

dynamics, and habitat of lynx in the contiguous United States, information necessary to delineate lynx range. The lynx is a medium-sized cat with long legs; large, well-furred paws; long tufts on the ears; and a short, black-tipped tail (McCord and Cardoza 1982). The lynx's long legs and large feet make it highly adapted for hunting in deep snow.

Lynx are highly specialized predators of snowshoe hare. The North American distribution of the lynx is nearly the same as that of the snowshoe hare, both of which are strongly associated with boreal forest (Bittner and Rongstad 1982; McCord and Cardoza 1982; Quinn and Parker 1987; Agee 2000; Aubry *et al.* 2000; McKelvey *et al.* 2000b). Boreal forests are cold and moist with conifer trees, the predominant type of trees being species of spruce and fir (Elliot-Fisk 1988). Lynx habitat can be generally described as boreal forests that have cold winters with deep snow and that provide a snowshoe hare prey base (Quinn and Parker 1987, McKelvey *et al.* 2000b, Mowat *et al.* 2000). For example, in the Northeast, lynx were most likely to occur in areas with greater than 268 centimeters (cm) (105 inches (in)) of annual snowfall (Hoving 2001). Boreal forests are naturally dynamic and, therefore, are known as "disturbance forests" (Elliot-Fisk 1988, Agee 2000). The landscape changes over time and location as the forest undergoes natural succession following natural or human-caused disturbances such as fire, insect epidemics, wind, ice, disease, and logging. Large-scale disturbance is necessary to create the mosaic of different successional forest stages that provide suitable foraging and denning habitat for lynx. Lynx in the contiguous United States are at the southern margins of a widely distributed lynx population that is most abundant in northern Canada and Alaska.

To understand habitat relationships of lynx one must first understand the habitat relationships of snowshoe hares, their primary prey. Snowshoe hares use spruce and fir forests with dense understories that provide forage, cover to escape from predators, and protection during extreme weather (Wolfe *et al.* 1982; Monthey 1986; Hodges 2000a, 2000b). Generally, earlier successional (younger) forest stages have greater understory structure than do mature forests and, therefore, support higher hare densities (Fuller 1999, Hodges 2000a, 2000b). Lynx generally concentrate their hunting activities in areas where hare populations are high (Koehler *et al.* 1979; Parker 1981; Ward and Krebs 1985; Major 1989; Murray *et*

*al.* 1994; O'Donoghue *et al.* 1997, 1998a). In Maine, snowshoe hare abundance and lynx occurrence are positively associated with late regeneration forests (forest stands that are growing back 12 to 30 years after being clear-cut and have greater than 50 percent canopy closure), evidence that lynx are selecting habitat primarily on the abundance of primary prey (Hoving 2001).

Lynx numbers and snowshoe hare densities in the contiguous United States generally do not get as high as in the center of their range in Canada, and there is no evidence they ever did so in the past (Hodges 2000a, 2000b; McKelvey *et al.* 2000b). It appears that northern and southern hare populations have similar cyclic dynamics but that in southern areas both peak and low densities are lower than in the north (Hodges 2000b). However, it is unclear whether hare populations cycle everywhere in the contiguous United States. Relatively low snowshoe hare densities at southern latitudes are likely a result of the naturally patchy, transitional boreal habitat at southern latitudes that prevents hare populations from achieving densities similar to those of the expansive northern boreal forest (Wolff 1980; Buehler and Keith 1982; Koehler 1990; Koehler and Aubry 1994). Additionally, the presence of more predators and competitors of hares at southern latitudes may inhibit the potential for high-density hare populations with extreme cyclic fluctuations (Wolff 1980). As a result of naturally lower snowshoe hare densities, lynx densities at the southern part of the range rarely achieve the high densities that occur in the northern boreal forest (Aubry *et al.* 2000).

The association between lynx and snowshoe hare is considered a classic predator-prey relationship (Saunders 1963; van Zyll de Jong 1966; Quinn and Parker 1987, Krebs *et al.* 2001). In northern Canada and Alaska, lynx populations fluctuate on approximately 10-year cycles that follow the cycles of hare populations (Elton and Nicholson 1942; Hodges 2000a, 2000b; McKelvey *et al.* 2000b). Generally, researchers believe that when hare populations are at their cyclic high, the interaction of predation and food supply causes hare populations to decline drastically (Buehler and Keith 1982; Krebs *et al.* 1995; O'Donoghue *et al.* 1997, Krebs *et al.* 2001). There is little evidence of regular snowshoe hare cycles in the Northeast and southern Quebec (Hoving 2001), but hare populations do fluctuate widely in this region. Hare fluctuations in this region may be more influenced by forest practices, weather, and other

ecological factors. Snowshoe hare provide the quality prey necessary to support high-density lynx populations (Brand and Keith 1979). Lynx also prey opportunistically on other small mammals and birds, particularly when hare populations decline (Nellis *et al.* 1972; Brand *et al.* 1976; McCord and Cardoza 1982; O'Donoghue *et al.* 1997, 1998a). Red squirrels (*Tamiasciurus hudsonicus*) are an important alternate prey (O'Donoghue *et al.* 1997; 1998a; Apps 2000; Aubry *et al.* 2000). However, a shift to alternate food sources may not sufficiently compensate for the decrease in hares consumed to be adequate for lynx reproduction and kitten survival (Brand and Keith 1979, Koehler 1990, Koehler and Aubry 1994). When snowshoe hare densities decline, the lower quality diet causes sudden decreases in the productivity of adult female lynx and decreased survival of kittens, if any are born during this time; as a result, recruitment of young into the population nearly ceases during cyclic lows of snowshoe hare populations (Nellis *et al.* 1972; Brand *et al.* 1976; Brand and Keith 1979; Poole 1994; Slough and Mowat 1996; O'Donoghue *et al.* 1997, Mowat *et al.* 2000).

Lynx den sites are found where coarse woody debris, such as downed logs and windfalls, provides denning sites with security and thermal cover for lynx kittens (McCord and Cardoza 1982; Koehler 1990; Koehler and Brittell 1990; Slough 1999; Squires and Laurion 2000; J. Organ, U.S. Fish and Wildlife Service, in litt. 1999). The integral component for all lynx den sites appears to be the amount of downed, woody debris present, not the age of the forest stand (Mowat *et al.* 2000). In Maine, 17 den sites have been located in a variety of stand types, including 10- to 20-year-old clear-cut and adjacent residual stands (J. Organ, U.S. Fish and Wildlife Service, in litt. 1999; G. Matula, Maine Department Inland Fisheries and Wildlife in litt. 2003). Maine den sites are characterized by regenerating hardwoods and softwoods, dense understory, and abundant coarse woody debris (J. Organ, in litt. 1999, 2003). In Washington, lynx denned in lodgepole pine (*Pinus contorta*), spruce (*Picea* spp.), and subalpine fir (*Abies lasiocarpa*) forests older than 200 years with an abundance of downed woody debris (Koehler 1990). A den site in Wyoming was located in a mature subalpine fir/lodgepole pine forest with abundant downed logs and dense understory (Squires and Laurion 2000).

Lynx require very large areas containing boreal forest habitat. In the Northeast, lynx were most likely to occur in areas containing suitable