OAK-BLACK BEAR RELATIONSHIPS IN SOUTHEASTERN UPLANDS

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Abstract—Bears (*Ursus americanus*) primarily occur in upland habitats in the Southeast because uplands were the last to be developed for agriculture and were more likely to become publicly owned. National parks and forests created in the early to mid-1900s served as sources to supply surrounding uplands with bears. Bears could not survive in southeastern uplands without oak mast. Bear reproductive and mortality rates in the region have been shown to be directly linked with acorn production. Masting is thought to be an adaptation by oaks to satiate predators during good acorn years, thus ensuring that the remainder will germinate. Acorn predator populations, however, cannot respond numerically to increased acorn production because the masting is episodic and synchronous. Consequently, bears have developed physiological, behavioral, and ecological adaptations to cope with such food shortages. Despite such adaptations, upland hardwood forests in the Southeast are of lower quality than they once were. The loss of the American chestnut (*Castanea dentata*), higrading, and soil degradation have markedly decreased the carrying capacity for bears and other wildlife. Other changes such as recent forest management practices, forest fragmentation, invasion by the gypsy moth (*Lymantria dispar*), and oak decline threaten to further degrade the capability of southeastern uplands to support bears.

UPLANDS BY DEFAULT

Although we tend to equate bear habitat in the Southeast with mountainous upland hardwood forests, bear occurrence in the mountains is probably by default rather than preference. Historically, bears were common in the bottomland hardwoods of the Southeast (Gerstacker 1854, Bartram 1955). Remnant bottomland forests in Louisiana and Arkansas continue to support some of the highest bear densities in North America (Beausoleil 1999, R. Eastridge, Arkansas Game and Fish Commission, unpublished data). Those fertile bottomlands, however, were among the first to be developed for agriculture and other uses and now comprise only about 15 percent of their historic acreage (Gosselink and others 1989). Bears rapidly disappeared from those developed areas and, today, black bear populations in fragmented bottomlands are at greatest risk of extinction (Neal 1992, Bentzien 1998).

As the conversion of bottomland forests to farmland occurred, the less fertile, rugged land in the mountains remained relatively undeveloped. During the early to mid-1900s, many such upland areas came into public ownership, primarily as national forests and parks. Bears managed to persist in inaccessible reaches of many of these areas and later served to repopulate adjacent uplands where bear densities had been severely reduced (Clark and Pelton 1998). Today, many consider bears to be overabundant in portions of the region's uplands. Although bears were extirpated in the Cumberland Plateau of Tennessee and Kentucky, and in the Interior Highlands of Arkansas and Missouri, bear reintroduction programs in these areas have been successful (Smith and Clark 1994, Eastridge and Clark 2001).

OAKS, THE DRIVING FORCE

Simply put, bears could not survive in southeastern uplands today without oak mast. Acorns have been found to be the major fall food item of bears in virtually every study conducted in southeastern uplands (Vaughan 2002). Pelton (1989) describes acorns as the "driving force for bear population dynamics" in the southern Appalachians; the same is probably true in the Interior Highlands of Arkansas (Clapp 1990, Clark 1991).

Acorns are an important energy source for bears because they are relatively high in fat and carbohydrates (Inman 1997). High-energy fall diets enable bears to withstand the rigors of winter denning, production of young, lactation, and food scarcity in early spring (Poelker and Hartwell 1973, Eagle and Pelton 1983). During good acorn years, bears are capable of fulfilling their energy requirements for 4 to 6 months of hibernation during a 2- or 3-month period of intense foraging in the fall. Bears have been known to consume >20,000 calories in a 24-hr period while feeding on acorns (Nelson and others 1983). Additionally, acorns are sometimes eaten in spring following years of mast abundance. In the Interior Highlands, hard mast comprised up to 45 percent volume and 75 percent frequency of spring diets of bears during some years (Clapp 1990).

Bear movements increase dramatically in response to acorn abundance, known as the "fall shuffle." Their activity patterns change from being primarily crepuscular, to nearly continuous activity to forage on acorns (Garshelis and Pelton 1980). Bears seasonally shift their home ranges and movement patterns to take advantage of localized mast (Garshelis and Pelton 1981) resulting in long-range movements during mast shortages. Acorn failures can have a marked effect on bear mortality rates, with increased highway deaths being associated with the extensive movements. Also, hunting mortality can be dramatically affected during poor acorn years (Kane 1989, McDonald and others 1994, Noyce and Garshelis 1997), with greater movements leading to higher success among hound hunters and localized mast resulting in increased effectiveness of archery hunters. With sequential years of mast failure, outright starvation can occur.

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The lack of acorns also can result in reproductive failure (Eiler and others 1989, Pelton 1989). Bears have delayed implantation, with breeding and fertilization occurring in summer, and implantation of the blastocyst into the uterine wall in fall. Failure to implant may occur in females in poor physical condition. If implantation does take place in such cases, the newborn cubs may not survive because of the inability of the female to lactate (Vaughan 2002). Following den emergence, cub mortality during mast failures has been shown to be >80 percent (Vaughan 2002). Reproductive rates may be particularly impacted when mast failures occur in 2 sequential years, as has occurred in the southern Appalachians (Pelton 1989). Such mast failures also delay age of first reproduction in females and can cause reproductive synchrony in this biennial breeder. In good mast years following poor ones, parturition occurs among nearly all adult females. This will result in a large cohort of dispersing 2-year-old subadults, an age class vulnerable to hunting and more prone to nuisance activity. Those 2-year-olds will likely breed the following year and subsequently contribute to another large cohort. Thus, acorn failures and, to a lesser extent, good acorn crops, have long-lasting ecological effects on bear population dynamics.

BEARS, OAKS, AND COEVOLUTION

Acorns are an important source of fats and carbohydrates in the diets of not only bears, but >180 other wildlife species as well. Reproduction and survivorship for many species are closely coupled with acorn production. Population fluctuations of white-footed mice (*Peromyscus leucopus*), gray squirrels (*Sciurus carolinensis*), white-tailed deer (*Odocoileus virginianus*), blue jays (*Cyanocitta cristata*), and red-headed woodpeckers (*Melanerpes erythrocephalus*) have all been linked with fluctuations in acorn mast crops (Pearson 1953, Smith 1986, Elkington and others 1996, McCracken and others 1999). Because of these many acorn predators, oaks have developed mechanisms which reduce such predation.

Masting is the intermittent production of large seed crops by a population of plants (Kelly 1994). One hypothesis to explain this phenomenon is predator satiation (Salisbury 1942; Janzen 1971, 1975; Silvertown 1980, 1982; Koenig and Knops 2002). Under that hypothesis, seed predator populations are kept low in non-masting years because of the scarcity of seeds whereas, during heavy mast years, overabundant fruit places foraging limitations on mast predators. Masting must be episodic so that populations of mast predators do not have enough time to respond reproductively. Masting must also be synchronous over broad areas so that acorn predation is not affected by immigration from poor to good mast areas. Although weather patterns (e.g., spring frosts, drought) can affect acorn production, recent evidence suggests a natural periodicity to acorn production consistent with the predator satiation hypothesis (Sork and others 1993).

Additionally, acorns have an anti-predator defense, tannin, which makes them less palatable and digestible. Red oaks have higher tannin content than do white oaks, but white oaks sprout soon after they fall to the ground and, thus, do not need as much protection from predation (Fox 1982). Red oak acorns, on the other hand, have about three times the fat content as white oaks. Both the fat and the tannin are localized to certain portions of the acorns. White-footed mice, squirrels, and other animals prefer red oak acorns, perhaps because they can select the portion of the acorn with the highest fat and lowest tannin content for consumption (Fox 1982, Line 1999). Black bears consume acorns whole; consequently, they prefer white oak acorns. Thus, masting and tannin content in oaks appear to be adaptations to acorn predation by bears and other species.

Conversely, bears are well adapted to endure such acorn shortages and to take advantage of years of acorn abundance. Pelton (1989), in his review of the importance of oak mast to black bears, states that bears adjust physiologically, behaviorally, and ecologically in response to oak mast. Physiologically, bears are adapted systemically and hormonally to digest the fats and carbohydrates found in acorns (Brody and Pelton 1988). Once digested, bears have the ability to store large quantities of fat and to use that stored energy when needed. During hibernation, another adaptation to periods of food scarcity, that fat is converted to energy and urea and other byproducts are recycled (Nelson and others 1983). Weight loss during hibernation is from adipose tissue only; lean body mass is conserved.

Behaviorally, bears are able to scale trees to eat acorns from the canopy before the fruits fall. In acorn-rich areas, bears tend to partition themselves spatially and temporally, with minimal intraspecific conflicts, thus maximizing caloric intake while minimizing caloric expenditure. Rogers (1987) suggested that bears may first visit such food-rich areas as cubs and later return as adults. The high level of intelligence of these mammals undoubtedly helps them relocate areas where foods have been plentiful in the past.

Ecologically, bears are typical of a species adapted to fluctuating environmental conditions (Stearns 1977). The basic strategy for bears, in a teleological sense, is to produce young only when environmental (and, thus, physiological) conditions are favorable and, once born, invest a maximum amount of energy to ensure their survival. For example, bears have a long gestation period, delayed age of first reproduction, and a lengthy rearing period to maximize the chances that their progeny will survive. Litter sizes are small, enabling mothers to invest more energy to care for cubs. Also, bears may defer reproduction during periods of environmental stress (e.g., by implantation failure, fetal absorption). In years when food is scarce, bears enter dens earlier and avoid further energy expenditures. Thus, oaks and acorn predators such as bears are engaged in what has been called a “coevolutionary arms race.”

A CHANGING LANDSCAPE

Although oaks are “the driving force” today, that may not have always been the case. The oak forests that we associate with southeastern uplands are essentially second- and third-growth replacements. Additionally, many important food-producing plants (e.g., American chestnut) have been lost within the past century. Consequently, upland habitat where most southeastern bears reside has been significantly degraded.

It is difficult to imagine how the southern Appalachians must have looked when the American chestnut was a dominant tree; >40 percent of the overstory in the southern Blue Ridge Mountains once was chestnut (Keever 1953). The chestnut blight fungus (*Cryphonectria parasitica*), introduced around 1900, resulted in the nearly complete loss of American chestnut in the eastern U.S. (Keever 1953). Those oak-chestnut forests have since been replaced largely by oak-hickory forests (McCormick and Platt 1980). Besides being common, annual crops of chestnuts were more reliable, without the extreme fluctuations common to oaks. In North Carolina, mast production was estimated for 2 10-year periods; one before and one 35 years after the chestnut blight fungus had killed all mature chestnut trees (Diamond and others 2000). Total hard mast output was 34 percent less after the chestnut blight and annual pre-blight mast production was relatively stable, whereas annual post-blight production fluctuated substantially. These findings suggest that the loss of mature chestnuts markedly reduced the carrying capacity of southern Appalachian forests for certain wildlife species, which certainly included the black bear.

Bears have remarkable adaptability, and have flourished even with the loss of the American chestnut in the East. Nevertheless, changes are taking place in southeastern upland hardwood habitats that could negatively affect bears in the future. Past logging practices have resulted, not only in young forests in southeastern uplands, but in forest higrading and soil degradation as well. Another important consideration for bears is soft mast production, the importance of which may have been underestimated in the past (Inman 1997). Clapp (1990) found that soft mast [dominated by Carolina buckthorn (*Rhamnus caroliniana*), Virginia creeper (*Parthenocissus quinquefolia*), black cherries, (*Prunus serotina*), devil's walkingstick (*Aralia spinosa*), pokeweed berries (*Phytolacca americana*), blackgum (*Nyssa sylvatica*), and persimmon (*Diospyros virginiana*)] comprised a greater proportion of black bear diets in the Interior Highlands in 2 of 3 years than did hard mast. Blueberries (*Vaccineum* spp.), blackberries (*Rubus* spp.), cherries, and grapes (*Vitis* spp.) all respond favorably to light gaps and disturbance. Pokeweed, for example, requires soil disturbance to generate. Given the trend away from the creation of early successional stage habitats on national forests, such buffer foods may not be as abundant as in the past.

That is not to say that bears cannot thrive in mature hardwood forests. In Great Smoky Mountains National Park, for example, bear densities are high (Eason 2002). Forests in the Smokies, however, have a substantial old-growth component (>20 percent), and the large trees that fall create light gaps. It may be many years before such a dynamic is achieved in the second- and third-growth upland forests found on our national forests. Soft mast production may be low in the interim.

A change that has yet to fully strike the southeastern uplands is the invasion of the gypsy moth. These insects have defoliated oaks in much of Virginia, but bears there were able to make use of buffer foods (primarily soft mast including grapes and pokeweed) and shift their movement patterns to patches of oaks that were not affected by the moths (Kasbohm and others 1998). Again, changes in forest composition and a reduction in soft mast could greatly affect the ability of bears to withstand chronic reductions in acorns.

Bears are a mobile, wide ranging species, and have developed the physical and intellectual ability to take advantage of patchy, sporadic food resources. Fragmentation through clearing of woodlands for other uses and the construction of roads through prime bear habitat will greatly diminish the ability of bears to exploit such food resources. Although bears have demonstrated the plasticity to adapt to historic and recent habitat changes (i.e., chestnut blight, gypsy moths, and forest fragmentation), the cumulative effects of these perturbations, along with future problems (i.e., climate change and oak decline), may have a more widespread and lasting effect on bears.

Bears are inextricably linked with oaks in southeastern uplands. Managers should strive for a landscape mosaic comprised of red and white oak species interspersed with a wide array of soft mast to serve as buffer foods during acorn shortages. It is important to monitor changes in food-producing plants within bear range and to evaluate the effects those changes may have on bear population dynamics. Only then will we be able to explore ways to mitigate their effects.

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