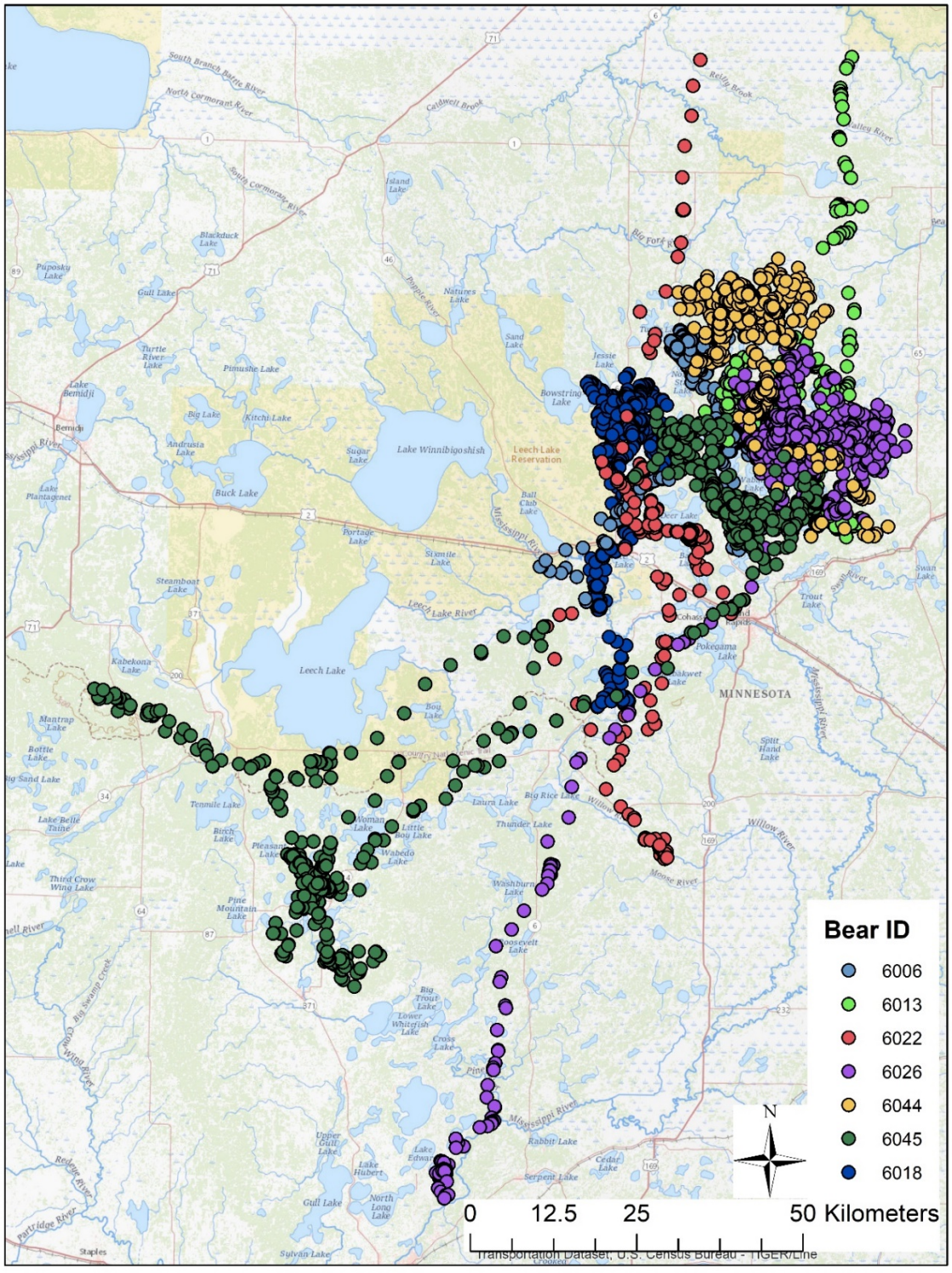

Figure 3. Fall migration movements of 7 GPS-collared bears (6 male, 1 female) from the CNF in 2017 in Minnesota.

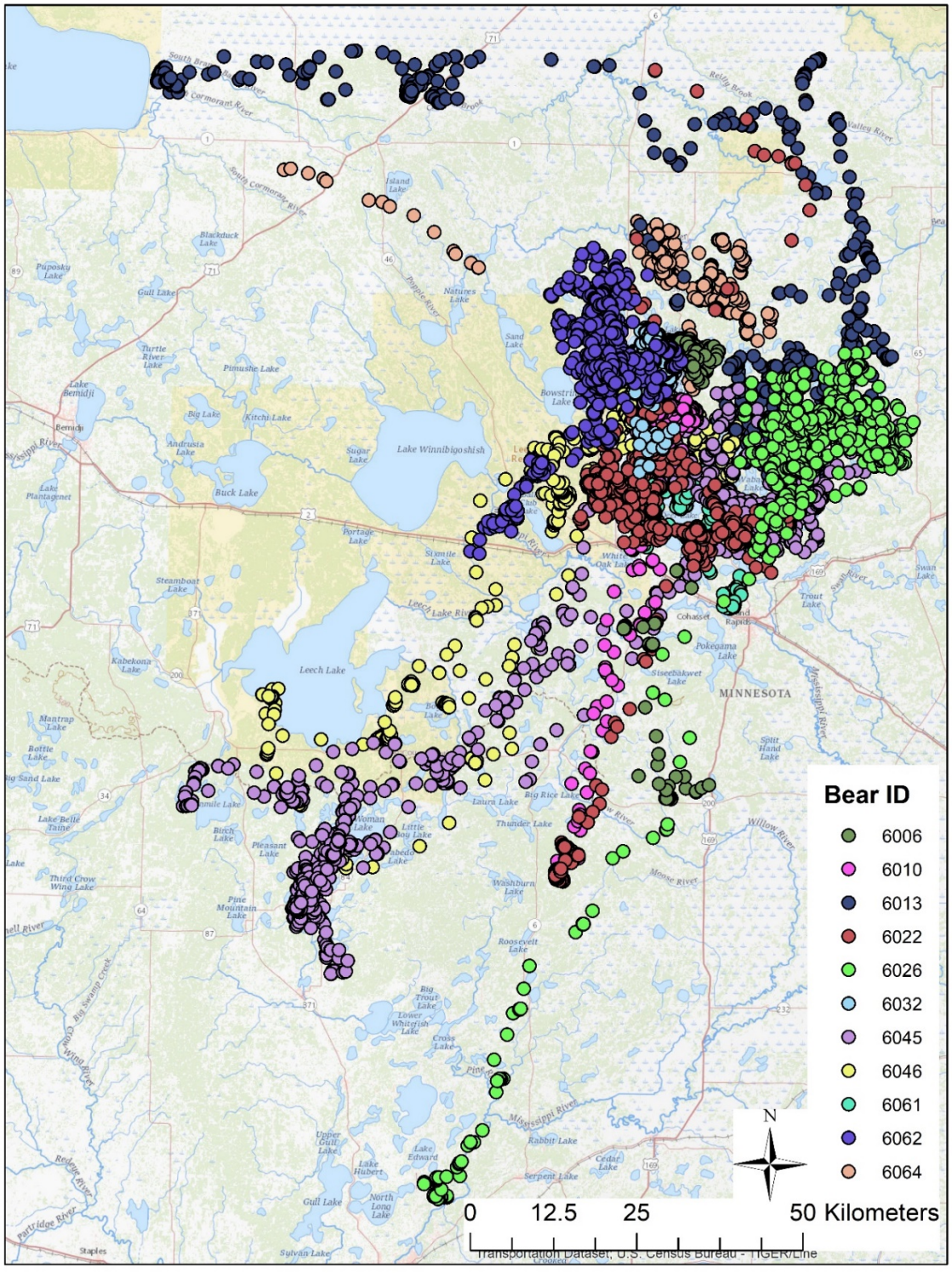

Figure 4. Fall migration movements of 11 GPS-collared bears (8 male, 3 female) from the CNF in 2018 in Minnesota.

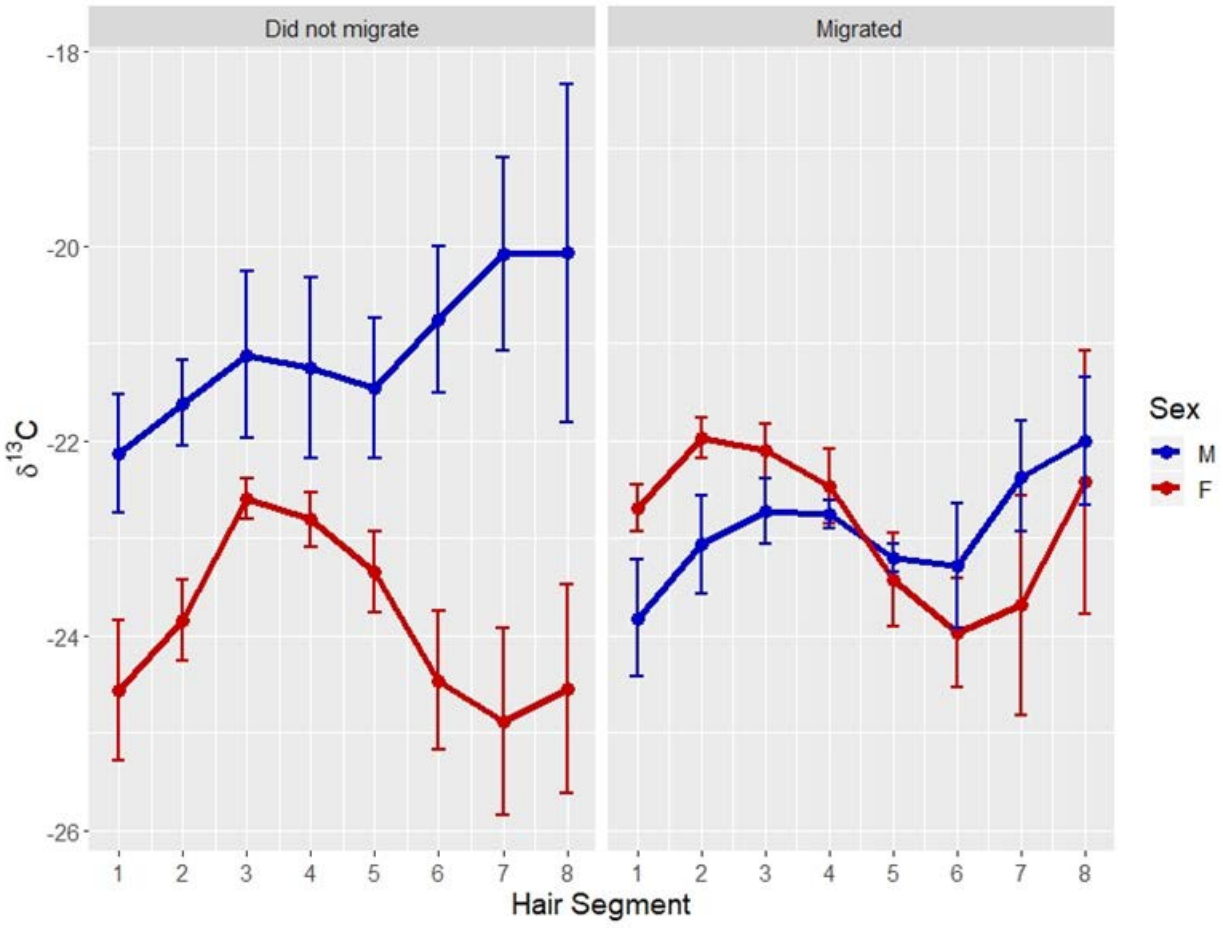

Figure 5. Isotopic mean values for $\delta^{13}C$ (±1 SE) for 8 equal-length hair segments (collected during hibernation) for male and female GPS-collared bears that did not (left panel) versus did (right) migrate to a fall feeding area outside their summer home range on the Chippewa National Forest study site during 2016 and 2017 in Minnesota. Hair segment 1 represents the oldest growth, which corresponds with the summer molt in late June to early July. Segments 7 and 8 are the newest growth, representing foods eaten in fall, prior to hibernation. The panel of migrating males excludes 1 bear that visited a cornfield in both 2016 and 2017 because his $\delta^{13}C$ values are so much higher than all other bears, which would greatly skew the mean. The data for this excluded bear are shown in Figure 6.

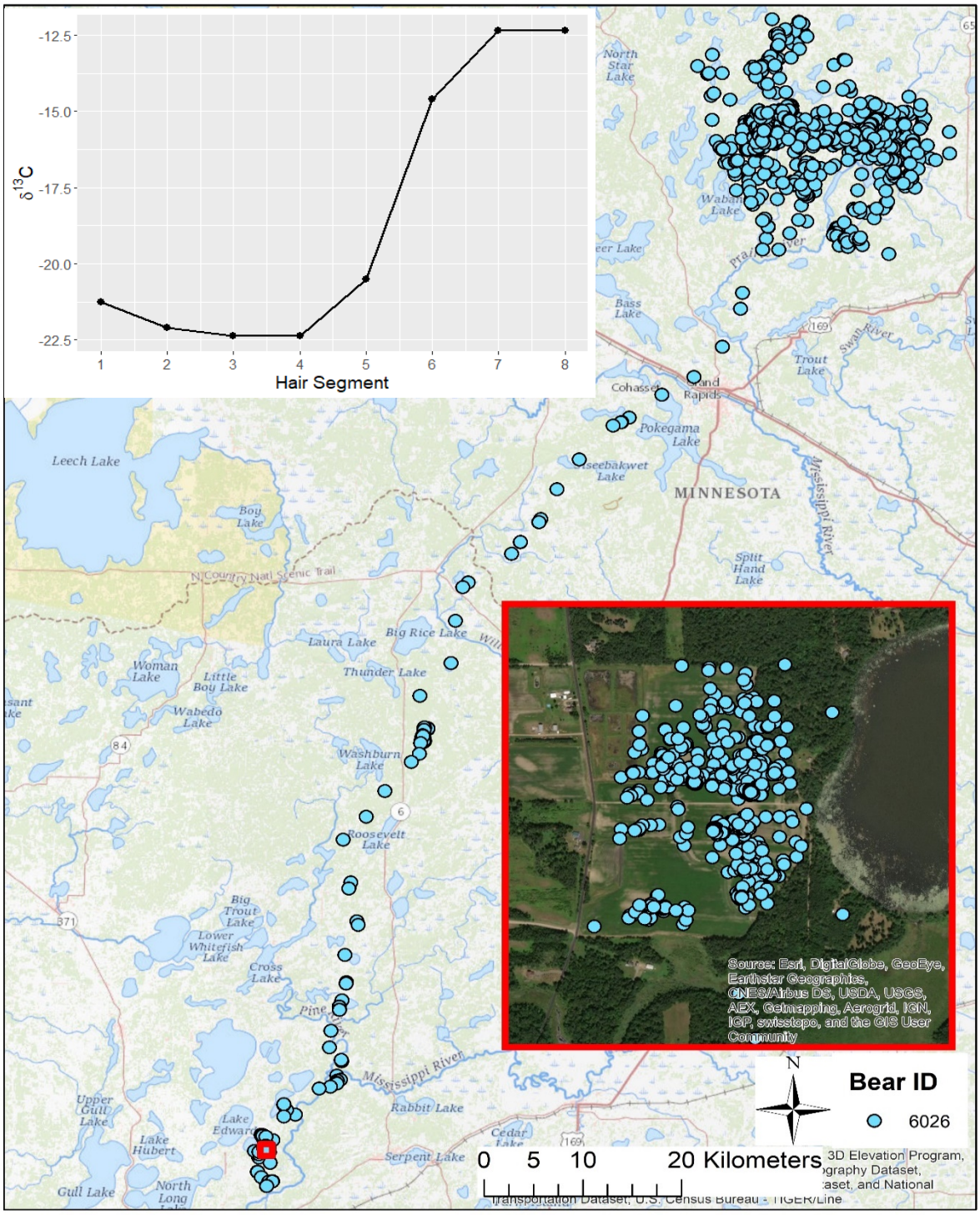

Figure 6. Fall migration of an adult male bear (#6026) from the CNF study site in 2017 in Minnesota. GPS locations and carbon isotope values (insets on right side and top, respectively) suggest that this bear primarily fed largely on corn in the fall. This bear migrated to the same area in 2016 and 2018 (data not shown). The $\delta^{13}C$ values of this bear in fall (hair segments 6–8) are much more extreme than all other bears (Figure 5).

Figure 7. A scat filled with corn, collected from a bear in the CNF during June 2018, indicating that although there are no large cornfields in the area (or ripe corn anywhere in Minnesota in June), the bear found corn, likely from a deer feeder at someone's house.