

**BLACK BEAR HABITAT
MANAGEMENT GUIDELINES
FOR FLORIDA**

TECHNICAL REPORT NO. 17

David S. Maehr, Thomas S. Hocht,
Luther J. Quinn, and Judith S. Smith

Florida Fish and Wildlife Conservation Commission
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ABSTRACT

The fragmented and patchy arrangement of black bear (*Ursus americanus floridanus*) populations throughout Florida is a daunting management challenge in this developed state. Successful management prescriptions must consider highly variable food habits as well as the effects of fire, timber management, and expanding development on this Threatened species. Saw palmetto (*Serenoa repens*) appears to be the single-most important food that is also common in all of the species' subpopulations. Fire may be the most important abiotic influence on bear nutrition, reproduction, and mortality. Winter burns have the potential to alter the fruiting phenology of important food plants and can cause direct mortality on neonatal cubs. Highways are problematic because they isolate bear populations, create travel barriers, and cause direct mortality. Opportunities for secure den sites and escape cover are likely more numerous in large patches of older forests. The limited use of hollow trees as den sites in Florida is likely linked to the relatively young age of most of Florida's forests. Generally, most widely used forest management practices (i.e., prescribed fire, herbicides, clear-cutting) are compatible with bear habitat management, especially if conducted in the context of large forests. Population viability analyses indicate that small populations such as those found in Highlands County and in the Greater Chassahowitzka Ecosystem are likely doomed to extinction without management intervention that promotes or restores landscape connectivity with other, larger populations. A metapopulation approach is recommended because the protection and reconnection of isolated population fragments will enhance the survival probabilities of the smallest populations as well as those of the entire population. The black bear would make an excellent flagship species for a statewide approach to ecosystem and landscape restoration.

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INTRODUCTION

The relation between the Florida black bear (*Ursus americanus floridanus*) and saw palmetto (*Serenoa repens*) epitomizes the complexities and challenges in developing habitat management guidelines for the Southeast's largest land mammal. Both species were once widespread throughout Florida, but now exhibit patchy distributions throughout the state. Both species provide keystone processes for the ecosystems in which they reside: the black bear as a seed disperser (Maehr 1984*a*, 1997*a*) and saw palmetto as preferred food and cover for hundreds of animal species (Maehr and Layne 1996*a,b*). The black bear lives at low density, but has extensive movement capabilities. Saw palmetto frequently grows profusely in dense thickets, but its heavy-seeded fruits require the transportation services of a large vertebrate to facilitate dispersal (Maehr and Layne 1996*a,b*, Abrahamson 1999). The fruit and heart of saw palmetto are depended upon by bears like few other plant species in Florida (Maehr and Brady 1982*a*, 1984*a,b*; Maehr and DeFazio 1985) (Table 1), and impenetrable thickets of saw palmetto provide bears with the most frequently used den cover in the state. Both species are affected by, and dependent upon, fire for the maintenance of environmental conditions that promote proper nutrition and reproduction (Maehr and Brady 1982*a*, Tanner et al. 1996, Abrahamson 1999). Today, both species face the threat of unmitigated harvest of saw palmetto fruit for the production of pharmaceutical products to treat human prostate hypertrophy (Maehr and Layne 1996*a,b*, Abrahamson 1999)—and Florida's human population continues to grow by about 700 each day (Royse 1997). Although the black bear can use a wide variety of plant communities and is still found in 50 of Florida's 67 counties (Brady and Maehr 1985), it is no exaggeration to suggest that the future of both the bear and this key element of its habitat are intertwined.

After more than two decades of research by state and federal agencies and universities, it is likely that most of the environmental conditions preferred, tolerated, or avoided by the Florida black bear have been described. With a distribution that ranged from the central Keys to the Okefenokee Swamp, and from the Perdido River to Daytona Beach, the black bear was one of Florida's most cosmopolitan animals. It could be argued that it would be easier to describe those habitats bears avoid than to characterize those habitats bears use. Today, the species in Florida is an obligate forest animal (Maehr and Wooding 1992, Maehr 1997*a*), and the state's largest populations are associated with large tracts of forest centered on public land. The purpose of this report is to synthesize the literature relevant to black bear habitat use in Florida, to synthesize literature relevant to the ecology and management of biotic communities used by bears in the southeastern coastal plain, and to offer guidelines that can serve as a practical handbook for the management of Florida black bear habitat.

Myers and Ewel, in their classic 1990 text, *Ecosystems of Florida*, recognized 13 major ecosystem categories in the state. Among these, the black bear was listed as a resident species in five: flatwoods and dry prairies (Abrahamson and Hartnett 1990), scrub and high pine (Myers 1990), south Florida rockland (Snyder et al. 1990), swamps (Ewel 1990), and mangroves (Odum and McIvor 1990). Another five ecosystems were implicated as black bear habitat by virtue of overlapping distribution (Maehr 1984*b*): temperate hardwood forests (Platt and Schwartz 1990), freshwater marshes (Kushlan 1990), dunes and maritime forests (Johnson and Barbour 1990), salt marshes (Montague and Wiegert 1990), and inshore marine habitats (Livingston 1990). Only lakes (Brenner et al. 1990), rivers and springs

Table 1. Dominant foods, by frequency of occurrence, in diets of the Florida black bear. Food items are listed in descending order of importance within each study area (across rows).

Location	Reference	Food 1	Food 2	Food 3
Osceola National Forest	Maehr and Brady 1982 <i>a</i>	Saw palmetto	Swamp tupelo	Yellow jacket
Apalachicola National Forest	Maehr and Brady 1984 <i>b</i>	Swamp tupelo	Odorless bayberry	Saw palmetto
Florida	Maehr and Brady 1984 <i>a</i>	Saw palmetto	Sabal palm	Fire flag
Florida	Maehr and DeFazio 1985	Saw palmetto	Swamp tupelo	Acorns
Southwest Alabama	Dusi et al. 1987	Acorns	Corn	Beetles
Central Florida	Roof 1997	Acorns	Saw palmetto	Sabal palm
Okefenokee National Wildlife Refuge	Scheick 1999	Saw palmetto	Acorns	Swamp tupelo
South Florida	Maehr 1997 <i>a</i>	Saw palmetto	Sabal palm	Brazilian pepper
Eglin Air Force Base	Stratman 1998	Acorns	Saw palmetto	Beetles

(Nordlie 1990), and coral reefs (Jaap and Hallock 1990) appear insufficient, in and of themselves, to support the species. Nonetheless, landscape features such as rivers, springs, and lakes may be important components of habitats occupied by the black bear in Florida. Even coastal regions were noted for their attractiveness to bears by several early naturalists (Chapman 1894, Bangs 1898, Bartram 1766), but this may have been as much a function of bear distribution as it was a human preference for more scenic and less insect-infested regions of the state.

In pre-Columbian North America, the black bear was one of the most abundant large mammals in the forests of the east (Bakeless 1961). This was true also for Florida—the black bear was commonly observed by early explorers and naturalists throughout the territory. Indeed, observations of the species from as far south as Matecumbe Key in Monroe County (De Pourtales 1877), the origin of the subspecific type specimen emanating from Key Biscayne (Merriam 1896), the consumption of crocodile (*Crocodylus actus*) eggs by bears in the Everglades (Moore 1953), and unpublished accounts of black bears excavating sea turtle (Family Cheloniidae) nests near Daytona Beach (C. Chappell, Florida Fish and Wildlife Conservation Commission [FWC] personal communication), point to a cosmopolitan distribution that transcends the simple availability of forest. The black bear was common throughout Florida until the late nineteenth century, when it became restricted to large isolated tracts (Maynard 1883, Hamilton 1941, Davis 1943). As late as 1959 (Hall and Kelson 1959), nonetheless, all of peninsular Florida was still recognized as the range of the subspecies. Early- to mid-twentieth century population centers were Royal Palm State Park in the Everglades (Safford 1919), Okefenokee Swamp (Harper 1927), east coast scrublands (Howell 1929), Lee County (Hamilton 1941), Highlands County (Rand and Host 1942), Welaka (Moore 1946, 1949), Gulf Hammock (Pearson 1954), Volusia County (Harlow 1959), Palm Valley (Ivey 1959), Paisley (Harlow 1962a), Ormond Beach and Panama City (Smith 1971), and Collier County (Layne 1974). The black bear was still considered a part, albeit rare, of the fauna of the west-central Florida phosphate lands, where a remnant population occurred in Sarasota and Manatee counties (Layne et al. 1977). While all current estimates of its modern Florida distribution emphasize the strong relation between bears and forest cover (Maehr 1984b, Brady and Maehr 1985, Maehr and Wooding 1992, Wooding et al. 1994), the presettlement landscape in the state likely supported the species in every available terrestrial and shallow wetland habitat.

Today, the species is still found in 50 of Florida's 67 counties (Brady and Maehr 1985).

Despite the widespread occurrence of the black bear in Florida, most estimates of even the largest populations were small to modest (Rand and Host 1942; Cahalane 1948; U.S. Department of Interior 1969, 1979; Schemnitz 1972, 1974). The totaling of such estimates yielded statewide populations of some several hundred animals (Frye et al. 1950, Harlow 1962a, Smith 1971, Pelton and Nichols 1972, East 1977). This is in contrast to modern population estimates that have been based on radio-telemetry studies throughout the state, and which have been used by the U.S. Fish and Wildlife Service to deny petitions to federally list the Florida black bear as Threatened (U.S. Fish and Wildlife Service 1998b). In its review of the petition, the U.S. Fish and Wildlife Service (1998b) recognized 9 separate populations of the Florida subspecies, including populations in Alabama ($N = 50$), Apalachicola National Forest and vicinity ($N > 400$), Big Cypress Swamp ($N = 390$), Chassahowitzka ($N < 20$), Eglin Air Force Base ($N = 60\text{--}100$), Highlands County ($N = 85$), Ocala National Forest ($N =$ "several hundred"), and Osceola National Forest/Okefenokee Swamp ($N = 1,200$), as well as the St. Johns population for which no estimate was given. In addition, these findings suggested that Green Swamp in Polk County had the potential to support 24–48 bears, but currently does not support a population. The wide distribution of populations that vary according to ecological regions and in size by an order of magnitude presents a unique management challenge. Some populations, such as Chassahowitzka and Highlands County, have been portrayed as declining (Cox et al. 1994, U.S. Fish and Wildlife Service 1998a), whereas others, such as Osceola/Okefenokee and south Florida (including Big Cypress Swamp), have relatively large populations that may be increasing. Layne (1974) recognized Big Cypress Swamp as the population center of the south Florida population more than 2 decades ago. Maehr's (1997a) estimate of over 1,000 for the south Florida bear population includes Collier County, where complaints of nuisance bears increased steadily during the last decade of the twentieth century (J. Schortemeyer, FWC, personal communication). Clearly, no single set of management guidelines is appropriate for all populations in Florida. On the other hand, before European settlement, Florida's black bears interacted as a single population unit without any known demographic barriers. This perspective may have important ramifications for future bear habitat management in Florida as both habitat fragmenting and landscape restoration efforts continue in this development state.

HABITAT USE

“The concept of habitat—fundamental to the study of ecology and management of wild populations—is centuries old.... Broadly defined, habitat is the place an organism lives or where you can find it...” (Schoen 1990, 143). This clearly led to the observation by the outspoken West Virginia black bear biologist and philosopher, Joe Rieffenberger, that black bear habitat is, simply, “where you find them” (paraphrase from many black bear workshops). Schoen (1990, 146) went on to observe that,

...many species of bears have relatively broad habitat requirements. A recurrent theme of many papers covering a variety of bear species and geographical regions is that mortality increases, and populations decline as forest clearing and roads penetrate bear habitat. However, bears can generally accommodate substantial human activity and some habitat alteration if humans can tolerate their presence without killing them.... Because human tolerance for bears is generally low, inaccessible, forested habitat appears to be a prerequisite for their continued existence near or adjacent to human populations....

Habitat management for the black bear is further complicated because they are most appropriately considered as landscape species, which means their habitat is not a specific vegetation type but rather an interspersion of various vegetation associations that occur across and within regions (Rogers and Allen 1987, Harris and Kangas 1988, Schoen 1990). Hillman and Yow (1986, 126) suggested that U.S. Forest Service managers should focus on 6 habitat elements: “freedom from constant human access, diversity, hard mast, soft mast and forage, dens, and key areas.” They suggested that black bears should be relatively easy to incorporate into forest management plans because the species has such generalized habitat requirements and adapts well to variable habitat conditions.

More has likely been written about black bear use of available habitat than any other aspect of its ecology, and few agree on the most important aspects of this variable and how to quantify it (McLaughlin and Maehr 1986). Despite this, the information tells us relatively little about black bear habitat requirements. For example,

The best bear range in Florida is a mixture of flatwoods, swamps, scrub-oak, ridges, bay-heads and hammock habitats thoroughly interspersed. These types of vegetation possess the most varied food conditions in greatest abundance (McDaniel 1974, 157).

One needs only to glance at the rich literature on bear diets to see that the family Ursidae exhibits extreme variation among and within taxa (Eisenberg 1981). The black bear exemplifies the generalist ursid in terms of diet, which is a reflection of its very broad tolerance for a variety of plant communities. As observed earlier, it may be a simpler matter to develop a list of foods bears do not eat (i.e., citrus) versus a comprehensive list of foods they do eat. What one derives from a close examination of the literature is not a list of habitats the black bear prefers, but a suggestion of the amount of forest cover necessary to support a population (Hellgren and Maehr 1992). For example, preserves of less than 10,000 ha may be insufficient to support black bear populations unless they are adjacent to larger tracts of occupied habitat (Maehr and Hellgren 1992). This issue will be developed further in the discussion of landscape issues and the Florida black bear.

Are any habitat use patterns of particular importance to managers? Certainly the issue of outright loss may override any other habitat issue, particularly when one considers the fact that Florida has more imperiled species and ecosystems than any other southeastern state (Ricketts et al. 1999). Florida is also highly ranked in national and continental analyses of environmental impacts and setting conservation priorities (Noss and Peters 1995). Jonkel and Cowan (1971) may have been the first to suggest that microhabitat variables are less important than regional landscape characteristics in their study of the black bear in the spruce-fir forest, an ecosystem that dominates the north-central Rocky Mountains Terrestrial Ecoregion (Ricketts et al. 1999) and includes parts of Montana, Idaho, Washington, Alberta, and British Columbia. This is clearly a very large region. Many studies have concluded that black bear habitat preferences are simply a function of food availability (Hatler 1967, Beeman 1975, Amstrup and Beecham 1976, Garshelis 1978, Fuller and Keith 1980, Carlock et al. 1983, Kendall 1983, Irwin and Hammond 1985, Grenfell and Brody 1986, Pelchat and Ruff 1986, Young and Beecham 1986, Elowe 1987, Rogers 1987a, Hellgren and Vaughan 1988,

Mykytko and Pelton 1990, Noyce and Coy 1990, Raine and Kansas 1990, Smith and Pelton 1990, Schwartz and Franzmann 1991, Samson and Huot 1998), that the species can exhibit extensive spatial overlap and sharing of resources (Horner and Powell 1990), and that management should focus on maintaining a diverse array of available plant communities (Smith and Pelton 1990), especially because oaks (*Quercus* spp.) (often considered a key food source [Rogers 1976]) are frequently not reliable acorn producers (Beck 1977; Arimond 1979; Grenfell and Brody 1983, 1986; Smith and Pelton 1990; Reagan 1991). Samson and Huot (1998) found that female black bears drawn out of a park

due to a paucity of soft mast-producing habitat were more vulnerable to human-related mortality. Although small sanctuaries may provide nutritional and survival benefits to local black bear populations (Beringer et al. 1998), preserves that are intended to support all of the habitat needs of wide-ranging species must consider the complex of seasonal habitats that are utilized in concordance with fruiting phenology. Such dynamics also occur in Florida. For example, black bears routinely abandoned core habitat areas and occasionally moved more than 20 km to access distant saw palmetto fruit (Maehr 1996). These movements often involved traveling through private land and crossing highways.

FOOD HABITS

Martin et al. (1951, 1) observed that,

As the wilderness gave way to farms and factories, deer, bear, wild turkey, and chickadees have had to adapt themselves to altered conditions. And the remarkable thing is that most wildlife species could and did adjust. The secret of success in this shift from primitive to artificial...conditions is largely in the food habits of wildlife.

More is likely known about the diet of the Florida black bear than any other aspect of its natural history. Although latitude may be a more powerful predictor of regional den entrance patterns, diet has been implicated as a proximate determinant of den entry date (Schooley et al. 1994) and as the primary factor determining reproductive success in the black bear (Rogers 1976). Mast failures can result in reduced litter size, interrupted reproductive cycles, and low cub survival (Rogers 1976, Eiler 1981, Beck 1991), and have been implicated in litter abandonment and wide-ranging movements of prematurely independent cubs and yearlings (Fair 1977).

Food habits studies have been conducted in every major population in the state as well as in adjoining states. The most detailed analyses were conducted in south Florida (Maehr 1997a), where 739 scats revealed the typical pattern of a plant- and insect-dominated diet. In this subtropical environment the two most common palms, saw palmetto and sabal palm (*Sabal palmetto*), dominated all other foods consumed. Both saw palmetto and sabal palm provided fat-rich seeds during fall and starchy apical meristems throughout the year. No single insect predominated the invertebrate portion of the diet; however, a variety of wasps and ants accounted for about 20% of the frequency of foods in every season. In the other extreme of the state, Stratman (1998) and Stratman and Pelton (1999) found that saw palmetto and insects, especially beetles, provided similar year-round nutrition on Eglin Air Force Base in the northwestern panhandle. Further, Stratman determined that saw palmetto fruit was preferred over acorns when both were available. In nearby Alabama, acorns were the dominant fall and winter foods, whereas corn and herbaceous plant parts were important during spring and summer (Dusi et al. 1987). Insects also appeared to be important year-round. In central Florida, Roof (1997) identified saw palmetto as prominent fruit and fiber components of

bear diets in the central Florida Wekiva River basin bear population. Acorns were most frequently consumed during fall. In north-central Florida, Maehr and Brady (1982a) found that saw palmetto far outweighed all other food items (Table 1). Insects, especially beetles and wasps, were of secondary importance. In Apalachicola National Forest, saw palmetto was an element of the fall diet, but its importance was overshadowed by swamp tupelo (*Nyssa biflora*) and odorless bayberry (*Myrica inodora*) (Maehr and Brady 1984a). Gallberry (*Ilex glabra*) was an unimportant dietary element despite its abundance in both Apalachicola and Osceola national forests (Maehr and Brady 1984a). From statewide perspectives, fruit and fibers of saw palmetto and sabal palm far exceeded all other foods in terms of frequency of occurrence (Maehr and Brady 1984b, Maehr and DeFazio 1985). These general patterns were also recognized by Harlow (1961), Williams (1978), and Maehr and Wooding (1992). The only location in which saw palmetto was not a dominant food of the subspecies was outside of the species' range in southwestern Alabama (Dusi et al. 1987).

It is likely that the modern diet of the Florida black bear is nearly identical to that of its precolonial ancestors. However, several exotics, including nine-banded armadillo (*Dasypus novemcinctus*), wild hog (*Sus scrofa*), honey bee (*Apis mellifera*), and Brazilian pepper (*Schinus terebinthefolius*), account for nearly 10% of the black bear's diet today, and sea turtle eggs have become unavailable, due primarily to development of east coast forests (Maehr and DeFazio 1985). Other foods of marine origin such as eggs of American crocodile may still be consumed in extreme south Florida where mangrove forests provide important denning and foraging habitat for the black bear (Maehr 1997a).

As in all of the species' range in North America (Pelton 1982), diet quality varies seasonally in Florida. Although the spatial and temporal distributions of food have been examined in Florida, only Maehr (1997a) has examined the nutritional characteristics of preferred foods. The patterns found in south Florida are likely representative of the rest of the state. In spring, diet quality is lowest because foods are dominated by high-fiber vegetation. These foods, which include the apical meristem of palms, can, however, be rich in total protein. Summer diets are higher in crude fat with the emergence of soft

mast such as wild grape (*Vitis* spp.), but protein content is generally low. Fall and winter foods dominated by acorns and fruits of sabal palm and saw palmetto are high in carbohydrates and crude fat, and are critical in supporting successful reproduction in winter (Rogers 1976). It is these foods, in addition to one of the longest growing seasons in occupied black bear range, that may also explain the fast growth-rates and large sizes of bears in Florida (Maehr 1996).

The black bear's diet is dissimilar to that of other native Florida carnivores; however, it exhibits a 42% dietary overlap with the naturalized coyote (*Canis latrans*) (Maehr 1997a). The coyote in Florida has been observed to use saw palmetto for both cover (Maehr et al. 1996) and food (Maehr, personal observation; Weeki Wachee State Preserve), and it has been implicated as a potential competitor with the

black bear (Maehr 1997a). As coyote populations continue to expand in Florida, and as increasing pressure is placed upon saw palmetto fruit by this naturalized omnivore as well as by humans, black bear diets may become locally compromised. Saw palmetto fruit is increasingly used as an herbal remedy for prostatic hypertrophy (enlarged prostate) (Maehr and Layne 1996a, Tanner et al. 1996), and the primary source is naturally occurring populations (Abrahamson 1999).

The diet of the black bear in Florida is so variable that it might be easier to list species that it does not consume. One of the more remarkable items on this list, given its increasing presence in the southern portion of the Florida black bear's range and its proximity to abundant bear populations, is citrus. Among the hundreds of items documented in the diet of the species, oranges are not among them.

DEN ECOLOGY

The black bear is the largest cavity nester in the southeastern United States (Maehr 1997*b*). Throughout its range, the species utilizes a variety of sites for day use and reproductive purposes. The activities involved in the construction of ground dens have been recognized as a zoogeomorphological force that affects soil turnover and local erosion (Butler 1995). While hollows in trees may be preferred winter den sites, the black bear's behavioral plasticity permits continued occupancy of relatively young forests when den trees are absent (Carlock et al. 1983). The quality of available den sites is a significant management consideration for some bear populations because, after human disturbance, ground dens are more readily abandoned than are more secure locations (Johnson and Pelton 1979, Pelton et al. 1980). Hamilton and Marchinton (1980) found that bears occupying ground dens in coastal North Carolina were easily aroused from hibernation and usually abandoned such sites. Accordingly, black bears, especially females, prefer cavities in trees to other den sites (Pelton et al. 1980, Wathen 1983, Smith 1986, Wathen et al. 1986). Thick understory cover appears to be a prerequisite for successful natal ground dens (Martorello 1998). In coastal North Carolina, natal ground dens were characterized by 74% shrub canopy coverage, 0.79 m²-basal area, 74-cm shrub height; 18.2 stems per m², mean stem diameter of 0.64 cm, and an overall cover density of 72% (Martorello 1998). Because this landscape is similar to much of Florida in terms of climate, topography, and vegetation, these values may be useful targets for natal den microhabitat in Florida.

Apparently, because most North American forests are relatively young second- or third-growth stands, most black bears use ground dens and utilize a variety of protective cover as a substitute for the more substantial visual and thermal benefits of wood. In Idaho, Michigan, south-central Montana, parts of Tennessee, and Colorado most dens were excavations into hillsides or under tree roots or shrubs (Eubanks 1976, Beecham et al. 1983, Manville 1987, Mack 1990, Beck 1991). Most (89%) Ontario winter dens in second-growth deciduous and boreal forest were excavations—only 2 out of 113 were located in hollow trees (Kolenosky and Strathearn 1987). In Alaska, where black bears may remain in winter dens for more than 240 days, excavated and other ground locations predominated, but use of trees was not uncommon in the virgin timber of a coastal rain forest (Schwartz et al. 1987). Jonkel and Cowan

(1971) and Lindzey and Meslow (1976) found that most bear dens in Montana and Washington were in hollow trees. All dens in central Arizona were ground excavations under boulders and protected by dense vegetation (LeCount 1980). In the southern Appalachians, chestnut oak (*Quercus prinus*) was the most frequently used den species (Wathen et al. 1986). Interestingly, even an American chestnut (*Castanea dentata*) snag was used as a den site. The black bear in coastal North Carolina is predominantly a ground nester in forests that were previously heavily logged (Hellgren and Vaughan 1989, Lombardo 1993, Martorello 1998). Taylor (1971) found dens ranging from 2 to 30 m above the ground in a variety of Louisiana wetland tree species. Although Taylor (1971) did not describe the study site in great detail, the diameters of den trees suggest old-growth conditions. Beecham and Rohlman (1994, 211) observed that where soil conditions are not conducive for digging ground dens, “they may depend more on old-growth timber stands for denning sites.” Thus, where black bears inhabit seasonally flooded forests such as are found in Louisiana and Florida, the lack of old-growth characteristics may limit bear populations. At the very least, allowing the return of some old-growth characteristics such as large, hollow trees may facilitate population survival and production (Hellgren 1988, Martorello 1998).

All female dens in Ocala National Forest and Apalachicola National Forest were ground nests in dense vegetation (Hardisky and Wooding 1988; Seibert 1993, 1995). In south Florida, nearly all natal dens and winter male dens were located on or near the ground (Maehr 1997*a*). The only exception was the den of a female that utilized the same 2-m-tall cypress stump for 2 consecutive litters. Although south Florida may support the state's largest bear population, it inhabits an area that was heavily logged as little as 50 years ago. With the exception of a few isolated remnants of old-growth, such as Corkscrew Swamp, the forests of the region (as in the rest of the state) are young second-growth that do not provide secure den locations. Remarkably, females have chosen dens in dense mangrove swamps where tidal fluctuations are sufficient to flood dens and cause abandonment of litters (Maehr 1997*a*). In addition, females in south Florida have denned within 1 km of inhabited human dwellings (Maehr 1997*a*).

Secure, insulated dens such as those found in hollow trees may not be needed in Florida to

ameliorate cold winter temperatures (Johnson et al. 1978, Hellgren and Vaughan 1989), but they may be important for sustained successful reproduction especially in small, isolated populations where human activities occur nearby or within bear-inhabited plant communities. Several studies have noted the propensity for black bears to abandon ground dens when approached by researchers (Poelker and Hartwell 1973, Hamilton and Marchinton 1980, Wathen 1983, Smith 1986, Hardisky and Wooding 1988, Mack 1990, Beecham and Rohlman 1994), a pattern most consistent in southern latitudes, where den occupants are more easily aroused. Den abandonment following disturbance by researchers appears less common in northern latitudes (e.g., Alt 1983). In south Florida, the only denning black bear that allowed approach to within an arm's reach was an adult female that used the hollow stump of a logged cypress tree in Fakahatchee Strand (Maehr, personal observation). In this case the bear lifted her head when researchers peered over the rim of the cavity, but she made no effort to escape. She was, however, too alert to permit handling of her two cubs. In most other instances, ground-nesting bears abandoned dens long before researchers could see them, even if cubs

were present. While most females returned to their cubs after an encounter with researchers, some abandoned litters and, at the very least, the absence of the female from a helpless litter rendered cubs vulnerable to predation and thermal compromise. Thus, where ground locations predominate Florida winter dens, protection from physical disturbances near the den should be an important management consideration. Hellgren (1988) and Martorello (1998) both suggested that secure den sites are critical to maintaining productive bear populations, and that dense vegetation at the den is part of this requirement. Thus, in order to maximize bear populations on industrial timber lands or on national forests, silvicultural practices in bear habitat should strive to maintain dense, shrubby vegetation as den habitat, and should consider avoiding intense forest management during the winter denning season when cubs are vulnerable. In particular, burning of potential black bear den habitat should be avoided during winter. Powell et al. (1997, 72) summarized the necessary components of black bear den habitat as "...late successional forest with large trees and forest that protects bears from disturbance by humans, dogs or wild predators such as coyotes."

THE FLORIDA BLACK BEAR AND SAW PALMETTO

Saw palmetto is clearly the most universal component of the black bear's diet in Florida (Table 1), and it serves as important winter cover for both males and females (Maehr 1997a). This plant has already suffered tremendous range contractions as pine flatwoods and dry prairies have been converted to cattle pasture, and saw palmetto was specifically targeted for eradication (Hilmon 1969). In addition, the widespread practice of winter burning may have altered patterns of flowering and fruiting in this diminutive palm (see below). Despite this, saw palmetto is likely the most important biotic component of black bear habitat. One of the most daunting challenges facing managers will be balancing the increasing human demands for saw palmetto fruit with the continuing reliance of the black bear on this ubiquitous plant. Maehr and Layne (1996b, 10) asked,

What impact does the annual disappearance of millions of pounds of a preferred food have on the wildlife species that depend on it? While this kind of harvest is prohibited on most public lands in Florida, private lands ranging in size from one-acre lots to 100,000-acre ranches support this growing industry. No studies have examined the effects of localized, annual palmetto famines on resident wildlife. However, potential impacts include forced shifts to other, perhaps less desirable foods; expansions in home ranges to accommodate alternate food searches; home range abandonments; and local population declines. Highly mobile species such as the black bear may suffer increased exposure to vehicular traffic and higher mortality as some individuals are forced to travel more widely in search of their favorite fall food. Together with loss of palmettos through development and conversion of wildlands to improved pasture, citrus groves, or other types of intensive agriculture, the human harvest of saw palmetto fruit poses an additional threat to the ability of Florida's natural areas to support a diverse fauna.

For a plant as common and widespread as saw palmetto, it seems contradictory to suggest that it deserves special attention. But when one considers the myriad of processes and interrelationships in which it is at the center, saw palmetto emerges as a keystone

species in many of Florida's biotic communities. The fact that hundreds of animals depend, in varying degrees, on this diminutive palm, should be reason enough to elevate saw palmetto to the status of live oak, cabbage palm, longleaf pine, and other plants recognized for both their beauty and their value to wildlife.

There is likely no other native mammal in Florida that depends on saw palmetto to the extent that the black bear does.

Saw palmetto, like scrub palmetto (*Sabal etonia*), is a fire-prone palm that can tolerate hot and frequent fires (Abrahamson 1999), as well as grazing by cattle that are compelled to consume its coarse leaves when provided food supplements containing urea-based nitrogen compounds (Tanner et al. 1996). Saw palmetto is found in a wide range of dry environments, but it can tolerate a variety of habitats with high water tables or those bordering wetlands (Brown et al. 1990). Saw palmetto grows slowly (Abrahamson 1995), and some individuals may exceed 500 years of age (Tanner et al. 1996). Saw palmetto has also been a perennial target of range-improvement programs that seek to eradicate it from native prairies and pine flatwoods (Tanner et al. 1988). Many studies of this species have occurred in longleaf pine (*Pinus palustris*)—sandhill communities, where saw palmetto is usually less common than in pine flatwoods and where other mast producing plants are equally scarce (Glitzenstein et al. 1995, Abrahamson and Abrahamson 1996, Gilliam and Platt 1999).

Abrahamson (1999) observed that saw palmetto flowered profusely after each of 3 fires conducted during an 8-year period. Although he equated flowering with reproduction, no measures of fruit production were made. Gholz et al. (1999) found that flowering occurred consistently from year to year, but that fruit production occurred irregularly. Hilmon's (1969) studies, which were conducted in pine habitats utilized by black bears, suggested that saw palmetto responds to burning with vegetative growth, but that fruit production did not resume immediately. He observed that,

Fire stimulates frond growth during the winter when unburned palmettos are relatively dormant, and plants regain 80% of their

crown coverage the first year after burning. Burning reduces the incidence of flowering and fruiting. Flowering increases significantly after 5 years of fire protection and substantial fruit crops are produced after 6 to 9 years of fire protection (Hilmon 1969, iv).

Hilmon's botanical dissertation (the research was not conducted with wildlife in mind) is of tremendous importance for managers of black bear habitat.

Florida land management programs in upland sites often call for frequent (~3-year-interval) burns as a means to reduce fuel loads and promote plant diversity. It is likely that current burning programs in Florida occur at a rate and during a time of year that artificially reduces fruit production in Florida's most important black bear food plant. Maximum fruit production is likely obtained in areas that approach or exceed a 10-year burn interval.

FOREST MANAGEMENT AND THE FLORIDA BLACK BEAR

FIRE IN FLORIDA BLACK BEAR HABITAT

As Christensen (1985, 86) observed,

...fires play a significant role in the maintenance of community structure and function, and have been important selective forces in the evolution of plant form and life history.... Fires are patchy phenomena and contribute significantly to temporal and spatial heterogeneity....

The use of fire as a wildlife management tool has a long history in post-Columbian America and likely was used by aboriginal Americans long before recorded history (Komarek 1981). We are aware of few studies that specifically addressed fire as a black bear management tool; however, a number of studies allude to fire as an important habitat variable, and Hamilton (1981) provided the only overview of the effects of this abiotic process on the species. Robbins and Myers (1992) concluded that information is insufficient to determine the effects of burn season on black bear habitat in Florida. Hamilton's (1981) synopsis of the relation between black bear productivity and burning was in keeping with the period's prevailing view of fire as a management tool: short-rotation fires were a valuable influence that facilitated soft mast production, increased habitat heterogeneity, and generally improved conditions for black bears. On the other hand, Hamilton (1981, 132) advised that fire should be "restricted from other areas due to possible detrimental effects on bear den trees, escape cover and hardwood regeneration." Further, Langdon (1981, 145) observed that

...successive annual burns imposed when food reserves are low may lower plant vigor to the point that it finally succumbs. Season or frequency of burning may break the reproductive portion of the life cycle of plants and thereby eliminate a species from a given community.

At the very least, managers should be sensitive to the link between the historical pattern of summer fire and the flowering and fruiting phenology of important black bear foods plants such as saw palmetto. An artificial switch to winter burns set at short intervals may override the adaptations that some plants have developed in response to lightning-induced burning that may have occurred over longer

intervals than are traditionally practiced in Florida forests.

Stratman (1998) found that fires set at 3- to 5-year intervals encouraged fruit production in huckleberry (*Gaylussacia* spp.), dwarf blueberry (*Vaccinium* spp.), sweet gallberry (*Ilex coriacea*), bitter gallberry (*I. glabra*), and greenbriar (*Smilax* spp.) at Eglin Air Force Base. More than 5 years appeared necessary for blueberry (*Vaccinium* spp.), sparkleberry (*V. arboreum*), blackgum (*Nyssa sylvatica*), persimmon (*Diospyros virginiana*), and other hard mast species to recover from fire. Although saw palmetto was preferred in this area, Stratman (1998) did not report an optimal recovery interval for this species. Nonetheless, it appears that optimal burning frequencies for black bear food production and other habitat characteristics may well exceed standard prescribed fire protocols.

Of Florida's 13,990,000 ha of land area, nearly half (6,700,000 ha) remains forested (Powell et al. 1993). Fire is a naturally occurring force in every forested terrestrial plant community in the state. Maehr and Brady (1982a, 569) suggested that, "The effects of burning on black bear foods and food preferences should be investigated further to outline procedures for restoring bear habitats, especially pine flatwoods, to their apparent, historic productivity." The black bear in Florida clearly is a forest obligate, as has been found elsewhere in the southeastern United States (Wooding et al. 1994, Nyland and Pace 1997), but it does not utilize all forests with the same predilection. This pattern is best exemplified by the species' avoidance of sandhill habitats (Wooding and Hardisky 1988), where natural fire most likely occurred with greater frequency than in any other plant community in Florida. Such short intervals between fires likely reduced mast-producing species, such as saw palmetto and oaks, and eliminated escape and denning cover.

Fire Frequency

The original sandhills which covered up to about 20% of the state (Davis 1967) were dominated by the keystone species longleaf pine which, along with wire grass (*Aristida stricta*), sandy well-drained soil, and summer lightning resulted in natural fires that occurred at 1- to 3-year intervals (Wells and Shunk 1931, Parrott 1967, Platt et al. 1988, Stout and Marion 1993). Such frequent fires resulted in the

creation of parklike understories with scattered turkey oak (*Quercus laevis*)—conditions that apparently do not provide sufficient food or cover for black bears. It could be argued that loss of sandhill communities throughout Florida have had little impact on the black bear. However, widespread distribution of sandhills in the upper peninsula and panhandle suggest that such habitat provided connections between adjacent systems of scrub, swamp, and hammock forests. At the very least, sandhill communities may provide some measure of the forest conditions preferred by the black bear—open, savannalike pinelands are avoided as permanent habitat, whereas closed-canopy forests with dense understories are preferred.

Fire may be the most important factor in maintaining conditions attractive to the black bear in Florida. Timing and frequency of burns can affect structural characteristics of the understory, and, subsequently, black bear habitat. Langdon (1981) found that unburned southern pine forests had higher stem densities than forests that experienced a variety of burning regimes. Conversely, among a variety of treatments, including periodic winter and summer burns, the lowest stem densities were found in pine forests burned on an annual basis (winter or summer). In addition, more frequent fires result in increased mortality of hardwoods such as blackgum and oaks (*Quercus* spp.) (Langdon 1981)—important black bear food plants. Less-frequent summer fires encourage hardwood survival and facilitate vegetative growth of blueberry. Thus, natural fire season burns appear to be optimal for maintaining bear food plants in southern pine forests.

While the complete exclusion of fire in fire-adapted ecosystems may be as detrimental as burning too frequently, where prescribed fire occurs more than once every 6 to 9 years (as suggested by fruiting phenology in post-fire saw palmetto; see Hilmon 1969), habitat suitability for the black bear may decline. Traditional pine flatwoods management for cattle typically involves burning on a 2-year rotation (Wade et al. 1980). This same interval has been recommended for increasing productivity of the northern bobwhite (*Colinus virginianus*) (Moore 1972), an animal that prefers early successional habitats. While frequent fires generally help maintain herbaceous forage plants for species that require early successional habitats and help reduce fuel loads that can support catastrophic fires, such short fire-intervals are not typical in most Florida ecosystems. For example, fires may occur just a few times per century in cypress (*Taxodium distichum*) swamps

(Ewel 1990), every 3 to 15 years in south Florida rocklands (Snyder et al. 1990), and less than once every 50 years in hammock forests (Duever et al. 1986). Florida scrub habitats experience a natural fire interval of 10 to 100 years (Myers 1990). Fires may even occasionally occur in mangrove forests as the result of an accumulation of woody debris transported by hurricanes, but these events are rare (Craighead 1971). Although the range in expected fire frequencies is tremendous in various black bear habitats, it is generally recognized that more-frequently burned pine flatwoods have sparse understories and fewer mast-producing species such as saw palmetto and oaks (Harper 1914, Heyward 1939, Edmisten 1963, Moore et al. 1982). In general, dry season fires in Florida have become more destructive to native plant communities where forests have been logged and where water tables have dropped (Hofstetter 1984).

Fire Season

Florida plant and animal communities have evolved with summer lightning fires (Komarek 1964); thus it is reasonable to assume that out-of-season fires may be disrupting the life cycles of some native plants and animals and perhaps favoring some exotic species (Duever et al. 1986, 216–218).

Perhaps the most graphic example of the threat of out-of-season fires to the black bear is the direct mortality that can result from prescribed burns set during the winter denning period. Such a situation destroyed a litter of cubs in Florida Panther National Wildlife Refuge during the early 1990s (Land 1994). The fate of this litter was known because the denning female was radio-collared. Stratman (1998) also documented the abandonment of a den by an adult female following a prescribed fire on Eglin Air Force Base. It is unknown to what degree the common practice of winter burning has increased Florida black bear mortality throughout the state, especially for bears that den in highly flammable saw palmetto thickets. Pine flatwoods containing saw palmetto were the second most used cover type for denning black bears in south Florida (Maehr 1997a). Clewell (1971) and Maehr and Brady (1982a) have suggested that winter fires in north Florida pine flatwoods may increase the vegetative spread of saw palmetto while reducing the abundance of other mast producers.

Apparently, the practice of winter burning encourages rapid regrowth of palmetto as well

as gallberry (Hughes and Knox 1964, Hough 1965), resulting in a competitive advantage over other flatwoods mast producers such as runner oak (*Quercus pumila*) and blueberry (*Vaccinium* spp.) (A Stockle, pers. commun.). It is likely, due to the higher nutrition and probably greater palatability of these species, that runner oak acorns and blueberries made up most of the fall black bear diet before the advent of intensive timber management in north Florida. With decreased availability of acorns and blueberries in Baker and Columbia counties, bears may have, out of necessity, turned to saw palmetto as their major food source during fall (Maehr and Brady 1982a, 568).

This may not, however, be a completely accurate statement inasmuch as fires that may be responsible for these changes were winter prescribed burns. While recent nutritional analyses have suggested that saw palmetto is important from a nutritional standpoint (Maehr 1997a), and the dominance of palmetto fruit in bear diets suggests that it is indeed a preferred species, fire is still likely to have altered the availability of this and other foods that could be important dietary components during periodic saw palmetto mast failures. Black bear diets are likely not compromised when feeding solely on saw palmetto fruit, but in years when it is not abundant, other mast-producing species must be available to avoid the negative consequences of reduced caloric intake on reproduction and overwintering condition (Rogers 1976).

FOREST AND TIMBER MANAGEMENT

Since the time of Spanish rule, the trend in natural resources use in Florida has been toward increasing intensity (Harris 1980, 310–311):

Exploitative timbering, suppression of summer fires, and cultivation have brought about great floristic changes in the southeastern forest. Both the removal of large diameter-class hardwoods, and fire suppression, which has occurred both on former hardwood sites and apparently on many former pineland sites as well, have facilitated the increase of second growth (Quarterman and Keever 1962, Knight and McClure 1971). Unfortunately, the increased density and distribution of many hardwoods of marginal value to wildlife has necessitated expensive brush control practices. The proliferation of water oak (*Quercus nigra*)

throughout pinelands seems particularly problematic inasmuch as it is an intermediate host for fusiform rust (*Fomes pini*) (Schmidt 1978); furthermore its mast appears to be of marginal value to wildlife (Swindell 1949, Beckwith 1957). A more recent trend involves the reforestation of cutover sites with slash and loblolly pine plantations. The original 25 million ha of open longleaf pine has been reduced to about 10 percent of its original extent (Croker 1979).

About 60 percent of the southeastern land area remains forested today, 90 percent of which is considered commercial (USDA 1978). Of the 80 million ha of forest land in the Southeast (Virginia, North Carolina, Tennessee, Arkansas, Oklahoma, Texas, Louisiana, Mississippi, Alabama, Georgia, South Carolina, Florida), slightly more than 70 percent is privately owned. Of this privately owned land, approximately 50 percent is softwood and 50 percent hardwood (USDA 1978). About 280,000 ha of pine are planted annually, bringing the total area of pine plantations to approximately 8 million ha.

The general competition for forest land in the Southeast is intense, despite the high yield of forest products. For example, Florida's forest acreage has been reduced by an average of nearly 50,000 ha per year for the last 25 years (USDA 1978). A recent analysis of land-use dynamics by the Soil Conservation Service identifies a loss of 11.1 million ha, or 12.6 percent, of southeastern forest acreage in the last 8 years. Surprisingly, the losses to urbanization and recreational use account for only a small percentage of the decrease (Dideriksen et al. 1977).

Handley (1979, 333–334) cited Lewis's (1928) observation in the Great Dismal Swamp, Virginia, that,

When a logging gang goes into a section of the swamp the bears move out and are seen no more until the cutting is finished and the roar of the "skidders," the crash of falling trees and the whistle of the "dinky" locomotives has died away; and then, almost as soon as the tracks are pulled up, they are back again.

On the other hand, a detailed behavioral study in British Columbia indicated that female grizzly bears (*Ursus arctos*) exhibited profound responses to

logging-truck traffic and did not habituate to the disturbance (Archibald et al. 1987). Similar findings were observed in bottomland forest black bear habitat in Louisiana (Weaver et al. 1990). Further, such reactions may result in abandonment of otherwise productive habitat and a reduction in effective carrying capacity. Where logging activities are not followed by forest regeneration, habitat loss results. The lack of stand replacement helps to explain the modern distributions of the species in Florida (Brady and Maehr 1985), Mississippi (Shropshire 1996), and eastern North America (Maehr 1984*b*). In areas where forests are permitted to regenerate, black bear populations can expand sufficiently so that within 10 years female productivity declines, intraspecific aggression increases, and resident animals expand home ranges in response to declining food resources (Lindzey et al. 1986). Forest management for timber production usually involves the construction of access roads, which are subsequently used by hunters to access local black bear populations (Brody and Stone 1987). Whereas some clearcutting operations may temporarily improve forage conditions for the black bear (Lindzey and Meslow 1977), increased hunter access and concomitant mortality may outweigh the benefits of increased fruit production (Brody and Stone 1987). Similar access issues are evident in other extractive industries such as surface mining for minerals (McLellan 1990).

Even-aged forests and pine plantations have been implicated in reducing the ability of forest lands to support the black bear in Florida (Maehr and Wooding 1992) and elsewhere in the southeastern United States (Perry et al. 1999). Site preparation reduces midstory and shrub layers in pine plantations (Harris et al. 1974) and reduced solar radiation further compromises the ability of masting species to produce fruit (Umber and Harris 1974)—changes that eliminate food and cover needed by the black bear. The most intensive site preparation eliminates almost all woody debris, increases erosion, and promotes loss of nutrients (Vitousek and Matson 1984, Hunter 1990). While erosion is generally not a problem in most of Florida, loss of all woody materials would greatly reduce carpenter ant (*Campanotus floridanus*) and termite populations—important black bear foods—in addition to reducing biodiversity in general. Loss of structural diversity, a common consequence of tree plantations, results in fewer wildlife species (Moore and Allen 1999). In Florida, loss of large downed logs may eliminate preferred female black bear den cover, especially where large hollow trees, extensive saw palmetto

thickets, or other dense cover is rare or absent. Young and Beecham (1986) and Zager (1981) cautioned that minimally scarified clearcuts may require 10 to 20 years for bear foods to recover. Studies suggest that bear food production increases quickly after small-scale logging (Rogers 1976, Lindzey and Meslow 1977, Mealy 1977, Zager 1980, Young and Beecham 1986). Clearcuts that include areas greater than 125 m from a forest edge may experience reduced bear use (McLaughlin et al. 1986). In general, fruit production increases from 3 to 5 years following intensive management such as a clearcut or shelterwood cut, but fruit production declines with canopy closure unless silvicultural treatments are regularly applied (Perry et al. 1999).

Bottomland hardwood forests have been recognized as an important component of black bear habitat (Harris and Gosselink 1990). These often linear systems are frequently positioned within a matrix of pine-dominated uplands, and provide hard mast such as acorns and sabal palm fruit and soft mast such as tupelo (*Nyssa* spp.) during fall and early winter, after the availability of saw palmetto fruit has waned. Although water levels can periodically be high in hardwood swamps, the seasonal nadirs in fluctuating hydrology normally occur in late fall and winter as foods in upland sites disappear. In places such as Osceola National Forest, heavy feeding on abundant fall fruits directly precedes selection of den sites and initiation of hibernation (D. Maehr, personal observation). In such pineland-dominated landscapes it is not unusual for black bears to spend more than half the year in hardwood bottomlands. During the latter half of the nineteenth century many of Florida's bottomland forests were drained (Harris and Gosselink 1990). Such activities frequently led to forest clearing. While clearing led to immediate loss of wildlife habitat, the direct impacts were temporary if hydrology was maintained and trees were allowed to regenerate. However, such activities were precursors to the construction of levees and dams—structures intended to create relatively permanent changes for the sake of flood control and agriculture. The responses of native fauna to human activities in bottomland forests follows a gradient ranging from alarm reactions that create stress and subsequent physiological responses such as abnormal reproduction to range restriction that follows reproductive declines—the result of reduced recruitment and range abandonment—to loss of genetic heterogeneity as populations (such as the Florida panther [*Puma concolor coryi*]) become small and isolated (Harris and Gosselink 1990).

It is virtually a truism that black bears require a variety of successional and habitat types for optimal productivity. Few efforts have been made, however, to quantify habitat variables with viable bear populations. Rogers and Allen (1987) recognized that seasonal variation in movements and habitat use was primarily the result of changing food supplies. Their habitat suitability index model (HSI), however, went beyond simple subjective measures of black bear habitat relations. They observed that,

Ideally, a measure of cover type interspersed of food and cover resources could be used to evaluate the quality of black bear habitat. Presumably, greater interspersed of cover types providing required resources would reflect habitat of higher suitability than would an equally sized area with low interspersed...1) correlations between a cover type interspersed in relation to habitat quality and black bear response (e.g., improved physiological condition, higher reproductive rates) are undetermined; and 2) black bears are highly mobile and are capable of making long movements in relatively short periods of time. For example, in Minnesota sows with cubs traveling to known sources of food had average movements of 12.1 km/day, whereas, sows without cubs had average movements of 23.2 km/day (Rogers 1987a). A 4-year-old male traveling to a familiar feeding area moved at a rate of 7.0 km/hr. Additionally, black bears appear to be capable of learning the locations of food-rich areas that are well outside their home range. Knowledge of these sites may be passed on from generation to generation and movements to them may be extensive. The sites are normally used for a relatively short period of time before the bears return to their normal home range. Therefore, due to the potentially large areas and the mobility of the species, evaluation of cover type interspersed may have little merit in the evaluation for the species.

This model, however, is based on the assumption that overall cover type composition is important in the evaluation of black bear habitat quality. ...for optimal conditions, 7% to 50% of an evaluation area must be in wetland cover types to provide spring food, 25% to 50% of an area must be in cover types that produce summer food, >35% of an area must be in cover types that produce fall foods.

This led Rogers and Allen (1987, 31) to examine seasonal cover type requirements that may be useful for forest managers who wish to promote black bear populations. They concluded the following.

1. Maximum availability of summer food occurs in areas where tree canopies are <25%, and are ≤ 250 m from forest cover types that compose 25–50% of the evaluation area.
2. Summer foods decrease where nonforested cover types >250 m from forest cover account for >50% of the total evaluation area.
3. Where nonforest accounts for >50% of the area, forest area is reduced, resulting in inadequate cover and reduced access to food.
4. The absence of hard mast reflects poor-quality fall black bear habitat.
5. Maximum availability of fall food occurs when $\geq 35\%$ of the area is in cover types that have $\geq 1\%$ canopy cover of hard mast-producing species.

The black bear can also be a significant problem in silvicultural operations because some trees provide edible bark (Poelker and Hartwell 1973). In Washington, the tree-girdling problem was so severe that harvest limits were increased in the early 1970s in order to reduce bear damage to valuable softwood species (Poelker and Parsons 1980). Liberal spring hunting seasons resulted in a 30% annual harvest increase in special damage abatement units and were deemed successful. Black bear depredation on plantation trees has not been documented in Florida.

HERBICIDES

Although Rogers (1987a) advised against the use of broad spectrum herbicides due to the likelihood that bear foods would be negatively impacted, we are unaware of studies that have examined the effects of such chemicals on black bear habitat. Herbicides received scant treatment in each of the last three wildlife techniques manuals (i.e., Giles 1971, Schemnitz 1980, Bookhout 1994). Giles (1971) mentioned herbicides only in passing. Schemnitz (1980) suggested use of chemicals as a means of manipulating habitat for ungulates such as deer (*Odocoileus virginianus*) and elk (*Cervus elaphus*), but also observed that the outcomes of herbicide applications were often unpredictable and more study was warranted. Bookhout (1994) addressed herbicides only from the standpoint of wetlands

management. Among surveyed users of herbicides, chemical impacts on wildlife were not research priorities (Campbell and Howard 1993).

Herbicides are commonly used in Florida and elsewhere to control exotic species (Johnson and Barbour 1990), maintain rights-of-way easements, improve growing conditions for plantation-grown trees (Monsanto 1994), and create early successional openings for wildlife (Yoakum et al. 1980, Thompson et al. 1991). Herbicides can enhance wildlife habitat by decreasing overstory foliage and enhancing grass and forb production for a variety of species (Yoakum et al. 1980, Thompson et al. 1991). On the other hand, reductions in small mammal abundance can occur as a result of declines in plant and invertebrate foods (Santillo 1987). Increased edge and decreased forest interior can result from herbicide applications at herbaceous/forest interfaces. Such changes might locally increase soft mast production if herbicides are selectively applied to trees and shrubs that are not important bear food plants. Increased light and reduced competition may increase fruit productivity in blueberries and blackberries (*Rubus* spp.); however, these species are often targeted in conifer release efforts. Such local improvement in habitat productivity may, however, be offset if herbicides are administered indiscriminately or if they reduce forest interior conditions needed by black bears for escape cover or denning habitat.

During the early years of herbicide use in forestry operations, their application was viewed as primarily beneficial to early successional species such as white-tailed deer. Wagner and Zasada (1991, 506) captured the production-oriented philosophy of most herbicide applications by observing that,

Forest managers across North America need to consider the potential effects of forest weeds or noncrop vegetation on nearly every hectare being considered for reforestation or afforestation. Competition for limited environmental resources (light, water, and nutrients) between crop species and noncrop vegetation is one of the primary factors determining the survival and growth of young trees. Therefore, vegetation management is strongly linked to reforestation success and future wood supplies.

This production-oriented perspective has expanded to consider herbicide impacts on more than just edge wildlife species and plant communities. Freedman et

al. (1993) noted that after application of glyphosate to kill “silvicultural weeds,” raspberry (*Rubus* sp.) was drastically reduced and most individuals of huckleberry, cherry (*Prunus* spp.), and blueberry (woody soft mast-producing shrubs) were killed after initial application. However, within 1 to 2 years raspberries had recovered, and no extinctions of woody shrubs occurred. Apparently, if the duration of suppression is limited, conifer release can occur and still allow vegetation to recover quickly.

Provided that conifers have been satisfactorily released, the vigorous regeneration of angiosperm shrubs also may not be an important silvicultural problem, and may result in an enhancement of browse present at a suitable height to allow use by ungulates, as well as other wildlife values (Freedman et al. 1993, 2310).

Subsequent studies have examined herbicide use from larger spatial and temporal perspectives. Although Lautenschlager (1993) noted that plant response to herbicide is largely species specific, and that some browse species are 3 to 7 times more abundant after 8 years, he suggested that herbicide use should be examined from a larger spatial scale.

Regardless of the effects of any silvicultural technique, including conifer release with herbicides, the shape of the forest system is not limited to specific managed forests or treated blocks, but rather to the landscape on which management is practiced. Managers, using a diverse set of tools, can produce a maximum diversity and abundance of wildlife, along with timber yield, if they understand the number of animals and (or) habitats desired, and that treated areas are only part of the total landscape (Lautenschlager 1993, 2297).

Sullivan et al. (1998) noted that plant species richness declined, but shrub diversity and small mammal diversity did not change 5 years after herbicide application. Like Lautenschlager’s (1993) study, Sullivan et al. (1998) suggest that temporal considerations are important—short-term reductions in plant diversity and abundance are usually compensated for within a few years after treatment if herbicides are not continually applied.

Diversity, in fact, may even be enhanced if different types of habitat (such as conifer-dominated stands with associated shrub and

herbaceous species or areas with extended time periods of early seral plant communities), which support particular wildlife communities, are part of the overall landscape mosaic (Sullivan et al. 1998, 176).

On 3 sites in north Florida, Wilkins et al. (1993) observed that plant response to the herbicide hexazinone (Velpar, DuPont) was species specific and related to application rate, edaphic conditions, and adaptive strategies of resident plant species. In a xeric sandhill in Gilchrist County, several black bear foods (*Quercus*, *Vaccinium*, *Rubus*, and *Asimina* [pawpaw]) were reduced over a 3-year period, whereas, *Smilax* (greenbriar; a relatively unimportant bear food) increased over the same time period. In a mesic flatwoods in Alachua County, oaks and gallberry increased, whereas several plants not eaten by bears

decreased in percent foliar coverage. In a hydric hammock in Levy County, grapes, oaks, persimmon, and greenbriar decreased, whereas sabal palm increased. Although available herbicides can control many woody plant species (Table 2), managers should be aware of potential toxic effects on nontarget species, including wildlife, and resistance that varies regionally.

Six herbicides are commonly used in forests of the southeastern United States: Arsenal, Krenite, Velpar, Roundup, Tordon, and Garlon (Table 2). In general, if these herbicides are applied using broadcast methods, mortality among many species may occur. Most are used to enhance pine (*Pinus* spp.) seedling establishment or to release young pines from competition (American Cyanamid Co. 1988a). In such situations, chemicals are applied in restricted

Table 2. Herbicides commonly used for southeastern U.S. wildlife and forestry applications, and the woody species (trees, vines, and shrubs) that can be controlled with them in Florida. Species highlighted in bold are commonly used by black bears for food. Active ingredient and manufacturer data are from individual manufacturer specimen labels.

Species killed	Arsenal ^a	Garlon ^b	Krenite ^c	Roundup ^d	Tordon ^e	Velpar ^f
<i>Acer</i> spp.	X	X	X	X	X	X
American Beech	X	X		X		
<i>Betula</i> spp.		X		X		
Blackgum	X	X	X	X		X
Carya spp.	X		X	X	X	X
Celtis spp.						X
Cornus spp.	X	X		X	X	X
Cypress	X					
Elderberry				X		
<i>Fraxinus</i> spp.	X	X	X	X		X
Ilex spp.		X				
Lantana					X	
<i>Magnolia</i> spp.		X				X
Morus spp.	X	X				X
Persimmon	X		X	X	X	X
<i>Pinus</i> spp.		X	X	X	X	
Poison ivy	X		X			
Prunus spp.	X	X	X	X		
Quercus spp.	X		X	X	X	X
Redbud				X		
Rubus spp.	X	X	X		X	
Brazilian pepper		X		X		
Smilax spp.	X					
<i>Ulmus</i> spp.		X	X			X
Virginia creeper	X					
Vitis spp.	X		X			
Wax myrtle		X				

^aActive ingredient is Isopropylamine salt of Imazapyr (American Cyanamid Co. 1988b).

^bActive ingredient is Triclopyr (DowElanco 1993).

^cActive ingredient is Ammonium salt of Fosamine (DuPont de Nemours and Co. 1992).

^dActive ingredient is Glyphosate (Monsanto Co. 1997).

^eActive ingredient is Picloram (DowElanco 1992).

^fActive ingredient is Hexazinone (DuPont de Nemours and Co. 1995).

areas or to leaves, bark, or cut stumps of individual plants (American Cyanamid Co. 1988*a*, Monsanto Co. 1994). These chemicals do not present long-term environmental contamination problems, but botanically simplified communities that offer less food and cover for black bears may result if herbicides are applied repeatedly. Most of these products are suggested to be wildlife-friendly; however, because they promote the rapid re-establishment of grasses and forbs—vegetation types that are often equated with productive white-tailed deer and northern bobwhite populations (Anonymous 1990, 1991)—the resulting communities may be less likely to retain attributes that enhance black bear habitat.

Where the black bear is a featured target of management in industrial forest lands, herbicide use should be applied with a landscape perspective in mind (Harris 1984, Lautenschlager 1993, Sullivan et al. 1998). When used in a patchy distribution over both space and time, pine release and reduced competition will be less likely to reduce the use of affected areas by black bears. Reduced structural and species diversity are the intended results of herbicide applications to understory vegetation in pine plantations—the antithesis of most occupied bear habitat in Florida. However, if used for only short time-periods to promote young pine establishment, black bear food plants should not experience long-term declines, especially when the landscape matrix contains biotically diverse habitat patches.

EXOTIC SPECIES

Biological invasions are an integral part of global biogeography and explain, in part, much of the biodiversity that we are familiar with on a day-to-day basis, particularly in urban areas. They are also powerful agents of extinction. Indeed, human colonization of North America during the Pleistocene glaciation as little as 10,000 to 12,000 years ago may help explain the pulse of extinctions that resulted in the elimination of at least 40 large mammal species (Noss and Cooperrider 1994). Florida is more impacted by exotic species than any other state in the continental United States (Simberloff et al. 1997, xi)—23% of the flora is of alien origin (Ricketts et al. 1999). While space is insufficient in this report to address the issue of exotics, several species may have relevance to black bear management in Florida. Maehr and DeFazio (1985, 8) observed that,

...several introduced species appear to be important foods. Brazilian pepper is a common winter food in south Florida, providing bears with abundant fruits during a period usually characterized by a food shortage. The honey bee, introduced to Florida by early European settlers, is the most commonly eaten insect. Because honey bees are normally obtained at commercial apiaries (beeyards), a serious conflict between black bears and beekeepers has developed (Maehr and Brady 1982*b*). Armadillos are the most common vertebrate in Florida black bear diets. Inasmuch as armadillos are “destroying the organization and productivity of the leaf-mold stratum of the forest” (A. Carr 1983), black bears might be important in regulating armadillo numbers in occupied bear range. Exotics account for 7% of the food items used by bears, and for 9% of total frequency.

EXOTIC SPECIES AND BLACK BEARS

Brazilian pepper is frequently consumed by bears in parts of Florida that escape frequent winter freezes, and it provides a highly nutritious seed that rivals other native foods (Maehr 1997*a*). It is unknown to what degree this dietary supplement has affected bear productivity, but it may reduce weight loss during winter, enhance cub survival, and allow adults to reach breeding condition earlier. The highly invasive Brazilian pepper (Ewel et al. 1982, Loope and Urban

1980), which covers at least 284,708 ha in Florida (Schmitz et al. 1997), presents a problem for managers of natural landscapes because it is increasingly a target for eradication (Ewel et al. 1982, Doren and Jones 1997) at the same time that it may locally increase habitat carrying capacity for the black bear. The black bear itself may be an agent in the spread of this exotic because Brazilian pepper seeds appear to benefit from digestion and dissemination by bears (Maehr 1984*a*). Where intensive eradication efforts are planned on public lands, the potential impact of the loss of this important food should be evaluated. It is likely that the loss of any other exotic plant food would not carry similar consequences.

Melaleuca (*Melaleuca quinquenervia*) is second only to Brazilian pepper in areal coverage of a woody exotic species in south Florida (Schmitz et al. 1997). Although melaleuca is not eaten by bears, nor has it been identified as a negative or positive component of black bear habitat, its wide and expanding distribution has altered forest habitat conditions in south Florida. Indeed, the colonization of wet prairies, native range, and other nonforested habitat, may facilitate bear movement through areas that were previously unforested. However, where melaleuca reaches high stem densities, productive understory food plants such as saw palmetto may become intolerably shaded. Additional study is necessary to accurately describe the relation between melaleuca and the Florida black bear and to determine its actual impacts on Florida biota.

The nine-banded armadillo is the vertebrate most frequently consumed by the black bear (Maehr and DeFazio 1985). During the 1970s the armadillo exhibited a spotty distribution in Florida (Layne 1974), but it is now widespread and one of the state's most abundant mammals (Layne 1997). While the wild hog has been a disruption in Florida's biotic communities (Maffei 1997) since the 1500s (Bakeless 1961), and suggested as a competitor with a variety of native mammals (Layne 1997), it is not uncommon as a part of the black bear's diet (Maehr and DeFazio 1985). Exotic vertebrates may provide occasional supplements to the black bear's predominately vegetable fare, but they appear to be no more than opportunistic nutritional bonuses. Should armadillos and wild hogs ever be successfully controlled in Florida, their loss would likely not negatively impact the black bear.

HIGHWAYS, DEVELOPMENT, AND THE FLORIDA BLACK BEAR

Maehr (1994, 145) observed that few studies have been conducted that examine development impacts on the black bear:

Summer homes in the southern Appalachians may leave plenty of good bear habitat but they bring with them seasonally high levels of human activity and many intolerant summer house owners. In New England, ski resorts have a very similar influence, and golf course developments, especially in the southeast, directly eliminate bear habitat. Government subsidized drainage in the coastal plain has reduced the quality of bear habitat and increased human access to these denatured landscapes. Hellgren and Maehr (1992)...indicated that areas smaller than 10,000 ha are unlikely to support a black bear population unless it is adjacent to a larger tract of public-owned land. Examples from other taxa included giant pandas [*Ailuropoda melanoleuca*] living in forest fragments of 10,000 ha and extinctions of mountain lions [*Puma concolor*] in urban California where travel corridors have been lost.

Kautz (1984) recognized the need for effective planning to prevent the continuation of wildlife habitat loss to development in Florida. The challenge is complicated by the

...large number of species, the habitat values of different plant community types, and the effects of various perturbations. Florida, for example, is inhabited by more than 150 species of reptiles and amphibians, 425 species of birds, and approximately 80 species of mammals...that are distributed over 17 major habitat types excluding open water estuarine and marine habitats...(Kautz 1984, 121).

Kautz did not specifically analyze the kinds of development that threaten wildlife in Florida, but concluded that development not only caused habitat loss but also fragmentation and isolation of remaining populations. Partial solutions to counteract such losses for the black bear are habitat corridors sufficiently wide to offset edge effects and other disturbances inherent to suburbs and other human developments.

Human activities ranging from industrial development to housing developments have affected bear habitat use, quality, and availability in a variety of ways (Mattson 1990). Highways are perhaps the most obvious of the anthropogenic threats to bears and bear populations (Wooding and Maddrey 1994). Although highways can exact considerable mortality on black bears through vehicle collision, the effects of such losses on populations are unknown. Nonetheless, highway underpasses, advisory road signs, and educational pamphlets for motorists have been employed in an effort to reduce the number of bear/vehicle collisions in Florida (Maehr and Wooding 1992). Highways may influence bear habitat in a more insidious manner by providing hunters access to bears (Wooding and Maddrey 1994), fragmenting habitat, and reducing local and regional carrying capacity (Martorello 1998). Powell et al. (1997) observed that,

Roads, including logging roads that are gated or otherwise closed, provide hunters and poachers with access to bears (Beringer et al. 1990, Brody 1984, Powell et al. 1992, 1996). Of the black bears harvested in the mountains of North Carolina, 50% and 73% are killed within 0.8 km (1/2 mi) and 1.6 km (1 mi) of a road usable by a four-wheel drive vehicle (Collins 1983).

Several North American black bear populations inhabit forests that are near human settlements and highways. Several locations are notable due to the absence of highway collision as a mortality statistic: Washington (Poelker and Hartwell 1973), Idaho (Beecham and Rohlman 1994), Apalachicola National Forest (Seibert 1993), and coastal North Carolina (Martorello 1998). Most bear populations near highways, however, exhibit some form of vehicle-related mortality, but it is generally not high. Dusi and King (1990) reported a single bear/vehicle collision in a 2-year study of 4 radio-collared bears in southwestern Alabama. Anderson (1997) recorded a single highway mortality among 20 radio-collared black bears in a fragmented, agricultural landscape in Louisiana. And Maehr et al. (1993) and Land (1994) recorded 3 highway mortalities among 60 radio-collared black bears in south Florida—vehicle collision accounted for 30% of the total recorded mortality in this population. Nonetheless, from a behavioral perspective, high-speed, high-volume highways such as interstates appear to diminish

crossings by black bears, and may result in local reductions in bear abundance (Brody and Pelton 1989).

Ocala National Forest in central Florida is notorious for producing abundant highway mortality statistics for the black bear (Cox et al. 1994). This situation precipitated an examination of wildlife underpasses as a solution to the continuing bear/vehicle collision problem in central Florida. Although bears used an underpass structure incorporated into State Road 46 (Roof and Wooding 1996), the results of the study were equivocal. Bears continued to use unfenced portions of the highway to cross, and there were no significant differences (for all mammal species) in the use of the crossing location during pre- and post-underpass construction surveys. Although underpasses seem to be effective for the Florida panther (Foster 1992, Maehr 1997*b*), and fencing appears to be an important component of the overall design, black bears may not perceive the integrated system of barrier (fence) and passageway (underpass) in the same way that panthers do. Interestingly, when considering relative population densities of the two species, bear use of underpasses in south Florida was an order of magnitude lower than the rate of use exhibited by the Florida panther (Lotz et al. 1997).

Black bears seem less encumbered by apparent landscape barriers as evidence by the long-distance dispersal (including large portions of treeless improved pasture) of a radio-collared male from Collier County to Highlands County (Maehr et al. 1988), the wide-ranging movements of an adult female in northwestern Florida (Wooding et al. 1992), and bears' occasional fence-crossings in sections of Interstate 75 that are far from underpasses (D. Maehr, personal observation). It is possible that the panther is more dependent upon forest cover for making routine movements and dispersal, and that it is apt to climb only when pursued. Thus, bears are less apt to benefit from the intended funneling effect of fences when incorporated into an underpass system.

Roads have also been examined for more subtle effects on bear behavior and demographics. P. C. Carr (1983) suggested that road access in bear habitat

should be minimized to protect females from overharvest. Beecham and Rohlman (1994) found that Idaho black bears stayed more than 50 yards (45 m) away from dirt and gravel roads. Seibert (1989) and Beringer et al. (1990) observed that black bears in North Carolina avoided roads with high traffic volume, and were more susceptible to hunting in areas of high road density. Lentz et al. (1980) found that potential responses of black bears to roads occurred from <1 km to >5 km. However, Manville (1983) found that black bears in Michigan used oil pipeline rights-of-way, oil well service lanes, and lumber roads for travel. Maehr (1997*a*) suggested that female panthers are less tolerant of human disturbance and vehicle-related noise because female black bears selected den sites that were closer to roads. Whereas panther natal dens were always >1 km away from a road, some black bears denned within 0.06 km of a road (Maehr 1997*a*). Quigley (1982) found that black bears, especially females, in Great Smoky Mountain National Park avoided areas within 200 m of roads. Female black bears in the Ozark Mountains avoided areas within 240 m of roads (Clark et al. 1993). Kasworm and Manley (1990) found that bears tended to avoid areas within 274 to 914 m of an open road or trail in northwest Montana, depending on the season. They argued that road closures were a necessary management tool for reducing the impacts of roads on black bears and grizzly bears. Martorello (1998) made a similar recommendation for restricting road access in coastal North Carolina bear habitat. Mattson et al. (1987) found that primary roads in Yellowstone National Park not only were avoided by grizzly bears, but that home range shifts by dominant individuals placed subordinate individuals at a competitive disadvantage because they were forced to use habitat adjacent to human developments and human activities. McCutchen (1990) found that black bears in Colorado avoided interactions with humans and developed environments to the extent that otherwise productive habitat was effectively lost to the population. Similar patterns also pertained to back-country grizzly bears, although some individuals became habituated to people (Gunther 1990). Habituated bears became more susceptible to "being removed from the population due to concern for human safety" (Gunther 1990, 77).

HUMAN-RELATED MORTALITY

The cessation of black bear hunting in 1993 effectively ended nearly 5 centuries of bear harvest by Europeans and their ancestors in Florida and followed the observation by Wooding (1990) that, "In Osceola National Forest...harvests have been excessive. In Apalachicola National Forest, the record high number of bears killed in 1989/90 is cause for concern." Despite this insight, the effects of hunting on eastern bear populations are largely unknown (Maehr 1994). On a local scale, hunting was thought to be the major factor leading to the extirpation of the species from Levy County (Pearson 1954, Cox et al. 1994). According to Beringer et al. (1999, 727),

Hunting has a large influence on survival rates of black bears (Cowan 1972, Bunnell and Tait 1981, Schwartz and Franzmann 1991), a species with a low reproductive rate (Rogers 1976, Bunnell and Tait 1981, Rogers 1983, 1987*b*, Elowe and Dodge 1989, Schwartz and Franzmann 1991). Therefore, given the low reproductive rate and human-influenced survival (Jonkel and Cowan 1971, Glenn et al. 1976, Kolenosky 1990), conservative harvests are warranted, especially for populations where detailed population data are lacking (Miller 1990).

Although many black bear populations are harvested without negative impact (Burton et al. 1994), there is ample evidence that human harvest can have a depressing influence on bear populations (Poelker and Parsons 1980, Beck 1991). In addition, hunting activity can alter movements and enlarge home ranges (Clevenger 1986), and can push bears toward nocturnal activity (Garris 1983). Males are particularly susceptible to harvest (Bunnell and Tait 1981, 1985; Kolenosky 1986; Beck 1991; Schwartz and Franzmann 1992), primarily due to their more wide-ranging movements. Because there are no current plans to reinstate bear hunting in Florida, legal harvest is unlikely to influence Florida black bear dynamics in the near future, except in north-central Florida where the population is contiguous with Okefenokee Swamp, Georgia, where hunting still occurs.

Maehr and Wooding (1992, 269) observed that, "Illegal killing and roadkill mortality are probably a significant consideration only at the fringes of occupied range where potential colonizers are eliminated from suitable habitat and small, isolated populations." The relatively recent closings of bear hunting seasons in Florida, coupled with the species'

low reproductive rates, may explain, in part, some local population rebounds. Although increased encounters with people as a result of increasing human numbers may also be a factor, steady increases in nuisance complaints in south Florida over the last 2 decades may be the result of a population that has been expanding since the 1960s, when bear seasons were closed statewide. Furthermore, recent trapping success in Osceola National Forest is in sharp contrast to the 6 bears that were caught over a 2-year period in the early 1980s, when fall hunting was legal in Baker and Columbia counties (Brady 1985). Comparable data are unavailable for Apalachicola National Forest, which was closed to hunting in 1993.

Small populations that are not hunted can experience mortality that simulates the numbers lost to harvest alone. In these cases, remaining habitat can be viewed as sanctuaries in the sense of Wharburton (1984), McCullough (1996), Powell et al. (1996), and Beringer et al. (1998). Small populations such as those found in Greater Chassahowitzka Ecosystem and in Highlands County might experience nonhunting-related mortality that could drive them to extinction and impact statewide metapopulation dynamics. McCullough (1996, 5) warned that

Harvesting could, and likely would, affect a metapopulation in two different but related ways. First, harvest would increase the likelihood of extinction in the habitat patches to which it was applied unless the harvest was completely compensated by reduction in alternative causes of mortality. Complete compensation seems unlikely in most scenarios. Second, harvest would decrease the probability of dispersal. Because harvest changes the two critical variables in metapopulation persistence (local extinction rate and dispersal rate), both in directions inimical to persistence, on the face of it a metapopulation structure could be concluded to have little prospect for sustainable harvest of any magnitude.

Thus, in order to encourage metapopulation dynamics within the Florida black bear, nonharvest-related mortality needs to be considered. Such mortality may be sufficient to prevent dispersal and genetic exchange among subpopulations—especially since young males (the currency of black bear population interchange) are so susceptible to a wide variety of mortality factors.

LANDSCAPE ECOLOGY AND MANAGEMENT

LANDSCAPE ECOLOGY

Landscape ecology emphasizes broad spatial scales and the interaction between spatial patterning and ecological processes (Turner 1989, Forman 1995). Landscape ecology research has led to a significant broadening in the focus of conservation research, planning, and management (Forman 1987, Pickett et al. 1997), and has become an increasingly important aspect of black bear management (Maehr 1997*a*). The landscape needs of the Florida black bear have been recognized in part for nearly 2 decades (Kautz 1984).

Coupled with the growth of this discipline has been an increasing awareness (within the synthetic discipline of conservation biology) of the spatial needs and landscape considerations involved in protecting viable populations of large carnivores and other wide-ranging species (Schoen 1990, Noss et al. 1996, Samson and Huot 1998). A landscape ecology perspective is necessary due to the importance of habitat heterogeneity and the large spatial scales needed to maintain many species and ecological processes. The effective conservation of wide-ranging species depends on a landscape focus that incorporates natural levels of spatial and temporal heterogeneity while minimizing the negative effects of artificial edges and barriers (Harris et al. 1996).

The black bear can be considered a landscape species because of large-size home ranges and typical dependence on more than one vegetation association or ecological community type (Harris and Kangas 1988, Schoen 1990, Maehr 1997*a*, Samson and Huot 1998). Schoen (1990, 146) explicitly links bear management to landscape ecology:

In fact, a narrow concept of habitat may be inapplicable for bears, which are wide-ranging creatures of landscapes rather than habitat types per se.... Clearly, the normal movements of bears are so extensive that bear habitat must be evaluated and managed on a landscape scale often exceeding thousands of square kilometers.... Even in large areas, managers should be as concerned about the composition and status of the surrounding habitat as they are about the area they wish to conserve.

Habitat loss and fragmentation are key reasons

for landscape-level management. Essentially all bear species have been impacted by habitat loss and fragmentation that have resulted in range contractions, smaller populations, and, frequently, populations that are isolated from one another. Habitat fragmentation refers to the loss of habitat accompanied by a decrease in habitat patch size and increasing isolation between patches and is considered by many biologists to be the greatest global threat to biodiversity conservation (Wilcox and Murphy 1985, Wilcove et al. 1986, Harris and Silva-Lopez 1992).

The direct impact that outright loss of habitat has on black bears is obvious: less habitat means fewer bears. However, effects of fragmentation are more subtle, yet pernicious. As habitat patches become smaller, bear populations also are reduced in size, and populations become more isolated or often completely separated. This reduction in population size and increasing isolation can lead to several processes adversely affecting the survivability of small populations: demographic stochasticity, inbreeding, negative edge effects, and catastrophic events (Harris and Silva-Lopez 1992). Even if a small population does persist, it will probably lose genetic diversity through genetic drift and, therefore, have a reduced ability to survive future environmental changes.

In Florida the significance of landscape ecology principles and landscape management considerations are extremely significant due to rapid human population growth and concomitant habitat loss and fragmentation (Kautz 1984). This rapid loss of habitat has resulted in Florida having the third highest number of threatened and endangered species behind Hawaii and California, and 31 species have been extirpated or become extinct since the arrival of Europeans (Kautz 1993). In addition, at least 44% of Florida's vertebrate species are declining in population (Millsap et al. 1990).

Habitat loss and fragmentation have resulted in vast reductions in the area occupied by black bears. The black bear used to be found throughout North America wherever sufficient forest cover existed, which was essentially everywhere except for prairie, desert, and tundra (Maehr 1984*b*, Pelton 1986). As forests have been cleared for agriculture, industry, and housing, occupied black bear range has receded into more remote, inaccessible areas such as mountainous regions, extreme northern forests, and large swamp

areas. In the eastern United States, and especially the Southeast, black bear habitat is quickly being relegated to only scattered, large public lands (Pelton 1986).

The range of the Florida black bear shows the same trend of range contraction and fragmentation of populations (Hellgren and Maehr 1992, Cox et al. 1994). Although bears probably occurred throughout most of Florida, several prevalent community types, such as dry prairies, large marshes, and open sandhills, are not primary bear habitat. These plant communities dominate several areas. Sandhills were found in large expanses on the ridge systems from the panhandle through north-central Florida and down the Lake Wales Ridge almost to Lake Okeechobee. Large, marsh-dominated landscapes include the Everglades as well as the headwaters of the St. Johns River, and dry prairies were common in south-central Florida. Bear densities in such areas must have always been fairly low, though bears probably utilized saw palmetto, hammock patches, and wetland strands in dry prairie marsh systems, and oak scrub patches found within sandhills. The Florida black bear is now restricted to approximately 27% of its former range. Currently, at least 7 “more-or-less separate” populations of Florida black bears (U.S. Fish and Wildlife Service 1998*b*) are centered primarily in Florida, with bears also occurring in the Okefenokee region in southeast Georgia and in a small population in southwest Alabama.

In Florida, the bulk of the former and existing range of the Florida black bear, secluded forests vital to bears, are quickly being whittled away and fragmented. Approximately 40% of potential bear habitat in Florida is in public ownership, and private lands are under ever-increasing development pressure as human populations continue to grow. The U.S. Fish and Wildlife Service (1998*b*) suggested that 4 of the populations (Apalachicola, Osceola-Okefenokee, Ocala, and southwest Florida) are viable, though they acknowledge that at least 2 of these (Ocala and southwest Florida) will suffer from continued habitat loss and fragmentation. Land development trends near Jacksonville and in the panhandle (such as a new emphasis on residential development by St. Joe Paper Company) suggest that they also underestimate the future loss of habitat in the other 2 populations. Florida currently has 15 million human residents and is projected to add 3 million more by 2010. In addition, the comprehensive growth management plans for the entire state would allow approximately 100 million people in build-out scenarios. It seems unlikely that Florida will attain such a population;

however, the threat of significant habitat loss and fragmentation over the coming decades is severe. In Florida, the rate of annual deforestation has been estimated to be as high as 150,000 acres (60,000 ha) per year (Harris and Scheck 1991), although more recent estimates of rural land loss (including both agricultural lands and natural communities) using aerial photography and satellite imagery indicates that approximately 130,000 acres (50,000 ha) are being destroyed each year through conversion to residential, commercial, and industrial developments (J. Reynolds, University of Florida, personal communication). At this rate at least 25% of private rural lands (over 6 million acres [2.5 million ha]) will be converted to intensive development in the next 50 years.

The pattern of habitat loss may be more important than the actual amount lost. For instance, depending on where habitat loss actually occurs, the smaller bear populations that now exist may be extirpated. Inappropriately placed development can sever areas that now serve as links between various bear populations, or “subpopulations,” including the Chassahowitzka, Highlands, St. Johns, Eglin, and southwestern Alabama populations. The importance of maintaining existing and potential connectivity between these smaller populations and the 4 larger “core” populations is discussed in more detail below. Regardless of the outcome of the Vortex-based population viability models presented later in this report and the opinion of the U.S. Fish and Wildlife Service (1998*b*), Cox et al. (1994) determined that a long-term, minimally viable population of 200 black bears would require at least 500,000 to 1,000,000 acres (200,000–400,000 ha) of suitable habitat. Only the Apalachicola, Okefenokee, and southwest Florida populations currently have protected habitat that exceeds the lower end of this threshold. Other estimates indicate that formerly widespread species may need effective populations on the order of at least 500 to 5,000 to maintain long-term viability and evolutionary potential (Franklin 1980, Lande 1995, Noss et al. 1997).

RESERVE DESIGN PRINCIPLES

Well before the popularization of island biogeography theory, wildlife biologists noticed that national parks were not of sufficient size to maintain many wildlife species, especially wide-ranging species (Wright et al. 1933, Shelford 1936, Cahalane 1948). One of the suggestions for improving this situation was to create buffer zones around these parks that would provide a moderate level of security for

animals that needed more space to meet seasonal habitat requirements or enough space to support a viable population (Wright and Thompson 1934, Shelford 1936).

Island biogeography theory (McArthur and Wilson 1967) helped spur discussion of the relevance of insularity to habitat fragments in continental landscapes (Wilson and Willis 1975, Shafer 1990). Though these discussions also included red herring debates such as SLOSS (single large or several small reserves) (Shafer 1990), conservation biologists and ecologists agreed that to conserve species sensitive to fragmentation and biodiversity, many large and strategically located reserves would be needed (Wilcox and Murphy 1985, Soule and Simberloff 1986). Furthermore, the disciplines of conservation biology and landscape ecology substantiated some of the reserve design principles proposed initially through the application of island biogeography and provided new principles as well (Noss and Cooperrider 1994, Forman 1995). Some of the most commonly considered rules of thumb for reserve design (Thomas et al. 1990, Soule 1991, Noss and Cooperrider 1994, Noss et al. 1997) include the following:

1. Large reserves (or blocks of habitat) are preferable to smaller reserves. Such reserves will tend to have larger blocks of habitat and larger populations of black bear; have more potential for supporting various ecological communities (and therefore more diversity); be resistant and resilient to disturbances; be more likely to support natural, functional disturbance regimes and other ecological processes; and be better insulated from potentially incompatible land uses outside the reserve (Harris 1984, Soule and Simberloff 1986, Thomas et al. 1990, Soule 1991, Noss and Cooperrider 1994, Noss et al. 1997).
2. Functionally interconnected reserves are preferable to isolated reserves. Depending on the situation and species, connectivity could be provided through corridors or landscape linkages providing at least suitable dispersal habitat, or through compatibly managed multiple-use landscapes surrounding reserves. Reserves that are close together may also provide functional connectivity for species that are either able to fly or, as is the black bear, able to traverse the matrix surrounding the reserves (Harris 1984; Noss and Harris 1986; Harris and Scheck 1991; Soule 1991; Noss 1993; Noss and Cooperrider 1994; Noss et al. 1996, 1997; Beier and Noss 1998; Soule and Terborgh 1999).
3. Reserves in contiguous or consolidated blocks are preferable to fragmented blocks. Types of fragmentation within reserves could include roads, inholdings with incompatible land uses, or clear cuts (Harris and Silva-Lopez 1992, Noss and Cooperrider 1994, Noss et al. 1997).
4. Reserves that are roadless, or otherwise inaccessible to humans, are better than conservation areas with roads (Noss and Cooperrider 1994, Noss et al. 1996). This principle is born out of the established relationship between areas of high road-density and avoidance of, or absence from, such areas by a number of wide-ranging species sensitive to humans in general or prone to hunting, poaching, and roadkills. These species include the grizzly bear (Mattson et al. 1987, McLellan and Shackleton 1988), wolf (*Canis lupus*) (Thiel 1985, Mech et al. 1988, Mladenoff 1995), elk (Lyon 1983), cougar (*Puma concolor*) (Van Dyke et al. 1986), and black bear (Brody 1984, Brody and Pelton 1989). Black bears clearly respond negatively to the influences of roads (see section on roads and development).
5. Reserves with native carnivores and wide-ranging species are preferred to reserves without these species (Terborgh 1988, Soule 1991, Noss et al. 1996). Although the rationale for this principle can be simply aesthetic or programmatic (such as a directive to maintain or restore all native species), sound ecological conservation reasons exist for maintaining and restoring such species and their habitats. Carnivores are often keystone species that affect the structure of entire communities by, for example, controlling seed predators in tropical forests (Terborgh 1988); providing carrion for other species as wolves now do in Yellowstone National Park (K. Murphy, National Park Service, personal communication); or controlling meso-omnivores such as raccoons, opossums, and feral cats that can reduce ground/shrub dwelling and nesting species (Soule 1991). Carnivores can also be important in

maintaining functional evolutionary relationships between predator and prey (Maehr et al., in press *a*).

6. Species well-distributed across their native range and in several reserves will have a better opportunity to maintain genetic variation and adaptability to environmental changes. This will make them less prone to extinction than species confined to a small portion of their former range (Thomas et al. 1990, Wilcove and Murphy 1991, Noss and Cooperrider 1994, Noss et al. 1997).

Obviously, these principles should be regarded as rules of thumb that can be used as general guidelines for designing reserves and managing habitat for the black bear, as well as for biodiversity and ecological systems. Exceptions are always possible, and options must be weighed carefully when addressing specific situations (Noss et al. 1997).

Along with the development of reserve design principles, the increasing recognition of the need for large areas to maintain wide-ranging species, intact ecological gradients, and ecological integrity have led to integrated regional landscape approaches to conservation (Noss 1983, Harris 1984, Noss and Harris 1986, Noss 1987, Noss and Cooperrider 1994, Harris et al. 1996, Noss et al. 1996, Soule and Terborgh 1999). Regional landscapes reflect the appropriate scale for conservation because they tend to be big enough to comprise diverse, interacting ecosystems; incorporate large natural disturbances; and maintain viable populations of large, wide-ranging species (Noss and Cooperrider 1994, Harris et al. 1996). While research and management at other scales is still important (i.e., autecology, community ecology), landscape ecology is increasingly necessary for addressing the effects of ongoing habitat destruction and fragmentation (Harris et al. 1996). A regional landscape conservation strategy also stresses the importance of interactions between the urban environment, rural lands, and native ecosystems by incorporating planning and management at large spatial and temporal scales so that land uses are effectively integrated to maximize compatibility and ensure the conservation of biological diversity (Harris 1984, Noss and Harris 1986, Harris et al. 1996).

The need for regional landscape approaches to black bear conservation stems from increasing attention on the design and protection of integrated reserve networks that incorporate landscapes

apportioned into functional networks of reserves, multiple-use buffer zones, and landscape linkages (Harris 1984, Noss and Harris 1986, Noss and Cooperrider 1994, Harris et al. 1996, Soule and Terborgh 1999). The overarching goals for such systems could include those described by Noss (1996, 95–96):

1. Represent, in a system of protected areas, all native ecosystem types and seral stages.
2. Maintain viable populations of all native species in natural patterns of abundance and distribution.
3. Maintain ecological and evolutionary processes, such as disturbance regimes, hydrological processes, nutrient cycles, and biotic interactions.
4. Design and manage the system to be responsive to short-term and long-term environmental change and to maintain the evolutionary potential of lineages.

Obviously, although such reserve systems include as the primary goal conserving biological diversity, landscape ecology and regional conservation strategies are relevant to conservation efforts for carnivores and other wide-ranging species. This has led to the zoning approach of biosphere reserves and multiple-use modules (see Noss and Cooperrider 1994) wherein core preserves that are protected from exploitation and receive low-intensity human uses are surrounded by increasing human uses. In an article focused on conservation strategies for carnivores in the Rocky Mountains, Noss et al. (1996, 955–956) elucidate the importance of regional conservation approaches:

The overwhelming message from population viability studies of large carnivores is that conservation planning must be undertaken at vast spatial scales and must consider connectivity.... If maintaining viable populations of species that have large home ranges and are vulnerable to human activities is an objective, then the conservation planner must grapple with the design and management of entire landscapes. Thus a zoning approach has come to dominate conservation strategies for large carnivores. Zoned landscapes should include refugia that are strictly protected, but they will often be dominated by multiple-use lands.

This review's section on black bear habitat management clearly indicates that many reserve design principles and a regional landscape

conservation approach are applicable to conservation and management for the Florida black bear. Black bears have large home ranges and need diverse plant communities in relatively close proximity to provide seasonally available food sources. Large areas are needed to support viable populations. Black bears also have low reproductive potential, making them potentially sensitive to hunting and poaching pressure. In addition, bears come into conflict with humans due, for example, to apiary depredations, garbage raiding, and occasional livestock depredations. Black bear populations are influenced by major roads and road densities which cause roadkills, fragment bear habitat, and allow hunters and poachers access to bears. Florida black bears are at least partially dependent on natural fire regimes in flatwoods and other fire-adapted habitat types, and these fire regimes are best generated in large, intact landscapes and over long temporal scales. For example, because of the many years required for saw palmetto to regain fruiting productivity after a burn, prescribed fires in bear habitat must be planned over large areas in order to provide a mosaic of fruit-producing palmetto stands. Furthermore, large, well-buffered reserves are easier to manage with prescribed fire than are small reserves surrounded by urban land. Bears are, however, also capable of exploiting, and sometimes benefitting from, some human activities such as timber management that allows effective integration of core areas strictly managed for biodiversity with buffer zones that support low- to moderate-intensity land uses. Finally, the once widespread and abundant Florida black bear has now been fragmented into several isolated populations that are arguably not large enough to support long-term viability of the species. This leads us to a specific list of potentially relevant landscape-management guidelines for conserving the Florida black bear.

Protect and Restore Landscapes with Functional Gradients and Juxtapositions of Natural Communities

Most habitat suitability models for black bears (Rogers and Allen 1987), including Cox et al. (1994) for the Florida black bear, consider plant community diversity (often called habitat diversity). The assumption is that areas with a higher diversity of plant communities used by black bears will have a higher probability of supporting a diverse array of food sources and act as a buffer during mast crop failures (Schoen 1990, Samson and Huot 1998). In Florida most plant communities can be considered primary or secondary bear habitat in landscapes that

historically supported gradients of communities that provided resource diversity for bears. Of particular importance are gradients between swamps and upland forests. In many cases, wetland and riparian communities still exist, but uplands have often been converted to uses that either range from being potentially suitable for bears (e.g., pine plantations, dependent on management activities such as the use of prescribed fire and site preparation) to low or no suitability (e.g., most agricultural and other intensive land uses). Therefore, maintenance of existing mosaics of large wetland and upland communities and restoration of such mosaics where feasible should be considered important management objectives for the Florida black bear (as well as for biodiversity conservation as a whole).

Although there may be intact sites with abrupt habitat gradients containing a variety of food sources, bears often have to move long distances seasonally or in response to mast failures to find suitable foraging sites, which can lead to conflicts in human-dominated landscapes. Schoen (1990, 147) observed that,

Although there may be a reasonable mix of productive foraging sites within a bear's normal range of movements, it may be forced to traverse many habitat types in search of those productive sites. And herein lies one of the most serious problems facing bear managers throughout the world—habitat fragmentation.

Maintaining and restoring relatively intact landscapes that can support such spatially demanding habitat and population requirements such as foraging, denning, and dispersal are relevant to the following guidelines.

Land Use Zoning

Zoning is potentially relevant to conserving black bear populations in Florida (Samson and Huot 1998). This zoning approach is based on 2 primary considerations. First, black bear populations either require or can greatly benefit from “wilderness” conditions that insulate them from human persecution and vehicle collision, and may support other favorable habitat conditions that are not typically found in human-dominated landscapes (Lentz et al. 1980). Second, viable black bear populations may need more space than that found in strictly protected areas, and they may benefit from human activities such as clear-cutting or other human land use activities that create

successional habitats. Samson and Huot (1998) found that many black bears in a relatively small national park in southeastern Quebec frequently ranged outside the park, either seasonally or in years when certain mast crops failed, to forage in early successional habitats created by clear-cutting on adjacent lands. Bears that ventured out the park were, however, also subject to higher mortality due to hunting, poaching, and vehicle collision. Samson and Huot (1998) recommended 2 complimentary approaches: control the loss of females by closing the fall hunting period, when females were most likely to be out of the park, while maintaining the spring hunt, when more bears were typically harvested anyway; and use prescribed fire to create early successional habitat within the national park.

Although hunting of black bears is currently not permitted in Florida, poaching and other forms of human-related mortality still occur. Furthermore, intense human activities, such as off-road vehicle use, may reduce the quality of potential bear habitat. Establishing sanctuaries, or core habitat, for females may be a useful strategy for re-establishing populations in the southern half of the Big Bend, Green Swamp, and other areas that could contribute to metapopulations dynamics. A zoning approach to black bear management in Florida might limit off-road vehicle use and prohibit the harvest of saw palmetto fruit to protect den sites and food sources. Harris (1984) and Noss and Harris (1986) recommended that multiple-use modules (MUMs) with strictly protected areas and buffer zones can be applied at various scales. For example, red-cockaded woodpecker (*Picoides borealis*) colonies are protected using a small buffer zone where no timber harvest is allowed (Noss and Harris 1986). This area is then surrounded by buffer zones that allow harvest compatible with foraging needs of the species. In regard to black bear habitat management, Florida has essentially no old-growth forest left; therefore, few areas offer large tree cavities, which, when available, tend to be preferred den sites. Also, the availability of thick, shrubby cover for ground nests could, in some cases, conflict with land use practices on private timber lands and the current emphasis of frequent fire regimes on public lands. Allowing old-growth forest to return on strictly protected public lands should be considered a priority. In addition, patches of old-growth allowed to regenerate on multiple-use public lands could serve as den site core areas in landscapes that otherwise provide suitable foraging habitat. The rapid clearing of forested wetland domes and strands on private lands in north Florida (S. Vince, University of Florida, personal

communication) and elsewhere in bear habitat is also a potential concern. It might be possible to adopt an incentive approach to maintain and restore core sites on private lands to provide optimal denning sites.

Road Considerations

The susceptibility of black bears to highway mortality in Florida is well-documented. Roads both fragment forested landscapes and increase the likelihood that bears and humans will interact in some way. Although the black bear can survive in areas with roads, landscape management can target restoring bear habitat with as few roads as possible or minimizing the impact of existing and proposed roads. Several papers suggest a relationship between road densities and productive bear habitat (e.g., Brody 1984, Brody and Pelton 1989). Roads cut up blocks of once-isolated bear habitat and almost invariably make these blocks more accessible to humans. This usually means that bears are more susceptible to hunting and poaching (Kellyhouse 1977, Landers et al. 1979, Pelton 1986). The kinds of roads that can influence bear habitat range from unpaved trails through forests, where bears could benefit from mast-producing shrubs or suffer from increased human access, to major highways that bisect occupied range or travel corridors and cause direct mortality due to vehicle collision. In an area of intense hunting pressure in Alaska, 16 of 18 monitored dispersing subadult males were shot next to roads (Schwartz and Franzmann 1992). The maintenance of existing larger roadless areas (Hellgren and Maehr [1992] suggested that 10,000 ha [25,000 acres] may be a minimal size for occupation) on public lands is essential, and restoring roadless areas by closing nonessential roads on public lands should be considered whenever possible. Overall road density is also important. Brody (1984) suggested that black bear populations may not be maintainable in the Appalachians, where road density exceeds 0.8 miles per square mile (0.5 km/km²). Pelton (1986) recommended that a very conservative approach be taken on planning new roads in bear habitat where road densities exceed 0.5 km per square km. A general guideline is that road densities below 0.5 miles per square mile (0.3 km/km²) are optimal for core areas. Road densities within buffer zones or multiple-use areas should be under 1 mile per square mile (0.6 km/km²) (Noss 1992). Florida currently has few areas with road densities below 1 mile per square mile, and many that do exist are found within occupied bear habitat (T. S. Hootor, University of Florida, unpublished data). On the other hand, if an area is particularly productive and provides

sufficiently remote habitat for denning and other key behaviors, black bears can exist in the face of extensive road networks. In Florida, Ocala National Forest serves as an example of this phenomenon. The Greater Chassahowitzka Ecosystem bear population, on the other hand, may be sufficiently small that road construction and concomitant development may render it unsustainable. Maintaining roadless areas and areas of low road density on privately owned bear habitat will be difficult without incentives and conservation easements. Impacts to bears in areas with high road densities might be reduced by discouraging poaching through education and law enforcement (Noss and Cooperrider 1994).

Black bears tend to avoid crossing major roads with high traffic-volume, such as interstate highways (Brody and Pelton 1989). All very large blocks (50,000–100,000 acres [20,000–40,000 ha] or greater) of bear habitat with no major roads (Cox et al. 1994) should be maintained. New highway projects in low road density areas should be avoided, and construction of new highways within occupied habitat should also be avoided in general. Widening and intensification of use of existing roads and highways should be monitored in black bear habitat. All roads within the Florida Department of Transportation Intrastate Highway Plan should be assessed for their potential to conflict with black bear conservation, since the plan calls for widening many of these roads in the near future.

The potential utility of road underpasses to reduce roadkills and promote connectivity has been discussed briefly. Although bears may be less prone to use underpasses, they are still one of the few options available to reduce roadkills and maintain or restore habitat integrity, especially in a state with such an intensive, and growing, major road network. New road construction, which facilitates massive growth, new residents, and seasonal migrations of millions of tourists yearly, has averaged about 5 miles (8 km) of new roadway per day for the last 50 years (Harris and Hootor 1992). The preferred option to ameliorate road impacts would be to build larger elevated road spans or a series of underpasses, similar to those along Interstate 75, instead of narrow, single underpasses like that used on State Road 46 and the one planned for Suncoast Parkway within Annuteliga Hammock CARL Project. Such bridge expanses or underpass arrays would be much more likely to promote use by black bears, as well as a whole suite of sensitive species that may not be able to find or use isolated underpass structures (T. S. Hootor, University of Florida, unpublished report). Another potentially

significant opportunity is the planned widening of many bridges throughout the state (Dan Smith, University of Florida, personal communication). In some cases, black bears use riparian features as movement corridors (Kellyhouse 1977, Mollohan and LeCount 1989, Weaver et al. 1990); therefore, widening bridges in black bear habitat and along potential dispersal corridors may be very important.

Landscape Connectivity and Managing for a Statewide/Rangewide Population

A regional landscape approach to conservation is based on the thesis that an integrated system of reserves would be of greater function than the sum of its parts. Noss (1992, 11) suggested that,

Connectivity is in many respects the opposite of fragmentation. A reserve system with high connectivity is one where individual reserves are functionally united into a whole that is greater than the sum of its parts.

A connectivity approach to conservation is simply an attempt to protect landscapes from further fragmentation and, where possible, to restore connectivity to culturally altered landscapes. Connectivity should not be used to link populations that were naturally isolated (Noss et al. 1996, 1997; Beier and Noss 1998).

Before the advent of cities, roads, housing developments, and large agricultural areas, bears roamed freely across the landscape. Although not all areas were prime habitat, bears were still capable of dispersing through such places to reach suitable habitat. Furthermore, even in marginal habitats, stepping stones or corridors of suitable habitat occurred. For instance, on sandhills, various sized scrub areas occurred in patches and linear strands. In and of themselves, these patches were probably insufficient to support intrinsically viable populations of bears, but they were sustained by repeated colonization. River systems provide another example. The Withlacoochee River begins in Green Swamp and runs between two ridge systems that once supported vast sandhills. The river incorporates several large expanses of swamp as it runs to the northwest and eventually empties into the Gulf of Mexico. At its outlet is a vast forest of flatwoods, swamp, and hammock. Although bears probably crossed sandhill areas, such rivers constituted the more natural dispersal corridors. The Withlacoochee River probably served as a landscape linkage for a large bear population that used its headwaters delta forest.

While the previous passage is a speculative illustration of black bear movement through the pre-European Florida landscape, the primary point is that the Florida black bear used to be one large, interacting population. Today, as a result of habitat loss and fragmentation, it functions primarily as a seven-part metapopulation (Levins 1970). It is possible that some populations are completely isolated, but there is also evidence and a strong likelihood that several populations are currently linked through occasional dispersal. In one instance, the Ocala and Okefenokee/Osceola populations may have enough interaction to be considered one population. A recent range map for bear populations in the southeastern United States also suggests that these populations are connected (Wooding et al. 1994). However, current conservation recommendations for the Florida black bear have focused on attempting to protect habitat around the 5 largest populations (southwestern Florida, Ocala, Okefenokee/Osceola, Eglin Air Force Base, and Apalachicola) to provide additional security (Cox et al. 1994). In several cases, Cox recommended Strategic Habitat Conservation Areas for the Florida black bear that include providing some local connectivity. The recommendation for the Okefenokee/Osceola population includes primarily Pinhook Swamp, which would ensure protection of a landscape linkage between Osceola National Forest and Okefenokee National Wildlife Refuge. The recommendation for the Eglin population includes protecting habitat linkages between air force property, Blackwater River State Forest, and Northwest Florida Water Management District lands along the Choctawhatchee River. The Ocala recommendation includes habitat linkages from Ocala National Forest to the Wekiva River conservation lands complex, which contains a high-density bear population (Roof and Wooding 1996), and across the St. Johns River to bear habitat on private timberlands and Tiger Bay State Forest. These areas cover approximately one million acres (400,000 ha) (Cox et al. 1994). We believe that the recommended Strategic Habitat Conservation Areas are essential to effectively conserve the Florida black bear. However, we also believe that there are other opportunities that would enhance the conservation recommendations. Cox et al. (1994) suggested that smaller populations such as Chassahowitzka and Highlands County are too small, potentially too isolated, and too threatened by encroaching development to warrant conservation attention.

The chances of an area supporting a stable population without recurring immigration is another criterion that should be used to

evaluate minimum habitat conservation priorities. The level of immigration required to sustain some of the smaller populations described may be achieved through the establishment of habitat corridors, but required immigration rates may also be higher than habitat corridors alone can provide. The small populations described for Chassahowitzka National Wildlife Refuge, Durbin and Twelvemile swamps, Green Swamp, and other areas would also require major new land conservation efforts in order to provide a sufficient habitat base to sustain these populations for acceptable lengths of time. Cox et al. (1994, 60)

This strategy will most likely ensure the loss of smaller populations/subpopulations, unless land-saving actions are taken quickly to protect or restore components of the Florida black bear metapopulation. We agree that funds, time, and political will to protect everything are limited (Simberloff et al. 1992, Cox et al. 1994), and that options must be weighed carefully, including detailed assessments of opportunities for connectivity and for conserving biological diversity (Noss et al. 1996, Beier and Noss 1998, Dobson et al. 1999).

Recent state and national trends suggest that regional and continental conservation is feasible (Soule and Terborgh 1999). National opinion polls suggest that Americans strongly support efforts to protect green space and wildlife. Florida has followed suit by renewing aggressive land protection efforts by passing the Forever Florida bill, which could provide as much as 300 million dollars per year for conservation efforts through 2010. Congress is close to passing comprehensive, landmark legislation that would fully fund the Land and Water Conservation Fund at 300 million dollars per year, and much of this money is to be funneled to the states for land and water conservation projects. Conservation easements are being increasingly used in Florida, allowing more land to be protected for less money, keeping lands in private ownership and on tax rolls, and reducing management costs, while maintaining land uses compatible with conservation objectives such as black bear habitat. Furthermore, University of Florida recently completed a 4-year modeling effort to identify a statewide ecological network, which may help protect a large, connected reserve system that stretches from the Everglades to the Perdido River in Alabama. The Florida Legislature passed a greenways implementation plan to support these efforts as part of the Florida Forever legislation.

Recent trends in land conservation efforts in Florida black bear habitat suggest that efforts to conserve the smaller populations may also be feasible. The state recently closed on a 60,000-acre (24,000-ha) acquisition and easement project in the Fisheating Creek basin with Lykes Brothers Corporation. An additional 80,000-acre (32,000-ha) conservation easement in the same area is planned. This project protects habitat that is likely essential to the Highlands County bear population because it secures an important part of existing habitat while protecting connectivity with the larger population south of the Caloosahatchee River. A conservation coalition including The Nature Conservancy is working with large landowners in southern Duval County and St. Johns County to protect a conservation network that may help maintain a bear population in the Durbin and Twelvemile Swamp area despite ongoing development in the region. The Nature Conservancy has also established a conservation partnership with Eglin Air Force Base, Georgia-Pacific, Blackwater River State Forest, and Conecuh National Forest in southern Alabama to integrate conservation and land use activities to conserve biological diversity in that region. These efforts include securing habitat connections that may support the continued existence of the Eglin bear population.

Recent demographic trends and individual phenomena bode well for future bear metapopulation management in Florida. Roadkills and anecdotal evidence suggest that the Apalachicola population is expanding to the east and south through coastal and riverine conservation lands and private timber lands in the Big Bend. Existing conditions and recent experiments in Lower Suwannee National Wildlife Refuge and surrounding lands supported the notion that the area could maintain a bear population (Wooding 1995, 1996). An adult male bear was recently captured on Goethe State Forest in the southern Big Bend and has exhibited a stable home range since capture and collaring in 1999 (D. Maehr, unpublished data). Wooding et al. (1992) documented the movements of an adult female to Alabama and, more recently, a subadult bear from the Eglin population moved to Alabama (M. Sunquist, University of Florida, personal communication), suggesting a dispersal linkage between northwestern Florida and southern Alabama. A relocated adult male bear recently traveled from Putnam County to Brooksville (Greater Chassahowitzka Ecosystem population) covering a straight-line distance of about 130 km through a highly fragmented and denatured landscape. Thus, the idea of a Florida black bear metapopulation is more than an armchair hypothesis.

Seasonal movements and dispersal events are the most important considerations for a connectivity approach to conserving the Florida black bear. After den emergence black bears steadily increase their activity, and their home ranges usually expand accordingly (Rogers 1987*a*). In some areas this can include complete shifts in home ranges as food availability changes and as males seek mates during the summer breeding season (Garshelis and Pelton 1981, Klenner 1987, Wooding and Hardisky 1988, Mollohan and LeCount 1989, Maehr 1997*a*). Such shifts can exceed 20 km (Maehr 1997*a*). In Minnesota, both male and female black bears moved considerable distances out of normal home ranges to utilize more abundant food resources in late summer and fall (Rogers 1987*a*). Trips of up to 83 km, with an average of 29.5 km, were recorded to reach one particular food resource, and one adult male went on a 13-week trip of 201 km, the longest movement recorded for a nondispersing bear (Rogers 1987*a*).

Dispersal refers to the movement of animals from their area of origin (Brown and Gibson 1983). In the black bear, dispersal usually occurs at 2 to 4 years of age (Pelton 1982; Rogers 1987*a,b*). Subadult females usually stay in the immediate area of their mother's home range, whereas subadult males may disperse widely either in response to "social pressure" from resident adult males (Pelton 1982) or due to socially independent factors (Rogers 1987*b*). In a sample of 51 subadults in Alaska, all males dispersed, whereas only 3% of females dispersed (Schwartz and Franzmann 1992). In Minnesota, dispersal distances ranged from 13 to 219 km, with an average of 61 km (Rogers 1987*a,b*). There was also evidence of a dispersal event over 324 km (Rogers 1987*a,b*). In north-central Florida, dispersal of 4 subadult males ranged from 22 to 56 km (Wooding and Hardisky 1988), and another subadult male moved 140 km in southwest Florida (Maehr et al. 1988). The longest known dispersal distance of a subadult female in Florida covered 60 km in southern Florida (Maehr 1997*a*).

Dispersal is an important demographic factor that plays a key role in population regulation (Kemp 1976, Bunnell and Tait 1981, LeCount 1982, Beecham 1983, Rogers 1987*b*). In Alberta, 26 adult males were removed from an experimental study area, and a large number of subadult males quickly moved in to take their territories (Kemp 1976). Other studies indicate that many transient subadult males routinely travel through occupied territories (Beecham 1983, Rogers 1987*a,b*). This ranging behavior of subadult males attempting to establish territories is a key factor in linking regional bear populations.

Corridors and landscape linkages (areas that link larger core reserves) are common connectivity tools. For bears and other species, these landscape features serve at least three purposes related to connectivity: 1) facilitate daily or seasonal movements; 2) allow dispersal that might facilitate gene flow between populations, buffer small populations, or recolonize vacant areas; and 3) allow range shifts in response to catastrophic events or long-term environmental change (Noss 1993).

Functional connectivity is more likely in corridors that not only support movement, but support home ranges as well (Harrison 1992, Noss and Cooperrider 1994, Noss et al. 1996). Based on the average home range requirements for male Florida black bears, a corridor would have to be at least 13 km wide for a “square” home range or 9 km wide if the home range was twice as long as wide. Landscape linkages could be much bigger. The best regional example is the Pinhook Swamp, which connects Osceola National Forest and Okefenokee National Wildlife Refuge.

Dispersal distance is an important consideration for landscape planning or restoration. Cox et al. (1994) chose 60 km as the average effective dispersal distance for Florida black bears. This value was halved and used to identify primary and secondary habitat surrounding core areas. Based on the known performance of dispersing bears in Florida, this estimate likely underestimates their dispersal capabilities.

The most common argument by those unconvinced of the utility of a landscape connectivity approach is that there is little evidence that corridors “work” (Simberloff et al. 1992). Corridor and connectivity experiments are especially difficult (or even impossible) to conduct at scales relevant to wide-ranging species. Although more evidence is accumulating, there is still a dearth of information on corridor function (Beier and Noss 1998). Observations of animal movement across naturally and culturally fragmented landscapes, however, provide ample evidence of corridor use (Maehr 1990; Harris and Scheck 1991; Beier 1995, 1996; Noss et al. 1996). Kellyhouse (1977) and Weaver et al. (1990) found that black bears used riparian strips to move within fragmented landscapes. In agricultural landscapes, bears restricted movements to wooded areas such as ravines, shelterbelts, and riparian zones (Klenner 1987, Weaver et al. 1990). Where suitable cover was limited in a naturally fragmented

landscape, bears used vegetated canyon corridors to make seasonal forays (Mollohan and LeCount 1989). Beecham (1983, 411) concluded that,

...migration corridors connecting the study area with other bear habitat to the north and south are critical in maintaining black bear numbers. These corridors tend to funnel dispersing subadult bears through the area, masking the influence of hunting on population size. If the migration corridors are not maintained, a significant decline in bear numbers can be expected unless hunting pressure is reduced.

A strategy that emphasizes broad landscape linkages and maintaining landscapes with low-intensity land uses will generally be more useful and successful for providing connectivity between bear populations than a system of narrow corridors. This view is supported by Noss et al. (1996), who reviewed and discussed the application of landscape conservation techniques for large carnivores.

Collectively these data suggest that in most cases connectivity will be best provided by broad, heterogeneous linkages, not narrow, strictly defined corridors.... With these in mind, biologists have recommended the retention or restoration of wide habitat linkages between population centers for large carnivores. ...reserves play vital roles in these networks, but so does the surrounding semi-natural matrix. The regional landscape must be considered and managed as a whole. Noss et al. (1996, 958–959)

Some suggest that instead of protecting linkages and pursuing a connectivity approach, intensive management such as translocation should be used (Simberloff et al. 1992). However, this view misses the point that conservation of biological diversity transcends species and even pattern. Soule and Terborgh (1999, 200) claim that,

Humans and nature can coexist, but peaceful coexistence cannot come about under present conditions. The revival and survival of nature across North America will require the establishment of a network of large nature reserves. Large areas managed for biodiversity are needed to ward off a host of ecological pathologies. Through conservation-oriented management of

extensive core and multiple-use areas, the vital abiotic and biotic processes that sustain biodiversity can be perpetuated.

The protection of ecological and evolutionary processes such as herbivory, migration, dispersal, gene flow, and predation are just as important and are also essential components of effective biodiversity conservation. A landscape connectivity approach would be, at the very least, an important part of meeting these conservation objectives. It should be the goal of wildlife managers to conserve self-managing systems that sustain natural processes, including evolution, a notion that is as old as the Wildlife Society (Bennitt et al. 1937, Errington and Hamerstrom 1937). Translocation of animals should be avoided when landscape connectivity approaches are still possible. Highly manipulative and artificial strategies should be viewed as last resorts and not blithely accepted as equal alternatives.

CONNECTIVITY BEYOND BEARS

Although this is meant to be a discussion about the applicability of landscape approaches to black bear conservation, it is extremely important to note that bear corridors and landscape linkages could serve many other functions. Bear movement is only a part of a connectivity approach to conserve biodiversity through the maintenance or restoration of natural landscape patterns and processes.

First, the black bear plays a potentially significant role in ecosystem dynamics. This role may not be as important as that of top-level carnivores such as the panther or red wolf, but bears are important seed and nutrient dispersers. Studies show that black bears may improve the germination of seeds that pass through their digestive tracts (Rogers and Applegate 1983, Maehr 1984a). Bears may also be particularly important seed dispersers of heavier fruits that cannot be carried by birds (Rogers and Applegate 1983). Therefore, although it is extremely important to design a conservation strategy for the black bear that will protect viable populations, it may also be advisable to maintain smaller populations and facilitate movement into smaller habitat patches. In other words, reserves that do not have bears are missing a potentially important ecological component (not to mention their aesthetic value).

Riparian corridors may be an important part of a linkage system that targets bears. They also tend to have diverse flora and fauna, are highly productive, and can serve as important buffer zones to protect

hydrological processes and water quality (Schaefer and Brown 1992). If wide enough, these areas can also serve as important habitat for forest interior bird species and cavity nesters (Harris 1989). Riparian strips could also serve as important habitat and corridors for otters and mink (Harris 1989).

The protection or restoration of landscape connectivity for the Florida black bear may also have important benefits for the Florida panther. Panthers have even larger habitat requirements than do bears, and it is extremely unlikely that any one core area now existing in Florida will be capable of supporting even a minimally viable population (Cox et al. 1994). However, a strategically connected reserve system might protect a viable and ecologically functional population of panthers (Harris and Gallagher 1989, Harris et al. 1996). Finally, the Florida black bear is a flagship and umbrella species that can be an important catalyst for protecting a statewide, integrated system of reserves that will benefit many native species sensitive to habitat fragmentation (Cox et al. 1994). Although managers must realize that umbrella species will never cover the habitat requirements for all species needing conservation attention (Caro and O'Doherty 1999), we tend to agree with Schoen (1990, 152) that, "It is highly probable that if we can maintain a region's capability for supporting bears, we will also have achieved the greater goal of maintaining the earth's biodiversity."

SPECIFIC LANDSCAPE CONSERVATION OPPORTUNITIES

The potential for creating an interconnected system of reserves for black bear conservation is very high. A number of active CARL projects will enhance connectivity of Florida black bear populations. The best known of these are the Wekiva River basin and Pinhook Swamp. Although both projects have already resulted in significant habitat protection, neither linkage has been completely protected.

Another linkage of significance is the Etoniah Creek-Camp Blanding landscape linkage between the Osceola-Okefenokee core area and Ocala National Forest. Etoniah Creek CARL Project is the lynchpin, which encompasses 50,000 acres (20,000 ha) between Interlachen and Palatka. In addition, St. Johns River Water Management District has been considering the purchase of land that would connect Etoniah Creek CARL Project to Camp Blanding. To complete the linkage to Osceola National Forest, a span of several miles between Camp Blanding and Raiford Wildlife Management Area (WMA) to the west would need protection. Finally, Raiford WMA is

connected to Osceola National Forest by a private WMA (Lake Butler). To ensure protection of this area, an easement or other incentives might need to be considered. These areas show up on the maps of Cox et al. (1994) as an area of secondary habitat that links Osceola National Forest with Ocala National Forest. This proposed corridor is a large landscape linkage containing a mosaic of flatwoods, pine plantations, forested wetlands, riparian hammocks, scrub, and sandhill of over 200,000 acres (80,000 ha) that already supports a bear population. Indeed, further research may show that these areas support a single population.

There is also an opportunity to protect linkages from Ocala National Forest to southern Duval County and to northern Brevard County. This region represents an expanse of over 1 million acres (400,000 ha) of occupied and potential bear habitat (Cox et al. 1994). However, less than 10% of this area is in public ownership. Therefore, if the linkages between Ocala National Forest and this St. Johns River bear region are to be protected, the best strategy will most likely be to seek conservation easements or agreements with industrial forest companies. Such action needs to occur quickly because of development pressure from Daytona/Ormond Beach and St. Augustine. Based on present land use, it would be feasible to protect 4 larger core areas (approximately 100,000–200,000 acres [40,000–80,000 ha] each) from north to south that could be connected by corridors from 2 to 5 miles (3–8 km) in width and 5 to 10 miles (8–16 km) long, extending from southeastern Duval County to northern Brevard County. Protection of this landscape, which could be connected with corridors as noted above, may also enhance the survival probability of a small population of bears in Tosohatchee State Reserve (Cox et al. 1994). Connectivity between the Ocala population and the large habitat area east of the St. Johns River is dependent on the maintenance of two linkages across the St. Johns, which were both included in the Strategic Habitat Conservation Area recommendation for the Ocala population (Cox et al. 1994).

The panhandle and the Big Bend region provide an opportunity to enhance the Apalachicola population with linkages to other populations. Cox et al. (1994) estimated that the Big Bend supports up to 1.5 million acres (600,000 ha) of potential bear habitat. It also contains a number of state and federal coastal conservation lands that connect with Greater Chassahowitzka Ecosystem. Inland of these

conservation projects is a vast landscape of pine plantations, forested wetlands, and shrub swamps associated with the headwaters of the Aucilla River, San Pedro Bay, Mallory Swamp, the Suwannee River, and Goethe State Forest. Although much of the area is intensively managed, it has very few paved roads and very low human population densities. As is suggested by the apparent growth of the Apalachicola bear population, this entire region could support a large population of bears that is distributed from Apalachicola National Forest to Goethe State Forest. Although it is likely that females will slowly colonize areas to the south, we recommend that the Florida Fish and Wildlife Conservation Commission consider the active establishment of females, as was started in Lower Suwannee National Wildlife Refuge (Wooding 1996). The presence of a radio-collared adult male in Goethe State Forest (D. Maehr, unpublished data) suggests the suitability of the region for black bears.

Goethe State Forest may be the strategic link for restoring connectivity to the small Chassahowitzka population (T. S. Hoctor, University of Florida, unpublished report). The long-term viability of the Chassahowitzka population may depend on such connectivity to a large, stable population. Although much of the land between occupied range in Greater Chassahowitzka Ecosystem and Goethe State Forest is protected, gaps and potential bottlenecks still need protection (i.e., near Homosassa and Crystal rivers, the Crystal River power plant, mouth of the Cross-Florida Barge Canal, and the Withlacoochee River). However, development in this region is rapid, and existing habitat and corridor protection efforts will have to happen in the near future. We also recommend that bear habitat managers consider restoring a bear population in Green Swamp. In a landscape analysis of bear habitat and potential connectivity in the region surrounding the Chassahowitzka core area from the Lower Suwannee River to Ocala National Forest and south to the upper Peace River, Green Swamp contained the largest areas of suitable habitat (T. S. Hoctor, University of Florida, unpublished data). Establishment of a population in Green Swamp, coupled with the protection of key corridors, might create a functional metapopulation in the Chassahowitzka region. A Green Swamp population may also serve as a key node linking the southwest Florida bear population with conspecifics to the north.

The most isolated core population of Florida black bears is in southwest Florida. The re-

establishment of small populations of bears and connectivity in south-central Florida may be augmented by dispersal from this large population. The highest connectivity priority is the linkage between the Big Cypress core population and the Highlands County subpopulation. Completion of the Fisheating Creek basin conservation project (potentially as much as 180,000 acres [73,000 ha] eventually protected primarily through conservation easements, with 60,000 acres [24,000 ha] recently secured) will be an important milestone, but efforts to protect habitat between Big Cypress National Preserve and the Caloosahatchee River are also essential. Successful protection and restoration of phosphate mines in the Peace River basin could provide additional habitat and connectivity for Green Swamp.

Many of these opportunities for landscape linkages have already been identified by University of Florida as part of the Florida Greenways Project, which used a broad, landscape-based approach to identify a statewide Ecological Network (Carr et al. 1998, Hctor et al. 2000). Although all of the above suggestions for establishing functional connectivity between various populations (or metapopulations), or even re-establishing statewide/rangewide connectivity, have real potential, in most cases a more thorough analysis needs to be conducted. This work will continue with the application of a model developed for Greater Chassahowitzka Ecosystem (T. S. Hctor, University of Florida, unpublished data) to a connectivity simulation for Florida's entire bear population.

POPULATION VIABILITY ANALYSIS

Population viability analysis (PVA) can be a useful tool for modeling the effects of demographics, environmental variability, habitat loss, catastrophes, and genetics on the persistence of small populations (Shaffer 1990; Meffe and Carol 1997, 215; Maehr et al., in press *b*). While management decisions should not be based solely on these simulations, PVAs have become virtual prerequisites to planning for listed species.

We used Vortex Version 8.21 (Miller and Lacy 1999) to simulate various future Florida black bear population scenarios with varying degrees of habitat availability, inbreeding depression, and metapopulation interchange. Population estimates for 9 Florida black bear populations (Tables 3–11) were derived from U.S. Fish and Wildlife Service (1998*b*) and Maehr (1997*a*). In the first 3 iterations of the model each population was simulated independently from the other 8. The final variants modeled a rangewide metapopulation with genetic interchange

between adjacent populations. In all variations each model was simulated for 100 years and repeated 100 times. Extinction was defined as no animals in one of either gender. Recolonization of extinct populations was allowed per metapopulation theory. Age of first reproduction was 3 years for females and males, maximum breeding age was 14 years, and the gender ratio at birth was 50:50. All models portrayed breeding as polygynous, with 50% of males in the breeding pool, and 50% of females breeding in any given year. Of those females producing litters, 25% produced 1 cub; 50%, 2 cubs; 20%, 3 cubs; and 5%, 4 cubs. Female mortality was 40% between the ages of 0 and 1 year (SD = 10%), 10% between the ages of 1 and 2 years (SD = 3%), 10% between the ages of 2 and 3 years (SD = 3%), and 5% among adults between the ages 3 and 14 years (SD = 1%). Mortality of males was 40% between the ages of 0 and 1 year (SD = 10%), 10% between the ages of 1 and 2 years (SD = 3%), 20% between the ages of 2 and 3 years (SD = 3%), and 10% among adults

Table 3. The first Alabama black bear population simulation ignored inbreeding depression. The second modeled inbreeding depression with 3.14 lethal equivalents per individual. The third modeled the same inbreeding depression value and added a 5% probability of an annual catastrophe that reduced reproduction by 50% and reduced survival by 10%.

Simulation	Starting Population	Ending Population	Number of Survivors	Probability of Extinction	Growth Rate
1	40	78	100	0.0	0.115
2	40	75	100	0.0	0.095
3	40	75	100	0.0	0.088

Table 4. The first Apalachicola black bear population simulation ignored inbreeding depression. The second modeled inbreeding depression with 3.14 lethal equivalents per individual. The third modeled the same inbreeding depression value and added a 5% probability of an annual catastrophe that reduced reproduction by 50% and reduced survival by 10%.

Simulation	Starting Population	Ending Population	Number of Survivors	Probability of Extinction	Growth Rate
1	400	798	100	0.0	0.116
2	400	798	100	0.0	0.118
3	400	789	100	0.0	0.105

Table 5. The first Big Cypress black bear population simulation ignored inbreeding depression. The second modeled inbreeding depression with 3.14 lethal equivalents per individual. The third modeled the same inbreeding depression value and added a 5% probability of an annual catastrophe that reduced reproduction by 50% and reduced survival by 10%.

Simulation	Starting Population	Ending Population	Number of Survivors	Probability of Extinction	Growth Rate
1	1,000	1,593	100	0.0	0.117
2	1,000	1,593	100	0.0	0.115
3	1,000	1,584	100	0.0	0.107

Table 6. The first Chassahowitzka black bear population simulation ignored inbreeding depression. The second modeled inbreeding depression with 3.14 lethal equivalents per individual. The third modeled the same inbreeding depression value and added a 5% probability of an annual catastrophe that reduced reproduction by 50% and reduced survival by 10%.

Simulation	Starting Population	Ending Population	Number of Survivors	Probability of Extinction	Growth Rate
1	20	25	100	0.02	0.001
2	20	22	100	0.04	0.070
3	20	18	100	0.0	0.063

Table 7. The first Eglin black bear population simulation ignored inbreeding depression. The second modeled inbreeding depression with 3.14 lethal equivalents per individual. The third modeled the same inbreeding depression value and added a 5% probability of an annual catastrophe that reduced reproduction by 50% and reduced survival by 10%.

Simulation	Starting Population	Ending Population	Number of Survivors	Probability of Extinction	Growth Rate
1	80	97	100	0.0	0.114
2	80	95	100	0.0	0.101
3	80	94	100	0.0	0.093

Table 8. The first Green Swamp black bear population simulation ignored inbreeding depression. The second modeled inbreeding depression with 3.14 lethal equivalents per individual. The third modeled the same inbreeding depression value and added a 5% probability of an annual catastrophe that reduced reproduction by 50% and reduced survival by 10%.

Simulation	Starting Population	Ending Population	Number of Survivors	Probability of Extinction	Growth Rate
1	2	44	100	0.54	0.116
2	2	26	100	0.72	0.064
3	2	25	100	0.71	0.052

Table 9. The first Highlands County black bear population simulation ignored inbreeding depression. The second modeled inbreeding depression with 3.14 lethal equivalents per individual. The third modeled the same inbreeding depression value and added a 5% probability of an annual catastrophe that reduced reproduction by 50% and reduced survival by 10%.

Simulation	Starting Population	Ending Population	Number of Survivors	Probability of Extinction	Growth Rate
1	50	86	100	0.0	0.115
2	50	87	100	0.0	0.099
3	50	86	100	0.0	0.089

Table 10. The first Ocala black bear population simulation ignored inbreeding depression. The second modeled inbreeding depression with 3.14 lethal equivalents per individual. The third modeled the same inbreeding depression value and added a 5% probability of an annual catastrophe that reduced reproduction by 50% and reduced survival by 10%.

Simulation	Starting Population	Ending Population	Number of Survivors	Probability of Extinction	Growth Rate
1	400	597	100	0.0	0.117
2	400	595	100	0.0	0.114
3	400	586	100	0.0	0.104

Table 11. The first Osceola black bear population simulation ignored inbreeding depression. The second modeled inbreeding depression with 3.14 lethal equivalents per individual. The third modeled the same inbreeding depression value and added a 5% probability of an annual catastrophe that reduced reproduction by 50% and reduced survival by 10%.

Simulation	Starting Population	Ending Population	Number of Survivors	Probability of Extinction	Growth Rate
1	1,200	1,494	100	0.0	0.118
2	1,200	1,499	100	0.0	0.116
3	1,200	1,480	100	0.0	0.108

between the ages of 3 and 14 years ($SD = 3\%$). Environmental variation in reproduction and mortality was considered concordant. The first of each individual population simulation ignored inbreeding depression, the second modeled inbreeding depression with 3.14 lethal equivalents per individual, and the third modeled the same inbreeding depression value and added a 5% probability of an annual catastrophe that reduced reproduction by 50% and reduced survival by 10%. Beginning populations and carrying capacities for all simulations were Alabama, 40 and 80; Apalachicola, 400 and 800; Big Cypress Swamp, 1,000 and 1,600; Greater Chassahowitzka Ecosystem, 20 and 30; Eglin Air Force Base, 80 and 100; Green Swamp, 2 and

100; Highlands County, 50 and 90; Ocala National Forest, 400 and 600; and Osceola National Forest, 1,200 and 1,500. Environmental variation in carrying capacity was set at 5% of the total population. When habitat loss was simulated for a particular population the rate ranged from 1 to 3% per year for 20 years (Tables 12–14).

All populations that were modeled individually exhibited a high probability of surviving for 100 years, except for the colonizing population of Green Swamp (Tables 3–11). Similarly, most populations, with the exception of Green Swamp and Chassahowitzka, maintained numbers near carrying capacity. In the larger established populations that

Table 12. Effects of metapopulation simulation under different scenarios for the Greater Chassahowitzka Ecosystem black bear population.

Simulation	Final Population	Probability of Survival	No. of Simulations Ending in Extinction	Habitat loss?	Probability of Catastrophe	Inbreeding Depression?
1	25	0.98	2	N	0	Y ^a
2	24	0.98	2	N	2	Y ^a
3	9	0.48	52	Y ^b	0	N
4	8	0.47	53	Y ^b	5	N

^aInbreeding depression was incorporated as 3.14 lethal equivalents per individual, comprised of 1.57 recessive alleles, and 1.57 lethal equivalents not subject to removal by selection.

^bHabitat loss (carrying capacity reduction) was simulated as an annual loss of 2% per year for 20 years in Alabama and Chassahowitzka, 3% per year for 20 years in Ocala, and 1% per year for 20 years Big Cypress Swamp, Highlands County, and Green Swamp.

Table 13. Effects of metapopulation simulation under different scenarios for the Green Swamp colonizing black bear population.

Simulation	Final Population	Probability of Survival	No. of Simulations Ending in Extinction	Habitat loss?	Probability of Catastrophe	Inbreeding Depression?
1	73	0.73	27	N	0	Y ^a
2	66	0.66	34	N	2	Y ^a
3	59	0.74	26	Y ^b	0	N
4	56	0.71	29	Y ^b	5	N

^aInbreeding depression was incorporated as 3.14 lethal equivalents per individual, comprised of 1.57 recessive alleles, and 1.57 lethal equivalents not subject to removal by selection.

^bHabitat loss (carrying capacity reduction) was simulated as an annual loss of 2% per year for 20 years in Alabama and Chassahowitzka, 3% per year for 20 years in Ocala, and 1% per year for 20 years Big Cypress Swamp, Highlands County, and Green Swamp.

Table 14. Effects of metapopulation simulation under different scenarios for the Ocala National Forest black bear population.

Simulation	Final Population	Probability of Survival	No. of Simulations Ending in Extinction	Habitat loss?	Probability of Catastrophe	Inbreeding Depression?
1	591	1.00	0	N	0	Y ^a
2	590	1.00	0	N	2	Y ^a
3	236	1.00	0	Y ^b	0	N
4	237	1.00	0	Y ^b	5	N

^aInbreeding depression was incorporated as 3.14 lethal equivalents per individual, comprised of 1.57 recessive alleles, and 1.57 lethal equivalents not subject to removal by selection.

^bHabitat loss (carrying capacity reduction) was simulated as an annual loss of 2% per year for 20 years in Alabama and Chassahowitzka, 3% per year for 20 years in Ocala, and 1% per year for 20 years Big Cypress Swamp, Highlands County, and Green Swamp.

began with at least 40 animals and had carrying capacities of at least 80, neither inbreeding depression nor the periodic occurrence of reproductive failures and survival declines appeared to affect survival over 100 years. Smaller populations exhibited theoretical problems related to these variables. Statewide, the total population ranged from 4,737 to 4,812 after 100 years (Table 15). Such an increase over current estimates seems possible, given apparent population growth in various portions of Florida black bear range. These results may not be realistic over the long term, given ongoing loss of forest cover in parts of Florida; however, continuing land acquisition and forest recovery in some areas may offset some of these losses.

Metapopulation modeling (Fig. 1) produced similar total population results, but perhaps was more realistic because these simulations incorporated occasional exchange among adjacent populations as is supported by recent dispersal records (Maehr et al. 1988, Wooding et al. 1992), and several included habitat loss, especially in rapidly developing portions of the state. A metapopulation model that allowed interchange and included inbreeding depression, but was otherwise similar to the individual simulations, derived a final population of 4,816 (nearly identical to the sum of individual simulations) (Table 16). Further, the exchange between populations seemed to

maintain population productivity where populations were already low. The addition of periodic reproductive failure and declines in survival produced a statewide population decline of about 1%. Removing inbreeding depression, eliminating periodic reproductive failure, and adding habitat loss resulted in a 15% decline in the statewide population. Returning periodic reproductive failure to the latter model created an additional 1% decline. Thus, the most influential variable in this set of simulations appears to be the trend in habitat availability. No other variable produced more than a 1% change in the final outcome of any model.

Within the metapopulation model, simulated habitat loss in areas where human populations are growing rapidly caused reductions of final population size ranging from 19% in Green Swamp, to 60% in Ocala National Forest, to 74% in Greater Chassahowitzka Ecosystem (Tables 12–14). The importance of metapopulation structure is most apparent for Chassahowitzka, where 7 simulations resulted in recolonization after a mean of 2 years following extinction (3 re-extinctions after a mean of 15 years), and for Green Swamp, where 8 recolonizations occurred after a mean of 1 year following extinction (2 re-extinctions after a mean of

Table 15. Total Florida population based on the sums of independent simulations.

Simulation	Total Population
1 No inbreeding depression; no catastrophes	4,812
2 Inbreeding depression; no catastrophes	4,790
3 Inbreeding depression; probability of annual catastrophe = 0.05	4,737

Table 16. Total Florida population based on metapopulation simulations.

Simulation	Total Population
1 Inbreeding depression; no catastrophe	4,816
2 Inbreeding depression; catastrophe	4,784
3 No inbreeding depression; habitat loss; no catastrophe	4,068
4 No inbreeding depression; habitat loss; catastrophe	4,033

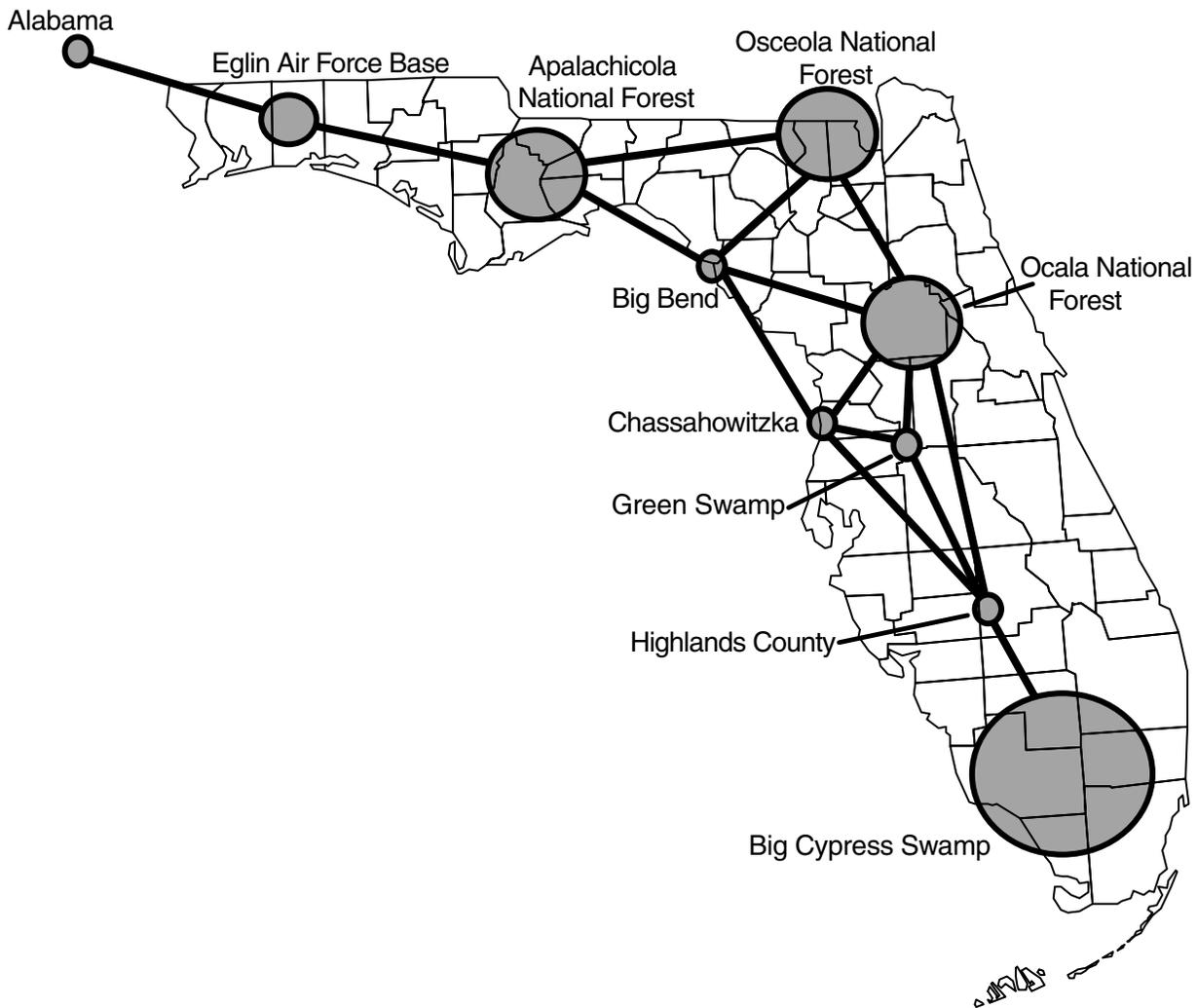


Fig. 1. Hypothetical metapopulation connections between black bear populations in Florida.

5 years). These simulations considered only the potential for natural dispersal to link areas in a metapopulation framework. Other solutions to isolation should also be considered by managers. However, these simulations are based in large measure on theoretical considerations such as the impact of inbreeding on demographics of bear populations. For example, despite clear genetic evidence that the black bear population in Chassahowitzka has been isolated for a considerable time period (M. Cunningham, FWC, personal communication), there has not been a concomitant increase in observed reproductive problems. The basic message in these analyses is that the future for individual bear populations in Florida is not absolutely clear, but that habitat loss should be the

primary concern of managers. Further, whereas genetic problems do not yet appear to be a problem for the Florida black bear, these Vortex simulations may have underestimated rates of habitat loss, or they may have been too optimistic with regard to interchange among populations. If nothing else, these simulations can serve as a baseline to which future simulations can be compared as additional genetic and demographic data are collected, and as better estimates of habitat change are developed. Another model that might be instructive to investigate would be a spatially explicit simulation that links the probability of successful dispersal to landscape structure and predicts habitat loss patterns based on human population growth projections and development pressure within particular regions.

BLACK BEAR HABITAT MANAGEMENT GUIDELINES FOR FLORIDA

Until recently, habitat management for bears was really management by default. No longer is this kind of approach acceptable, however. Instead we must clearly define specific, long-term population goals, and then determine what quantity, quality, and juxtaposition of habitats within the larger landscape mosaic are necessary to meet those goals. (Schoen 1990, 150)

Schoen (1990, 152) concluded a review of the status of worldwide bear habitat management with 5 recommendations:

1. quantitatively define the biological requirements of bears;
2. develop, in cooperation with an informed public, objectives for the management and conservation of bear populations and their habitat;
3. develop models to predict the effects of human activities on bear habitat and populations;
4. develop a clear and objective public education program describing bear habitat requirements and the influence of human activities; and
5. recognize the significant impacts on bear populations throughout the world created by the economic, political, and social pressures of the 5 billion people now inhabiting the earth.

Of course the human population of Earth is now more than 6 billion—which emphasizes that bear management is increasingly the challenge of modifying human demands on nature. In a growth state like Florida, this challenge is more acute than in most parts of the black bear's fragmented range. The literature review upon which the following guidelines are based is firmly anchored in empirical studies of black bear behavior and demographics, as well as literature on landscape ecology. Thus, our efforts have addressed only two of the recommendations listed above: defining biological requirements and developing predictive models. Certainly, a strong biological foundation for an agency's management philosophy is a critical component of successful black bear conservation, but human sociological issues will ultimately determine the fate of black bears and the management programs intended to perpetuate them. Perhaps this literature review and the accompanying

recommendations can serve as a starting point for an effective program that not only addresses black bear habitat needs, but also addresses the task of communicating this information to the public and developing a strong base of support for statewide management of the species. Nonetheless, several issues emerge as important considerations for managers of the Florida black bear.

Common themes that run through the reports, studies, papers, monographs, theses, and books examined in this review include the following.

1. Black bears are negatively impacted by roads.
2. Black bears require diverse habitats that are sufficiently large to satisfy seasonally changing food requirements.
3. Black bears in Florida utilize many habitats that are evolutionarily adapted to fire.
4. Fire frequency impacts the fruiting phenology and fruiting abundance of many bear food plants, including both hard and soft mast.
5. Fire season is an important determinant of subsequent flowering and fruiting performance of several important bear food plants and successional patterns of black bear habitat.
6. Improperly placed and timed fires can cause mortality to black bear cubs.
7. Saw palmetto is the most important plant to black bears in Florida.
8. Traditional silvicultural methods such as clearcutting can temporarily increase soft mast production, but intensively managed pine plantations and standard site preparation techniques eliminate cover for denning and escape, and reduce the abundance of mast-producing plants and invertebrate food resources.
9. Old-growth forest characteristics tend to offer black bears the most secure habitat conditions, especially with regard to den sites.
10. Black bears prefer tree cavities as den sites, but are capable of successful overwintering and cub-rearing if ground dens are located in dense, well-drained vegetation and are not disturbed.
11. Habitat loss is a generally accepted

- aspect of black bear distribution in Florida; however, some areas appear to be experiencing population growth.
12. Exotic plants appear to have minimal impact on black bear ecology in Florida.
 13. Some exotic wildlife species are occasionally eaten by black bears, but only the coyote has the potential to compete with the black bear for food.
 14. Legal harvest and poaching of black bears has the potential to reduce population numbers and constrict inhabited range.
 15. Some populations may still be recovering from legal bear hunting seasons.
 16. Large, interconnected forest systems are the most important landscape features that explain the presence of black bear populations.
 17. The black bear is a landscape species that requires regional planning and management to effectively conserve populations.
 18. Dispersing animals are critical to maintaining the genetic variability of naturally diverse, evolutionarily adaptable black bear populations.
 19. The dispersal capabilities of the black bear may be sufficient to link all of Florida's subpopulations as a single, interacting metapopulation.
 20. Connectivity between populations can best be maintained or enhanced by protecting wide swaths (or landscape linkages) of low-intensity, multiple-use landscapes between subpopulations. Although smaller subpopulations such as Chassahowitzka, Highlands County, northeast Florida, and southwest Alabama will be harder to conserve, especially if habitat loss continues, opportunities to maintain or restore connectivity to larger populations are still possible.
 21. Black bears are an important component of Florida's native landscapes. Therefore, efforts to maintain small populations may benefit both bear conservation and ecological integrity.
 22. Population viability analyses suggest that most of Florida's bear populations are relatively secure for the next 100 years, but that interconnectivity among subpopulations enhances survival probabilities.
 23. Black bears will use highway underpasses designed to reduce traffic-related injury and mortality, but such wildlife crossings are not completely practical for the species.
 24. Harvest-free sanctuaries appear to be useful tools in maintaining core bear populations that provide the reproduction needed to maintain regional populations.
 25. Forest patches that are at least 10,000 ha seem to be minimal units of occupied black bear range.
 26. All Florida black bear populations have at least a significant portion of their habitat in private ownership. In addition, all opportunities for connectivity between populations are largely dependent on private lands. Since black bear habitat requirements can be compatible with private land management, conservation easements and agreements are a viable, cost-effective option.
 27. The Florida black bear is a flagship species for the conservation of Florida's native landscapes and natural heritage. In this context all populations should be considered important.

SPECIFIC BLACK BEAR HABITAT MANAGEMENT GUIDELINES FOR FLORIDA

1. Because forest patch size seems to be the best predictor of black bear occupation, efforts should be made to maintain forest conditions for Florida's largest bear populations, and to increase available forest cover in the smaller, more marginal populations. Forest patches of 10,000 ha, especially if close to large occupied habitat, appear to be a rule of thumb as a minimal occupied unit. Large forest patches are better capable of withstanding harvest (legal or otherwise), fragmentation, unpredictable food availability, mast failures, and human disturbance.

2. The Florida black bear should be managed as a metapopulation. This requires that the landscape matrix between populations is managed to encourage natural interchange among subpopulations. Corridors and landscape linkages that possess characteristics of occupied home ranges (diverse forest cover, abundant food resources, dense understories for denning and escape) should be protected or restored.

3. Managers should consider extending the time between prescribed fires in occupied bear range. Short fire rotations (2–3 years) in upland sites may be insufficient to allow important mast-producing species to recover peak fruiting performance (flowering does not equal fruiting). Specifically in habitats where saw palmetto—the most universally important plant in the range of the Florida black bear—is a dominant food, and where it is a featured management target, fire rotations should likely not be more frequent than 10 years. Ecosystem approaches to management on public lands may dictate prescribed fire regimes that are not always optimal for bears (i.e., some public lands include timber harvesting as a primary objective, and others are very close to urban areas). In these cases, a multiple use module (MUM) approach could be applied to create natural, heterogeneous landscapes that also provide high-quality habitat nodes, such as old-growth forest for high-quality den sites, and altered fire regimes to provide dense stands of infrequently burned saw palmetto for food and cover.

4. Palmetto fruit harvesting on public land should be completely prohibited or severely limited in occupied bear range. On the other hand, because of its economic significance, saw palmetto fruit harvesting could be used as an incentive to private landowners to maintain natural conditions that favor the black bear.

5. Prescribed fires in occupied black bear range should be avoided during the winter denning period. Summer, lightning-season fires would not only reduce the potential for causing cub mortality, but would encourage fruit production in many plant species that evolved under a regime of periodic rainy season burns.

6. Forest management in occupied black bear range, or in forests targeted for restoring bear populations, should encourage dense understory vegetation and important mast-producing plants. Intensive site-preparation generally reduces the value of an area to black bears; however, small clearcuts in a larger forest matrix may encourage production of soft mast. Clearcuts larger than 250 m in diameter may discourage bear use even if productive food supplies occur there.

7. Roads are universally detrimental to black bear populations. Wherever possible, logging roads should

not only be closed to human access, but reclaimed after timber harvest. Black bear managers should encourage regional developers and highway planners to avoid new roads through black bear habitat. As a general guideline, road densities in bear habitat should preferably be below 1 mile per square mile (0.6 km/km²).

8. Construction of new highways or intensification of existing highways within bear habitat should be avoided, especially in large blocks of habitat currently without major roads. Road projects planned in bear habitat should require very significant road-crossing and habitat mitigation. Where roads must be built through occupied black bear range, or through potential corridors and landscape linkages, pavement should be elevated to allow for unrestricted travel. Underpasses, because of their equivocal utility to black bears should be used only when other impact-mitigating measures cannot be taken.

9. Managers of black bear populations should encourage forest managers to promote old-growth characteristics in occupied black bear range in Florida. Hollow logs, cavities in large trees, and downed timber provide important winter dens for pregnant females. Such sites are usually more protected from severe flooding and from human disturbance.

10. Because of the species' inherent rarity and slow reproductive rate, hunting can easily reduce black bear densities and cause range constrictions. This fact has led to effective nuisance management in western states, and likely explains the increasing population in north Florida national forests. If hunting seasons for the Florida black bear are reconsidered, regulations should be sufficiently conservative to maintain core populations and allow continued dispersal for maintaining the statewide metapopulation.

11. Managers should develop a bear sanctuary philosophy where important core areas are managed to enhance reproduction and production of dispersing animals that link adjacent populations. Buffer zones would support multiple uses and greater human activity than would be permitted in core or sanctuary areas. Such a strategy is in keeping with black bear social structure, their response to human activity, and the principles of landscape ecology.

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- Archibald, W. R., R. Ellis, and A. N. Hamilton. 1987. Responses of grizzly bears to logging truck traffic in the Kimsquit River Valley, British Columbia. *International Conference on Bear Research and Management* 7:251–257.
The impact of truck traffic was studied using sound levels recorded along transects

- perpendicular to a logging road which bisected the home range of 2 radio-collared adult female grizzly bears. Both females were alienated from the zone of hauling activity for 14 hours per day. This area encompassed 3–23% of their home ranges. Both females returned to the zone of hauling activity when logging truck traffic was absent. The authors believe that if a survival cost is associated with avoiding the active hauling zone, grizzly bears will move into the zone and become habituated to the disturbance.
- Arimond, S. R. 1979. Fruit production in black bear *Ursus americanus* habitat of northeastern Minnesota. Thesis, University of Minnesota, Duluth, Minnesota, USA.
Low-density stands (<800 trees/ha) showed significantly more total fruit production (blueberry, raspberry, and cherry) than high-density stands (1,000–2,100 trees/ha). Wild sasparrilla was more productive in high-density stands, while hazelnut production showed no significant relationship to tree density. Stands with low tree-density constitute a critical component of favorable black bear habitat in Minnesota. Manipulation of tree density to less than 800 trees per hectare creates potentially favorable bear habitat. However, managing for fruit production satisfies only one critical habitat requirement.
- Bakeless, J. E. 1961. The eyes of discovery: the pageant of North America as seen by the first explorers. Dover Publications, New York, New York, USA.
- Bangs, O. 1898. The land mammals of peninsular Florida and the coast region of Georgia. Proceedings of the Boston Society of Natural History 28:157–235.
- Bartram, J. 1766. Diary of a journey through the Carolinas, Georgia, and Florida. In F. Harper, editor and annotator. Transactions of the American Philosophical Society Volume 33, Part 1. American Philosophical Society, Philadelphia, Pennsylvania, USA.
- Beck, D. E. 1977. Twelve-year acorn yield in southern Appalachian oaks. U.S. Department of Agriculture Forest Service Research Note SE-244:1-8.
- Beck, T. D. I. 1991. Black bears of west-central Colorado. Technical Publication No. 39. Colorado Division of Wildlife, Fort Collins, Colorado, USA.
Past hunting pressure created long-lasting demographic effects on this population. Human-caused mortality was the leading cause of death. Mast failures resulted in reduced cub production the following spring.
- Beckwith, S. L. 1957. Purple squirrels. Florida Wildlife 11(5):18–20.
Beckwith suggested that acorns preferred by wildlife in Florida are of the wide oak group including live oak and bluejack oak.
- Beecham, J. J. 1983. Population characteristics of black bears in west central Idaho. Journal of Wildlife Management 47:405–412.
- Beecham, J. J., D. G. Reynolds, and M. G. Hornocker. 1983. Black bear denning activities and den characteristics in west-central Idaho. International Conference on Bear Research and Management 5:79–86.
Den entry and emergence varied among bears and years, and the denning season extended from mid-October through mid-April. Forty-seven of 65 dens were ground dens excavated into a hillside or under the base of a tree, stump, or shrub. Thirteen of 65 dens were located in the base of hollow trees and 5 were in hollow logs or rock cavities. Bears denned at various elevations, slopes, and aspects, and under a variety of canopies. Four instances of den reuse were observed. Concealment was important for bears denning at mid- to low elevations. Protection from exposure to inclement conditions appeared important. In areas where soil conditions are not suitable for excavation, black bears may depend on old-growth timber stands for denning sites.
- Beecham, J. J., and J. Rohlman. 1994. A shadow in the forest: Idaho's black bear. University of Idaho Press, Moscow, Idaho, USA.
This book summarizes the results of the Idaho Department of Fish and Game's biological data collected for the development of a comprehensive management program for black bears in 6 geographically separate populations. Timber was the most frequently used

habitat on the Council study area. Priest Lake bears preferred more diverse habitats created by selection-cut logging and wildfires, with timber areas being second in preference. Bears avoided clearcuts and roads. The authors recommended that forest managers use logging techniques that minimize soil disturbance. Hunting pressure can affect population age structures, with adult males particularly vulnerable. Habitat quality and quantity were important factors controlling population size because they influenced bear reproduction. Forty-five of 56 dens were ground dens dug into a hillside or under the base of a tree, stump, or fallen tree, and 11 were tree dens. Tree dens were found at higher elevations than ground dens, possibly because preferred tree species were found at higher elevations. Dens at lower elevations were located within dense vegetation. Most bears preferred secure areas for denning.

- Beeman, L. E. 1975. Population characteristics, movements and activities of the black bear (*Ursus americanus*) in the Great Smoky Mountains National Park. Dissertation, University of Tennessee, Knoxville, Tennessee, USA.
- Beier, P. 1995. Dispersal of juvenile cougars in fragmented habitat. *Journal of Wildlife Management* 59:228–237.
This study in southern California found that cougars in a small population were willing to use explicit, low-quality corridors to get to larger habitat blocks. Guidelines include minimizing nighttime lighting, which seem to negatively affect the ability of cougars to move through potential low-quality corridors.
- Beier, P. 1996. Metapopulation models, tenacious tracking, and cougar conservation. Pages 293–323 in D. R. McCullough, editor. *Metapopulations and wildlife conservation*. Island Press, Washington, D.C., USA.
Beier presents an integrated account of all the research on a small cougar population in southern California. The study demonstrated the importance of habitat connectivity for maintaining small populations of cougars in the region. It also outlines the difficulties of maintaining corridors in the face of intense development pressure, and the importance of assuming that connectivity is significant for maintaining populations.
- Beier, P., and R. F. Noss. 1998. Do habitat corridors provide connectivity? *Conservation Biology* 12:1241–1252.
Beier and Noss review much of the literature on experiments to test whether habitat corridors facilitate movement of focal species. They argue that small-scale experiments with experimental nontarget organisms are not very relevant to conservation decisions. Well-designed, observation-based studies can be very useful to demonstrate the importance of corridors for connectivity. Real, natural landscapes tend to be connected, therefore a connectivity approach is the opposite of fragmentation and should be considered desirable unless proven otherwise.
- Bennitt, R., J. S. Dixon, V. H. Cahalane, W. W. Chase, and W. L. McAtee. 1937. Statement of policy. *Journal of Wildlife Management* 1:1–2.
- Beringer, J. J., S. G. Seibert, and M. R. Pelton. 1990. Incidence of road crossing by black bears on Pisgah National Forest, North Carolina. *International Conference on Bear Research and Management* 8:85–92.
This study related the number of times bears crossed roads to the road density within their home range and to the traffic volume associated with the roads. Bears strongly avoided roads with traffic volumes of 10,000+ vehicles per day, and avoided the roads more as road density within home ranges increased. Bears crossed roads with high traffic volumes significantly less often than they crossed roads with traffic volumes less than 100 vehicles per day. Bears crossed roads more frequently during daylight hours than at night. Management implications include the following: high traffic volumes impede bear movements; accessibility that roads provide to hunters may be detrimental to bear populations; impact on the local bear population should be considered before constructing new roads in bear habitat; unused roads should be closed permanently to reduce hunter access and illegal hunting; other roads should be gated and locked.

- Beringer, J., S. G. Seibert, S. Reagan, A. J. Brody, M. R. Pelton, and L. D. Vangilder. 1998. The influence of a small sanctuary on survival rates of black bears in North Carolina. *Journal of Wildlife Management* 62:727–734.
Hunting-free areas appear to be effective in protecting adult female black bears and promoting reproduction that is need to repopulate adjacent areas where bear hunting occurs. Males that dispersed from sanctuary natal ranges were usually killed. Threats to females using sanctuaries are primarily related to logging and road construction.
- Bookhout, T. A. 1994. Research and management techniques for wildlife and habitats. Wildlife Society, Bethesda, Maryland, USA.
- Brady, J. R. 1985. Black bear habitat studies. Annual Performance Report. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida, USA.
Two years of intensive trapping in Osceola National Forest produced 6 captures of black bears. Although forest management did not appear to reduce food availability, there was no speculation about the role of hunting on this population. “Big Gum Swamp, a large forested wetland dominated by swamp tupelo (*Nyssa biflora*) was a common feature in 5 of 6 home ranges. The swamp provided escape cover during the hunting season for 5 bears, fall food for 4 bears and winter den cover for 2 bears. Bears not using Big Gum Swamp at these times utilized similar areas nearby.”
- Brady, J. R., and D. S. Maehr. 1985. Distribution of black bears in Florida. *Florida Field Naturalist* 13:1–7.
The black bear exhibits a patchy distribution in Florida, but is still found in 50 of 67 counties. The species was once widespread throughout the state, and even occurred in the Florida Keys.
- Brenner, M., M. W. Binford, and E. S. Deevey. 1990. Lakes. Pages 364–391 *in* R. L. Myers and J. J. Ewel, editors. *Ecosystems of Florida*. University of Central Florida Press, Orlando, Florida, USA.
- Brody, A. J. 1984. Habitat use by black bears in relation to forest management in Pisgah National Forest, North Carolina. Thesis, University of Tennessee, Knoxville, Tennessee, USA.
- Brody, A. J., and M. R. Pelton. 1989. Effects of roads on black bear movements in western North Carolina. *Wildlife Society Bulletin* 17:5–10.
Bears avoided crossing interstate highways and crossed smaller roads with low traffic volumes more frequently than smaller roads with higher traffic volumes. Bears may react to increases in road densities by shifting the locations of their home ranges to areas of lower road densities.
- Brody, A. J., and J. N. Stone. 1987. Timber harvest and black bear population dynamics in a southern Appalachian forest. *International Conference on Bear Research and Management* 7:243–250.
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- Brown, R. B., E. L. Stone, and V. W. Carlisle. 1990. Soils. Pages 35–69 *in* R. L. Myers and J. J. Ewel, editors. *Ecosystems of Florida*. University of Central Florida Press, Orlando, Florida, USA.
- Bunnell, F. L., and D. E. N. Tait. 1981. Population dynamics of bears—implications. Pages 75–98 *in* C. W. Fowler and T. D. Smith, editors. *Dynamics of large mammal populations*. John Wiley and Sons, New York, New York, USA.
- Bunnell, F. L., and D. E. N. Tait. 1985. Mortality rates of North American bears. *Arctic* 38:316–323.
- Burton, T., D. Koch, D. Updike, and A. Brody. 1994. Evaluation of the potential effects of sport hunting on California black bears. *International Conference on Bear Research and Management* 9:231–235.
Hunting mortality appears to have little negative impact, and hunting mortality is believed to be compensatory in California, where harvest removes about 8% of the population annually.
- Butler, D. R. 1995. *Zoogeomorphology: animals as geomorphic agents*. Cambridge University Press, New York, New York, USA.
- Cahalane, V. H. 1948. The status of mammals in the U.S. national park system. *Journal of Mammalogy* 29:247–259.

- Campbell, R. A., and C. A. Howard. 1993. Priorities for forestry herbicide application technology research. *Canadian Journal of Forestry Research* 23:2204–2212.
- Carlock, D. M., R. H. Conley, J. M. Collins, P. E. Hale, K. G. Johnson, A. S. Johnson, and M. R. Pelton. 1983. The tri-state black bear study. Technical Report No. 83-9. Tennessee Wildlife Resources Agency. Knoxville, Tennessee, USA. This was a cooperative project between Tennessee, Georgia, and North Carolina to characterize black bear populations and habitats in the tri-state study region. Management recommendations include the following: regionwide surveys should be established, maintained, standardized, and coordinated; continue and expand the sanctuary system; establish a consistent, stable, and conservative road policy on national forest lands; establish a late hunting season to better protect females; enhance communications between wildlife agencies and hunters; conduct tree den surveys; and enhance tree den availability and hard and soft mast production.
- Caro, T. M., and G. O'Doherty. 1999. On the use of surrogate species in conservation biology. *Conservation Biology* 13:805–814. A broad review of the use of indicator or focal species to do conservation planning. The authors recommend that such strategies be used conservatively since no umbrella, indicator, or focal species will match up perfectly with the habitat requirements of other species of conservation interest.
- Carr, A. 1983. Armadillo dilemma. *Animal Kingdom* 85(5):40–43. Carr suggested that armadillos were destroying the leaf-layer fauna of Florida's forests and that predation may help reduce such impacts.
- Carr, M., P. Zwick, T. Hootor, W. Harrell, A. Goethals, and M. Benedict. 1998. Using GIS for identifying the interface between ecological greenways and roadway systems at the state and sub-state scales. Pages 68–77 *in* G. Evink, P. Garrett, D. Ziegler, and J. Berry, editors. Proceedings of the international conference on wildlife ecology and transportation. Florida Department of Transportation, Tallahassee, Florida, USA.
- Carr, P. C. 1983. Habitat utilization and seasonal movements of black bears in the Great Smoky Mountains National Park. Thesis. University of Tennessee, Knoxville, Tennessee, USA.
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- Clark, J. D., J. E. Dunn, and K. G. Smith. 1993. A multivariate model of female black bear habitat use for a geographic information system. *Journal of Wildlife Management* 57:519–526. Female black bears used areas within 240 m of roads and >600 m from streams less than expected in the Ozark Mountains of Arkansas.
- Clevenger, A. P. 1986. Habitat and space utilization of black bears in Cherokee National Forest, Tennessee. Thesis, University of Tennessee, Knoxville, Tennessee, USA. Bears used habitat in a fashion typical of the southern Appalachians. Increases in male home ranges were attributed to hunting activities in the national forest. Illegal hunting of this population is exacerbated by easy access into the forest. A nearby sanctuary appeared beneficial to the local bear population.
- Clewell, A. F. 1971. The vegetation of the Apalachicola National Forest: an ecological perspective. Contract 38-2249. U.S. Department of Agriculture Forest Service, Atlanta, Georgia, USA.
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- Cox, J., R. Kautz, M. MacLaughlin, and T. Gilbert. 1994. Closing the gaps in Florida's wildlife habitat conservation system. Florida Game and

- Fresh Water Fish Commission, Tallahassee, Florida, USA.
- Craighead, F. C. 1971. *The trees of south Florida*. University of Miami Press, Coral Gables, Florida, USA.
- Croker, T. 1979. The longleaf pine story. *Journal of Forest History* 23:32–43.
- Davis, J. H. 1943. The natural features of southern Florida, especially the vegetation and the Everglades. *Geological Bulletin* 25. Florida Department of Conservation, Florida Geological Survey, Tallahassee, Florida, USA.
- Davis, J. H. 1967. General map of natural vegetation of Florida. *Institute of Food and Agricultural Science Circular S-178*. University of Florida, Gainesville, Florida, USA.
- De Pourtales, L. F. 1877. Hints on the origin of the flora and fauna of the Florida Keys. *American Naturalist* 11:137–144.
- Dideriksen, R. I., A. R. Hidlebaugh, and K. O. Schmude. 1977. Potential cropland study. *Station Bulletin* 578. U.S Department of Agriculture Soil Conservation Service. Washington, D.C., USA.
- Dobson, A., K. Ralls, M. Foster, M. E. Soule, D. Simberloff, D. Doak, J. A. Estes, L. S. Mills, D. Mattson, R. Dirzo, H. Arita, S. Ryan, E. A. Norse, R. F. Noss, and D. Johns. 1999. Corridors: reconnecting fragmented landscapes. Pages 129–170 *in* M. E. Soule and J. Terborgh, editors. *Continental conservation: scientific foundations of regional reserve networks*. Island Press, Washington, D.C., USA.
This book chapter contains a review of and recommendations for the use of corridors and other approaches for facilitating connectivity in reserve systems.
- Doren, R. F., and D. T. Jones. 1997. Plant management in Everglades National Park. Pages 275–286 *in* D. Simberloff, D. C. Schmitz, and T. C. Brown, editors. *Strangers in paradise*. Island Press, Covelo, California, USA.
- DowElanco. 1992. Tordon 101 mixture. Specimen label. DowElanco, Indianapolis, Indiana, USA.
- DowElanco. 1993. Garlon 3A herbicide. Specimen label. DowElanco, Indianapolis, Indiana, USA.
- Duever, M. J., J. E. Carlson, J. F. Meeder, L. C. Duever, L. H. Gunderson, L. A. Riopelle, T. R. Alexander, R. L. Myers, and D. P. Spangler. 1986. *The Big Cypress National Preserve*. Research Report Number 8. National Audubon Society, New York, New York, USA.
- DuPont de Nemours and Co. 1992. Krenite S brush control agent. Specimen label. E.I. DuPont de Nemours and Co., Wilmington, Delaware, USA.
- DuPont de Nemours and Co. 1995. Velpar herbicide. Specimen label. E.I. DuPont de Nemours and Co., Wilmington, Delaware, USA.
- Dusi, J. L., D. T. King, and L. K. Malo. 1987. Ecology of the black bear in southwest Alabama. Final Report, Project W-44. Alabama Department of Conservation and Natural Resources, Alabama Agricultural Experiment Station, and U.S. Department of Interior, Washington, D.C., USA.
- Dusi, J. L., and D. T. King. 1990. The black bear in southwestern Alabama. *Journal of the Alabama Academy of Science* 61:41–49.
Study objectives were to determine the feasibility of delineating ecological characteristics of a low density black bear population. Three areas were looked at: black bear movement ecology in Alabama, black bear population density and distribution, and optimal black bear habitat requirements. The study determined that titi swamps were the most critical habitat. Management suggestions included protection of remaining choice habitat; exclusion of bears from areas where they are causing damage (bee yards, gardens, field crops); removal of the cause of the trouble rather than the nuisance bear; and production of an intensive educational program about bears and other wildlife.
- East, B. 1977. *Bears*. Crown Publishers, New York, New York, USA.
- Edmiston, J. E. 1963. *The ecology of the Florida pine flatwoods*. Dissertation, University of Florida, Gainesville, Florida, USA.

- Eiler, J. H. 1981. Reproductive biology of black bears in the Smoky Mountains of Tennessee. Thesis, University of Tennessee, Knoxville, Tennessee, USA.
- Eisenberg, J. F. 1981. The mammalian radiations: an analysis of trends in evolution, adaptation, and behavior. University of Chicago Press, Chicago, Illinois, USA.
- Elowe, K. D. 1987. Factors affecting black bear reproductive success and cub survival in Massachusetts. Dissertation, University of Massachusetts, Amherst, Massachusetts, USA.
- Elowe, K. D., and W. E. Dodge. 1989. Factors affecting black bear reproductive success and cub survival. *Journal of Wildlife Management* 53:962–968.
- Errington, P. L., and F. N. Hamerstrom Jr. 1937. The evaluation of nesting losses and juvenile mortality of the ring-necked pheasant. *Journal of Wildlife Management* 1:3–20.
- Eubanks, A. L. 1976. Movements and activities of the black bear (*Ursus americanus*) in the Great Smoky Mountains National Park. Thesis, University of Tennessee, Knoxville, Tennessee, USA.
- Ewel, J. J., D. S. Ojima, D. A. Karl, and W. F. DeBusk. 1982. Schinus in successional ecosystems of Everglades National Park. Report T-676. National Park Service, Homestead, Florida, USA.
- Ewel, K. C. 1990. Swamps. Pages 281–323 in R. L. Myers and J. J. Ewel, editors. *Ecosystems of Florida*. University of Central Florida Press, Orlando, Florida, USA.
- Fair, J. S. 1977. Unusual dispersal of black bear cubs in Utah. *Journal of Wildlife Management* 42:642–644.
A late freeze and summer drought are thought to have caused a mast failure and subsequent widespread abandonment of black bear cubs in eastern Utah.
- Forman, R. T. T. 1987. The ethics of isolation, the spread of disturbance, and landscape ecology. Pages 213–229 in M. G. Turner, editor. *Landscape heterogeneity and disturbance*. Springer-Verlag, New York, New York, USA.
- The author outlines some of the significant emerging principles of landscape ecology. He also recommends adoption of the ethics of isolation in land use and conservation planning: “Simply stated, in land use decisions and actions, it is unethical to evaluate an area in isolation from its surrounding or from its development over time. Ethics impel us to consider an area in its broadest spatial and temporal perspectives.”
- Forman, R. T. T. 1995. *Land mosaics: the ecology of landscapes and regions*. Cambridge University Press, Cambridge, U.K.
This book is a broad review of the principles of landscape ecology and the relevant literature. It is an excellent source for the principles undergirding the importance of connectivity and landscape-level approaches to conservation.
- Foster, M. L. 1992. Effectiveness of wildlife crossings in reducing animal/auto collisions on Interstate 75, Big Cypress Swamp, Florida. Thesis, University of Florida, Gainesville, Florida, USA.
In addition to radio telemetry on 26 bobcats, Foster monitored 4 wildlife crossings with infrared game counters and cameras for periods of 2–16 months. Certain species seem to favor using certain crossings and different species used the crossings at different times of day. Most species exhibited seasonal peaks in the frequencies of crossings. The level and frequency of use of a crossing varied according to the location and configuration of home ranges and movement patterns and density of individuals in the area. Most successful applications of wildlife underpasses have identified wildlife trails and placed crossing structures in or near these traditional paths. The underpass should provide animals with an unobstructed view of the habitat or horizon on the far side of the underpass. Medians should be open rather than covered.
- Franklin, I. R. 1980. Evolutionary changes in small populations. Pages 135–149 in M. E. Soule and B. A. Wilcox, editors. *Conservation biology: an evolutionary-ecological perspective*. Sinauer Associates, Sunderland, Massachusetts, USA.

- Freedman, B., R. Morash, and D. MacKinnon. 1993. Short-term changes in vegetation after the silvicultural spraying of glyphosate herbicide onto regenerating clearcuts in Nova Scotia, Canada. *Canadian Journal of Forestry Research* 23:2300–2311.
- Fuller, T. K., and L. B. Keith. 1980. Summer ranges, cover-type use, and denning of black bears near Fort McMurray, Alberta. *Canadian Field Naturalist* 94:80–83.
Adult females without cubs occupied average areas of 7.5 km². Dens were excavated on level ground in stands of mixed aspen and birch, which were likely excavated in previous years. All females denned on or near the periphery of the ranges they occupied during the summer. The proportion of bears excavating dens is correlated with decreasing winter temperatures and the need for increased insulation.
- Frye, E. O., B. Piper, and L. Piper. 1950. The black bear...saint or sinner? *Florida Wildlife* 4(6):6–7, 28.
- Garris, S. 1983. Habitat utilization and movement ecology of black bears in Cherokee National Forest. Thesis, University of Tennessee, Knoxville, Tennessee, USA.
- Garshelis, D. L. 1978. Movement ecology and activity behavior of black bears in the Great Smoky Mountains National Park. Thesis, University of Tennessee, Knoxville, Tennessee, USA.
- Garshelis, D. L., and M. R. Pelton. 1981. Movements of black bears in the Great Smoky Mountain National Park. *Journal of Wildlife Management* 45:912–925.
- Gholz, H. L., D. N. Guerin, and W. P. Cropper. 1999. Phenology and productivity of saw palmetto (*Serenoa repens*) in a north Florida slash pine plantation. *Canadian Journal of Forest Research* 29:1248–1253.
Although saw palmetto flowers readily after being burned, fruiting does not occur successfully for some time after a fire. The authors suggest that longer than standard fire rotations are appropriate when saw palmetto fruit production is a feature of black bear habitat management in Florida.
- Giles, R. H., Jr. 1971. *Wildlife management techniques*. Third edition, revised. Wildlife Society, Washington, D.C., USA.
- Gilliam, F. S., and W. J. Platt. 1999. Effects of long-term fire exclusion on tree species composition and stand structure in an old-growth *Pinus palustris* (longleaf pine) forest. *Plant Ecology* 140:15–26.
- Glenn, L. P., J. W. Lentfer, J. B. Faro, and L. H. Miller. 1976. Reproductive biology of female brown bears, *Ursus arctos*, McNeil River, Alaska. Pages 381–390 in M. R. Pelton, J. W. Lentfer, and G. E. Folk, editors. *Bears—their biology and management*. International Union for the Conservation of Nature and Natural Resources, New Series 40.
- Glitzenstein, J. S., W. J. Platt, and D. R. Strong. 1995. Effects of fire regime and habitat on tree dynamics in north Florida longleaf pine savannas. *Ecological Monographs* 65:441–476.
- Grenfell, W. E., and A. J. Brody. 1983. Seasonal foods of black bears in Tahoe National Forest, California. *California Fish and Game* 69:132–150.
- Grenfell, W. E., and A. J. Brody. 1986. Black bear habitat use in Tahoe National Forest, California. *International Conference on Bear Research and Management* 6:65–72.
- Gunther, K. A. 1990. Visitor impact on grizzly bear activity in Pelican Valley, Yellowstone National Park. *International Conference on Bear Research and Management* 8:73–78.
Gunther used visual observations to determine if human recreational activity affected grizzly bear use of open meadow areas. When the valley was open to visitors, bear activity in areas greater than 500 m from forest cover was significantly reduced and bears avoided areas around occupied back-country campsites. No differences in diurnal hourly activity patterns were observed among open, restricted, and closed periods. Foot parties were more likely to be charged by a grizzly than people on horseback. All incidences in which hikers were charged by bears involved groups of one or two people. Restricting public use during peak grizzly activity time-periods prevents human-caused displacement of bears from productive open habitats, as well as allows

recreational use and limits opportunities for bear/human encounters. Subadults and females with cubs of the year are more day-active and therefore more vulnerable to disturbance by recreational activity.

Hall, E. R., and K. R. Kelson. 1959. The mammals of North America. Volume II. Ronald Press, New York, New York, USA.

Hamilton, R. J. 1981. Effects of prescribed fire on black bear populations in southern forests. Pages 129–134 *in* G. W. Wood, editor. Prescribed fire and wildlife in southern forests. Belle W. Baruch Forest Science Institute of Clemson University, Georgetown, South Carolina, USA.

Hamilton recognized the value of fire in promoting soft mast production, but cautioned that some areas, particularly denning habitat, should be free from fire during sensitive seasons, such as winter when females den.

Hamilton, R. J., and R. L. Marchinton. 1980. Denning and related activities of black bears in the coastal plain of North Carolina. *International Conference on Bear Research and Management* 4:121–126.

The authors determined that black bear activities in southeastern North Carolina decreased progressively through autumn. Den types included ground nests in dense vegetation and one hollow bald cypress tree. Average denning period was 102 days. Postdenning movements gradually increased, peaking during breeding season. Authors noted that few suitable den trees were available.

Hamilton, W. J., Jr. 1941. Notes on some mammals of Lee County, Florida. *American Midland Naturalist* 25:686–691.

Hamilton suggested that overhunting eliminated the black bear from this area of west central Florida.

Handley, C. O., Jr. 1979. Mammals of the Dismal Swamp: a historical account. Pages 298–357 *in* P. W. Kirk, editor. *The Great Dismal Swamp*. University Press of Virginia, Charlottesville, Virginia, USA.

Harlow, R. F. 1959. Tomoka Wildlife Management Area. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida, USA.

Harlow, R. F. 1961. Characteristics and status of Florida black bear. *Transactions of the North American Wildlife Conference* 26:481–495.

Harlow, R. F. 1962*a*. Facts about Florida black bear. *Florida Wildlife* 15:12–17.

Harper, F. 1927. Mammals of Okefinokee (sic) Swamp. *Proceedings of the Boston Society of Natural History* 38:191–396.

Harper, R. M. 1914. Geography and vegetation of northern Florida. *Florida Geological Survey Annual Report* 6:163–451.

Harris, L. D. 1980. Forest and wildlife dynamics in the Southeast. *Transactions of the North American Wildlife and Natural Resources Conference* 45:307–322.

High regional human population growth and increased agriculture and rangeland are exerting severe pressure on southeastern forest lands. There is a trend of annual loss of forest acreage with the remaining forest being managed more intensively. Loss of former within-stand habitat diversity must be compensated for by between-stand heterogeneity. Planning for wildlife should be an integral part of current reforestation decisions if forests of the future are to be of maximum value to wildlife. Attention should be focused on the role of forest habitats during winter months, when resident wildlife remain more active than northern counterparts and migrants become abundant. Management should focus on time-space interactions in order to ensure habitat quality throughout the year.

Harris, L. D. 1984. *The fragmented forest*. University of Chicago Press, Chicago, Illinois, USA.

This classic work was one of the first to point out the dangers of increasing artificial patchiness in North America's forests. Wide-ranging forest species, such as bears and panthers, are especially vulnerable to these influences. Among other recommendations, the author stresses the need to manage forests in a mosaic that maintains old-growth conditions for interior-sensitive wildlife.

Harris, L. D. 1989. The faunal significance of fragmentation of southeastern bottomland

- forests. Pages 126–134 *in* D. D. Hook and R. Lea, editors. Proceedings of the symposium: the forested wetlands of the southern United States. General Technical Report SE-50. U.S. Department of Agriculture Forest Service, Southeastern Forest Experiment Station, Asheville, North Carolina, USA.
- Harris, L. D., and P. Gallagher. 1989. New initiatives for wildlife conservation, the need for movement corridors. Pages 11–36 *in* G. Mackintosh, editor. *In defense of wildlife: preserving communities and corridors*. Defenders of Wildlife, Washington, D.C., USA.
- Harris, L. D., and J. G. Gosselink. 1990. Cumulative impacts of bottomland hardwood forest conversion on hydrology, water quality, and terrestrial wildlife. Pages 259–322 *in* J. G. Gosselink, L. C. Lee, and T. A. Muir, editors. *Ecological processes and cumulative impacts: illustrated by bottomland hardwood wetland ecosystems*. Lewis Publishers, Chelsea, Michigan, USA.
- Forest loss at local sites may have only a moderate impact on the natural services of bottomland hardwood ecosystems. The cumulative impact of small conversion actions may be significant and include less-frequent flooding during normal weather conditions and higher downstream stages with increasingly unstable streams during severe floods. As watersheds are cleared, erosion increases and streamwater quality decreases. Bottomland hardwood forest loss is first felt by individual species, which suffer abnormalities in reproduction, range restriction, and loss of genetic heterogeneity. Black bears will frequently be among the first that are lost. As the cumulative stress level increases and the whole ecosystem is modified, trophic webs become simplified, biotic community composition and structure are modified, and native species are lost due to invasion by exotic species, parasites, and diseases. The ecosystem collapses and is transformed, with resulting extinctions of native species and depletion of migrant bird populations.
- Harris, L. D., and T. S. Hoctor. 1992. Biological Issues. *In* The cross-Florida greenway report. Volume 4. Florida Department of Natural Resources, Tallahassee, Florida, USA.
- Harris, L. D., T. Hoctor, D. S. Maehr, and J. Sanderson. 1996. The role of networks and corridors in enhancing the value and protection of parks and equivalent areas. Pages 173–197 *in* R. G. Wright, editor. *National parks and protected areas*. Blackwell Science, Cambridge, Massachusetts, USA.
- The authors suggest that the traditional park paradigm for conserving biodiversity is insufficient, particularly from the perspective of wide-ranging wildlife species and long-term ecosystem change. A landscape approach must be embraced that allows not only movement of individuals and populations over space and time, but that allows entire biotic communities to shift with changing climatic conditions.
- Harris, L. D., and P. Kangas. 1988. Reconsideration of the habitat concept. *Transactions of the North American Wildlife and Natural Resources Conference* 53:137–144.
- Harris, L. D., and J. Scheck. 1991. From implications to applications: the dispersal corridor approach to the conservation of biological diversity. Pages 189–220 *in* D. A. Saunders and R. J. Hobbs, editors. *Nature conservation 2: the role of corridors*. Surrey Beatty and Sons, Chipping Norton, New South Wales, Australia.
- This book chapter reviews and explores the application of the corridor concept to the conservation of biological diversity. There are examples of corridors being used in wildlife conservation across the globe and even early in the twentieth century and before. Applications range from using small linear features such as hedgerows to maintain some forest species in predominantly agricultural landscapes, to protecting riparian forests to maintain connectivity in timber plantations, to broader corridors and landscape linkages facilitating regional connectivity.
- Harris, L. D., and G. Silva-Lopez. 1992. Forest fragmentation and the conservation of biological diversity. Pages 197–237 *in* P. Fielder and S. Jain, editors. *Conservation biology: the theory and practice of nature conservation*. Chapman and Hall, New York, New York, USA.
- Harris, L. D., L. D. White, J. E. Johnston, and D. G. Milchunas. 1974. Impact of forest plantations

on north Florida wildlife and habitat. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 28:659–667.

Bird and small mammal abundance and diversity were much greater in mature longleaf pine forests than in nine-year-old slash pine and other mature natural stands. Low-intensity preparation of sites generally resulted in greater numbers of birds and small mammals than the high-intensity plots. In general, high-intensity silvicultural practices reduce biodiversity in Florida pine forests.

Harrison, R. L. 1992. Toward a theory of inter-refuge corridor design. Conservation Biology 6:293–295.

The author argues that corridors may be most effective when they can incorporate habitat that will support individuals of the target species and assesses how wide corridors might need to be to incorporate home ranges of selected large carnivores.

Hatler, D. F. 1967. Some aspects in the ecology of the black bear (*Ursus americanus*) in interior Alaska. Thesis, University of Alaska, Fairbanks, Alaska, USA.

Hellgren, E. C. 1988. Ecology and physiology of a black bear population in the Great Dismal Swamp and reproductive physiology in the captive female black bear. Dissertation, Virginia Polytechnic Institution and State University, Blacksburg, Virginia, USA.

Hellgren, E. C., and D. S. Maehr. 1992. Habitat fragmentation and black bears in the eastern United States. Proceedings of the Eastern Black Bear Workshop on Management and Research 11:154–165.

Habitat fragmentation impacts several biological factors, including reductions in distribution, habitat population size, potential effects on genetic diversity, demographics, range dynamics, and dispersal. Internal habitat fragmentation by roads is of particular interest to managers of hunted black bear populations. Low-density populations and slow rates of population growth increase the susceptibility of bears to local extinctions by making them more vulnerable to stochastic demographic or genetic effects or

environmental variation. However, black bears have considerable dispersal abilities, are ecological generalists, do not have highly fluctuating populations, are long-lived, and can exploit modified habitats, which partially mitigates the effects of habitat fragmentation. The dispersal abilities of bears can naturally overcome most geographic barriers to periodically augment many fragmented populations. Fragmented bear populations may become vulnerable to changes in habitat productivity due to climate change. If habitat conditions change, then population dynamics can change. Population models need to include habitat projections if they are to be applicable. Management of human access and activity is paramount for bear populations in fragmented and fissured landscapes.

Hellgren, E. C., and M. R. Vaughn. 1988. Seasonal food habits of black bears in Great Dismal Swamp, Virginia-North Carolina. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 42:295–305.

Hellgren, E. C., and M. R. Vaughan. 1989. Denning ecology of black bears in a southeastern wetland. Journal of Wildlife Management 53:347–353.

Den types included 14 ground nests, 11 excavated ground cavities, 2 ground-level tree cavities, 1 above-ground-level tree cavity, and 1 stump den. Tree den availability was not estimated, although 25% of the study area appeared to contain potential tree dens. Denning was 11–48 days shorter on average than in other regions with mild winter climates. The authors concluded that large den trees may not be necessary for successful denning and reproduction in certain southeastern wetlands because bears can use dense cover and microelevational factors to overwinter. Flooding and human disturbance may be stronger forces affecting den site selection than energetics in regions that have very mild winter climates. Timber harvest probably would decrease the number of available tree dens, but may not seriously affect overall den availability. Hollow trees with diameters >1 m should be left standing. Also, denning chronology of adult females with newborn cubs should be

- considered before winter burns are planned. Den availability is not a problem in southeastern wetlands if bears are provided with habitat patches large enough to offer seclusion from human disturbance.
- Heyward, F. 1939. The relation of fire to stand composition of longleaf pine forests. *Ecology* 20:287–304.
- Hillman, L. L., and D. L. Yow. 1986. Timber management for black bear. *Eastern Workshop on Black Bear Management and Research* 8:125–134.
The authors suggested that black bears need freedom from constant human access, diversity, hard mast, soft mast and forage, dens, and key areas. They suggested that black bears should be relatively easy to incorporate into forest management plans because the species has such generalized habitat requirements and adapts well to varying habitat conditions. They also suggested that connectivity, with “travelways,” was important among forest patches.
- Hilmon, J. B. 1969. Autecology of saw palmetto (*Serenoa repens* (Batr.) Small). Dissertation, Duke University, Durham, North Carolina, USA.
In this examination of methods to control saw palmetto, Hilmon discovered that this extremely important black bear food plant does not recover its fruiting potential until 6–9 years after a fire. Given the generally short fire rotation prescription on many upland forests in Florida, saw palmetto fruit production may be artificially reduced throughout the state.
- Hocctor, T. S., M. H. Carr, and P. D. Zwick. 2000. Identifying a linked reserve system using a regional landscape approach: the Florida ecological network. *Conservation Biology* 14:984–1000.
- Hofstetter, R. H. 1984. The effect of fire on the pineland and sawgrass communities of southern Florida. Pages 465–476 in P. J. Gleason, editor. *Environments of south Florida: present and past II*. Miami Geological Society, Coral Gables, Florida, USA.
- Horner, M. A., and R. A. Powell. 1990. Internal structure of home ranges of black bears and analyses of home-range overlap. *Journal of Mammalogy* 71:402–410.
Female black bears appear tolerant of neighboring adult females and exhibit extensive overlap of habitat in space and time. Home range and habitat analyses must examine more than just the boundaries of use areas in order to understand the dynamics of black bear spatial distribution.
- Hough, W. A. 1965. Palmetto and gallberry regrowth following a winter prescribed burn. *Georgia Forest Resources Council Paper* 31.
Winter fires appear to have a negative influence on the production of important black bear food plants.
- Howell, A. H. 1929. Florida’s mammals. *Nature Magazine* 13:338–340, 378–379.
- Hughes, R. H., and F. E. Knox. 1964. Response of gallberry to seasonal burning. U.S. Department of Agriculture Forest Service Research Note SE-21.
- Hunter, M. L. 1990. *Wildlife, forests, and forestry*. Prentice Hall, Englewood Cliffs, New Jersey, USA.
- Irwin, L. L., and F. M. Hammond. 1985. Managing black bear habitats for food items in Wyoming. *Wildlife Society Bulletin* 13:477–483.
Fruit production in this area of multiple use can be encouraged in a mosaic of successional stages with the use of <10-ha clearcuts and cutting or burning of aspen. Fire suppression and livestock grazing have created food availability problems by altering successional patterns.
- Ivey, R. D. 1959. The mammals of Palm Valley, Florida. *Journal of Mammalogy* 40:585–591.
- Jaap, W. C., and P. Hallock. 1990. Coral reefs. Pages 574–618 in R. L. Myers and J. J. Ewel, editors. *Ecosystems of Florida*. University of Central Florida Press, Orlando, Florida, USA.
- Johnson, A. F., and M. G. Barbour. 1990. Dunes and maritime forests. Pages 429–480 in R. L. Myers and J. J. Ewel, editors. *Ecosystems of Florida*. University of Central Florida Press, Orlando, Florida, USA.

- Johnson, K. G., D. O. Johnson, and M. R. Pelton. 1978. Simulation of winter heat loss for a black bear in a closed tree den. Proceedings of the Eastern Workshop on Black Bear Management and Research 4:155–166.
- Johnson, K. G., and M. R. Pelton. 1979. Denning behavior of black bears in the Great Smoky Mountains National Park. Proceedings of the Southeastern Association of Fish and Wildlife Agencies 33:239–249.
- Jonkel, C. J., and I. M. Cowan. 1971. The black bear in the spruce-fir forest. Wildlife Monographs 27:1–55.
The *Picea-Abies/Pachistima* association was important during all seasons. Clearcut logged areas were avoided. Home ranges were very small compared to those in other regions. Bears den 1.5 months longer than in other regions due to severe winters. Territorial behavior is strongly indicated. Cub survival was high from 0.5 to 1.5 years of age, but the young then rapidly disappear from the population through death and dispersal.
- Kasworm, W. F., and T. L. Manley. 1990. Road and trail influences on grizzly bears and black bears in northwest Montana. International Conference on Bear Research and Management 8:79–84.
The study examined 3 grizzly bears and 26 black bears to determine the effects of roads and trails on seasonal habitat use patterns. Grizzly bears avoided habitat within 914 m of open roads and black bears avoided habitat within 274 m of open roads. Trails displaced both species less than open roads; road closures are suggested as a tool for bear habitat management. Grizzly bear avoidance of high-quality habitat near roads and trails may lessen the opportunity for individuals to obtain food and increase intraspecific competition by further forcing bears into limited remote habitat. Black bear tolerance of disturbance may provide an opportunity for black bears to exploit habitat in the relative absence of grizzly bears.
- Kautz, R. S. 1984. Criteria for evaluating impacts of development on wildlife habitats. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 38:121–136.
- Factors that influence biotic diversity on a site include habitat type, successional stage, habitat island size, presence or absence of connecting corridors, edge effects, interspersed habitat types, and presence of snags and fallen logs.
- Kautz, R. S. 1993. Trends in Florida wildlife habitat, 1936–1987. Florida Scientist 56(1):7–24.
- Kellyhouse, D. G. 1977. Habitat utilization by black bears in northern California. International Conference on Bear Research and Management 4:221–227.
- Kemp, G. A. 1976. The dynamics and regulation of black bear *Ursus americanus* populations in northern Alberta. International Conference on Bear Research and Management 3:191–197.
- Kendall, K. C. 1983. Use of pine nuts by black and grizzly bears in the Yellowstone area. International Conference on Bear Research and Management 5:166–173.
Spring use of pine nuts appeared to be correlated with cone production in the preceding year, while fall use was correlated with the current crop. Most of the nuts eaten by bears came from cones cached by red squirrels. Pine nuts were a nutritious food which was often present in early spring and late fall, when alternate foods were scarce or low in digestible energy and when nutritional requirements of bears were high.
- Klenner, W. 1987. Seasonal movements and home range utilization patterns of the black bear, *Ursus americanus*, in western Manitoba. Canadian Field-Naturalist. 101:558–568.
Subadult males had greater home range (506.4 km²) than subadult (35.2 km²) or adult females (29.1 km²). Males used larger seasonal ranges than females and showed much greater variability in utilization patterns. Adult and subadult females showed up to 100% overlap of their home range, indicating that the overlap was both spatial and temporal. Movements in agricultural zones were restricted primarily to wooded areas, ravines, and shelter belts. High mortality and population rates were observed. Klenner recommends a program of preventative measures aimed at protecting apiaries and livestock, along with selective

- removal of problem animals for management and control of depredations by bears in agriculture-forest ecotones, rather than removing or destroying animals at the site of damage. "The removal of resident animals will likely be offset by the recruitment of animals through reproduction by remaining residents and the immigration of bears from adjacent areas."
- Knight, H. A., and J. P. McClure. 1971. Florida's timber, 1970. U.S. Department of Agriculture Forest Service, Southeastern Forest Experiment Station Research Bulletin 20.
- Kolenosky, G. B. 1986. Effects of hunting on an Ontario black bear population. *International Conference on Bear Research and Management* 6:45–55.
Hunting reduced population size and lowered the mean age of captured males. Delayed maturation in Ontario black bears and increased vulnerability of females with increased hunting pressure suggest the need for conservative harvest strategies.
- Kolenosky, G. G. 1990. Reproductive biology of black bears in east-central Ontario. *International Conference on Bear Research and Management* 8:385–392.
- Kolenosky, G. B., and S. M. Strathearn. 1987. Winter denning of black bears in east-central Ontario. *International Conference on Bear Research and Management* 7:305–316.
The authors examined 110 dens of black bears in east-central Ontario. Den entrance order was yearlings, pregnant females, solitary females, females with cubs, adult males, and subadults of both sexes. Eighty-nine percent of dens were excavations below ground-level and 84% occurred on well-drained upland sites. Suitable tree dens were scarce in the study area. Smaller dens were energetically more efficient than larger dens. Most dens were only large enough to accommodate the occupants. Den location may be related to social status of the individual. Young bears exhibited greater alertness and abandoned dens more frequently. There was no indication of den reuse. Bears that fed on acorns denned later than those that did not. Males emerged from dens first, females with cubs emerged from dens last. The study recommended closing spring bear hunt season earlier to protect females with cubs.
- Komarek, E. V., Sr. 1964. The natural history of lightning. Pages 139–183 in *Proceedings of the third annual Tall Timbers fire ecology conference*. Tall Timbers Research, Tallahassee, Florida, USA.
- Komarek, E. V. 1981. History of prescribed fire and controlled burning in wildlife management in the South. Pages 1–14 in G. W. Wood, editor *Prescribed fire and wildlife in southern forests*. Belle W. Baruch Forest Science Institute of Clemson University, Georgetown, South Carolina, USA.
This keynote address stressed the historical role of humans in southeastern United States fire ecology, and suggested that private conservation/research institutions such as Tall Timbers need to be more involved in management of native landscapes.
- Kushlan, J. A. 1990. Freshwater marshes. Pages 324–363 in R. L. Myers and J. J. Ewel, editors. *Ecosystems of Florida*. University of Central Florida Press, Orlando, Florida, USA.
- Land, E. D. 1994. Southwest Florida black bear habitat use, distribution, movements, and conservation strategy. Final Report. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida, USA.
Habitat use and activity data from 60 radio-instrumented black bears were analyzed. Cabbage palm fruit, Brazilian pepper fruit, ants, and aquatic emergent vegetation were important bear foods in southwest Florida. Average litter size was 1.8. Average annual home range sizes were 57 km² for adult females and 303 km² for adult males. Poaching and roadkills were responsible for 80% of all mortalities.
- Lande, R. 1995. Mutation and conservation. *Conservation Biology* 9:782–791.
This paper suggests that a population will often have to be much bigger (approximately an order of magnitude larger) than Franklin's (1980) recommendation of an effective population of 500 to maintain genetic diversity and evolutionary potential.
- Landers, J. L., R. J. Hamilton, A. S. Johnson, and R. L. Marchinton. 1979. Foods and habitat of black

- bears in southeastern North Carolina. *Journal of Wildlife Management* 43:143–153.
- Langdon, O. G. 1981. Some effects of prescribed fire on understory vegetation in loblolly pine stands. Pages 143–153 *in* G. W. Wood, editor. Prescribed fire and wildlife in southern forests. Belle W. Baruch Forest Science Institute of Clemson University, Georgetown, South Carolina, USA.
Frequent fires in southeastern United States pine forests can create conditions that bears avoid. Higher stem densities of important bear plant foods and escape cover are encouraged when burning frequency is reduced.
- Lautenschlager, R. G. 1993. Response of wildlife to forest herbicide applications in northern coniferous ecosystems. *Canadian Journal of Forestry Research* 23:2286–2299.
- Layne, J. N. 1974. The land mammals of south Florida. Pages 386–413 *in* P. J. Gleason, editor. Environments of south Florida: present and past. Memoir 2. Miami Geological Society. Miami, Florida, USA.
- Layne, J. N. 1997. Nonindigenous mammals. Pages 157–186 *in* D. Simberloff, D. C. Schmitz, and T. C. Brown, editors. Strangers in paradise. Island Press, Covelo, California, USA.
Some exotics species, such as wild hogs and armadillos, are considered ecological pests in Florida. However, they provide bears with regularly consumed food items.
- Layne, J. N., J. A. Stallcup, G. E. Woolfenden, M. N. McCauley, and D. J. Worley. 1977. Fish and wildlife inventory of the seven-county region included in the central Florida phosphate industry areawide environmental impact study. Volume II. Archbold Biological Station, Lake Placid, Florida, USA.
The black bear was an uncommon resident in this area at the time of this document's preparation.
- LeCount, A. L. 1980. Some aspects of black bear ecology in the Arizona chaparral. *International Conference on Bear Research and Management* 4:175–179.
Minimum population density was estimated to be 1 bear per 2 km². Subadult male home ranges averaged 42 km², adult male home ranges averaged 29 km², adult female home ranges averaged 18 km², and subadult female home ranges averaged 13 km². Home ranges overlapped considerably among adult males. Entry into dens occurred from 1 November through 15 November. Emergence from dens occurred from 15 March through 15 April.
- LeCount, A. L. 1982. Characteristics of a central Arizona black bear population. *Journal of Wildlife Management* 46:861–868.
- Lentz, W. M., R. L. Marchinton, and D. M. Carlock. 1980. Black bear habitat in north Georgia: some implications of wilderness designation. *Proceedings of the Annual Conference of Southeastern Fish and Wildlife Agencies* 34:550–556.
Upland hardwoods away from roads were preferred, especially by denning females. The authors support the idea of bear sanctuaries as refugia from sport hunting, but note that wilderness designation may eliminate some opportunities for active habitat management.
- Levins, R. 1970. Extinction. Pages 77–107 *in* M. Gerstenhaber, editor. Some mathematical questions in biology. Lectures on mathematics in the life sciences, Volume 2. American Mathematical Society, Providence, Rhode Island, USA.
- Lewis, J. B. 1928. Wild life of the Dismal Swamp. *Game and Fish Conservationist* 8(November-December):95–98.
- Lindzey, F. G., K. R. Barber, R. D. Peters, and E. C. Meslow. 1986. Responses of a black bear population to a changing environment. *International Conference on Bear Research and Management* 6:57–63.
Varying levels of food abundance caused by normal succession in the vegetative communities of clear-cut areas caused changes to the local bear population. Changes in black bear population size corresponded to changes in food resources. Variations in levels of production, cub survival, recruitment, dispersal of progeny and adults, and conspecific aggression within the population facilitated both growth and decline. Poor nutrition led to termination of pregnancy or the death of

cubs shortly after birth as well as loss of entire litters after leaving the den. Adults (male and female) emigrated from the island. The authors expected the bear population to continue to decline until the island was logged again, providing greater food resources.

- Lindzey, F. G., and E. C. Meslow. 1976. Characteristics of black bear dens on Long Island. *Northwest Science* 50:36–42.
- Lindzey, F. G., and E. C. Meslow. 1977. Home range and habitat use by black bears in southwestern Washington. *Journal of Wildlife Management* 41:413–425.
Average home range for adult males was 505 ha and for adult females was 235 ha—smaller than home range estimates for bears in other regions of the United States. Richness of habitat presumably allowed the smaller home ranges. Home ranges did not appear to be physically confined by the size of the island. Population density did not affect home range size. Home ranges of sex and age groups overlapped with use of shared areas apparently determined by a social hierarchy. Bears apparently selected areas logged since 1963 over areas logged before 1935. This may be due to availability of soft mast, as fruit-producing shrubs were 7 to 8 times more abundant in recently logged areas. The relationship between bears and clearcuts, based principally on food availability, should be recognized in the formulation of timber management programs that include clearcutting and in the formulation of management plans for the black bear.
- Livingston, R. J. 1990. Inshore marine habitats. Pages 549–573 in R. L. Myers and J. J. Ewel, editors. *Ecosystems of Florida*. University of Central Florida Press, Orlando, Florida, USA.
- Lombardo, C. A. 1993. The population ecology of black bears on Camp LeJeune, North Carolina. Thesis, University of Tennessee, Knoxville, Tennessee, USA.
- Loope, L. L., and N. H. Urban. 1980. A survey of fire history and impact in tropical hardwood hammocks in the east Everglades and adjacent portions of Everglades National Park. Report T-592. National Park Service, Homestead, Florida, USA.
- Burning in subtropical hammocks severely reduces plant diversity. However, diversity increases with hammock recovery and maturation of a period of several decades. The exotic species melaleuca and Brazilian pepper are encouraged by fire.
- Lotz, M. A., E. D. Land, and K. G. Johnson. 1997. Evaluation and use of precast wildlife crossings by Florida wildlife. *Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies* 51:311–318.
Bear use of wildlife underpasses was much lower (order of magnitude) than that exhibited by the Florida panther, when, in fact, it should have been an order of magnitude higher, given the relative difference in population densities.
- Lyon, L. J. 1983. Road density models describing habitat effectiveness for elk. *Journal of Forestry* 81:592–595.
- Mack, J. A. 1990. Black bear dens in the Beartooth Face, south-central Montana. *International Conference on Bear Research and Management* 8:273–277.
Dens ($n = 33$) were located on steep slopes at high elevations. Most dens were associated with rock structures. Excavated dens made up 71% of the total. Most bears entered dens between 8 October and 15 October. Twenty percent of radio-collared bears abandoned den sites and relocated to new dens during the two years of study. Security of dens appeared to be important.
- Maehr, D. S. 1984a. The black bear as a seed disperser in Florida. *Florida Field Naturalist* 12:40–42.
The black bear in Florida, as elsewhere in its range, provides an important ecosystem function as a seed scarifier and disseminator. Germination of cabbage palm seeds, red bay seeds, and Brazilian pepper seeds were documented. Black bears may distribute more seeds farther than do other mammals because of larger scat volume and potentially extensive daily movements.
- Maehr, D. S. 1984b. Distribution of black bears in eastern North America. *Eastern Workshop on Black Bear Management and Research* 7:74.
The original distribution of the black bear in eastern North America was continuous

and extensive throughout all forested landscapes. Today, the range of the species is very patchy and reflects human development throughout this part of the continent. The map of the modern distribution of black bears in eastern North America was based on a survey of black bear biologists and other qualified persons. Black bears have been extirpated from approximately half of their historic range in the east. The isolation of once-interacting black bear populations may have significant negative impacts on the species. The area of greatest concern appears to be all of the southeastern United States.

Maehr, D. S. 1990. The Florida panther and private lands. *Conservation Biology* 4:167–170.

Maehr, D. S. 1994. Sustainable development and black bears. *Eastern Workshop on Black Bear Management and Research* 12:144–147.

Eastern states exhibit a variety of population objectives for the black bear: increase, stability, and decrease. This summary of this workshop discussion raised several questions that need to be addressed in eastern North America. 1) What is a viable population? 2) Is there an area threshold below which black bears disappear? 3) How does habitat quality influence population viability and area requirements? 4) What level of human activity is compatible with bears? 5) How do preserve design and corridors influence bear sustainability? 6) What do we need to know about genetics to properly manage bears? 7) How does poaching affect bear sustainability?

Maehr, D. S. 1996. The comparative ecology of bobcat, black bear and Florida panther in south Florida. Dissertation, University of Florida, Gainesville, Florida, USA.

Similar to Maehr (1997a), but includes an appendix that compares black bear mass growth in south Florida with a Mexican bear population at similar latitude. Florida black bears tended to grow faster and reach adult size sooner than conspecifics in Mexico. This is likely due to warmer temperatures, more soil moisture, and a longer growing season in Florida. Such conditions may enhance potential productivity of the bear population.

Maehr, D. S. 1997a. The comparative ecology of bobcat, black bear, and Florida panther in south Florida. *Bulletin of the Florida Museum of Natural History* 40:1–176.

Dietary comparisons indicated low overlap among black bear, bobcat, and Florida panther. Coyotes exhibited a food resource overlap of 0.38 with panthers, 0.43 with black bears, and 0.64 with bobcats. Such high levels of dietary overlap may have negative consequences on large native carnivores. Seasonally changing habitat requirements that compel extensive movements make bears vulnerable to changes in outlying portions of their range. Restricted nutritional opportunities caused by coyote competition may reduce overall bear numbers, but not to the point where black bear persistence will be in jeopardy. Conservation of these species involves the management of landscapes. If meeting the needs of one landscape-level species satisfies the need of the others, then conservation dollars can be more efficiently distributed. Large preserve size is, in and of itself, insufficient for the conservation of large carnivores. Successful conservation of large carnivores depends on lands that are not owned by the public. Corridors between large preserves are used when they are available. Large carnivores use corridors for seasonal movements, dispersal, and protection from anthropogenic disturbances. Planning for wide-ranging species must go beyond the traditional approach of static-boundary nature preserves.

Maehr, D. S. 1997b. The Florida panther: life and death of a vanishing carnivore. Island Press, Covelo, California, USA.

Maehr mentions the black bear as the largest cavity nester in Florida.

Maehr, D. S., and J. R. Brady. 1982a. Fall food habits of black bears in Baker and Columbia counties, Florida. *Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies* 36:565–570.

The authors examined the stomachs of 36 hunter-harvested black bears. Saw palmetto was the most important item in the diet. Other important foods included black gum, gallberry, yellow jackets, and armadillo. Findings support the claim that

black bears in Florida require a mixture of habitats for their survival. The practice of winter burning may have artificially increased the importance of saw palmetto to bears. The effects of burning on black bear foods and food preferences should be investigated further to outline procedures for restoring bear habitats to their apparent historic productivity. A diverse autumn food supply in Osceola National Forest would reduce the possible deleterious impacts of a saw palmetto mast failure. Substantial differences in food habits between Baker and Columbia counties and Ocala National Forest were noted. The authors suggested the initiation of food habits studies throughout Florida to pinpoint habitats essential to the production of preferred or heavily utilized food sources. This information would allow important food-producing habitats to be acquired or otherwise protected and managed to benefit local black bear populations.

Maehr, D. S., and Brady, J. R. 1982*b*. Florida black bear-beekeeper conflict: 1981 beekeeper survey. *American Bee Journal* 122:372–375.

Annual losses from black bear depredations on apiaries were estimated at \$100,000. The majority of the state experienced a peak in bear depredations in May; south Florida did not experience an annual peak. Electric fences were the preferred method of protection. The cost of an electric fence and regular maintenance is much less than the losses sustained by an unprotected apiary. Electric fences should be required in bear habitat before responses to nuisance complaints are made by Florida Fish and Wildlife Conservation Commission personnel. Differing seasonal rates of depredation should indicate when special attention should be given to apiary protection (March–July in central and north Florida, year-round in south Florida). Brochures should be created to disseminate information to Florida beekeepers.

Maehr, D. S., and J. R. Brady. 1984*a*. Food habits of Florida black bears. *Journal of Wildlife Management* 48:230–235.

The dominance of plant foods in the diets of black bears in Florida is consistent with

studies from other locations. The food items appearing most often and in the greatest volume and frequencies were seasonally available fruits and colonial insects. Because many of the habitats used by bears in Florida produce food throughout the year, substantial shifts in habitat use were not apparent. The use of plants by bears in Florida changes from mostly herbaceous matter in spring to soft mast in summer and hard mast during fall. Spring foods were dominated by cabbage palm hearts, early growths of alligator flag, and saw palmetto hearts. Summer foods were dominated by blueberries, berries of inkberry holly, raspberries, and saw palmetto fruit. Insects provided most of the nonvegetable protein in the summer diet. Fall food dominance varied by region and reflected locally abundant hard mast sources. Diverse habitats are required to satisfy bear diets. The substantial and regional differences in diet appear to be a function of habitat variation and food availability. Mast production must be considered in management of Florida black bears. Forest management practices such as conversion of mast-producing flatwoods and hardwood communities to slash pine plantations and winter burning to control the understory growth may reduce the availability of mast and other foods important to bears.

Maehr, D. S., and J. R. Brady. 1984*b*. Comparison of food habits in two north Florida black bear populations. *Florida Scientist* 47:171–175.

This study indicated a less diverse habitat in Osceola National Forest than in Apalachicola National Forest. Although saw palmetto was the most important food item in Osceola, it was insignificant in Apalachicola diets. A palmetto mast failure would have minimal impacts on Apalachicola bears because of the availability of fall foods such as odorless bayberry, but could cause an energetic hardship on bears in Osceola.

Maehr, D. S., and J. T. DeFazio. 1985. Foods of black bears in Florida. *Florida Field Naturalist* 13:8–12.

The authors present a comprehensive list of foods eaten by black bears in Florida. The use of distinctly different foods from a

variety of plant and animal taxa emphasizes the extremely opportunistic and omnivorous habits of black bears. Less common or unpreferred foods may serve as replacements during years of mast failures or otherwise low food availability. It may be the presence of less commonly eaten foods that distinguishes occupied bear habitat from other apparently suitable forest land. The majority of food items are native plants and animals. However, several introduced species, including Brazilian pepper and honey bees, appear to be important foods.

- Maehr, D. S., T. S. Hoctor, and L. D. Harris. In press *a*. Using the Florida panther as a flagship in regional ecological restoration. *In* D. S. Maehr, R. F. Noss, and J. L. Larkin, editors. Large animal restoration challenges for the 21st century. Island Press, Washington, D.C., USA.
Large, wide-ranging carnivores are valuable from a conservation standpoint, not only because they are popular with the public, but because they provide keystone ecological services and drive evolutionary processes.
- Maehr, D. S., R. C. Lacy, E. D. Land, O. L. Bass, and T. S. Hoctor. In press *b*. A reassessment of Florida panther population viability analysis and recovery efforts from multiple perspectives. *In* S. R. Beissinger and D. R. McCullough, editors. Population viability analysis. University of Chicago Press, Chicago, Illinois, USA.
Even small populations, such as those of the Florida panther, may have good survival probabilities for 100 years without measurable consequences of inbreeding. This suggests that small populations of the Florida black bear, such as the one inhabiting Greater Chassahowitzka Ecosystem, may have a reasonable probability for persisting in its remnant forests. Establishing or maintaining demographic linkages within a metapopulation framework increases survival prospects for small populations.
- Maehr, D. S., E. D. Land, and J. C. Roof. 1993. Southwest Florida black bear habitat use, distribution, movements, and conservation strategy. Annual Report. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida, USA.
This study of the southernmost black bear

population in eastern North America confirmed the species as an obligate forest animal that used even mangrove swamps for denning and other activities.

- Maehr, D. S., and J. N. Layne. 1996*a*. Saw palmetto. *Gulfshore Life* 26(7):38–41, 56–58.
Saw palmetto is likely a keystone species in Florida by providing food and cover to hundreds of species ranging from insects to black bears. This raises the question of potential impacts on the black bear of palmetto harvest by humans.
- Maehr, D. S., and J. N. Layne. 1996*b*. The saw palmetto: Florida's all-purpose plant. *The Palmetto* 16(4):6–10, 15, 21.
This is an expansion of Maehr and Layne (1996*a*).
- Maehr, D. S., J. N. Layne, E. D. Land, J. W. McCown, and J. C. Roof. 1988. Long distance movements of a Florida black bear. *Florida Field Naturalist* 16:1–6.
- Maehr, D. S., R. T. McBride, and J. J. Mullahey. 1996. Status of coyotes in south Florida. *Florida Field Naturalist* 24:101–107.
An expanding coyote population throughout Florida may have negative impacts on native fauna, such as black bears, because of overlapping habitat and food requirements.
- Maehr, D. S., and J. B. Wooding. 1992. Florida black bear. Pages 265–275 *in* S. R. Humphrey, editor. Rare and endangered biota of Florida. Volume 1: mammals. University Press of Florida, Gainesville, Florida, USA.
The authors present a summary of existing literature to this date.
- Maffei, M. D. 1997. Management in national wildlife refuges. Pages 267–273 *in* D. Simberloff, D. C. Schmitz, and T. C. Brown, editors. Strangers in paradise. Island Press, Covelo, California, USA.
- Manville, A. M. 1983. Human impact on the black bear population in Michigan's Lower Peninsula. *International Conference on Bear Research and Management* 5:20–33.
Positive effects of humans on bears included changes in hunting regulations possibly resulting in an increasing bear

population, as well as oil pipeline rights-of-way, oil well service lanes, and lumber roads frequently used by bears as travel routes; early-successional vegetation induced by roadside cutting, commercial lumbering, clear-cutting for deer management projects, and controlled burns; and bee-keeping. Negative effects included loss of habitat due to human encroachment, heavy automobile traffic, hunting aided by service roads, poaching, and disturbances from approaching researchers which caused bears to flee their dens. Average home range was 150.4 km² for males and 68.9 km² for females. Large landscapes need to be protected from human encroachment.

Manville, A. M. 1987. Den selection and use by black bears in Michigan's northern lower peninsula. *International Conference on Bear Research and Management* 7:317–322.

Martin, A. C., H. S. Zim, and A. L. Nelson. 1951. *American wildlife and plants: a guide to wildlife food habits*. McGraw-Hill, New York, New York, USA.

Martorello, D. A. 1998. *Ecology of black bears in coastal North Carolina*. Dissertation, University of Tennessee, Knoxville, Tennessee, USA.

Mattson, D. J. 1990. Human impacts on bear habitat use. *International Conference on Bear Research and Management* 8:33–56.

Human-origin bear foods have supplanted native bear foods on some wildlands converted to agriculture. Human intolerance has made most human foods unavailable in bear habitat due to the elimination of bears, and virtually all remaining bear populations depend on wild native foods. Bear populations that rely heavily on human foods do so only in areas where sufficient secure habitat is available. Human-induced changes in wildlands are probably of greater significance to surviving bear populations than is introduction of exotic foods. Humans have disrupted (i.e., through fire control, timber harvest, game management, and atmospheric pollution) otherwise stable, dynamically equilibrated processes in virtually all wildland ecosystems occupied by bears. Increased isolation and

fragmentation of bear populations continue. Habitat available to a bear population must be sufficiently large so that perturbations can be averaged across the landscape. Subadult males and adult females tend to forage closer to humans because of their energetic predicament and because more secure sites are often preempted by adult males. Although male bears are typically responsible for most livestock predation, adult females and subadult males are more likely habituated to humans. Elimination of human-habituated bears predictably reduces effective carrying capacity and is more likely to be a factor in preserving bear populations where humans are present in moderate to high densities. If humans desire to preserve viable bear populations, they will either have to accept increased risk of injury associated with preserving habituated animals or continue to crop habituated bears while at the same time preserving large tracts of wildlands free from significant human intrusion.

Mattson, D. J., R. R. Knight, and B. M. Blanchard. 1987. The effects of developments and primary roads on grizzly bear habitat use in Yellowstone National Park, Wyoming. *International Conference on Bear Research and Management* 7:259–273.

Grizzly bear occupancy of habitat near human facilities was reduced, efficient foraging strategies were disrupted, and cohorts tending to be subordinate or security-conscious were displaced into habitat closer to developments by more dominant cohorts, particularly during summer and fall. Adult females and subadults bore a disproportionate part of costs associated with avoiding roads and developments; therefore, avoidance of developments and roads may have resulted in higher mortality and lower productivity among the adult female cohort.

Maynard, C. J. 1883. The mammals of Florida. *Quarterly Journal of the Boston Zoological Society* 2:1–8, 17–24, 38–43, 49–50.

McArthur, R. H., and E. O. Wilson. 1967. *The theory of island biogeography*. Princeton University Press, Princeton, New Jersey, USA.

- McCullough, D. R. 1996. Spatially structured populations and harvest theory. *Journal of Wildlife Management* 60:1–9.
- McCutchen, H. E. 1990. Cryptic behavior of black bears (*Ursus americanus*) in Rocky Mountain National Park, Colorado. *International Conference on Bear Research and Management* 8:65–72.
- McDaniel, J. 1974. Habitat of the black bear in Florida. *Eastern Workshop on Black Bear Management and Research* 2:157–162.
- McLaughlin, C., and D. Maehr. 1986. Evaluating black bear habitat (panel discussion). *Eastern Workshop on Black Bear Management and Research* 8:185–195.
In Florida, those factors that have led to local population extinctions need to be identified before populations can be successfully restored. Bear habitat analyses in the East address a range of issues from long-term planning, species management, impact assessment, and mitigation.
- McLaughlin, C. R., G. J. Matula, and J. H. Hunt. 1986. A draft habitat suitability index model for black bears in the conifer-deciduous forests of New England: its application in Maine. *Eastern Workshop on Black Bear Management and Research* 8:137–167.
This planning exercise indicated that black bears seldom venture further than 125 m into unforested patches of early successional habitat. The authors recognized the importance of interspersions of habitat types, but cautioned that the relation between black bear ecology and plant community variability is poorly understood. They assumed, however, that bear densities are inversely related to the level of human development.
- McLellan, B. N. 1990. Relationships between human industrial activity and grizzly bears. *International Conference on Bear Research and Management* 8:57–64.
Resource extraction activities can affect individual bears by 1) causing strong, energetically expensive reactions that disrupt normal behavior; 2) displacing bears from areas of human use; 3) altering habitats in which bears live; 4) disrupting the bears' social system; and 5) directly killing bears or increasing mortality rates indirectly by improving access for hunters, poachers, other resource users, and settlers. Increased motorized access that results in a long-term increase in human activity and/or settlement with a consequent increase in bears being shot is the most significant impact of industrial developments. Closing access to bear habitat after job completion is necessary to maintain the bear population at a satisfactory level.
- McLellan, B. N., and D. M. Shackleton. 1988. Grizzly bears and resource extraction industries: effects of roads on behavior, habitat use and demography. *Journal of Applied Ecology* 25:451–460.
- Mech, L. D., S. H. Fritts, G. L. Radde, and W. J. Paul. 1988. Wolf distribution and road density in Minnesota. *Wildlife Society Bulletin* 16:85–87.
- Meffe, G. K., and C. R. Carroll. 1997. *Principles of conservation biology*. Sinauer Associates, Sunderland, Massachusetts, USA.
- Merriam, C. H. 1896. Preliminary synopsis of the American bears. *Proceedings of the Biological Society* 10:65–83.
- Miller, P. S., and R. C. Lacy. 1999. *Vortex: a stochastic simulation of the extinction process. Version 8 user's manual*. Conservation Breeding Specialist Group, Apple Valley, Minnesota, USA.
- Miller, S. D. 1990. Population management of bears in North America. *International Conference on Bear Research and Management* 8:357–373.
- Millsap, B., J. Gore, D. Runde, and S. Cerulean. 1990. Setting priorities for the conservation of fish and wildlife species in Florida. *Wildlife Monographs* 111.
- Mladenoff, D. J., T. A. Sickley, R. G. Haight, and A. P. Wydeven. 1995. A regional landscape analysis and prediction of favorable gray wolf habitat in the northern Great Lakes region. *Conservation Biology* 9:279–294.
- Mollohan, C. M., and A. L. LeCount. 1989. Problems of maintaining a viable black bear population in a fragmented forest. *Conference on the multiresource management of ponderosa pine*

- forests, Northern Arizona University, 14–16 November.
- Montague, C. L., and R. C. Wiegert. 1990. Salt marshes. Pages 481–516 *in* R. L. Myers and J. J. Ewel, editors. *Ecosystems of Florida*. University of Central Florida Press, Orlando, Florida, USA.
- Monsanto Co. 1994. Targeting unwanted brush—and costs—in utility rights-of-way. Monsanto Company, St. Louis, Missouri, USA.
- Monsanto Co. 1997. Industrial, turf and ornamental label and MSDS book. Monsanto Company, St. Louis, Missouri, USA.
- Moore, J. C. 1946. Mammals from Welaka, Putnam County, Florida. *Journal of Mammalogy* 27:49–59.
- Moore, J. C. 1949. Putnam County and other Florida mammal notes. *Journal of Mammalogy* 30:57–66.
- Moore, J. C. 1953. A mound on a key in Florida Bay. *Everglades Natural History* 1:67–75.
- Moore, S. E., and H. L. Allen. 1999. Plantation forestry. Pages 400–433 *in* M. L. Hunter Jr., editor. *Maintaining biodiversity in forest ecosystems*. Cambridge University Press, Cambridge, U.K.
- Moore, W. H. 1972. Managing bobwhites in the cutover pinelands of south Florida. Pages 56–65 *in* First national bobwhite quail symposium proceedings. Stillwater, Oklahoma, USA.
- Moore, W. H., B. F. Swindel, and W. S. Terry. 1982. Vegetation responses to prescribed fire in a north Florida flatwoods forest. *Journal of Range Management* 35:386–389.
- Myers, R. L. 1990. Scrub and high pine. Pages 150–193 *in* R. L. Myers and J. J. Ewel, editors. *Ecosystems of Florida*. University of Central Florida Press, Orlando, Florida, USA.
- Myers, R. L., and J. J. Ewel, editors. 1990. *Ecosystems of Florida*. University of Central Florida Press, Orlando, Florida, USA.
- Mykytka, J. M., and M. R. Pelton. 1990. Management strategies for Florida black bears based on home range habitat composition. International Conference on Bear Research and Management 8:161–167.
- Large swamp systems and surrounding pine flatwoods were major components of bear habitat in north-central Florida. Upland forest cover (pine stands) represented 60% of the composite home range. Wetland forests represented 40% of the composite home range. Road density was a major factor affecting bear vulnerability during hunting seasons (increased access). Preservation and restoration of the interconnectivity of large swamps and forested upland buffers surrounding these swamps (>300 ha), and maintaining longer timber rotation, would encourage use by bears and reduce vulnerability of bears to overharvest. Construction of new roads should be restricted and those that bisect swamp systems and upland buffers should be closed. Forest management practices that promote stand diversity and mast production should be used.
- Nordlie, F. G. 1990. Rivers and springs. Pages 392–428 *in* R. L. Myers and J. J. Ewel, editors. *Ecosystems of Florida*. University of Central Florida Press, Orlando, Florida, USA.
- Noss, R. F. 1983. A regional landscape approach to maintain. *Bioscience* 33:700–706.
- Noss, R. F. 1987. Protecting natural areas in fragmented landscapes. *Natural Areas Journal* 7:2–13.
- Noss, R. F. 1992. The Wildlands Project: land conservation strategy. *WildEarth Special Issue*:10–25.
- The author outlines the theory behind a regional landscape approach for conserving biological diversity, especially large, wide-ranging species that are extremely sensitive to habitat fragmentation and human disturbance. Goals for a reserve system include representing all native ecological communities, maintaining viable populations of all native species, maintaining ecological and evolutionary processes, and maintaining or restoring the potential for response to environmental change such as global warming. The paper also includes various recommendations on the size of reserves, characteristics of core areas and buffer zones, and design considerations for corridors.

- Noss, R. F. 1993. Wildlife corridors. Pages 43–68 in D. S. Smith and P. C. Hellmund, editors. Ecology of greenways. University of Minnesota Press, Minneapolis, Minnesota, USA.
- Noss, R. F. 1996. Protected areas: how much is enough? Pages 91–120 in R. G. Wright, editor. National parks and protected areas: their role in environmental protection. Blackwell Science, Cambridge, Massachusetts, USA.
- Noss, R. F., and C. A. Cooperrider. 1994. Saving nature's legacy: protecting and restoring biodiversity. Defenders of Wildlife and Island Press, Washington, D.C., USA.
- Noss, R. F., and L. D. Harris. 1986. Nodes, networks, and MUMs: preserving diversity at all scales. Environmental Management 10:299–309.
- Noss, R. F., M. A. O'Connell, and D. D. Murphy. 1997. The science of conservation planning: habitat conservation under the Endangered Species Act. Island Press, Washington, D.C., USA.
- Noss, R. F., and R. L. Peters. 1995. Endangered ecosystems of the United States: a status report and plan for action. Defenders of Wildlife, Washington, D.C., USA.
- Noss, R. F., H. B. Quigley, M. G. Hornocker, T. Merrill, and P. C. Paquet. 1996. Conservation biology and carnivore conservation in the Rocky Mountains. Conservation Biology 10:949–963.
- Noyce, K. V., and P. L. Coy. 1990. Abundance and productivity of bear food species in different forest types of northcentral Minnesota. International Conference on Bear Research and Management 8:169–181.
- Nyland, P. D., and R. M. Pace III. 1997. Utility of National Wetlands Inventory data for black bear habitat assessment in coastal Louisiana. Proceedings of the Annual Conference of Southeastern Fish and Wildlife Agencies 51:297–310.
This paper clearly supports the notion that the black bear in the southeastern United States is a forest obligate. They recommend fine tuning future landscape analyses to include tree density and canopy height.
- Odum, W. E., and C. C. McIvor. 1990. Mangroves. Pages 517–548 in R. L. Myers and J. J. Ewel, editors. Ecosystems of Florida. University of Central Florida Press, Orlando, Florida, USA.
- Parrott, R. T. 1967. A study of wiregrass (*Aristida stricta*) with particular reference to fire. Thesis, Duke University, Durham, North Carolina, USA.
- Pearson, P. G. 1954. Mammals of Gulf Hammock, Levy County, Florida. American Midland Naturalist 51:468–480.
- Pelchat, B. O., and R. L. Ruff. 1986. Habitat and spatial relationships of black bears in boreal mixed-wood forest of Alberta. International Conference on Bear Research and Management 6:81–92.
Mean sizes of areas occupied by bears when food was scarce were 102 km² for males and 39 km² for females. Mean sizes of areas when food was abundant were 65 km² for males and 19 km² for females. Home ranges of females were generally stable in size and location each year regardless of food abundance.
- Pelton, M. R. 1982. Black bear. Pages 504–514 in J. A. Chapman and G. A. Feldhammer, editors. Wild mammals of North America. Johns Hopkins University Press, Baltimore, Maryland, USA.
- Pelton, M. R. 1986. Habitat needs of black bears in the East. Pages 49–53 in D. L. Kulhavy and R. N. Conner, editors. Wilderness and natural areas in the eastern United States: a management challenge. Stephen F. Austin State University, Nacogdoches, Texas, USA.
- Pelton, M. R., L. E. Beeman, and D. C. Eagar. 1980. Den selection by black bears in Great Smoky Mountains National Park. International Conference on Bear Research and Management 4:149–151.
Bears preferred cavities located high in large trees. Dens were associated with northern hardwood and cove hardwood forests. The average dbh of 7 den trees was 97.1 cm. Inside dimensions of 7 tree dens averaged 218.4 x 59.6 x 62.0 cm. Tree dens are of survival value to bears, offering protection from precipitation, cold temperatures, and human activities. Attention should be given to preserving prime den sites as an important component of black bear management; prime den sites

- may be particularly important in maintaining viable black bear populations in marginal habitat.
- Pelton, M. R., and R. G. Nichols. 1972. Status of the black bear (*Ursus americanus*) in the Southeast. Pages 18–23 in North American workshop on black bear management and research. New York State Department of Environmental Conservation, Delmar, New York, USA.
- Perry, R. W., R. E. Thill, D. G. Peitz, and P. A. Tappe. 1999. Effects of different silvicultural systems on initial soft mast production. *Wildlife Society Bulletin* 27:915–923.
- Pickett, S. T. A., R. S. Ostfeld, M. Shachak, and G. E. Likens, editors. 1997. *The ecological basis of conservation: heterogeneity, ecosystems, and biodiversity*. Chapman and Hall, New York, New York, USA.
- Platt, W. J., G. W. Evans, and S. L. Rathbun. 1988. The population dynamics of a long-lived conifer (*Pinus palustris*). *American Naturalist* 131:491–525.
- Platt, W. J., and M. W. Schwartz. 1990. Temperate hardwood forests. Pages 194–229 in R. L. Myers and J. J. Ewel, editors. *Ecosystems of Florida*. University of Central Florida Press, Orlando, Florida, USA.
- Poelker, R. J., and H. D. Hartwell. 1973. *Black bear of Washington*. Washington State Game Department, Olympia, Washington, USA. This state-produced monograph includes examinations of bear/forest relationships, natural history, and management. Study objectives were to 1) determine why black bears feed on sapwood of coniferous trees (see Poelker and Parsons 1980), 2) determine population densities of black bears in various forest types and forest successional stages, 3) study distribution patterns and the effect of food supplies on these patterns, 4) examine and evaluate available information concerning food habits of black bears, and 5) study the effect of hunter harvest and/or control measures on black bear populations and determine the maximum allowable harvest consistent with good game management principles.
- Poelker, R. J., and L. D. Parsons. 1980. Black bear hunting to reduce forest damage. *International Conference on Bear Research and Management* 4:191–193. Prior to 1973, the state of Washington had a spring black bear season from 1 April through 30 June, as well as extensive efforts by professional control hunters to attempt to alleviate damage to forest tree reproduction. After 1973 an effort was made to concentrate hunting in problem damage areas, ending the spring hunt and establishing a system of special hunts. Bear harvest increased by 230 animals, suggesting that the sport-hunting program succeeded in harvesting bears in problem areas and preserving bears in nonproblem areas. Field surveys showed that bear damage was reduced or eliminated in most problem areas. They recommended making this system a permanent program for timber protection and also recommended hunting with hound as essential for adequate harvesting of damage-causing bears.
- Powell, D. S., J. L. Faulkner, D. R. Darr, Z. Zhu, and D. W. MacCleery. 1993. *Forest resources of the United States*. General Technical Report RM-234. U.S. Department of Agriculture Forest Service, Washington, D.C., USA.
- Powell, R. A., J. W. Zimmerman, and D. E. Seaman. 1992. Evaluation of a black bear sanctuary in the mountains of western North Carolina. Final report. Project W-57. Wildlife Management Division, North Carolina Wildlife Resources Commission.
- Powell, R. A., J. W. Zimmerman, and D. E. Seaman. 1997. *Ecology and behaviour of North American black bears: home ranges, habitat and social organization*. Chapman and Hall, London, England. This project was a theoretical modeling effort to understand bear habitat use in western North Carolina (despite the suggestion of the title that it covers a wider area). They observed that, “Home ranges should not always be quantified with respect to time that an animal spends, or is predicted to spend, in different places. Most researchers use time to index importance, but what really counts is fitness. For some questions, home ranges need to be quantified by probability

density functions of energy expenditure or energy acquisition. Ultimately, home ranges should be quantified as probability density functions for contributions to fitness.”

- Powell, R. A., J. W. Zimmerman, D. E. Seaman, and J. F. Gilliam. 1996. Demographic analyses of a hunted black bear population with access to a refuge. *Conservation Biology* 10:224–234. Pisgah Bear Sanctuary in North Carolina provides dispersing bears for hunters and provides some protection for resident bears. The sanctuary may not, however, provide resident bears with enough protection to maintain a viable breeding population within its boundaries. Reducing human access to bears and their habitat appears crucial, either by making large sanctuaries or by eliminating roads.
- Quarterman, E., and C. Keever. 1962. Southern mixed hardwood forest: a climax in the southeastern coastal plain. *Ecological Monographs* 32:167–185.
- Quigley, H. B. 1982. Activity patterns, movement ecology, and habitat utilization of black bears in the Great Smoky Mountains National Park, Tennessee. Thesis, University of Tennessee, Knoxville, Tennessee, USA.
- Raine, R. M., and J. L. Kansas. 1990. Black bear seasonal food habits and distribution by elevation in Banff National Park, Alberta. *International Conference on Bear Research and Management* 8:297–304. The 4 black bear food seasons were defined as 1) den exit to mid-June, horsetails and graminoid vegetation as the dominant food source; 2) mid-June to mid-July, ants and ant larvae as the dominant food source; 3) mid-July to end of August, buffaloberry as the dominant food source; and 4) end of August to den entry, alternate foods such as crowberry, bearberry, and juniper berry as dominant foods. The mean elevation of habitats used during the first three seasons ranged from 1,500 to 1,543 m and increased to 1,694 m during the fourth season.
- Rand, A. L., and P. Host. 1942. Mammal notes from Highland (sic) County, Florida: results of the Archbold expeditions: Number 45. *Bulletin of*

the American Museum of Natural History 80:1–21.

- Reagan, S. R. 1991. Habitat use by female black bears in a southern Appalachian bear sanctuary. Thesis, University of Tennessee, Knoxville, Tennessee, USA.
- Ricketts, T. H., E. Dinerstein, D. M. Olson, C. J. Loucks, W. Eichbaum, D. DellaSala, K. Kavanagh, P. Hedao, P. T. Hurley, K. M. Carney, R. Abell, and S. Walters. 1999. *Terrestrial ecoregions of North America: a conservation assessment*. Island Press, Covelo, California, USA.
- Robbins, L. E., and R. L. Myers. 1992. Seasonal effects of prescribed burning in Florida: a review. *Miscellaneous Publication No. 8*. Tall Timbers Research, Tallahassee, Florida, USA.
- Rogers, L. L. 1976. Effects of mast and berry crop failures on survival, growth, and reproductive success of black bears. *Transactions of the North American Wildlife and Natural Resources Conference* 41:431–438. The social system of black bears varies with the distribution and abundance of food and probably serves to increase foraging efficiency, which leads to increased survival and enhanced reproductive success. Failures of berry and mast crops correlate with marked increases in bear damage to farm crops, beehives, and livestock. Assessment of the foods of the black bear makes it apparent that most are available only briefly or are too small and scattered to be gathered rapidly. The few foods that potentially are abundant, long-lasting, and easily secured are dependent upon the annual vagaries of temperature and precipitation, with the result that over much of the range of the black bear there tends to be a surfeit of food in some years and absolute or relative shortages in others. Rogers describes the effects of shortages of mast (*Corylus cornuta*) and berries (*Vaccinium* spp., *Prunus* spp., *Cornus* spp., and *Rubus* spp.) on survival, growth, maturation, and reproductive success of black bears as determined during a 7-year study in the aspen-birch-conifer forests of northeastern Minnesota.
- Rogers, L. L. 1987a. Effects of food supply and kinship on social behavior, movements, and

- population growth of black bears in northeastern Minnesota. *Wildlife Monographs* 97:1–72.
- Fruit and mast crop failures reduced bear reproductive rates to less than half the biological potential. Cub survival was 59 to 88% depending on the food supply in the year of conception and year of birth. Females first reproduced at 4–8 years of age, depending upon food supply, and produced subsequent litters at 2- to 4-year intervals. Annual cycle of behavior was closely tied to the annual cycle of plant growth and fruiting. Large areas of unbroken habitat are needed when food sources are unreliable. Management considerations include protecting important food sources (e.g., oaks, ash), limiting unspecific herbicides, leaving islands in large clearcuts, leaving hollow trees for den sites, and closing logging roads to limit human access.
- Rogers, L. L. 1987*b*. Factors influencing dispersal in the black bear. Pages 75–84 in B. D. Chepko-Sade, and Z. T. Halpin, editors. *Mammalian dispersal patterns: the effects of social structure on population genetics*. University of Chicago Press, Chicago, Illinois, USA.
- Male dispersal appears voluntary and not forced by conspecifics. Although male black bear dispersal effectively reduces the potential for inbreeding, this did not seem to be the driving force behind subadult movements away from natal areas. Female black bears tend to establish home ranges adjacent to or within the home ranges of their mothers.
- Rogers, L. L., and A. W. Allen. 1987. Habitat suitability index models: black bear, Upper Great Lakes region. U.S. Fish and Wildlife Service Biological Report 82.
- Rogers, L. L., and R. D. Applegate. 1983. Dispersal of fruit seeds by black bears. *Journal of Mammalogy* 64:310–311.
- This study compared the germination of seeds retrieved from feces of black bears with germination of seeds of ripe, uneaten fruit from northeastern Minnesota. The habits of swallowing small fruits whole and of traveling long distances could make black bears particularly important dispersers of fruit seeds if enough defecated seeds germinate. Germination rates of seeds from feces were higher than those of seeds in uneaten fruits for all species. Differences were significant in 5 of 8 taxa.
- Roof, J. C. 1997. Black bear food habits in the Lower Wekiva River basin. *Florida Field Naturalist* 25:92–97.
- Acorns, saw palmetto, sabal palm, walking sticks, blueberries, tupelo fruit, bessie bugs, and carpenter ants were the most commonly eaten foods. Variation in diet among years was due to differential availability, and suggests the need to maintain diverse food supplies over large areas so that black bears can successfully incorporate spatial and temporal uncertainty into their diets.
- Roof, J., and J. Wooding. 1996. Evaluation of S.R. 46 wildlife crossings. Technical Report #54. Florida Cooperative Fish and Wildlife Research Unit, University of Florida, Gainesville, Florida, USA.
- This study evaluated an experimental wildlife crossing and adjacent barrier fencing on S.R. 46 near Ocala National Forest. The system was designed to allow black bears to safely cross the highway. Five black bears used the crossing as the result of 50 encounters with the fence or the highway. In 1,033 documented instances in which animals encountered the fence or crossing, 69% did not cross the highway, 27% used the wildlife crossing, and 4% crossed the highway by crawling under the fence or entering at the end. Barrier fencing was effective in keeping bears and other large mammals off the fenced section of highway in the vicinity of the crossing. With a series of crossings, structures should be spaced no further than 1 km apart and should be located at points where bears and other species cross the highway with the greatest frequencies.
- Royce, D. 1997. Florida growth slows with fewer retirees arriving. *Gainesville Sun* 14 August.
- Safford, W. E. 1919. Natural history of Paradise Key and the nearby Everglades of Florida. Pages 377–434 in *Annual report of the Smithsonian Institution for 1917*. Smithsonian Institution, Washington, D.C., USA.
- Samson, C., and J. Huot. 1998. Movements of female black bears in relation to landscape

vegetation type in southern Quebec. *Journal of Wildlife Management* 62:718–727.

Declining use of a national park was attributed to a paucity of early successional stands and resulted in increased bear mortality outside of the park. Increasing early successional patches and creating a buffer zone (excluding agriculture and residential development) around the park would reduce bear movements outside of the protected area.

Santillo, D. J. 1987. Response of small mammals and breeding birds to herbicide-induced habitat changes on clearcuts in Maine. Thesis, University of Maine, Orono, Maine, USA.

Schaefer J. M., and M. T. Brown. 1992. Designing and protecting river corridors for wildlife. *Rivers* 3(1):14–26.

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Acorns, saw palmetto, and swamp tupelo dominate the diet of black bears in this population, although some variation occurred between Florida and Georgia. Radio-collared females preferred loblolly forest and cypress swamp over slash pine forest, and tended to use forests that were older than 16 years. Although nutrition in Georgia was superior to north Florida, black bears benefitted in Florida from hunting season closures and corn used to attract deer.

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Schoen, J. W. 1990. Bear habitat management: a review and future perspective. *International Conference on Bear Research and Management* 8:143–154.

Schooley, R. L., C. R. McLaughlin, G. J. Matula Jr., and W. B. Krohn. 1994. Denning chronology of female black bear: effects of food, weather, and reproduction. *Journal of Mammalogy* 75:466–477.

Short supplies of hard mast in fall stimulate early den entry of females in poorer condition than when beech nuts are abundant.

Schwartz, C. C., and A. W. Franzmann. 1991. Interrelationship of black bears to moose and forest succession in the northern coniferous forest. *Wildlife Monographs* 113.

Schwartz and Franzmann compared characteristics of 2 black bear populations living in middle-aged and recently burned forests in Alaska. Population density and sex ratios were similar between areas. Age structures differed, with more yearlings in the recently burned area due to higher cub production and survival. Females in the middle-aged burn area produced litters at an older age and weaned yearlings later than females in the recent-burn area. Cub survival was lower in the middle-aged burn area. Superior growth and reproduction of black bears in the recent-burn area was attributed to greater consumption of moose calves.

Schwartz, C. C., and A. W. Franzmann. 1992. Dispersal and survival of subadult black bears from the Kenai Peninsula, Alaska. *Journal of Wildlife Management* 56:426–431.

All male subadults dispersed, as opposed to only 3% of females, which tended to establish home ranges adjacent to their mothers'. Larger litters also tended to stay

together longer. Gender-related differences in dispersal must be considered when managing heavily harvested populations or those that are geographically isolated. In continuous habitat, local overharvest of females can reduce sustained yields; in fragmented habitat an adequate reservoir of females must be maintained to ensure population stability.

- Schwartz, C. C., S. D. Miller, and A. W. Franzmann. 1987. Denning ecology of three black bear populations in Alaska. *International Conference on Bear Research and Management* 7:281–291. Mean number of days spent in dens varied from 189 to 233. Timing of emergence in the spring and entrance in the fall appeared to be related to weather, snow accumulation and melt, and food availability. Chronology of denning differed among pregnant females and other sex and age groups with overlap occurring among all age and sex groups. Site selection, vegetation type, and den type varied with area and was related to winter weather conditions, soil type, and topography.
- Seibert, S. G. 1989. Black bear habitat use and response to roads on Pisgah National Forest, North Carolina. Thesis, University of Tennessee, Knoxville, Tennessee, USA.
- Seibert, S. G. 1993. Status and management of black bears in Apalachicola National Forest. Final Report. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida, USA. Minimum bear density for the Apalachicola National Forest was 1 bear/19 km². The total population estimate was 126 ± 67 bears. Male bear home ranges averaged 109 ± 46 (SE) km². Female home ranges averaged 65 ± 22 km². Pregnant females entered dens earlier, emerged later, and denned for longer periods of time than other sex and age classes. Denning periods ranged from 13 to 150 days. Den types of 2 pregnant females included a hollow stump and an excavated ground cavity. Habitat preference was not detected, although freshwater marsh and shrub and brush habitats were avoided. Estimated harvest rate for bears was 42%. Saw palmetto and black gum were the most important fall foods. Management implications include wise management of the remaining large forests in Florida, with forest management limiting the amount of acreage in young plantations at any given time; limiting the amount of mechanical soil disturbance during site-preparation activities; maintaining a variety of stand ages and a diversity of forest types, especially hardwood/cypress swamps; and controlling or discouraging new road construction and road improvements.
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- Shropshire, C. C. 1996. History, status and habitat components of black bears in Mississippi. Dissertation, Mississippi State University, Mississippi State, Mississippi, USA. This study examined the historic significance and distribution of the black bear in Mississippi, determined habitat features where reliable sightings of black bears have occurred, determined habitat (occupied and unoccupied) suitable for bear management in Mississippi, and determined landowner and public attitudes regarding black bear management in Mississippi.
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- Smith, T. R. 1986. Activity and behavior of denned black bears in the lower Mississippi River valley. *International Conference on Bear Research and Management* 6:137–143.
- Mean activity level of radio-collared black bears declined from 53% to 29% between mid-October and early December before the denning period began. Denning length ranged from 37 to 141 days. The transition to dormancy began before den entry and a shift in behavior toward activity commenced before den emergence. Mean level of activity of denned bears was significantly lower than that of bears before denning and following den emergence. Nine of 14 cases of den abandonment were attributed to research activities, 4 to flooding, and 1 was unexplained.
- Smith, T. R., and M. R. Pelton. 1990. Home ranges and movements of black bears in a bottomland hardwood forest in Arkansas. *International Conference on Bear Research and Management* 8:213–218.
- Smith and Pelton studied movements of 23 radio-collared bears in a remnant bottomland hardwood forest. The size of annual home range was inversely related to habitat diversity and, in adult males, to weight. Typically, bears used significantly larger ranges in summer than in spring or fall–winter. Radio-tagged bears did not disperse from the study area nor did they move far from their natal ranges, indicating that this remnant population is closed. Bears relied almost exclusively on one food type in spring and one in fall–winter, making them vulnerable to annual vagaries in abundance and distribution of these foods. Management strategies should emphasize maintenance of forest diversity to provide alternate sources of fall mast critical to bears when staple mast-producing species fail.
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- The authors analyzed 259 scats collected on Eglin Air Force Base from 1994 to 1996. Spring diets were dominated by insects and hearts of saw palmetto (*Serenoa repens*). Early summer diets consisted primarily of blueberries (*Vaccinium* spp.). Late summer diets were primarily sweet gallberry (*Ilex coriacea*) and acorns (*Quercus* spp.). Fall food varied per year between saw palmetto fruit and acorns. Seasonal shifts in feeding ecology of black bears on Eglin Air Force Base were similar to other studies. In saw palmetto, starch content decreases and sugar production increases during spring and summer, corresponding to the time when bears consume the largest amount of saw palmetto hearts. Soft mast (blueberries) provides necessary proteins for growth and rebuilding of muscle mass. Bears may be selecting saw palmetto fruit over acorns. Acorns and saw palmetto fruit likely serve as replacements for each other during years of mast failures or low food availability.
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 One hundred sixty-one black bears from Minnesota were released in Madison, Tensas, and Pointe Coupee parishes in Louisiana. Bears dispersed into 37 parishes in Louisiana and into Texas, Arkansas, and Mississippi. Six bears were radio-collared. Minimum male home ranges were 27,440 acres (11,109 ha); minimum female home ranges averaged 4,866 acres (1,970 ha). Dens were in standing hollow trees. Temperature appeared to be unrelated to denning activities. Taylor concluded that the continued clearing of bottomland hardwood forests will result in a declining bear population.
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- Wathen, W. G., K. G. Johnson, and M. R. Pelton. 1986. Characteristics of black bear dens in the southern Appalachian region. *International Conference on Bear Research and Management* 6:119–127.
Most dens were located in tree cavities high above ground. Entrance height differed among tree species. Species differed with elevation, macrotopography, and microtopography. Chestnut oaks and northern red oaks comprised 10 of 15 tree dens outside of Great Smoky Mountains National Park. Timber management should be coordinated with den tree use and based on short-term and long-term management strategies. Short-term management should assess the availability of den trees and ensure preservation of individual den trees through careful coordination of logging activities. Long-term considerations should include initiating research to determine site and vegetative characteristics useful in quantitatively classifying and mapping areas with high potential for den tree production. Areas with high potential should be placed in old-growth management compartments or wilderness areas.
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- Wooding, J. B. 1990. Black bear harvest analysis. Final Report. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida, USA.
A long history of liberal hunting

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- Wooding, J. B. 1995. Black bear reintroduction planning study. Final Report. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida, USA.
In many parts of Florida the black bear is below carrying capacity and is a good candidate for restocking. The Big Bend area, in particular, would be a good place for a preliminary field study.
- Wooding, J. B. 1996. Feasibility of stocking black bears in the Big Bend region. Final Report. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida, USA.
Two yearling female black bears established home ranges and behaved in a manner that suggests that the Big Bend region is capable of supporting a black bear population. Natural recolonization will likely occur, but it will be a very slow process. The study concludes that a breeding population should be established on Lower Suwannee National Wildlife Refuge.
- Wooding, J. B., J. A. Cox, and M. R. Pelton. 1994. Distribution of black bears in the southeastern coastal plain. *Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies* 48:270–275.
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- Wooding, J. B., and T. S. Hardisky. 1988. Black bear habitat study. Final Performance Report, W-42-35. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida, USA.
- Wooding, J. B., and R. C. Maddrey. 1994. Impacts of roads on black bears. *Eastern Workshop on Black Bear Management and Research* 12:124–129.
In most areas highway mortality is readily compensated for by local black bear populations. However, highways cause outright habitat loss and provide hunter access to bear populations, thus increasing the black bear's vulnerability.
- Wooding, J. B., S. M. Shea, M. L. Richardson, and D. Y. Dowling. 1992. Movements of a female black bear in northwestern Florida. *Florida Field Naturalist* 20:46–48.
The authors speculate that the wide-ranging movements (77 km) of an adult female black bear that was originally captured as a nuisance may be related to habitat alteration in her original home range.
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- Young, D. D., and J. J. Beecham. 1986. Black bear habitat use at Priest Lake, Idaho. *International Conference on Bear Research and Management* 6:73–80.
Habitat use was determined from radio locations of 9 adult bears. Black bears preferred selectively logged areas during spring, summer, and fall; clearcuts were avoided during all seasons. Females preferred forested habitats and avoided roads. Males used timber and roads in proportion to their availability. Food production should be maintained or enhanced using a let-burn fire management policy and prescribed burns. Food production should be maintained or improved on logged sites. Soil scarification should be minimized to prevent damage to vegetatively reproducing food species. Disturbances to bears should be minimized by coordinating logging activities with seasonal habitat use patterns of bears. Timber should be retained near potential

or existing feeding areas, leaving patches of timber or strips within cutting units.

Clearcuts with irregular borders provide greater cover. Coordinate logging activities to maintain an acceptable mix of different aged cutting units. Leave mature standing trees in cutting units.

Zager, P. 1980. The influence of logging and wildfire on grizzly bear habitat in northwestern Montana. Dissertation, University of Montana, Missoula, Montana, USA.

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Rates of germination of seeds which passed through the digestive tracts of bears were higher than those that did not. Bears are also important dispersal mechanisms.
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Analyses of scat and stomachs collected during 1969 and 1970 indicated that herbaceous species were most common in spring, and soft mast was most common in fall. Animal foods were not common. Colonial insects were found in small amounts. Food habits of cubs were similar to those of adults. Direct relationships were found between garbage consumption and increased camping and picnicking by people.
- Beeman, L. E., and M. R. Pelton. 1980. Seasonal foods and feeding ecology of black bears in the Smoky Mountains. *International Conference on Bear Research and Management* 4:141–147.
Seventy-five stomachs and 1,025 scats from black bears in Great Smoky Mountains National Park were examined between June 1969 and January 1972. Diets consisted of 81% plant matter (grasses, other herbaceous leaves, stems, squawroot [*Conopholis americana*], huckleberries [*Gaylussacia* spp.], black cherry [*Prunus serotina*], acorns [*Quercus* spp.], blackberries [*Rubus* spp.], and blueberries [*Vaccinium* spp.]); 11% animal matter (predominantly Coleoptera and Hymenoptera); 6% artificial food of human origin; and 2% debris.
Spring diet was 90% grasses and other herbaceous stems and leaves and 10% squawroot. Summer diet consisted primarily of fruits and seeds. Early fall diet consisted of a variety of fruits. Late fall was a critical season and diet was primarily oak, hickory, and beech mast. Overall, the diet had high carbohydrate content, but low protein. Bear mortality, due to both legal and illegal means, increased during years of low mast production.
- Black Bear Conservation Committee. 1992. Black bear management handbook for Louisiana, Mississippi, and East Texas.
The Louisiana black bear (*U. a. luteolus*) is jeopardized by habitat alteration and/or reduction. Forest management practices that can be advantageous to black bears are also compatible with normal management activities and are beneficial to other wildlife species. This text lists agricultural management practices that can enhance black bear habitat. Additional management strategies should focus on protection through prevention and resolution of human/bear conflicts and on public education.
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Bowman et al. describe techniques which could be used to monitor bear population response to habitat change: hunter surveys of bear sighting during two-day deer hunt with Peterson-Lincoln estimator and cameras triggered by infrared monitors using both CAPTURE and Minta-Mangel mark-resight model. CAPTURE was the most reliable estimate, although flaws in the data collection were present in all estimates.
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Clark and Van Manen discuss different approaches to modeling, including habitat suitability indices, cumulative effects, and biometric models for habitat analyses using GIS.
- Conti, J. A., D. J. Forrester, and J. R. Brady. 1983. Helminths of black bears in Florida. *Proceedings of the Helminthological Society of Washington* 50:252–256.
Fourteen species of helminth parasites were observed in examinations of 46 black bears.

Observations included 12 nematodes, 1 trematode, and 1 acanthocephalan. The mean number of parasite species per bear was 4, with no significant differences observed among sexes and ages. Mean intensities were significantly higher in males.

Doan-Crider, D. L., and E. C. Hellgren. 1996. Population characteristics and winter ecology of black bears in Coahuila, Mexico. *Journal of Wildlife Management* 60:398–407.

Doan-Crider and Hellgren studied the Serranias del Burro population from 1991 to 1994. They captured 42 bears and collared 28. All pregnant females denned, 2 of 5 females with yearlings denned, and all other bears remained active throughout the winter. Dates of den entry and exit were late December and late April, respectively. The study estimated survival of adult females, cubs, and subadult males. Population density was estimated at 0.35 bears/km². The area could serve as a source of bears for relocation/emigration to western Texas.

Eason, T. H. 1995. Weights and morphometrics of black bears in the southeastern United States. Thesis, University of Tennessee, Knoxville, Tennessee, USA.

Eason found evidence of weight variance and morphometric differences in black bears supporting subspecies demarcations, but also found evidence that subspecies demarcations may not account for all of the morphometric variation found in black bears in the eastern United States. Differences were not correlated with regional habitat quality indices as measured by crop yields, latitude, actual evapotranspiration, and soil fertility. Black bears may respond temporally to habitat quality at a subregional level.

Eiler, J. H. 1981. Reproductive biology of black bears in the Smoky Mountains of Tennessee. TWRA Technical Report No. 81-4. University of Tennessee.

Denning of bears in the Smoky Mountains averaged 114 days, starting in the first 3 weeks of December and ending in April. Dens were usually located in trees. Average litter size during 1979-80 was 2.5 cubs. Breeding activity was observed during the last week of June and the first 3 weeks of July. Minimum reproductive age was 4 to 5 years.

Foster, G. W., and T. A. Cames. 1995. Chewing lice, *Trichodectes pinquius euarctidos*, from a black bear in Florida. *Florida Field Naturalist* 23:17–18.

Hardisky, T. S., and J. B. Wooding. 1988. Black bear habitat study. Final Performance Report, Statewide Wildlife Research. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida, USA.

This report was based on 9 bears captured and radio-collared in Ocala National Forest. Habitat use appeared to shift with changes in food availability. Study animals used densely vegetated areas for winter bedding. Tentative mean home range sizes were 99 ± 19 (SE) km² for males and 28 ± 7 (SE) km² for females.

Harlow, R. F. 1962*b*. Osteometric data for the Florida black bear. *Florida Scientist* 25:257–273.

Harris, L. D. 1988. The nature of cumulative impacts on biotic diversity of wetland vertebrates. *Environmental Management* 12:675–693.

Wetlands help maintain the biotic diversity within and among vertebrate populations. Environmental perturbations can interact to reduce biotic diversity. Habitat fragmentation can have severe effects at all levels, reducing the usable range of the larger habitat generalists while threatening the genetic integrity of small, isolated populations. Impacts must be assessed on a landscape or regional scale to produce informed management decisions. Harris concludes that a system of replicate wetland reserves that are allowed to interact naturally with the surrounding landscape will be more effective in preserving biotic diversity than will isolated sanctuaries.

Harris, L. D. 1999. Remembering Florida's ancient forests: old Florida in words and pictures. *Special Bulletin*. Summer. Florida Defenders of the Environment.

This pictorial examination of Florida's ancient forests suggests that the state was richly populated with extensive forests that included very large trees. These trees likely supported a different set of animal communities that required old-growth conditions.

Harris, L. D., and P. Kangas. 1979. Designing future landscapes from principles of form and function.

Pages 725–729 in National Conference on Applied Techniques for Analysis and Management of the Visual Resources. General Technical Report PSW-35. U.S. Department of Agriculture Forest Service, Washington, D.C., USA.

Future landscapes will consist of a gradient of types ranging from wilderness areas to totally “humanized” environments. The future environment will necessarily serve multiple functions. The landscape level of hierarchy has been neglected by the disciplines of ecology and planning. By coupling basic principles of form and function with the demands of future society we may leave behind a planned rather than a default environment.

Hellgren, E. C., and M. R. Vaughan. 1994. Conservation and management of isolated black bear populations in the southeastern Coastal Plain of the United States. *Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies* 48:276–285.

Hellgren and Vaughan offer a strategy for maintaining large, contiguous forest tracts with minimal human disturbance. The authors indicate that identification, maintenance, and enhancement of key habitat patches, such as pocosins and mesic islands, are also important. They suggest the use of remote sensing data to identify corridors to be targeted for conservation. Large tracts of occupied bear range serve as reservoirs for black bear reproduction and dispersal into smaller, more fragmented habitats. Determining female survival rates and maintaining contiguous forest blocks are the most critical conservation needs. A second strategy consists of restricting human access.

Hunt, C. L. 1984. Behavioral responses of bears to tests of repellents, deterrents, and aversive conditioning. Thesis, University of Montana, Bozeman, Montana, USA.

Deterrents and repellents were tested on 31 free-ranging black bears visiting baits at a sanitary landfill. Ammonia and male human urine deterred most bears from eating. Test responses were the result of the effect of a stimulus on an individual bear, dominance activities by other bears at the site, and availability of natural foods in the

area. Certain bears appeared to tolerate the more noxious deterrents or returned repeatedly following tests of the triggered repellents. Stimuli can be developed that will repel most bears. Inclusion of an odor cue with a repellent stimulus seemed to increase its effectiveness. Effective stimuli appeared to reduce aggression in subsequent encounters. Bears not repelled or submissive in response to a stimulus were more aggressive during later encounters.

Irvine, J. E., B. L. Legendre, and H. P. Fanguy. 1983. Selective bear damage and deterioration in sugarcane varieties. *The Sugar Journal* 46(3):25–26.

Selection by bears among varieties of sugarcane was “especially evident” at farms near Atchafalaya swamp of southern Louisiana.

Kasbohm, J. W., M. R. Vaughan, and J. G. Kraus. 1994. Black bear harvest and nuisance behavior in response to gypsy moth infestation. *Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies* 48:261–269.

Gypsy moth infestation from 1987 to 1990 resulted in widespread defoliation and acorn failure. The number of bears harvested during infestation increased from pre-infestation numbers. The proportion of females harvested also increased. These increases may have resulted from increased bear movements in fall and greater bear susceptibility to hunting during infestation. Nuisance behavior was not affected by canopy loss or acorn failure. Defoliation enhanced soft mast production and may have allowed bears to avoid turning to high levels of nuisance activity that might be expected during conventional hard mast failures.

Kordek, W. S. 1973. An investigation of the structure, stability, and movements of Pennsylvania black bear with particular emphasis on Pike County. Thesis, Pennsylvania State University, State College, Pennsylvania, USA. Survival rate was 68% for males and 71% for females in Pike County. A pattern of reproductive synchrony was apparent. Females were observed to have a more restricted range than males. Survivability

statewide for males was determined to be 63.3% in 1971 and 67.8% in 1972 and 70.4% and 77.0% for females during the same periods.

Landers, J. L., R. J. Hamilton, A. S. Johnson, and R. L. Marchinton. 1979. Foods and habitat of black bears in southeastern North Carolina. *Journal of Wildlife Management* 43:143–153.

Landers et al. analyzed 732 fecal droppings and 28 stomach contents and radio-monitored 10 bears. They determined that bears in the region need large areas with a variety of habitat types to meet annual food and cover requirements.

LeCount, A. L. 1986. Black bear field guide: a manager's manual. Special Report No. 16. Arizona Game and Fish.

A basic management guide including how to recognize sign; capture, immobilization, and transportation methodology; marking devices; collection of data and biological samples; and handling of bear depredation problems.

Lentz, W. M., R. L. Marchinton, and R. E. Smith. 1983. Thermodynamic analysis of northeastern Georgia black bear dens (*Ursus americanus*). *Journal of Wildlife Management* 47:545–550.

Denning locations of selected bears captured from 1 July 1972 through 15 November 1976 were revealed through the use of radio collars. A metal cylinder holding a propane lantern was used to measure relative heat retention. Ninety-six percent of the heat retention of a den was accounted for by three variables: bedchamber height (59%), thickness of wood surrounding the bed chamber (26%), and whether the entrance was on the top or side of the den cavity (11%).

Maddrey, R. C., and M. R. Pelton. 1995. Black bear damage to agricultural crops in coastal North Carolina. *Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies* 49:570–579.

Hunting can be used to reduce bear densities and thus reduce bear/farmer conflict and bad public relations. Bear/farmer conflict occurs due to habitat fragmentation and agricultural development. Bears will use fragmented

habitat and the nonforested habitat matrix if food resources are high in the matrix.

McCullough, D. R. 1981. Population dynamics of the Yellowstone grizzly bear. Pages 173–196 *in* Dynamics of large mammal populations. John Wiley and Sons, New York, New York, USA.

McCullough analyzed and synthesized the available data on the Yellowstone population of *Ursus arctos horribilis* and offered an alternative interpretation of the dynamics of the population. The study includes segments on total population size, recruitment of juvenile classes, cause of suppression of recruitment, sex ratios, time lags, expected response of the population to exploitation, MSY and population stability, and comparison with other Yellowstone grizzly bear models.

Mealey, S. P. 1977. Method for determining grizzly bear habitat quality and estimating consequences of impacts on grizzly bear habitat quality. Final draft. U.S. Department of Agriculture Forest Service, Region 1, Missoula, Montana, USA.

Miller, D. A., H. A. Jacobson, and B. D. Leopold. 1994. Effects of vegetation composition and land-use variables on bait station visitations by black bears. *Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies* 48:252–260.

The authors investigated influences of habitat characteristics on bait station visitations. Vegetation and land-use variables were evaluated using overstory, midstory, and understory vegetation composition at bait stations visited and not visited by black bears on two islands in Arkansas. The site-specific variables measured had no influence on the probability of a bait station being visited.

Miller, D. A., B. D. Leopold, and H. A. Jacobson. 1995. Use of bait stations to monitor black bear populations in the Mississippi alluvial valley. *Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies* 49:560–569.

Experimental bait station surveys were conducted from May to August to evaluate effect of bait type, sampling duration, and sampling month on bait station visitation rates by black bears. The authors

- recommend conducting bait station surveys in August using fish. Bait station surveys should be conducted annually where visitation rates allow monitoring of population trends and every 3–5 years in areas of low bear density to provide baseline distributional information.
- Modafferi, R. D. 1982. Black bear movements and home range study. Alaska Department of Fish and Game.
Population identity, density, habitat use, sex and age composition, vulnerability to hunting, and behavior of black bears were determined from 60 live-captured bears (41 individual bears, 30 radio collared). Movement patterns are related to habitat use, feeding strategy, and reproductive behavior. Large bodies of saltwater, large glaciers, and extensive snowfields were not barriers to movement.
- Mykytka, J. M., and M. R. Pelton. 1988. Evaluation of four standard home range methods based on movements of Florida black bear. Pages 159–164 *in* Tenth international symposium on biotelemetry. Department of Zoology, University of Arkansas, Fayetteville, Arkansas, USA.
Home range data from 8 Florida black bears were utilized to evaluate the convex polygon, the modified minimum area, the elliptical or bivariate normal model, and the harmonic mean measure of activity model. None of the models accurately delineated the areas used by all 8 bears. A method's ability to estimate home range size and describe boundaries of space used depended upon the degree of conformance of the locational data to the assumptions of the methods.
- Newton, M. 1975. Constructive use of herbicides in forest resource management. *Journal of Forestry* 73:329–336.
- Pence, D. B., J. M. Crum, and J. A. Conti. 1983. Ecological analyses of helminth populations in the black bear, *Ursus americanus*, from North America. *Journal of Parasitology* 69:933–950.
Faunal similarity was determined using a data base of 23 helminth species from 104 black bears collected in the southeastern United States. Studies such as this may lead to a more decisive means of delineating
- predictive models for the parasite species involved in epidemics.
- Pursley, D. 1974. History and status of black bear in West Virginia. Thesis, West Virginia University, Parkersburg, West Virginia, USA.
A strong protective attitude towards the black bear existed among state residents. The West Virginia Department of Natural Resources should initiate information and education programs to inform the public about the contemporary status of black bears, including present and potential problems, bear research projects, and management goals. Pursley recommended research goals that included evaluation of black bear activities with regard to roads, livestock grazing, apiaries, and other agricultural areas; seasonal movements; and vegetational and physical components of existing bear habitat. Management goals should include preservation of existing bear habitat, evaluations of potential black bear habitat, and reintroduction of bears into suitable areas.
- Radwan, M. A. 1969. Chemical composition of the sapwood of four tree species in relation to feeding by the black bear. *Forest Science* 15:11–16.
The contents of sugars, nitrogen, and mineral elements of 4 tree species were determined on 2 areas in western Washington. One area was subject to considerable damage by black bears and the other showed very little damage. Total sugars and ash were the only components which seemed to be related to bear preference. Chemical analysis alone was not sufficient to explain the problem of bears feeding on tree sapwood.
- Rogers, L. L. 1977. Social relationships, movements, and population dynamics of black bears in northeastern Minnesota. Dissertation, University of Minnesota, Minneapolis, Minnesota, USA.
Rogers describes social relationships and population dynamics of black bears in northeastern Minnesota, based on a 7-year telemetry study. One hundred eleven individuals were collared and monitored. Rogers compared social interactions between related and unrelated adults. Findings emphasized the annual cycle of behavior and changes in behavior that occur as young

bears grow to maturity and establish permanent ranges. Rogers concluded that family members behave in ways that benefit close kin in accordance with kinship theory.

Rogers, L. L., D. W. Kuehn, A. W. Erickson, E. M. Harger, L. J. Verne, and J. J. Ozoga. 1976. Characteristics and management of black bears that feed in garbage dumps, campgrounds, or residential areas. *International Conference on Bear Research and Management* 3:169–175.

More males than females were found to supplement their diets with garbage. Females that supplemented their diets with garbage had higher than average numbers of cubs per litter than females that did not.

Rogers, L. L., and S. M. Rogers. 1976. Parasites of bears: a review. *International Conference on Bear Research and Management* 3:411–430.

This is a summary of the available information for 77 species of parasites including species of host, pathological effects, whether hosts were captive or wild, and proportion of infected bears from a given geographical region.

Scott, M. G. 1991. Body fat prediction, nutrition and reproduction of black bears in the interior highlands of Arkansas. Thesis, University of Arkansas, Fayetteville, Arkansas, USA.

Easily measured and reliable indices to predict body fat in black bears are necessary for evaluation of the nutritional condition of live and harvested animals, as well as for the standardization of physiological indicators in nutrition research. Techniques to predict body fat in other animals appear to have little predictive value for black bears. Because body fat is strongly correlated with body water, new techniques such as isotope dilution may hold some promise for future attempts to estimate fat stores in bears.

Stirling, I., C. Jonkel, P. Smith, R. Robertson, and D. Cross. 1977. The ecology of the polar bear (*Ursus maritimus*) along the western coast of Hudson Bay. Occasional Paper Number 33. Canadian Wildlife Service.

This paper summarizes 10 years of data collected by the Canadian Wildlife Service and the Manitoba Department of Renewable Resources and Transportation Services. It includes a summary of

historical records of polar bears in the Manitoba area, development of polar bear management in Manitoba, and documentation of bear-man problems in the Churchill area. Two hundred twenty-seven polar bears were ear-tagged and 23 were radio collared. Movement data and tag returns show that bears move on to the newly formed ice in early November and winter on the ice to the north and east of the Cape Churchill area, returning to the southern Manitoba coast in late July to August when the final ice remnants dissipate. A crude population estimate of the Churchill area was 308 bears. The polar bear problem in the Churchill area should be reduced once the garbage problem is resolved. Additional management options in Manitoba include establishment of an annual harvest and utilization of polar bears as a tourist attraction.

Tisch, E. L. 1961. Seasonal food habits of the black bear in the Whitefish Range of northwestern Montana. Thesis, Montana State University, Bozeman, Montana, USA.

Tisch examined 815 scats and 4 stomachs to determine the food habits of black bears in the Whitefish Range. Spring foods were predominantly herbaceous. Summer foods were herbaceous until the middle of July, when fruits matured. Berries and pine-nuts comprised most of the fall diet. Plant material occurred in 99.9% of the samples, insects in 45.3%, mammals in 5.0%, and birds occurred in 0.4%. There was an apparent correlation between the availability of huckleberry and its intake by bears in the fall.

van Manen, F. T., and M. R. Pelton. 1997. A GIS model to predict black bear habitat use. *Journal of Forestry* 95(8):6–12.

Possible consequences of forest management were assessed to produce habitat use models using GIS data of forest types, and male and female black bear habitat use on the nearly 500-km² Tellico Ranger District of the Cherokee National Forest in eastern Tennessee. Several variables were used to describe habitat use by female bears (overstory vegetation type, proximity to streams, elevation, aspect, stand age richness, proximity to improved roads, and proximity to human activity

sites) and male bears (overstory vegetation type, overstory vegetation richness, understory vegetation type, proximity to streams, aspect, landform index, proximity to improved roads, and proximity to human activity sites). Elevation accounted for most variation in the female habitat use model, while most variation in the male model was explained by proximity to human activity sites.

Willey, C. H. 1974. Aging black bears from first premolar tooth sections. *Journal of Wildlife Management* 38:97–100.

The first premolar was ascertained to be equally as reliable as the canine tooth as an age indicator of black bears. Advantages of the first premolar over the canine include ease of collection, near elimination of tooth replacement costs, and increased sample size.

Willey, R. D., J. W. Butfiloski, and T. T. Fendley. 1996. Population characteristics and female denning of black bears in a managed South Carolina forest. *Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies* 50:599–608.

Radio-tracked adult females in a managed forest in the mountains of South Carolina exhibited a mean litter size of 2.3 ($n = 7$); suspected mean age at primiparity was 4 years, and interbirth interval was 2.2 years. These parameters suggested a productive population and good-quality habitat. Dens included ground nests, root systems, tree cavities, brush piles, and hollow logs. Most dens were associated with early successional communities.

Wooding, J. B. 1987. Black bear hibernation study. Final Performance Report. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida, USA.

Wooding investigated hibernation by using serum levels of urea and creatinine

collected from 24 bears. There was no significant difference in the urine/creatinine ratio between serum collected December–March and that collected April–November. Low urea levels, believed a result of a low-protein diet, limit the usefulness of the urea/creatinine ratio as an indication of hibernation. Hibernation in Florida black bears may be restricted to females producing cubs.

Wooding, J. B., and B. J. Bakata. 1996. Litter size and age of first breeding of Florida black bears. *Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies* 50:609–613.

Wooding and Bakata examined 139 female reproductive tracts. Corpora lutea occurred in 81 of the tracts. Most females (75%) bred initially when 2.5 years old and the remainder at 3.5 years. Their results were “comparable to those found in other productive areas of eastern North America.”

Wooding, J. B., and T. S. Hardisky. 1987. Black bear population index and estimation development. Final Performance Report. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida, USA.

Bait stations were not effective as a population estimate due to low visitation rate. Bear track counts conducted on Ocala National Forest from 1983 to 1986 were analyzed. This method is sensitive only to major changes in the mean number of tracks observed. The authors present recommendations for estimating bear population trends with track counts and an evaluation of mast production on Ocala National Forest.



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