BLACK BEAR ASSESSMENT AND STRATEGIC PLAN 1999

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INTRODUCTION

Since 1968, the Maine Department of Inland Fisheries and Wildlife (MDIFW) has aggressively pursued development and refinement of wildlife species assessments and implementation of cost-effective comprehensive programs that support selected goals and objectives for the next 15 years. Assessments are based upon available information and the judgments of professional wildlife biologists responsible for individual species or groups of species. Precise data may not always be available or are too limited for meaningful statistical analysis; however, many trends and indications are sometimes clear and deserve management consideration.

The assessment has been organized to group information in a user-meaningful way. The Natural History section discusses biological characteristics of the species that are important to its management. The Management section contains history of regulations and regulatory authority, past management, past goals and objectives, and current management. The Habitat and Population sections address historic, current, and projected conditions for the species. The Use and Demand section addresses past, current, and projected use and demand of the species and its habitat. A Summary and Conclusions sections summarizes the major points of the assessment.

NATURAL HISTORY

Description

The American black bear (*Ursus americanus*) is the smallest of the three species of bears found in North America, and is the only bear inhabiting the Eastern United States (Pelton 1982). Black bears have compact bodies, stocky limbs, a massive skull, and short, round ears (Kolenosky and Strathearn 1987). Males grow 50% larger than females, reaching 6 ft from nose to tail, and stand 40 inches at the shoulder; females will reach 5 ft in length, and rarely stand more than 30 inches at the shoulder (Kolenosky and Strathearn 1987). Males normally weigh 250-350 pounds, with large specimens weighing over 500 pounds; adult females weigh 150-200 pounds but can exceed 300 pounds or more in unusual circumstances (Kolenosky and Strathearn 1987).

Maine black bears are nearly always black in color with a brown-blond muzzle; about one in four have a white chest patch, or “blaze” (MDIFW file data). However, elsewhere in North America, black bears exhibit a variety of color phases. In western States and Provinces, black bears are commonly some shade of brown, ranging from a deep chocolate through a reddish-brown “cinnamon” phase to blonde (Pelton 1982, Kolenosky and Strathearn 1987). A white color phase is found in coastal British Columbia, and coastal Alaska and British Columbia are home to a bluish-gray phase of the black bear (Kolenosky and Strathearn 1987).

Black bears have dense, coarse fur, with guard hairs that can grow up to four inches long during the late winter, and a woolly undercoat that insulates them from cold

temperatures and wet weather. They are plantigrade (walk on the flat of their feet), and appear clumsy. However, bears are capable of short bursts of speed, and have been clocked at nearly 35 miles per hour (Kolenosky and Strathearn 1987). Black bears are strong swimmers, and have been observed swimming over 1.5 miles to reach offshore islands (Lindzey and Meslow 1977). They have short curved claws, useful for digging in soil, extracting insects from decaying wood, and climbing trees (Rogers 1987).

Bears have well developed senses of smell and hearing (Kolenosky and Strathearn 1987). They can distinguish color and have good near vision, but black bears do not distinguish objects at a distance as well as humans (Bacon and Burghardt 1976).

Bears pass the winter months of food shortage by entering a lethargic state (torpor), usually within an enclosed den. Across North America, their denning period may last from less than a month to over 7 months, depending upon latitude and seasonal abundance of food. In Maine, bears usually enter dens from mid October - late November, and emerge in late April. They usually do not eat, drink, urinate, or defecate for the entire period (Folk et al. 1972). Bears undergo several physiological changes during the denning period to minimize energetic demands. Their body temperature drops slightly, and their breathing and heart rate are dramatically depressed (Folk et al. 1972). Although denned bears are in a deep sleeping state, they are easily aroused and will sometimes leave their dens if disturbed.

Distribution and Status

Historically, black bears occurred throughout all forested regions of North America (Pelton 1982). Following European settlement, bear numbers and distribution were reduced by deforestation and excessive killing. By the late 1800's, black bears were absent from much of their former range in the southeastern United States, and their populations were severely restricted in most of the remainder of the East. Early in the twentieth century, the Industrial Revolution and concurrent decline of agriculture allowed northeastern forests to reclaim abandoned farmland. Bears were given greater protection by the 1950s, and have repopulated much of their historic range in the North. Black bears are slowly recolonizing vacant habitat in Missouri, Kentucky, Ohio, New Jersey, and Maryland. Southeastern bear populations have expanded in the lower Appalachian Mountains, but many coastal plain populations remain isolated due to permanent loss of forested habitat and travel corridors. Habitat conversion has not been a significant factor for black bear conservation in the western United States and throughout Canada and Alaska, where bears remain in good numbers. The current North American black bear population numbers about 750,000, and regional populations are secure in all but the extreme south and southeastern United States.

Food Habits

Black bears are omnivores. Vegetation makes up most of their diet, but they will eat a variety of animal matter obtained as carrion or prey (Pelton 1982). Insects and colonial beetles are a small but important part of their diet, and bears also consume a variety of mammals, birds, reptiles and amphibians (Pelton 1982). Although they have

traditionally been considered inefficient predators of mammals (Pelton 1982), black bears are important predators of juvenile deer, moose, caribou, and elk (Ballard 1994).

In the Northeast, bears begin feeding in early spring on new herbaceous growth in moist forest openings and wetlands; on the buds and new leaves of aspen, birch and maples; and on nuts remaining on the forest floor from the previous fall's crop (Spencer 1955, Hugie 1982, Lamb 1983, Caron and McLaughlin 1985). As spring progresses to summer, bears take advantage of ripening berries and the abundance of insect life. They begin to eat hazelnuts and apples in early September, and start to climb for beechnuts, often breaking the tops of beech trees as they feed. Most berries dry up in mid-September, and nuts drop to the forest floor to become the dominant late fall food of bears.

Although acorns and apples are an additional fall food source in southern and western portions of the State, in northern Maine bears are restricted to one major food item: beechnuts. Beechnut crops fluctuate widely in abundance; in Maine, years of plentiful beechnut crops are often followed by years when beechnuts are scarce to nonexistent. When shortages of natural foods occur, bears often eat human-associated foods (e.g., garbage, bird food, bee hives, cultivated crops) that are high in protein, fat, and/or carbohydrates.

Habitat Requirements

The black bear is closely associated with forestland throughout North America. Forests supply black bears with food and escape cover, and provide shade that may help regulate their body temperature. Bears do not persist in open grasslands or open

agricultural areas without tree cover. The species occurs throughout a range of forest types across the continent, from the cypress swamps of the Southeast to the temperate deciduous forests of the East and coniferous forests of the North and West.

In the Northeast, bears use forest stands of different ages, size classes and species composition, depending upon the season (Hugie 1982, Lamb 1983, Elowe 1984, Schooley 1990). Their movements and activities are largely determined by the distribution and developmental stages of vegetation that they use as food. In the spring, bears will visit the edges of wetlands, roadsides, recently clear-cut areas, and agricultural fields to feed on newly emerging grasses and herbaceous vegetation. They also frequent regenerating stands of aspen and mature hardwoods to eat buds and new leaves. If the previous fall's beechnut or acorn crops were abundant, bears will move to mature beech or oak stands to eat nuts that over wintered on the forest floor.

During the summer months, bears continue to use roadside openings and regenerating forests, including recently clearcut and partially cut stands of hardwood and softwood. These areas provide an abundance of berries and insects, and usually contain dense understories for escape cover. By fall, bears move to mature hardwood-dominated stands to take advantage of beechnut and acorn crops, and to a lesser extent, beaked hazelnuts and persistent berries of mountain ash and cherries. If nut crops are scarce, bears may forage on cranberries and winterberries along the fringes of wetlands. They will also visit the fringes of agricultural areas to feed on apples, corn and oat crops, but rarely venture far into open areas devoid of protective cover.

Throughout the year, bears are never far from dense cover; swamps, thickets and regenerating clearcuts are preferred resting sites. Mature softwood stands provide

escape and resting cover, but little food regardless of the season of the year. Timber harvesting improves softwood stands as bear habitat by opening the canopy and stimulating growth of understory vegetation, providing spring and summer foods. Harvesting of hardwood stands can likewise be beneficial to bears provided enough mature trees remain following cutting to ensure nut production.

Black bears den in a variety of cover types, and choose den sites on the basis of existing structure, which is not limiting in Maine. Dens can be located in alder swamps, spruce-fir thickets, regenerating clearcuts, partial cuts or mature stands of hardwoods or softwoods. Bears use cavities in the root masses of wind thrown trees or within standing trees as dens, and they dig into dirt mounds, crawl under brush piles, create ground nests of twigs or grasses in thickets, or den in rock cavities (Hugie 1982, Schooley 1990).

Interactions With Other Species

Black bears can be important predators on newborn young of deer, moose, caribou and elk (Schlegel 1976, Franzmann et al. 1980, Adams et al. 1988, Ballard 1994). The role of bear predation in limiting or regulating populations of moose or deer continues to be debated (Boutin 1992), and probably depends on the density of bears in relation to the number and density of other predator and prey species (Ballard 1994). Black bear predation on young calves is considered the major limiting factor for low density moose populations (Gasaway et al. 1992), and several studies have documented black bears killing 2-50% of moose calves (see summary in Ballard 1994).

Rogers et al. (1992) estimated that 2 black bears in Minnesota killed or scavenged 10% of the white-tailed deer fawns that were born within the bears' home ranges.

Black bears are known to kill moose calves and deer fawns in Maine, but the impacts of these losses on the State's moose and deer populations have not been studied. If bears affect deer populations in a manner similar to that documented for moose, they would have the greatest impact in northern and eastern Maine, where deer densities are low (Lavigne 1999).

Bear-human interactions are often characterized by conflicts over space or food sources. Most complaints about bears causing damage or nuisance problems occur during the spring and summer months (MDIFW file data). This is often a period of food stress, particularly when droughts reduce the growth of vegetation and the abundance of berry crops.

Residential development, land clearing for agriculture, and increased road densities associated with growing human populations have altered and fragmented bear habitat throughout the East (Hellgren and Maehr 1993). As humans develop and occupy bear habitat, bear-human conflicts (i.e., damage/nuisance, bear-vehicle collisions) increase, and bear survival usually declines (Hellgren and Maehr 1993). Bear-vehicle collisions have become a major mortality factor in some mid-Atlantic states, and some bears have demonstrated an avoidance of roads with high traffic volumes (Wooding and Maddrey 1994). However, few bears are killed on roads in rural states such as Maine, which have low human population densities and few high-speed highways. Maine's Department of Transportation recorded 50 accidents involving bears during 1996-1997 (R. Baker, MDOT report 1999). MDIFW records do not reflect a complete accounting of

bears killed to control damage, but, in recent years, less than 50 bears are estimated to be killed annually (H. Hilton, ADC Coordinator, pers. comm.).

Reproduction

Bears are slow to reach sexual maturity, and have a low reproductive potential. In Maine, females produce their first litters at 4-6 years of age (Hugie 1982, McLaughlin et al. 1994, McLaughlin 1998). A female's first litter is usually 2 cubs, and subsequent litters average 3 cubs (McLaughlin 1998). Females enter estrus in May-June, with breeding season lasting through July-August (Alt 1989). Bears have delayed implantation[1] and fetal development, and the young are born from late December-February (Pelton 1982, Alt 1989). Newborn cubs weigh about 12 ounces (Alt 1989), are nearly hairless, and depend on their mother's warmth and milk for survival within the den. Family groups den together the following winter, and remain intact for 14-18 months (Alt 1977, Rogers 1987). Consequently, individual females generally produce successive litters at 2-year intervals. Early loss of a litter may short-circuit the cycle and allow consecutive-year litter production (McLaughlin 1998).

Reproduction is controlled by the nutritional condition of the female during fall. If female bears are unable to obtain sufficient food to reach a threshold weight, they rarely produce offspring that winter (Rogers 1987, Elowe 1987, McLaughlin 1998). Males may become sexually mature as young as 18 months, but probably do not participate in breeding until they attain full stature (4-5 years in Maine).

[1]The implantation (attachment) of fertilized eggs into the wall of the female's uterus is delayed for several months. Embryonic development is suspended at the 16-cell (blastocyst) stage. Blastocysts float freely in the uterus until implanting in late November. Most embryonic development occurs over the subsequent 2-months, although the entire gestation period lasts 6-7 months.

Cub production has become synchronized in northern Maine, due to regular, alternate-year shortages of late fall food (e.g., beechnuts)(Schooley 1990, McLaughlin et al. 1994, McLaughlin 1998). From 1982-1997, 124 of 132 litters (94%) examined in the region were produced on odd-numbered years (i.e., 1999), following abundant beechnut crops. During years of beechnut scarcity, most adult females entered dens with little stored body fat, and only 15% of the few females that were in breeding condition produced cubs.

Behavior

Black bears have a social system that changes with season and food availability. They are solitary most of their lives, except for breeding pairs in the summer months, and females accompanied by dependent young. Adult males (4 years of age and older) often dominate food sources, and adults are known to prey on smaller bears. However, black bears do not actively defend territories. When food is abundant, they tolerate other bears in close proximity at food patches. Black bears use large areas; in Maine, ranges of females are 6-9 mi^2, and males use areas up to 100 mi^2 or more (Hugie 1982, Lamb 1983, MDIFW file data). Ranges overlap and are shared among bears of different ages and sexes. In most hunted populations there is little direct conflict among bears, except during breeding season.

Black bears will occasionally kill and cannibalize other bears. Most cannibalization documented in Maine has been on subadult bears (2-3 years of age) during spring and summer, although 1 entire family group (female with newborn cubs) was killed and eaten by a larger bear in early spring (MDIFW file data). Although large

males are presumed to do most killing of other bears, adult females also kill and eat others (various studies cited by Garshelis 1994).

Female bears remain within or close to the area they were born in, but males disperse as subadults, usually at 2-4 years of age in Maine (Hugie 1982, MDIFW file data). Males often disperse up to 50 miles; eartagged bears from Maine have been killed or captured in Quebec and New Brunswick. These long-distance movements, and the tendency for males to use large home ranges, contributes to lower survival of male bears, as they have more frequent interactions with humans.

Bears will travel 40-50 miles to exploit distant food sources, such as stands with concentrated berry or nut crops, or fields of agricultural crops (Hugie 1982, Schooley 1990). They have a well-developed homing instinct, and commonly travel outside of their annual ranges for short periods (up to 4 weeks) during the late summer or fall months (Alt 1977, Hugie 1982).

Bears are most active in early morning and late afternoon-evening hours (Garshelis and Pelton 1980). Their activity levels increase in fall, as they begin an intensive foraging period in preparation for winter. In Maine, bears stop feeding and enter dens by mid-late October when nut crops fail (Hugie 1982, Lamb 1983, Schooley 1990, McLaughlin 1998). When fall food is abundant, they will forage until late November- early December, or until snow depths make travel and feeding difficult.

Bears may spend up to 6 months of the year in winter dens in Maine, emerging during April. They rarely feed during the first 2 weeks after leaving their dens, as their bodies undergo the shift from winter dormancy to spring activity (Folk et al. 1972).

Survival and Cause of Death

Although black bears are long-lived mammals capable of surviving for 25 years or more in the wild (McLaughlin 1998), few bears in a population ever reach 10 years of age (Pelton 1982). With few natural predators, black bear survival is governed by food supply and man's activities (Pelton 1982, Miller 1990, Garshelis 1994). Malnutrition (Rogers 1976, Elowe and Dodge 1989), and cannibalism (Young and Ruff 1982, LeCount 1987, Schwartz and Franzmann 1991, Higgins 1997) may be significant causes of cub and yearling mortality, with cannibalism remaining an important mortality factor for yearlings and subadults (Rogers 1976, Garshelis 1994). Humans become the principal mortality agent for subadult and adult bears through hunting, collisions with vehicles, and lethal removal of bears in conflict with human activities (Rogers 1976, Bunnell and Tait 1985, Garshelis 1994, Higgins 1997). In Maine, adult females survived periods of scarce food that sometimes caused starvation of yearlings and subadults (2-3 years of age)(MDIFW file data). Much of the food energy obtained by young bears is used to fuel body growth, and therefore less is available to maintain condition. Adult females may forego reproduction to utilize critical stores of body fat for their own survival following fall food failures (Rogers 1976, Elowe 1987, Kolenosky 1990), but it is rare for adults to die from starvation (Noyce and Garshelis 1994, McLaughlin 1998; Table 1). During the winter months, when bears are in dens, adults exhibit very high survival, approaching 100% (Rogers 1987). In Maine, winter survival of yearlings and subadults dropped as low as 86% and 91%, respectively (McLaughlin 1998).

Although males generally have lower survival rates than females (Elowe 1987, Schwartz and Franzmann 1991), survival of both sexes increases as bears mature

(Bunnell and Tait 1985, Elowe and Dodge 1989, McLaughlin 1998). In Maine, cubs experience 58-83% survival their first year of life (McLaughlin 1998). By the time female bears are adults (4 years of age), their survival increases to nearly 100% in the absence of hunting.

In Maine, most deaths of bears over 2 years of age are recorded during the fall hunting season (Table 1). Cubs and yearlings die more frequently from natural causes, including starvation, during the spring and summer months (Table 1; McLaughlin 1998). The State's bear range has relatively few high-volume, high-speed highways, and few bears die from collisions with vehicles. Only 3% of 436 recorded deaths of bears that were eartagged on 3 study areas in central and northern Maine were caused by collisions with vehicles (Table 1), and none were killed as nuisances (McLaughlin 1998).

Disease does not appear to play a major role in the regulation of bear populations (Pelton 1982). Bears in Maine are susceptible to a variety of parasites, primarily round worms and ticks (MDIFW file data). Tumors are rare (MDIFW file data), and the incidence of trichinosis is low (G. Matula, personal comm.). Rabies is extremely rare in bears, and there are no records of rabies occurring in bears in Maine. Dental problems, including caries (cavities) and broken and missing teeth associated with advanced age, are the most common diseases of Maine bears (MDIFW file data).

MANAGEMENT

Regulatory Authority

The State Legislature has retained authority to regulate bear populations, although much of the practical aspects of regulation have been transferred to the Department of Inland Fisheries and Wildlife (MDIFW). The Legislature still sets the season dates within which hunting and trapping is permitted, and specifies legal methods of take, bag limits, and license fees. The Commissioner of MDIFW and his Advisory Council have latitude in controlling bear harvests. They determine the time that particular hunting and trapping methods are permitted, and are also able to define legal hunting implements and hunting hours. The Commissioner's actions are governed by Maine's Administrative Procedures Act, which mandates a public comment period on all regulatory actions before they are implemented.

In 1990, the Legislature established a bear permit system, requiring hunters to possess a bear permit in addition to a big game license when hunting bears. Bear permit fees have ranged from $3 (1990) to $6 (1999) for residents, and from $11 (1990) to $16 (1999) for nonresident hunters. This additional licensing provision allows the Department to determine how many hunters specifically pursue bears in the State, and to assess hunting effort and success. The permit requirement is waived during the last 4 weeks of the 13-14 week bear season, which runs coincidental to the November firearms deer season. Bears have been regarded as a bonus quarry by many deer hunters, who are opposed to paying extra fees to hunt bear incidentally while they pursue deer. In addition, the chances of deer hunters taking bear in the firearms deer

season are strongly influenced by the dates that bears enter dens each fall. When food is scarce, bears often enter dens in mid-late October, before deer season. They remain active through late November if late fall food is abundant. Consequently, the success rates of November bear hunters can fluctuate dramatically with little relationship to the size of the bear population.

Past Goals and Objectives

The first bear management goal was established in 1975, which was to maintain bear abundance, distribution, and use at pre-1974 levels. The accompanying harvest objective was to provide annual harvests of 800-1,000 bears statewide, with harvests in each Wildlife Management Unit (WMU) limited to less than 15% of the Unit's minimum estimated bear population. The bear management goal remained unchanged in 1980.

In 1985, the goal was updated -- to maintain the population at 1985 levels, which was estimated at 21,000 bears statewide. Associated abundance objectives were to maintain prehunt population densities at 0.8 - 1.3 bears/mi^2 in WMU's 2 and 5 (approximately WMD's 1, 2, 4, 5, 9, 10, southern half of 11, eastern half of 18, and 19) and at 0.5-0.7 bears/mi^2 in WMU's 1, 3, 4, and 6, (approximately WMD's 3, 6, 7, 8, northern half of 11, eastern half of 26, 27, 28, 29) and 0.2-0.5 bears/mi^2 in WMU 7 and 8 (approximate WMD's: 16, 20, 21, 22, 23, 25, western half of 26) (Figure 1). The harvest objective was revised -- to increase harvests to 1,500-2,500 bears statewide, or levels needed to stabilize the population. This management goal and associated objectives have governed the Department's bear management through 1999.

Past Management

The earliest efforts to manage bears were township-level bounties to reduce bear depredations on agriculture. The first bounty on bears was offered by the town of Scarboro in 1770, and bounties were offered in parts of Maine most years from 1880 through 1957 (Table 2). Bears were not protected by a closed season until 1931, when the legislature classified them as game animals and instituted a short open season that ran coincidentally with the fall deer season. This protection was in effect for 10 years, even though bounties continued on bears in northeastern and southern Maine. By 1942, bears were once again legal game year round. The next protection they were offered was in 1966, when a June 1 - December 31 season was enacted. A bag limit of one bear/hunter/year was first imposed in 1969, the same year that mandatory registration of harvested bears was required, cubs were protected, and cable traps were legalized for trapping.

Cubs became legal game in 1971, and minor changes in season dates occurred during the next few years, although bears were essentially hunted during most of the period that they were not in dens (May - November). The 1970s marked greater efforts to monitor the bear population, and the Department began its bear study in 1975 to provide data for management. Rapidly increasing harvests in the late 1970s led to a series of actions to reduce harvest levels and maintain bear numbers. The Commissioner ordered an emergency closure of the bear season in September 1980 (Table 2), after the season harvest (through November) was projected to greatly exceed the management objective of 800-1,000 bears. In 1981, legislative action created two

separate bear seasons, held in the spring and fall. By 1982 a fall-only season framework was in place, and no spring seasons have been held since.

The Wildlife Division sampled the ages of harvested bears during the 1970s through voluntary collections of premolar teeth from guides and hunters. Mandatory submission of premolars from hunter-killed bears was in effect from 1981 through 1986. These tooth collections allowed Department biologists to determine the age distribution of the harvest. The tooth age collection was dropped because no direct relationship had been established between changes in the age distribution of the harvest and concurrent changes in the composition and status of the bear population. Increased restrictions on the timing and placement of bear bait, and on the timing and areas open to training hounds on bear, became law in 1987.

Current Management

Bear management has remained relatively constant since 1990, with only minor changes in harvest regulations. Harvest regulations continue to be applied uniformly statewide, with no regional differences despite WMU-specific abundance objectives. Current season dates resulted from concern over sustained growth in bear harvests during 1986 -1989, which exceeded the objective of 1,500-2,500 bears. The large harvests were primarily due to greater participation in hunting over bait. In 1990, the bait hunting period was reduced from 9 weeks to 4 weeks, opening in late August (Figure 2). Hunting with hounds was restricted from 9 weeks to 6-7 weeks starting in mid-September, and still-hunting/stalking was reduced from 13-14 weeks to 4 weeks during the firearms deer season in November. Lastly, the trapping season was

shortened from 9 weeks to a 4-week period encompassing October. To minimize conflicts between hunters using bait and hunters pursuing bears with hounds, the opening date of the houndsmen's season was delayed, opening 2 weeks after bait season began. The Department also removed the trapping period from the baiting season in response to concerns about the illegal use of traps near hunters' baits.

These season changes were designed to minimize restrictions on hunting opportunity, while ensuring that annual harvests would be conservative enough to maintain the population at 21,000 bears. The Department has used an interim harvest objective of less than 2,300 bears per year since 1990 to promote positive population growth, following the population decline in the late 1980s.

A few lesser changes in season structure have occurred since 1990. The baiting and houndsmen's hunting periods have remained unchanged, but both the period of still-hunting/stalking and the trapping season were expanded. Beginning in 1994, still-hunting and stalking were allowed throughout the 3-month bear season, and the trapping season was expanded from 4 weeks to 5 weeks in length. In 1997, the trapping season was extended to its pre-1990 length of 2 months (September and October). Few bears are harvested by still-hunting/stalking prior to November, or by trapping. Consequently, liberalization of harvesting opportunity for these methods of take had little effect on overall harvest levels (Figures 2, 3; Table 3).

HABITAT ASSESSMENT

Past Habitat

The black bear is associated with forested areas throughout most of North America, and historical trends in the amount of forestland in Maine can be used to describe gross changes in bear habitat over time. Beginning with the time of European settlement and lasting into the late 1800s, forestland declined steadily with the expansion of agriculture. Land clearing for farming was prevalent in coastal regions, and spread up the major river drainages through central and western Maine. Most agricultural operations in northern Maine were limited to the northeastern portion of Aroostook County, along the St. John River valley. At the height of land clearing in 1880, only 68-78% (13-15 million acres) of the State remained forested. Changes in agricultural practices and farm abandonment led to an expansion of forestland over the past 120 years. By 1950, about 80-82% of Maine was forested, and by 1982 about 89% of the State was in forestland (Powell and Dickson 1984).

In addition to changing the quantity of bear habitat in Maine, human use of the land has influenced the quality of bear habitat. Efforts to farm much of central and northern Maine nearly a century ago, and widespread industrial forest practices in recent years have combined to generate an unprecedented change in much of northern Maine's forests, greatly improving habitat quality for bears over the last 25 years.

Forests that regrew on previously-farmed areas probably created higher quality bear habitat than forests that originally covered the region. Apple trees continued to

produce fruit for decades on abandoned farms, and grasses, forbs, and berry-producing shrubs and trees, that grew in reverting cropland and meadows, were used by bears.

The industrialization of Maine's northern forestlands also affected bear habitat, primarily in the last 30 years. Mechanized tree harvesting and associated road building has created a mosaic of smaller stands of various ages and species composition, interspersed with small open areas. The greater interspersion of vegetative types probably improved habitat for bears by providing seasonal foods in close proximity. In general, the State's forests have become more hardwood-dominated (Chilelli 1998, Gadzik et al. 1998), and stands regenerating in the aftermath of logging for pulpwood produce more food for bears than the mature softwood stands they replaced. Roadsides and log landings are persistent openings that are often seeded with herbaceous plants to control erosion. These areas provide a variety of early spring and summer foods (i.e., grasses, forbes, berries, and colonial insects).

Compared to the widespread influences of agriculture and forestry, urbanization and residential development have not significantly affected the State's bear habitat. Maine's human population expanded from about 850,000 in 1940 to about 1.2 million in 1990 (USBC 1990), but most human population centers are located in south-central regions, along the edge, or outside of, occupied bear range.

In 1975, bear habitat was estimated at 22,775 mi^2, or 71.4% of the State's inland area (Hugie 1975). This estimate was derived by adding the area in suitable woodlands and usable wetlands to 10% of the area in idle and active farmland (Appendix I); unfortunately, no definition of suitable woodland (the dominant habitat category) was given. The 1980 bear assessment retained the 1975 estimate of bear habitat.

During the 1985 assessment, the amount of bear habitat was estimated at 25,850 mi^2, based upon the 1980 Maine Forest Resurvey (USFS 1982) (Appendix I; McLaughlin 1986). Bear habitat was defined as all forestland in WMU 1-6, 65% of the forestland in WMU 7, and 50% of forestland in WMU 8. Portions of the forestlands in WMU 7 and 8 were excluded from bear range because much of the forested areas in these units occur as small, dispersed wood lots that were considered unsuitable for bears. Because different criteria were used to estimate the amount of bear habitat in 1975 and 1985, changes over time could not be measured.

Habitat quality was only evaluated in a general sense in both 1975 and 1980, using human activity levels and the amount of forest in mature or nearly-mature coniferous forest as indicators of habitat suitability for bears (Hugie 1975, Hugie 1980). Although WMU 2 was judged to be most suitable for bears, no additional ranking of regional habitat conditions was included in these assessments. In 1985, a Habitat Suitability Index (HSI) (McLaughlin 1986) was developed and applied to Maine's bear habitat, using the 1980 Maine Forest Resurvey (Powell and Dickson 1982) and the Habitat Evaluation Process (HEP) (Schamberger and Krohn 1982). The HEP approach to habitat assessment relies on knowledge of the life requisites of bears and measurable biological and physical characteristics of the State's landscape. Habitat quality within each WMU was rated on a scale of 0 - 1.0, with a value of 0 representing habitat conditions unsuitable for bears, and a value of 1.0 representing optimum habitat conditions (Appendix I).

Bears are not known to negatively influence the capacity of the land to support them, through changes in vegetational structure. Within this assessment, the term

carrying capacity is defined as the maximum density for bears that a unit of land area can support. The density figures used in this document refer to bear densities during the spring season, which is the season of greatest density on an annual basis.

There is little evidence that bear populations are regulated by internal factors, such as behavior that controls spacing of individuals, or declines in reproductive success. It is more likely that they are limited by their food supply, which may control age of sexual maturity, proportion of adult females that reproduce, and survival of bears (primarily cubs, yearlings, and subadults) (Taylor 1994, McLaughlin 1998). Density-dependent changes in the vital rates of bear populations probably only occur when population levels are very close to carrying capacity (Figure 4). Acknowledging these limitations, the statewide carrying capacity for bears was estimated at 33,000 bears in 1985 (McLaughlin 1986). The statewide carrying capacity was developed using the HSI, assuming that optimum habitat in the Northeast could support 1.5-2 bears/mi^2 (McLaughlin 1986). Little information was available to project habitat changes from 1985 through 1990, but a 10% reduction in carrying capacity (30,000 bears by 1990) was adopted as a reasonable estimate for planning purposes. This projection assumed the amount of forestland would remain nearly constant during the period. However, it also assumed that habitat quality would decline due to a loss of mature hardwood stands through timber harvesting, and greater conflicts between bears and an expanding human population.

Current Habitat

In this assessment, bear habitat is described using a new system of 30 ecologically based Wildlife Management Districts (WMDs), adopted by MDIFW in 1998 (Figure 5). Forest composition is described based upon the 1995 Maine Forest Resurvey (USFS 1997, Chilelli 1998). The amount of forestland used as a basis for quantifying bear habitat was obtained from the vegetation and landcover map used in the Gap Analysis of Maine (Hepinstall et al. 1999, Krohn et al. 1998) - modified to incorporate all National Wetland Inventory polygons. Potential bear habitat, measured for each WMD, was considered to include all categories of forestland and 5 categories of forested/shrub-scrub wetlands measured by remote sensing (Appendix II). The 1985 habitat assessment was based upon larger geographic units (WMU's) with different boundaries (Figure 1), and Maine Forest Resurvey estimates of area by forest covertypes (Powell and Dickson 1984). Therefore, only general comparisons can be made between present habitat conditions and those in 1985.

Regular, alternate-year scarcities of beechnuts are associated with an alternate-year reproductive synchrony in northern Maine, where most cubs are produced on odd-numbered years (i.e., 1995,1997, 1999; McLaughlin et al. 1994, McLaughlin 1998). This strong relationship occurs in regions where bears are limited to beech mast as their major fall food source; bears in central Maine have more diverse fall diets and produce more consistent annual cub crops (McLaughlin 1998). To account for these regional differences in bear reproduction and food availability, the State was divided into 3 regions for habitat assessment (Figure 5). The Forest Region is a group of 11 WMDs (and Baxter State Park) with similar characteristics that represents the expansive

contiguous forestlands in northern Maine. Bears in the Forest Region are largely restricted to beechnuts as their primary late-fall food source; this area has very little agricultural land, and few oaks, hazelnuts, or trees or shrubs producing persistent fruit. The Forest-Farm Region comprises 17 WMDs that encompass much of the remainder of the State's inland area, where bears have access to agricultural crops and/or a wider range of fall foods. The Unsuitable for Bear Region includes WMD 24 in extreme south coastal Maine, and WMD 30, which represents coastal islands. Both WMDs have high human populations and fragmented forests that are largely unsuitable as bear habitat.

Since 1982, the quantity of forestland in Maine has remained virtually unchanged, as gains in some regions were offset by losses in others (Griffith and Alerich 1996). Spruce-Fir acreage has declined nearly statewide, in association with the conversion of softwood forests to hardwoods, as a result of hardwoods outcompeting softwoods in regenerating clearcut, and the selective harvesting of spruce and fir during spruce budworm salvage operations during the 1980s (Chilelli 1998). However, it is uncertain whether this decline in spruce-fir forest acreage and associated expansion of hardwood forests will continue during the next 20 years (Chilelli 1998), as forestry practices are changing. Current timber harvest methods are encouraging the development of softwood forest types, and increased harvesting of mature hardwood stands should reduce the abundance of large, nut-producing hardwoods, primarily beechnuts (Chilelli 1998). The 1995 Forest Resurvey indicates that beech has increased in prevalence in Maine since 1982, with a slight decline in size class (Griffith and Alerich 1996). Statewide, potential bear habitat is estimated at 26,973 mi^2, with 14,452 mi^2 in the Forest Region and 12,521 mi^2 in the Forest-Farm Region (Table 4).

Present habitat suitability was evaluated by applying updated Maine Forest Inventory data (MFI) (USFS 1997) and modified Maine Gap data (Hepinstall et al. 1999, Krohn et al. 1998) to a revised version of the HSI (Appendix III; McLaughlin et al. 1988; Appendix II). The HSI values were computed for each of the 2 bear habitat regions (Forest and Forest-farm), as MFI sampling was too sparse to provide reliable estimates of several parameter values for smaller geographic units (i.e., WMDs). Bear habitat quality was rated highest in the Forest (HSI = 0.82) and slightly poorer in the Forest-Farm Region (HSI = 0.72) (Table 4). These values are comparable to the HSI values assigned to the State's bear habitat in 1985 (Appendix II). Overall habitat suitability in the Forest was limited by the value of food variables, and cover suitability values limited habitat suitability in the Forest-Farm Region.

Maine's carrying capacity for bears is estimated at 36,515 bears (range 31,299 - 41,732) (Table 4). Slightly greater than half of this carrying capacity (20,739 bears) is attributed to the Forest Region; the Forest-Farm Region's carrying capacity is estimated at 15,776 bears. These estimates of habitat and carrying capacity differ from the 1985 assessment, and they are not directly comparable. Both the data and assumptions used to describe bear habitat differ between 1985 and 1999. In particular, the amount of suitable bear habitat in south central and western Maine (WMU's 7 and 8) were estimated using GIS coverages in 1999 (Appendix II). This technology was not available in 1985 and consequently the earlier estimate of bear habitat in that region was overly conservative.

Habitat Projection

In the future, portions of Maine's bear habitat will probably be altered as much by recreational and residential development as by traditional forest practices. Greater human presence and recreational development in western Maine and expansion of urban areas along the periphery of bear range in southern and central regions are changing the character of bear habitat. Black bears are able to live in close proximity to humans, as long as dense cover is available for escape and seclusion, and human residents tolerate conflicts with them.

The primary habitat change in the Forest Region may be a reduction in the amount of beechnut mast for bears. Accelerated logging of hardwood stands could reduce the number of mature, nut-producing beech trees on the landscape, given expected market conditions that favor continued use of hardwood species. However, some foresters have been receptive to recent efforts by the Department that promote retention of mature beech trees as important wildlife food sources. Management guidelines for beech are being finalized (Wiley 1999), and some industrial forest landowners have entered into cooperative agreements with the Department to manage hardwood stands for future beech mast production. Although these cooperative efforts have produced positive results, they encompass only a small fraction of the acreage in hardwood stands, and loss of mature beech trees to timber harvest continues to be a management issue in much of northern Maine.

More problematic is the threat of widespread mortality of beech trees due to beech bark disease (Houston 1975). Although this disease has been known in Maine throughout the last century, the present age and size structure of hardwood stands may

predispose them to an epidemic (Houston 1975). Most stands containing beech have infected trees, and high rates of tree mortality have been reported in northcentral Maine (D. Kane, pers. comm.). Most infected trees live and continue to produce mast for many years before dying from the disease. Little is known about how the disease impacts longevity of trees and production of beechnuts over their lifetimes. Therefore, the likelihood of a die-off of beech trees due to beech bark disease is questionable. This uncertainty of a widespread loss of beechnut crops makes projecting future habitat conditions in the Forest Region difficult. Continued monitoring of the status of forest stands containing beech trees, including mortality and beechnut production, is needed to ensure timely management action if a die-off occurs. In any event, beech mast abundance in the Forest is more likely to decline than to increase.

Without a fall food source that replaces beechnuts, the population's rate of cub production will drop, and the mean age of bears in the population will increase as fewer young bears are recruited into adult age classes. If a disease-driven catastrophic loss of beech trees did occur, both the carrying capacity of the region's habitat and bear productivity would decline. Assuming this worst-case scenario, the HSI model projects that habitat suitability in the Forest Region would decline from the present value of 0.82 to 0.50. This drop in habitat suitability translates to a reduction in the region's carrying capacity to 12,646 bears, or 61% of present carrying capacity (Table 5). Annual harvests would have to be reduced substantially to maintain bear densities in the Forest Region close to present levels. Modeling simulations indicate that, in the absence of beech mast, the Forest region's adult female population could not sustain annual mortality as light as 2% without declining (McLaughlin 1998).

In most of the Forest-Farm WMD's, bear habitat is expected to change little in overall quality. Residential development will reduce the amount of bear habitat and may result in more conflicts between bears and humans living in the region. To limit bear-human conflicts, bear densities may have to be limited well below the physical capacity of the habitat. Animal damage control efforts will probably become a larger component of future bear management in this region.

The Unsuitable for Bear Region will likely remain unusable as bear habitat in the near future. Human densities in this region will probably rise, and forests will become increasingly fragmented.

The composition of bear habitat, and the manner in which both man's activities and natural forces may affect Maine's landscape, differ across the State. Therefore, greater flexibility in the bear management system will be needed to accommodate regional perspectives and management objectives. The potential catastrophic loss of beech trees due to disease is the only factor that may severely limit bear numbers and harvests in the Forest Region. However, the likelihood of this occurrence is impossible to predict. In the Forest-Farm Region, human attitudes are expected to become increasingly important in limiting bear numbers, primarily the public's tolerance of bear damage and nuisance, rather than by restrictions based upon habitat conditions.

POPULATION ASSESSMENT

Past Populations

Bears were distributed statewide at the time of European settlement (Spencer 1955), and they have been abundant in Maine throughout modern history. Deforestation and persecution of bears to reduce conflicts with agriculture caused their extirpation from much of southern and coastal Maine by 1900. However, they remained common throughout the northern half of the State, outside of the region influenced by farming. Bear range expanded southward as forests regrew following the collapse of agriculture early in the century (Spencer 1955, McLaughlin 1986). By 1985, about 86% of Maine was occupied by bear (Figure 6) (McLaughlin 1986).

Bears are secretive animals that occur in low densities in thick forests, and are difficult to count. In the 1950s, Spencer (1955) estimated the statewide bear population at 5,000-7,000 and increasing, based upon the incidence of tracks, scat and feeding sign along transects traveled on foot or by canoe, and on the age composition of annual harvests (Table 6). In 1975, Hugie relied primarily on harvest statistics to estimate the population at 7,000-10,000 bears statewide. He revised the population estimate to 6,000-9,000 bears in 1979, using both harvest and movement data from radiocollared bears (Hugie 1980). It was later determined that both the 1975 and 1980 population assessments severely underestimated the number of bears in Maine. Neither of these assessments included the trend in population size.

In 1984, bear density estimates from telemetry studies were extrapolated to the 1975 estimate of occupied bear range (22,775 mi^2) to produce a statewide estimate of

18,000 bears (Matula and McLaughlin 1984). The dramatic increase in estimated bear densities, and thus the statewide population estimate, resulted from the realization that female bears were not territorial, as was assumed in earlier population assessments. Instead of excluding other bears from their ranges (territoriality), the movements of radio-collared females indicated that their ranges overlapped considerably. Consequently, considerably greater densities of bears were supported by Maine's forestlands.

During the 1985 bear assessment, updated density estimates from telemetry study sites were extrapolated to a statewide habitat base developed from the 1980 Maine Forest Resurvey (25,850 mi^2) to estimate the spring 1985 population at 21,000 bears and increasing (McLaughlin 1986). Although bear numbers probably increased from 1950 to 1985, the rising population estimates over time period are not direct measures of the growth in bear numbers during the period. Recent knowledge of bear behavior and movements (including their lack of territoriality), and more sophisticated approaches to population monitoring, suggest that early methods to count bears produced conservatively biased estimates.

Population modeling using the vital rates (rates of reproduction, recruitment and mortality) of radiocollared bears on MDIFW study sites indicated that female bear densities began to decline in the late 1980s. Statewide population estimates dropped from 21,000 to 18,490 bears from 1985 to 1990 (McLaughlin et al. 1991). This decline was attributed to unsustainable mortality rates due to excessive hunting harvests (Table 6; McLaughlin 1998). Hunting has been the primary mortality agent for subadult and

adult bears, with few bears killed on roads or to control damage or nuisance problems (Table 1; McLaughlin 1998).

Current Populations

The bear range has remained relatively static, with perhaps a minor expansion in distribution in southwestern Maine. Survival of radiocollared bears has increased since the last hunting restrictions were implemented in 1990, and modeling indicates that the population is growing (Figure 7). Fluctuating cub production in the Forest Region generates large annual variance in total population size, and confounds efforts to assess population trends. Consequently, we have based management decisions since 1990 on running 2-year mean population sizes, which reduce the variance in population trajectories (Figure 7). By 1996, population estimates had risen to the management objective of 21,000 bears (McLaughlin 1996). The spring 1999 population approximates 23,000 bears (Figure 7).

Population Projections

Under present harvest regulations and current levels of hunting effort, productivity, and habitat conditions, Maine's bear population is expected to grow at the rate of about 2-3% annually for the next 10 years. This projection assumes no net loss in the abundance of mature, nut-producing beech trees in northern Maine, and no significant loss or conversion of forested habitat in southern Maine during the upcoming decade. Both of these assumptions are in line with current trends. The projection also assumes that conditions on 2 small study areas (144 mi^2), located in WMD 5 and 17-18,

are representative of the remainder of bear range in Maine. This assumption may not be valid, as habitat, access, and hunting effort likely differ significantly across the State (McLaughlin 1998).

Limiting Factors

Habitat conditions, human attitudes, and hunting-related mortality are expected to limit Maine's bear population in the foreseeable future. Habitat conditions limit a bear population by influencing both reproduction and survival. Given suitable habitat, bear populations exhibit sufficient reproduction to offset mortalities; when reproduction exceeds mortalities, the population has a positive growth rate. The productivity of bears appears to be influenced primarily by food abundance. Maine's female bear population's growth rate, in the absence of hunting, would result in the doubling of the population in 5 years (McLaughlin 1998). Human attitudes toward bears are reflected in management actions and ultimately, in the density of bears on the landscape. Given adequate habitat and public tolerance for bears, hunting harvests are effective in controlling the population's size and limiting the level of conflicts between bears and humans. Other mortality factors, such as those associated with collisions with vehicles, animal damage control, illegal killing, and disease, are inconsequential to the bear population's status at this time.

Because the bear population's viability depends on the status of the adult female cohort, management focuses on this population segment. Male bears travel widely and often mate with several females in a breeding season. Their survival is generally lower than females', but short-term population growth and viability does not appear to be

strongly associated with male survival rates. Instead, population growth is closely associated with the proportion of breeding females producing litters, and with survival of adult females (McLaughlin 1998). Regional variation in the composition and quality of Maine's bear habitat translates into differences in the productivity of bears throughout the State.

Forest region

In the Forest Region, beechnut abundance appears to control the productivity of bears. A substantial change in the abundance and distribution of mature, nut bearing beech trees would have a significant impact on bear productivity, and therefore on the population's ability to withstand harvests. Computer modeling of simulated bear populations (McLaughlin 1998) suggests that, under present nutritional conditions, adult female bears in the Forest Region can withstand annual harvest rates of 10% without declining. The modeling effort incorporated data on the densities and vital rates of radio-collared female bears studied over a 15-year period (McLaughlin 1998).

The productivity of bears in the Forest WMDs would probably decline severely given a widespread loss of beechnut mast. Such a region-wide loss of beechnuts would most likely be caused by large scale beech tree mortality from disease or excessive timber harvest (see Habitat). Because beech does not produce regular nut crops until 40 years of age (Fowells 1965), a sudden, catastrophic loss of beech trees would probably translate into a long-term reduction in the nutritional plane of bears living in the region, and a drastic reduction in cub production (McLaughlin 1998). Under such a scenario, the age structure of the population would become markedly older, with

proportionately fewer cubs and subadult bears. Consequently, hunting harvests would have to be severely curtailed or even eliminated to sustain current population densities in northern Maine (McLaughlin 1998).

Forest-farm region

No major threats to the population are known in the Forest-Farm Region (most of central, southern, and northeastern Maine). Computer simulation modeling indicates that the bear population in this region is able to sustain 15% adult female mortality (McLaughlin 1998). Cub production in this region may also decline if beech mast was lost, but less dramatically than in the Forest, as bears utilize a wider range of fall foods in central and southern Maine. Programs to educate private landowners on ways to maintain and enhance a variety of fall food-producing vegetation on their lands (Wiley 1999) may help to mitigate the affect of beech bark disease on bears in this region.

Although residential development is occurring in Maine, housing densities are likely to remain sparse enough to support bears over most of presently occupied bear range. Therefore, no net loss in habitat is expected through 2016. Maine's habitat is able to support greater bear densities than people would tolerate. As development continues in the Forest-Farm Region, the incidence of bear-vehicle collisions, nuisance complaints and other bear-man conflicts will rise. In this region, the major factor limiting future bear densities will be human attitudes. Elsewhere, programs to increase people's knowledge and tolerance of bears have been responsible for coexistence of bears and people on relatively urbanized landscapes (e.g., Pennsylvania, New Jersey, Arizona, Massachusetts).

USE AND DEMAND ASSESSMENT

Past Use and Demand

Over the past century, the black bear was regarded as both a species that caused conflicts with other land uses, primarily agriculture (i.e., crop and livestock depredation, nuisance in campgrounds/backyards) and as a desirable species of high esthetic value (i.e., big game trophy, symbol of the wild). During the early 1900s, bears were bountied as pests and occasionally sold to nonresident sportsman as trophies from the north woods (Spencer 1955). As Maine's economy became less agricultural, the nature of bear-man conflicts changed and bounties were removed from bears in 1957 (Table 2). Coincidentally, interest in hunting bears as big game fueled an outfitter industry that capitalized on the practice of hunting bears with bait, and to a lesser extent with hounds (Hugie 1975). This commercialization of bear hunting catered to nonresident hunters, primarily those traveling from other Eastern states with few bears and limited opportunities to hunt them. Bear hunting became popular in Maine in the early 1970s, and demand continued to rise through the 1980s. The popularity of hunting over bait was largely responsible for a rapid and sustained increase in bear harvests during the 1970s, and again in the late 1980s (Table 2, Figure 3). Harvests rose from a level just below 1,000 bears to 1,630 bears in 1979, when the Department shortened the bear season drastically by removing the spring hunting period. Harvests were curtailed to about 1,000 bears for a few years, but rapidly rose to 2,690 bears during the late 1980s. The Department placed additional restrictions on season length in 1990 to curtail harvests.

Historically, the number of individuals participating in bear hunting appears to have been a small fraction of licensed big game hunters. From 1971 to 1983, the Game Kill Questionnaire was used to survey licensed hunters and determine effort expended on many wildlife species. This survey produced estimates of 21,000 - 34,000 bear hunters most years of the period (Table 2). Over 200,000 hunters purchased licenses each year of the survey period, and the survey's estimates of bear hunters included those that pursued bears incidentally while hunting other species, primarily deer and upland birds.

A survey of bear hunters in 1988 (Reiling et al. 1991) estimated that 20,676 hunters (14,321 residents; 6,355 nonresidents) pursued bears that year. Seventy percent of respondents indicated that they hunted bears in September, but only 23% hunted bears in November. Most nonresident respondents (62%) hired a Registered Maine Guide to assist them during their hunt; only 4% of resident bear hunters used the services of a guide. Seventeen percent of the 1988 survey respondents reported that they were successful in killing a bear, including 26% of nonresidents and 13% of resident hunters.

The 1988 survey of bear hunters estimated that bear hunting generated $6.4 million, including $3.4 million of new money for the State's economy provided by nonresident hunters (Reiling et al. 1991). No other measures of the economic benefit of bear hunting have been published.

Nonconsumptive demand for bears is difficult to measure. Maine's dense forests provide few opportunities to view bears. However, bears remain a popular

species with campers, fishermen, and other outdoor enthusiasts that are able to catch a glimpse of them.

Current Use and Demand

Since 1990, bear hunting permit sales have provided a reliable measure of bear hunting effort for the first 2 months of Maine's 3-month bear season. This hunting period represents most of the hunting effort directed specifically at bears each year. Although hunters take bears in conjunction with deer hunting, few hunting trips are taken specifically to hunt bears in November. Just over 12,000 permits were sold in 1990, and hunter numbers have remained relatively stable since then, with 10,000-11,000 permits sold each year (Table 2). This level of participation represents approximately 5-6% of big game hunting license sales during the period (MDIFW file data). Over half of the permits sold each year have been purchased by Maine residents (Table 7). Not all permit buyers actually hunt bear. Hunting participation rates are lower for resident bear permit-buyers (74-79%) than for nonresidents (93-96%) (Table 7). However, residents hunted more days each season than nonresidents, regardless of hunting method. Consequently, residents expended 66% of the bear hunting effort by permit holders from 1991-1994 (Table 8). Hunting effort could not be evaluated on a geographic basis, as many hunters responding to the survey were unable to accurately recall which townships they had hunted in.

Bear harvests were effectively reduced with the harvest controls implemented in 1990, but they soon began to increase, and are returning to the levels of the late 1980s (Table 3, Figure 3). In addition to hunting effort, harvests are also influenced by annual

food abundance and distribution, weather during the hunting season, and the size of the bear population. Much of the harvest increase can be attributed to increased hunting pressure prior to the firearms deer season (Figure 3). The trend of increasing harvest over a period of stable hunting effort is a strong indicator that the bear population is increasing. Success rates of hunters using various methods were explored in a random survey of permit-buyers following the 1991-1994 seasons. Nonresident hunters were 2-3 times more successful than residents for all methods (Table 9). This disparity in success, despite substantially lower number of days hunting by nonresidents, results from most nonresidents employing Registered Maine Guides to assist them.

Most of the annual bear harvest is contributed by hunters using bait. Houndsmen's harvests have fluctuated markedly, and constitute a rather small proportion (12-16%) of annual harvests. Maine still allows trapping of bears, but few bears are trapped each year, and a consistent 2% of the harvest is reported by trappers. The number of bears taken by hunters that are still-hunting or stalking bears fluctuates, but relatively few bears are harvested in this manner (Figure 3). Most of these hunters pursue bears near seasonal food sources in September and October.

During November, the bear harvest is strongly correlated with the abundance of beechnut mast in northern Maine; when beechnuts are scarce, most bears enter dens early, often before the November firearms season opens. Consequently, they are unavailable for harvest, and few are killed. Conversely, when beechnuts are abundant, bear remain active and late-fall harvests increase. A pattern of alternating years of high and low harvests during November has been recorded for over a decade (Figure 3).

Although bear harvests during deer season fluctuated with beechnut crops in the Forest WMDs, the relative contribution of this late-fall harvest to the overall harvest waned as early season harvests over bait climbed through the 1990s (Figure 3). In recent years, late-fall harvests have accounted for about 7-25% of the season total (Table 3, Figure 3).

Nonconsumptive use of bears is difficult to quantify. Statistics on the public's interest in viewing bears in particular are unavailable, but 54% of people traveling to view wildlife in Maine during 1996 were interested in watching large land mammals, including deer, bear and moose (USFWS and USBC 1998).

Use and Demand Projections

Demand for bear hunting opportunity is expected to remain at current levels over the next decade. Although overall participation in hunting in Maine is declining, bear permit sales appear stable. Although demand for bear hunting opportunity continues, the consumptive use of Maine's bear resource may be affected by changing views of hunting by the nonhunting public. The ethics of hunting bears, and the methods used to hunt bears, are being debated elsewhere in North America. Voters in Oregon, Washington, Colorado and Massachusetts have outlawed the use of bait and/or hounds to hunt bears in recent years. Ontario's Minister of Natural Resources closed the 1999 spring bear hunting season in the Province, in response to concern over orphaning of young cubs. Maine is one of a dwindling number of states (currently 6) that still permit the use of bait and hounds to hunt bear, and is the only state that permits trapping for bear. If these 3 harvest methods are outlawed, the Department's ability to control bear

numbers through regulated hunting seasons will be compromised. A significant expansion of stillhunting or stalking opportunities, including longer seasons and multiple-bear bag limits, would probably be the most likely approach to increase harvest levels and attempt to manage the population.

SUMMARY AND CONCLUSIONS

Black bears are widely distributed in Maine, occurring in all but the extreme southcentral and southwestern portions of the State. Bears use large areas, and are usually associated with expansive tracts of forestland. They are omnivores, and although most of their diet is vegetation, bears will eat a variety of animal matter. Their movements and activities revolve around the distribution and abundance of foods. Bears restrict their movements when food is abundant, but often travel up to 50 miles in summer or fall to take advantage of berry or nut crops. Studies elsewhere have shown that black bears can be important predators on newborn deer and moose, but their impact on Maine's deer and moose populations is not known.

Although bears are long-lived, they are slow to reproduce, and have a low reproductive potential. Females do not produce cubs until 4-6 years of age in the State, and normally produce litters of 1-4 cubs at 2-year intervals. Cub production is strongly influenced by beechnut abundance in the expansive forests of northern Maine. Alternate-year beechnut crop failures have synchronized the reproductive cycles of most females in the population. Consequently, cub production in the region occurs as strong, alternate-year pulses. Fall food abundance influences the timing of den entry, which varies from mid-October when food is scarce to late November in years of abundant nut crops. Bears spend up to 6 months of the year in dens in Maine.

Cub and yearling bears die primarily from natural causes, including starvation and disease, and are occasionally killed by larger bears. The deaths of most subadults and adults are hunting related, and few die from collisions with vehicles. Disease does

not appear to play a significant role in the regulation of bear populations. Instead, bears seem to be regulated by food abundance, which influences reproductive success and survival.

Bear management in Maine reflects the species' rise in status from a pest to big game species. Concurrently, they have received increased protection and monitoring over the last hundred years. Bear were hunted year round for much of the first half of the century, and were bountied until 1957. Bear seasons were shortened to a 6-month period in the 1960s. Since 1982, a 3-month fall-only season has been in place, and additional restrictions on the periods that individual harvest methods were permitted within the fall season were enacted in 1990. These restrictions were designed to maintain bear populations in the face of escalating interest in bear hunting and rising harvests. Since 1990, hunting over bait has been allowed for 4 weeks, and houndsmen have been restricted to a 6-7 week hunting period. Trapping was expanded from a 1-month to a 2-month period during the 1990s, and stillhunting and stalking is now permitted for the entire 13-14 week season. Hunters are restricted to taking one bear per year, regardless of method. A bear hunting permit is required of hunters that pursue bears during the first 2 months of the season.

The first bear management goal in 1975 was to maintain bear abundance, distribution and use at pre-1974 levels. Harvests were to be maintained at 800-1,000 bears per year. This goal and objective remained unchanged in 1980. In 1985, the Department's bear management goal was changed -- to maintain the distribution and abundance of bears at 1985 levels. The associated population objective was to maintain the population at about 21,000 bears, with a harvest objective set at 1,500-

2,500 bears per year. This goal and objectives have guided bear management through 1999. Since 1990, an interim harvest objective, of maintaining the harvest at no greater than 2,300 was used to ensure positive population growth.

The Department began monitoring bear harvests in 1969, and began the bear study in 1975. Harvests escalated in the 1970s, exceeding the 1,000 bear objective and resulting in the closure of spring bear hunting season in 1980-1981. Harvests were initially curtailed to less than 1,500 bears, but soon rose rapidly in the late 1980s, and exceeded the 1985 management objective (1,500-2,500) in 1988 and 1989. Additional restrictions on hunting opportunity were implemented in 1990. Harvests were curtailed once again, but soon began to rise. Since 1990 harvests have exceeded the management objective twice (1995 and 1998), despite stable hunting effort during the period.

Land clearing for agriculture reduced bear habitat to the northern half of Maine by the turn of the century. Since then, bear range has expanded with the regrowth of forests on previously-farmed areas in much of eastern, central, and western portions of the State. The amount of bear habitat has remained relatively static over the past 20 years, and is currently estimated at 26,973 mi^2. Maine has sufficient habitat to support about 36,000 bears.

The bear population has been estimated several times over the past 50 years. Improved monitoring techniques and knowledge of bear ecology resulted in rising population estimates between 1950 and 1985. Estimates of the statewide bear population rose from 5,000-7,000 bears in 1950 to 21,000 bears in 1985, then declined to 18,500 in 1990. With restricted hunting seasons during the 1990s, the population has

been growing, and numbered about 23,000 bears by spring 1999, slightly over the management objective of 21,000 bears. Given no change in habitat conditions, harvest regulations, and hunter participation, the population should continue growing at about 2-3% annually for the next few years.

The future productivity of bears in northern Maine is expected to track the availability of mature, nut-producing beech trees. It is uncertain whether a catastrophic loss of beech trees will occur in the region; many stands are heavily infected with beech bark disease, and mature beech trees continue to be removed through timber harvests. If a region-wide loss of beech does occur, productivity of the area's bear population, and its capacity to sustain hunting harvests, will probably decline precipitously. In western, central and eastern Maine, bear productivity will be less affected by a loss of beechnut crops, as they have alternate fall foods. This region is likely to continue to undergo residential development, and as human populations rise, bear-human conflicts will increase. Bears in this region will likely be limited by the public's tolerance of them.

Since the early 1970s, demand for bear hunting opportunity by nonresidents has fueled a commercial guiding industry that concentrates on providing hunts over bait and behind hounds. Since 1990, sales of bear hunting permits have allowed the Department to monitor hunting pressure; between 10,000-11,000 hunters purchase permits annually, and 8,000-9,000 permit buyers actually hunt bears. Most permit buyers are residents of Maine, but more nonresidents are successful in taking bears. About 60% of recent bear harvests were taken by nonresidents. Harvests averaged 2,408 bears during 1990-1998, and increased despite a steady level of hunting effort. Maine continues to offer considerably more hunting opportunity for bears than other

eastern States, with longer seasons and a greater variety of legal hunting methods. The bear season currently extends from late August through November. Hunters may take 1 bear per year; bait, hounds, still hunting, stalking, and trapping are legal methods of take. About 60% of recent harvests have been taken over bait, 15% over hounds, and 2% by trapping. The remainder (23%) are taken by hunters that still hunt or stalk bears, often taking them incidentally while hunting other species. The number of bears taken during the November deer season fluctuates about 3-fold, from about 150-450 bears, depending upon the timing of den entry by northern Maine bears. This late fall harvest is less predictable than earlier harvests by bait, hounds or trapping, but it has contributed less to the overall harvest in recent years, as early season harvests increase in size.

Demand for hunting opportunity is expected to continue at current levels into the near future. Hunting has been used as the primary tool to regulate bear numbers, but in the future, public debate about the ethics of hunting bears, primarily with bait and hounds, may complicate bear management and force changes in bear seasons, and policy regarding nuisance bears. If hunting over bait is outlawed in the future and current habitat conditions and productivity continue, substantial liberalization of hunting seasons and/or bag limits will be required to maintain bear harvests large enough to control population growth. The uncertainty of widespread loss of beech trees in northern Maine further complicates the projection of bear supply and demand. Given the potential for less flexibility in harvest methods and a potential change in bear productivity, future bear management systems need to improve monitoring of the population and habitat, and incorporate harvest controls at a regional scale.

LITERATURE CITED

Adams, L. G., B. W. Dale, and F. J. Singer. 1988. Neonatal mortality in the Denali Caribou herd. Pages 33-34 *in* R. D. Cameron and J. L. Davis, eds. Proc. 3rd n. Am. Caribou Workshop. Alaska Dep. Fish and Game Wildl. Tech. Bull. No. 8. Juneau.

Alt, G. L. 1977. Home range, annual activity patterns, and movements of black bears in northeastern Pennsylvania. M.S. Thesis. Pennsylvania State Univ., University Park. 67pp.

_____. 1989. Reproductive biology of female black bears and early growth and development of cubs in northeastern Pennsylvania. Ph.D. Thesis, Univ. West Virginia, Morgantown. 116pp.

Bacon, E. S., and G. M. Burghardt. 1976. Learning and color discrimination in the American black bear. Pages 27-36 *in* M. R. Pelton, J. W. Lentfer, and G. E. Folk, Jr., eds. Bears: their biology and management. Third Int. Conv. Bear Res. and Manage. IUCN Publ. New Series No. 40. 467 pp.

Baker, R. F. 1999. Letter to Senator Leo Kieffer and Representative Roger Sherman summarizing Maine highway accidents involving wildlife, 1996-1997.

Ballard, W. B. 1994. Effects of black bear predation on caribou -- a review. Alces (30):25-35.

Boutin, S. 1992. Predation and moose population dynamics: a critique. J. Wildl. Manage. 56(1):116-127.

Bunnell, F. L., and D. E. N. Tait. 1985. Mortality rates of North American bears. Arctic 38:316-323.

Caron, M. A., and C. R. McLaughlin. 1985. Black bear study. Maine Dept. Inland Fish. and Wildl. Job Performance Rpt., Fed. Aid Proj. Maine W-67-R15, Job II-181. 8pp.

Chilelli, M. 1998. Maine's forests: trends (1982-1995) and projections (1998-2020). Maine Dept. Inland Fisheries and Wildlife, Augusta. 21 pp.

Elowe, K. D. 1984. Home range, movements, and habitat preferences of black bear in western Massachusetts. M. S. Thesis, Univ. Massachusetts, Amherst. 112pp.

_____. 1987. Factors affecting black bear reproductive success and cub survival in Massachusetts. Ph. D. Thesis, Univ. Massachusetts, Amherst. 71pp.

_____., and W. E. Dodge. 1989. Factors affecting black bear reproductive success and cub survival. J. Wildl. Manage. 53:962-968.

Folk, G. E.; Folk, M. A., and J. J. Minor. 1972. Physiological condition of three species of bears in winter dens. Pages 107-124 in S. Herrero, ed. Bears: their biology and Management. IUCN New Ser. Publ. 23. Int. Conserv. nature and Nat. Resourc., Morges, Switzerland. 371 pp.

Fowells, H. A. 1965. Silvics of forest trees of the United States. U.S. Dep. of Agric. For. Serv. Agric. Handb. 271. 762 pp. (cited on p. 173 - age of beech production)

Franzmann, A. W., C. C. Schwartz, and R. O. Peterson. 1980. Causes of summer moose calf mortality on the Kenai Peninsula. J. Wildl. manage. 44:764-768.

Gadzik, C. J., J. H. Blanck, and L. E. Caldwell. 1998. Timber supply outlook for Maine: 1995-2045. Dept. Conserv., Maine Forest Serv., Augusta, ME. 39 pp.

Garshelis, D. L. 1994. Density-dependent population regulation of black bears. Pages 3-14 *in*: M. Taylor, ed. Density-dependent population regulation in black, brown, and polar bears. Int. Conf. Bear Res. and Manage. Monogr. Series No. 3. 43pp.

_____, and M. Pelton. 1980. Activity of black bears in the Great Smoky Mountains National Park. J. Mammal. 61:8-19.

Gassaway, W. C., R. D. Boertje, D. V. Grangaard, D. G. Kelleyhouse, R. O. Stephenson, and D. G. Larsen. 1992. The role of predation in limiting moose at low densities in Alaska and Yukon and implications for conservation. Wildl. Monogr. No. 120. 59 pp.

Griffith, D. M., and C. L. Alerich. 1996. Forest statistics for Maine. 1995. U.S.D.A. Forest Service. NE Forest Experiment Station. Resource Bull NE-135.

Hellgren, E. C., and D. S. Maehr. 1993. Habitat fragmentation and black bears in the eastern United States. Proc. East. Workshop Black Bear Manage. Res. 11:154-165.

Hepinstall, J. A., S. A. Sader, W. B. Krohn, R. B. Boone, and R. I. Bartlett. 1999. Development and testing of a vegetation and landcover map of Maine. Maine Agricultural and Forest Experiment Station Technical Bulletin 173. Univ. Maine, Orono. 104pp.

Higgins, J. C. 1997. Survival, home range and spatial relationships of Virginia's exploited black bear population. M. S. Thesis. Virginia Polytechnic Institute and State University, Blacksburg. 124pp.

Houston, D. R. 1975. Beech bark disease: the aftermath forests are structured for a new outbreak. J. For. 73:660-663.

Hugie, R. D. 1980. Black bear management plan. pp 69-109 *in*: Planning for Maine's fish and wildlife resources, Volume I. Part 1. Maine Dept. Inland Fisheries and Wildlife, Augusta.

_____. 1982. Black bear ecology and management in the northern conifer-deciduous forests of Maine. Ph. D. Thesis. Univ. Montana, Missoula. 202pp.

_____, and C. Banasiak. 1975. Black bear management plan. *in*: Planning for Maine's fish and wildlife resources, Volume I. Part 1. Maine Dept. Inland Fisheries and Wildlife, Augusta.

Kolenosky, G. B. 1990. Reproductive biology of black bears in East-Central Ontario. Int. Conf. Bear Res. and Manage. 8:385-392.

_____, and S. M. Strathearn. 1987. Black bear. Pages 442-455 *in* M. Novak, J.A. Baker, M.E. Obbard, and B. Mallock, eds. Wild furbearer management and conservation in North America. Ont. Minist. Nat. Resour., Toronto, Can.

Krohn, W. B., R. B. Boone, S. A. Sader, J. A. Hepinstall, S. M. Schaefer, and S. L. Painton. 1998. Maine Gap Analysis - a geographic analysis of biodiversity. Final contract report to USGS Biological Resources Division, Gap Analysis Program, Moscow, ID.

Lamb, G. R. 1983. Home range and habitat use of female black bears in northern Maine. M. S. Thesis. Univ. Maine, Orono. 25 pp.

Lavigne, G. R. 1999. White-tailed deer assessment and strategic plan 1997. Maine Dept. Inland Fisheries and Wildlife. Augusta. 101pp.

LeCount, A. L. 1987. Causes of black bear cub mortality. Int. Conf. Bear Res. and Manage. 7:75-82.

Lindzey, F. G., and E. C. Meslow. 1977. Population characteristics of black bears on an island in Washington. J. Wildl. Manage. 41:408-412.

Matula, G. J., and C. R. McLaughlin. 1984. The black bear population in Maine. Maine Dept. Inland Fisheries and Wildlife, Augusta. 7pp (unpublished).

McLaughlin, C. R. 1986. Black Bear Assessment - 1985. pp.359-405 in: Planning for Maine's Inland Fish and Wildlife - species assessments and strategic plans 1986-1991. Vol. 1, Part 1.4. Dept. Inland Fish. and Wildl., Augusta.

_____., G. J. Matula, Jr., and J. H. Hunt. 1988. A draft habitat suitability index model for black bears in the conifer-deciduous forests of New England: its application in Maine. Proc. East. Workshop Black Bear Manage. Res. 8:137-164.

_____., K. D. Elowe, and M. C. Caron. 1991. Maine Status Report. Proc. East. Workshop Black Bear Manage. Res. 10:30-34.

_____., K. D. Elowe, M. C. Caron, and R. A. Cross. 1993. Maine Status Report. Proc. East. Workshop Black Bear Manage. Res. 11:46-50.

_____., G. J. Matula, Jr., and R. J. O'Connor. 1994. Synchronous reproduction by Maine black bears. Int. Conf. Bear Res. and Manage. 9(1):471-479.

_____., and R. C. Cross. 1996. Maine status report. Proc. East. Workshop Black Bear Manage. Res. 13:25-31.

_____. 1998. Modeling effects of food abundance and harvests on female black bear populations. Dissertation, Univ. Maine, Orono. 263pp.

Miller, S. D. 1990. Population management of bears in North America. nt. Conf. Bear Res. and Manage. 8(1):357-373.

Morris, K. I. 1999. Moose assessment and strategic plan 1997. Maine Dept. Inland Fisheries and Wildlife. Augusta. 55pp.

Noyce, K. V., and D. L. Garshelis. 1994. Body size and blood characteristics as indicators of condition and reproductive performance in black bears. Int. Conf. Bear Res. and Manage. 9(1):481-496.

Pelton, M. R. 1982. Black bear (*Ursus americanus*). Pages 504-514 in J. A. Chapman and G. A. Feldhamer, eds. Wild mammals of North America. John Hopkins University Press, Baltimore and London. 1147pp.

Powell, D. S., and D. R. Dickson. 1984. Forest statistics for Maine, 1971 and 1982. Resource Bulletin WE-81. U.S.D.A. Forest Service. Broomall, PA. 194pp.

Reiling, S. D., M. R. Teisl, and K. J. Boyle. 1991. Highlights from the 1988 survey of bear hunting in Maine. Dept. Agr. Res. Econ. Staff Paper Series in Res. Econ. ARE 430, Univ. Maine. 5pp.

Rogers, L. L. 1976. Effects of mast and berry crop failures on survival, growth, and reproductive success of black bears. Trans. North Am. Wildl. and Nat. Resour. Conf. 41:431-438.

_____. 1987. Effects of food supply and kinship on social behavior, movements, and population growth of black bears in northeastern Minnesota. Wildl. Monogr. 97. 72pp.

_____., P. S. Beringer, D.A. Trauba, and G. A. Wilker. 1992. Fawn predation by black bears in northeastern Minnesota. Ninth Intl. Conf. Bear Res. and Manage., Missoula, MT (abstract only).

Schooley, R. L. 1990. Habitat use, fall movements, and denning ecology of female black bears in Maine. M. S. Thesis, Univ. Maine, Orono. 115pp.

Schlegel, M. 1976. Factors affecting calf elk survival in northcentral Idaho -- a progress report. Proc. 56th Ann. Conf. W. Assoc. State Game Fish Comm. 56:342-355.

Schamburger, M., and W. B. Krohn. 1982. Status of the habitat evaluation procedures. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 47:154-164.

Schwartz, C. C., and A. W. Franzmann. 1991. Interrelationship of black bears to moose and forest succession in the northern coniferous forest. Wildl. Monogr. No. 113. 58pp.

Spencer, H. E., Jr. 1955. The black bear and its status in Maine. Maine Dept. Inland Fish. and Game Div. Bull. 4. 55pp.

Taylor, M., ed. 1994. Density-dependent population regulation in black, brown, and polar bears. Int. Conf. Bear Res. and Manage. Monogr. Series No. 3. 43pp.

U. S. Bureau of Census. 1990. (Maine population statistics, 1990).

U. S. Fish and Wildlife Service and U. S. Bureau of Census. 1998. 1996 National survey of fishing, hunting, and wildlife-associated recreation. Maine. 47pp.

U. S. Forest Service. 1982. 1980 Maine forest resurvey. Northeast. For. Exp. Stn., Broomall, Penn.

U.S. For. Serv. 1997. 1995 Maine data file (METRE_95.DAT). U.S. For. Serv., For. Inventory and Anal. Unit, Northeast. For. Exp. Stn., Radnor, Penn.

Wiley, J. 1999. (in prep) Draft beech management guidelines for mast production. Maine Dept. Inland Fisheries and Wildlife, Augusta.

Wooding, J. B., and R. C. Maddrey. 1994. Impacts of roads on black bears. East Workshop Black Bear Res. and Manage. 12: 124-129.

Young, B. F., and R. L. Ruff. 1982. Population dynamics and movements of black bears in east central Alberta. J. Wildl. Manage. 46(4):845-860.

Table 1. Cause of death of black bears studied in Maine, 1981-1996[a].

Study Area	Sex	Age Class	Hunting	Crippling	Auto	Research	Disease/ Starvation	Other Predation	Bear Predation	Unknown	Total
Spectacle Pond	Female	Cub	2	0	0	0	0	0	2	30	34
		Yearling	9	1	0	3	5	1	1	0	20
		Subadult	19	3	0	2	2	0	4	0	30
		Adult	44	0	0	5	0	1	2	1	53
		Combined	**74**	**4**	**0**	**10**	**7**	**2**	**9**	**31**	**137**
	Male	Cub	5	0	0	1	0	0	2	28	36
		Yearling	4	0	0	0	2	0	1	0	7
		Subadult	47	0	0	0	0	0	0	0	47
		Adult	40	0	1	0	0	0	0	0	41
		Combined	**96**	**0**	**1**	**1**	**2**	**0**	**3**	**28**	**131**
Stacyville	Female	Cub			0	0	0	0	0	7	7
		Yearling	0	0	0	2	2	0	0	1	5
		Subadult	5	0	0	2	1	0	0	0	8
		Adult	6	1	0	0	0	0	0	0	7
		Combined	**11**	**1**	**0**	**4**	**3**	**0**	**0**	**8**	**27**
	Male	Cub	0	0	0	0	0	0	0	7	7
		Yearling	9	0	0	0	0	0	0	0	9
		Subadult	10	0	0	0	0	0	0	0	10
		Adult	10	0	0	0	0	0	0	0	10
		Combined	**29**	**0**	**0**	**0**	**0**	**0**	**0**	**7**	**36**

Table 1. Cause of death of black bears studied in Maine, 1981-1996[a]. (cont'd)

Study Area	Sex	Age Class	Hunting	Crippling	Auto	Research	Disease/ Starvation	Other Predation	Bear Predation	Unknown	Total
Bradford	Female	Cub	1	0	1	3	2	0	0	19	26
		Yearling	11	0	0	6	2	0	0	1	20
		Subadult	14	1	2	4	1	0	1	1	24
		Adult	17	1	1	2	1	0	1	0	23
		Combined	**43**	**2**	**4**	**15**	**6**	**0**	**2**	**21**	**93**
	Male	Cub	3	0	0	5	0	0	1	22	31
		Yearling	7	0	1	0	0	0	1	0	9
		Subadult	59	0	2	1	0	0	0	0	62
		Adult	23	1	3	0	0	0	0	0	27
		Combined	**92**	**1**	**6**	**6**	**0**	**0**	**2**	**22**	**129**

[a] Cause of death-- for cubs (either sex): determined by in-den counts of newborns and yearlings;-- for yearlings and older: telemetry studies for females, and ear tag returns for males.

Table 2. Bear management history in Maine.

Year(s)	Harvest	Estimated effort (no. hunters)	Status and Regulations: Season length	Status and Regulations: Bag limit	Status and Regulations: Remarks
1770	No records	No records	No closed season	No limit	Bounty paid in Scarborough
1880's	Bounty payment (incomplete)	"	"		Bounties paid in various parts of State
1931-41	Bounty payment (incomplete)	"	Same as deer season		Classfied as game animal; bountied in parts of State
1941-57	1,569[1]	"	No closed season		Bountied.
1943		"	"		Hunting prohibited on Sundays and at night.
1952-53		"	"		Study on status of bears in State completed (Spencer, 1955).
1957		"	"		Bounty repealed.
1958-65		"	"		Only partial kill figures exist from 1958-68.
1963		"	"		Mandatory reporting of all bears killed.
1966-68		"	June 1-December 31		
1967		"	"		Trapping season restricted to June 1-December 31.
1969	806	"	"	1/hunter/yr	Cubs protected, cable traps legalized, mandatory registration of all harvested bears after Oct. 1, 1969.
1970	970	"	"	"	
1971	989	31,358[2]	"	"	Cubs become legal game.
1972	786	31,110	"	"	
1973	1,078	34,444	June 1-November 24	"	
1974	751	24,146	May 1-November 30	"	
1975	959	26,985	"	"	Intensive study of exploitation, movements, and habitat selection begun.
1976	1,008	23,296	May 1-Saturday following Thanksgiving		
1977	1,066	22,244	"	"	
1978	1,320	21,021	"	"	
1979	1,630	22,665	"	"	
1980	1,058	9,658	May 1-September 13	"	Hunting season truncated on Sept. 13 by Commissioner to limit harvest size.
1981	1,001	24,518	May 1-June 13; October 1-November 28	"	Mandatory submission of premolars for aging purposes.

Table 2. Bear management history in Maine (continued).

Year(s)	Harvest	Estimated effort (no. hunters)	Status and Regulations: Season length	Bag limit	Remarks
1982	1,221	33,417	September 1-November 30	"	
1983	1,412	33,545[2]	"	"	
1984	1,601		"	"	
1985	1,544		"	"	
1986	1,955		"	"	Repealed mandatory submission of premolars.
1987	2,394		"	"	New baiting restrictions, and dog training seasons go into effect.
1988	2,673	20,676[3]	August 29-November 30	"	
1989	2,690		August 28-November 30	"	
1990	2,088	11,803[4]	August 27-November 30	"	Additional restrictions on length of time baiting, use of dogs, and still hunting/stalking. Trapping permitted during Oct. 1-Oct. 31.
1991	1,665	10,204	September 2-November 30	"	
1992	2,042	10,133	August 31-November 28	"	
1993	2,055	10,195	August 30-November 27	"	
1994	2,243	9,991	August 29-November 26	"	Trapping period extended to 5 weeks, still hunting/ stalking extended to entire season.
1995	2,645	10,929	August 28-November 25	"	
1996	2,246	10,928	August 26-November 30	"	.
1997	2,300	10,669	August 25 - November 29	"	Trapping period extended to Sep. 1 - Oct. 31
1998	2,618	10,871	August 31 - November 28	"	

[1]Mean calculated kill 1946-59.
[2]Estimated number of bear hunters, based on Department of Inland Fisheries and Wildlife, Personal Hunting Report (Game Kill Questionnaire). The Game Kill Questionnaire was sent to a sample of licensed hunters annually. The resulting estimate of bear hunter numbers was likely inflated and includes hunters who pursued bears during deer season.
[3]Estimated based upon the 1988 survey of bear hunters (Reiling et al. 1991)
[4]Since 1990, the actual number of bear hunting permits sold. A bear permit is only required for hunting bears prior to firearms deer season opening, which is usually about November 1.

Table 3. Bear harvest by method of take, 1982-1998.

	Method of Take					
Year	Bait	Hounds	Trap	Deer Season	All Other Methods[1]	Totals
82	187	152	12	603	267	1,221
83	386	231	43	366	386	1,412
84	443	230	47	422	459	1,601
85	687	322	45	214	276	1,544
86	920	311	52	456	216	1,955
87	1,358	428	77	174	357	2,394
88	1,387	374	75	701	136	2,673
89	1,698	397	55	281	259	2,690
90	1,277	287	50	325	158	2,088
91	1,027	241	40	256	94	1,658
92	1,123	257	32	551	62	2,025
93	1,364	316	35	193	147	2,055
94	1,297	282	45	524	95	2,243
95	2,020	329	25	110	161	2,645
96	1,398	273	41	458	76	2,246
97	1,701	344	56	101	98	2,300
98	1,755	258	59	429	117	2,618

[1]All other legal methods include still hunting, stalking, incidental to deer, bird hunting.

Table 4. Present bear habitat suitability - 1999.

WMD	Bear Habitat Category	Land Area (sq. mi)	Percent Bear Habitat	Estimated Bear Habitat (sq. mi)	Bear Habitat Suitability index value	Number of Bear Habitat Units	Carrying Capacity (Number of Bears) High	Carrying Capacity (Number of Bears) Low	MidPoint
1	Forest	1,419.62	0.98	1,392.43	0.82	1,142	2,284	1,713	1,998
2	Forest	1,189.89	0.98	1,171.22	0.82	960	1,921	1,441	1,681
3	Forest-Farm	966.29	0.85	816.61	0.72	588	1,176	882	1,029
4	Forest	1,962.74	0.98	1,917.38	0.82	1,572	3,145	2,358	2,751
5	Forest	1,549.07	0.97	1,508.79	0.82	1,237	2,474	1,856	2,165
6	Forest-Farm	1,416.85	0.76	1,079.13	0.72	777	1,554	1,165	1,360
7	Forest	1,393.26	0.98	1,364.96	0.82	1,119	2,239	1,679	1,959
8	Forest	2,054.45	0.98	2,003.25	0.82	1,643	3,285	2,464	2,875
9	Forest	978.71	0.97	950.31	0.82	779	1,559	1,169	1,364
10	Forest	897.87	0.94	839.74	0.82	689	1,377	1,033	1,205
11	Forest-Farm	1,700.15	0.90	1,530.35	0.72	1,102	2,204	1,653	1,928
12	Forest-Farm	996.00	0.92	919.02	0.72	662	1,323	993	1,158
13	Forest-Farm	574.91	0.91	521.55	0.72	376	751	563	657
14	Forest	798.15	0.96	766.98	0.82	629	1,258	943	1,101
15	Forest-Farm	1,038.34	0.83	862.27	0.72	621	1,242	931	1,086
16	Forest-Farm	826.06	0.79	653.05	0.72	470	940	705	823
17	Forest-Farm	1,430.45	0.80	1,143.79	0.72	824	1,647	1,235	1,441
18	Forest	1,367.23	0.89	1,218.90	0.82	1,000	1,999	1,499	1,749
19	Forest	1,175.83	0.93	1,096.67	0.82	899	1,799	1,349	1,574
20	Forest-Farm	646.25	0.75	484.40	0.72	349	698	523	610
21	Forest-Farm	629.39	0.69	437.23	0.72	315	630	472	551
22	Forest-Farm	576.26	0.72	413.33	0.72	298	595	446	521
23	Forest-Farm	1,035.45	0.79	815.29	0.72	587	1,174	881	1,027
24	Unsuitable for Bear	373.65	0.00	0.00	0	0	0	0	0
25	Forest-Farm	550.26	0.77	425.50	0.72	306	613	460	536
26	Forest-Farm	654.36	0.79	519.03	0.72	374	747	561	654
27	Forest-Farm	895.83	0.86	766.13	0.72	552	1,103	827	965
28	Forest-Farm	831.03	0.86	718.63	0.72	517	1,035	776	905
29	Forest-Farm	512.52	0.81	415.40	0.72	299	598	449	523
30	Unsuitable for Bear	355.08	0.00	0.00	0	0	0	0	0
Baxter	Forest	241.33	0.92	221.65	0.82	182	364	273	318
State		**31,037.28**	**0.87**	**26,973.00**		**20,866**	**41,732**	**31,299**	**36,515**
Bear Habitat by Region									
Forest		15,028.14	0.96	14,452.29	0.82	11,851	23,702	17,776	20,739
Forest-Farm		15,280.42	0.82	12,520.71	0.72	9,015	18,030	13,522	15,776
Unsuitable for Bear		728.73	0	0.00	0	0	0	0	0

Carrying capacity calculations assume that optimal bear habitat in the Northeast could support 1.5 -- 2 bears/sq. mile

Table 5. Projected bear habitat suitability - 2016, assuming loss of beechnut production in the Forest Region[1], and no net loss of habitat.

WMD	Bear Habitat Category	Land Area (sq. mi)	Percent Bear Habitat	Estimated Bear Habitat (sq. mi)	Bear Habitat Suitability index value	Number of Bear Habitat Units	Carrying Capacity (Number of Bears) High	Carrying Capacity (Number of Bears) Low	MidPoint
1	Forest	1,419.62	0.98	1,392.43	0.5	696	1,392	1,044	1,218
2	Forest	1,189.89	0.98	1,171.22	0.5	586	1,171	878	1,025
3	Forest-Farm	966.29	0.85	816.61	0.72	588	1,176	882	1,029
4	Forest	1,962.74	0.98	1,917.38	0.5	959	1,917	1,438	1,678
5	Forest	1,549.07	0.97	1,508.79	0.5	754	1,509	1,132	1,320
6	Forest-Farm	1,416.85	0.76	1,079.13	0.72	777	1,554	1,165	1,360
7	Forest	1,393.26	0.98	1,364.96	0.5	682	1,365	1,024	1,194
8	Forest	2,054.45	0.98	2,003.25	0.5	1,002	2,003	1,502	1,753
9	Forest	978.71	0.97	950.31	0.5	475	950	713	832
10	Forest	897.87	0.94	839.74	0.5	420	840	630	735
11	Forest-Farm	1,700.15	0.90	1,530.35	0.72	1,102	2,204	1,653	1,928
12	Forest-Farm	996.00	0.92	919.02	0.72	662	1,323	993	1,158
13	Forest-Farm	574.91	0.91	521.55	0.72	376	751	563	657
14	Forest	798.15	0.96	766.98	0.5	383	767	575	671
15	Forest-Farm	1,038.34	0.83	862.27	0.72	621	1,242	931	1,086
16	Forest-Farm	826.06	0.79	653.05	0.72	470	940	705	823
17	Forest-Farm	1,430.45	0.80	1,143.79	0.72	824	1,647	1,235	1,441
18	Forest	1,367.23	0.89	1,218.90	0.5	609	1,219	914	1,067
19	Forest	1,175.83	0.93	1,096.67	0.5	548	1,097	823	960
20	Forest-Farm	646.25	0.75	484.40	0.72	349	698	523	610
21	Forest-Farm	629.39	0.69	437.23	0.72	315	630	472	551
22	Forest-Farm	576.26	0.72	413.33	0.72	298	595	446	521
23	Forest-Farm	1,035.45	0.79	815.29	0.72	587	1,174	881	1,027
24	Unsuitable for Bear	373.65	0.00	0.00	0	0	0	0	0
25	Forest-Farm	550.26	0.77	425.50	0.72	306	613	460	536
26	Forest-Farm	654.36	0.79	519.03	0.72	374	747	561	654
27	Forest-Farm	895.83	0.86	766.13	0.72	552	1,103	827	965
28	Forest-Farm	831.03	0.86	718.63	0.72	517	1,035	776	905
29	Forest-Farm	512.52	0.81	415.40	0.72	299	598	449	523
30	Unsuitable for Bear	355.08	0.00	0.00	0	0	0	0	0
Baxter	Forest	241.33	0.92	221.65	0.5	111	222	166	194
State		**31,037.28**	**0.87**	**26,973.00**		**16,241.06**	**32,482.11**	**24,361.58**	**28,421.85**
Bear Habitat by Region									
Northern Forest		15,028.14	0.96	14,452.29	0.5	7,226	14,452	10,839	12,646
Mixed Forest-Farm		15,280.42	0.82	12,520.71	0.72	9,015	18,030	13,522	15,776
Unsuitable for Bear		728.73	0	0.00	0	0	0	0	0

Carrying capacity calculations assume that optimal bear habitat in the Northeast could support 1.5 – 2 bears/sq. mile

[1] The value of Habitat Suitability Variable V11 (nuts produced by trees) was set to 0, for the Forest region, and then the HSI was calculated to simulate total loss of beechnut produciton in the retion. Acorn production is very low in this portion of bear range, and has limited influence on bear food abundance.

Table 6. Estimates of Maine's black bear population, 1950-1999.

Date	Population Estimate	Trend	Method
1950--1955	5,000-7,000	Increasing	Transects -sign
1975	7,000-10,000	No Estimate	Harvest Statistics
1979	6,000-9,000	No Estimate	Harvest and Telemetry
1984	18,000	Increasing	Extrapolation of Telemetry-based density estimates to area in bear habitat
1985	21,000	Increasing	"
1990	18,490	Decreasing	"
1996	21,000	Increasing	"
1999	23,000	Increasing	"

Table 7. Bear hunting effort - permit sales and participation.

	Permit Sales and Participation				Estimated # Participants		
Year	Res	% Hunt	Non Res	% Hunt	# Res	# Non Res	# Total Hunters
90	7,167	78	4,636	94	5,590	4,358	9,948
91	6,255	75	3,949	95	4,691	3,752	8,443
92	6,107	78	4,026	93	4,763	3,744	8,507
93	6,188	79	4,007	96	4,889	3,847	8,736
94	5,979	74	4,022	93	4,417	3,740	8,157
95	6,680		4,249				
96	5,999		4,929				
97	6,012		4,657				
98	5,970		4,901				
99	6,619		5,905		4,964	5,315	10,279
00	6,255		6,535				

Table 8. Bear hunting effort by method, year, and residence for (A) hunting over bait and with hounds and for (B) still hunting and miscellaneous forms of hunting.

A.

	Bait						Hounds					
	% Bait		Mean Days Hunted		Total Hunter Days		% Hounds		Mean Days Hunted		Total Hunter Days	
Year	R	N	R	N	R	N	R	N	R	N	R	N
1991	42	77	8	5	15,762	14,445	9	14	8	5	3,378	2,626
1992	57	81	8	5	21,719	15,163	14	15	8	5	5,335	2,808
1993	60	83	7	5	20,534	15,965	11	14	8	6	4,302	3,231
1994	61	82	7	5	18,861	15,334	14	14	9	5	5,565	2,618
1999	67	84	6	5	19,955	26,788	10	10	8	5	4,964	4,252

B.

	Still						Other						
	% Still		Mean Days Hunted		Total Hunter Days		% Other		Mean Days Hunted		Total Hunter Days		Total Hunter Effort Days
Year	R	N	R	N	R	N	R	N	R	N	R	N	
1991	35	10	7	4	11,493	1,501	4	1	7	4	1,313	150	50,668
1992	41	10	8	5	15,623	1,872	4	1	7	2	1,334	75	63,929
1993	42	10	7	4	14,374	1,538	6	1	9	4	2,640	154	62,738
1994	37	10	6	5	9,806	1,870	7	1	9	3	2,783	112	56,949
1999	30	7	6	5	8,935	1,860	5	1	9	5	2,234	266	69,254

Table 9. Mean bear hunting success rate statewide by method for (A) hunting over bait, (B) hunting with hounds, (C) miscellaneous hunting methods.

A.

Overbait by Year and Residence

	Projected Number of Hunters		Actual Number of Bears Taken		Success Rate			
Year	N	R	N	R	N		R	
1990	3,574	3,354						
1991	2,889	1,970	776	247	0.27		0.13	
1992	3,033	2,715	860	263	0.28		0.10	
1993	3,193	2,933	949	415	0.30		0.14	
1994	3,067	2,694	936	361	0.31		0.13	
1999	4,465	3,326	2,109	730	0.47	(0.53)	0.22	(0.33)

B.

With Hounds by Year and Residence

	Projected Number of Hunters		Actual Number of Bears Taken		Success Rate			
Year	N	R	N	R	N		R	
1990	375	783						
1991	528	422	167	74	0.32		0.18	
1992	562	667	184	73	0.33		0.11	
1993	539	538	218	98	0.40		0.18	
1994	524	618	185	97	0.35		0.16	
1999	532	496	255	72	0.48	(0.54)	0.14	(0.12)

C.

Other Methods by Year and Residence

	Projected Number of Hunters		Actual Number of Bears Taken		Success Rate			
Year	N	R	N	R	N		R	
1991	413	1,830	37	62	0.09		0.03	
1992	411	2,144	35	40	0.09		0.02	
1993	423	2,346	48	100	0.11		0.04	
1994	411	1,948	28	67	0.07		0.03	
1999	425	1,737	71	181	0.17	(0.12)	0.10	(0.09)

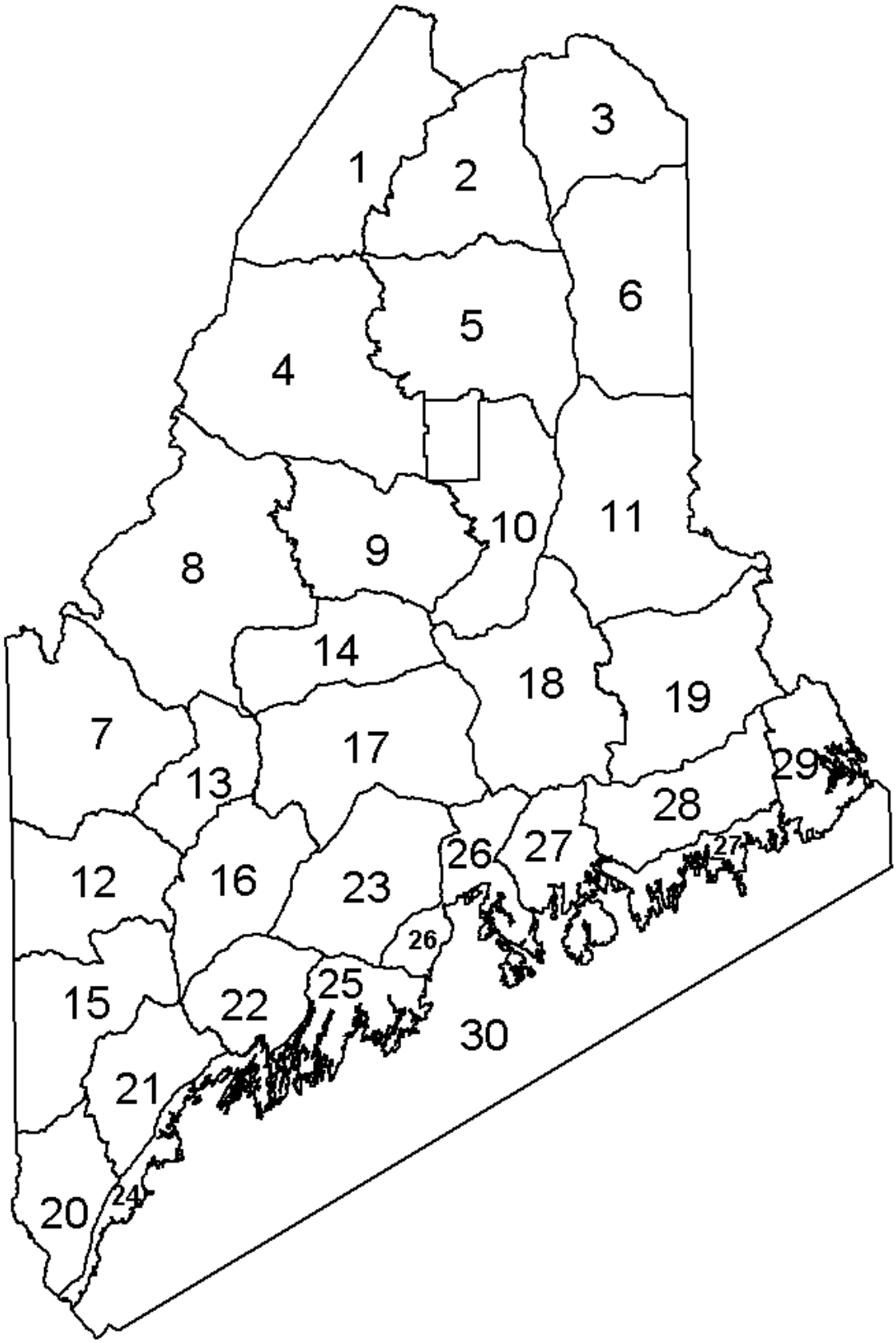


Figure 1A. Wildlife Management Districts.

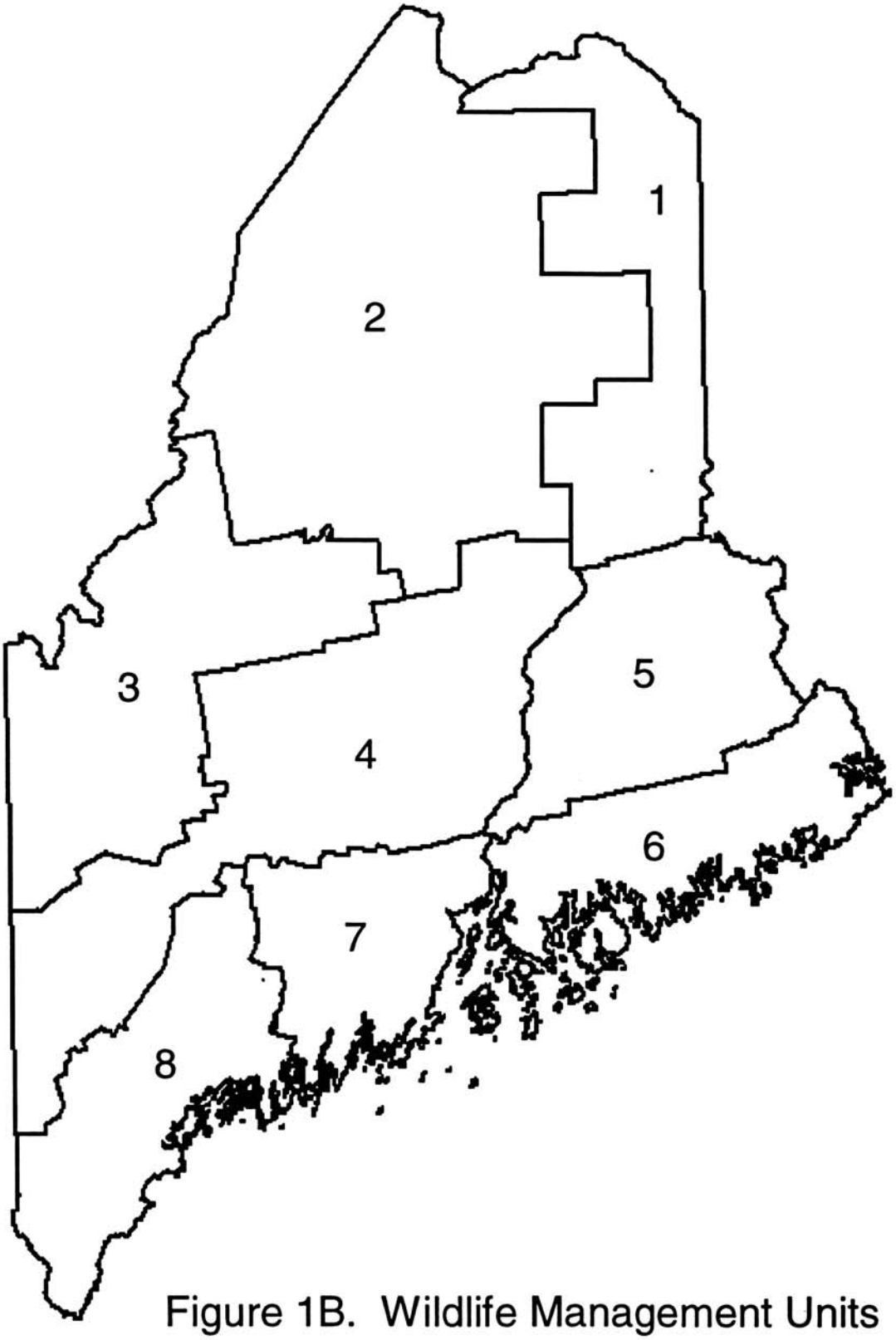


Figure 1B. Wildlife Management Units

Figure 2. Timing of Maine bear hunting periods, by hunting method, 1982-1989 and 1990-1998.

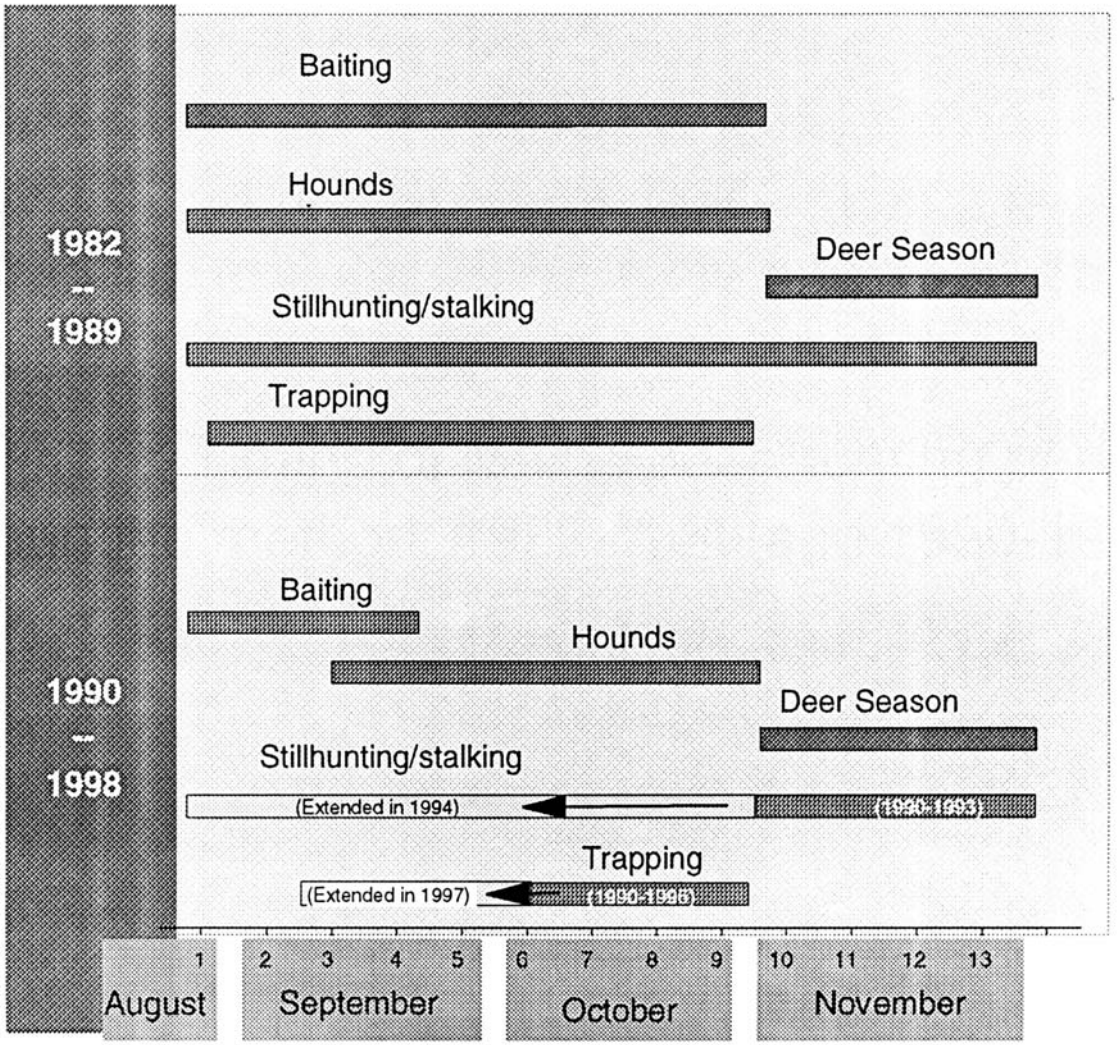


Figure 3. MAINE BEAR HARVESTS BY METHOD OF TAKE
1982-1998

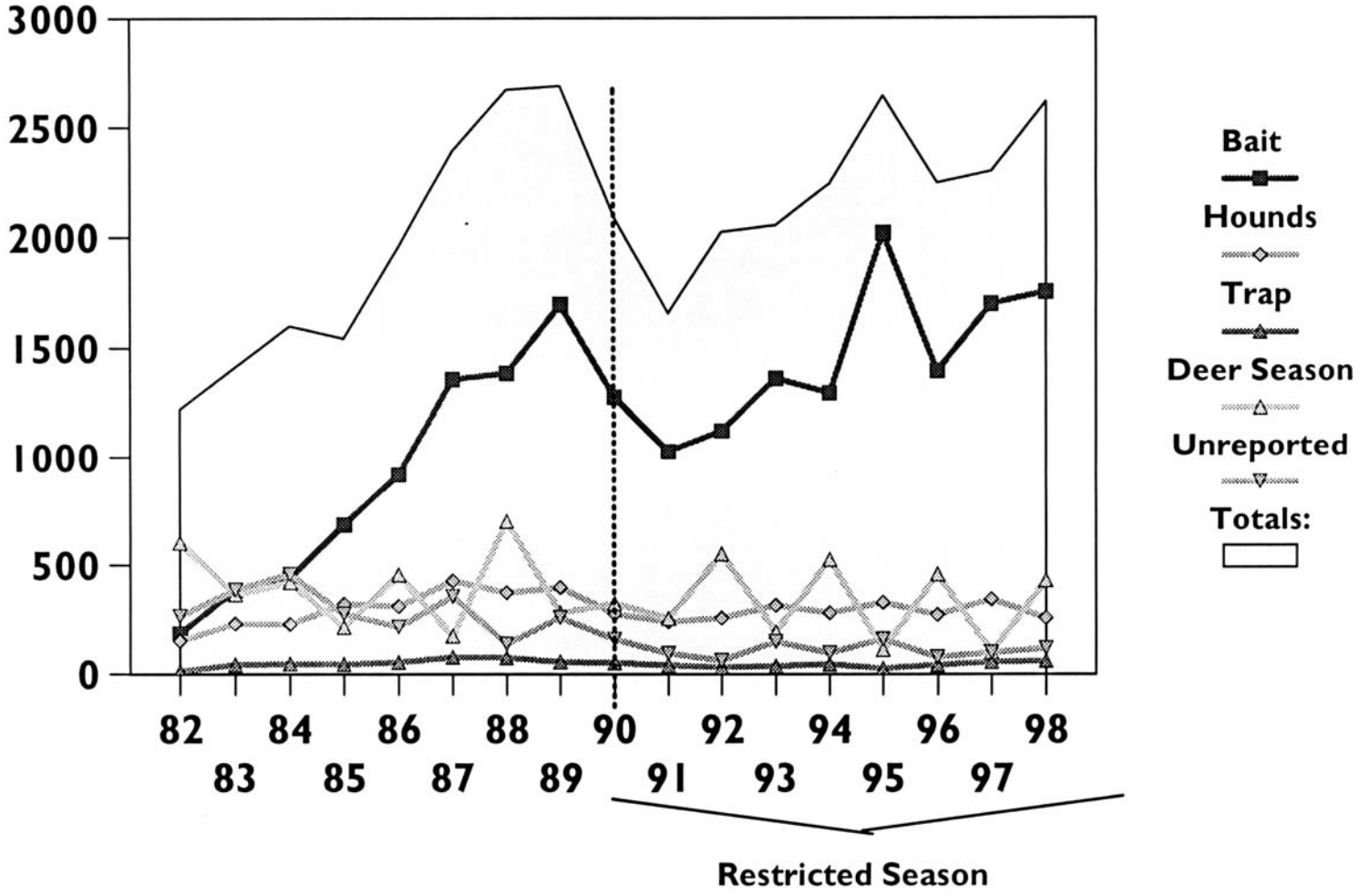
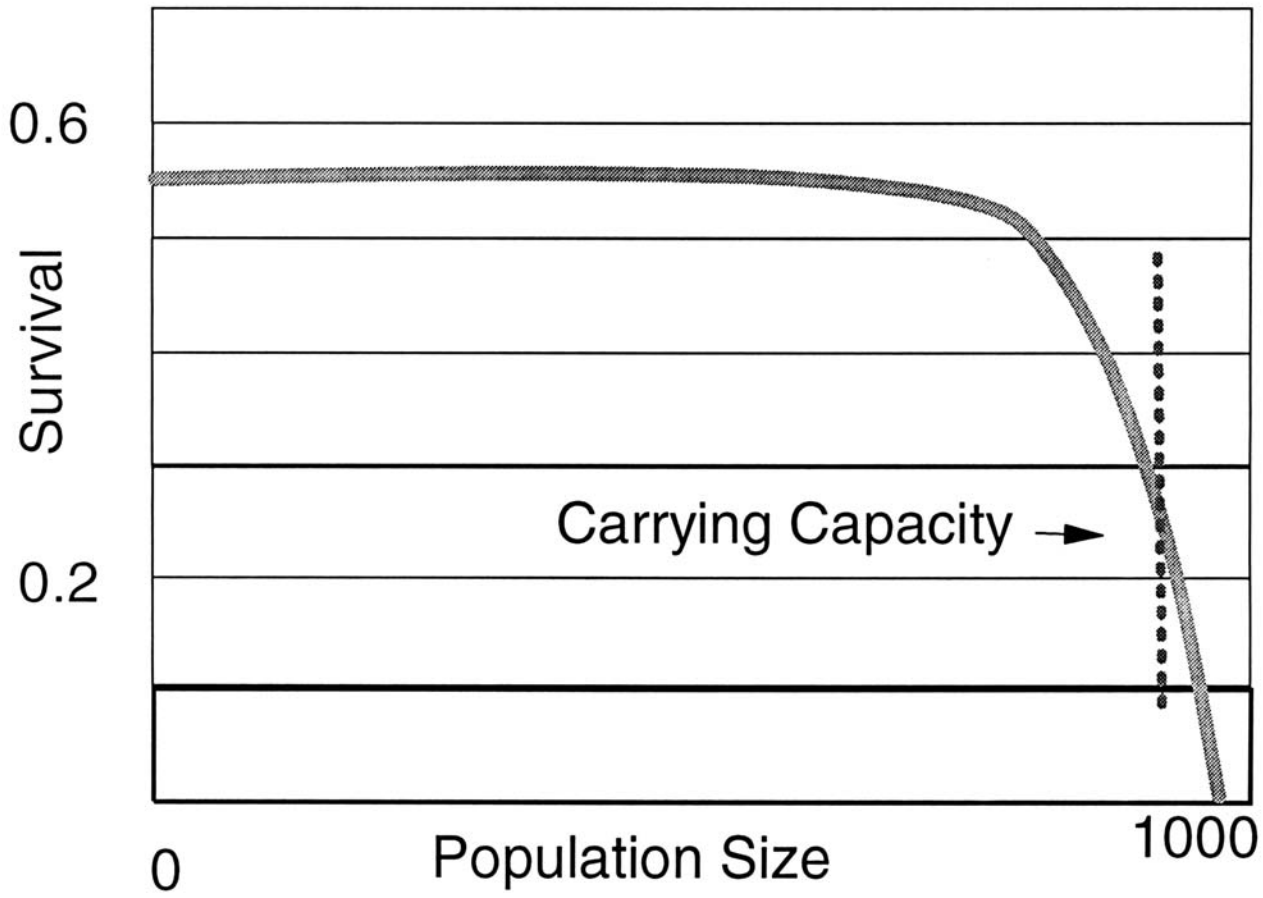


Figure 4. Example of Nonlinear Reduction in Survival



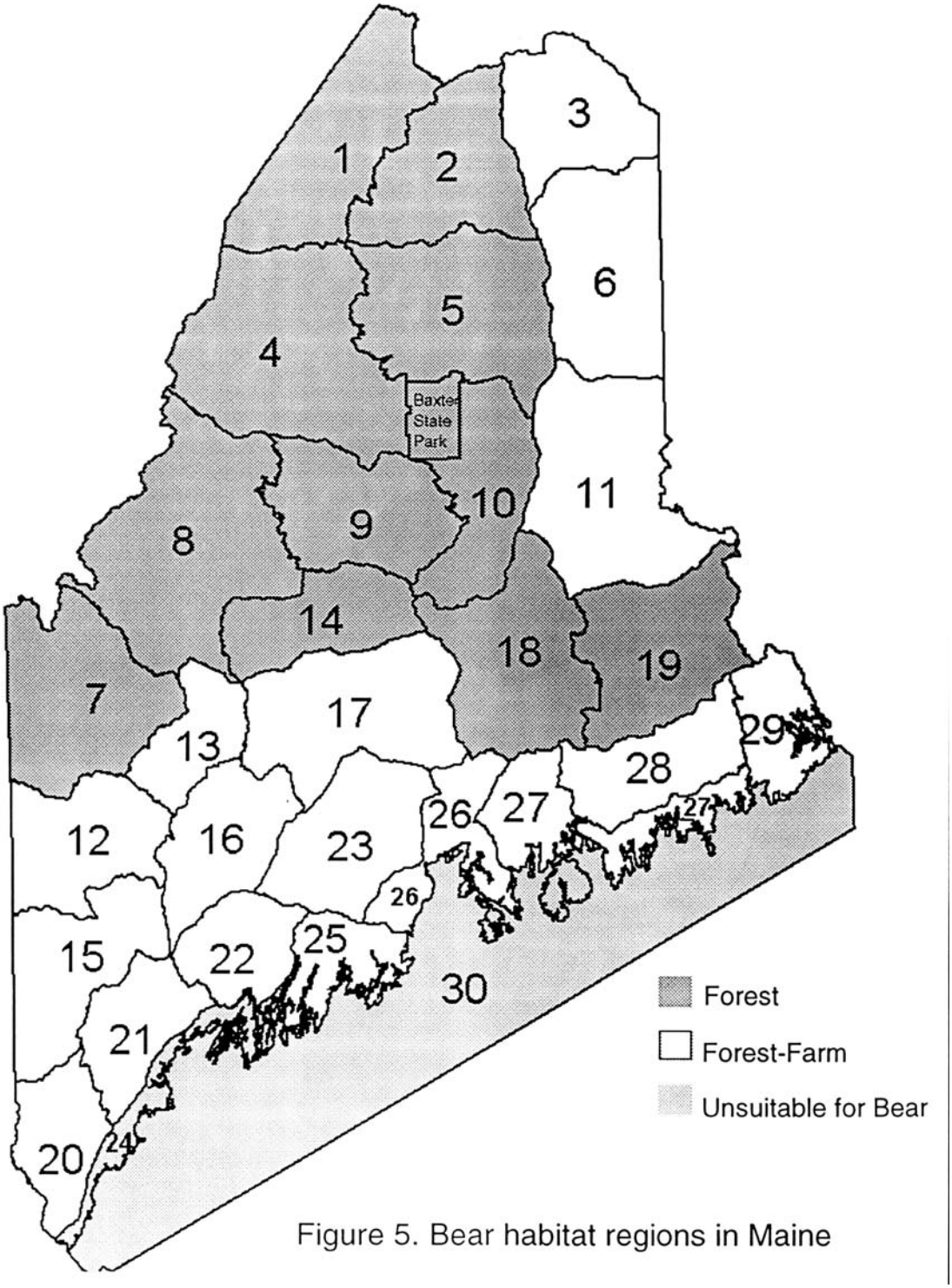


Figure 5. Bear habitat regions in Maine

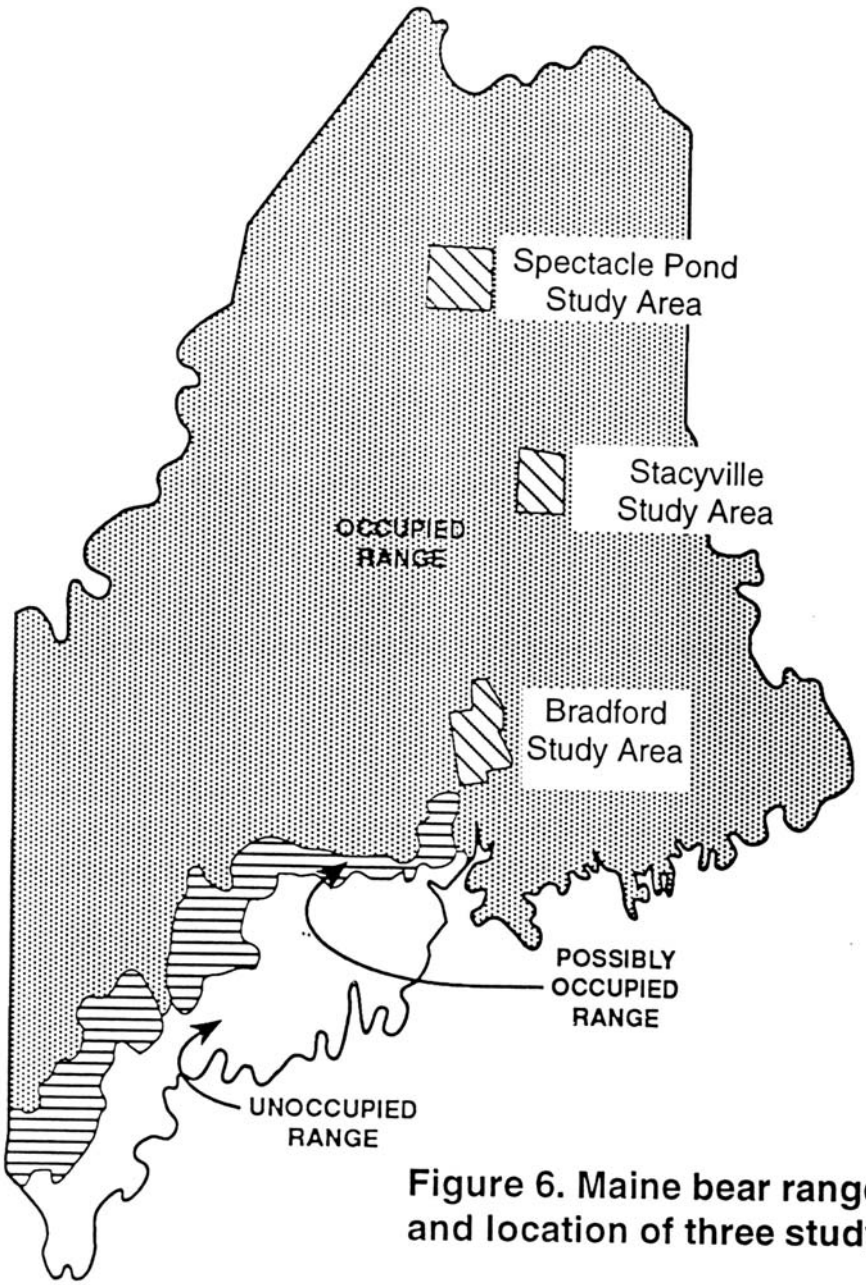
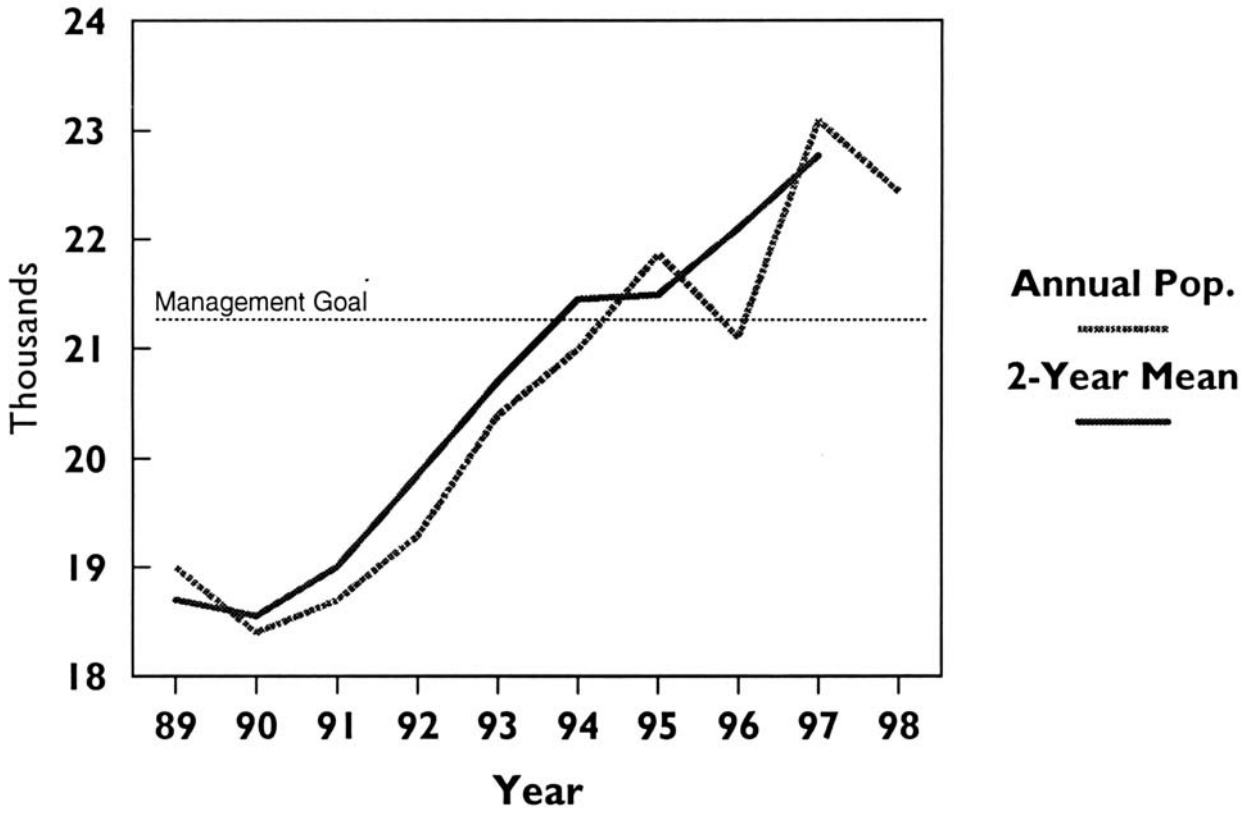


Figure 6. Maine bear range (1985), and location of three study areas.

Figure 7. Maine Bear Population Trend 1989-1998



Appendix I

Tables of Bear Habitat Suitability Used In Previous Assessments

Table I-1. Bear Habitat in Maine (1975 and 1980 Assessments).

Mgm't Unit	Bear Habitat					% of Unit in Bear Habitat	Bear Habitat (Sq. Miles)	% Bear Habitat Forested	% of Total Bear Habitat in Maine
	Area[1]	Suitable[2] Woodland	Farmlands[3]	Useable[4] Wetlands	Total[1]				
1	1,553,423	1,044,632	40,625	11,485	1,096,742	70.6	1,719	95.2	7.5
2	5,970,378	5,447,060	5,502	68,003	5,520,565	92.5	8,626	98.7	37.9
3	2,544,753	2,291,130	trace	25,589	2,316,719	91.0	3,620	98.9	15.9
4	3,636,155	2,720,173	19,715	40,523	2,780,411	77.0	4,344	97.8	19.1
5	1,884,023	1,616,315	3,298	42,520	1,662,133	88.2	2,597	97.2	11.4
6	1,670,291	1,068,204	8,877	10,802	1,087,883	65.1	1,700	98.2	7.5
7	1,365,573	46,080	1,439	496	48,015	3.5	75	96.0	0.3
8	1,781,715	61,279	1,835	619	63,738	3.6	100	96.1	0.4
State	20,406,311	14,294,873	81,291	200,038	14,576,206	71.4	22,775	98.1	100.0

[1]All areas given in acres unless otherwise noted
[2]Woodland includes wooded swamp
[3]Farmlands include 10 percent of all types of farmland, except that occurring in Units 7 and 8.
[4]Useable wetland includes 50 percent of : seasonally flooded basins, fresh meadow, shrub swamp, and bog, except for those that occur in Units 7 and 8.

Table I-2. Bear Habitat Suitability - 1985.

Wildlife Management Unit	Total Area (mi^2)	Bear Habitat (mi^2)	Bear Habitat Suitability Index Value	Number of Bear Habitat Units
1	3,216	2,416	0.77	1,860
2	8,397	7,908	0.70	5,536
3	4,234	3,864	0.74	2,859
4	5,726	4,839	0.80	3,871
5	2,949	2,598	0.77	2,000
6	2,610	2,181	0.80	1,745
7	2,113	1,028[1]	0.71	730
8	2,825	1,016[1]	0.63	640
Statewide	32,070	25,850		19,241

[1]Assumption: only 65% of forestland in WMU 7, and 50% of forestland in WMU 8 is suitable for bears.

Appendix II

Assumptions and Variables used to Assess Bear Habitat Suitability in the 1999 Black Bear Assessment

Craig R. McLaughlin
MaryEllen R. Wickett

December, 1999

Procedure Used to Assess Bear Habitat in Maine – 1999

This appendix summarizes the data sets, procedures, and assumptions used to generate the Habitat Assessment portion of the 1999 Bear Assessment and Strategic Plan. Data summaries are archived by the Wildlife Habitat Group at the Bangor Office and by the Wildlife Planner at the Augusta Office.

Bear habitat was quantified in the following order:

1. Determine the amount of potential bear habitat in the state.
2. Determine the suitability (quality) of bear habitat.
3. Determine carrying capacity.

Data Sources

The vegetation and land cover map used in the GAP Analysis of Maine (ME-GAP; Hempinstall et al. 1999, Krohn et al. 1998) – modified to incorporate all National Wetland Inventory polygons, 1995 Forest Inventory of Maine (USFS 1997), 1997 Census of Agriculture (USBC 1999), miles of public roads by town (Maine Dept. of Transportation 1997 data), and the 1999 Deer and Moose Assessments (Lavigne 1999, Morris 1999) provided data for this evaluation of the quantity and quality of bear habitat.

Amount of Bear Habitat

The modified ME-GAP provided data for determining the amount of bear habitat. This information was summarized by Wildlife Management District. Habitat-related differences in the distribution and abundance of fall foods influence the reproductive schedules of female bears. In northern Maine, bear productivity is limited, due to dependence on a solitary food source that fluctuates in abundance from year to year, i.e., beechnuts. In much of the remainder of the State, bears use a variety of fall foods (partly due to past and present agricultural practices), and populations are more productive. Parts of south-coastal Maine and offshore islands have fragmented forestland and dense development, and are not considered to be bear habitat. Therefore, the 30 WMDs in the State were grouped into 3 categories, according to how much agricultural land they contained, and knowledge of forest fragmentation and human presence.

WMDs with ≤6% of their areas in agricultural lands (Table II-1) were assigned to the Forest Region (Figure 5 of Bear Assessment). Baxter Park was also assigned to this region, as 1.5% of its area is considered agricultural lands. The remaining WMDs (except WMD 24 and 30) contained 6.3% - 25.4% agricultural lands (Table II-1), and these were assigned to the Forest-Farm Region (Figure 5 of Bear Assessment). WMD 24 and 30 were excluded from bear range due to development and fragmented forestland.

The amount of land in all categories of forestlands and 5 categories of forested/scrub-shrub wetlands (Table II-1) within each WMD were considered potential

bear habitat. The Bear Habitat Suitability Index was applied to this estimate of potential bear habitat.

Suitability of Bear Habitat

The Bear Habitat Suitability Index (McLaughlin et al. 1988 – Appendix III) developed for the 1985 bear assessment was updated, and the modified ME-GAP data, 1995 Forest Resurvey data, 1997 Census of Agriculture, 1997 public road miles, and MDIFW data on deer and moose densities were applied to the model to generate a HIS value for each of the bear habitat regions (Forest and Forest-Farm; Table II-1).

The published model (McLaughlin et al. 1998 – Appendix III) was modified as follows for the 1999 assessment of bear habitat:

1) Removal of one food variable (V_{12}: garbage);
2) Correction of the equation for V_3 – units had been mislabeled on the suitability index axis;
3) Several variables measured during the 1982 Forest Resurvey were not included in the 1995 Resurvey, and data measures used to determine the suitability indices for several variables were refined:

    V_1 – herbaceous vegetation: permanent opening and time since harvest were not recorded during the 1995 Forest Resurvey. Modifications took into account whether forest stands were classified as seedling or nonstocked stands, and whether agricultural edge was present in the stand. In addition, calculations which determined the percentage of

forestland in each sample plot incorporated ecotype (e.g., forest vs. grasslands) delineation and weighting by area (acres);

V_3 – colonial insects: The presence of a cavity was not recorded during the 1995 Forest Resurvey. Modification included using dead-down tree categories and condition/damage levels to indicate the presence of colonial insects;

V_{11} – nuts produced by trees: We established minimum dbh limits for trees identified as nut producers (see details below);

V_{14} – interspersion of food sources: Forest stand area was not collected during the 1995 Forest Resurvey. This measure was refined by calculating the area of homogeneous cover type patches delineated from modified ME-GAP;

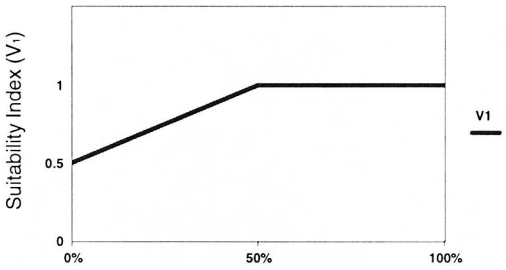
4) We changed the measure of V_{15} – suitable forestland to reflect our knowledge that bears tolerate greater fragmentation of forestland than was assumed in 1985. For the 199 assessment, suitable forestland was identified as all forest habitat (modified ME-GAP) with public road density ≤2 km public road/km^2 town area.

Changes in HSI Model Relationships

Suitability Index Curves

Cover Type	Variable
Forestland All forest type groups, stand sizes, and stocking	V_1

Herbaceous Vegetation

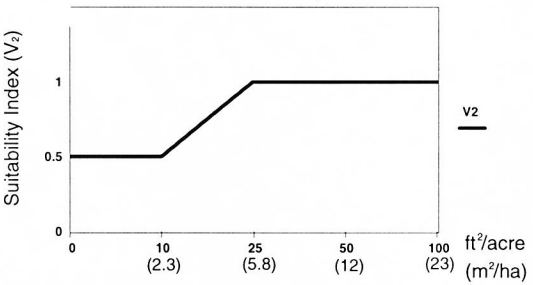


% Forestland with indicator of herbaceous vegetation
a) stand size classified as seedling or nonstocked, or
b) presence of agricultural edge
(forest/agriculture, shrub/agriculture)

Suitability Index Curves

Cover Type	Variable
Forestland All forest type groups, stand sizes, and stocking	V_2

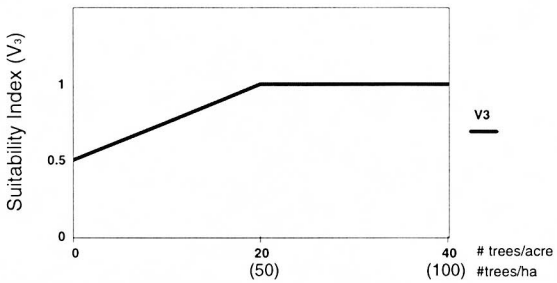
Buds/leaves of Birch, Beech, Aspen, Maple (live seedling, sapling, poletimber, and sawtimber)



Basal area of these species in ft^2/acre and m^2/ha of forest.

Cover Type	Variable
Forestland All forest type groups, stand sizes, and stocking	V_3

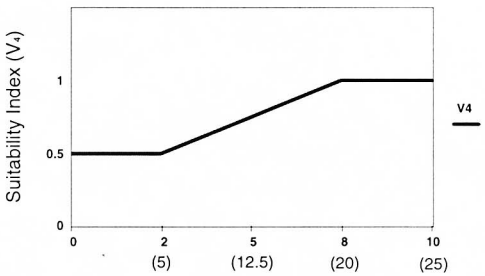
Colonial Insects



Number of snag, dead and dead down trees, and trees indicating general insect damage or specific damage by borers and bark beetles/acre and per hectare of forest.

Cover Type	Variable
Forestland All forest type groups, stand sizes, and stocking	V_4

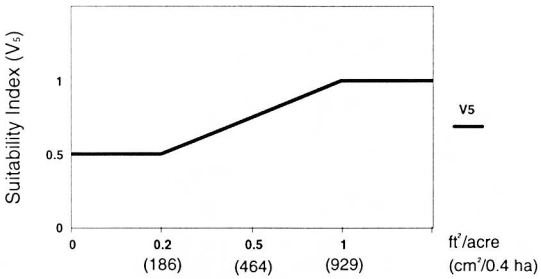
Berries produced by shrubs or vines



Thousands of stem-diversity units/acre and per hectare of forest.

Cover Type	Variable
Forestland All forest type groups, stand sizes, and stocking	V_5

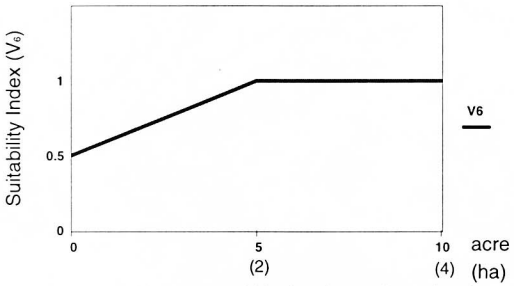
Berries produced by trees



Basal area of serviceberry and cherries (pin, black, and choke) in ft^2/acre and cm^2/0.4 ha of forest.

Cover Type	Variable
Forestland (All forest type groups, stand sizes, and stocking) and cropland	V_6

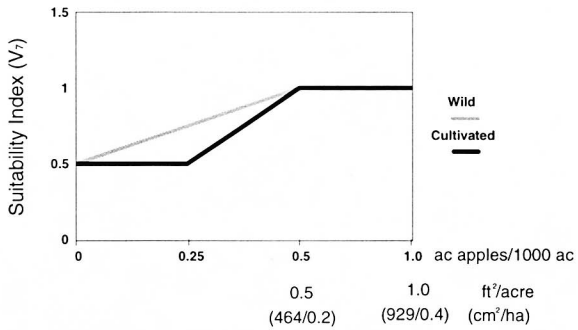
Cultivated berries



Acres and hectares of blueberries and raspberries under cultivation/1000 acres (405 ha) of forest.

Cover Type	Variable
Forestland (All forest type groups, stand sizes, and stocking) and cropland	V_7

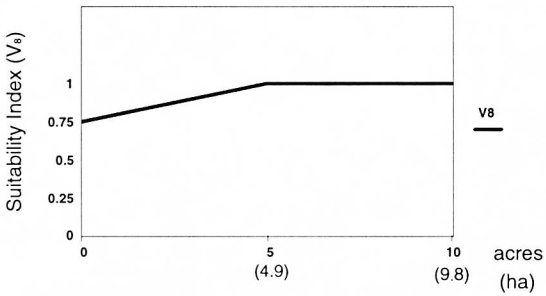
Apples (wild and cultivated)



Acres of apple orchards/1000 acres of forest
Basal area of wild apples (trees > 1.0 inch dbh)
in ft²/acre and cm²/hectare (ha) of forest

Cover Type	Variable
Forestland (All forest type groups, stand sizes, and stocking) and cropland	V_8

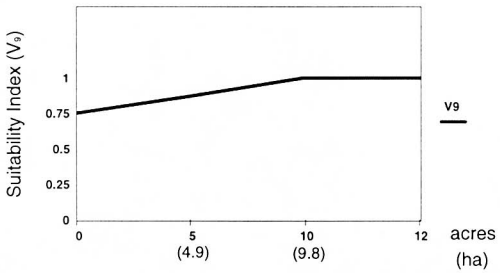
Corn



Area of corn expressed as acres/1000 acres
and as hectares/1000 ha of forest.

Cover Type	Variable
Forestland (All forest type groups, stand sizes, and stocking) and cropland	V_9

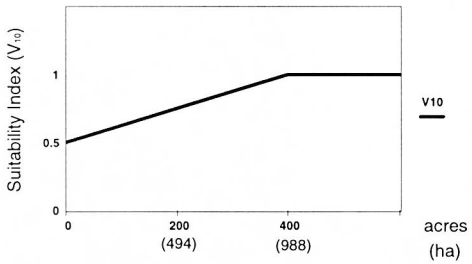
Oats



Area of oats expressed as acres/1000 acres and as hectares/1000 ha of forest.

Cover Type	Variable
Forestland All forest type groups, stand sizes, and stocking	V_{10}

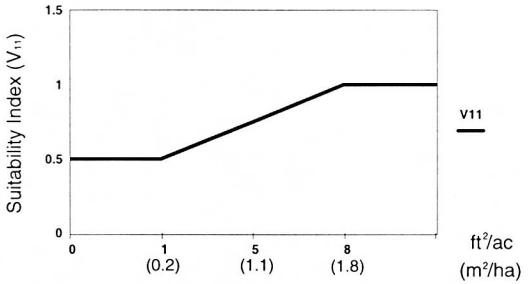
Nuts produced by shrubs



Stem-diversity units in acres and hectares of forest.

Cover Type	Variable
Forestland All forest type groups, stand sizes, and stocking	V_{11}

Nuts produced by trees

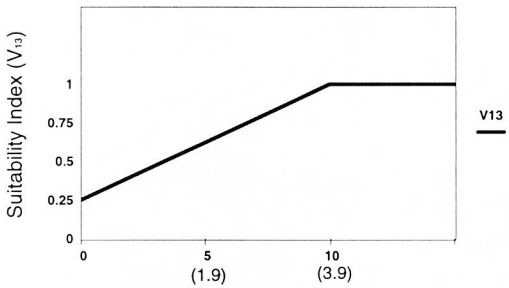


Aggregate basal area of nut producing tree species (scrub oak: dbh $\geq$ 1.0 inch; American beech: dbh $\geq$ 8.0 inches; other oaks: dbh $\geq$ 10.0 inches)/acre of forest, multiplied by diversity factor based on number of species groups present. Units are in ft²/acre (ac) and m²/hectare (ha).

Variable V_{12} -- Removed from the model.

Cover Type	Variable
Forestland All forest type groups, stand sizes, and stocking	V_{13}

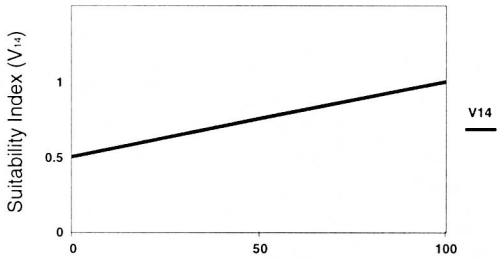
Vertebrates



Ungulate units/mi² (km²).
(1 ungulate unit = 1 deer-sized ungulate)

Cover Type	Variable
Forestlands and forest/ scrub-shrub wetlands (modified ME-GAP)	V_{14}

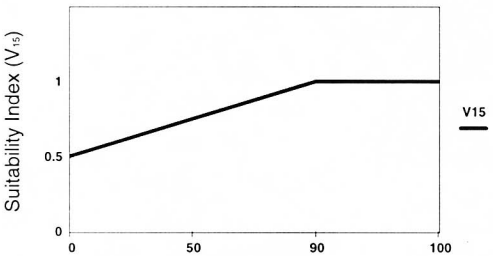
Interspersion of food sources



Cumulative % forest area in homogeneous stands <100 acres (40 ha) in size.

Cover Type	Variable
Forestlands and forest/ scrub-shrub wetlands (modified ME-GAP)	V_{15}

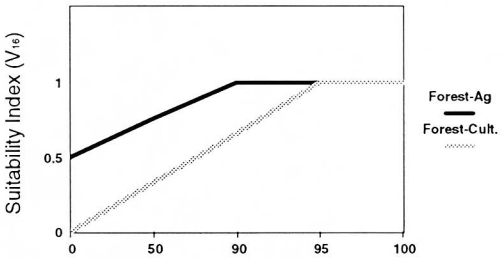
Percent of area in forestland



% of land area in suitable forestland.
(suitable forestland = forested habitat in towns with public road density < 2 km public road/km^2 of town area.

Cover Type	Variable
Forestland All forest type groups, stand sizes, and stocking	V_{16}

Juxtaposition of forest and non-forest lands



---- % of sample plots with ≤ 6 forest-agriculture edge hits

· · · · % of sample plots with 0 forest-cultural edge hits

V16 value = average of both measures.

Determining Carrying Capacity

Each WMD was assigned the HSI value developed for the bear habitat region of which it was a part (Table II-2). The number of habitat units (HUs) within each WMD were calculated by multiplying the respective HSI value by the amount of potential bear habitat in the WMD. Carrying capacity was estimated by multiplying the number of HUs in each WMD by the range (and midpoint) of maximum bear densities used in the 1985 assessment (1.5-2.0 bears/mi^2).

LITERATURE CITED

Hepinstall, J. A., S. A. Sader, W. B. Krohn, R. B. Boone, and R. I. Bartlett. 1999. Development and testing of a vegetation and landcover map of Maine. Maine Agricultural and Forest Experiment Station Technical Bulletin 173. Univ. Maine, Orono. 104pp.

Krohn, W. B., R. B. Boone, S. A. Sader, J. A. Hepinstall, S. M. Schaefer, and S. L. Painton. 1998. Maine Gap Analysis - a geographic analysis of biodiversity. Final contract report to USGS Biological Resources Division, Gap Analysis Program, Moscow, ID.

Lavigne, G. R. 1999. White-tailed deer assessment and strategic plan 1997. Maine Dept. Inland Fisheries and Wildlife. Augusta. 101pp.

McLaughlin, C. R., G. J. Matula, Jr., and J. H. Hunt. 1988. A draft habitat suitability index model for black bears in the conifer-deciduous forests of New England: its application in Maine. Proc. East. Workshop Black Bear Manage. Res. 8:137-164.

Morris, K. I. 1999. Moose assessment and strategic plan 1997. Maine Dept. Inland Fisheries and Wildlife. Augusta. 55pp.

U.S. For. Serv. 1997. 1995 Maine data file (METRE_95.DAT). U.S. For. Serv., For. Inventory and Anal. Unit, Northeast. For. Exp. Stn., Radnor, Penn.

U.S. Bureau of Census. 1999. 1997 Census of Agriculture. Vol. I. Geographic Area Series. Part 19. Maine: State and County data. U.S. Dep. of Commerce, Washington, D.C.

Table II-1. Percentage of MDIFW Wildlife Management Districts composed of different land cover designations, based upon the modified Maine GAP project.

WMD	Agricultural Lands	Forestlands[1]	Forested/ Scrub-shrub Wetlands[2]	Other Wetlands	Developed Lands	Other	Totals	Standard estimate of land area (sq. mi) used in MDIFW species assessments
1	0.12%	91.65%	6.43%	1.73%	0.06%	0.00%	100.00%	1,419.62
2	0.62%	92.84%	5.59%	0.88%	0.07%	0.00%	100.00%	1,189.89
3	12.82%	73.79%	10.72%	1.96%	0.71%	0.00%	100.00%	966.29
4	0.04%	88.27%	9.42%	2.27%	0.00%	0.01%	100.00%	1,962.74
5	0.71%	86.72%	10.68%	1.87%	0.02%	0.00%	100.00%	1,549.07
6	21.12%	63.94%	12.23%	1.40%	1.31%	0.00%	100.00%	1,416.85
7	0.89%	93.54%	4.43%	0.84%	0.30%	0.00%	100.00%	1,393.26
8	0.05%	90.83%	6.67%	2.33%	0.10%	0.01%	100.00%	2,054.45
9	0.25%	90.55%	6.55%	2.51%	0.05%	0.10%	100.00%	978.71
10	2.06%	83.83%	9.70%	3.40%	1.01%	0.00%	100.00%	897.87
11	6.28%	72.32%	17.69%	2.29%	1.42%	0.00%	100.00%	1,700.15
12	6.37%	87.90%	4.37%	0.75%	0.60%	0.02%	100.00%	996.00
13	7.44%	85.16%	5.56%	1.24%	0.60%	0.00%	100.00%	574.91
14	1.86%	89.37%	6.72%	1.54%	0.53%	0.00%	100.00%	798.15
15	14.30%	75.53%	7.51%	1.62%	1.00%	0.03%	100.00%	1,038.34
16	16.85%	71.49%	7.56%	2.18%	1.90%	0.01%	100.00%	826.06
17	15.99%	68.52%	11.44%	2.15%	1.90%	0.00%	100.00%	1,430.45
18	3.01%	73.13%	16.02%	5.53%	2.31%	0.00%	100.00%	1,367.23
19	1.34%	80.29%	12.98%	4.03%	1.36%	0.00%	100.00%	1,175.83
20	20.81%	63.06%	11.90%	2.25%	1.84%	0.14%	100.00%	646.25
21	25.40%	62.04%	7.43%	1.74%	3.20%	0.19%	100.00%	629.39
22	21.08%	65.71%	6.01%	3.36%	3.84%	0.00%	100.00%	576.26
23	16.08%	67.84%	10.89%	2.93%	2.25%	0.00%	100.00%	1,035.45
24	21.72%	49.51%	8.47%	6.90%	13.12%	0.29%	100.00%	373.65
25	14.97%	70.18%	7.15%	4.68%	3.03%	0.00%	100.00%	550.26
26	12.40%	72.71%	6.60%	3.98%	4.30%	0.00%	100.00%	654.36
27	6.32%	79.26%	6.26%	4.27%	3.34%	0.55%	100.00%	985.83
28	7.86%	74.72%	11.76%	4.90%	0.77%	0.00%	100.00%	831.03
29	11.08%	71.29%	9.76%	5.99%	1.87%	0.01%	100.00%	512.52
30	5.23%	36.77%	2.76%	53.29%	1.88%	0.06%	100.00%	355.08
Baxter	0.74%	87.98%	3.87%	1.30%	0.00%	6.12%	100.00%	241.33
Statewide	7.43%	78.95%	9.19%	3.04%	1.31%	0.08%	100.00%	31,037.28

[1]Modified ME-GAP landcover designations in forestlands include clearcut, early regeneration, late regeneration, light partial cut, heavy partial cut, deciduous forest, deciduous/coniferous forest, coniferous/deciduous forest, and coniferous forest.

[2]Modified ME-GAP landcover designations in forested/scrub-shrub wetlands include deciduous forested wetland, coniferous forested wetland, dead-forest wetland, deciduous scrub-shrub wetland, coniferous scrub-shrub wetland, and dead scrub-shrub wetland.

Table II-2. Individual black bear HSI variable values (food SI, cover SI), and overall HSI values assigned to each of 8 MDIFW Wildlife Management Units (WMU) and to the 2 bear habitat zones for the 1999 bear assessment, with comparable HSI values calculated during the 1985 black bear assessment.

Variable	WMU								Bear Zone	
	1	2	3	4	5	6	7	8	Forest	Forest-Farm
V1	0.93	0.67	0.68	1.00	0.73	0.82	1.00	1.00	0.69	1.00
V2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
V3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
V4	0.88	0.97	1.00	0.78	0.81	0.73	0.70	0.69	1.00	0.86
V5	0.72	0.88	1.00	0.92	0.69	0.82	1.00	1.00	0.91	0.99
V6	0.50	0.50	0.50	0.52	0.85	1.00	0.73	0.52	0.56	0.71
V7	0.62	0.50	0.50	0.71	0.50	0.51	0.92	0.86	0.50	0.83
V8	0.81	0.75	0.76	0.98	0.75	0.76	1.00	1.00	0.76	0.92
V9	1.00	0.75	0.75	0.76	0.75	0.75	0.75	0.75	0.75	0.81
V10	1.00	1.00	1.00	1.00	0.93	0.83	1.00	1.00	1.00	1.00
V11	0.55	0.66	0.66	0.80	0.61	0.53	0.86	0.92	0.66	0.72
V12										
V13	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
V14	0.77	0.74	0.78	0.80	0.76	0.75	0.84	0.84	0.75	0.79
V15	0.95	1.00	1.00	0.98	1.00	0.97	0.93	0.85	1.00	0.95
V16	0.91	1.00	0.93	0.73	0.96	0.80	0.50	0.44	0.98	0.72
Food Value	0.84	0.81	0.82	0.87	0.80	0.81	0.91	0.90	0.82	0.90
Cover Value	0.91	1.00	0.93	0.73	0.96	0.80	0.50	0.44	0.98	0.72
HSI	0.84	0.70	0.82	0.73	0.80	0.80	0.50	0.44	0.82	0.72
1985 VALUES										
FOOD	0.77	0.70	0.74	0.80	0.77	0.80	0.81	0.79		
COVER	0.93	1.00	0.99	0.88	0.97	0.90	0.71	0.63		
HSI	0.77	0.70	0.74	0.80	0.77	0.80	0.71	0.63		
CHANGE	0.07	0.11	0.08	0.07	0.03	0.01	0.10	0.11		
	-0.02	0.00	-0.06	-0.15	-0.01	-0.10	-0.21	-0.19		
	0.07	0.11	0.08	-0.07	0.03	0.00	-0.21	-0.19		

Appendix III

Draft Habitat Suitability Index model for black bear in the conifer-deciduous forests of New England: its application in Maine

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A draft habitat suitability index model for black bears in the conifer-deciduous forests of New England: its application in Maine.

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A draft Habitat Suitability Index (HSI) model is described for black bears in the conifer-deciduous forests of New England. The HSI incorporates suitability index ratings for 14 food variables and 2 cover variables. Application of the HSI in Maine is discussed, including practical limitations of the model and difficulties in obtaining appropriate data on several variable values. The HSI is considered valuable for planning purposes, but has not been verified with field data.

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Key Words: black bear, cover, food, habitat suitability, Maine, model, New England, Ursus americanus

For years, wildlife managers have recognized the constraints that habitat availability and suitability place on species management goals (Farmer et al 1982). The National Environment Policy Act (NEPA) of 1969, and subsequent legislation, have mandated that the environmental impacts of federally funded activities, including impacts on wildlife, be described before such activities begin. Consequently, it has become essential for wildlife managers to understand and describe the relationships between habitat conditions and species abundance, and to predict species response to habitat alterations (Thomas, 1982).

The Maine Department of Inland Fisheries and Wildlife (MDIFW) recently attempted to assess habitat suitability for bears in the State's 8 ecologically-based Wildlife Management Units (WMU) (Figure 1). The Habitat Evaluation Procedures (HEP) developed by the U. S. Fish and Wildlife Service were selected for this assessment (Schamberger and Krohn 1982). After a literature review uncovered no existing habitat models for black bears, the following Habitat Suitability Index (HSI) model was constructed. This HSI attempts to numerically rate bear habitat suitability in the conifer-deciduous forests of Maine and nearby New England States (New Hampshire, Vermont, and Massachusetts). It incorporates index ratings from 14 variables reflecting food abundance and distribution and 2 variables representing cover conditions.

The HSI is presented below, according to the Standards for the Development of Habitat Suitability Index Models (U.S. Fish and Wildlife Service Document 103-ESM). It includes a literature review of habitat use by black bears, followed by descriptive and graphic representations of the HSI model.

A discussion of the application of the HSI in Maine follows the model description. Methods and data used to measure variable values, and the HSI ratings for each WMU are presented. Limitations of the model, and difficulties encountered in its application, are discussed.

ACKNOWLEDGEMENTS

We thank the Wildlife Biologists of the Maine Department of Inland Fisheries and Wildlife who critiqued earlier drafts of this HSI model. Their comments added significantly to its quality. J. Connolly and A. Ritter provided statistical support. B. Jackson and G. Gordon cheerfully typed the manuscript, and L. Tudor constructed the figures. This work has been part of Maine black bear research, conducted under Federal Aid in Fish and Wildlife Restoration Project W-67-R.

BLACK BEAR (Ursus americanus)

HABITAT USE INFORMATION

General

Historically, the black bear (Ursus americanus) occurred throughout all forested sections of North America, including Mexico (Pelton, 1982). Its range has been substantially reduced during the last century; black bears have been extirpated from many midwestern and eastern states, and only remnant populations remain in others. In New England, bears have been extirpated from Rhode Island, but are well distributed throughout most of New Hampshire and Vermont, and range through western Massachusetts and parts of northern Connecticut (Cardoza 1976). Maine has remained a stronghold for black bears. It is heavily forested, with large amounts of suitable habitat for bears, a relatively small human population, and a bear population estimated at 21,000 animals (McLaughlin, 1986).

In the past, bears were regarded as pests in New England (Cardoza 1976, Hugie 1982, Elowe 1984). They were bountied throughout the region (as late as 1957 in Maine) because of their inclination to damage camps, apiaries and crops, and to kill livestock. Although some people still regard the black bear with disdain, many New England residents consider it a

valuable big game resource. The number of bear hunters, guides, and sporting camps catering to bear hunters in the region has increased substantially in the past decade. Bear hunting is now a substantial industry in Maine and New Hampshire. Almost 35,000 hunters specifically pursue bears in Maine alone (MDIFW unpubl. data).

Food Requirements

Black bears feed primarily on vegetation throughout their North American range (Cottam et al. 1939, Bennett et al. 1943, Tisch 1961, Hatler 1972, Poelker and Hartwell 1973, Rogers 1976, Reiffenberger et al. 1981, Hugie 1982, Pelton 1982, Warburton 1982, Lamb 1983). In Maine, the food habits of bears have been documented by scat collections and telemetry studies (Hugie 1982, Lamb 1983, Matula 1983, Caron and McLaughlin 1985). In the spring, bears consume mostly grasses, forbs, sprouting beechnuts (Fagus grandifolia) and acorns (Quercus spp.), and buds and leaves of woody plants. Berries and fruits are major summer food items, although bears continue to feed on grasses and forbs throughout summer and fall. Hard mast (beechnuts, acorns, hazelnuts (Corylus spp.) is utilized heavily as it becomes available in the fall. Bears living near agricultural regions feed upon orchard fruits and berry and grain crops, especially during years of hard mast failure (Cardoza 1976, Hugie 1982, Elowe

1984, McLaughlin and Matula unpubl. data). They will also visit sanitary landfills, open dumps, camp sites and backyards to obtain garbage.

Bear scat collections in Maine indicate that only a small portion of the annual diet consists of animal matter. The most frequently encountered animal remains in scats are colonial insects and beetles, which bears consume from spring through fall. Although black bears are not considered active predators over much of their range (Pelton 1982), they have been reported to be important predators on caribou (Rangifer tarandus) and moose (Alces alces) calves (Franzmann et al 1980, Mahoney 1984). Vertebrates are obtained both as prey and carrion, primarily in the spring (Spencer 1955, Hugie 1982). Bears appear to prefer foods rich in protein and fat, since their diet is generally low in these nutrients (Pelton 1982). Therefore, animal matter is believed to be a small but important food source (Pelton 1982, Lamb 1983).

Water Requirements

Black bear distribution and abundance has not been associated with water availability in New England. The region's moist conifer-deciduous forests, and the large areas used by bears probably allow them adequate access to water (Hugie 1982, Lamb 1983, Elowe 1984).

Cover Requirements

Black bears are closely associated with forested lands in New England (Spencer 1955, Hugie 1982, Lamb 1983, Elowe 1984). Large open areas are generally not included in their home ranges, and bears are usually found only along the fringes of agricultural land. Most forest cover-types in the region have dense understories which are believed to satisfy the black bear's requirements for shelter and escape cover.

Seasonal habitat-use patterns of bears in New England seem to follow the chronology of food availability (Hugie 1982, Lamb 1983, Elowe 1984). Studies elsewhere have also reported this behavior (Jonkel and Cowan 1971, Amstrup and Beecham 1976, Matula 1976, Alt 1977, Rogers 1977, McLaughlin 1981).

Forest openings, such as clear-cuts, roadsides, skidder trails, log landings, and the edges of open bogs, produce the major spring and summer bear foods in Maine (insects from rotting logs, berries, grasses and forbs). Selectively cut softwood, hardwood, and mixed wood stands, 9-18m (30-60 ft) in height, also supply these spring and summer foods. Mature hardwood stands supply hard mast during the fall. During springs following abundant fall mast crops, bears forage for sprouting beechnuts and acorns in these same stands. In agricultural areas, bears utilize farm crops (blueberries

(Vaccinium spp.), raspberries (Rubus spp.), apples (Malus spp.), corn, oats) as additional late summer and fall food sources, especially in years of mast crop failures.

Bears stop active foraging in late fall and pass the winter in a dormant state, generally within enclosed dens. Den site selection in Maine is apparently related to structure (root cavities, blow-downs, brush piles, dirt mounds) rather than surrounding cover-type (Hugie 1982, Lamb 1983). However, Elowe (1984) reported bears in Massachusetts selected dens in slash piles on recently logged areas.

All of the above cover types, except newly clear-cut areas and agricultural lands, are thought to provide adequate escape cover for bears in the New England states. Therefore, no need exists to define cover requirements for this species beyond the gross requirement for forestland.

Reproductive Requirements

Habitat requirements for bear reproduction are not believed to differ from food and cover requirements. Reproductive success is apparently related to the abundance of high quality summer and fall foods. Bears in Maine and elsewhere produce more offspring when and where an abundance of summer or fall foods occur.

Although black bears are opportunists and utilize a wide variety of plant and animal foods, their simple stomachs are

inefficient at extracting nutrients from plant matter. Therefore, they require berries, nuts, and other highly-digestable plant foods to provide them with sufficient nutrition to meet their reproductive requirements. A diet of grasses and forbs may sustain bears, but they generally lose weight when feeding on these items.

The importance of berry and mast crops has been documented in Minnesota, where bears had lowered reproductive success following years of failures of these foods (Rogers 1976). In a northern Maine study area, 100% of 13 radio-collared female bears produced cubs following a year of beechnut abundance. Conversely, both litter production and survival of yearling bears declined in years following mast failures (McLaughlin and Matula unpubl. data).

The size of berry and mast crops can vary markedly from year to year as a result of vagarities in temperature and precipitation. The flowering and fruiting dates of these shrub and tree species vary slightly, and the probability of some berry and/or mast crops being produced on an area each year increases with the number of these species that are present. Consequently, an area's suitability as bear habitat should increase as the diversity of berry and mast producing species increases.

Where bears have access to agricultural crops and/or garbage in Maine, their reproductive success may become

stabilized (McLaughlin and Matula unpubl. data). Females living along the fringes of agriculture seem to have less year-to-year variation in litter production, and synchronous breeding is not apparent, unlike the reproductive patterns of females without ready access to agricultural crops. In Minnesota, bears with access to garbage grew faster and produced more offspring than bears without access to this man-associated food source (Rogers 1976).

Female bears apparently den in existing cavities, or sites where cavities are easily created, with little or no preference for surrounding cover types (Hugie 1982, Lamb 1983, Elowe 1984, McLaughlin and Matula unpubl. data). Limited reuse of dens has been documented in Massachusetts (Elowe 1984), but is extremely rare in Maine; therefore, an adequate supply of den sites is assumed.

Interspersion Requirements

Lamb (1983) found home ranges of radio-collared female bears to average 24.7 km^2 (9.5 mi^2) (range 17.6-40 km^2) in a northern Maine study area. A previous study reported even larger home range sizes, with male bears using hundreds of square kilometers (Hugie 1982). Elowe (1984) reported similar home range sizes for radio-collared male and female bears in Massachusetts. Hugie also reported that radio-collared bears rarely ventured more than 125 m into

large open raspberry or blueberry stands. Berries in the central portions of large openings were apparently not utilized because adequate escape cover was unavailable. Therefore, the size, shape, and frequency of these open cover types in an area may influence its suitability for bears.

Bears in Maine and Massachusetts are known to travel long distances outside their home ranges in response to seasonally abundant food sources (Hugie 1982, Lamb 1983, Elowe 1984, McLaughlin and Matula unpubl. data). Radio-collared female bears have been observed traveling up to 48 km (30 mi) to areas of raspberry and beechnut abundance; males have moved more than 80 km (50 mi). Such long movements may allow bears to compensate for local food shortages. However, the number of bears which might benefit from a given concentrated food source, and the size of an area from which bears can respond to a food source, are unknown. Therefore, while the interspersion of cover-types producing seasonally abundant foods, such as raspberries or beechnuts, may be important for determining the carrying capacity of an area for bears, the relationship between interspersion and habitat suitability is poorly understood.

Special Considerations

In portions of New England, forestland occurs in small blocks interspersed with agricultural land and residential

and industrial developments. Such development generally lowers habitat quality for bears by removing the forestland they require as cover, and increases man's access to, and contact with, bears. The increased density of roads in these areas increases highway mortality. Furthermore, damage to property and agricultural crops by bears can result in the destruction of bears for damage control. Consequently, bear densities are assumed to be inversely related to the level of development by man.

HABITAT SUITABILITY INDEX (HSI) MODEL FOR THE BLACK BEAR (*Ursus americanus*)

Model Applicability

Geographic area. This model describes habitat suitability in Maine, New Hampshire, Vermont, Massachusetts, and similar areas within the spruce-fir-northern hardwood and northern hardwood-hemlock-white pine forests of the Northeast (Westveld et al. 1956).

Season. This model is designed to produce HSI values for year-round habitat needs of the black bear. It is assumed that carrying capacity is restricted by food availability in the spring, summer, and fall seasons, and that black bears can overcome some seasonal food stress by leaving their annual home ranges. However, the relative contribution of spring, summer, and fall foods toward meeting the annual food requirements of the species is unknown. Consequently, foods available in each of these seasons are weighted equally, and no compensatory relationships are assumed between them.

Cover types. The following cover types are utilized by black bears in New England: Deciduous Forest (DF), Evergreen Forest (EF), Evergreen Forested Wetland (EFW), Deciduous Forested Wetland (DFW), Evergreen Scrub-Shrub Wetland (ESSW),

Deciduous Scrub-Shrub Wetland (DSSW), Mined Areas (MA), and Agricultural Land (A), including Cropland (C), Orchards (O), Vineyards (V), and Pasture and Hayland (PH). Development by man lowers bear habitat suitability and bears do not use areas having substantial Urban and Built up Land (UBL).

Minimum habitat area. The minimum size of a suitable habitat block is judged to be about 100 km^2 (39 mi^2) based on home range size of male and female black bears in Maine and Massachusetts (Hugie 1982, Lamb 1983, Elowe 1984, McLaughlin and Matula unpubl. data). Most of the block should include forests in various stages of succession, with some open areas, to insure adequate abundance of seasonal food sources.

Verification level. This model was reviewed by the Maine Department of Inland Fisheries and Wildlife. It has not been tested under field conditions.

Model Description

Graphic overview. This HSI model for the black bear considers specific variables and their relationship to life requisites and the HSI as shown in Figure 2. Cover and reproductive needs are assumed to be the same and it is assumed that water is not limiting.

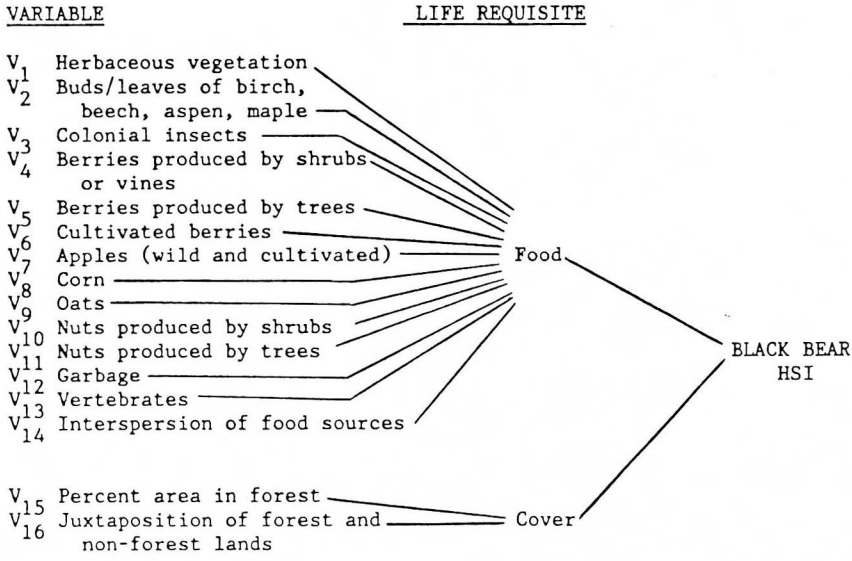


Figure 2. Tree diagram showing relationship of habitat variables and life requisites to the HSI for the black bear.

Life requisite components

Food. Black bears are omnivorous but feed primarily on vegetation. In New England, bears consume the following plant foods: herbaceous vegetation, buds and leaves of woody plants, berries, hard mast, and agricultural crops (apples, corn, oats). Animal matter, chiefly colonial insects and vertebrates, makes up a small but important portion of their annual diet. They will also utilize garbage in most situations, given ready access to it. The availability of major foods on an area may be estimated using data from forest and agricultural surveys, and land use regulatory agencies.

Spring foods are most abundant in forest openings and bog edges (herbaceous vegetation), regenerating hardwood stands containing birch (Betula spp.), beech, maple (Acer spp.), and aspen (Populus spp.) (buds and young leaves), and stands containing large pole-sawtimber beech and/or oaks (beechnuts, acorns). Although some herbaceous species are adapted to life in shaded conditions or certain soil types, this model assumes canopy closure is the principal factor influencing the abundance of herbaceous vegetation.

Summer foods (insects, berries, herbaceous vegetation) are most abundant in selectively-cut mixed wood stands, forest openings, and clear-cut areas 0-10 years after harvest. The abundance of colonial insects is assumed to be

related to the abundance of dead and down trees. Overmature stands, and stands with recent harvesting activity are assumed to contain more dead and down trees than other forest stands, and therefore greater numbers of insects.

In the early fall months, bears will use hazelnuts and cherries (Prunus spp.). Apples from both wild and cultivated trees will be eaten throughout the fall. Hardwood stands containing poletimber- and sawlog-sized beech and oak provide high-quality fall foods (beechnuts, acorns). In agricultural areas, orchard and grain crops (corn, oats) provide an important additional fall food source for bears, especially in years of mast crop failure.

Bears will use garbage throughout the spring, summer and fall months where it is available (dumps, landfills, backyards or campsites). Heaviest use of garbage usually occurs in the spring and fall. Where ungulates and other vertebrate species are abundant, they are assumed to provide bears with carrion, and occasional prey. The presence of other predatory and scavenger species (e.g. coyotes (Canis latrans)) may decrease carrion and prey availability to bears, but the impact of their competition with bears for this food source is not clear.

The relative size, shape, and distribution of forest cover-types and agricultural areas producing important foods probably impact an area's capacity to support bears, but the

influence of interspersion on carrying capacity is poorly understood. This model assumes that as the frequency of homogeneous forest stands ≤40 ha (100 ac) in size increases on an area, its suitability for bears increases.

Cover. Black bears are restricted to forested regions throughout North America. In New England's conifer-deciduous forests, most cover-types are believed to provide adequate escape cover and shelter for bears. Areas used by bears will be primarily forested and nearly 100 km^2 (39 mi^2) in size; bears will not use small woodlots dispersed through agricultural or developed areas.

Special Considerations

Bears have a special need for undeveloped land area. As land becomes developed, its suitability as bear habitat declines; highly developed areas are not used by bears. The elevated human population densities associated with development lead to bear-man conflicts and increased bear mortality. An area's suitability for bears is also inversely related to the density of roads it contains, for highway mortalities increase with road density. And finally, the attitudes of an area's human residents toward bears may be an important factor determining its suitability for bears. Their tolerance of bears may reflect current or historical

land-use practices and/or levels of bear damage and nuisance, and will be reflected by out-of-season mortalities from illegal hunting and protection of property.

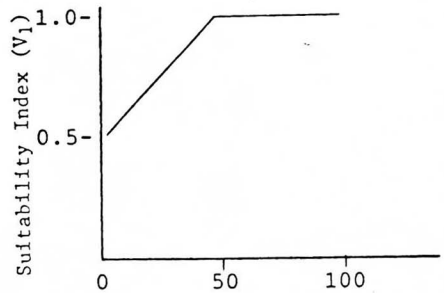
Model Relationships

This section contains suitability index curves and equations to quantitatively describe the relationships discussed in the previous section. These curves and equations can be used to produce an HSI for the black bear in New England.

Suitability index curves.

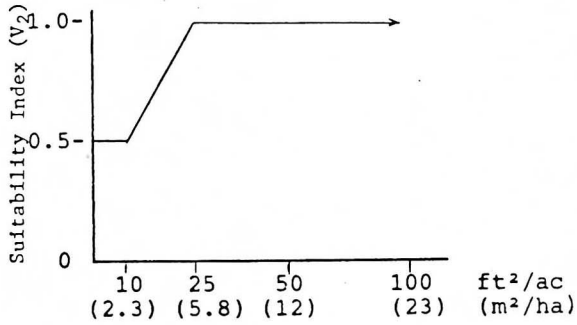
Cover Type	Variable
DF, EF, DFW, EFW, DSSW, ESSW	(V_1)

Herbaceous vegetation



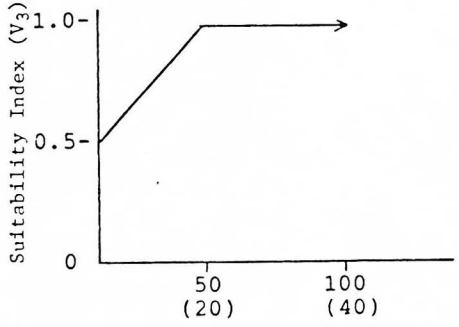
% of forested sample plots with at least 1 of the following present:
a) permanent opening
b) strip, partial or block cut 0-3 yrs previously
c) forest-agricultural edge

Cover Type	Variable	
DF, EF, EFW, DFW, ESSW, DSSW	(V_2)	Buds/leaves of birch, beech, aspen, maple



Basal area of these species/acre (m²/ha) of forest.

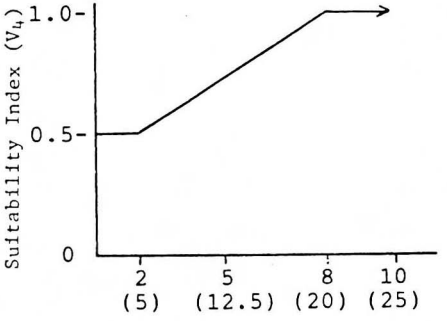
DF, EF, EFW, DFW, ESSW, DSSW	(V_3)	Colonial Insects



Number of cavity and dead trees/acre (ha) of forest.

Cover Type	Variable
DF, EF, EFW, DFW, ESSW, DSSW	(V_4)

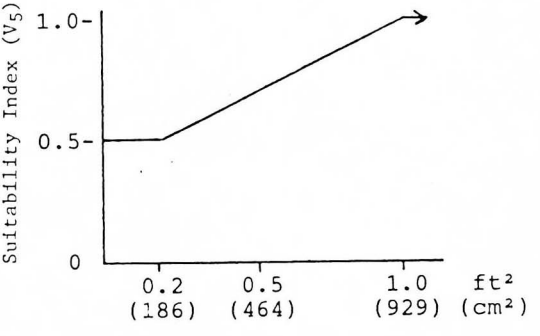
Berries produced by shrubs or vines



Thousands of stem-diversity units/acre (ha) of forest.

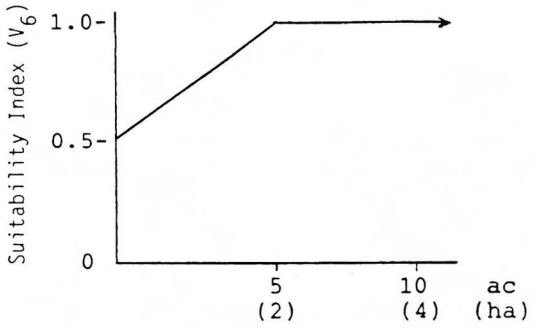
DF, EF, DFW, EFW	(V_5)

Berries produced by trees



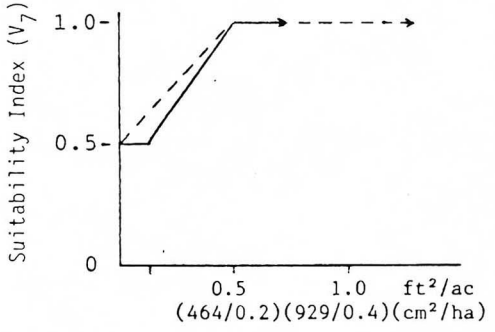
Basal area of service-berry and cherries (pin, black, and choke)/acre (0.4 ha) of forest.

Cover Type	Variable
DF, EF, DFW, EFW, DSSW, ESSW	(V_6) Cultivated Berries



Acres (ha) of blueberries and raspberries under cultivation/1000 acres (405 ha) of forest.

DF, EF, (V_7) Apples (wild and cultivated)

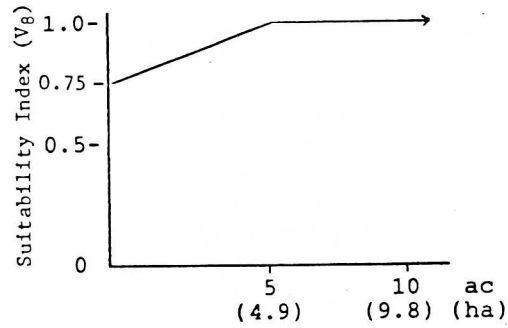


0.25 0.5 ac apples/1000 ac

--Basal area of wild apples/acre (0.4 ha) of forest.
—Acres of apple orchards/1000 acres (405 ha) of forest

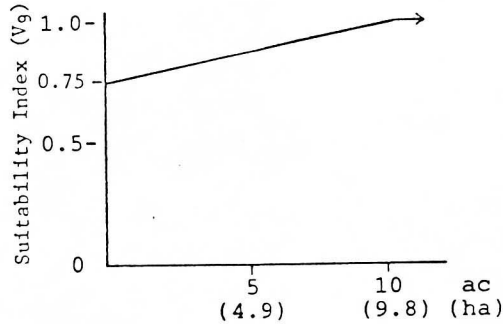
V_7 value = $\bar{x}$ of wild and orchard measures.

Cover Type	Variable	
C	(V_8)	Corn



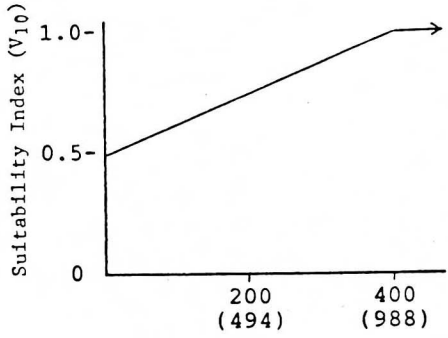
Acres of corn/1000 acres (ha/1000 ha) of forest.

C	(V_9)	Oats

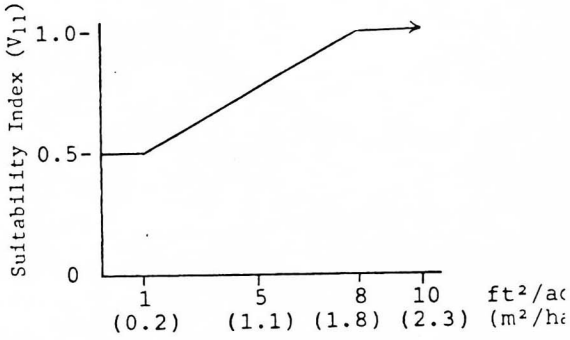


Acres of oats/1000 acres (ha/1000 ha) of forest.

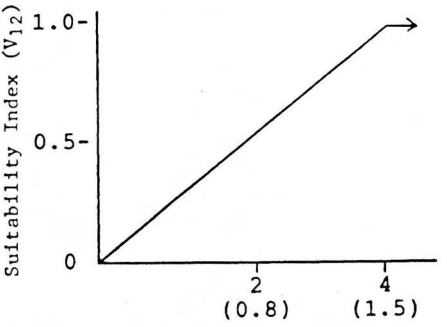
Cover Type	Variable
DF, EF, DFW, EFW, DSSW, ESSW	(V_{10})



DF, EF, DFW, EFW	(V_{11})

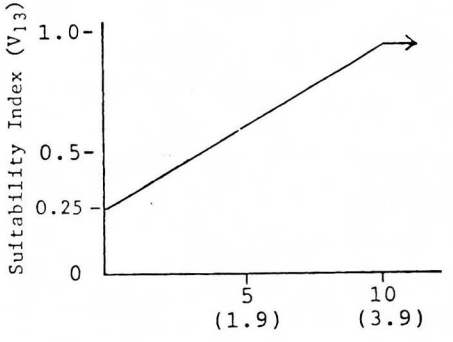


Cover Type	Variable	
DF, EF, MA	(V_{12})	Garbage



Number of dumps and landfills/100 mi² (100 km²) of land area.

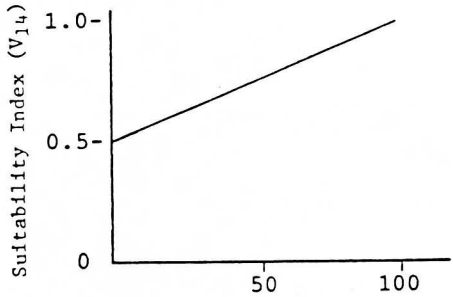
DF, EF, DFW, EFW DSSW, ESSW, O,V,C, PH	(V_{13})	Vertebrates



Ungulate units/mi² (km²).

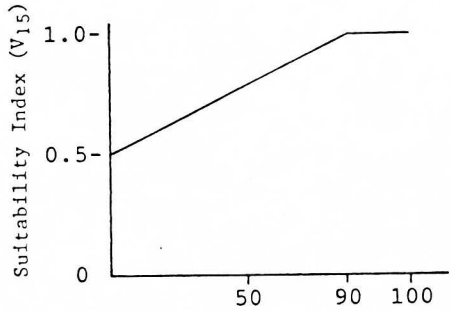
(1 ungulate unit = 1 deer-sized ungulate)

Cover Type	Variable
DF, EF, DFW, EFW, DSSW, ESSW	(V_{14}) Interspersion of food sources



Cumulative % forest area in homogeneous stands <100 acres (40 ha) in size.

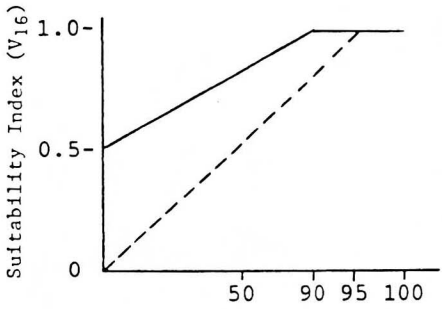
DF, EF, DFW, EFW DSSW, ESSW, O,V,C, PH	(V_{15})	Percent of area in forestland



% of area in forestland.

Cover Type	Variable
DF, EF, DFW, EFW, DSSW, ESSW, O,V,C, PH, MA, UBL	(V_{16})

Juxtaposition of forest and non-forest lands



- % of sample plots with ≤ 6 forest-agriculture edge hits
--% of sample plots with 0 forest-cultural edge hits

V_{16} value = $\bar{x}$ of both measures.

Equations

Equation for food component. The following equation integrates the index values for each variable to obtain a life requisite value for food in each cover type.

Food Value = 0 if: $V_1+V_2+V_3=1.5$

or if: $V_4+V_5+V_6+V_7+V_{10}+V_{11}=3.0$

otherwise, the Food Value =

$$\frac{V_1+V_2+V_3+V_4+V_5+V_6+V_7+V_8+V_9+V_{10}+V_{11}+V_{12}+V_{13}+V_{14}}{14}$$

Equation for cover component. The following equation integrates the index values for each variable to obtain a life requisite value for cover in each cover type.

Cover Value = V_{15} or V_{16}, whichever is lowest

HSI Determination

Based on the limiting factor concept, the HSI is equal to the lowest life requisite value.

APPLICATION OF THE MODEL

The level of detail needed for a particular application of this model will depend on time, money, and accuracy constraints. Detailed field sampling of all variables will provide the most reliable and replicable HSI values. Any or all variables can be estimated, in order to reduce the amount of time required to apply the model. Increased use of subjective estimates decreases reliability and replicability, and these estimates should be accompanied by appropriate documentation to insure that decision makers understand both the method of HSI determination and quality of the data used in the HSI model.

Definitions of variables, suggested measurement techniques, and calculations necessary to compute variable values are presented in Table 1. A listing of the species of berry and nut producing shrubs and trees considered in the model is presented in Table 2.

SOURCES OF OTHER MODELS

No other habitat models for black bears were located during literature searches.

APPLICATION OF THE HSI IN MAINE

Data Sources

The HSI was applied to existing data bases to assess bear habitat suitability in each of Maine's WMU's. Published forest survey data (1980 Maine Forest Resurvey, USFS 1982) supplied value estimates for variables V_1-V_7, V_{10}, V_{11}, and V_{14}-V_{16}. The forest survey information originated from a plot sampling design, and produced value estimates subject to large standard errors. Direct measures of V_7-V_9 were obtained from farming activity data in the 1982 Census of Agriculture-Preliminary Reports (USBC 1983).

The Maine Department of Environmental Protection (DEP) supplied file data on the location of dumps and sanitary landfills as a measure of V_{12} (garbage). Because many dumps in unorganized territory were not recorded in these files, the amount of land in organized and unorganized territory was determined for each WMU from Maine Land Use Regulation Commission (LURC) records. Dump numbers were then estimated, assuming that only 20% of dumps in unorganized territory were recorded in DEP files.

Densities of deer (Odocoileus virginianus) and moose were obtained from current MDIFW population studies of these species. Based on our assumption that each moose carcass approximated the food value of 5 deer, moose density

estimates were weighted by a factor of 5, then added to estimated deer densities to obtain a measure of ungulate units for V_{13} (vertebrates).

All USBC statistics were compiled at the county level. These data collections were converted to a WMU basis using estimates of the amount of farmland in each county that occurred in each Unit.

RESULTS AND DISCUSSION

Index values for each variable, food values (FV), cover values (CV), and the HSI values assigned to WMU's ranged from 0.63 to 0.80 (Table 3). These values suggest Maine contains fair to good quality bear habitat. Food values determined the HSI values of WMU's 1-6, while the HSI values of Units 7 and 8 were determined by cover values. The amount of forestland (V_{15}) limited the cover value of WMU 7, while WMU 8's cover value was limited by the juxtaposition of forest and non-forestlands (V_{16}) (Table 3).

The HSI model and the HSI values generated for Maine's 8 WMU's were reviewed by several MDIFW biologists. Most agreed that the model ranked WMU's according to their opinions of habitat suitability. However, the actual HSI values assigned to each WMU's bear habitat, and the range of HSI values assigned by the model were questioned. Most criticism focused on assumed relationships between

individual variable values and their suitability index values, many of which are hypothetical and based on limited data. As understanding of the relationships between each of these variables and bear habitat suitability increases, modifications of the model, including restructuring of variable suitability curves, addition or deletion of variables, and adjustments to the equations for food or cover values are expected.

The model's precision and repeatability would be enhanced by detailed field sampling, or by direct measure of all variables. However, the answers to most questions facing managers of bear habitat (impacts of habitat alteration, mitigation, species planning) can probably be supplied by HSI values generated with data bases that estimate most variable values.

The HSI model only describes black bear habitat relationships. It does not account for relationships between bears and man or between bears and other wildlife species, except for wildlife species which are food sources. These interspecific relationships, especially bear-man conflicts, exist throughout New England. Wherever people are present in bear range, their intolerance for agricultural and property damage by bears acts to decrease maximum attainable bear densities below carrying capacities based solely on habitat suitability. Therefore, any

evaluation of an area's potential to support bears must integrate measures of special considerations for the species, including their need for undeveloped forestland and the negative impacts of bear-man conflicts. We suggest 3 variables may quantify these considerations: road density, human population density, and land use practices.

SUMMARY

This model attempts to describe black bear-habitat relationships in the conifer-deciduous forests of New England. Its application to Maine's bear habitat, using existing data bases, suggests that it can properly rank large areas of bear habitat in order of suitability. However, its precision in assigning index values to bear habitat has not been tested. The linear relationships which are assumed between HSI values and carrying capacity for black bears are also untested. The model is intended as a planning document, and additional verification and/or modification is recommended before it is employed as a management tool.

Authors' Note: The model was modified after it was presented at the Workshop in Williamsburg. Three variables, representing special considerations of bears, were deleted from the model following discussions with D. Garshelis and A. Brody. This change may result in a disparity between the published model, and verbal discussions recorded at the Workshop.

REFERENCES CITED

Alt, G. L. 1977. Home range, annual patterns, and movements of black bears in northeastern Pennsylvania. M.S. Thesis, Pennsylvania State Univ., University Park, PA 77pp.

Amstrup, S. C., and J. Beechum. 1976. Activity patterns of radio-collared black bears in Idaho. J. Wildl. Manage. 40(2):340-348.

Bennett, L. J., P. F. English, and R. L. Watts. 1943. The food habits of the black bear in Pennsylvania. J. Mammal. 24(1):25-31.

Cardoza, J. E. 1976. The history and status of the black bear in Massachusetts and adjacent New England States. Res. Bull. 18. Mass. Div. Fish. and Wildl. 113pp.

Caron, M. A., and C. R. McLaughlin. 1984. Black bear study. Maine Dept. Inland Fish. and Wildl. Job Performance Rpt., Fed. Aid Proj. Maine W-67-R15, Job II-181 8 pp.

Cottam, C., A. L. Nelson, and T. E. Clarke. 1939. Notes on early winter food habits of the black bear in George Washington National Forest. J. Mammal. 20(3):310-314.

Elowe, K. D. 1984. Home range, movements, and habitat preferences of black bear (Ursus americanus) in western Massachusetts. M.S. Thesis. Univ. of Mass. 112pp.

Farmer, A. H., M. J. Armbruster, J. W. Terrell, and R. L. Schroeder. 1982. Habitat models for land-use planning:assumptions and strategies for development. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 47:47-56.

Franzmann, A. W., C. C. Schwartz, and R. O. Peterson. 1980. Moose calf mortality in summer on the Kenai Peninsula, Alaska. J. Wildl. Manage. 44(3):764-768.

Hatler, D. F. 1972. Food habits of black bears in interior Alaska. Canad. Field Nat. 86:17-31.

Hugie, R. D. 1982. Black bear ecology and management in the northern conifer-deciduous forests of Maine. Ph.D. Dissert. Univ. Montana, Missoula. 201pp.

Jonkel, C. J., and Ian McT. Cowan. 1971. The black bear in the spruce-fir forest. Wildl. Monogr. No. 27. 57pp.

Lamb, G. R. 1983. Home range and habitat use of female black bears in northern Maine. M.S. Thesis, Univ. of Maine at Orono, Orono. 26pp.

Mahoney, S. 1984. Newfoundland status report. Proc. East. Workshop Black Bear Manage. Res. 7:17-20.

Matula, G. J., Jr. 1976. Behavioral and physiological characteristics of black bears in northeastern Pennsylvania. M.S. Thesis, Pennsylvania State Univ., Univ. Park, PA. 187pp.

_____. 1983. Black bear study. Maine Dept. Inland Fish. & Wildl. Job Performance Rpt., Fed. Aid Proj. Maine W-67-R-13, Job II-181. 7pp.

_____, and C. R. McLaughlin. 1984. The black bear population in Maine. Maine Dept. Inland Fish. & Wildl. (mimeo.).

McLaughlin, C. R. 1981. Home range, movements and denning behavior of female black bears in northcentral Pennsylvania. M.S. Thesis, Pennsylvania State Univ., Univ. Park, PA. 63pp.

_____. 1986. Black bear assessment - 1985. Pages 359-398 in Planning for Maine's inland fish and wildlife. Vol I, Part 1.4. Maine Dept. Inland Fish. & Wildlife, Augusta.

Pelton, M. R. 1982. Black bear (Ursus americanus). Pages 504-514 in J. A. Chapman and G. A. Feldhamer, eds. Wild mammals of North America. John Hopkins Univ. Press, Baltimore and London.

Poelker, R. J., and H. D. Hartwell. 1973. Black bear of Washington - its biology, natural history and relationship to forest regeneration. Bull. No. 14, Washington State Game Dep., Olympia. 180pp.

Rieffenberger, J. C., R. J. Anderson, W. S. Brown, K. B. Knight, and J. I. Cromer. 1981. West Virginia black bear. W. Virginia Dept. Nat. Res., Wildl. Res. Div. Bull. No. 9. 55pp.

Rogers, L. L. 1976. Effects of mast and berry crop failures on survival, growth, and reproductive success of black bears. Trans. N. Am. Wildl. Conf. 41:431-437.

_____. 1977. Social relationships, movements, and population dynamics of black bears in northeastern Minnesota. Ph.D. Dissertation, Univ. Minnesota, Minneapolis. 194pp.

Schamberger, M. and W. B. Krohn. 1982. Status of the habitat evaluation procedures. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 47:154-164.

Spencer, H. E., Jr. 1955. The black bear and its status in Maine. Maine Dept. Inland Fish. and Game, Game Div. Bull. 4. 55pp.

Thomas, J. W. 1982. Needs for and approaches to wildlife habitat assessment. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 47:35-46.

Tisch, E. L. 1961. Seasonal food habits of the black bear in the Whitefish range of northwestern Montana. M.S. Thesis, Montana State Univ., Bozeman. 108pp.

U.S. Bureau of Census. 1983. 1982 Census of Agriculture preliminary reports, Maine counties. ACB2-A-23(P).

U.S. Forest Service. 1982. 1980 Maine forest resurvey. Northeastern Forest Experiment Station, U.S. Forest Service, Broomall, PA.

Warburton, G. S. 1982. Contents of black bear scats from the central Adirondacks in late summer. New York Fish and Game J., (29)2:210-213.

Westveld, M. R., et al. 1956. Natural forest vegetation zones of New England. J. For. 54:332-338.

April 7, 1987

Table 1. Definition of black bear HSI variables, suggested measurement techniques, and calculations required to obtain some variable values.

Variable	(Definition)	Cover Types	Suggested Measurement Technique	Required Calculations
(V_1)	Herbaceous vegetation, principally grasses and forbs.	DF, EF, DFW, EFW, DSSW, ESSW	Plot sampling. (from photos or directly). Measure presence or absence of permanent openings ≥ 0.1 ac in size; strip, partial or clear-cuts ≤ 3 yrs previous; forest agricultural edges (See recent USFS Forest Surveys for definitions and data source).	Divide total sample by number of plots having at least 1 condition present.
(V_2)	Buds and leaves of birches, beech, aspen, maples	DF, EF, DFW, EFW, DSSW, ESSW	Plot sampling. Measure basal area of each species. For large areas, obtain from recent USFS Forest Survey.	
(V_3)	Colonial insects	DF, EF, DFW, EFW, DSSW, ESSW	Plot sampling. Measure number of cavity trees, dead trees per acre of forest. USFS Forest Survey will provide data for large areas.	
(V_4)	Berries produced by shrubs or vines	DF, EF, DFW, EFW, DSSW, ESSW	Plot sampling. Stem count of all fruiting species present. For large areas, obtain estimates from USFS Forest Survey.	Stem Diversity Units = (total stems/forested acre) x Diversity factor. Diversity factor = 1, when number of species is ≤ 10 and $1+\left[\frac{\text{number species}-10}{10}\div 2\right]$ when number species >10
(V_5)	Berries produced by trees	DF, EF, DFW, EFW,	Plot sampling. Use USFS Forest Survey for estimates of large areas.	Weight for species div. if > 4, < 4 present.
(V_6)	Cultivated berries	DF, EF, DFW, EFW, DSSW, ESSW	Plot sampling, or obtain from USBC Census of Agriculture.	
(V_7)	Apples, both wild and in cultivated orchards	DF, EF, O	Wild: Plot sampling, or obtain from USFS Forest Survey. Cultivated: Plot sampling or obtain from USBC Census of Agriculture.	Obtain measures of both, calculate mean V_7 value.
(V_8)	Corn planted for silage/green chop, grain or seed, and sweet corn	C	Plot sampling, or obtain from USBC Census of Agriculture.	
(V_9)	Oats	C	Plot sampling, or obtain from USBC Census of Agriculture.	
(V_{10})	Nuts produced by shrubs	DF, EF, DFW, EFW, DSSW, ESSW	Plot sampling, or obtain estimates of stem counts from USFS Forest Survey.	Weight for species diversity if more than 1 present.
(V_{11})	Nuts produced by trees	DF, EF, DFW, EFW,	Plot sampling to estimate basal area of beech and all species of oaks, or obtain estimates from USFS Forest Survey.	Species diversity: Multiply by 0.75 if only oaks, or only beech present.
(V_{12})	Garbage	DF, EF, MA	Obtain from land use regulation authority (Dept. of Environmental Protection)	
(V_{13})	Vertebrates	DF, EF, DFW, EFW, DSSW, ESSW, O, V, C, PH	Derive density estimates of deer, moose from track, pellet group counts, or obtain estimates from state wildlife agency.	Ungulate Units: assign 1 for each deer, 5 for each moose
(V_{14})	Interspersion of food sources	DF, EF, DFW, EFW, DSSW, ESSW	Forest cover-type maps, or obtain from USFS Forest Survey data.	
(V_{15})	Percent area in forestland	DF, EF, DFW, EFW, DSSW, ESSW	Measure from maps (direct or point sampling). Derive from USFS Forest Survey, land regulatory agency file.	
(V_{16})	Juxtaposition of forest and non forest lands	DF, EF, DFW, EFW, DSSW, ESSW, O,V,C, PH, MA, UBL	Measure using USFS procedures, or obtain from USFS Forest Survey data.	

Table 2. Species of shrubs and trees producing berries and nuts, and measured for variables V_4, V_5, V_{10}, and V_{11} in the black bear HSI.

Shrubs producing berries (V_4)	Trees producing berries (V_5)
Blueberries (*Vaccinium* spp.)	Serviceberry (*Amelanchier* spp.)
Brier (*Rubus* spp.)	Black Cherry (*Prunus serotina*)
Red Osier Dogwood (*Cornus stolonifera*)	Choke Cherry (*Prunus virginiana*)
Gooseberry (*Ribes* spp.)	Pin Cherry (*Prunus pensylvanica*)
Hobblebush Viburnum (*Viburnum alnifolium*)	
Mapleleaf Viburnum (*Viburnum acerifolium*)	
Other Viburnums (*Viburnum* spp.)	
Dogwoods (Silky, other) (*Cornus* spp.)	
American Elder (*Sambucus canadensis*)	
Red Berry Elderberry (*Sambucus pubens*)	
Mt. Holly (*Nemopanthus mucronata*)	
Largeleaf Holly (*Ilex montana*)	
Huckleberry (*Gaylussacia* ssp.)	
Common Winterberry (*Ilex verticillata*)	
Black Chokeberry (*Pyrus melanocarpa*)	
Laborador Tea (*Ledum groenlandicum*)	
New Jersey Tea (*Ceanothus americanus*)	
Rose (*Rosa* spp.)	
Buckthorn (*Rhamnus alnifolia*)	
Grapes (*Vitis* spp.)	

Shrubs producing nuts (V_{10})	Trees producing nuts (V_{11})
Hazelnuts (*Corylus* spp.)	American Beech (*Fagus grandifolia*)
	White Oak (*Quercus alba*)
	Bur Oak (*Quercus macrucarpa*)
	Scarlet Oak (*Quercus coccinea*)
	Red Oak (*Quercus rubra*)
	Black Oak (*Quercus velatina*)
	Scrub Oak (*Quercus ilicifolia*)
	Swamp Oak (*Quercus bicolor*)
	Chestnut Oak (*Quercus prinus*)
	Chinquapin Oak (*Quercus muehlenbergi*)
	Dwarf Oak (*Quercus prinoides*)

Table 3. Suitability index values for individual variables, and food, cover, and habitat suitability index values calculated for each of Maine's 8 Wildlife Management Units.

Variable	Wildlife Management Unit							
	1	2	3	4	5	6	7	8
V_1	1.00	0.98	0.82	1.00	1.00	1.00	1.00	1.00
V_2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
V_3	0.66	0.67	0.65	0.66	0.67	0.58	0.63	0.61
V_4	0.86	0.84	0.66	0.63	0.88	0.87	0.61	0.65
V_5	0.63	0.58	1.00	0.98	0.53	0.73	1.00	1.00
V_6	0.50	0.50	0.50	0.52	0.60	1.00	0.66	0.52
V_7	0.55	0.50	0.52	0.88	0.50	0.53	1.00	0.83
V_8	0.78	0.75	0.78	1.00	0.78	0.86	0.90	1.00
V_9	1.00	0.75	0.75	0.77	0.75	0.75	0.75	0.75
V_{10}	0.90	0.78	0.83	0.67	0.58	0.50	0.76	0.81
V_{11}	0.50	0.69	0.82	0.66	0.94	0.75	0.58	1.00
V_{12}	0.70	0.11	0.54	0.70	0.83	0.90	0.50	0.28
V_{13}	0.85	1.00	0.91	1.00	0.84	0.80	1.00	0.72
V_{14}	0.84	0.71	0.64	0.77	0.81	0.87	0.91	0.92
V_{15}	0.93	1.00	1.00	0.99	1.00	0.98	0.71	0.71
V_{16}	0.94	1.00	0.99	0.88	0.97	0.90	0.81	0.63
[a]FV	0.77	0.70	0.74	0.80	0.77	0.80	0.81	0.79
[b]CV	0.93	1.00	0.99	0.88	0.97	0.90	0.71	0.63
[c]HSI	0.77	0.70	0.74	0.80	0.77	0.80	0.71	0.63

[a]FV = Food value; [b]CV = Cover value; [c]HSI = Habitat suitability index.

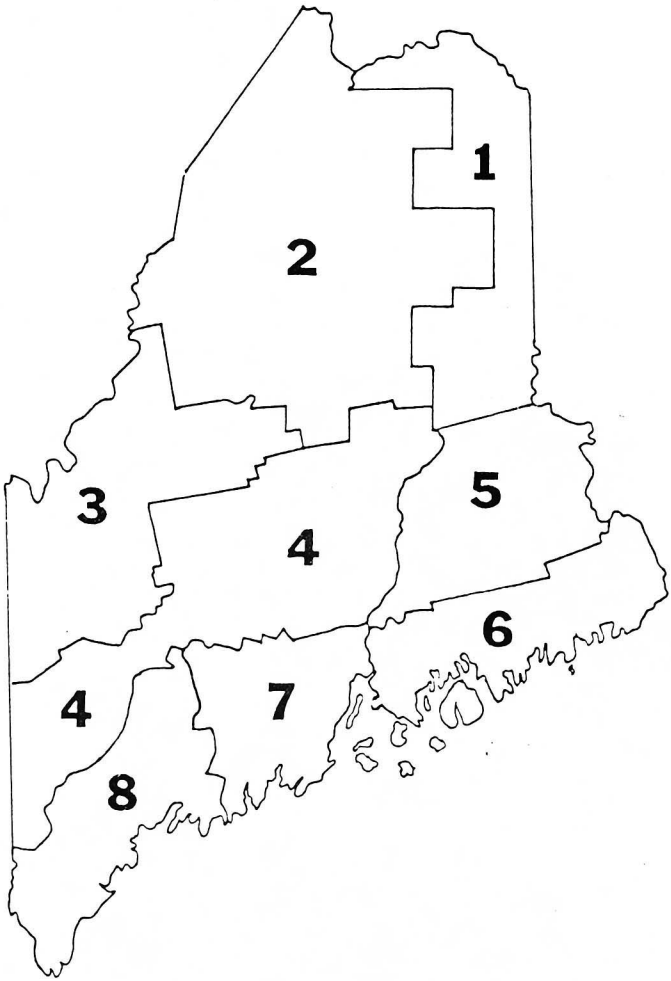


Figure 1. Maine Wildlife Management Units.