U.S. Fish & Wildlife Service

Northwest Boreal Lynx Project
2016 Summary Report for Tetlin National Wildlife Refuge

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Refuge Report
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Project Summary

Biologists and staff at Tetlin NWR have now completed two successful field seasons live-capturing Canada lynx (*Lynx canadensis*) for the purpose of tracking their long-term movements. GPS collars were deployed on 6 lynx during the winter of 2014-15. Of those 6 lynx, 3 are known to have survived until the 2015-16 field season, 1 female was confirmed to have 4 kittens, and GPS locations from another female indicated denning activity. Two of the surviving lynx were recaptured and given new GPS collars during the winter of 2015-16, and an additional 10 lynx were collared for the first time in 2015-16. Juveniles were captured on 4 occasions in late winter of 2015-16, but were too small to carry GPS collars. Den sites were located for 4 females in June of 2016 and litter sizes ranged from 4 to 6.

Project Goal

The primary objective of this project is to determine changes in movements by lynx during the course of a snowshoe hare population cycle. It has been postulated that, at large spatial scales, lynx move long distances in response to a wave-like decline in hare abundance across the boreal forests of North America; lynx that locate sufficient prey resources survive and reproduce at a higher rate than lynx that move to or remain in areas of low prey abundance. For example, as hare abundance in western Canada begins to decline, some lynx residing in that region are likely to move into and across Alaska as they follow a traveling peak of hare abundance to the northern and western extents of their range. By deploying GPS collars on lynx distributed throughout interior Alaska and western Canada, we hope to collect location data and document some of these long-range movements made by lynx in response to fluctuating hare abundance. Tetlin NWR is working in collaboration with Dr. Knut Kielland (University of Alaska Fairbanks), Koyukuk/Nowitna NWR, Yukon Flats NWR, Kanuti NWR, Gates of the Arctic NPP, Fort Wainwright Military Lands, as well as researchers operating in the Yukon Territory to collar lynx throughout much of the northwestern boreal forests of North America. Large-scale movements by lynx might also be detected through differences in isotopic signatures in parts of the animal and the surrounding landscape. We will be using strontium isotopes in teeth from lynx skulls, provided by fur trappers from around the state, to determine the likelihood that lynx emigrated from different regions of Alaska or Canada.

The secondary objective of the project is to learn about the habitat use, diet, reproduction, predation rates, and general movement patterns of lynx on Tetlin NWR by documenting their locations on a shorter time scale. We are using 4-hr GPS fix intervals and satellite data transmissions to estimate diel movement rates and behavior patterns, home ranges, and to track individuals on foot in order to measure rates of predation and identify prey items. Satellite data transmissions also notify us of mortality events, enabling rapid recovery of carcasses and identification of the causes of mortality. We also plan to use genetic and isotopic analyses of biological samples (e.g. hair, whiskers, blood, and feces) taken from captured and deceased lynx to assist us in determining the movements and relationships between lynx populations at local and regional scales.

Study Area

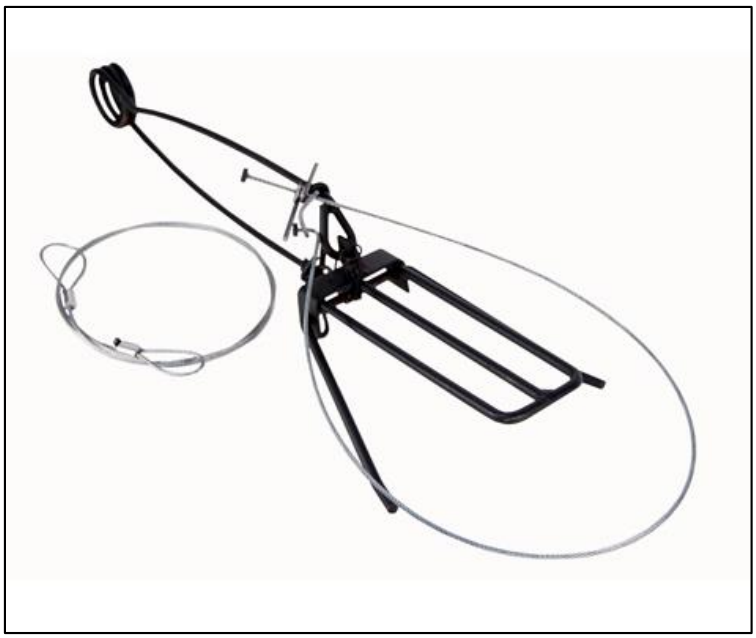
We conducted live-capture efforts on Tetlin NWR as well as on state lands up to 30 miles west and 20 miles south of Tok, Alaska (Figure 1). Trapping effort was higher during the late winter months (February-April) when snow cover enabled the use of snowmachines for travel on the refuge, although attempts were made to trap as early as November along the road system near Tok. Trapping efforts on the refuge were conducted near 3 cabins, spanning an area approximately 90 km across. Traplines were primarily located in black spruce (*Picea mariana*), white spruce (*Picea glauca*), Alaska birch (*Betula neoalaskana*), aspen (*Populus tremuloides*), and mixed forests, as well as in 10- to 60-year-old burns, muskeg, lake margins, and within willow (*Salix spp.*), alder (*Alnus spp.*) and balsam poplar (*Populus balsamifera*) creek bottoms and river corridors.

Capture Methods

We followed live-capture methods approved by University of Alaska Fairbanks IACUC (protocol #135202-8). In order to safely live-capture lynx in the cold temperatures that characterize winters in interior Alaska, we used modified Belisle (#6) and Fremont foot-snare devices, as well as box traps, which offered a higher level of safety by allowing captured individuals to move freely within a cage until released. Belisle traps have a pair of jaws and springs that function much like a traditional foothold trap, but one of the jaws delivers a snare cable above the paw of the captured animal. After the jaws have closed, the springs are intended to fall away from the trap and release the jaws from the animal's foot, leaving the animal attached to an anchor only by the snare cable. We weakened the spring tension on the spring arms of the Belisle traps to minimize the risk of injury from the jaws, and we flattened and shortened the ledges on which the spring arms rest in order to facilitate the release of the spring arms and the reopening of the trap jaws after the snare was delivered.

Examples of box traps pre-fabricated with lumber, wire mesh, and poultry netting (left), or constructed on site with logs and plywood (right). The sliding door closes by way of a cable-actuated release mechanism connected to either a wooden treadle or bait.

The Fremont trap delivers a snare cable to the captured animal's foot by way of a single, elongated spring arm that is released when the pan is depressed. The manufacturer's trap pan consists only of bare metal rods, which we felt was not ideal for trapping lynx in winter conditions. Consequently, we attached the plastic lid from a 2-gallon paint bucket to each of the pans in order to provide a larger, continuous surface for the lynx to step on. We sanded the lids until they no longer had a slippery texture. We then attached 16-gauge wire to the enlarged pans of the Fremont traps in order to provide a reliable and adjustable ledge on which to rest the snare cable above the pan. However, after finding that this arrangement appeared to prevent the snare cable from closing above the lynx's paw, we instead propped up the snare cable with sticks placed around the trap, or with wire attached to the support legs of the trap (independent of the pan's movement). We attempted to rest the snare cable 1-2" above the pan.



Comparison of the original Fremont foot snare (left) and our modified version (right) with surgical tubing, plastic pan, and snare support wires.

We used both 3/32" and 1/16" snare cables in combination with slim locks (non-relaxing) and micro locks (relaxing) and outfitted them with at least 9 cm of surgical tubing to ensure that blood circulation to the capture foot was not cut off. We feel that relaxing locks are preferable for our work as they allow the foot snare to relax, increasing blood flow to the capture foot without the snare opening enough for the animal to escape. Traps were monitored on a daily basis, most often with the use of VHF trap monitors, which were programmed to change pulse rates when triggered by an animal.

Foot snare traps were placed in a variety of set types that included cubbies, blind sets in animal tracks or snowmachine trails, scent posts, and pee posts. We used a combination of scent lures and visual attractors to bring lynx into trap sets. We baited cubbies with snowshoe hare, grouse carcasses, beaver, muskrat, and fish, and used both commercial and homemade lures that were primarily castor-based with catnip oil or skunk essence as additional components. We used lynx urine at pee post sets, and often at scent post or cubby sets as well. We used grouse and duck wings, CD's, aluminum foil, and other reflective or mobile items as visual attractors ("flashers").

Belisle foot snare in a cubby set (left) and Fremont foot snare in a pee post set (right).

Foot snare traps were initially anchored to standing trees using 3/32" steel cable (1x19 or 7x7 strand) that was wrapped around the base of the anchor tree and secured to the trap and/or snare cable using a steel quick-link. Branches were cleared from the base of the anchor tree up to approximately 1.5 m. All standing vegetation in the trap site was cut, and any structural items used in the set were small enough to fall over easily in order to prevent injuries to a captured animal. Large sections of green trees weighing at least 15 kg were also used as anchors by cutting and clearing them of branches, then burying them in the snow. These buried logs were later used exclusively as the anchor point for traps because, unlike standing anchor trees, it was nearly impossible for the snare and anchor cables to become entangled around a buried tree.

Captured lynx were anaesthetized by delivering Telazol (100 mg/mL) to the hindquarters using a jabstick. Depending on the apparent size and age of the animal, we initially administered between 0.1 and 0.3 mL of Telazol using a 16 gauge ¾" needle. If additional doses were needed, we typically injected them by hand in 0.1 mL increments using a 20 gauge 1" needle. Lynx were often immobilized for more than 1 hour before gradually regaining use of their limbs. During this time, we monitored vitals and recorded morphological measurements while a GPS collar (Advanced Telemetry Systems G2110L) was fitted to the animal. We also collected hair and whisker samples from individuals when they were first captured.

Most GPS collars were deployed without a breakaway mechanism in the hopes that a collar would be returned by fur trappers (if caught) or by whomever might recover the carcass in the event of a long-distance movement away from the refuge. In some instances, the collar was not large enough to fit around a lynx neck without a breakaway mechanism, and in these cases we deployed breakaways programmed to release after 5 years.

Lynx Captures and Trap Effectiveness

2014-15 Field Season - We conducted trapping efforts from January to April in 2015 and captured and collared 6 adult lynx (3 males, 3 females). All captures took place between 6 March and 3 April. The only recaptured animal was a male caught 2 days after he was collared. Half of the captured lynx were caught in Belisle traps and the other half were caught in Fremont traps, although we observed differences in the effectiveness of these traps. We used only 5 Fremont traps compared with 36 Belisle traps, but the Fremont traps had a 100% success rate, whereas we had numerous lynx pull out of the Belisle snares. We suspect that lynx often stepped on the Belisle trap in a way that prevented the snare cable from closing above their paws, which allowed them to pull out of the snare. This was probably a function of the trap's

jaw size which was small relative to a lynx paw. While this problem can partially be alleviated with the use of numerous guide sticks that lead a lynx to step squarely inside of the trap jaws, we concluded that Fremont traps, despite being more awkward and time consuming to set, were a better trap for our purposes.

We also used 2 Tomahawk box traps and 2 box traps that we constructed from wood, chicken wire, and wire mesh, which employed a sliding door that was released by a cable attached to a treadle. However, lynx did not enter any of the box traps.

2015-16 Field Season - We conducted trapping efforts from October 2015 to April 2016 and captured and collared 13 adult lynx (8 males, 5 females; Table 1). Captures took place between 11 February and 26 March. Two of these animals (1 male, 1 female) were first captured during the previous field season. Juveniles (2 males, 2 females) were captured on 4 occasions, but due to the absence of identifying marks we cannot be sure whether they were 4 different individuals. We were unable to deploy GPS collars on juveniles because the weight of the collar exceeded 5% of the animal's body mass and their necks were not of adult size. There are lighter GPS collars available, but they would require the use of expandable collar material in order to safely accommodate the growth of a juvenile's neck over time.

We used 50 Fremont traps and 35 Belisle traps in 2015-16 with mixed results. Fremont traps most often failed when snow prevented the pan from depressing entirely and the snare was not delivered. At other times, the snare was knocked out of position by small animals, wind, or falling snow. There were also instances when the Fremont snare cable closed entirely but it appeared that the lynx had pulled out in a manner similar to the Belisle snares, possibly by retracting its footstep in reaction to the trap pan depressing. We observed numerous misses in the Belisle traps similar to what was seen in 2014-15 and thus maintain our opinion that Fremont traps are generally more effective for our purposes. However, we reiterate that the nature of the spring arm's release action on the Fremont trap makes it difficult to use this trap in situations where the lynx is walking in line with the spring arm rather than perpendicular to it.

During a live-capture (left), crews work quickly but deliberately to record data and deploy GPS collars on a lynx while the animal is under anaesthesia. One member of a capture crew monitors the vital signs of the lynx while another member records morphological measurements. A third person prepares the GPS collar for deployment. Den visits (right) go at a similar pace, ensuring minimum disturbance to the litter and den site while collecting important data on the litters.

We used the same Tomahawk and self-constructed box traps as in 2014-15, but also made log cabin style box traps on site using spruce trees, birch trees, and chicken wire. These were often modeled after wolverine traps that have a cable connecting bait inside of the cage to the handles of a pair of vice grips; by pulling on the bait, the handles of the vice grips open and release a cable that is holding the door suspended above the ground. One lynx was captured in a log cabin style trap, but it escaped through the chicken wire roof at a weak point of attachment. In another instance, a lynx set off the door-release mechanism from the outside of the cage by pulling at the bait, but this was later prevented by placing branches and brush around the sides and back of the traps. The advantage of using a treadle as a door release mechanism is that it does not require a lynx to commit to pulling on bait in order to capture it. Lynx often completely ignored baited cubby sets, or investigated but did not enter these sets, suggesting that a door release mechanism that depends on the lynx making contact with the bait may not be ideal. However, the accumulation of snow or ice beneath a treadle can prevent it from depressing, and non-target animals such as hares can depress the treadle and become caught in the trap. Thus, there are trade-offs between these and other release mechanisms that should be considered when building and operating box traps.

Fates and Movements of Collared Lynx

Of the 3 male lynx collared in 2014-15, 2 survived to 2016, and the third moved approximately 175 km northwest from his capture location near Takomahto Lake on Tetlin NWR to an area just southeast of Tok (see Figure 1) over the course of several months. It later died of unknown causes in September of 2015. One of the surviving males relocated to a new home range in April of 2016 (see Figures 1 and 3), approximately 10 km east of his previous range southwest of Tok. The other surviving male maintained the same home range through the summer of 2016.

Of the 3 females collared in 2014-15, one survived to 2016, another died in a neck snare set by a fur trapper in December 2015, and the fate of the third female is unknown due to collar malfunction. The surviving female maintained the same home range through the summer of 2016.

We observed a single dispersal event among the lynx captured in 2015-16 in which a male moved approximately 20 km northwest across the Nabesna River at the beginning of April (see Figure 1). This male has survived in his current home range since May.

Fine-scale data from the GPS collars enables us to investigate seasonal changes in movement rates (Figure 2) and home ranges (Figure 3).

Reproduction and Den Visits

We visited the den site of one collared female in late May of 2015. The den was located in a large swath of wind-felled trees in black spruce-dominated forest. We found and ear-tagged 4 kittens that were estimated to be 8 days old based on clusters of GPS locations. All kittens weighed approximately 0.2 kg. The night after our den visit, the mother relocated her litter to a new den site 800 m away. Two weeks later, we installed a trail camera at the second den site, but the mother moved the litter again later that night. After another 2 weeks, the mother relocated her litter to a third den site. We began tracking the collared female in October when snow was present and confirmed the survival of all 4 kittens into November, at which point 2 of them were harvested by hunters.

We inferred from tight clusters of GPS locations and reduced movement rates in late May of 2015 that another collared female gave birth to a litter, but this was never confirmed in person. However, this female survived the year and snow tracking in her home range suggested that she was traveling with young in February and March.

In early June of 2016, we visited the den sites of 4 collared females when we expected the kittens to be 2-3 weeks of age. The den sites were generally located on slopes with abundant fallen trees and thick deciduous growth that made moving extremely difficult for us. We found two litters of 6 kittens, one of 5 kittens, and one of 4 kittens. There were more male than female kittens (male:female ratios of 5:1, 4:2, 4:1, and 2:2, respectively). All kittens weighed approximately 0.5 kg and were given ear tags. As in 2015, at least 2 of the females relocated their litters to new den sites immediately following our visits. We attempted to revisit these new den sites in July, but by this time the kittens were mobile and capable of eluding us in the thick vegetation and steep terrain in which their dens were located. Based on GPS data, it appears that female lynx regularly relocate their litters to new den sites every 1-2 weeks until the kittens are ambulatory, at which time they relocate them even more frequently to shorter-term "resting" sites.

GPS Collar Performance

We programmed GPS collars to record locations at 4-hour intervals each day and to transmit these locations through an Iridium satellite service every 4 days. Collars were programmed to attempt a GPS fix for up to 120 seconds at each scheduled fix time. Overall, 89% of 6,857 fixes attempted by 5 collars deployed in 2014-15 were successful (range: 79-94%). Approximately 90% of these successful fixes were made in <60 seconds during the fix attempt. Despite high fix success rates, 2 of these 5 collars stopped transmitting data months before the batteries were expected to fail, and 1 collar never transmitted any data (although the VHF transmitter continued to function). Additionally, 2 of 13 collars deployed in 2015-16 have not transmitted data and are not expected to, based on collar failures in the previous year. This is an unfortunate record considering the cost of the collars and the effort expended to deploy them. Corrective actions on the part of the manufacturer, including reimbursement or product replacement, have been less than satisfactory.

Trail Cameras and Tracking

We used trail cameras to investigate the behavior of lynx around traps, to identify family groups and individuals, and to document other behaviors such as vocalizations and movement patterns. This data can be used to inform trap placement and to estimate the number of lynx available for collaring in a given area.

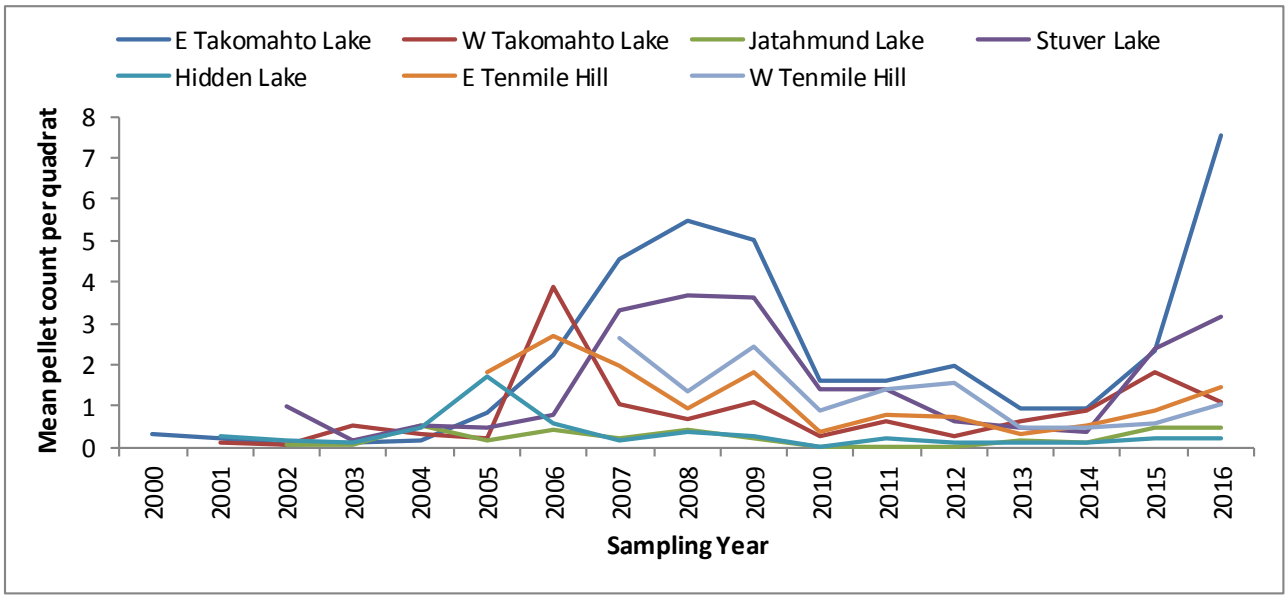
We also followed the tracks of collared lynx when snow was present in order to quantify predation on different species. When paired with GPS locations from the same individual over a known time interval, we can quantify rates of predation as well as compare the actual distance moved by lynx over these time intervals with the straight line distance between GPS locations. This latter measure would improve the estimation of hourly and daily movement rates of lynx.

Snowshoe Hare Population Monitoring

Lynx abundance tends to follow the same pattern as snowshoe hare abundance, but often with a 1-2 year time lag. By monitoring snowshoe hare abundance on the refuge, we can predict changes in lynx abundance and dispersal rates, and adapt our collaring efforts accordingly. Snowshoe hare abundance has been monitored in a variety of habitats on the refuge since the 1990's using pellet count indices. Hares last reached a cyclical peak on the refuge in 2007-08, and they appear to be peaking again in 2016-17.

In conjunction with the pellet indices, we established a live-capture grid for snowshoe hares in mature spruce forest where we expected to find high densities of hares. Mark-recapture methods allow us to more accurately estimate hare densities, as well as collect data on sex and age distribution, body size, and survival. We first live-captured hares for 4 nights in September 2016. Using 40 box traps arranged in a 5x8 grid with 50 m spacing between traps, we captured 40 individuals (10 males, 30 females), which equates to a density of approximately 3.5 hares/ha. We will continue to monitor snowshoe hare

abundance throughout the lynx project in order to compare timing of lynx movements with changes in hare abundance.



Snowshoe hare pellet counts on Tetlin NWR track cyclical changes in relative hare abundance on the refuge.

Discussion

Trap Types

The live-capture traps used in this study differed in their shape, snare delivery, and spring mechanisms. The large size of the Fremont traps meant that excavation of the snow and/or ground was necessary in order to seat the trap below the snow level and conceal it. Even when great care was taken to clear all snow from beneath the pan when initially setting the Fremont traps, the pan often did not depress fully when animals stepped on it due to obstruction by hardened snow or debris. In shallow snowpack, this could be prevented by clearing the snow around the trap down to bare ground. One could also fill the space beneath the pan with collapsible material such as foam, cotton, or conifer branch tips so long as it does not freeze and prevent the pan from depressing. When compared with the Belisle traps, it is possible to make the snare opening much larger on a Fremont to accommodate the large size of a lynx paw. In addition, the spring on a Fremont trap both lifts and closes the snare cable as soon as the pan is triggered, which potentially offers a huge advantage over the Belisle traps in capture rates. The spring arm of the Fremont then acts as a built-in spring that softens the jerk of a captured animal and minimizes the chance of injury from pulling against the trap, whereas a separate spring must be built in-line with a chain on the Belisle traps. One serious consideration when using the Fremont trap is preventing the spring arm from hitting the target animal upon release from the pan. Due to the possibility of injury from the spring arm, it is necessary to place the trap in a way that prevents the target animal from moving its head or body over the spring arm when the pan is depressed (we typically accomplished this by placing a large stick vertically at the head end of the spring arm to force a lynx to step to the side of the spring arm). This effectively restricts the orientation of the Fremont trap to one that is perpendicular to the path of the lynx's movement.

The Belisle trap is shaped and set more like a conventional foothold trap, lending itself to blind sets and confined areas more than Fremont traps. When compared with a Fremont trap, we have also found it easier to conceal the Belisle trap beneath snow without hindering the movement of the pan or jaws. However, the diameter of the jaws on the #6 Belisle is just larger than the diameter of an average lynx paw. This essentially means that a lynx must step perfectly within the jaws of the trap in order to

properly catch them above the paw. Subsequent closure of the snare above the paw is dependent on the captured animal pulling back against the snare cable, and if the jaws of the trap close on the paw itself (i.e. a toe catch), the animal is usually able to pull its paw out of the snare as the protective surgical tubing rolls freely around the snare cable. In order to consistently and safely live-capture lynx with the Belisle trap, one must use a very careful arrangement of guide sticks, and even then success is never guaranteed. If the jaw diameter were slightly larger we might see a noticeable increase in success with these traps, but the jaws on the larger Belisle (#8) are too wide, the steel is of a thicker gauge, and the springs are much too strong for use in live-capturing lynx. We have had a large amount of bycatch (e.g. red squirrels, gray jays, and snowshoe hares) in Belisle traps, primarily at cubby sets where bait is present, and regardless of the pan tension. For these reasons, we have a general preference for Fremont traps where it is possible to make the desired set using a Fremont.

Both Fremont and Belisle traps require that the snare cable be anchored to a fixed object. Typically, this is done by securing the snare cable to a standing tree via an anchor cable. Because lynx are especially susceptible to bone breaks and other serious injuries when pulling against an anchored trap or cable, it is of the utmost importance to prevent wrapping and tangling of the snare cable or anchor cable around any tree or vegetation. In most cases, simply clearing the trap site of all trees and stems, and clearing the lower limbs of the anchor tree up to 4 feet above the ground, is sufficient. However, we observed captured lynx clawing at surrounding trees with their free limbs and at least one was able to pull a small tree down into the trap site and tangle the snare cable around the top of it. Other captured lynx repeatedly moved around the anchor tree to the point where both the anchor and snare cables were wrapped about the tree, pinning the capture foot to the anchor tree. To prevent this, we made a loose ring of 9-gauge wire around the base of the anchor tree and secured the anchor cable to the wire in a manner that should have enabled the anchor cable to move freely about the base of the tree without wrapping. However, we tested this arrangement with our hands in the snares and found that it was still possible for the anchor and/or snare cable to become wrapped around the tree. While other studies have reported the successful use of 9-gauge or thinner wire loosely wrapped around the base of an anchor tree, we decided that it posed too much of a risk to the animals. From that point on, we anchored the snares only to downed trees that were buried in snow and were heavy enough to prevent a lynx from moving the tree, or to standing trees that were large enough in diameter that it was impossible for the snare cable to become wrapped around the tree. We made the anchor cable as short as possible (app. 1-2 feet) and cleared all vegetation from the trap site. The use of downed trees as anchors made it more difficult to build cubby sets and to attach trap monitors to trees that were close enough to the trap, but it was used with great success and dramatically improved the safety of captured animals. However, it is of the utmost importance that the lynx not be able to move the tree, so the tree must be considerably heavier than the lynx or braced against movement if it is used in the absence of snow. Crossed rebar or metal stakes may be used as an alternative if they can be driven securely into the ground.

Box traps offer the safest method of live-capture and have been used successfully for that purpose in Alaska and Montana, among other locations. Because they permit a captured animal to move freely within the box, the animal is less likely to sustain circulation-related injuries at colder temperatures and the traps need not be checked as frequently. In addition, it possible to release unwanted or recaptured animals from box traps without anaesthetization or physical restraint. Some drawbacks to box traps are that they can be expensive, often are not collapsible, and are difficult to transport to remote locations. One way to circumvent these issues is to build the traps on site using trees available at the site. This is a valid option in our long-term study where we expect to reuse the traps year after year without needing to move them. However, some lynx seem to perpetually avoid box traps. It is therefore unlikely that box traps could be used exclusively to catch all lynx in a given area, but they could prove very useful in combination with other trap types.

All trap types used in this project are susceptible to malfunctioning under snow accumulation, snow melt, and ice development. Covering the pans of the Belisle traps with wax paper was effective in keeping the traps functional after concealing them with snow or after snow events. Similarly, wax paper can be used to conceal the pans on the Fremont traps and prevent snow from accumulating under the pan. However, the greatest problem that falling snow poses to the effectiveness of the foot traps is concealment of the stepping and guide sticks. These guides must be kept visible to ensure that a lynx steps squarely on the pan and inside of the snare cable rather than on it. We routinely missed lynx after overnight snowfalls covered the guides around our traps. Snow melt can also cause guide sticks to change position or fall out of place, and traps can quickly melt and re-freeze into the snow in warming spring conditions, especially under direct sunlight. Placing wax paper, spruce boughs, cardboard, or any other flat objects beneath the Belisle traps can slow the rate of sinking into the snow and keep them functional. Fremont traps can also be maintained in these conditions by keeping the trap legs suspended on some broad support piece. Alternatively, clearing the snow down to bare ground will likely avoid any future disturbance of the set by melting conditions.

Set Types

We placed our traps in a variety of set types that included cubby sets, blind trail sets, pee post sets, and scent post sets. We did not document the activity at each set thoroughly enough to quantify the relative success of each set type, but the general consensus was that most lynx avoided cubbies earlier in the winter (through February), but began walking into cubby sets in March.

We did not see any trends in visits to scent posts or pee posts and believe that they would work at any point in the year, although pee posts may elicit a stronger response in late March when breeding activities commence. Blind trail sets were very productive once we identified trails that were repeatedly used by lynx. For example, we caught 3 different lynx in a single trail set during just one month. It is much easier to identify these trails after a month or two of field observations, although close inspection of snow compaction under lynx tracks may also be used to identify heavily used trails. Once identified, these locations can likely be trapped successfully year after year.

Anaesthetization

Based on the use of Telazol for anaesthetizing lynx in a parallel study near Fairbanks, Alaska, we initially administered 0.3 mL of the drug (reconstituted to 100 mg/mL) to captured adults. However, after observing numerous recoveries that were prolonged beyond 1.5 hours, we attempted the use of 0.25 and 0.2 mL amounts on adult lynx and found 0.2 mL to be more than sufficient for our purposes. The handling time required for collaring, taking morphological measurements, and collecting biological samples from lynx in our study has typically been 30-45 minutes, so keeping the anaesthetization period to less than 1 hour is ideal.

The kittens that we anaesthetized in our study appeared to spend more time recovering from the Telazol than the adults. We used smaller doses to anaesthetize them, but even with as little as 0.1 mL of Telazol, it was typically 2 hours before kittens became mobile again. On colder days, we used heat packs in combination with insulation to help ensure a stable body temperature, but their vital rates were otherwise normal. We suspect that the kittens remained calmer than the adults during the recovery period and would have remained in a prone position for even longer periods of time had we not completely removed the insulating blankets from them after 2 hours. We believe that the extended recovery period that took place beneath the blankets was to their benefit because their movements were more coordinated than the adults when departing the capture sites.

We covered the faces and eyes of anaesthetized lynx using fleece blankets and found that keeping their faces and bodies covered during the recovery period reduced their tendency to struggle to move. Telazol has no antagonist and lynx are known to metabolize the immobilizing component (Tiletamine) before the

sedative and muscle relaxing component (Zolazepam). This means that the lynx struggle to regain a standing position before they have full coordination of their limbs. Keeping them calm and immobilized until they are fully capable of walking might be accomplished by placing them in portable cages or storage containers.

Other Remarks

Scheduling field crews of 6 or more people for work in a remote area is difficult, especially when operating out of 3 different locations while also coping with obstacles such as a shallow or melting snowpack, mechanical issues with snowmachines, foul weather, and illnesses. We covered approximately 600 km^2 by working in teams of 2 for up to 18 days at a time. We reconvened in the office for 3-4 days to discuss our trapping approach and replenish field supplies before returning to the traplines. Naturally, these breaks mandated the closure of our traps until we returned to the traplines, and during these periods we had lynx step into closed traps. Some of these lynx may have been captured and collared at a later date, but others may have avoided our traps during the remainder of the season. Depending on capture rates in a given area, one might consider rotating field crews on a single trapline so that the traps remain open until most or all of the lynx in that area have been captured. Focus may then be shifted to a different trapline that is kept open continuously until all lynx have been captured in that area. Ultimately, there is a tradeoff between the percent of the population of lynx that can realistically be collared in a given area and the total geographic area that can be covered by the trapping efforts.

Acknowledgments

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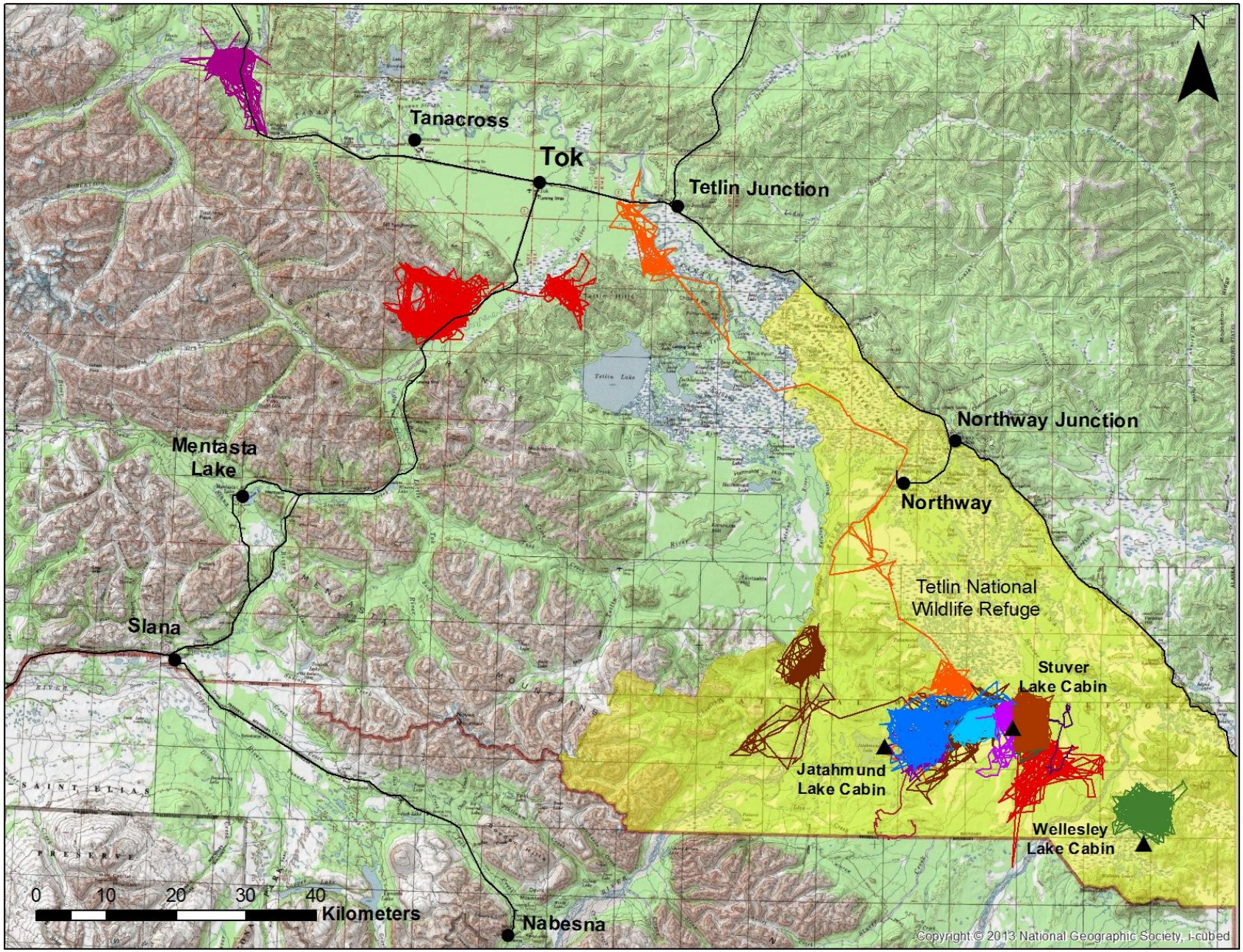

Figure 1. Study area at Tetlin National Wildlife Refuge showing movement paths by GPS-collared lynx from March 2015 to September 2016.

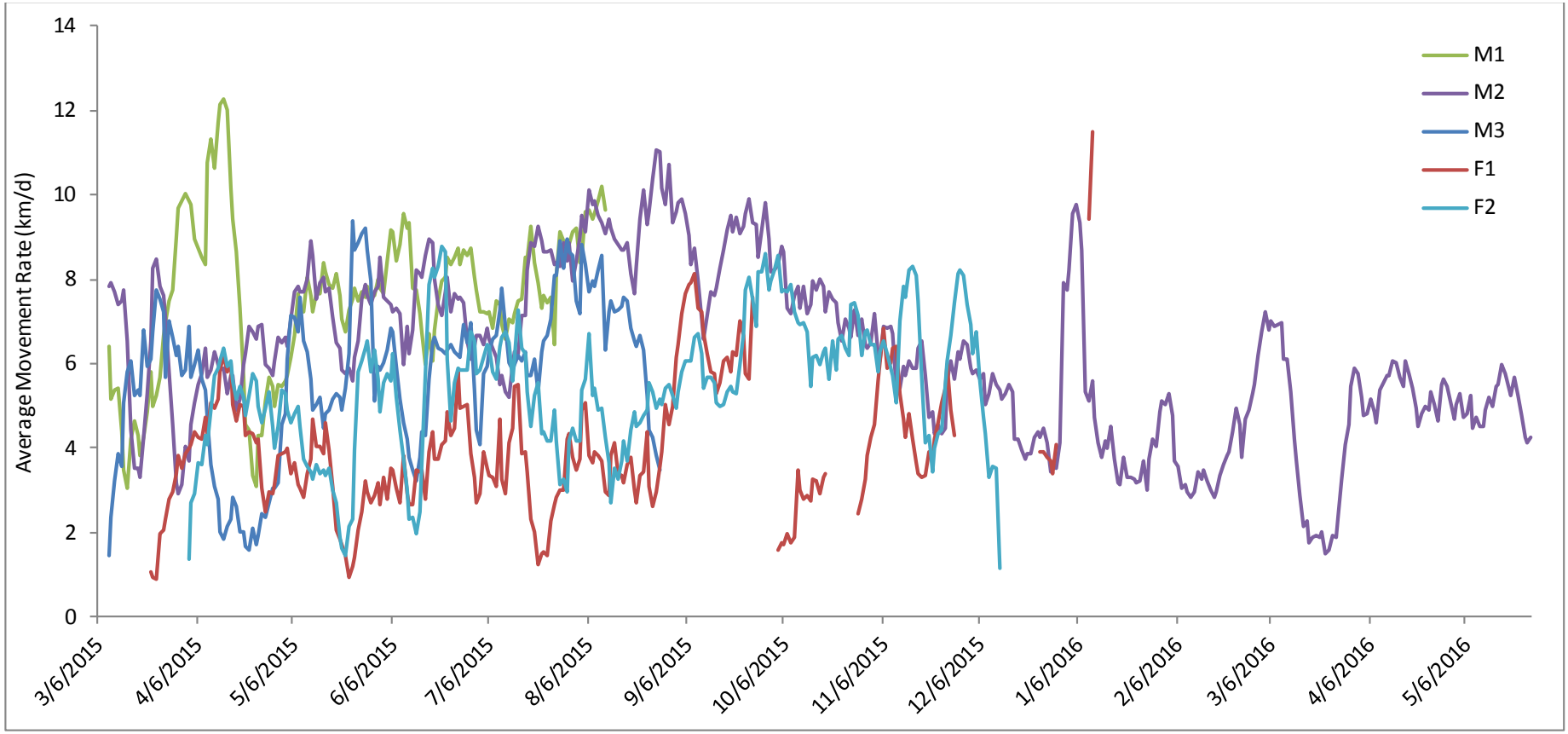

Figure 2. Average movement rates (7-day moving mean) for male (M#) and female (F#) lynx collared near Tok, Alaska, in 2015.

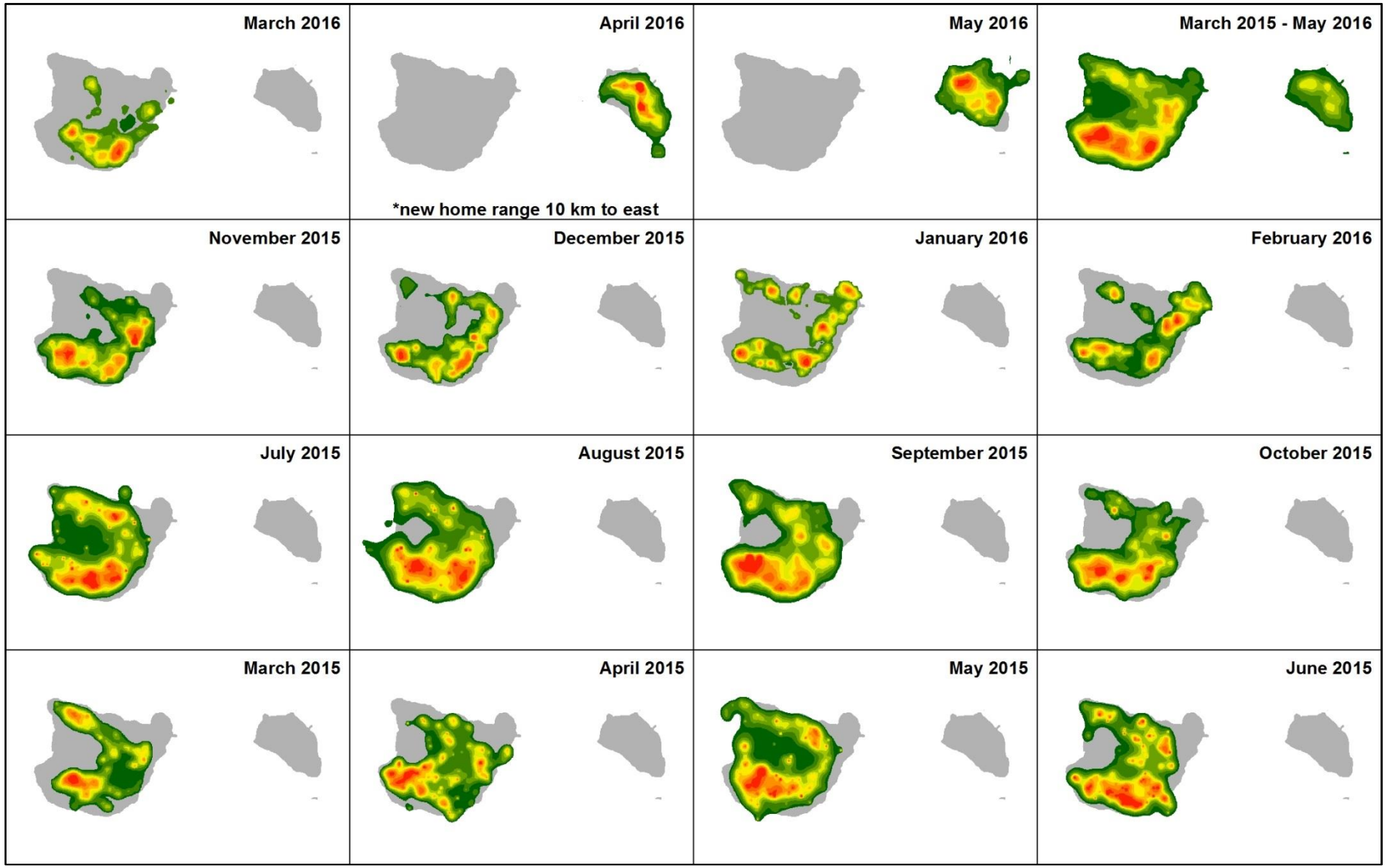

Figure 3. Monthly home ranges for a male lynx collared from March 2015 to May 2016. Home ranges were estimated using Brownian Bridge movement models. Colors indicate intensity of use (red is high, green is low). Monthly ranges are superimposed over the entire space used by the animal during the study (in gray).

Table 1. Lynx captured in live traps in and around Tetlin National Wildlife Refuge, Alaska, March 2015 to April 2016.

Capture Date[a]	Lynx ID[b]	Sex[c]	Age[d]	Capture Foot[e]	Trap type[f]	Set Type[g]	Recapture[h]	Collar Deployed[i]	Hair Taken[j]	Whiskers Taken[k]	Feces Taken[l]	Weight[m]	Body Length[n]	Tail Length[o]	Shoulder Height[p]	Chest Circumference[q]	Foot Length[r]	Foot Circumference[s]	Wrist Circumference[t]	Nose Pad Width[u]	Neck Circumference[v]	Head Circumference[w]	Ear Tuft Length R[x]	Ear Tuft Length L[y]	Canine Length Upper R[z]	Canine Length Upper L[aa]	Canine Width Upper R[bb]	Canine Width Upper L[cc]	Canine Breadth Upper R[dd]	Canine Breadth Upper L[ee]
3/6/2015	1	M	A	FR	F	C	n	y	n	n	n	11	100	10	54	43			13		28				21					
3/7/2015	2	M	A	FR	B	B	n	y	n	n	n	12	104	14			24				23		45							
3/8/2015	3	M	A	FR	B	C	n	y	n	n	n	12.5	107	12		46			13		31				24					
3/10/2015	3	M	A	FR	B	B	y	n/a	n	n	n																			
3/11/2015	4	F	A	RR	F	C	n	y	n	n	n																			
3/24/2015	5	F	A	FL	F	C	n	y	n	n	n	11.5	93	11		42			13		25									
4/3/2015	6	F	A	FL	B	C	n	y	n	n	n	10.5	90	9		39			11		24				19	17				
2/11/2016	7	M	A	FL	F	C	n	y	y	y	n	13.3	90	12			23	47			28	38	74	74	6	19	7	7	7	8
2/13/2016	8	F	J	FL	B	C	n	n	y	y	y	5.3	75	8	37		21	42		16	20	27	34	35	15	16	5	6	6	5
2/17/2016	9	M	A	FR	F	B	n	y	y	y	n	12.8	100	10			27	19		30	30	34	50	52	22	23	3	3	6	6
2/17/2016	10	F	A	FR	B	B	n	y	y	y	n			10							27		65	56						
2/17/2016	11	M	J	FR	F	C	n	n	y	y	n	5.7	76	11	44		23	44		15	20	27	34	39	17	16	6	6	6	7
3/3/2016	12	M	A	RR	F	C	n	y	y	y	n	10.9		10	53		24	51		19	29	36	62	65	14	16	6	6	6	7
3/5/2016	1	M	A	FR	B	B	y	r	y	y	n	13.1		13			25	54			31									
3/6/2016	12	M	A	FR	F	C	y	n/a	n	n	n																			
3/8/2016	13	F	A	FL	F	B	n	y	y	y	n	11.3	93	6	43		21	46		25	24	32	55	55	18	20	7	6	8	9
3/16/2016	5	F	A	FL	F	B	y	r	y	y	y	10.8	83	13			24	53		20	24	33	47	52	18	19	7	7		
3/19/2016	14	F	A	FR	B	C	n	y	y	y	n	10.9	97	12	57		22	18		24	28	38	42	47	20	17	6	6	7	7
3/19/2016	1	M	A	FL	F	B	y	n/a	n	n	n																			
3/22/2016	12	M	A	FL	B	B	y	n/a	n	n	n																			
3/22/2016	15	M	A	FL	F	B	n	y	y	y	n	13.0	101	15	46		25	22		30	30	34	65	52						
3/23/2016	16	M	A	FL	F	B	n	y	y	y	n	12.9		10			25	57			28		60	60						
3/23/2016	17	M	J	FL	B	B	n	n	y	y	n	6.4	90	10	44		23	15		16	22	28	36	31	16	18	6	6	5	4
3/23/2016	18	M	A	FL	B	S	n	y	n	n	n	12.5	102	14			26	18		26	27	38	68	64	17	17	8	10	7	6
3/23/2016	19	F	J	FL	F	C	n	n	y	y	n	5.4	85	12	47		22	14		16	21	26	42	18	15	16	6	6	5	5
3/23/2016	20	F	A	FR	F	B	n	y	y	y	n	9.7	101	14	56		24	17		21	31	36			18	16	5	5	7	6
3/23/2016	12	M	A	FL	B	B	y	n/a	n	n	n																			
3/26/2016	21	M	A	FL	B	C	n	y	y	y	n	11.0	98	12	53		25	17		22	26	33	59	53	18	19	5	5.5	7.5	7

a. Date of lynx capture.
b. Unique ID for captured lynx.
c. Sex of lynx (M = male, F = female).
d. Age of lynx(A = adult, J = juvenile).
e. Foot by which lynx was captured (FL = front left, FR = front right, RL = rear left, RR = rear right).
f. Type of trap in which lynx was captured (F = Fremont, B = Belisle).
g. Type of set in which lynx was captured (C = cubby, B = blind, S = scent post).
h. Whether the capture was a recapture of the individual (y = yes, n = no).
i. Whether a collar was deployed (y = yes, n = no, r = an old collar was replaced with a new one, n/a = lynx already had a fu nctioning collar).
j. Whether a hair sample was collected (y = yes, n = no).
k. Whether whisker samples were collected (y = yes, n = no).
l. Whether a fecal sample was collected (y = yes, n = no).
m. Body weight (kg).
n. Body length measured from the rostrum to the distal end of the tail (cm).
o. Length of the tail (cm).
p. Height of the shoulder (cm).
q. Circumference of the chest (cm).
r. Length of the right hind foot (cm).
s. Circumference of the right hind foot (cm).
t. Circumference of the "wrist" above the paw (cm).
u. Width of the nose pad (mm).
v. Circumference of the neck (cm).
w. Circumference of the head (cm).
x. Length of the right ear tuft (mm).
y. Length of the left ear tuft (mm).
z. Length of the upper right canine (mm).
aa. Length of the upper left canine (mm).
bb. Width of the upper right canine (mm).
cc. Width of the upper left canine (mm).
dd. Breadth of the upper right canine (mm).
ee. Breadth of the upper left canine (mm).