Den sites of radiocollared Canada Lynx in Minnesota 2004-2007

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Summary

Den sites are used by female Canada lynx to raise kittens for a period of about 50 days after parturition. We reported on litter size, movements around the den site, and broad-scale habitat types around ten den sites in a peer-reviewed publication (Moen et al. 2008). Pictures of each den site, personal observations, and comments on den site characteristics that are not in the peer-reviewed publication are included in this report, in which we describe den sites found in Minnesota in more detail than can be done in a peer-reviewed publication. We also discuss characteristics of Minnesota den sites with respect to the den sites described in published literature.

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Introduction

The Canada lynx (*Lynx canadensis*) has received much attention from federal land managers in the lower 48 states since 1998 when it was proposed for listing as a Threatened Species under the Endangered Species Act (FWS 1998). The listing was finalized in 2000 when Canada lynx were classified as threatened in the continental United States with Distinct Population Segments (DPS) in northeastern, midwestern, and western states (FWS 2000). For the midwest DPS, the only consistent recent lynx presence documented has been in northeastern Minnesota (Burdett et al. 2006). The Superior National Forest (SNF) defines Lynx Analysis Units (LAUs) as the spatial basis for lynx management on the SNF. LAUs are consistent with the den site requirements set forth in the Lynx Conservation and Assessment Strategy (LCAS) (Ruediger 2000). Management policies for Canada lynx were included in the revision to the forest plans for both SNF and the Chippewa National Forest (USFS 2004a,b,c).

Management consideration of Canada lynx is mandated by law under the Endangered Species Act (ESA), and federal land managers in states with DPSs have developed management plans that address perceived needs of Canada lynx. Lynx biology is reviewed in two reports that are geographically broad in scope (Ruggerio et al. 2000, Ruediger et al. 2000) in addition to the listing documents and proposals for critical habitat by the Fish and Wildlife Service (FWS 1998, 2000, 2005a, 2008). Most of these documents were developed based on peer-reviewed literature available prior to publication, which means that data on lynx in Minnesota could not be included. The Canada lynx radiotelemetry research project began in 2003, and between 2003 and 2007 32 lynx were radiocollared in northeastern Minnesota (Moen et al. 2008).

Because Canada lynx in the continental U.S. is listed as a threatened species under the ESA, the SNF and other federal agencies consult with the Fish and Wildlife Service before making management decisions that might affect Canada lynx. Prior to this radiotelemetry project (Moen et al. 2008) the consultation was based on research conducted on lynx in other areas of the U.S. and Canada, even though conditions in the SNF are quite different from those encountered by the western lynx population. There is little altitudinal relief, and vegetation patterns and tree species vary. Common characteristics are also present for both regions, winter prey of lynx is primarily snowshoe hare in Minnesota (Hanson and Moen 2008) as in other regions (Squires and Ruggiero 2007).

Den site characteristics may be another feature of lynx biology that is relatively consistent across the geographic range, at least at the fine scale. The LCAS defines denning habitat as "Habitat used during parturition and rearing of young until they are mobile. The common component appears to be large amounts of coarse woody debris, either down logs or root wads. Coarse woody debris provides escape and thermal cover for kittens. Denning habitat may be found either in older mature forest of conifer or mixed conifer/deciduous types, or in regenerating stands (>20 years since disturbance)…." (Ruediger et al. 2000).

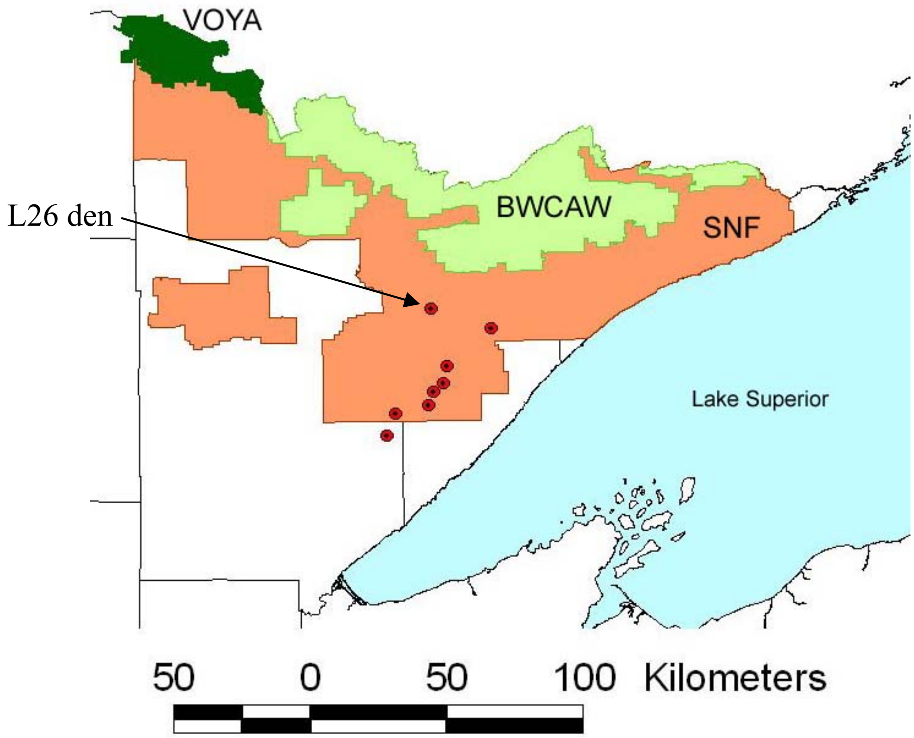
Because consultations with the FWS and actions undertaken using federal funds are required to be based on the best biological knowledge, a summary of characteristics of den sites found during the radiotelemetry research project on Canada lynx in the SNF would be useful. We briefly review existing literature on Canada lynx denning behavior and den sites. Next, we provide narrative descriptions and some summary data that is not published elsewhere on the 10 den sites of Canada lynx in Minnesota that were located as a part of the radiotelemetry study. We also include aerial photographs taken in 1991, 2003, and 2006 that show cover type composition around den site locations.

Methods

We have previously described the protocol for visiting den sites (Moen et al. 2004, 2005, 2008). Briefly, radiocollared females are monitored in early May and restricted movements indicated that kittens have been born (Apps 2000, Squires and Laurion 2000). We walked around the presumed den site when possible, taking multiple bearings at a distance of about 300 m before a den visit (Apps 2000, Squires and Laurion 2000). We visited dens when the ears of kittens are strong enough to hold ear tags, about 3-4 weeks after kittens were born (Moen et al. 2008).

We measured characteristics of the natal den site and maternal den sites if the female moved the kittens during the denning period. Some of the results from these measurements are published (Moen et al. 2008) and we include other results here. We measured vegetation characteristics at the den site and in the surrounding area after females and kittens left den sites. We recorded species, dbh, and status (alive or dead) for all stems ≥ 5.0 cm dbh within a 0.025 ha circular plot centered on the den site. We sampled the same attributes at 7 to 10 randomly placed plots within 200 m of the den site. One maternal den was on the edge of a clearcut and we modified random plot placement to prevent placing vegetation plots in the clearcut.

Figure 1. Locations of dens of radiocollared lynx in Minnesota from 2003 – 2007. Lynx den sites are shown in red (some overlap at this scale). The den site marked L26 is a presumed den area based on localization during early May but we did not confirm kittens or find actual den site. Other radiocollared females had kittens in far northern Minnesota or Ontario, and uncollared females likely had kittens in other areas of the SNF and BWCAW and surrounding areas. SNF = Superior National Forest, BWCAW = Boundary Waters Canoe Area and Wilderness, and VOYA = Voyageurs National Park.



All values are presented as means ± SD. The animal care protocol was approved by the Institutional Animal Care and Use Committee at the University of Minnesota (Codes 0301A39326 and 0602A81086).

Literature Review and Comparison to Minnesota Telemetry Project

The number of den sites found in research projects on Canada lynx varies among study locations and among studies (Table 1). The largest projects, from which 80% of recorded dens were found, included 39 dens from the Yukon Territory (Slough 1999), 52 dens in Montana (Squires et al. 2008), 37 dens in Colorado (T. Shenk, pers. comm.) and 27 dens in Maine (Organ et al. 2008). In other research projects 1 to 10 dens were found because the number of radiocollared lynx was low or den sites were not the research focus (Table 1). Despite this, some general patterns emerge.

Table 1. Den sites found in different types of cover at a small scale. In each case den sites were visited and categorized by cover at the den site in the original source, or we estimated based on descriptions in the source. In one case (Hatler 1988) it was unclear whether den site was in blowdown or logging debris. The last row indicates den site cover types used by *Lynx lynx* in Europe.

Location	Blowdown or CWD	Logging debris	Dense shrubs	Rocks	Base of tree	Total	Reference
AK	3	0	0	0	0	3	Berrie (1974)
AK	1	0	0	0	0	1	Stephenson (1986)
AK	0	0	0	0	0	0	Kesterson (1988)
BC	0.5	0.5	0	0	0	1	Hatler 1988[a]
YT	34	0	3	0	2	39	Slough 1999
AB	5	0	0	0	0	5	Poole 1992
WY	1	0	0	0	1	2	Squires and Laurion 2000
MT	4	0	0	0	0	4	Squires and Laurion 2000
WA	4	0	0	0	0	4	Koehler 1990
MN	9	1	0	0	0	10	Moen 2008
MT	42	3	0	5	2	52	Squires et al. 2008
ME						27	Organ et al. 2008
CO	26	0	5	3	2	37 [b]	T. Shenk (Pers. Comm.)
BC	1	0	0	0	0	1	Apps 2000
Sum	130.5	4.5	8	8	7	159	
All (%)	82	3	5	5	4		All studies above
$n \leq 10$ (%)	92	5	0	0	3		Studies with ≤ 10 dens
Lynx lynx	10	2	2	64	17	42	Boutros et al. 2007 [c]

[a] Cited in Mowat et al. 2000
[b] One den did not fit these categories (Hollowed out log)
[c] 5% (2 of 42) dens located in earth lair without cover

Microsite locations

At the microsite level, structure at the den site is more important than cover type (Mowat et al. 2000). Presence of horizontal and vertical cover appears to be more important than whether a den site is located on mature forest or regenerating forest. Downed trees, branches, or thick regeneration provide some sort of horizontal and vertical cover in most den sites. Den sites in Montana had more horizontal cover and a higher log volume (Squires et al. 2008). Den sites have been found in blowdown (crown, roots, or along bole), in logging debris, areas with dense shrubs, in rocks, or at the bases of large trees (Organ et al. 2008). Blowdown trees, in which the boles are horizontal, are the most common den site used. Den sites are located either under the branches at the top of the tree which provide thick cover, or closer to the root clump. About 85% of dens have been found in blowdown areas across all studies (92% if the three large studies are excluded). Other types of den sites provide the functional equivalent of a downed tree: root wads of trees along a river bank (Berrie 1975), dense shrubby undergrowth, or logging slash.

Den sites in Minnesota were mostly found in blowdown areas. The size and intensity of the blowdown area varied. The range that we observed went from 1 stem to a cluster of 5-6 stems to an area > 1 ha with multiple stems that had been blown over. As with den sites located in other areas, the common theme seemed to be dense vertical and horizontal cover which was often provided by the tops of trees in Minnesota (Fig. 1). However, dense cover was in some cases limited to the blowdown tree which the den site was located under.

Sites used for denning also vary by types of den locations that are available and by *Lynx* species. *L. lynx* used primarily rock dens in the mountains of Europe (Table 1) with no difference between natal and maternal dens (Boutros 2001). Tree dens were located at the bases of trees and windthrows rather than at the tops of windthrown trees. *L. pardinius* maternal dens were all in hollow trees (Fernandez and Palomares 2000; Fernandez et al. 2002), a site type not used by other *Lynx* species. Maternal dens for *L. pardinius* were located in trees in brushy areas.

Figure 2. Views of den site locations: (A) Looking away from L17 den site in 2006, (B) looking at L13 den site in 2005, (C) Looking at den site of L07 in 2004, (D) looking away from L07 den site in 2004 (L07 visible in center), (E) pointing at location of L07 kittens (note balsam fir as source of horizontal cover, and kittens not underneath branches and twigs), and (F) L14 den site in 2004 was located in this cluster of blowdown trees.

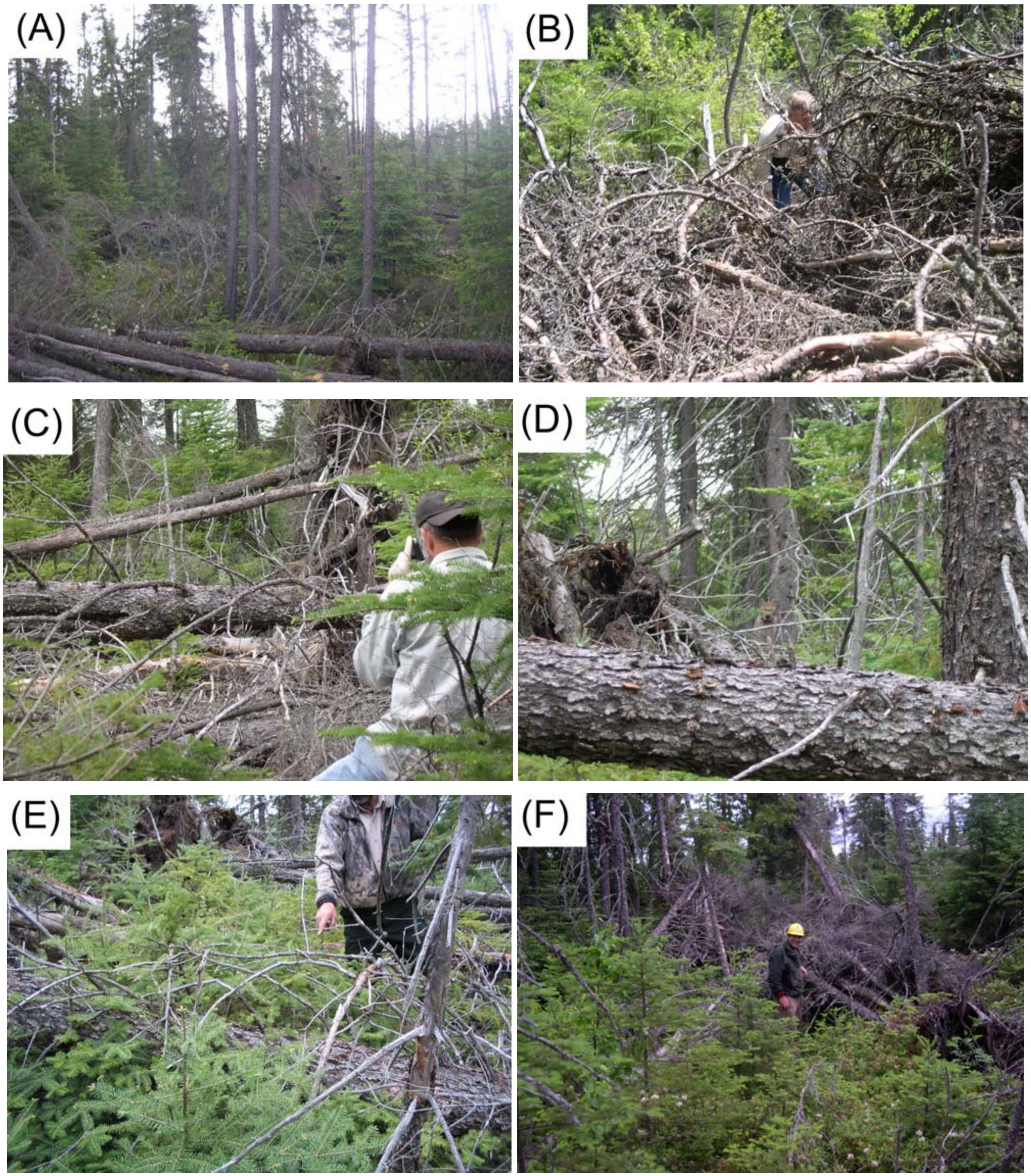


Figure 3. Views of den site locations: (A) L14 den site close-up in 2004, (B) L14 den site in 2005, (C) L17 den site in 2006 was underneath this pile, boles are about 1.75 m above ground, (D) looking away from den site of L17 in 2006, (E) downed tree associated with L31 den site in 2005, and (F) area adjacent to downed tree where kittens were found (kittens are huddled in center of picture). The den site in (F) is the only den site in an open area we located.

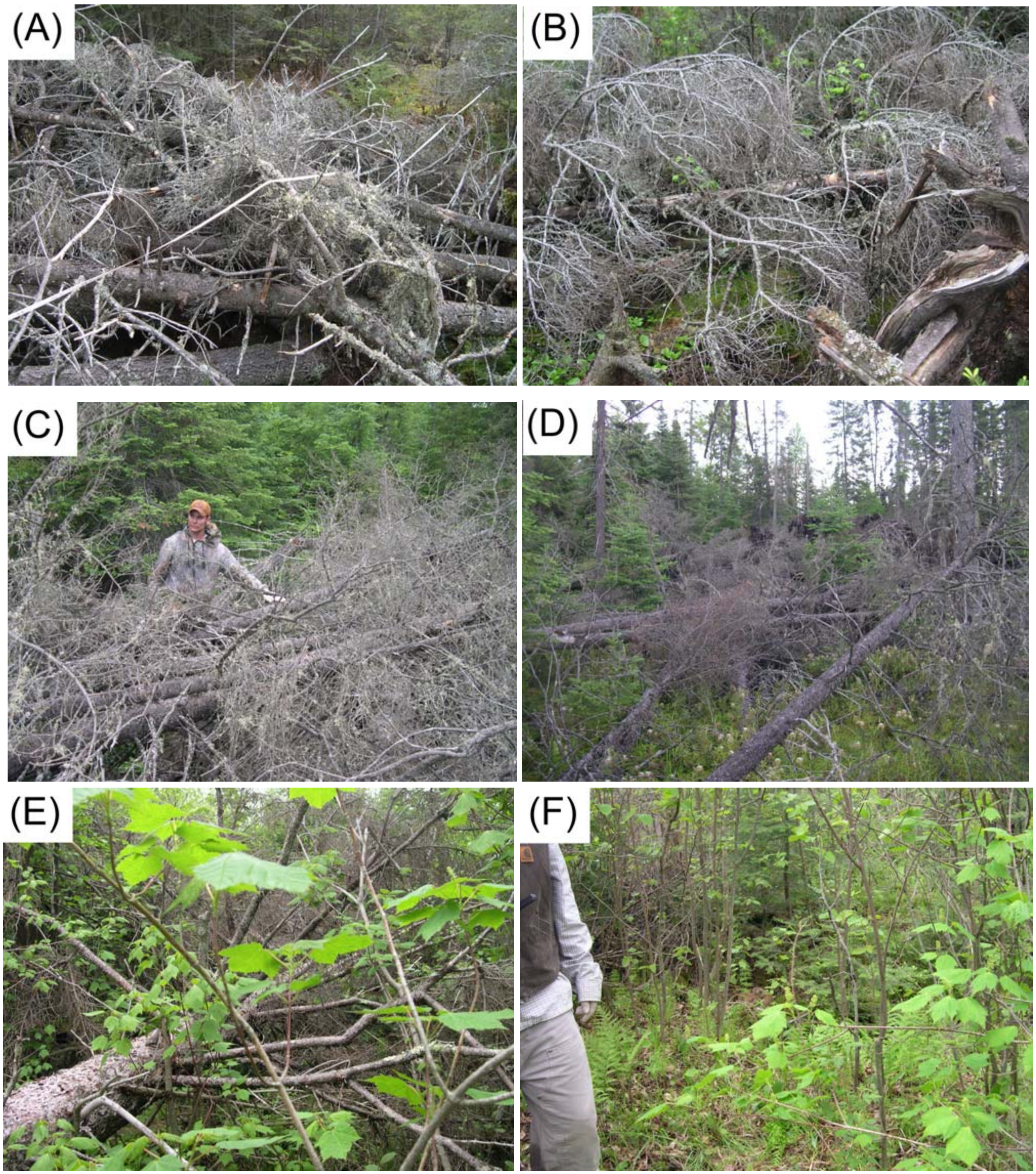
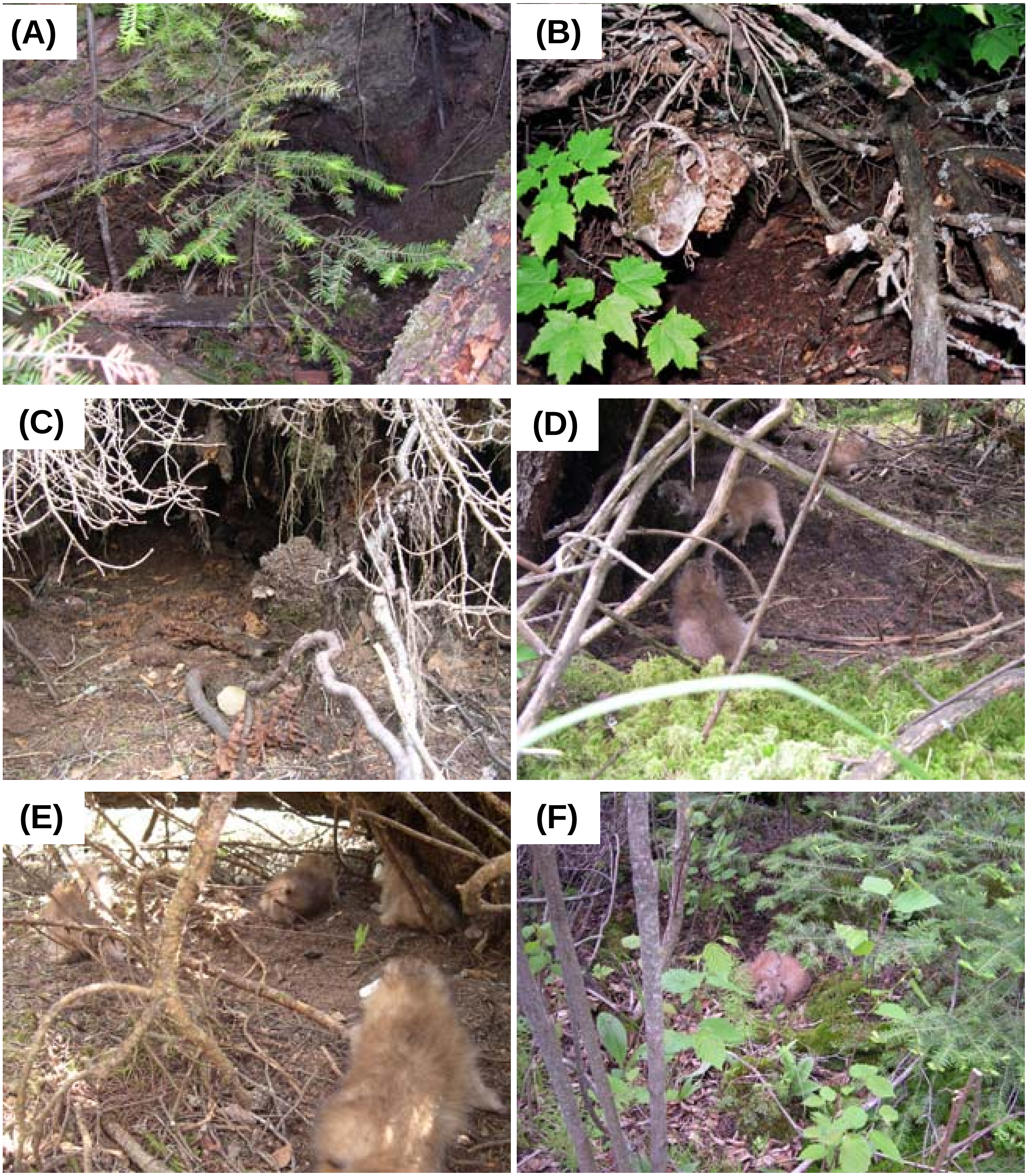


Figure 4. Views of depression in which kittens were found for: (A) L07 in 2004 (underneath hole behind the small balsam fir, (B) L13 in 2004, (C) L14 in 2004, (D) L07 in 2005, (E) L13 in 2005, and (F) L31 in 2005.



Parturition dates and time at den

Selection of den site location does not appear to occur much before parturition. Females do not spend extended periods of time where the future den will be located. We used GPS collars set to collect locations 4 times per day. In a sample of about 100 locations for each female prior to parturition there were very few locations near the future den location. In 40 days prior to parturition, the mean distance from the den site (± SEM) was 2294 ± 178 m for L07, L13, and L14 in the year that they wore a GPS collar. The GPS collar locations were < 500 m from the future den site in only 4 ± 1% of locations and only once < 100 m. A female could have visited the future den site in between GPS collar locations taken 6 hours apart, but evidence suggests that she was not at or near the future den site frequently.

Lynx have a gestation period of about 60 days, and most kittens are born in May and June. Lynx in northern latitudes give birth in late May and early June (Poole, 2003). In the Yukon Territory at 60^{o} latitude, mean date of parturition was May 23 (± 6 days) for adult females and June 17 (± 7 days) for 5 yearlings (Slough 1999). Date of parturition in Minnesota, at about 45^{o} latitude was 7 May (± 2 days) for 3 adult females based on GPS collar locations (Moen et al. 2008). A known-age 2-year old female (bred at 22 months) had a later litter, estimated at May 24 (Moen et al. 2008). Kittens in other southern populations of lynx are also born in early May, but parturition dates have not been published (Squires et al. 2008, Organ et al. 2008).

Dens are used until kittens are 6 to 8 weeks old (Mowat et al. 2000). When we used GPS collars on females with kittens, female and kittens left the den at about 7 weeks of age (Moen et al. 2008). The 6-8 week estimate of Mowat et al. was based on VHF telemetry which did not allow as frequent locations as are possible with GPS collars. Based on GPS collar data with locations taken 6 hours apart, the female did not return to the den site after kittens left the den. For two females, the mean distance (± SEM) from the den site after leaving it with the kittens 7 weeks after parturition was 1948 ± 12 for L07 and L14. After leaving a den with her kittens, the GPS collar locations were < 500 m from the den site in only 3 ± 1% of locations and only once < 100 m, very similar to the location data before parturition (see above).

Movement of dens – natal / maternal and between years

The lynx literature refers to natal and maternal dens. Natal dens are the dens at which kittens are born, while maternal dens are dens which the female moves the kittens to. *Lynx lynx*, *L. canadensis*, and *L. pardinius* all use both natal and maternal dens (Fernandez and Palomares 2000, Boutrous et al. 2007, Fernandez et al., 2002). Females moved kittens both before and after den site visits are made (Slough 1999, Squires and Laurion 2000). We detected one case of a female moving her kittens before a den site visit from GPS collar locations, and another case of a female moving her kittens after a den site visit based on ground telemetry locations (Moen et al. 2008). Movements between natal and maternal den sites are relatively short, with older literature indicating the longest recorded movements being 300 m (Slough 1999), a movement of 200 m was recorded in Montana (Squires and Laurion 2000). From a large recent data set, the longest distance between natal and maternal dens was 2.7 km, with a median distance of 107 m indicating that most distances between den sites were shorter (Squires et al. 2008). Distances between natal and maternal dens in the Minnesota telemetry project were 300 m before the den site visit and 140 m after the den site visit (Moen et al. 2008).

A subjective analysis of den site characteristics suggested that natal and maternal dens are not different (Slough 1999). Similarly, there were no statistical differences in measured characteristics between natal and maternal dens for *L. lynx* in Europe or for *L. canadensis* in Montana (Koubros 2002, Squires et al. 2008). Thus natal and maternal dens are considered together in analyses in this report as elsewhere.

When lynx populations are high adjacent females can den from 0.3 to 2.5 km apart (Slough 1999). Females usually use different den sites each year that they den. Of 8 females that were monitored over 2 years, den sites between years were separated by 300 to 900 m, and females monitored over 4 years had den sites that were 1.8 to 4.2 km apart (Slough 1999). Similarly, in the Minnesota telemetry project distances between dens in consecutive years were close and far away, with distances between den sites in consecutive years of 28, 172, 6344, and 8320 m. Longer movements occurred in Montana, with average distance moved of 2.2 km between years (Squires et al. 2008). In one case in Montana a female used the same den two years in a row while in another case the den was 7.3 km from the previous year's den (Squires et al. 2008).

Broader scale habitat – aerial pictures

Female lynx use a habitat mosaic that includes both foraging habitat and cover for denning in Minnesota (Moen et al. 2008). In a western landscape dominated by mature forests and cut areas, lynx tended to use older forests for denning (Squires et al. 2008). However, lynx do not require mature forest for den sites (Murray et al. 2008). In a 25-year old regenerating forest that included patches of mature timber, most lynx dens were found in the regenerating forest but dens were also found in mature timber and seedling areas (Organ et al. 2008). Lynx with home ranges inside of a 30-year old burn in the Northwest Territories denned in the regenerating burnt area under deadfalls (Slough 1999), even though some mature forest habitat was available. Use and Availability statistics were not calculated by either Slough or Organ et al.

Until recently papers on lynx den sites were not written from landscape perspective. In the study of Slough (1999) lynx home ranges were inside of a regenerating burn with very little mature forest present. Prey should have been available in this regenerating forest, just as prey would be available in younger forests in the habitat matrices in Maine and Minnesota. Assuming that female lynx needed both cover and food near the den site, Moen et al. (2008) mapped areas that had the highest probably of being used by lynx for denning in northeastern MN.

In Minnesota den sites are often associated with wetland areas. It was not emphasized in Moen et al. (2008) but the area around a den site had markedly different cover type composition from even 300 m away. There was an increase in lowland conifer cover type because the dens were often located in low-lying wet areas. Dens were on small patches of upland that were surrounded by these wetter low-lying areas. The cause for this has not been determined, but it is possible that shallow soils in the low-lying areas increased the chance that windthrow would occur. A possibly similar correlation was detected in Maine: even though lynx do not use tip-up mounds, there was a positive correlation between tip-up mounds and lynx dens because the CWD associated with tip-up mounds was used by lynx for denning (Organ et al. 2008).

It appears that lynx are adaptable in terms of the selection of habitats to den in, but also that there are preferences for specific types of areas being used for denning. The mix of either wet bog or older forest cover types associated with younger forests that would provide a food resource is evident in Figs. 5 – 8, as well as the transitions in cover types that can occur over the scale of a den site and daily foraging radius.

Figure 5. Aerial view of den site of L13 in 2004 with pictures taken in 1991 and 2003. In 1991 after cutting there was little snowshoe hare habitat available. By 2003 the future den site was surrounded by red pine and jack pine plantations with a high density of snowshoe hare.

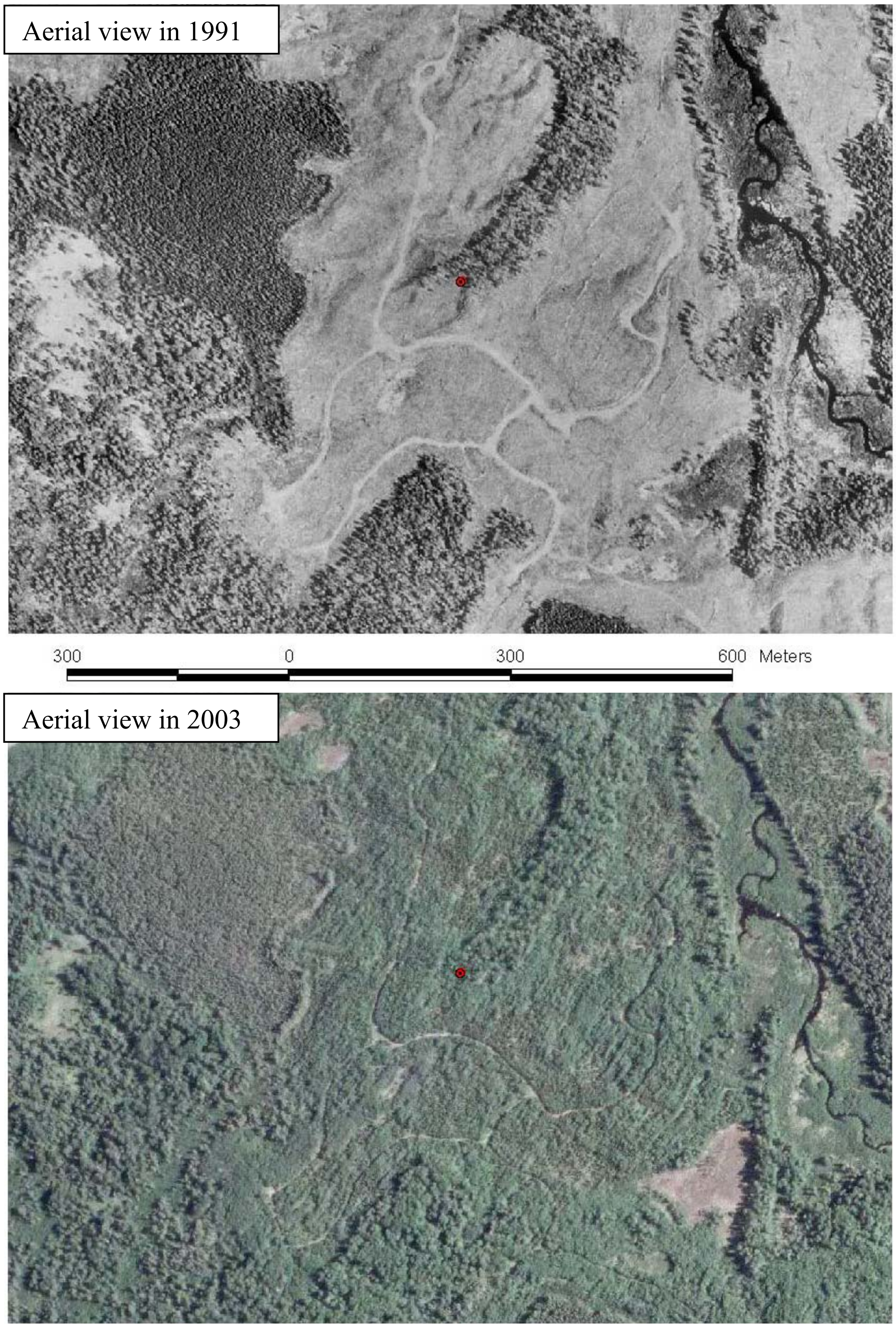


Figure 6. Aerial view of den site of L13 in 2005 with pictures taken in 1991 and 2003. This location was 8 km north of L13's den site in 2004. Note the house (with dog and cats) 300 m west of den site. The area to the SW of den site was cut and regenerated to aspen with no conifer in the understory.

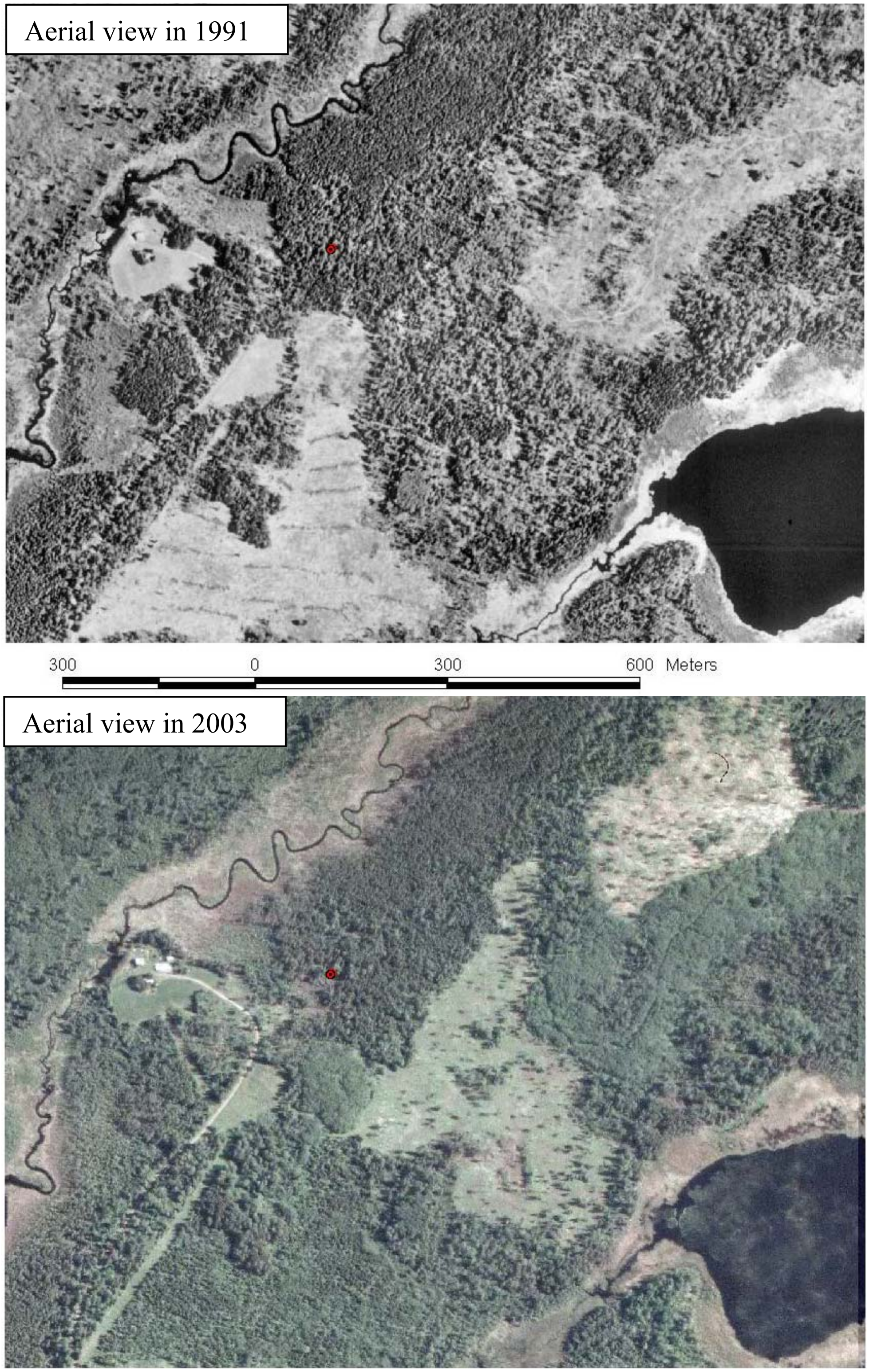


Figure 7. Aerial view of den sites of L07 in 2004 and 2005 with pictures taken in 1991 at low and high resolution. In (B) the 50% and 95% kernel home range for L07 is shown.

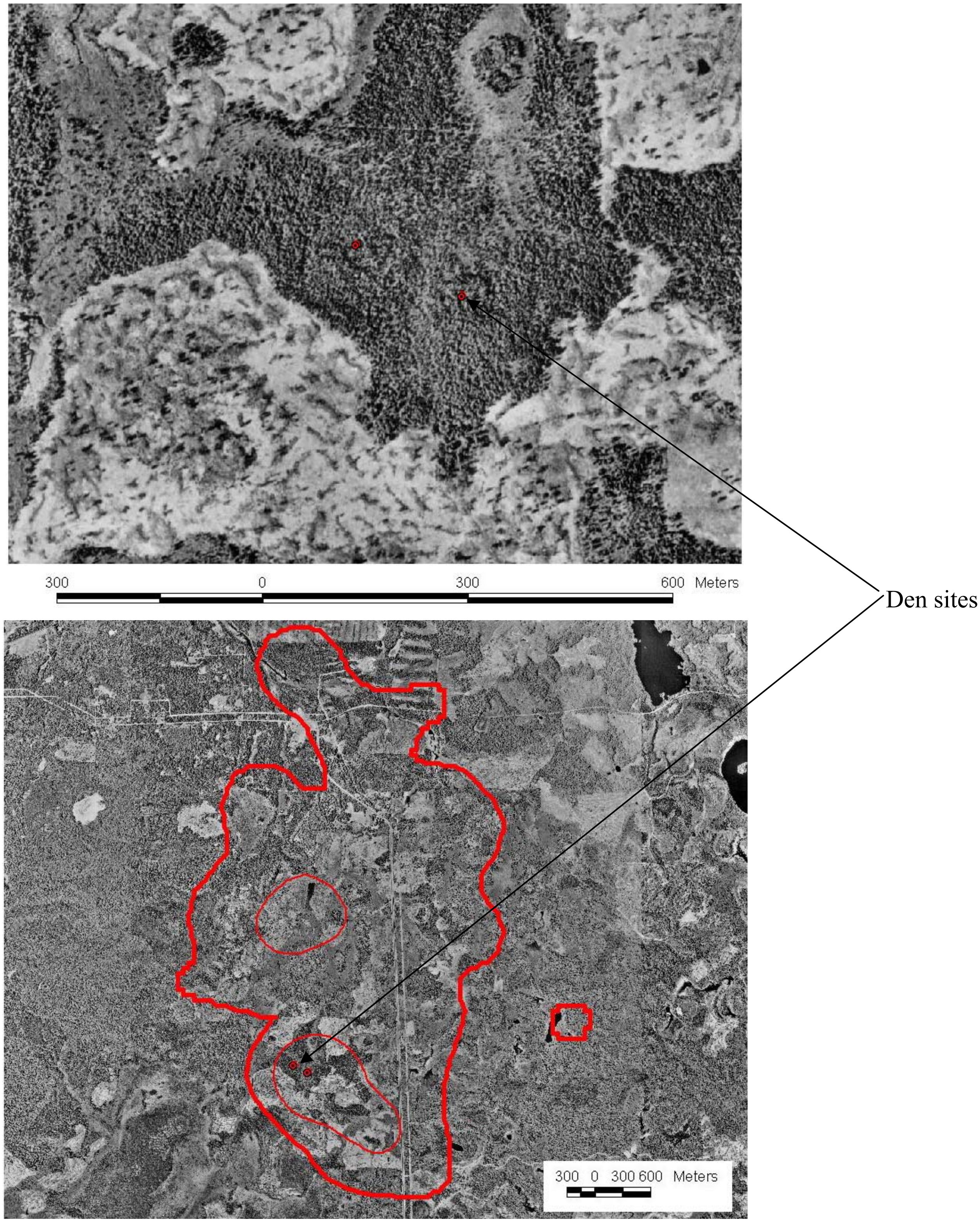


Figure 8. High resolution aerial view of area around 2004 den site of L07 with pictures taken in 2005. The blowdown trees existed in 2004 when L07 denned here.

Forest characteristics surrounding den sites

In some cases the results from field measurements may initially be counter-intuitive. We measured stem density and basal area for trees (> 5 cm dbh) and found that the stem density was lower at the den site in all but one den, and that basal area was usually lower at the den site (Fig.

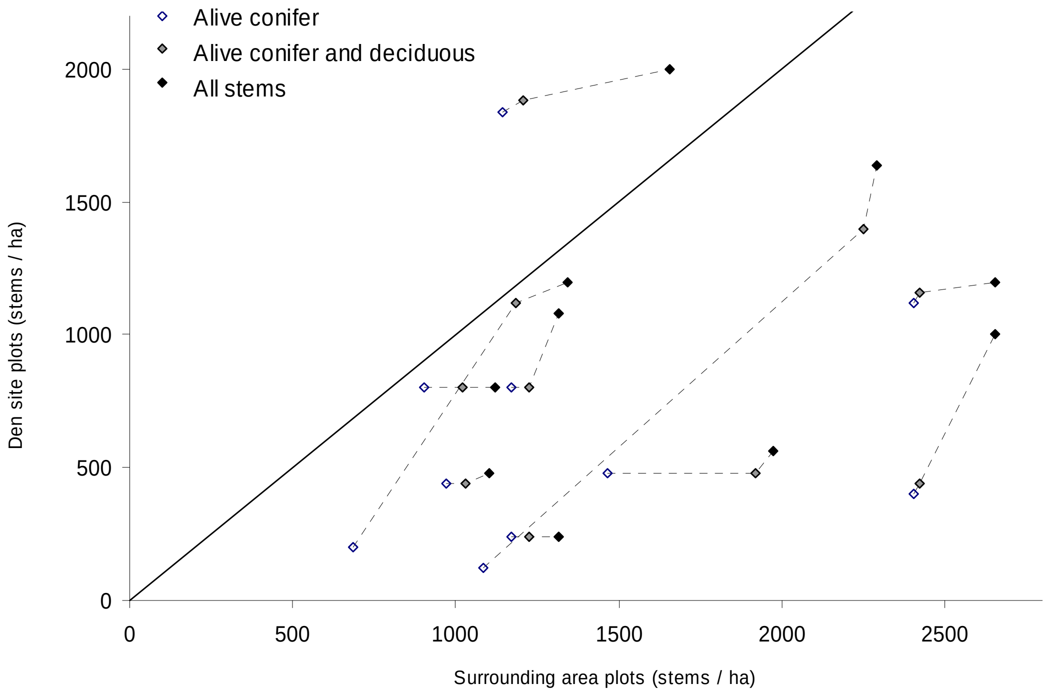
9). This is not what one might expect given the past emphasis on the importance of horizontal and vertical cover. However, because den sites are often located in blowdown areas, the tree stem density is decreased and basal area is lower (visible in Fig. 8). There is a horizontal cover component that comes from dead blowdown trees. Another component of horizontal cover visible in Figs. 2-8 is thick regeneration of balsam fir that would not be measured when measuring stems with dbh > 5 cm.

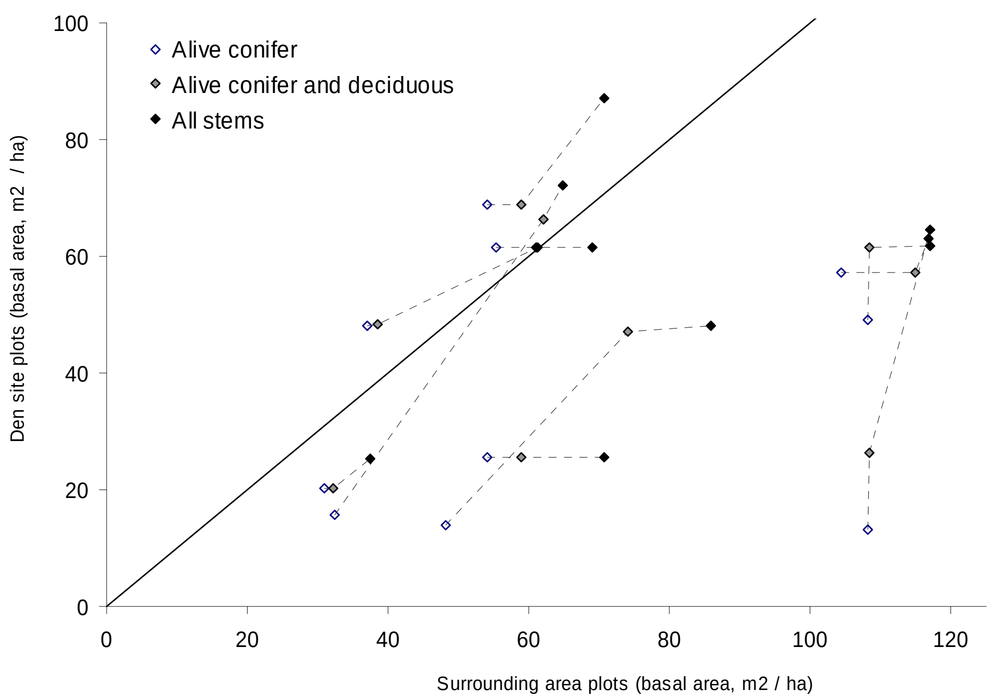
Summary

This report describes typical lynx den sites that we found in Minnesota. A generalization for the dens that we found is that vertical cover is very thick but does not need to extend more than 1-2 m above ground level. The LCAS description of denning habitat as "…large amounts of coarse woody debris, either down logs or root wads. Coarse woody debris provides escape and thermal cover for kittens. Denning habitat may be found either in older mature forest of conifer or mixed conifer/deciduous types, or in regenerating stands (>20 years since disturbance)…." (Ruediger et al. 2000) fits, but should perhaps be extended to consider flexibility demonstrated by female lynx in Minnesota and elsewhere. Horizontal cover is usually very dense at the den site, but varies as one moves away from the den site, and even varies based on the direction away from the den site one is looking. There are residual trees, but because dens are usually associated with a blowdown area, the residual trees are less dense than trees in the background forest cover type matrix. At the broader scale, lynx did not need to move out of their home ranges in order to find a den site that was suitable. In some cases lynx denned on the edge of their home range, in other cases the den site was closer to the center of a home range.

Because females are able to find den sites within an existing home range, there probably are suitable den sites at the scale of a lynx home range in Minnesota, just as there are in Maine (Organ et al. 2008). One possible way to test this assumption would be to use transects across known lynx home ranges and identify how many potential den site locations exist at the scale of the foraging radius documented for lynx while kittens are in dens (Moen et al. 2008). One could measure blowdown clump density in lowland conifer, upland conifer, mixed forest either in the field or with high-resolution aerial photographs. Blowdown clump density may be higher in the lowland conifer cover type, or other characteristics may make the lowland conifer cover type more desirable for lynx dens.

Figure 9. Stem density and basal area at the den site and in surrounding areas. Dashed lines connect the measurements from the same plot of alive conifer, alive conifer and deciduous, and all stems. If measurements were similar at the den site and in the surrounding area, they would fall near the diagonal line.





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