HABITAT UTILIZATION BY BLACK BEARS IN NORTHERN CALIFORNIA

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Abstract: A study was conducted during May-September 1974 as an integral part of a comprehensive population analysis of black bears (*Ursus americanus* Pallas) in Trinity County, California, by the California Department of Fish and Game. Habitat types on the study area were delineated and evaluated, and the selection and use of each type by black bears were estimated from all fresh bear sign encountered during trapping and radiotracking activities. Scats were collected and analyzed for frequency of occurrence and percentage volume of food items. Bear sign in wet meadows accounted for 55 percent of all sign found during May although wet meadows comprised less than 1 percent of the study area. Mixed conifer forest received heavy bear use during all periods except late August, when bears foraged for insects in decayed logs and stumps in high-elevation partial cuts. Black bears used manzanita (*Arctostaphylos* spp.) brush habitats extensively during late summer and fall to feed on manzanita berries. A failure of the manzanita berry crop in 1973 was believed to have caused a higher rate of subadult mortality and a lower rate of cub production in 1974.

Current land-use decisions in northern California are being made with little concern for black bears. Increasingly intensive silvicultural practices are disrupting black bear habitat — sometimes critical habitat. Few studies have dealt specifically with habitat use by black bears. Jonkel and Cowan (1971) measured habitat selection by relative trapping success in various habitat types in Montana. In western Oregon, McCollum (1973) based his investigation of habitat selection by black bears on tracks and other bear sign. Amstrup and Beecham (1976) studied habitat relationships of black bears in Idaho, and Poelker and Hartwell (1973) investigated the effects of sapwood and cambium feeding by black bears on commercial timber production in western Washington.

Objectives of this study were to delineate and quantitatively describe the habitat types in an area currently supporting a high density of black bears and to determine, by month, their selection and use of each type. Field work extended from May to late September 1974, with incidental observations being made well into November. This investigation was part of a more comprehensive black bear population study conducted by the California Department of Fish and Game (Kelleyhouse 1975).

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STUDY AREA

This study was conducted in a 192-km^2 area in Trinity County, California (Fig. 1). The area is bounded by the Stuart Fork of the Trinity River on the west, the East Fork of the Stuart Fork on the east, the Trinity Alps Wilderness Area on the north, and Lewiston Lake on the south. To expedite field work and data analyses, the study area was separated by Claire Engle Lake into the 83-km^2 Stuart Fork Unit and the 109-km^2 Buckeye-Lewiston Unit (Figs. 2, 3).

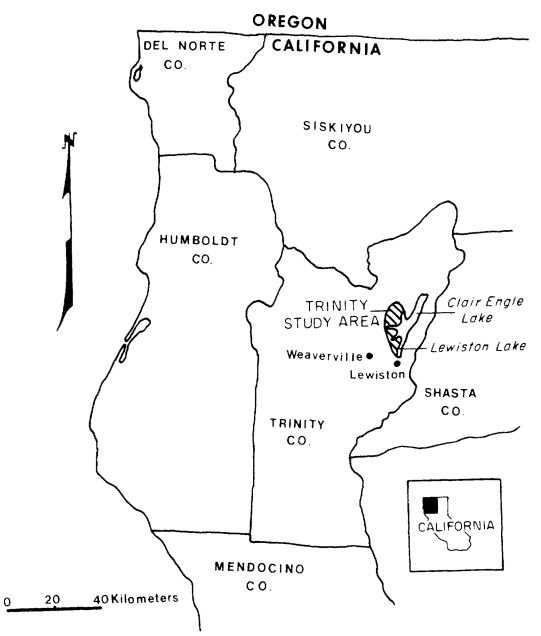

Fig. 1. Map showing location of the study area in Trinity County, northern California.

Topography in the area is generally steep and rugged. Elevations range from 579 m at Lewiston Lake to 2,466 m at Granite Peak. The Stuart Fork Unit has many small streams; the Buckeye-Lewiston Unit has fewer streams and is more arid. The area is characterized by hot, dry summers and cold, wet winters. Mean monthly temperatures in Weaverville, 20 km south of the study area, ranged from 44 C in July to

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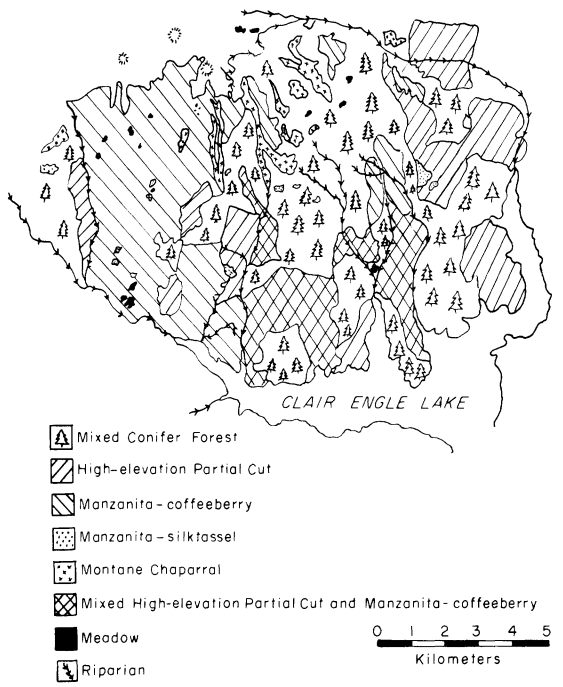

Fig. 2. Habitat types on the Stuart Fork Unit of the study area in Trinity County, northern California.

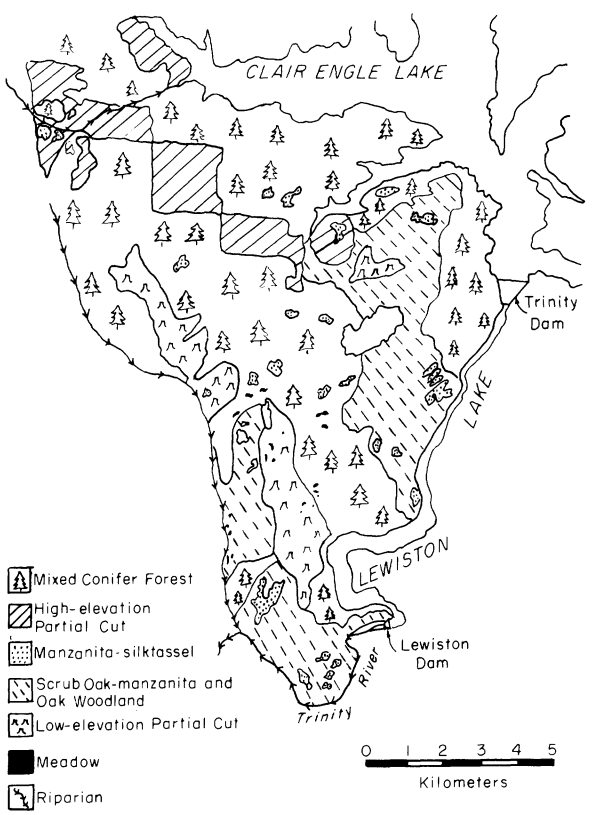

Fig. 3. Habitat types on the Buckeye-Lewiston Unit of the study area in Trinity County, northern California.

−23 C in January. Temperatures at higher elevations were lower.

The Upper Sonoran, the Transition, and the Canadian life zones (Merriam 1898) are represented on the study area. Much of the lower-elevation Buckeye-Lewiston Unit is typified by extensive stands of chaparral and by oak (*Quercus* spp.) woodlands that yield to mixed conifer forests of Douglas-fir (*Pseudotsuga menziesii*) and ponderosa pine (*Pinus ponderosa*) at middle elevations. The higher elevations are sparsely forested with red fir (*Abies magnifica* var. *shastensis*). Montane chaparral occurs in avalanche zones above 1,676 m (Ferlatte 1970).

METHODS

Types of vegetation on the study area were delineated with the aid of high-altitude, infrared photographs obtained from the National Aeronautics and Space Administration. The relative area occupied by each vegetation type was estimated with a planimeter. Vegetation in 8 of the habitat types discernible on the photographs was sampled using 5 random 30.5-m transects in each type. Each transect had 20 randomly selected 0.09-m^2 quadrats that were used to estimate the percentage of canopy cover of all plants with stems less than 5.1 cm dbh (diameter at breast height). A 0.08-ha circular plot was sampled on each transect to gather data on species composition and density and to estimate the percentage of canopy cover for woody species measuring 5.1 cm or greater dbh.

Seasonal food habits of black bears were determined from scats collected during 1972, 1973, and 1974. Food items present in each scat were recorded and frequencies calculated. Scats collected in 1973 and 1974 were subjected, by month, to a volume analysis for food items.

The selection and use of each habitat type by black bears was estimated from all fresh bear sign (1-3 days old) encountered during each month, May-September 1974. Habitat selection is expressed as the percentage of bear sign found in each of 9 habitat types sampled by month. Habitat use was determined from 69 sets of tracks, 35 radiolocations, 13 sightings, 52 feeding sites, and 106 scats.

If a food item available in only 1 habitat type was identified in a scat found in another habitat type, the scat was counted as use of both habitats. Evidence of bear use was recorded as use of 2 or more habitat types if found on an ecotone or within 30.5 m of adjacent habitat types. This situation commonly occurred in small wet meadows and manzanita patches. If sign was found in a restricted habitat type surrounded by forest,

it was recorded as use of that type and of the surrounding forest type.

Frequent travel on the numerous roads and trails in the study area during trapping and radiotracking activities provided a relatively uniform coverage of the area. Statistical analysis of habitat selection by black bears in relation to the amount of area occupied by each habitat type was considered inappropriate because data collection was not of a random or systematic design.

Information on the parameters and social organization of the black bear population was obtained through intensive livetrapping and radiotelemetry. Both techniques, as used during this study' were discussed by Kelleyhouse (1975) and Piekielek and Burton (1975).

RESULTS AND DISCUSSION

Description of Habitats and Their Use by Black Bears

Eleven habitat types were identified on the Trinity study area. Two of the types, red fir forest and montane chaparral, were not included in the study because of their inaccessibility. Ferlatte (1970) has described the vegetation of these 2 types. Red fir forest was mapped as mixed conifer forest because of the difficulty of differentiation (Fig. 2). Vegetation in dry meadows was not sampled because bear use of this habitat type was not detected.

Habitat components suspected of being important to black bears are mentioned in text. The lengthy tables resulting from analyses of vegetation and food habits were presented by Kelleyhouse (1975).

Meadows. — Both dry and wet meadows were found on the study area and were widely distributed although they covered less than 1 percent of the area (Figs. 2, 3). Wet meadows occurred at middle elevations (900 m) in the Stuart Fork Unit and ranged in size from 0.05 to 20.20 ha. Grasses and forbs (*Bromus, Carex, Equisetum, Festuca, Juncus, Poa, Trifolium,* and others) covered 59 percent of the wet meadows sampled.

Fifty-five percent of all bear sign encountered during May and 18 percent encountered during June was found in wet meadows (Fig. 4). Grasses and forbs comprised 52 percent and 48 percent, respectively, of the May 1974 diet and 52 percent and 22 percent of the June 1974 diet. This intensive use of wet meadows as a feeding habitat by black bears in spring is probably the result of the abundant herbaceous forage available in meadows at this time of year. Through intensive trapping and radiotelemetry, an old adult male, an adult female, a 4-year-old male, and a 2-year-old female were all known to use the same 0.8-ha wet meadow during June.

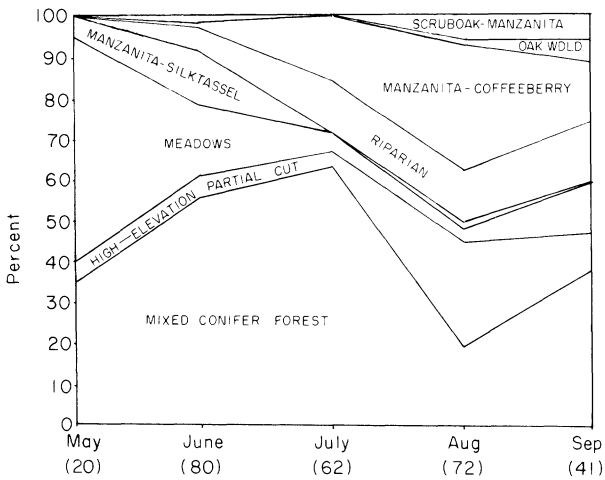

Fig. 4. Proportion of bear sign found in specified habitats on the study area in Trinity County, northern California, 1974. Monthly sample sizes are shown in parentheses.

Use of wet meadows by black bears declined as grasses and forbs desiccated during late June. Reports from Forest service personnel indicated that many bears then moved to higher elevations, apparently in response to later maturation of plants at those altitudes. Mountain meadows provided palatable grasses and forbs well into July.

Some wet meadows at middle elevations contained small ponds that bears used for wallowing. Sign of wallowing accounted for much of the bear use recorded in wet meadows from July through September (Fig. 4).

Because wet meadows are relatively scarce and are obviously favored as a feeding habitat during May and June, they may constitute a seasonally critical habitat for black bears in this area.

Riparian Areas.— Riparian habitat covered less than 1 percent of the study area (Fig. 2). Most of it was found in the Stuart Fork Unit. The lower-elevation Buckeye-Lewiston Unit, with fewer creeks, had fewer riparian areas (Fig. 3). The extent and species composition of riparian habitat varied with the width of the associated watercourse.

Tree species common to riparian habitat and listed according to their abundance were Douglas-fir, alder (*Alnus* spp.), Pacific dogwood (*Cornus nuttallii*), and Pacific yew (*Taxus brevifolia*). Tree density was 440 trees/ha, and estimated canopy cover was 41 percent.

Riparian areas associated with the larger streams supported a rich understory of creek dogwood (*Cornus sessilis*), California hazel (*Corylus cornuta* var. *californica*), and various species of *Rubus* and willows (*Salix* spp.). Grasses and forbs covered 19 percent of the ground. A run of king salmon (*Oncorhynchus*

tschawytscha) congregated at the base of the Lewiston Dam on the Trinity River in late September and early October during each year of study.

Riparian areas were used by black bears as feeding habitat and travel lanes from June through September (Fig. 4). Although grasses and forbs in most middle-elevation wet meadows had desicated by mid-June, herbaceous forage in shaded riparian areas remained palatable and was eaten by bears well into July. Similarly, Tisch (1961) reported that creek bottoms in Montana provided black bears with important herbaceous foods in summer.

Creek dogwood was an important food plant in riparian areas. Creek dogwood berries were taken by black bears during August and September of all years, but were taken in greater quantities during 1973 because of a failure of the manzanita berry crop throughout the area.

Some adult male bears, including 1 radiocollared animal, moved as far as 17.7 km during the last week of September to feed on king salmon spawning below Lewiston Dam. Few scats containing fish were found, however, because the bears bedded away from the river and presumably defecated in that vicinity.

Well-defined bear trails in most riparian areas indicated extensive use of this habitat type as cover while traveling. Black bears may also use streams for thermoregulation during periods of heat stress. On 2 occasions, black bears recovering from the effects of drugging immersed themselves in shaded streams, presumably to reduce body temperature. One recently used muddy bathing hole was found in a small creek outside of the study area when the temperature was approximately 40C.

Mixed Conifer Forest.— Mixed conifer forest covered approximately 30 percent of the study area (Figs. 2, 3.). Tree density on sample plots was 906 trees/ha, and estimated canopy cover was 68 percent. Common tree species listed in order of abundance were Douglas-fir, California black oak *(Quercus kelloggii),* and ponderosa pine. Golden chinquapin *(Castanopsis chrysophylla)* and Pacific dogwood were the most common species of shrubs in the sparse understory.

Logs and stumps in various stages of decay covered 8 percent of the ground. Ants (Formicidae), other insects, and their larvae living in these logs and stumps were eaten by bears. Leaves, twigs, and acorns from Oregon white oak *(Q. garryana)* and California black oak covered 50 percent of the ground, indicating that acorns were readily available to bears.

Black bears made considerable use of mixed conifer forest during all periods except late August (Fig. 4). Bears used this habitat for traveling, resting, and escape cover during all months and as feeding habitat during July-early August (insects) and October-November (acorns). No evidence of sapwood or cambium feeding was noted such as that reported in western Washington by Poelker and Hartwell (1973).

Most bear sign was encountered near ecotones of mixed conifer forest with wet meadows, manzanita brush fields, and high-elevation partial cuts. McCollum (1973) found concentrations of bear sign near ecotones of mixed conifer forest with other habitat types in southwestern Oregon. All bear beds found in mixed conifer forest were within 30.5 m of a potential seasonal food source that was usually located in a different habitat type such as a meadow or berry patch.

Although no dens were inspected on the study area, nearly all dens found in surrounding areas were in mixed conifer forest. One exception, reported by a logger, was a den located in the base of a Douglas-fir in an older high-elevation partial cut in the Stuart Fork Unit. Bear sign found soon after bears emerged from their dens indicated that most black bears probably denned in mixed conifer forest.

Partial Cuts.— An estimated 40-50 percent of the study area had been logged since 1950, creating a mosaic of seral vegetation types (Piekielek and Burton 1975). Selective logging resulted in 2 types of partial cuts: low-elevation cuts (below 762 m) and, on more mesic sites, high-elevation cuts (above 762 m) (Figs. 2, 3).

Low-elevation partial cuts had 741 trees/ha, and estimated canopy cover was 49 percent. The understory lacked species diversity. No bear use of this habitat type was noted.

Mean tree density in high-elevation partial cuts 3-9 years old was 583 trees/ha; estimated canopy cover was 44 percent. The sparse understory included Pacific dogwood, California hazel, and wild rose (*Rosa* sp.). Logs and stumps covered 18 percent of the ground.

Bear use of high-evelation partial cuts was relatively high only during August, when increased foraging by bears in logs and stumps was noted. August was the only month during which this habitat type received more use than the mixed conifer forest (Fig. 4).

Berry-producing plants and herbaceous plants known to be used by bears were not abundant in partial cuts on the study area, although such species commonly occur on clearcut areas in southwestern Oregon (McCollum 1973). Observed differences in secondary plant succession between the 2 areas are probably caused by en-

vironmental factors rather than silvicultural practices. The lack of vegetative food sources for bears after disturbance of timbered sites in the study area may be typical of other arid areas in California. If so, extensive logging in such areas probably has at least a short-term (1-10 years) adverse impact on black bear populations.

High-elevation partial cuts 15-25 years old resembled mixed conifer forest and were used by bears in essentially the same ways. All recently logged areas were avoided by bears. Jonkel and Cowan (1971) also noted that black bears made little use of recently logged areas, whereas bear use of a 10-year-old logged area was essentially the same as that of the surrounding spruce (*Picea* sp.)-fir (*Abies* sp.) forest. McCollum (1973) reported that the incidence of bear sign in clearcuts decreased dramatically beyond 183 m from cover.

Manzanita Brush Types.— Three manzanita brush types covering an estimated 36 percent of the study area and occurring at elevations of 579 m to 1,676 m were identified and mapped. The manzanita-coffeeberry (*Rhamnus californicus*) type, with 348 trees/ha and an estimated canopy cover of 15 percent, provided more cover than either of the other brush types. This habitat was located in the western one-third of the Stuart Fork Unit at elevations of 760 to 1,520 m (Fig. 2). The manzanita-silktassel (*Garrya* sp.) type occurred in small patches in both study units at mid-elevations (Figs. 2, 3). The scrub oak (*Q. dumosa*) - manzanita type was located at elevations below 600 m in the eastern portion of the Buckeye-Lewiston Unit (Fig. 3). Oaks in this habitat type were canyon live oak (*Q. chrysolepis*), scrub oak, and Oregon white oak.

Black bears in the study area depend heavily upon manzanita berries as a staple food during late summer and fall. Manzanita-silktassel habitat was also used during early summer, when black bears were observed to eat unripened manzanita berries (Fig. 4). Manzanita-coffeeberry habitat appeared to be the most frequently used of the manzanita brush types (Fig. 4). The scrub oak-manzanita habitat sustained some bear use as adult males began moving into the lower elevations of the Buckeye-Lewiston Unit during September (Fig. 4). Black bears in many other regions of the West depend upon various species of *Vaccinium* for a late-summer and fall staple food (Jonkel and Cowan 1971, Poelker and Hartwell 1973).

Analysis of scats collected during 1972 and 1974 indicated a high incidence of manzanita berries in summer and fall scats. Manzanita berries were present in 97 percent (1972) and 83 percent (1974) of the August scats and in 96 percent and 57 percent of the September scats. Manzanita berry production was greatly reduced after the extremely low temperatures and light snow pack of the winter of 1972-73. Leaf galls were present on most manzanita plants during the following summer. Manzanita berries occurred in only 33 percent of the scats collected during August 1973; creek dogwood and coffeeberries occurred in 50 and 67 percent of the scats, respectively.

Oak Woodland.— The oak woodland habitat type covered approximately 5 percent of the total study area but was found only in the Buckeye-Lewiston Unit. Because oak woodland and scrub oak-manzanita habitats were found in close association, they were combined on the habitat map (Fig. 3). Oregon white oak, the most abundant tree species, occurred in dense stands of 764 trees/ha. Estimated canopy cover was 33 percent. The understory was sparse, but oak litter covered 63 percent of the ground. Acorns began dropping during early September in 1974. Bear use of oak woodlands increased thereafter (Fig. 4). Use of oak woodlands by bears was highest where fingers of mixed conifer forest extended into the woodlands, thus providing escape cover in close proximity to food. Bears continued to feed in oak woodland habitat until denning.

In summary, black bears in the study area selected wet meadows in May and June shortly after emerging from dens. Bears then moved into riparian areas and high mountain meadows in late June to feed on palatable herbaceous plants. Mixed conifer forest then received its share of use when bears sought insects in decayed logs and stumps. This type was also used as traveling cover throughout the year. High-elevation partial cuts were used by bears for a brief period in August in their quest for insects. Manzanita brush habitats provided the bulk of early-fall staple food until acorns became available in late September in oak woodland and mixed conifer forest. Most bears then presumably denned in mixed conifer forest habitat.

Parameters of the Bear Population and Home Range Use

A total of 70 black bears were captured during the population study. All resident bears and most transient bears using the study area were believed to have been captured (Kelleyhouse 1975). Estimates of population density in the Stuart Fork Unit ranged from 0.8 bear/km^2 in 1972 (Piekielek and Burton 1975) to 0.4 bear/km^2 in 1974 (Kelleyhouse 1975).

The sex ratio of captured bears (43 males, 27 females) differed significantly from an even ratio at the

0.05 level. The preponderance of males may be explained by longer mean movements and larger home ranges than those of females or by a slightly uneven sex ratio. The mean summer home range size for 4 adult males was 10.6 km^2; summer home range size for 6 adult females averaged 3.6 km^2.

The study area was considered a complete ecological unit for black bears because of its large size, altitudinal extremes, and habitat diversity and interspersion. The more mesic Stuart Fork Unit supported high numbers of black bears throughout the year. The Buckeye-Lewiston Unit served primarily as a fall foraging area for adult male bears that moved long distances to feed on seasonally abundant salmon, manzanita berries, and acorns (Piekielek and Burton 1975). Stickley (1961) and Erickson and Petrides (1964) reported similar fall movements by black bears in the East.

Summer home ranges of sows on the study area may actually represent annual home ranges since no sows were killed by hunters or observed outside of their summer ranges. Summer home ranges of adult sows were located at elevations of 760 m to 1,680 in the Stuart Fork Unit. Sows selected home ranges with extreme habitat diversity; all ranges included wet meadows, riparian areas, mixed conifer forest, and at least 1 of the manzanita brush types within a relatively small area. Theoretically, habitat diversity within the home range favors cub survival by reducing the length of foraging expeditions during the cubs' first year of life.

The summer home ranges of adult male bears 4 years old or older were larger than those of sows. Some males had separate fall home ranges connected to their summer ranges by a migratory corridor similar to that described for grizzlies (*Ursus arctos*) by Craighead and Craighead (1972). This arrangement allows males to take advantage of widely spaced sources of seasonal foods (such as king salmon and manzanita berries) and may actually allow more males than females to occupy an area.

Transient subadult bears 1-3 years old made frequent movements in the study area, although there is evidence suggesting that some subadult females may coinhabit their sow's home range through the second year of life. When food is scarce and the population of resident adult bears is relatively dense, intolerance by adults may force subadults to use suboptimal habitat. Skinner (1952), Jonkel (1962), and Erickson (1965) have reported various degrees of intraspecific intolerance among black bears. Two subadult bears were captured repeatedly in seasonally suboptimal habitat types. A 2-year-old male remained near a desiccated meadow for 1 week in late June after adult bears had left the area, and a 3-year-old female remained in an area of mixed conifer forest after resident adults had moved to patches of manzanita-coffeeberry in late August to feed on ripening berries.

Reported fluctuations in black bear numbers can perhaps be explained by differential mortality of subadults. Transient subadults constituted a large but variable portion of the black bear population. They comprised 39 percent of all bears captured during 1973, after the good manzanita berry crop in 1972, but only 22 percent the next year, after the poor berry crop of 1973.

The failure of the manzanita berry crop in 1973 coincided with reduced survival of cubs born in 1973 and was followed by reduced production or early survival of cubs in 1974. No yearling bears were captured or observed on the study area during 1974, suggesting high mortality of cubs born in 1973, and only 1 set of cubs was known to be on the study area during 1974. The manzanita berry crop was estimated to have been highest in 1972, lowest in 1973, and intermediate in 1974. Jonkel and Cowan (1971) reported a similar relationship between huckleberry (*Vaccinium* spp.) crops and black bear reproduction in Montana. Hence, it appears that major food shortages are linked to low cub production or survival and high subadult mortality, resulting in low subadult to adult ratios in black bear populations. Successive failures of manzanita berry crops could therefore decrease population size by affecting only subadult survival.

CONCLUSION

Bray and Barnes (1967) noted that forested habitat is a common denominator in all descriptions of black bear habitat. However, the logging industry is placing ever-increasing demands upon the mixed conifer forests in northern California. Despite the extensive cutting of mixed conifer forest on the study area during the past 20 years, logging continues at an accelerated rate. In this study, recently logged areas were found to be of only limited seasonal value to bears whereas mixed conifer forest habitat was used continually. I therefore believe that the bear population in this area is likely to be adversely affected by large-scale logging operations.

Another habitat type being lost to logging and logging road construction is wet meadow habitat. It is noteworthy that sow home ranges were located in an elevational belt that included all the wet meadows in

the study area but were absent in the low-elevation Buckeye-Lewiston Unit where all major habitats except wet meadows were represented. This important habitat type could be protected and its use by bears ensured by leaving a buffer zone of timber around each meadow and by locating new roads and log landings a reasonable distance from meadows.

Construction of new logging roads and continued maintenance of existing roads results in ready access to black bear habitat. Hunting black bears with hounds is a popular sport in northern California, but extensive forest road systems may allow this hunting method to become too efficient. The potential for overharvest is a real problem. Although main forest roads must be maintained for fire control, many of the spur roads and skid trails should be gated or bermed. Bears now have ample escape cover in the region, but true refuge cover is rapidly being lost through expansion of forest road systems.

A recent development near the study area is the conversion of manzanita-silktassel habitat to monotypic ponderosa pine plantations. If this stand conversion proves successful and is later accepted for large-scale operations, the further loss of important habitat will be certain to affect resident bears adversely.

Reducing the harvest of black bears after failures of the manzanita berry crop seems a reasonable way of compensating for the adverse effects of poor berry crops on production and survival of young. Although black bears are difficult to census on an annual basis, berry production can be gauged and bear management made more responsive, particularly in heavily hunted areas.

Successful management of black bears in California requires cooperation between land and wildlife managers in the recognition and conservation of the various habitat types necessary to meet all seasonal needs of black bears. In addition agreements must be reached to protect black bears from overharvest by regulating access to bear habitat.

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