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Note

Longevity and Reuse of Black Bear Dens in Managed Forests of Coastal British Columbia

HELEN DAVIS,[1] *Artemis Wildlife Consultants, 4515 Hullcar Road, Armstrong, BC, Canada V0E 1B4*
ANTHONY N. HAMILTON, *Ministry of Environment, P.O. Box 9338, STN PROV GOVT, Victoria, BC, Canada V8W 9M1*
ALTON S. HARESTAD, *Department of Biological Sciences, Simon Fraser University, Burnaby, BC, Canada V5A 1S6*
RICHARD D. WEIR, *Artemis Wildlife Consultants, 4515 Hullcar Road, Armstrong, BC, Canada V0E 1B4*

ABSTRACT We evaluated longevity and reuse of denning structures by American black bears (*Ursus americanus*) in coastal temperate rainforests of British Columbia from 1992 to 2010 to assess potential impacts of forest management on these critical habitat features over time. We identified 67 dens during a 4-yr intensive radio-telemetry study (1992–1995): 40 dens of 21 radio-collared black bears and 27 dens found incidentally. Dens occurred in or beneath large diameter trees or wooden structures derived from trees (i.e., logs, root boles, and stumps; $\bar{x} = 143$ cm diameter, SD = 49 cm). Longevity of dens varied by type, tree species that formed the den, and forest management that occurred at or near the den. Twenty-four of 28 dens of radio-collared bears that were monitored were still usable in 2010, whereas only 5 of 14 dens found incidentally were still usable in 2010. We assessed reuse of bear dens 3 times following initial identification: during the radio-telemetry study, again in 2000, and finally in 2010. Radio-collared bears reused dens from previous years on 7 of 25 potential occasions during the course of the radio-telemetry study. Upon assessment in 2000 and 2010, 17 of 24 (71%) available dens first used by radio-collared bears were reused at least once between 1993 and 2010. The high rate of reuse may indicate low availability of den structures in our study area. Because black bears in coastal British Columbia only used trees or structures derived from trees for winter dens and forest harvesting reduces the supply of these necessary structures, conservation and recruitment of suitable den trees is necessary if maintaining black bear populations is a management goal in these areas. © 2011 The Wildlife Society.

KEY WORDS American black bear, British Columbia, dens, forest management, reuse, *Ursus americanus*.

American black bears (*Ursus americanus*) hibernate to survive periods of low food availability and low temperatures by accumulating body fat, entering a period of dormancy in which metabolic expenditures are lowered, and drawing on these stored energy reserves. Consequently, winter hibernation is a vital aspect of the life history of bears and selection of winter den sites is important because dens meet several life requisites during the over-wintering period. Specifically, dens must confer thermal benefits, protect bears from inclement weather, and provide security from disturbance and predation (Johnson and Pelton 1981).

A wide range in frequency of reuse of winter dens by black bears has been reported. In various studies, reuse has ranged from nonexistent (Tietje and Ruff 1980, Kolenosky and Strathearn 1987), to low (15%; Crook and Chamberlain 2010) to high (47–71%; Schwartz et al. 1987). Lindzey and Meslow (1976) found that at least 6 of 12 dens of black bears were reused in an area of Washington with extensive forest harvesting.

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[1]*E-mail: hdavis@artemiswildlife.com*

Bears may occasionally use previously occupied dens for a variety of reasons. In areas with few denning opportunities, bears have few sites from which to select and therefore may reuse dens frequently. Many researchers have concluded that the rate of reuse may be linked to the supply of potential den sites. Several researchers have suggested that high rates of reuse may indicate low availability of suitable den sites (Johnson 1978, Beecham et al. 1983, LeCount 1983, Alt and Gruttadauria 1984). Alternatively, bears may reuse dens from year-to-year because a site was successfully used during 1 over-wintering period, so use continues in subsequent periods.

In coastal temperate rainforests of western North America, black bears hibernate through cool, wet winters that present denning animals with considerable environmental challenges that limit the range of structures suitable for denning. The combination of persistent rainfall, lack of permanent snow cover, and cool temperatures affects the types of structures that provide shelter from these abiotic factors. Because black bears in coastal British Columbia rely heavily upon large diameter trees or wooden structures derived from trees (i.e., logs, root boles, and stumps; Noble et al. 1990, Davis 1996), the broad-scale harvest of late-successional forests may diminish the supply of dens for black bears. Our objectives were

to 1) report reuse of black bear dens to determine whether special management actions were necessary to preserve an adequate supply of dens for coastal black bear populations, and 2) investigate the efficacy of past management actions at retaining existing dens.

STUDY AREA

Our 20,000-ha study area was located in the Nimpkish Valley (50° 14′, 126° 52′), 40 km south of Port McNeill on northern Vancouver Island, British Columbia, Canada. The study area was comprised of the Coastal Western Hemlock and Mountain Hemlock biogeoclimatic zones (Nuszdorfer 1991), with elevations ranging from 20 m to >1,500 m. Average annual precipitation was 1,780 mm, with 4–5% of that falling as snow. Dominant species of coniferous trees included Douglas-fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), mountain hemlock (*T. mertensiana*), western redcedar (*Thuja plicata*), yellow-cedar (*Chamaecyparis nootkatensis*), Pacific silver fir (*Abies amabilis*), and Sitka spruce (*Picea sitchensis*). Deciduous tree species were rare except in riparian zones.

Our study area had a long history of commercial forest harvesting typical of coastal temperate rainforests in British Columbia. Forests in the area had been harvested by clear-cutting since the 1920s and most clearcuts regenerated to conifer-dominated, structurally and floristically depauperate, second-growth stands with closed canopies. Approximately 45% of the forests in the study area were exposed to disturbance (primarily forest harvesting) between 1923 and 1995 (Green 2000). Most harvesting occurred in old-growth forests but harvesting of second-growth forests began in the 2000s. When forest harvesting began in the valley, tall stumps and large pieces of coarse woody debris were left in clearcuts because of lower utilization standards than present day.

METHODS

We identified winter dens of black bears using 2 methods. Between 1992 and 1995, we followed radio-collared black bears to their dens (Davis 1996). We also found other dens incidentally while collecting field data and forestry crews found dens while surveying proposed cutblocks during both denning and non-denning seasons. We initially radio-collared bears in 1992, so dens for each individual were first identified during the winter of 1992–1993. Thus, the first opportunity to observe reuse occurred during the winter of 1993–1994. For each den, we recorded den type, species and diameter of tree used, the amount and species of vegetation used as bedding material inside the den, and searched the immediate area for fecal plugs (Hamilton and Marchinton 1980). We photographed dens and den bedding to allow for comparisons among years.

We used several methods to assess reuse of known dens by black bears. During visits to dens of radio-collared bears in the spring, we noted that recently used dens contained green vegetation that the bears carried into the den for bedding. We used this obvious sign as the primary criteria to evaluate recent reuse in subsequent visits. We also considered reuse to have occurred if additional bedding had been added or modifications were made since we last visited the den. Furthermore, we looked for recent fecal plugs near the den and the presence of spider-webs and fungus growing within cavities to determine whether use was recent or not. Our estimates of reuse may be conservative because we were probably only able to conclusively detect reuse during the previous 2–3 yr.

We monitored each den structure for reuse by black bears during 3 periods. During 1993–1995, we tracked radio-collared bears to dens. Radio-collared bears were monitored for up to 3 consecutive winters, which allowed us to estimate an intensive, annual rate of reuse of dens by these bears. We then assessed a sample of known dens again in 2000 and in 2010. The same observer visited the dens during each assessment period to reduce observer bias. These subsequent visits allowed us to assess whether dens were reused at least once during the intervening period. We were unable to revisit all dens because of closed roads and funding constraints; we did not continue to assess dens that were decayed or destroyed.

We also examined the efficacy of several forest management prescriptions for conserving den structures. With the cooperation of forest managers, several dens identified during our radiotelemetry study were retained in or around proposed forest harvest units. Dens in hollow trees were retained as single trees within clearcuts, within retention patches in clearcuts, or on edges of clearcuts through boundary modifications. Some dens in logs were also retained in clearcuts. Prescriptions were typically applied in old-growth and second-growth stands that were scheduled for clearcut harvesting. We visited these dens to determine if they were still usable (i.e., structurally intact) in 2000 and 2010.

RESULTS

We identified 40 unique dens of 21 radio-collared black bears and incidentally located 27 dens of unmarked black bears during the 3 winters of 1992–1993, 1993–1994, and 1994–1995. Black bears used dens in or beneath large diameter trees or wooden structures derived from trees (i.e., logs, root boles, and stumps; $\bar{x} = 143$ cm diameter, SD = 49 cm). We categorized dens found between 1992 and 1995 into 5 types (Davis 1996): in live or dead hollow trees ($n = 37$, 55%), under the root masses of overturned trees (root bole, $n = 15$, 22%), in the base of high-cut tree stumps ($n = 8$, 12%), inside or under large logs ($n = 4$, 6%) or amongst the roots of standing live trees ($n = 3$, 4%).

During the radio-telemetry monitoring period, we had the potential to observe 25 incidents of reuse (i.e., the bear was monitored during a denning period subsequent to its first-detected den period). Radio-collared black bears reused dens on 7 occasions (28%). The proportions of reuse during the radio-telemetry study were not noticeably different between male and female bears (4 cases of reuse by 3 males, 3 cases of reuse by 3 females). Five bears used the same den twice (2 males, 3 females) and 1 adult male used the same den for 3 consecutive winters. We did not observe any radio-collared

bears reusing dens of other radio-collared bears during our radio-telemetry monitoring period.

We revisited known dens during 2000 and 2010 to verify whether they were still intact and useable and to evaluate reuse by black bears since initial den identification in the 1990s (Table 1). We assessed 28 dens of radio-collared bears during the 2 visits, 22 of which we visited in both 2000 and 2010. Additionally, we assessed 14 incidentally found dens in 2000 and 2010; we visited 8 in both years, whereas 6 were only visited once. Many dens showed conspicuous signs of reuse, with obvious recent, green bedding and several had clearly been reused the previous winter. In other cases, although reuse had occurred since the previous assessment, it was not possible to determine the year in which the den had been reused. Use of den sites among years was not limited to a single bear; we documented dens being used after the known occupant had perished.

Most dens of radio-collared bears and incidentally located dens were reused at some time between 1993 and 2010, with 17 of 24 (71%) dens of radio-collared bears reused during this period (Table 1). Similarly, 3 of 5 incidentally located dens were reused between 1993 and 2010; only 5 of 14 incidentally located dens were available for reuse by 2010 because 9 dens had either decayed, been cut down during forest harvesting, or had blown down after being retained during forest harvesting.

Longevity of den structures used by radio-collared bears varied by den type and tree species (Table 1). Of the 9 root bole structures that were used as dens between 1992 and 1995, 6 remained after 18 yr. Three were decayed or destroyed in second-growth harvesting, and thus no longer available for bears. However, only 3 of the 9 root bole dens were still well-suited for bear dens as of 2010; 3 were judged to be of low quality due to decay since use was first documented. In contrast, all 12 dens in hollow western redcedar and yellow-cedar trees, and 3 dens in stumps (2 Sitka spruce and 1 western hemlock) showed no significant signs of decay that made them unusable. Dens in standing trees remained usable through the entire assessment period, unless they were cut down during forest harvesting operations or blew down after retention as single trees. Of the 19 dens in or under standing trees, 5 were still usable as dens in old-growth forests as of 2010, 7 were retained by modifying forest harvest plans, 1 was felled and 6 could not be visited because of remoteness but were not known to be within harvested areas.

Dens that occurred in second-growth forests showed considerable decline in suitability over the assessment period (Table 1). Only 7 of 14 dens (50%) of radio-collared bears that occurred in second-growth forests in 1995 were fully intact and useable in 2010. Of the other 7, 4 were of much decreased quality (i.e., decay had increased the entrance size) but could possibly still be suitable, 2 were too decayed for use, and 1 was destroyed during second-growth harvesting.

The frequency of reuse varied considerably among different types of den structures used by radio-collared bears (Table 1). All 3 dens in large high-cut stumps showed evidence of recent reuse in 2000 and 2010. We assessed 3 log dens in 2000, all of which had recently been reused; however, by 2010, 1 den under a Douglas-fir log had decayed considerably and was marginally useable. Eight of 12 hollow tree dens were reused at some time between 1993 and 2010. However, we observed considerably less reuse of root bole dens: 3 of 9 root bole dens had been reused (3 were too decayed for use). We were unable to assess reuse of any dens located under trees because of their remote locations.

Reuse of dens by radio-collared bears also varied by disturbance history of the stand in which they occurred. Although reuse was high across the landscape, reuse was greater in second-growth stands (9 of 11 dens reused, 82%) than in old growth stands (8 of 13 dens reused, 62%). Four of the 8 reused dens that were within old growth forests when first used continued to be used after they were retained within clearcuts.

We investigated the efficacy of forest management prescriptions to conserve 15 dens between 1993 and 2010. One den that was found incidentally was not suitable for retention as a standing tree because of safety concerns, it was cut so that a stump approximately 2 m in height remained. This den had

Table 1. Number of dens suitable for reuse and frequency of den reuse by American black bears in the Nimpkish Valley, British Columbia, Canada between 1993 and 2010. Not all dens that were identified could be assessed for reuse during each assessment period.

		Old-growth dens			Second-growth dens					
Den type	No. revisited	Intact in old-growth	Retained in harvested areas[a]	Cut down in old-growth harvesting	Intact in second-growth	Of decreased quality	Decayed, not reuseable	Destroyed during second-growth harvesting	Total available for reuse	Reused ≥1 time
Dens of radio-collared bears										
Hollow tree	13	6	6	1					12	8
Log	3				2	1			3	3
Root bole	9	1			2	3	2	1	6	3
Stump	3				3				3	3
Total	28	7	6	1	7	4	2	1	24	17
Incidentally located dens										
Hollow tree	12	2	6[b]	4					5	3
Log	1		1							
Root bole	1						1			
Total	14	2	7	4			1		5	3

[a] Retained as a single tree, retention patch, or on edge of clearcut.
[b] Three trees blew down of the 6 retained.

not been reused when checked in 2000 and 2010. One den in a Douglas-fir log was retained in a clearcut but it was subsequently destroyed by a bear foraging for insects. A den in a hollow tree used by a male radio-collared bear was preserved through boundary modifications so that the den remained 30 m inside contiguous old-growth forest. A road was constructed approximately 50 m below the den the summer after we first documented use of the den; despite this, the bear reused the den for a second winter. Prior to the third winter of consecutive use, a clearcut was harvested 30 m away. The den was reused again between 1995 and 2000. Six dens in hollow trees were left as single trees within clearcuts; 2 of these had blown down by 2010. Five dens in hollow trees were retained as wildlife tree patches; none of these dens had blown down by 2010, although 1 was only checked in 2000 and could not be surveyed in 2010. One hollow tree den left on the boundary of a cutblock had also blown down by 2000. This den, and 1 other den in a hollow tree within the cutblock that also blew down, may be suitable for use by bears in the future as log dens.

DISCUSSION

Black bears in coastal environments prefer hollow trees for denning, likely for the thermal and security benefits that these structures confer relative to other structures (Johnson et al. 1978, Noble et al. 1990, Davis 1996), but large hollow trees are generally removed during forest harvesting operations. Hence, denning opportunities are likely substantially lesser in areas with extensive forest harvesting compared to less disturbed landscapes (Johnson and Pelton 1981). Depending on the forest utilization standards, few suitable structures (e.g., logs and high stumps) remain after forest harvesting, and these are likely much rarer in managed forests than hollow trees in old-growth forests. Thus, in second-growth forests, bears likely have a narrower range of structures in which to den and this may be reflected in a high rate of reuse of the few remaining structures.

The different types of structures used by bears for denning appeared to have different longevity rates, which likely further affected the rate of den reuse that we observed. Den structures can only be reused if they remain structurally sound. For example, dens excavated into the ground and brush piles may only last 1 or 2 yr before collapsing, whereas rock cavities may persist for many years (Alt and Gruttadauria 1984, Beck 1991). Longevity of tree dens in our study depended upon tree species and the type of den structure. Dens comprised of western redcedar may persist for hundreds of years because of this species' relatively high resistance to decay (Minore 1983). Living hollow trees appeared to have the highest longevity rate of den structures that we observed, and thus are the most likely to be available for longer durations than other structures. However, large old trees are also those most likely to be removed during forest harvesting. Because of their growth and decay characteristics, dens in hollow cedar trees may be very important structural legacies that should be protected during harvesting of future forest rotations.

In the temperate rainforests of coastal British Columbia, we found considerable reuse of den structures by black bears among years by the same bear and even among bears. The frequency of repeated use of dens during the telemetry study (28%; Davis 1996) was relatively high compared to that reported in several studies (e.g., 4.8%, Pennsylvania, Alt and Gruttadauria 1984; 15%, Louisiana, Crook and Chamberlain 2010) but not others. Over our longer period of monitoring, the high rate of 71% reuse of dens over the >15 yr was greater than that found in other studies in coastal temperate forests with extensive forest harvesting (e.g., $\geq$50%, coastal Washington, Lindzey and Meslow 1976), although their monitoring period was shorter.

Black bears may not reuse dens every year for a number of reasons. First, dens may not be reused because predators, such as other bears (Alt and Gruttadauria 1984, Davis and Harestad 1996) or wolves (*Canis lupus*; Horejsi et al. 1984), may repeatedly check low-security dens for occupants. In fact, 1 of only 2 dens not reused in second-growth forests was a root bole den at which a female and cubs were killed by another bear (Davis and Harestad 1996). Second, repeated use may increase the load of ectoparasites in the den structure, as suspected by Beck (1991). We encountered fleas (Siphonaptera: Vermipsyllidae *Chaetopsylla* spp.) in numerous black bear dens in the study area, although the presence and longevity of fleas was not assessed directly. Fleas that we collected were alive several months after bears had left their dens and may be able to remain dormant in dens for long periods, supporting the hypothesis that ectoparasite load may affect reuse. Other species of fleas have been found to rest for long periods as larva (up to 600 days; Bacot 1914). For this reason, it may be important to quantify reuse over longer periods of times; den structures may need to be vacant for several years for the ectoparasite load to diminish.

The high rate of den reuse that we observed may be linked to either the low supply of these structures, the benefits that known dens confer upon the individual, or both. Bears may reuse a specific den in consecutive years because the benefits of the den are known to the bear and the individual does not risk using an unknown den site. However, the most likely explanation is that the availability of den sites is constrained in the Nimpkish Valley. In portions of the study area with extensive second-growth forests, 9 of 11 (82%) dens were reused at least once, with several being used at least 4 times. This suggests that den structures are limited in these structural stages; high reuse may indicate low availability of suitable alternatives (Beecham et al. 1983, LeCount 1983, Alt and Gruttadauria 1984). However, although reuse rates in old growth were somewhat lesser than that in second-growth forests, the rate was still high (62%) which suggests that the overall landscape supply of dens may be diminished.

MANAGEMENT IMPLICATIONS

Conversion of late-successional forests to younger even-aged stands is detrimental to the supply of dens for black bears in coastal British Columbia. Conservation of adequate dens and denning habitat in forest management plans is appropriate because individual den sites are important structural legacies

to black bear populations and a lack of suitable den sites may lead to decreased black bear populations because of increased cannibalism (Alt and Gruttadauria 1984, Davis and Harestad 1996), predation by wolves (Horejsi et al. 1984), or deaths due to increased energetic costs from using less thermally advantageous dens (e.g., dens prone to inundation; Alt 1984). If maintaining current population levels is a management goal, then conservation and recruitment of adequate numbers of safe winter den sites across the landscape needs to be included in forest management plans. Our findings suggest that the most effective method for retaining highly persistent, hollow tree dens is to retain these important structures within contiguous forests or patches of trees rather than as single trees. In other forest types, researchers have found that retention patches >1 ha in size, placed in topographically sheltered locations, with minimized edge exposure to prevailing winds, are more windfirm (Steventon 2011). Further research on the longevity of wildlife tree patches is required in coastal forests to determine the most effective management prescriptions for long-term retention of individual den trees. However, managing habitat for black bears must include not only retention of current den structures but also recruitment of new den structures and the ecological processes that create those structures.

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