Putative Canada Lynx (*Lynx canadensis*) Movements across Hwy 40 near Berthoud Pass, Colorado

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Jake Ivan, Mammals Researcher
Colorado Parks and Wildlife
317 W. Prospect
Fort Collins, CO 80526
970-472-4310

INTRODUCTION

Berthoud Pass is located is located along State Highway 40 mid-way between the communities of Empire and Winter Park. As such, it lies within the Berthoud Pass Linkage Zone (USDA Forest Service 2008) that supposedly provides an important travel corridor for Canada lynx (*Lynx Canadensis*) moving between the Mosquito Range of central Colorado and the Front Range in the northern part of the state. U.S. Forest Service District Wildlife Biologists requested that the Colorado Parks and Wildlife (CPW) provide maps depicting lynx movements through this linkage zone to aid in their review of proposed projects in the vicinity as well as to assess the general importance of the area. Here I summarize the methods, results, and deficiencies of a simple, preliminary analysis conducted to fulfill this request.

METHODS

Data

CPW collected location data from reintroduced and Colorado-born lynx from 1999-2010 using both traditional VHF telemetry and the Argos satellite system. VHF locations were obtained from daytime flights using fixed-winged aircraft. The mean interval between consecutive VHF locations was 20.6 days, although about half of intervals were ≤7 days. The positional error of VHF is assumed to be ±400m.

Dual-transmitter satellite/VHF collars were first deployed on Colorado lynx in April, 2000. Satellite transmitters were designed to transmit 1 day per week, but it was possible to obtain several locations on that day. The Argos system computes locations when transmissions from a satellite collar are received and time-stamped by a single Argos satellite orbiting from pole to pole. After 4 successive transmissions have been received, a location is calculated based on the Doppler Effect (CLS America 2008). This system differs markedly from the satellite system that produces GPS locations. For the latter, signals from multiple satellites are received by a GPS collar (rather than the collar transmitting to a single satellite). The time stamps of the signals and orbital information from each satellite are then used by the processor in the collar to "triangulate" its position (Garmin 2011). Because of these important differences, the error distributions associated with the 2 systems are substantially different. Whereas the error associated with GPS locations is often <15m (Garmin 2011), accuracy of Argos locations is often several hundred to >1000m. Specifically, Argos lists the standard deviation of the error distribution of its locations as 250m, 250-500m, 500-1500m, and >1500m for class 3, 2, 1, and 0 locations, respectively (CLS America 2008). Therefore if a transmitter remains stationary while an Argos satellite passes over multiple times, computing numerous class 3 location estimates, 68% of the resultant estimates can be expected to fall within 250 m of the true location of the transmitter; 95% will fall within 2 SD (500 m) of the true location. Similarly, 95% of class 1 locations can be expected to fall within 3000m (1.9 miles) of the true location. Argos systems also produce location estimates of class A, B, and Z, but these locations do not have associated error estimates.

Analysis

For each lynx, I excluded VHF and Argos data collected within 6 months after its initial release, assuming that movements during that period were atypical. Additionally, I excluded Argos locations that fell outside of Colorado as well as locations of class 0, A, B, and Z (i.e., ignoring locations with no or extremely poor error estimates). I then imported these data into ArcGIS 10 (ESRI, Redlands, CA) and ordered them by Lynx ID and date. Next, I divided the state into 2 pieces using State Highway 40 as the dividing line (Fig. 1; note the dividing line depicted also includes small segments of I-70). I identified the subset of lynx that were located both south and north of this dividing line and used the "Points to Lines" Tool within ArcGIS to construct polylines connecting successive locations from each individual. I then plotted the segments that a) crossed Hwy 40, and b) had endpoint locations separated by ≤14 days. These segments were intended to identify broad areas lynx have used to make their way from the central to northern parts of the state and vice-versa. They in no way represent actual locations where lynx traversed the highway comprising the dividing line. Based on lynx movement patterns (Theobald and Shenk, unpublished data), I defined "winter" as November through March and "summer" as April through October. Lines are color-coded to reflect the season during which the crossing occurred.

RESULTS

I identified 38segments from 31 lynx (15 females, 16 males) that crossed Hwy 40 and had endpoints separated by ≤14 days (Fig. 1). Nineteen (50%) of these segments occurred within a 40-km stretch of Hwy 40 spanning the timbered areas east and west of Berthoud Pass between Winter Park and Empire. Many of these segments pass through the Berthoud Pass Linkage area and/or the USFS Berthoud Pass Analysis unit (Fig 2). The vast majority of crossings occurred during summer months.

DISCUSSION

Due to the poor precision of location estimates and the amount of time elapsed between locations, the straight line movement paths depicted in this analysis ***DO NOT*** represent exact or even approximate locations where lynx crossed Hwy 40. Additionally, VHF locations were obtained during daylight hours when lynx were least likely to be moving. Given these sources of bias, inference from this analysis is limited to identification of broad areas likely used by lynx to travel from the central mountains of Colorado to ranges north of Hwy 40. Based on lynx ecology, biologists from various state and federal agencies have postulated that the high elevation bottleneck at Berthoud Pass likely provides a corridor for lynx making make north-south movements in Colorado (USDA Forest Service 2008). The analysis presented here is consistent with that hypothesis. Given that few known lynx became residents in the northern portion of the state during the reintroduction, it is sensible that most crossings appeared to occur during summer when lynx often make large movements beyond their winter home range.

The location data used to conduct this analysis were not collected for the purpose of analyzing lynx movement or habitat use. The relatively high degree of error inherent in the locations, combined with the long period of time between consecutive points, makes such an analysis difficult. However, methods exist that may enable stronger inference from these data. By treating the locations, as well as the putative tracks between them, in a probabilistic fashion, it may be possible to develop a density surface that depicts probable travel routes across broad areas within the state. CPW will collaborate with faculty at Colorado State University this calendar year to determine whether such approaches are feasible given these data.

LITERATURE CITED

CLS America. 2008. Argos User's Manual. http://www.argos-system.org.

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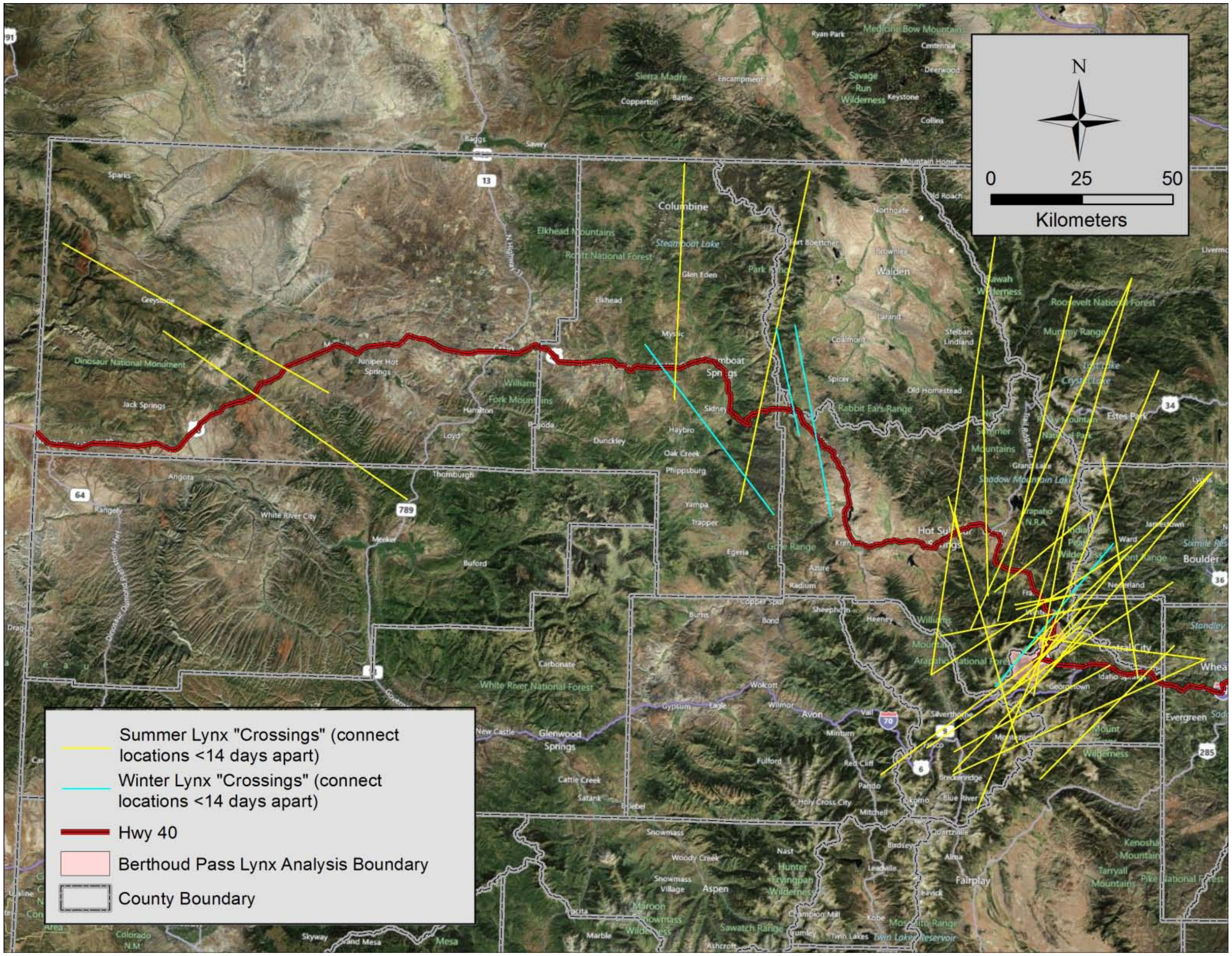

Figure 1. Line segments that a) crossed Hwy 40 (red), and b) had endpoint locations separated by ≤14 days, north-central Colorado, 1999-2010. Note that segments do not indicate actual or even approximate location of lynx crossings because locations are imprecise and separated by up to 2 weeks.

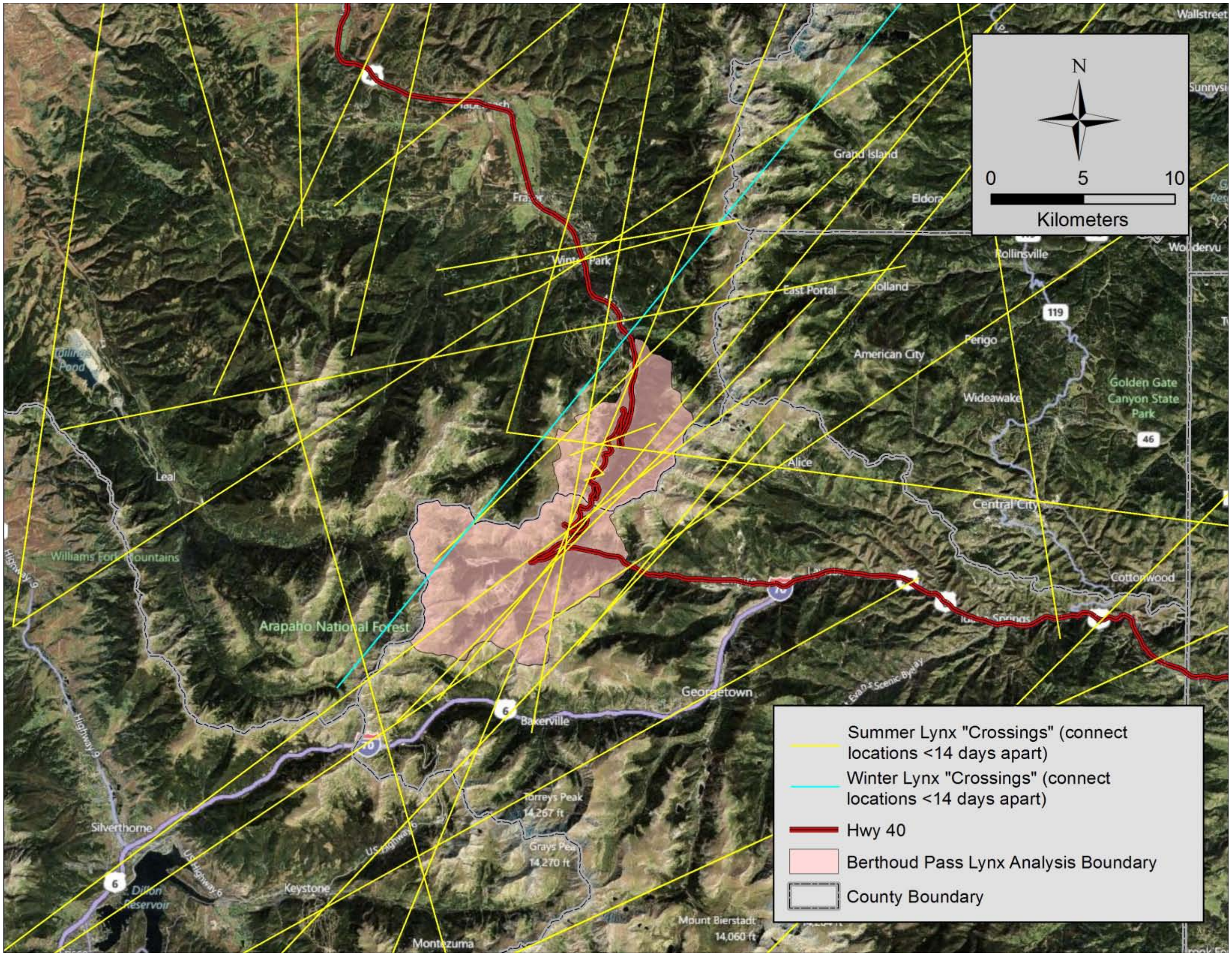

Figure 2. Line segments that a) crossed Hwy 40 (red), and b) had endpoint locations separated by ≤14 days, 1999-2010. Colored polygons depict the Berthoud Pass Lynx Analysis Boundary. Note that segments do not indicate actual or even approximate location of lynx crossings because locations are imprecise and separated by up to 2 weeks.