CAPTURE HETEROGENEITY IN HAIR-TRAPPING OF BEARS

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SUMMARY OF FINDINGS

During the spring and summer of 2012, we conducted genetic capture–mark–recapture (CMR) of black bears in the Chippewa National Forest (CNF) using hair traps in order to ascertain changes in bear abundance since our last estimates of this same population during the 1980s and 1990s. Because previously we captured bears in physical traps or by camera traps, one objective here was to examine potential sources of bias specifically related to hair-trapping, which could hinder comparisons with previous estimates. We set 121 2-stranded barbed wire hair traps in the same study area as used in the 1980s and 1990s. We checked sites during 6 sampling sessions at 10-day intervals during late-May to mid-July. Visitation by bears was high (55% of site-session checks), yielding 2784 hair samples in 1642 clusters of 1–11 adjacent barbs. We assumed that clusters of barbs with hair represented places where a bear went over or under a wire and rubbed across several barbs. We submitted a sample from each of 1113 clusters for genetic analysis, and 1019 (92%) were successfully genotyped. We examined data for evidence of capture heterogeneity due to annual molt and barbed wire position. In nearly two-thirds of the clusters, hair occurred only on the lower strand of barbed wire, suggesting that most hair was snagged when bears crawled under the lower wire. Hair occurred on both upper and lower wires in 22% of clusters and only on upper wires in 16% of clusters. Samples from both males and females were more common on lower wires, but male hair was relatively more common than female hair on upper wires, suggesting that 2-strand designs may better capture population diversity than a single strand of barbed wire, as used in many studies. The total number of sites visited by bears per sampling session increased from the first to second session, and was relatively consistent thereafter. The number of barbs and clusters with hair at each site, however, declined through the study, as did the relative frequency of clusters involving both wires, suggesting that hair was harder to snag during later sessions because the long winter coat had been molted and the new summer coat was harder to pluck out. Awareness of these trends will help inform modeling and interpretation of CMR population estimates. Further work with camera traps at hair snares is needed to ascertain whether cubs are sampled by hair snaring, an important consideration in comparing this estimate to previous estimates that excluded cubs.

INTRODUCTION

During summer 2012 we conducted DNA-based capture–mark–recapture (CMR) of black bears to estimate bear population size in a 300-km^2 study area in northern Itasca County, Minnesota, mainly within the Chippewa National Forest. We specifically sought to examine population change since the 1980−1990s, when we last estimated abundance on the same study area using physical trapping and camera trapping. Multiple lines of evidence suggested that bear numbers had declined significantly since our last estimates.

DNA-based CMR, using hair collected from barbed-wire hair traps, has become the “gold standard” for estimating bear population size where logistics and budgets allow. Genetic CMR has many advantages over marking bears through physical captures and radiocollaring. Because bears are not handled, checking hair traps requires a lower level of skill and less equipment. Also, more traps can be set because they do not have to be checked daily, and bears likely have less aversion to the traps, so are more likely to be recaptured. Thus, sample sizes from hair trapping are apt to be large (improving precision) and less biased. However, hair trapping potentially introduces new sources of sampling heterogeneity that are unique to this method. Hence it was important to consider potential forms of bias that may have differed from our physical mark-recapture work.

Most hair trapping studies have employed a barbed wire enclosure constructed by stretching a single strand of barbed wire around several trees at a height of about 50 cm above the ground. A scent lure, hung over the center of the enclosure but out of reach of bears, entices bears into the enclosure (Woods et al. 1999). This design was developed originally for grizzly bears (*Ursus arctos*) and was intended to snag hair from all sizes of bears – i.e., the barbed wire was high enough to sample large bears that climbed over the wire, but still low enough to sample smaller bears that crawled underneath, including cubs of the year (Woods et al. 1999, Kendall et al. 2008). Other protocols made use of hair left at trees (Kendall et al. 2008) or power poles (Karamanlidis 2007) where bears naturally rub, scratch, and mark. In this case, barbed wire is secured to the tree or pole to increase the amount of hair sampled when bears rub.

Each of these methods has some degree of bias with regard to size and/or sex of bears sampled (Kendall et al. 2008; Boulanger et al. 2006). Where both methods have been employed, as in Banff National Park, Alberta, Canada, hair traps caught relatively few male grizzly bears, whereas at rub trees, males were more likely to be captured than females (Sawaya et al. 2012).

This method has been adapted for use on black bears in locations around North America, with some modifications. Researchers found that often, bears entered hair traps but did not leave hair on the barbed wire. To increase capture efficiency, Tredick et al. (2007) added a lower wire to their hair traps (20 cm above ground) to force animals to squeeze through more restricted spaces and improve the detection of small bears that could otherwise crawl under wires without leaving hair. However, they concluded that samples from the lower wire were of poor quality and thus did not increase efficiency enough to offset the extra expense and time of construction. Lowe (2011), however, working in south central Louisiana, suspected that large males might be systematically under-represented using 1-strand hair traps; photos from remote cameras showed large males entering enclosures by stepping on or over wires and leaving no hair (Hooker 2010). Estimated capture rate for females was twice as high as for males. Subsequent work in the same study area, using hair traps with an added upper wire at 70 cm resulted in more equal estimates of capture probability for males and females (O'Connell 2013).

Other potential problems stem from the timing of genetic CMR studies, which often run through much of the spring and summer. In temperate regions, this coincides with a bear's annual molt. In May and June, when most underfur and guard hair are lost, shedding hair is easy to snag, whereas the hairs of new pelage are more tightly bound, so significant changes in capture probability may occur among sampling sessions. If the molt proceeds differently for different sex-age groups, this further complicates the task of categorizing capture heterogeneity and accounting for it in analysis of data.

In our CMR study, we wished to sample all age groups except cubs of the year, because our previous estimates (physical capture and camera capture) excluded cubs. A pilot project suggested that a 2-strand hair trap with wires placed at approximately 45 and 75 cm above the ground would be the most likely to catch bears of all sizes except cubs. Here we examine patterns in the hair we captured so as to discern types and magnitude of sampling bias that barbed wire hair traps introduced into our population estimation procedure.

OBJECTIVES

1. Determine if hair snaring introduces significant sampling bias and/or heterogeneity into CMR sampling, and if so, what type(s).
2. Determine if cubs of the year were sampled by hair snares.

METHODS

The study area was same CNF study site where previous CMR estimates were obtained (Figure 1). It contains good access via 2 main paved roads, smaller unimproved roads, and forest trails. Ownership is mainly national and state forest, with additional county and private lands.

We erected hair-snare traps using 2 strands of 4-pronged barbed wire wrapped around 3-5 trees, forming an enclosure. Barbed wire was placed at 45 cm and 75 cm off the ground (Figure 2). We erected 1 trap in each of 121 square-mile sections (121 mi^2). Within each of these grid cells, we set a trap in what we perceived as good bear habitat to maximize visitation. We set traps at least 100m from main roads, but often along trails that bears might use.

We suspended a bag of bacon and a scent lure from a string (above the reach of a bear) across the middle of each trap, and put bait and scent lure on a pile of brush in the middle of the enclosure (Figure 2). Baits and lures were refreshed at each trap visit. We added different types of lures at each trapping session to maintain novelty for the bears. We checked all traps 6x at intervals of 10 days. We did not move traps between sessions. At each trap check, all bear hair was removed from the wire. Each clump of hairs on a barb was collected in a separate envelope, and labeled as to proximity to other barbs with hair, trap number, and date. We coded barbs of hair that were adjacent (next to, on either the same wire or the one above/below) as being from the same cluster. A cluster could include only a single barb.

We set camera traps at some of the hair traps that were visited by bears to gauge whether cubs of the year left hair on wires, and to assess the responses of different bears to the wires and the baits. Hair traps were erected the third week of May, 2012. We checked all 121 hair traps 5 times (605 site-sessions), then dismantled 36 traps that were never visited by a bear, leaving 85 to be checked in session 6 and removed the third week of July.

Hair samples were submitted to Wildlife Genetics International (Nelson, British Columbia, Canada) for genotyping. As our budget was not sufficient to analyze all collected hair samples, we subsampled the collection. In subsampling we made an attempt to maximize the number of different bears that visited the sites, so (1) we included at least 1 sample from each site-sesson with hair, and (2) we did not submit hairs from multiple barbs within the same cluster. We also submitted hair samples from 4 radiocollared bears and their current offspring living on the study area (collected during den visits) to determine whether they visited the hair traps. The lab also identified likely family groups.

RESULTS

Bears visited 101 of the 121 hair trap sites, resulting in 377 of 690 (55%) total site-sessions yielding hair (Table 1). We collected hair from 2784 barbs that occurred in 1642 separate clusters of 1–11 adjacent barbs. For genotyping, we initially chose (randomly) 1 barb from each of the 377 site-sessions with hair. We then chose additional random samples from among the remaining 1265 barb clusters.

Of 1113 samples that were analyzed, 14 appeared to be mixtures of >1 bear and 80 failed to amplify. Thus 1019 samples (92%) were successfully genotyped; these were from 96 different sites and 333 site-sessions. Genotyping identified 43 different individuals: 26 males and 17 females. Individual bears were detected up to 132 times each and up to 32 times in a single sampling session. Sex ratio of individuals visiting hair traps was heavy to males in all sampling sessions and did not vary through time (χ^2=0.96, *df*=5, *P*=0.97).

Females that visited hair traps did not differ from males in either the number of sessions in which they were detected (Figure 3; χ^2=2.52, *df*=5, *P*=0.77) or the number of sites they visited (Figure 4; χ^2=0.83, *df*=3, *P*=0.84, for M vs.F visiting 1, 2-3, 4-7, or 8+ sites). About a third of both males (31%) and females (29%) were detected in only 1 sampling session. A similar percent of males (31%) and females (24%) were detected at only 1 site during the study. The number of

sites and the number of sessions a bear was detected were positively related (Figure 5).

Camera trap photos revealed that many individuals visited the same hair trap multiple times during a session. The same bear often entered and left a trap at different locations along its perimeter, variously crawling under, between, or over the wire (Figure 6). Multiple individuals sometimes used the same location for entering or exiting traps, conceivably producing mixed hair samples. Only 1% of analyzed samples were unusable for this reason, however, so this did not constitute a significant inefficiency in sampling.

The number of hair traps that yielded bear hair ranged from 30–79 per session (Table 1). The number of different individuals detected in a session ranged from 14–28 (Table 2). Visitation varied through time (χ^2= 50.3, *df*=5, *P*<0.0001), with fewer sites visited during the first session (late May) than in subsequent sessions (25% vs. 52 – 75% of hair traps visited; χ^2 multiple comparisons for proportions; α=0.05). Visitation by bears was also higher during the last session than in sessions 2 or 3, at least in part because sites that had not been previously visited were removed for this session (Table 1).

We found that over the course of 6 sampling sessions, at sites visited by bears, the mean number of barbs/site that snagged hair, the number of clusters of barbs/site, and the number of adjacent barbs that comprised each cluster all showed significant declines (Figure 7; one-way AOV: *F*=8.69, 4.41, and 12.93, respectively; *df*=5.0, *P*<0.001). These changes, most noticeable in late June and July (sessions 4 – 6) coincided with changes observed in coat condition as bears molted (Figure 8), suggesting that hair became increasingly less likely to snag on barbs when bears entered or exited hair traps as the season progressed.

Bears left nearly twice as many hair samples on lower strands of barbed wire than on upper strands (Table 1). This was true for both males and females, although males were more likely to leave hair on upper wires only (χ^2=3.9, *df*=1, *P* =0.047) or in clusters on both wires (χ^2=11.6, *df*=1, *P* <0.0001) than were females (Figure 9). (Conversely, females were more likely to leave hair only on lower wire; χ^2=19.9, *df*=1, *P* <0.0001). Clusters of barbs included only barbs on lower wires 62% of the time, only barbs on upper wires 16% of the time, and barbs on both wires 22% of the time. Clusters that included both wires decreased from May to July (Figure 10; χ^2=44.1, *df*=10, *P*<0.0001), concurrent with an increase in the proportion left only on lower wires.

Genotyping identified several family groups that were sampled together at the same site and during the same session. Only 1 genotyped family group, a radio-collared mother and her yearlings, occurred where there was a camera. Two males also photographed at these sites were detected by hair. One camera site detected a mother with at least 1 cub present; this cub was not identified among the hair samples analyzed from the site. We had no means of ascertaining whether other detected family groups included cubs of the year.

DISCUSSION

Capture heterogeneity is a vexing problem in capture–recapture studies of most mammals because a fundamental requirement for deriving unbiased estimates of animal numbers and demographic parameters is that individuals are equally vulnerable to capture. This is rarely the case. Recent advances in analytic methods accommodate some degree of capture heterogeneity among groups and through time, however, these methods still require classifying data such that within identifiable groups likelihood of capture is rather uniform.

Most studies involving physical capture of bears in traps exhibit a trapping bias toward males, despite a living population with more females (at least in hunted populations). Previous trapping in the Chippewa National Forest produced a male-biased capture. Trap vulnerability was also influenced by age and, for females, reproductive status (with or without cubs of the year): subadult males (3–5 years old) and females without cubs were more vulnerable to capture than other bears and juvenile females (1–2 years) and adult males (>5 years old) were less vulnerable (Noyce et al. 2001). Some of these biases shifted through time (e.g. adult males and adult females with cubs were more likely to be caught toward the end of the breeding

season in early July than during peak breeding in late May – mid-June). Further compromising any assumptions of equal catchability were differences among individuals that were not sex- or age-based, likely attributable to individual differences in behavior and/or proximity to traps,

In designing this study we attempted to lessen some of the biases apparent in our earlier capture data by doubling trap density relative to that used in the 1980s and 1990s, making it more likely that small yearling home ranges would include at least 1 hair-trap, and by running the sampling season through mid-July, to sample adult females with cubs and adult males with about the same likelihood as other demographic groups (Noyce et al. 2001). We also specifically ended sampling by mid-July to minimize violation of the assumption of geographic closure, as 40% of bears in the study area, on average (and double that some years), left their summer home range after mid-July to migrate, mainly southward, in search of concentrated food where they could fatten for winter (Noyce and Garshelis 2011). Presumably other bears from elsewhere likewise moved into the study area

Despite these efforts, hair trapping in this study still produced a male-biased capture. We could not discern age-related effects because genetic samples do not provide information about age. The fact that we did not capture a rash of new bears in session 6, yet more new bears in this session than in sessions 4 and 5 (Table 2), suggests that we ended sampling just as seasonal movements began.

Nevertheless, our analysis also suggested that hair trapping may have introduced at least 2 more sources of capture heterogeneity that are unique to this method of capture, adding further complexity to the heterogeneity already present in bait- and trap-based capture projects. As in other studies (Lowe 2011, Sawaya 2012, O'Connell 2013), evidence suggested that the number and height of barbed wire strands potentially introduces size-based differences in capture probability (thus also tied to sex and age). Large bears (most likely males) can be under-represented in studies using a single-wire placed at ~50 cm because they can step over the wire without leaving a hair sample, particularly late in the molt when belly hair is sparse (Hooker 2010). We obtained a photograph of one large bear stepping over even a 75-cm-high wire (Figure 11), though clearly at this height contact with the bear's underside was likely.

The seasonal molt causes declines in capture vulnerability, likely in all individuals, though to varying degrees. Molt varies among individuals in timing (Figure 12), and it is unclear if the timing varies among identifiable demographic groups. We suspect that some bears that visited sites late in the trapping season did not leave hair, or left insufficient hair for genotyping. We did not collect hair from barbs containing only 1 or 2 hairs, and these became increasingly common in July. Nevertheless, the genetics lab used an average of 7.2 hairs per sample, and reported to us that this accounted for the genotyping success exceeding 90% (compared to ~70% in many similar studies).

One aspect of hair trapping in black bear studies that begs more documentation is how to optimize trap design to either include or exclude cubs of the year. Depending on rates of cub mortality in a population, this age class can be up to twice the size of the yearling class. In populations such as Minnesota, where juveniles experience heavy loss each year to hunters, cubs comprise 15–20% of the population. Clearly it is important to know whether or not this age class is included in hair sampling, particularly where an objective is to enumerate the hunted population for management purposes, which, in most places (including Minnesota), does not include cubs of the year. Specific to our case here, a population decline could be obfuscated by exclusion of cubs in the 1980–1990s trap and camera-based population estimates, but inclusion of this large cohort in the recent hair-snaring estimate. Although we attempted to exclude cubs, it is possible that as cubs grew, they became more susceptible to contacting the lower wire while visiting a site with their mother. This possibility requires further investigation with camera traps.

Whereas estimators have been developed that can handle a degree of capture heterogeneity, study design should still include measures to identify likely sources of sampling bias, minimize them by adjusting study design, and, where that is difficult, assess their potential effect on resulting estimates. We plan to further explore some of these questions with better camera documentation of bear behavior at hair traps.

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Table 1. Bear hair collected at 121 barbed wire hair traps in the Chippewa National Forest during 6 sampling sessions in summer 2012.

Session	Trap sites with hair[a]	Total clusters[b] with hair	Total barbs with hair		
			Lower	Upper	Both
1	30 (25%)	149	206	92	298
2	63 (52%)	308	389	237	626
3	65 (54%)	279	318	152	470
4	79 (65%)	392	446	204	650
5	76 (63%)	303	321	127	448
6	64 (75%)	211	221	71	292
Total	377 (55%)	1642	1901	883	2784

[a] Each hair-snare was checked in each of sessions 1 – 5. Snares that were never visited by bears during that period (n = 36) were dismantled prior to session 6.
[b] Barbs with bear hair that were adjacent to each other, either on the same or different wires, were considered the same cluster, possibly representing a single bear entering or leaving a hair snare.

Table 2. Bears detected at hair traps in the Chippewa National Forest during 6 sampling sessions, summer 2012.

Session	Dates of hair collection	Different bears detected			New bears detected
		M	F	Total	
1	25 – 31 May	7	7	14	14
2	5 – 10 June	14	9	23	13
3	15 – 21 June	15	9	24	8
4	25 – 30 June	16	12	28	3
5	5 – 10 July	15	10	25	1
6	13 – 19 July	11	10	21	4

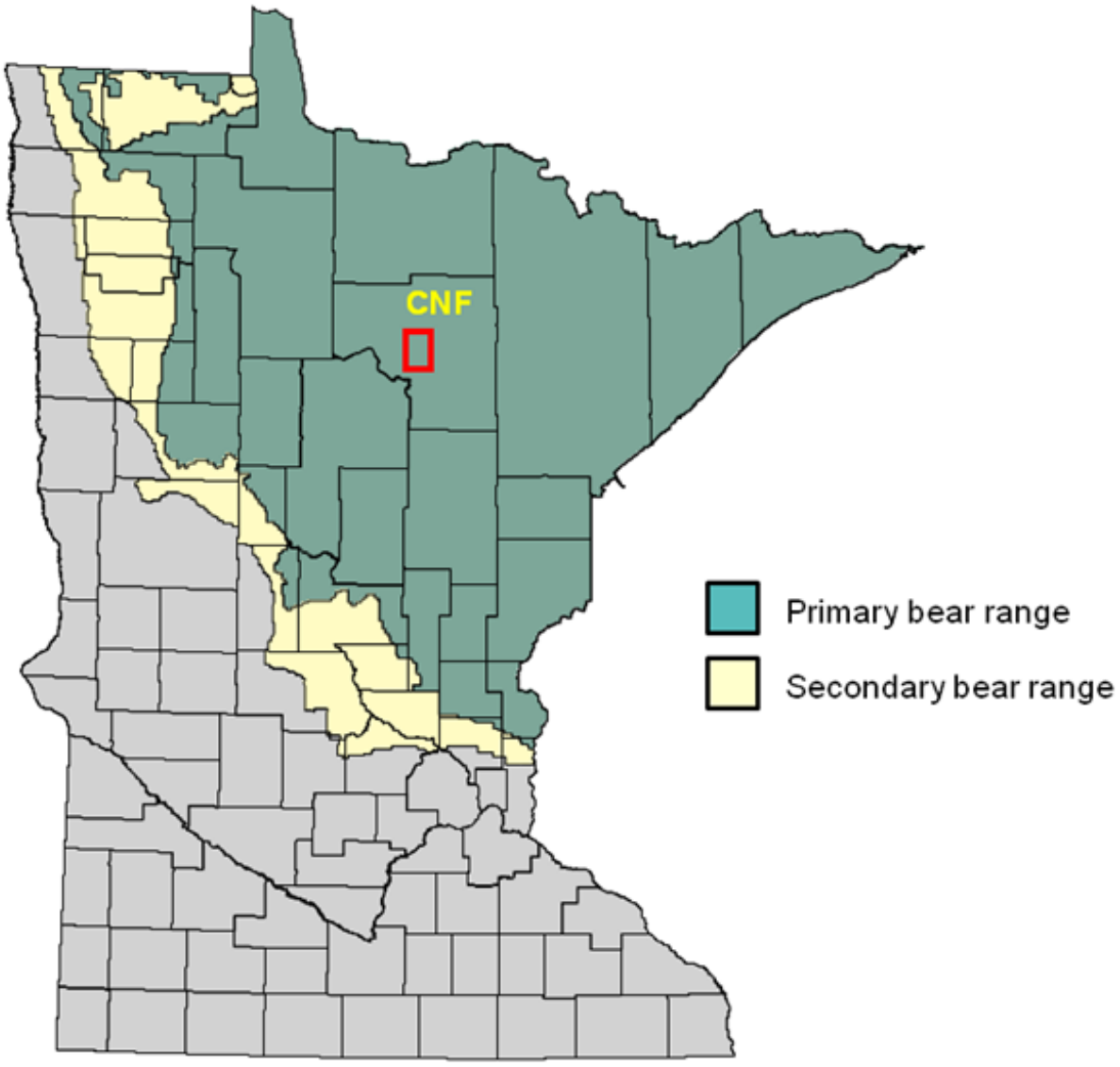

Figure 1. Location of hair-sampling study site in Chippewa National Forest, central bear range.

Figure 2. Set-up of barbed wire hair snare, showing 2 strands of barbed wire, central pile of bait and scent, and suspended bait and scent cup.

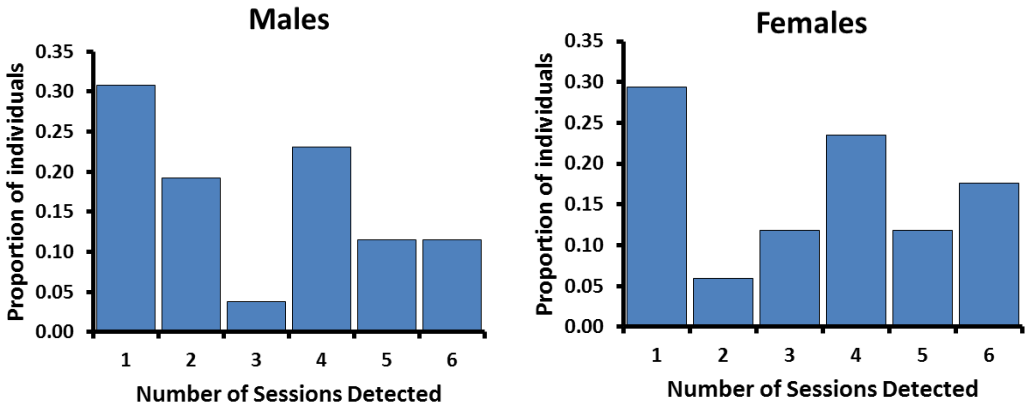

Figure 3. Number of sampling sessions in which black bears (26 M, 17 F) were detected at ≥1 hair trap during a DNA-based capture-mark-recapture study on the Chippewa National Forest, north-central Minnesota, 2012. Six 10-day sampling sessions ran from 25 May to 19 July.

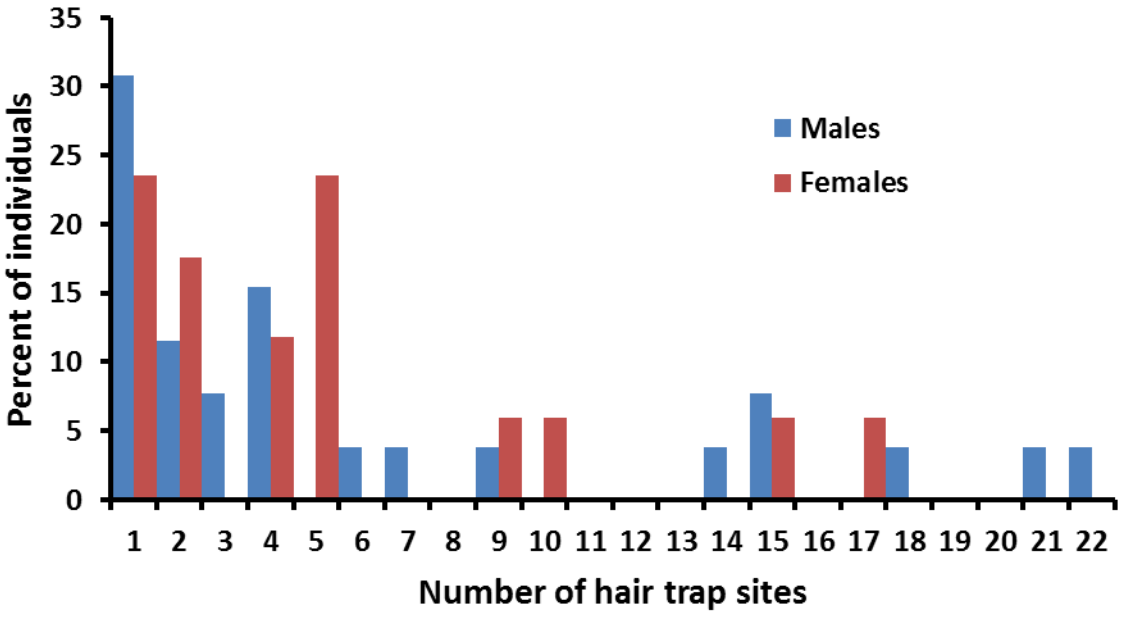

Figure 4. Number of hair trap sites at which individual male and female black bears (26 M, 17 F) were detected during 25 May – 19 July in the Chippewa National Forest, summer 2012. Hair traps were placed in a systematic grid at a density of 1/mi^2.

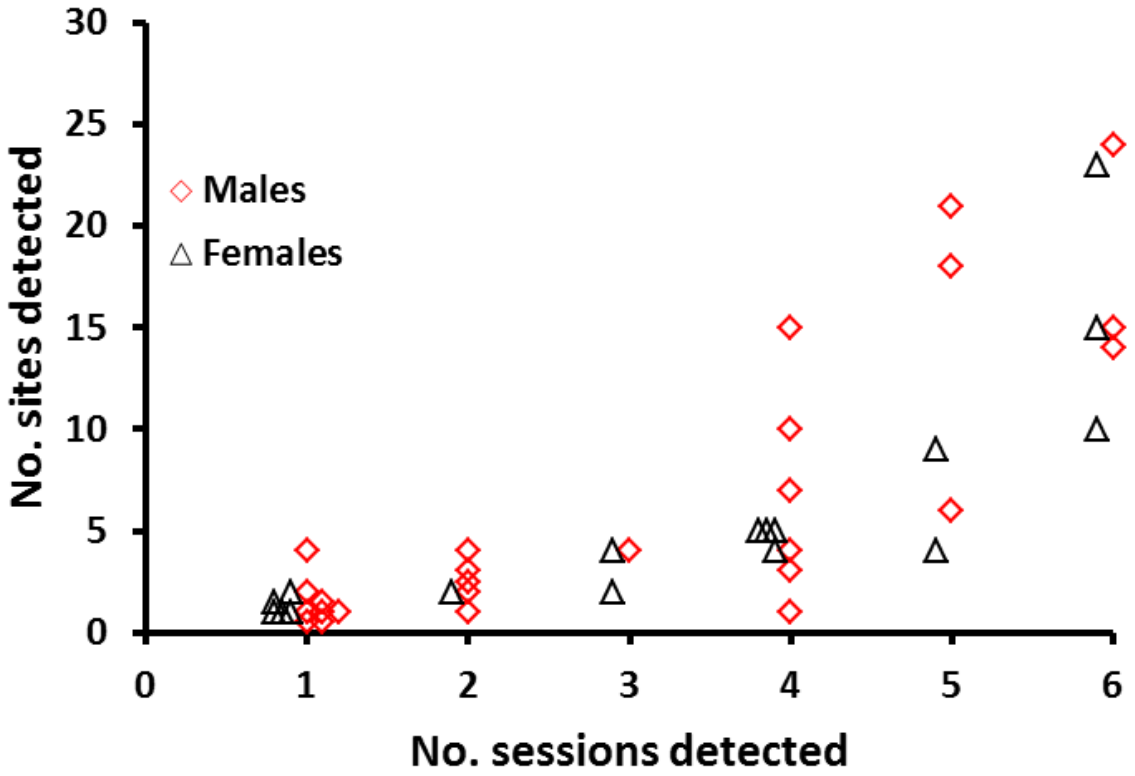

Figure 5. Relationship between the number of hair trap sites and the number of sessions in which individual male and female black bears (26 M, 17 F) were detected during 6 10-day sampling sessions in the Chippewa National Forest, north-central Minnesota, 2012.

Figure 6. Radiocollared and eartagged adult female bear entering a hair trap by going between wires (upper photo) and the same bear entering a hair trap by going below the lower wire (lower photo).

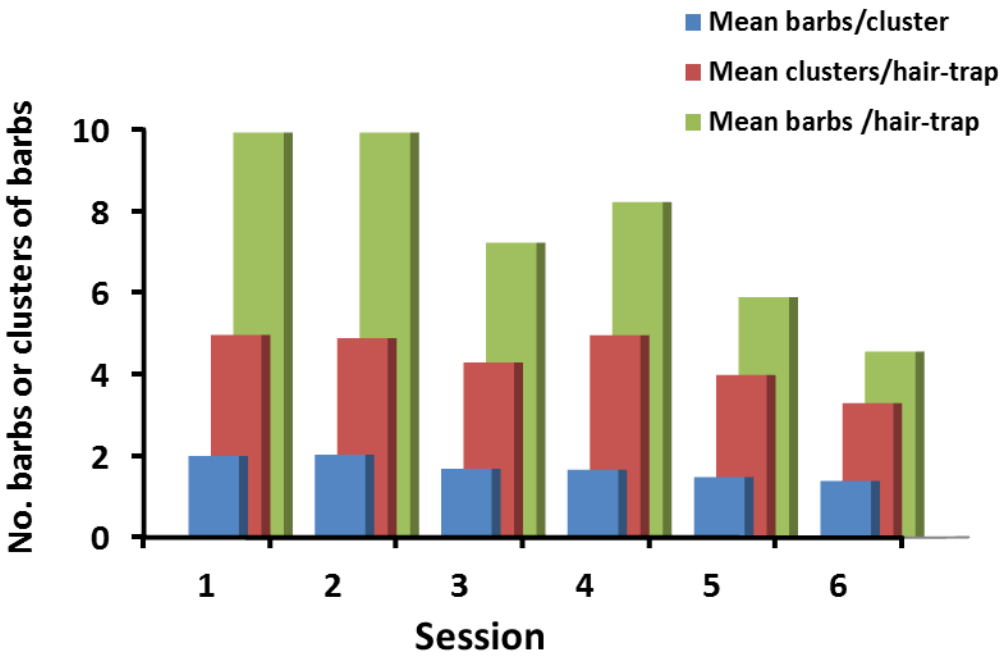

Figure 7. Changes through time in the mean number of barbs that snagged bear hair at barbed-wire hair traps (excluding sites with no hair), the number of clusters of adjacent barbs containing hair, and the number of barbs in each cluster during a DNA-based capture-mark-recapture study in the Chippewa National Forest, north-central Minnesota. Hair traps were checked 6 times, once every 10 days, from 25 May – 19 July, 2012.

Figure 8. (Left) Bear in June still wearing its long winter coat: note the clumps of matted shed hair near the rump, ready to be snagged on the barbed wire. (Right) Bear in mid-July that has nearly finished molting its winter fur: notice areas where a thin layer of longer brown hair is still present over the new black shiny summer coat (which is harder to pluck).

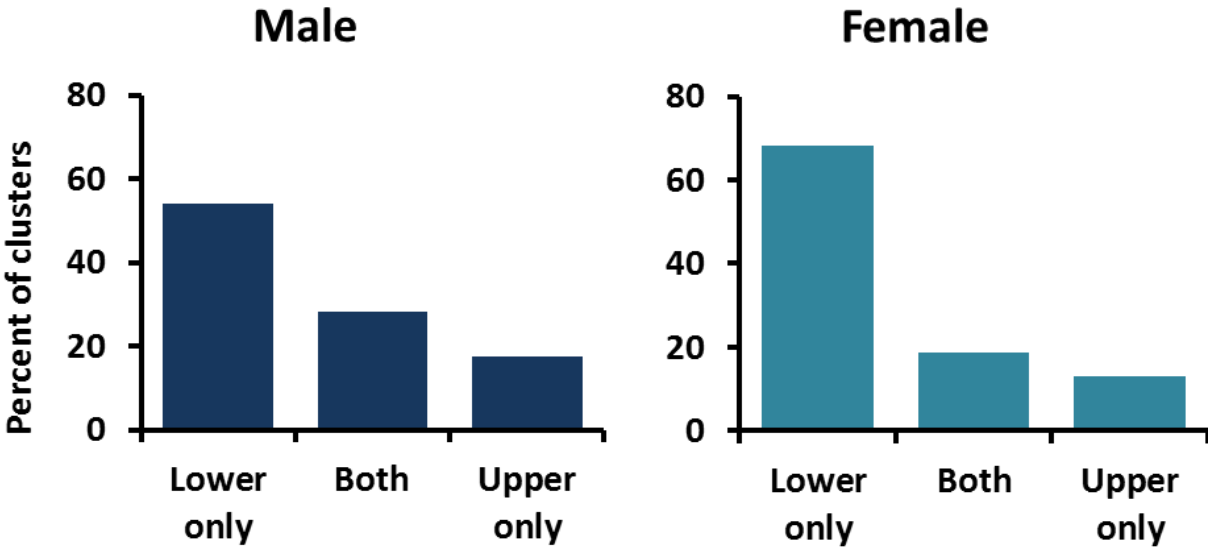

Figure 9. Percent of hair samples from barb clusters (adjacent barbs with hair) comprised of lower wires only, upper wires only, or both upper and lower wires. Only 1 barb from a cluster was genotyped, so clusters were categorized as male or female based on the 1 sampled barb (recognizing that some clusters could have included multiple bears). Males appeared more likely to leave hair on upper barbs only or both upper and lower wires than were females.

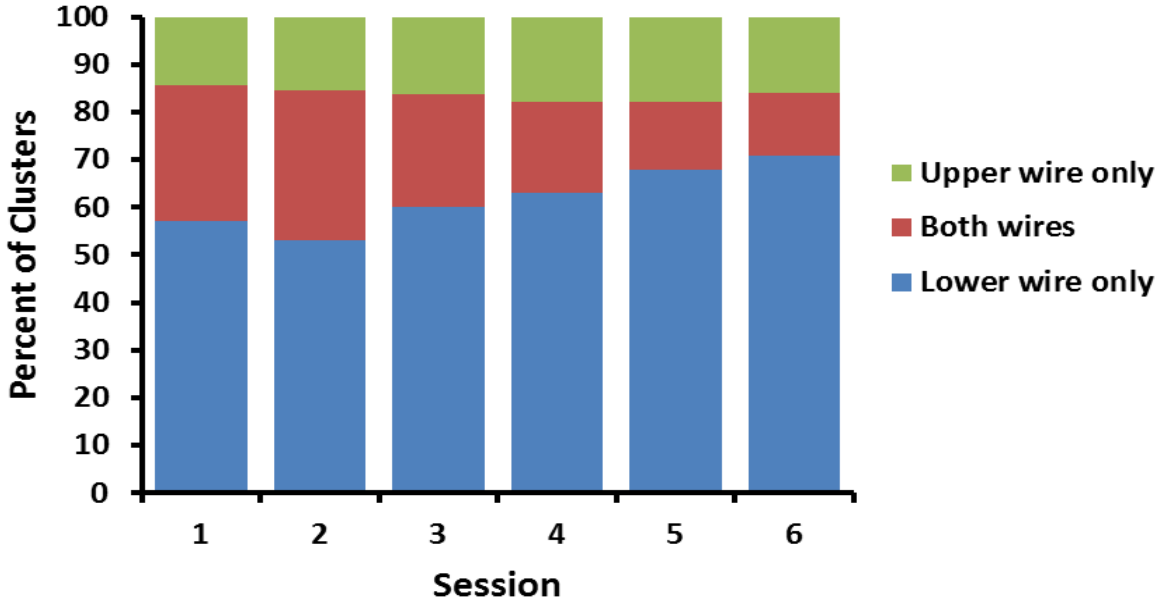

Figure 10. Changes through time in the relative proportion of bear hair samples that occurred in clusters comprised of adjacent barbs on only the lower wire, only the upper wire, or both wires of hair traps in the Chippewa National Forest, north-central Minnesota, 2012. Sampling sessions were 10 days long, spanning 25 May – 19 July.

Figure 11. Large bear stepping over the 75-cm high top wire to enter a hair trap at night. It is likely that its belly hair was caught on the wire.

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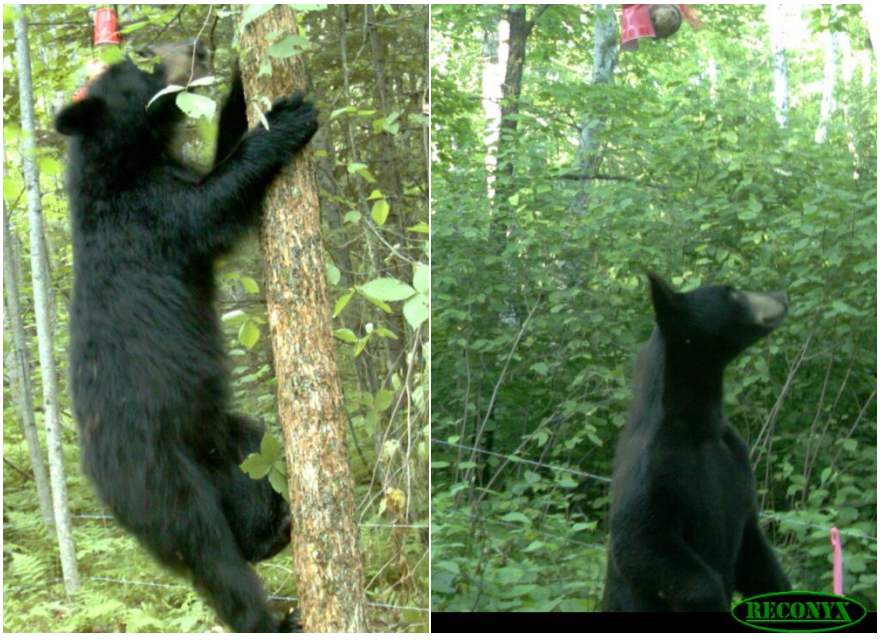

Figure 12. Two bears photographed only 1 week apart — 2 July (left) and 9 July (right) — exhibiting very different degrees of shedding.