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Effects of Forest Fuel Reduction on Black Bear Spatial Ecology at the White Mountains Wildland-Urban Interface- 2007 Report

1. Introduction

Since 2006, Arizona Game and Fish Department (AZGFD) has been investigating mechanisms of black bear (*Ursus americanus*) resource selection in response to wildland-urban interface (WUI) fuel reduction timber management in the White Mountains of east-central Arizona. The White Mountains are a forested landscape that have been intensively managed for >50 yr. Using a quasi-experimental study design, we are testing the widely held hypothesis that forest fuel reduction plots will be avoided by black bears by examining global positioning system radiotelemetry data. Our specific objectives are threefold: (i) determine differences in black bear selection of fuel reduction plots (patch or third-order selection); (ii) describe selection by season for individual plots (within patch or fourth-order selection); and finally (iii) examine whether there are any differences in selection of plots during diurnal or crepuscular/nocturnal periods. Because we are employing a BACI (before, after, control, impact) sampling design, and fuel reduction treatments have yet to be fully implemented, our report is restricted to the "before" phase of the research. That is, the information contained herein corresponds to black bear spatial ecology prior to the initiation of fuel reduction treatments.

2. Methods

2.1. Study area

The Black Bear Study Area (BBSA) is located in the White Mountains of east-central Arizona near the Arizona-New Mexico border (see figure 1 for composite [both sites combined] study area). The BBSA includes the towns of Greer, Nutrioso, and Alpine, which have relatively small year-round populations (<500), but experience an intense (>200,000 visitors) summer tourist season. The area is characterized by an elevational gradient ranging from 1300-3000 m, and habitat associations characteristic of Rocky Mountain montane and subalpine conifer forests (Brown et al. 1979). Areas above 2700 m are predominantly comprised of Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*). Douglas fir (*Pseudotsuga menziesii*), white fir (*Abies concolor*), and blue spruce (*Picea pungens*) associations occur between 2400 and 2750 m; ponderosa pine (*Pinus ponderosa*), Gambel oak (*Quercus gambelii*), and aspen (*Populus tremuloides*) occur at lower-elevations (<2400 m). The BBSA is almost entirely located within the Apache-Sitgreaves National Forest, which encompasses a major portion of the watershed providing water to the Phoenix metropolitan area (Salt and Gila

rivers). Land use within the Apache-Sitgreaves includes timber production, livestock grazing, and recreation.

The United State Forest Service (USFS) scheduled WUI fuels reduction treatments to begin in the BBSA in summer of 2007. The purpose of the treatments is to reduce risk of wildland fire to public and private lands adjacent to focal urban area, and to provide safety for firefighters undertaking wildland fire suppression operations. Need for this ameliorative action results from an accumulation of natural fuels in the area. Because of fire suppression and past logging techniques, fuel loadings and vegetative growth have increased in the BBSA, and risk for fire to burn uncontrollably is high. Accordingly, WUI fuels reduction treatments will focus primarily on 3 key objectives: (i) decrease the amount of dead and down material on the ground; (ii) increase crown base height by decreasing ladder fuels; and (iii) reduce crown bulk density within the canopy. Treatment areas will be irregularly shaped and range in size from 0.1-4.4 km^2.

2.2 Black bear resource selection

To date, we have placed spread spectrum GPS radiocollars on 21 (12 males, 9 females) of 35 captured adult bears. Radiocollars were programmed to acquire locations at intervals of every 4 h. Point locations were imported into a geographic information system (GIS) and used to delineate 95% fixed kernel (FK) home ranges. These home ranges were then used to identify "available" locations for each individual using a random-point generator in ArcGIS. To account for variation in habitat use through time, we stratified black bear location data into the following 3 seasons based on food habits and selection patterns for the region (LeCount and Yarchin 1990): (i) hypophagia (April to 14 June)- defined as den emergence, where black bears typically feed on carrion and herbaceous forage; (ii) early hyperphagia (15 June- August)- when black bears add myrmecophagy to their array of foraging options; and (iii) late hyperphagia (September to denning)- when black bears seek out soft mast.

For each season, we developed resource selection function (RSF) models following Manly et al. (2002):

$$w(x) = exp(\beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k)$$

where w(x) is the resource selection function for a vector of predictor variables (e.g., dominant vegetation, slope, elevation, aspect, distance to water, distance to roads), x_i and β_i values are the corresponding selection coefficients. Linear predictor variables were assessed for collinearity through Pearson's correlations (r) and variance inflator function (VIF) diagnostics. Variables with correlations $r > |0.6|$, individual VIF scores >10, or the mean of VIF scores considerably larger than 1 (Chatterjee et al. 2000) were assumed to be collinear. We evaluated models using Akaike's information criteria (AIC; Burnham and Anderson 1998): Akaike weights (w_i) were used to determine the approximate 'best' Kullback-Liebler model.

During the 2007 growing season (May-August), we established vegetation sample plots within future fuel treatment areas and reference forest stands. All reference forest stands are representative of habitat associations used by black bears and will not be disturbed by anthropogenic activities. We sampled a subset of bear point locations (n = 131) and used a GIS to generate random coordinates stratified within treatment and reference forest sites. At each plot, we established a 20 m transect running south-to-north with the 10 m location being the plot center. Five 0.5 m^2 herbaceous quadrats were

established along each transect at 5 m intervals. Within these quadrats, we recorded the presence of key black bear food items (see LeCount and Yarchin 1990). Presence of mast-producing species were measured in the shrub-layer (plants >0.5 m in height) along a belt transect 1 m × 20 m (20 m^2) in size. At each plot, we estimated mast production: berries and acorns were counted within quadrats or belt transects using hand-held tally counters and standardized to a per hectare basis. A sub-sample of ripe fruit was weighed to estimate average fresh weight productivity (kg/ha) for each species. Finally, we recorded presence of ants (in mounds and/or woody debris) using meander searches within 10 m of either side of the established transect (20 m × 20 m; 400 m^2). After treatments are implemented, we will compare the distribution of bear foods between treatment and reference plots. In this report, we restrict our comments to the distribution of bear foods at bear point locations versus random plots.

3. Results

A total of 4,217 locations have been obtained and radiocollared bears have ranged from New Mexico to the White Mountain Apache Reservation (figs 1 and 2). Home ranges sizes varied by sex with females averaging 77.3 km^2 (95% CI= 56.2-96.7 km^2), whereas males averaged 193.3 km^2 (95% CI= 161.8-229.4 km^2). Estimates of maximum distance moved per day varied by sex and seasonal interval. During hypophagia, estimated distances moved by males ranged from 2-11 km, whereas distances moved by females ranged from 1-7 km. By late hyperphagia, distances moved by males ranged from 9-23 km, whereas distances moved by females ranged from 10-18 km.

During hypophagia, probability of black bear occurrence increased in meadow/grassland and mixed conifer habitats of modest slope (<15°). The estimated odds ratio for meadow/grassland selection was 1.7 times greater than that for mixed conifer habitats. In contrast, for early hyperphagia, we found nearly equal probabilities of occurrence in meadow/grassland and mixed conifer habitats. During this seasonal interval, meadow/grassland and mixed conifer selection were 1.4 and 1.2 times greater, respectively, than for ponderosa pine. Finally, during late hyperphagia, the probability of bear occurrence increased in mixed conifer and oak habitats, with increasing slope (>15°), and decreased in meadow/grassland habitats. During all intervals, the probability of black bear occurrence increased with distance from roads and decreased with distance from water.

Ants, acorns (*Quercus spp.*), squawroot (*Conopholis mexicana*), grass, and gooseberry (*Ribes pinetorum*) had significantly higher occurrence at bear point locations than random sites (Table 1). Ants had the largest odds ratio at 13.9, with an observed difference in plot frequency of 38.9% for bear point locations and only 4.4% for random plots. Although not as substantial, acorns and squawroot also had high odds ratios of 6.7 and 5.4, respectively. Grass and gooseberry had smaller, but still significant odds ratios of 2.4 and 1.8. For bear point locations where mast-producing (hard and soft) species were present, soft mast (fruit) production for gooseberry averaged 63,600 berries/ha, while hard mast production averaged 118,300 acorns/ha. At reference plots, soft mast production for gooseberry averaged 21,800 berries/ha, and hard mast production averaged 49,400 acorns/ha.

4. Discussion

Using data collected in 2006 and 2007, we have been able to determine how black bears use available habitat types and physiographic features prior to fuel reduction treatments. Bears appear to be very specific in the selection of habitats and selection patterns are influenced by bear nutritional status (hypophagia and hyperphagia). As bears progressed from hypophagia through late hyperphagia, patterns of resource selection shifted from disproportionate use of meadows/grasslands to oak patches. However, it is important to note that bears consistently used mixed conifer habitats regardless of seasonal interval. The consistent use of mixed conifer habitats highlights its importance to bears. Bears likely prefer mixed conifer habitats because they are often characterized by multi-story canopies, moderate slopes (>15°), and dense horizontal cover. Such habitat types appear to meet requirements for both bedding and foraging sites, particularly when located near water features (LeCount and Yarchin 1990).

As in previous studies (Lindzey 1997, Zager 1980, Young and Beecham 1986, McLellan 1998, Neilsen et al. 2002), bears displayed a strong avoidance of roads and, interestingly. Avoidance of roads is understandable because nearly all anthropogenic activity (including forest management) in the BBSA occurs along roads (both primary and ephemeral roads). Thus it appears that avoidance of roads by bears is motivated by 2 factors: (i) general aversion to human activity and (ii) effects of forest management activities that occurs at roadsides. The latter is of concern since it is the focus of our study and represents a disturbance sustained over a greater temporal scale. Forest management practices that reduce structural complexity may degrade the value of habitat to bears, particularly when it occurs in mixed conifer habitats. We believe that "value" to bears occurs in 2 principal forms- forage availability and protective cover. When management activities reduce either, the focal habitat is degraded to some extent— we cannot comment on the magnitude of degradation, as perceived by bears, until post-treatment data are available.

While it is obviously important to determine which habitats bears preferred, it also is important to make note of habitats that were underutilized. We found that bears generally avoided ponderosa pine habitat. We suspect that avoidance of ponderosa pine was likely a result of a lack of structural complexity and food resources in that habitat type. With regards to the former, of the 37 day beds examined, 19 were located in mixed conifer habitat, 11 were located in oak stands, and 7 were located in ponderosa pine. As for the latter, the plot frequency of gooseberry averaged 25.6% in mixed conifer compared to 11.7% in ponderosa pine. Moreover, many of the meadow/grassland point locations visited by bears during hypophagia were adjacent to mixed conifer habitats, and we suspect that bears favor this juxtaposition so that they can forage close to protective cover.

We have established baseline data on black bear resource selection prior to the implementation of fuel reduction treatments. Based on our baseline data, we can make the following hypotheses of the effects of fuel reduction treatments on bear habitat selection:

H_1- treatments that reduce structural complexity will functionally degrade habitat value to bears;

H_2- treatments within mixed conifer will reduce availability of key bear foods;

H_3- treatments within ponderosa pine will have no impact on bear space use;

H_4- treatments within ponderosa pine will have no impact on the availability of key bear foods;
H_5- treatments within oak stands will have no adverse impact on bear space use provided the density of mast-producing trees is not altered; and
H_6- reduction of bear food availability in areas adjacent to human development will result in increased human-bear interactions (e.g. Peine 2001).
The collection and analysis of post-treatment data will allow us to address the above hypotheses.

5. Future work (2008)

We will snare and radiocollar bears in the spring of 2008. Currently, 8 radiocollared bears are roaming the BBSA, and we plan to collar 5-6 additional individuals. We will continue to non-invasively sample bear relative abundance using hair-snags.

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Figure 1. Movements of bear #30 (5 yr-old male) captured on the west side of Escudilla Mountain. Bear #30 made a long distance foray into New Mexico in early September. The radiocollar dropped off in early November, as programmed.

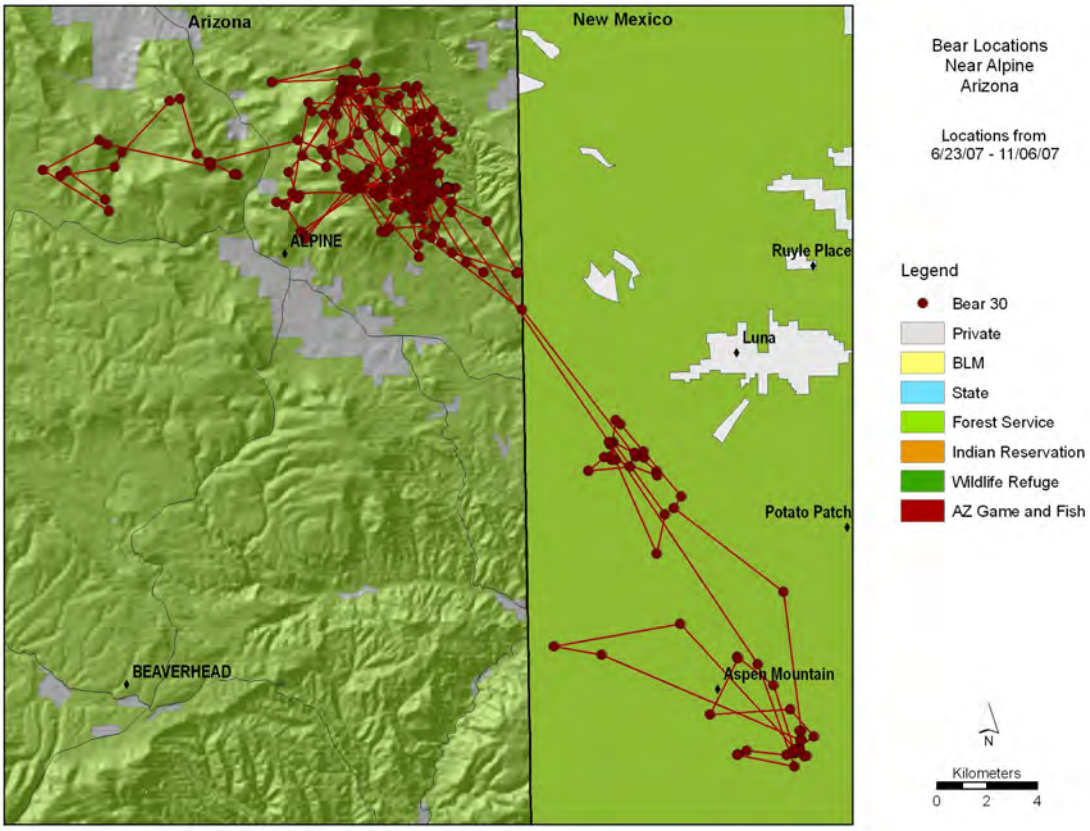

Figure 2. Movements of bear #19 (4 yr-old female) captured north of Winn Campground. Bear #19 made a long distance foray to the White Mountain Apache Reservation in September, and then returned to the Winn area to den.