

# HAVE CHANGES IN FOREST COMPOSITION ALTERED FOOD ABUNDANCE, HABITAT USE, AND REPRODUCTION IN BEARS?

Spencer J. Rettler<sup>1</sup>, David L. Garshelis, Andrew Tri, James Forester<sup>1</sup>

## SUMMARY OF FINDINGS

During the summer of 2016, we measured abundance (coverage) of black bear (*Ursus americanus*) food-producing plants and their production of fruits and nuts in 12 main forest types in and around the Chippewa National Forest, north of Grand Rapids, MN. We used the same methodology in the same area that was sampled through the 1980s and found that in most forest types, key bear foods were greatly reduced. This was true for both the abundance of the plants as well as the fruit production, resulting in greatly diminished biomass of bear foods in the forest. This change was likely due, in part, to changes in forest age and composition; however, even in young stands (e.g., 5–15 year-old aspen), bear foods were greatly reduced compared to the same stand types in the 1980s. Unexpectedly, we did not witness obvious changes in body condition between bears in the 1980s and those we captured this summer (n = 28). One explanation may be that bears are now exploiting more human-related foods. We observed, for example, that 70% of bears with GPS radiocollars (10 of 14) selected areas in proximity to hunters' baits in the fall.

### INTRODUCTION

Population growth of black bears (Ursus americanus) in Minnesota is affected by hunting pressure, food availability, and by the interaction between these (bears are more susceptible to hunting when natural food supplies are low; Noyce and Garshelis 1997, Garshelis and Noyce 2008). Food availability affects bear body mass and condition, which in turn influences reproduction (Noyce and Garshelis 1994, Costello et al. 2003) and thus the resilience of the population to hunting (Kontio et al. 1998). Bear foods can vary enormously year-to-year due to year-specific environmental conditions (Noyce and Coy 1990). Additionally, bear foods on the landscape are subject to long-term trends with changes in forest age (canopy closure) and forest composition. For example, on an island in Washington state, reduced food supplies associated with forest succession led to a crash in black bear numbers (Lindzey et al. 1986). In the only other example of "bottom-up" control of bear numbers that we know of, grizzly bears (Ursus arctos) in southern British Columbia, Canada, relied heavily on huckleberries (Vaccinium membranaceum) and their body condition and population fitness was strongly affected by production of this single food item (McLellan 2011). When the forest was young, grizzly bear reproduction and density at this site were among the highest in North America, but as trees shaded out the huckleberries, bear reproduction plunged (in just 10 years) to one of the lowest in North America, and bear density declined by 36% (McLellan 2015).

<sup>&</sup>lt;sup>1</sup> Department of Fisheries, Wildlife and Conservation Biology, University of Minnesota, St. Paul.

Here we examine long-term changes in availability of bear foods, and their effects on a bear population in Minnesota. In 1981, we initiated a long-term study of bears in the Chippewa National Forest (CNF), near the geographic center of the bear range. From the early 1980s through the early 1990s, we studied bear use of different habitat types, and also examined their body condition and reproduction (Noyce and Garshelis 1994). Concurrently, we collected data on bear food production by habitat type (Noyce and Coy 1990). Since then, forests on the CNF study site appear to have changed radically: food-rich stands of young aspen (*Populus* spp.) and young pine (*Pinus* spp.) plantations, which were common in the 1980s, have matured, and much of the upland forest is now dominated by maple (*Acer spp.*), which produces little food for bears. Concurrently, the CNF population declined drastically (MN DNR, unpublished data); we do not know whether this was attributable solely to over-hunting, or if habitat-related changes also played a role. Population modelling suggests that despite similar harvest pressure, the statewide population appears to be growing much more slowly than it did in the 1980s (Garshelis and Tri 2017). This study aims to investigate whether changes in habitat composition are affecting population growth.

## **OBJECTIVES**

- 1. Quantify and assess changes in natural food abundance over the past 30 years.
- 2. Ascertain how bears have reacted to changes in food abundance.

## METHODS

This study is being conducted primarily in the Chippewa National Forest, north of Grand Rapids, Minnesota. The ~130-mi<sup>2</sup> study area also includes a patchwork of state, county, and private lands, which are managed differently (e.g., more timber cutting) than the CNF.

This study involves the collection of 2 general types of data: (1) availability of bear foods by habitat type, and (2) responses of bears to altered food supplies. We will make comparisons from the early study period (1980s) to the present (2015–17). Data collection involves: (1) assessing fruit production in all major habitats; (2) capturing and fitting bears with GPS-Iridium collars to assess habitat use, movements, and home range size; and (3) visiting bears in their winter dens to measure body condition and reproduction. Results of den visits are addressed in a companion report (Garshelis et al. 2017).

### Availability of Bear Foods

We visually assessed fruit production of 19 species (or species groups; Table 1) during the fruiting season (July–Aug, 2016) within fairly homogeneous stands of 12 different types of forests (the predominant forest types on the study area; Table 2). We situated 12 circular plots (3-m radius) within each stand such that 1 row of 4 were along the edge of the stand (if there was a clear edge), where light penetration was greatest and fruit production expected to be highest. We separately rated abundance (areal coverage within the plot) on a 0-4 scale (0= absent; 4=67-100%), and production of fruits (0 = no fruit; 4 = bumper crop) for each of these bear food species. We matched our scale to that of Noyce and Coy (1990), who sampled in the same area in the same way during 1984–1989. We estimated biomass of each type of fruit within each stand using Noyce and Coy's (1990) counts of fruits and measurements of mass corresponding to each productivity rating. We used Kruskal-Wallis tests to compare biomass estimates in this study with that of Noyce and Coy during the 1980s.

### **Bear Responses to Foods**

During May–Aug 2016 we captured a sample of bears in barrel traps and immobilized them with ketamine-xylazine. We measured, weighed, assessed body condition using bone prominence and skin-fold thickness (Noyce et al. 2002), and quantified body fat with bioelectrical impedance

analysis. We extracted a vestigial first premolar to estimate age. We ear-tagged all captured bears and collared all females and larger (older) males that we thought would not disperse from the study area. We used GPS-Iridium collars (Telonics Inc., Mesa, AZ) or VHF collars with an attached GPS pod (Telemetry Solutions, Concord, CA 94520), programmed to obtain locations at 2-hour intervals.

We postulated that diminished natural food supplies (compared to the 1980s) could affect bears in a number of ways: (1) result in reduced body fat and general condition; (2) prompt bears to expand home ranges; (3) prompt bears to select different habitats; (4) entice bears to rely more on human-related foods. We will test each of these hypotheses, but for this report we only deal with the last one. As an initial investigation into the use of human-related foods, we investigated bears' use of hunters' baits. Licensed hunters are permitted to set baits in mid-August, about 2 weeks prior to the start of the hunting season on September 1. They must register the location of their baits, so we were able to overlay these sites with the GPS locations of bears over the same time frame (12 Aug-15 Oct). We compared the proximity of bear locations to hunters' baits and to random points in the study to create resource selection functions (RSF; Manly et al. 2002). We used RSFs to quantify the degree of attraction of each individual bear to hunters' baits for 3 periods within the day (diurnal, nocturnal, crepuscular). We generated 95% kernel density estimates (Worton 1989) for GPS locations of each bear within these daily periods to delineate period-specific home ranges, and generated 1 random point per hectare within each home range as the availability data for the RSF. We controlled for confounding variables such as habitat type, distance to roads and trails, and how recently a timber harvest occurred in the area.

### RESULTS

### **Bear Foods**

We conducted fruit surveys in 102 stands in 2016 (Table 2). These, combined with the 68 stands sampled in 2015, showed a significant decline in both the abundance and productivity of bear foods since the 1980s. Raspberry and sarsaparilla, 2 important early-summer foods whose abundance (coverage) varies year to year, were much less abundant in 2015 and 2016 compared to even the lowest years of the 1980s (Figure 1). Conversely, the abundance of beaked hazel and round-leaf dogwood, both tall woody shrubs that do not die-back over winter, did not vary much in abundance year to year, and showed no trend in abundance across decades (Figure 2). However, fruit production of all species varied enormously year to year (Figures 3–4). Although beaked hazel remained abundant in the study area, hazelnut production was extremely low in both 2015 and 2016 (Figure 4).

Combining abundance and productivity scores, we derived biomass estimates (kg/ha) that were extraordinarily low in both 2015 and 2016; this was true even for young forests, which were also much less common on the landscape. Red pine plantations (8–20 years old), previously a robust source of raspberries, blackberries, and chokecherries, had almost nonexistent bear foods the past 2 years (Table 3, Figure 5). Likewise, regenerating aspen stands (5–15 years), a previous source of abundant raspberries, round-leaf dogwood, and hazelnuts, had greatly diminished biomass in 2015 and 2016 (Table 3, Figure 6). Overall, hazelnut biomass in the forest in 2015 and 2016 was about an order of magnitude less than the average in the 1980s, and even less than the poorest year of that decade (1985, Table 3).

### **Bear Responses to Foods**

We captured 28 bears (21M; 7F), and collared 19 (12M; 7F); 1 was killed in a collision with a car, 3 GPS units failed, and 3 bears were shot by hunters. We have not yet completed a rigorous comparison of sex- and age-specific weights or body condition with bears from the

1980s, but our impression is that despite the poor foods, recently captured bears were in good condition, especially in winter. One explanation for this may be their use of hunters' baits: 70% of bears (10 of 14 with adequate data during the fall) exhibited a significant selection for proximity to bait piles. Both females (88% of bear-time period combinations, n = 7 bears) and males (63%, n = 7) selected for hunters' baits during at least 1 time period (Figure 7). Male and female confidence intervals on RSF coefficients overlapped, but males intersected zero, whereas females did not.

Four bears (3M, 1F) consistently used areas distant from hunters' bait piles (positive coefficients, Figure 7). One of these (#6026) migrated 75 miles to corn fields near Brainerd and remained there for nearly 2 months (mid-Aug to mid-Oct) before returning to the study area (Figure 8). Another (#6005) was known to visit birdfeeders and dumpsters. A third (#6015) lived in a lowland swamp, where people generally do not hunt; notably, this bear's yearlings were much smaller (34 and 40 lbs) than those of a nearby female who visited baits (Figure 7, #6016; 72 and 91-lb yearlings). The fourth bear that stayed away from baits (#6007) was particularly thin in its den.

## DISCUSSION

This study provided strong evidence of a reduction of bear foods on the Chippewa National Forest since the 1980s. Some of the reduction in biomass was due to especially poor production of fruits in 2015 and 2016, and some due to diminished abundance of some key fruit-producing plants. Through further research we aim to discern why this occurred. Our initial hypothesis appears at least partly correct, that increased forest age and altered forest composition, with less light penetration and less edge, has altered both abundance and productivity of many bear foods. Notably, we intentionally situated some of our sampling plots along the forest edge, and we observed that this is where fruit abundance was highest. The fruit surveys in the 1980s did not do this, so we only compared our interior forest plots to the data from the 1980s. Beyond the effects of more mature forests, we found that even young stands (e.g., aspen regeneration; Table 3), produced a low biomass of key foods in 2015 and 2016.

Possibly in response to the extraordinary reduction in natural bear foods, bears readily took advantage of human-related food sources, especially hunters' baits. We cannot conduct a comparable analysis of proximity of bear locations to hunters' baits for the 1980s because those bait locations are unavailable (and also, the 1980s bears had VHF collars, which were located by airplane weekly, versus every 2 hours for GPS collars). Therefore, the high use of hunters' baits that we observed here may or may not represent a change in bear behavior. Notably, only 3 of the bait-using bears were shot by hunters because we asked hunters not to shoot collared bears (all of which were prominently marked with large, colorful ear tags).

The migratory movement of one bear to a cornfield this year was not novel; in fact, during the 1980s we observed this commonly (averaging ~40% of bears each year, range = 3-87% among years; mean male movement 16 miles; Noyce and Garshelis 2011). However, most migrations in the 1980s were to southerly oak stands, not human-related food sources. We hope to investigate possible changes in use of human-related foods through stable isotope analysis of hair samples collected in the 1980–1990s versus the present.

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Table 1. Bear food-producing plants sampled in the Chippewa National Forest, Minnesota 2015 and 2016.

Common name	Scientific name
Sarsaparilla American Spikenard Currant Gooseberry	Aralia nudicaulis Aralia racemosa Ribes spp. Ribes spp.
Blueberry	Vaccinium spp.
Red raspberry	Rubus idaeus
Common blackberry	Rubus allegheniensis
Red elderberry	Sambucus racemosa
Juneberry	Amelanchier spp.
Pin cherry	Prunus pensylvanica
Chokecherry	Prunus virginiana
Wild plum	Prunus americana
Alder-leaved buckthorn	Rhamnus alnifolia
Highbush cranberry	Viburnum trilobum
Downy arrowwood	Viburnum rafinesquianum
Beaked hazel	Corylus cornuta
Pagoda dogwood	Cornus alternifolia
Red osier dogwood	Cornus sericea
Round-leaved dogwood	Cornus rugosa

Table 2. Forest stands sampled for availability of bear foods in the Chippewa National Forest, Minnesota 2015 and 2016.

Stand type	2015	2016
Aspen (mature: 30+ years)	9	10
Aspen regeneration (5-15 years old)	12	10
Birch	6	10
Black ash	a	8
Black spruce-tamarack	2	10
Cedar	5	8
Clearcut	a	8
Lowland aspen	4	8
Lowland deciduous shrub	4	5
Maple	8	9
Pine (mature: 35+ years)	12	10
Pine plantation (8-20 years old)	6	6

<sup>a</sup> Not sampled

Table 3. Estimated biomass (kg/ha) for important summer and fall bear foods on the CNF, Minnesota, in key forest types where they tend to occur, comparing the 1980s to 2010s (2015 and 2016). In each decadal comparison shown, the mean for 2015 and 2016 was significantly less than that of the 1980s (P<0.05, Kruskal-Wallis test).

Food species	Stand type -	Mean		Lowest yearly mean (year)		Highest yearly mean (year)	
		1980s	2010s	1980s	2010s	1980s	2010s
Beaked hazel	Aspen regen	16.04	1.42	0.78 (1985)	0.60 (2015)	37.01 (1988)	2.17 (2016)
	Aspen	10.11	2.87	1.31 (1985)	0.60 (2015)	20.31 (1987)	4.69 (2016)
	Pine	11.56	1.02	2.09 (1985)	0.77 (2015)	22.87 (1988)	1.27 (2016)
Round-leaf dogwood	Aspen regen	5.74	3.01	0.34 (1985)	0.36 (2015)	11.99 (1987)	5.40 (2016)
Raspberry	Aspen regen	27.95	8.85	0.00 (1989)	7.97 (2016)	83.68 (1985)	9.83 (2015)
	Pine plantation	97.55	0.02	2.78 (1989)	0.00 (2015)	224.64 (1985)	0.04 (2016)
Sarsaparilla	Aspen regen	2.45	0.01	0.15 (1985)	0.00 (2015)	4.16 (1986)	0.03 (2016)



Summer Species Abundance

Figure 1. Yearly mean percent cover  $(\pm SE)$  of raspberry and sarsaparilla, important early summer bear foods, in forest stand types where they are commonly found in the CNF, Minnesota, 1984–2016.



Fall Species Abundance

Figure 2. Yearly mean percent cover  $(\pm SE)$  of beaked hazel and round-leaf dogwood, important fall bear foods, in forest stand types where they are commonly found in the CNF, Minnesota 1984–2016.



Summer Species Production

Figure 3. Yearly mean production index (0–4 scale;  $\pm$ SE) of raspberry and sarsaparilla, important early summer bear foods, in forest stand types where they are commonly found in the CNF, Minnesota 1984–2016.



Fall Species Production

Figure 4. Yearly mean production index (0–4 scale;  $\pm$ SE) of beaked hazel and round-leaf dogwood, important fall bear foods, in forest stand types where they are commonly found in the CNF, Minnesota 1984–2016.



Figure 5. Yearly mean biomass (kg/ha) of bear foods in red pine plantations in the CNF, Minnesota 1984–2016.



Figure 6. Yearly mean biomass (kg/ha) of bear foods in regenerating aspen stands in the CNF, Minnesota 1984–2016.



Figure 7. Resource selection function (RSF) coefficient estimates for the effect of distance to hunters' bait piles on habitat selection of black bears in the CNF, Minnesota, 12 Aug–15 Oct (the period during which hunters were allowed to maintain baits), 2016. RSFs are divided by sex and 3 periods of the day. The more negative the coefficient, the closer the bear's GPS locations were to bait piles versus random points in its home range (individual bear identification numbers shown). Four bears with positive coefficients in all 3 time periods used habitats away from baits. Red points and lines represent bootstrapped means and 95% CIs.



Figure 8. Long-distance migration of a GPS-collared male black bear from north of Grand Rapids to near Brainerd, Minnesota during autumn 2016. In mid-August, this bear left his summer home range and traveled south along a corridor of oak forest with poor acorn production (top panel). He spent 2 months primarily feeding in 2 corn fields <2 miles apart (bottom panels) before returning in mid-October, via the same path, to his home range to den.