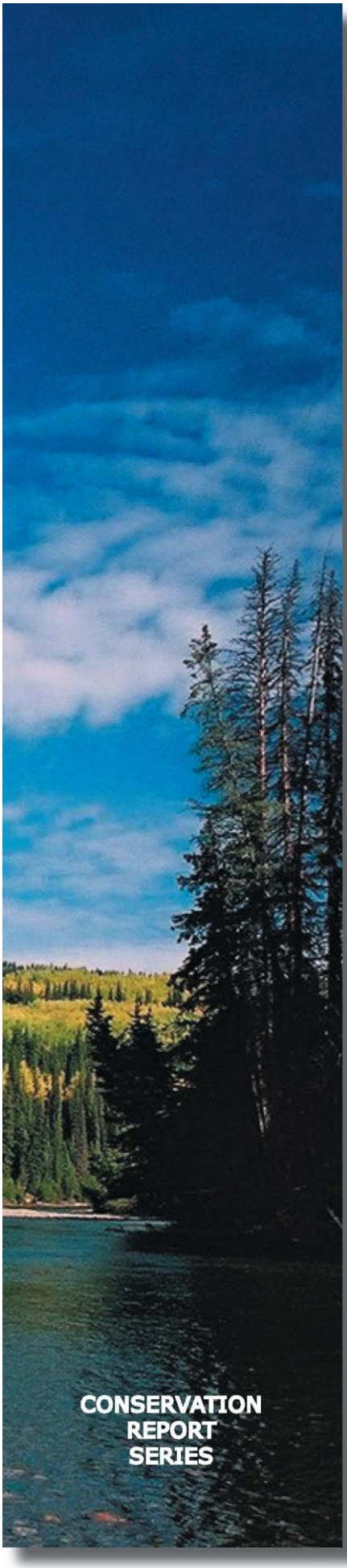

Wolverine Harvest Summary from Registered Traplines in Alberta, 1985 – 2011

Alberta Conservation Association

Conserving Alberta's Wild Side

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Wolverine Harvest Summary from Registered Traplines in Alberta, 1985 – 2011

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Alberta Conservation Association

Conserving Alberta's Wild Side

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EXECUTIVE SUMMARY

Wolverines are among the most rare and least understood carnivores in the world. Lack of data has classified the status of wolverines as *Data Deficient* in Alberta. Large home ranges, low densities, and remote habitat use make wolverines challenging to study. Long-term trapping records are valuable and can be used to assess distribution and relative abundance. Previous studies have suggested that wolverine harvests and potential populations may be declining, but more recent data have not been analyzed. Thus, we completed a comprehensive update on long-term wolverine harvest trends in Alberta.

We used wolverine harvest data collected from fur affidavits (1985-2011), fur registrations (1989-2011), and Statistics Canada pelt export records (1971-2010). Our results show that the total number of registered traplines harvesting a wolverine in a year, and the average number of harvested wolverines, has increased since the early 1990s. The distribution of harvest data suggest that wolverines primarily occur in the Rocky Mountains, Foothills, Boreal Forest, and Canadian Shield natural regions of Alberta. When comparing two time periods (1989-1999; 2000-2011), wolverine harvests have more than doubled in the Northwest Boreal (105%) and increased in the Northeast Boreal (47%) and Foothills (33%), while declining in the Canadian Shield (40%) and Rocky Mountains (32%). However, it is not clear whether these results are related to changes in trapper effort, wolverine population, or other factors.

Some registered traplines in the Rocky Mountains had the highest wolverine harvest densities, but wolverines have been harvested the most consistently, over the past 23 years, in the Boreal Forest, primarily north of 58 degrees latitude (WMU 530, 536, 539). Despite a lack of consistent spring snow cover (thought to be a critical factor for wolverine occurrence), wolverine harvest success on some traplines in the Boreal Forest was moderately high, indicating that other factors may be responsible for wolverine persistence.

We also found a high spatial and temporal overlap between lynx and wolverine harvests, indicating that the number of lynx is possibly associated with the number of wolverine harvested each year. However, these results may also be related to trapper effort or other factors. We will be working with trappers to further investigate these

trends as part of a larger project to determine wolverine occupancy and gene flow across Alberta.

Key words: wolverine, furbearer, harvest, spring snow cover, traplines, Alberta

ACKNOWLEDGEMENTS

We thank the trappers of Alberta for submitting fur registrations and affidavits over the years, thus providing information on furbearer populations that is difficult to obtain otherwise. We also thank Rob Corrigan and Jim Allen of Alberta Environment and Sustainable Resource Development (ESRD) for access to the furbearer harvest database and hard copy records. Nate Webb, Lonnie Bilyk, and Jacqui Gerwing (ESRD) also provided important technical assistance and expertise on the furbearer database, wolverine ecology, and trapping regulations. Rhonda Kindopp and John McKinnon (Parks Canada) provided background information about trapping in Wood Buffalo National Park. Jim Mitchell, Brian Bildson, and Bill Abercrombie (Alberta Trappers Association), and Len Peleshok (ACA) were an important sounding board for advice related to general furbearer ecology and harvest details. Jeff Copeland, Kevin McKelvey, and Audrey Magoun provided fruitful discussions on wolverine distribution in Alberta and provided the snow cover data used in our analysis. Lastly, we thank Sue Peters (ACA) for her comments on this manuscript.

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1.0 INTRODUCTION

Wolverines (*Gulo gulo*) are one of the most rare and least understood carnivores in the world. They are broadly distributed primarily in circumpolar regions, including Canada, United States, Finland, Russia, and China. In Canada, the status of the eastern wolverine population is *Endangered*, while the western population is classified as *Special Concern* (COSEWIC 2003). The status of wolverines in Alberta is *Data Deficient*, meaning that there is insufficient data to determine whether the population is at risk or secure (Alberta Fish and Wildlife 2008). However, there is evidence to suggest that wolverines may be sensitive to overharvest and need to be carefully managed (Banci 1994).

Wolverines are trapped primarily for their fur, and pelts are sold in a commercial market to manufacture garments and taxidermy products (rugs, mounts). Since the inception of the fur trade, wolverine fur has been sought after for its rugged durability, warmth and frost-resistant properties on parkas and other garments, and has remained particularly important to northern communities to the present day (Banci 1994). Being both cryptic and difficult to catch, even basic information on wolverines is a challenge to obtain. These factors, coupled with a vast home range and naturally occurring low densities (Banci 1994), make wolverines one of the least understood and charismatic carnivores in North America. With a paucity of basic information available from Alberta, we examined wolverine trapping records to gain a better understanding of the distribution and trend in harvest numbers over time.

Observations and harvest records from trappers have played a key role in the management of furbearers. Biologists have used harvest records to help monitor furbearer relative abundance (Smith and Brisbin 1984), adjust harvest quotas (Fryxell et al. 2001), estimate population densities (Fryxell et al. 1999), examine cyclic fluctuations (Viljugrein et al. 2001), evaluate status and distribution (Erickson 1982), collect biological information (Simon et al. 1999), and assess the effects of trapping and other forms of human disturbance on furbearers (Payer 1999; Webb and Boyce 2009). In Alberta, the best large-scale data currently available for wolverines is harvest data from registered traplines. Wolverines can be legally harvested on Registered Fur Management Areas (RFMAs/registered traplines), which overlap primarily with the forested regions on public Crown land. Beginning in 1989, a quota of one wolverine per trapline per season

(1 November - 31 January, for most of Alberta) was established along with a mandatory registration program requiring all wolverine pelts be recorded and tagged before they can be exported.

What little is known about wolverines in Alberta has been primarily obtained from trapping records and anecdotal information. A trapper opinion survey in 1987 indicated that wolverines were declining throughout Alberta (Skinner and Todd 1988). The status of wolverine in the province was assessed, in large part by using trapping records compiled by Petersen (1997), which showed a downward trend in wolverine harvests through time (1972-1995). Poole and Mowat (2001) also used trapping records to assess wolverine harvest trends from 1977-1999, which showed a general decrease, as well as reduced distribution over time; however, it is likely that the harvest quota initiated in 1989 played an important role in affecting these trends. Thus, previous work suggests that wolverine harvests, and potential wolverine population and distribution have declined over time in Alberta, but analysis of more recent data is lacking.

As part of a larger wolverine research program in Alberta, we initiated an analysis of the trapping data in order to evaluate the spatial and temporal trends in wolverine harvest. Specifically, our objectives were to use trapping data to determine the distribution of wolverines and identify some of the variables that may influence the spatio-temporal pattern of wolverine harvest success. This work provides an updated summary of wolverine harvest trends on registered traplines in Alberta. Based on discussions with trappers, biologists and fish and wildlife officers, we predicted that there has been an increasing trend in wolverine harvest since the last harvest analysis was completed over a decade ago (Poole and Mowat 2001).

Previous studies have also shown a strong relationship between lynx and wolverine harvests (Poole and Mowat 2001), so we explored this relationship to better understand what factors may affect how many wolverines were harvested. We predicted that there would be no relationship between wolverine pelt price and harvest because wolverines are primarily sold to taxidermists; however, we expected there to be a relationship between lynx pelt price and wolverine harvest because of increased effort to catch lynx when prices were high. We expected to find a positive relationship between the number of wolverine and lynx harvested, both at the provincial, as well as the trapline scale.

Since traps set for lynx can also catch wolverine, we predicted that traplines with a greater lynx harvest would have a greater opportunity to catch wolverine.

Wolverines are built for living in cold places with deep snow. In fact, the number of years with persistent spring snow cover has been a key factor in explaining where wolverines occur and den around the world (Copeland et al. 2010). Researchers believe that snow serves many purposes for wolverines, including thermal refuge and predator avoidance for dens, and an ideal environment to "refrigerate" cached prey items for extended periods of time (Copeland et al. 2010; Inman et al. 2012). Thus, we expected a high degree of overlap between registered traplines with wolverine harvests and locations with persistent spring snow cover. Wolverines also tend to occur in remote places far from humans, so we expected to see increased wolverine harvests in areas with more intact forest. Because males tend to have much larger home ranges than females, we expected the wolverine harvests to be biased towards catching more males than females.

2.0 STUDY AREA

There are three main types of trapping licenses in Alberta: (a) *Resident Fur Management* (n=914 trappers), where trapping occurs on private property primarily in the Grasslands and Parkland; (b) *RFMA* (n=1543 trappers), where trapping occurs on registered traplines (n=1667 RFMAs) that overlap Crown land primarily in the Rocky Mountains, Foothills, Boreal Forest and Canadian Shield; and (c) *Indian/Metis Fur Management*, where trapping occurs on Indian Reserves and Metis Settlements across the province (Government of Alberta 2012; Figure 1; Appendix 1).

We collected harvest data from RFMAs because these areas are mapped and have remained somewhat consistent over time (Figure 1). Registered traplines give exclusive rights for individuals (Jr. and Sr. partners) to trap furbearers in a specific area as managed by Alberta Environment and Sustainable Resource Development (ESRD). Created in 1938, the registered trapline system was meant to prevent over-harvest by limiting competition and improve the overall management of furbearers (Pybus 2005). Trapline boundaries are defined by anthropogenic (roads), political (National Parks) or natural (rivers, ridges) features. Registered traplines range in size from one-half of a

township to 30 townships, with traplines tending to be larger as you move north in the province. There is no trapping in National Parks, with the exception of Wood Buffalo National Park in northern Alberta, which allows both commercial and subsistence trapping (R. Kindopp and J. McKinnon pers. comm.).

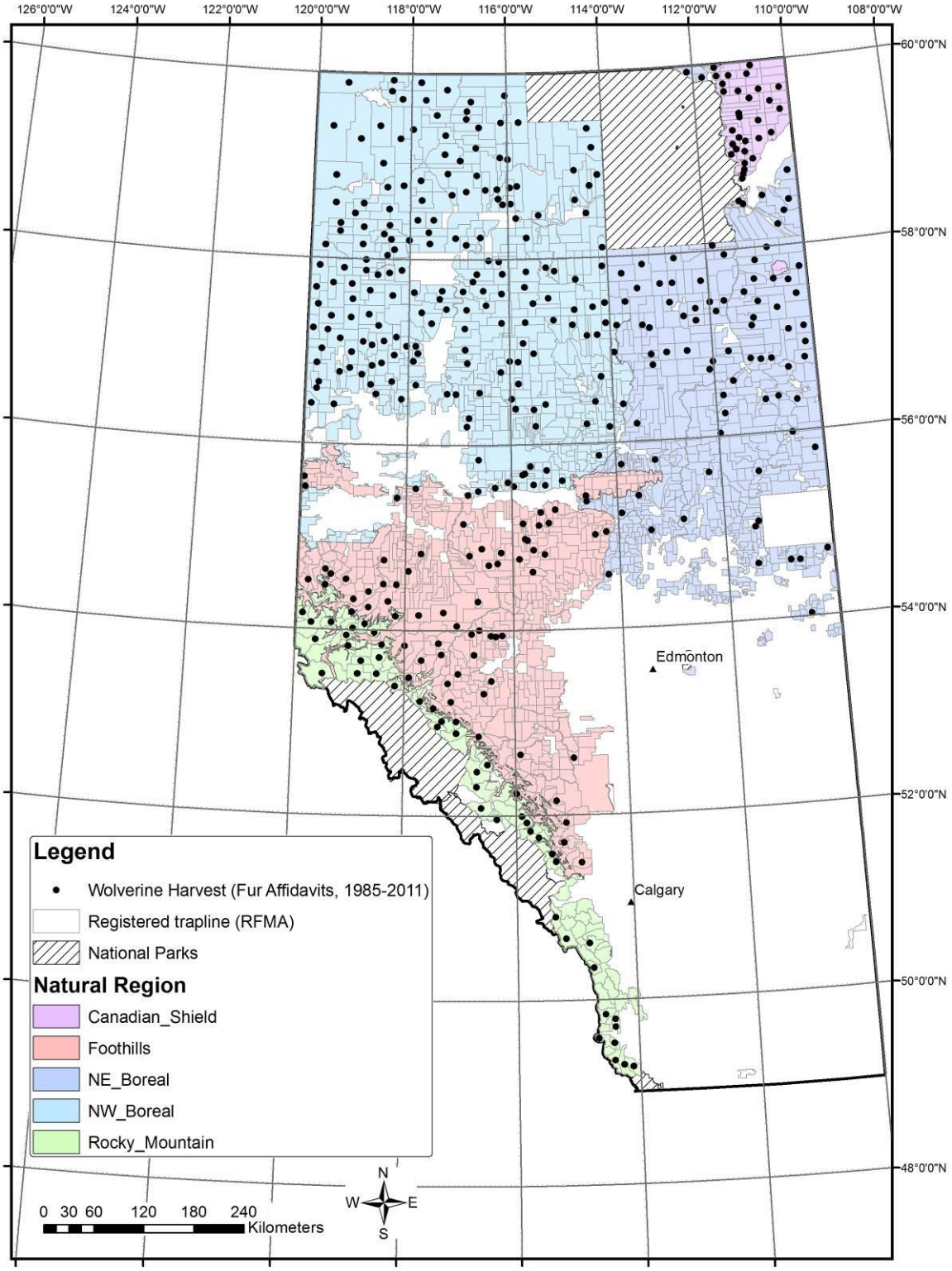

Figure 1. Distribution of registered traplines (RFMA, n=1667), wolverine harvests (dot is centered on RFMA polygon), and natural regions in Alberta. (National Parks and non-trapline areas are excluded.)

3.0 MATERIALS AND METHODS

3.1 Data sources

We collected wolverine and lynx harvest data from three main sources: (a) fur affidavits, (b) fur registrations, and (c) Statistics Canada pelt export records. Additional wolverine data were gathered from the Fisheries and Wildlife Management Information System (FWMIS) database and from the literature. The FWMIS data includes credible sightings and locations of wolverines documented from research from 2002-2011.

Fur affidavit records were exported into an Excel spreadsheet from the Licensing and Commercial Harvest database (R. Corrigan pers. comm.) for the available time period (1985-2010); we also entered 2011 hard copy affidavits and appended them to the Excel database. Trappers are required to submit fur affidavits to record how many of each furbearer species were caught in the previous trapping season on a given trapline. Affidavits are typically filled out when a trapper renews their annual trapping license at a Fish and Wildlife office and are based solely on memory recall. We supplemented the affidavit data with information from Alberta Fish and Wildlife (1990) that reported affidavits by species and year from 1971-1989. We estimated the number of wolverine harvests from a graph in the report but omitted 1971 data because it was suspiciously low (n=6) as compared to Statistics Canada export records for that same year (n=23).

Fur registration records were exported into an Excel spreadsheet from the Licensing and Commercial Harvest database (R. Corrigan pers. comm.) for the available time period (1989-2011). Trappers are required to register all wolverine harvests at a Fish and Wildlife office or fur dealer within 30 days of the end date of the wolverine trapping season (January 30th for most of Alberta). Trappers must bring in evidence of the wolverine (pelt or carcass) so that it can be marked with the metal tag that is required for the pelt to be exported and sold. Fur registrations record the trapper's name, trapline number, harvested species and gender, harvest date, and trap type. Unlike fur affidavits, fur registration records are based on actual physical evidence that a wolverine was caught. Since 1989, trappers are only allowed to harvest one wolverine annually per trapline. Additional wolverine caught over the quota is at the discretion of the Fish and Wildlife Officer, but typically, trappers are allowed to keep one additional

wolverine if accidentally caught; if greater than two wolverines are caught or if caught out of season, then they are turned over to Fish and Wildlife (J. Gerwing pers. comm.).

In addition to registered traplines, wolverines are also registered as a result of road kill, trapping in Wood Buffalo National Park, Indian Reserve or Metis Colony, and incidental capture from resident trapping in the white zone. However, specific locations of non-trapline mortalities were often not recorded so we removed all non-trapline records from the database and focused on harvests from registered traplines.

Fur export records and pelt price were extracted from the Statistics Canada CANSIMs database for the available time period (1971-2010; Stats Canada 2012). Fur export records are collected consistently across all the provinces and provide the total number of exported pelts for each species in Canada. Unlike fur affidavits and fur registrations, export records are reported only by province so they do not include harvest location. We supplemented the Statistics Canada (2012) records with comparable data reported in Todd and Geisbrecht (1979) to examine longer term provincial trends.

3.2 Data entry/proofing

We sorted wolverine harvest records by registered trapline number, year of harvest, and wolverine count in order to identify potential outliers or obvious data entry errors (duplicate records, wrong species, high counts). We cross-checked trapline numbers with a trapline description database and a geographic information systems (GIS) shapefile to determine that the trapline was valid, and updated the database accordingly when trapline amalgamations occurred. Harvest records without a valid trapline number were removed from the database (roadkill, Indian Reserve). Multiple affidavits for a trapline were summed to create a total count of wolverines caught each year on a given trapline. Suspect records were checked with hard copy records, when available, in order to verify the data. In addition, we cross-referenced fur affidavits with fur registrations and vice versa to determine how well the data matched up from 1989 to 2011.

We created a new affidavit record when a registration confirmed a wolverine harvest but the affidavit appeared to be missing. Affidavits could be missed if the trapper did not trap in the consecutive year and thus would not complete an affidavit for the

previous trapping season. High wolverine counts (>6 wolverine on a trapline in a given year) that could not be verified with hard copy records were removed from the database. We also mapped wolverine harvests to determine potential outliers based on location (edge of white zone) and checked hard copies when possible. We entered wolverine harvest records from hard copy forms not yet entered into the electronic database for 2011-2012.

Lynx harvests were a secondary priority and had a large sample size, making it difficult to adequately verify with hard copy records. We sorted the lynx records by registered trapline number, year of harvest, and lynx count, and identified potential outliers. Suspect records, including high counts (>50 lynx on a trapline in a given year) were verified and updated with hard copy records, when available. Harvest records without a valid trapline number were removed.

3.3. Distribution and harvest success

We used natural regions to summarize wolverine harvest data into landscapes with similar climate, soil, topography, and vegetation. Refer to Natural Regions Committee (2006) for a complete description of natural regions in Alberta. Registered traplines overlap the Boreal Forest, Rocky Mountains, Foothills, and Canadian Shield natural regions, so we limited our analysis to these regions. Because the Boreal Forest is large, we summarized results into Northwest (NW) and Northeast (NE) Boreal based on the Fur Management Zone (FMZ) map (Zones 1+3 = NE; Zone 2 = NW; Government of Alberta 2012; Figure 1). To simplify the map and remain consistent with the FMZs, we grouped the small section of Boreal Forest located south of Grande Prairie into the Foothills region.

Registered traplines are assigned to the nearest Fish and Wildlife office, so we used the office location to determine which natural region a fur affidavit would be located in. Rocky Mountains included offices in Canmore, Blairmore, Pincher Creek, High River, Sundre, Nordegg, and Grande Cache. Foothills included Rocky Mountain House, Edson, Hinton, Foxcreek, Slave Lake, and Swan Hills. NW Boreal included Grande Prairie, Valleyview, Fairview, Fort Vermilion, High Level, High Prairie, Manning, Peace River, Spirit River, and Red Earth. NE Boreal included Athabasca, St. Paul, Lac La Biche, Cold Lake, and Fort McMurray. In this case, fur affidavit records from the

Canadian Shield were included with the NE Boreal because the majority of the Ft. McMurray district traplines are located in the Boreal Forest region.

We used ArcMap 10 (ESRI 2011) for making maps and summarizing data. We used a GIS to determine wolverine harvest distribution from fur affidavit and registration records. We mapped wolverine harvests by registered trapline and Wildlife Management Unit (WMU) (Government of Alberta 2012). Refer to Appendix 1 to determine specific WMUs and natural regions in the province. In order to protect the identity of individual traplines, we summarized data by WMU when presenting harvest densities. When traplines overlapped multiple WMUs, we assigned traplines to the WMU that encompassed the greatest area.

We separated the fur affidavit harvest data into five time periods to compare long-term changes in harvest distribution and success (1985-1989, 1990-1994, etc.). Similarly, we compared fur registrations for 2 time periods (1989-1999; 2000-2011) to determine trends by natural region. For the registration data, we assigned each registered trapline to a natural region to compare spatio-temporal trends, and in this case, we separated the Canadian Shield natural region. We determined the area of each natural region that overlapped the registered trapline map (National Parks were excluded). We examined the fur registrations to determine the proportion of female versus male wolverine harvests, as well as the timing of the harvest.

We summarized lynx data using fur affidavits and registrations to determine whether consistent trends were apparent from the different sources of data. When mapping lynx distribution, we used the Natural Jenks function in ArcGIS to summarize density by WMU. We plotted wolverine harvests against lynx harvests and pelt value to examine whether potential relationships existed. We assumed our data was non-parametric and used the Spearman rank correlation (r_s) to determine the strength of the relationship between different trapping-related variables (Zar 1999).

Researchers have found a strong relationship between the occurrence of wolverines, particularly female dens, and years with persistent spring snow cover (snowpack existing between 24 April - 15 May, 2000-2006; Copeland et al. 2012). We overlaid wolverine harvest data onto the snowpack layer (Copeland et al. 2012) to determine the relationship between wolverine occurrence and spring snowpack in Alberta. We

selected female harvests and determined the proportion of harvests that overlapped the snowpack map by natural region.

We compared wolverine harvest registration data to Global Forest Watch Canada's (GFWC) map of large, intact forest landscapes (Lee et al. 2010). We measured the number of years with a wolverine harvest as an indication of consistency in harvest over time. We used Natural Jenks in ArcGis to group harvest data into three time periods. An intact forest landscape as defined by GFWC is, "*a contiguous mosaic of naturally occurring ecosystems, including forest, bog, water, tundra, and rock outcrops, that is within a forest ecozone, and that is essentially undisturbed by significant human influence visible on Landsat satellite images. Intact forest landscape fragments are the best remaining pieces of our once-intact forest landscapes and they are therefore critical to the restoration of ecosystem functioning in areas affected by human development*." (Lee et al. 2010).

We decided that intact forest was an appropriate metric for human footprint (roads, towns, wells, etc.) and to investigate how it relates to wolverine harvest at a very coarse level. There were several categories of large, intact forests including: Intact Forest Landscape (IFL) = >50,000 ha within all forest ecozones; IFL Fragment = 5,000-50,000 ha within all forest ecozones; Temperate IFL = 1,000-5,000 ha within Temperate ecozone; and Small Island = <5,000 ha within the Boreal/Taiga or <1,000 ha in Temperate ecozone. We predicted that wolverine harvest success would be higher in areas with large, intact forest landscapes based on previous research that shows that wolverines may be sensitive to human activity and development.

4.0 RESULTS

4.1 Data quality

The original harvest database was relatively clean with few errors identified. We verified approximately 11% of the wolverine registrations, and 20% of the wolverine affidavits with original hard copy records. For lynx, approximately 1% of the affidavits were verified with original hard copy records. Organization and availability of hard copy records varied, so we are more confident in the database in some years than others. Wolverine registrations in 2011 and 2012 are likely underestimated since we may be missing records that had not yet been received by Fish and Wildlife district offices at the time of data entry. The low number of wolverine typically harvested each year made it relatively easy to identify potential data entry errors based on high counts. We identified two common errors for fur affidavits, incorrect species (such as marten or wolf) mistakenly entered by the trapper or data entry staff on the wrong line of the affidavit, and duplicate records entered (identified based on the same information in every field). Similarly, mistakes were found in fur registrations when the incorrect species was checked off on the registration form. By cross-referencing registered trapline numbers to the GIS shapefile of traplines, we were able to easily identify harvests from non-registered traplines. However, it is still possible that some of these harvests may overlap and were included in our analysis.

We observed a discrepancy between the data sources (Figure 2). It was expected that the Statistics Canada data would not match the other data sources because it only included pelts that were exported from the province, and also included wolverines caught in all locations (Wood Buffalo National Park and Indian Reserves). Wolverines used domestically or for taxidermy purposes, in which the pelt was tanned in Alberta, would not receive an export permit and thus not be captured by Statistics Canada. In addition, the Statistics Canada dates may not be comparable to affidavits or registrations because it is based on what year the wolverine pelt was sold at auction as opposed to the year it was harvested. However, we expected the fur affidavits and fur registrations to better align since there is compulsory registration for every wolverine caught after 1989. In general, the annual number of wolverines recorded by affidavits was higher than on registrations. Roughly 25% of affidavits had missing registrations (indicating a wolverine was caught on a given trapline in the same year but was not registered), and

24% of registrations were missing affidavits, from 1989–2011. There are some plausible reasons for the discrepancy, including data entry errors and missing data (records from district offices or fur dealers were not forwarded to ESRD). However, the timing of when wolverines are reported on affidavits versus registrations likely explains much of the variation. Trappers register wolverines during the same winter that the wolverines were caught, whereas the affidavit may not be reported until the following summer or fall. Trappers may forget to report it or may not fill out an affidavit altogether if they do not trap the following season. A certain degree of uncertainty exists with each data source and we recognize these data limitations.

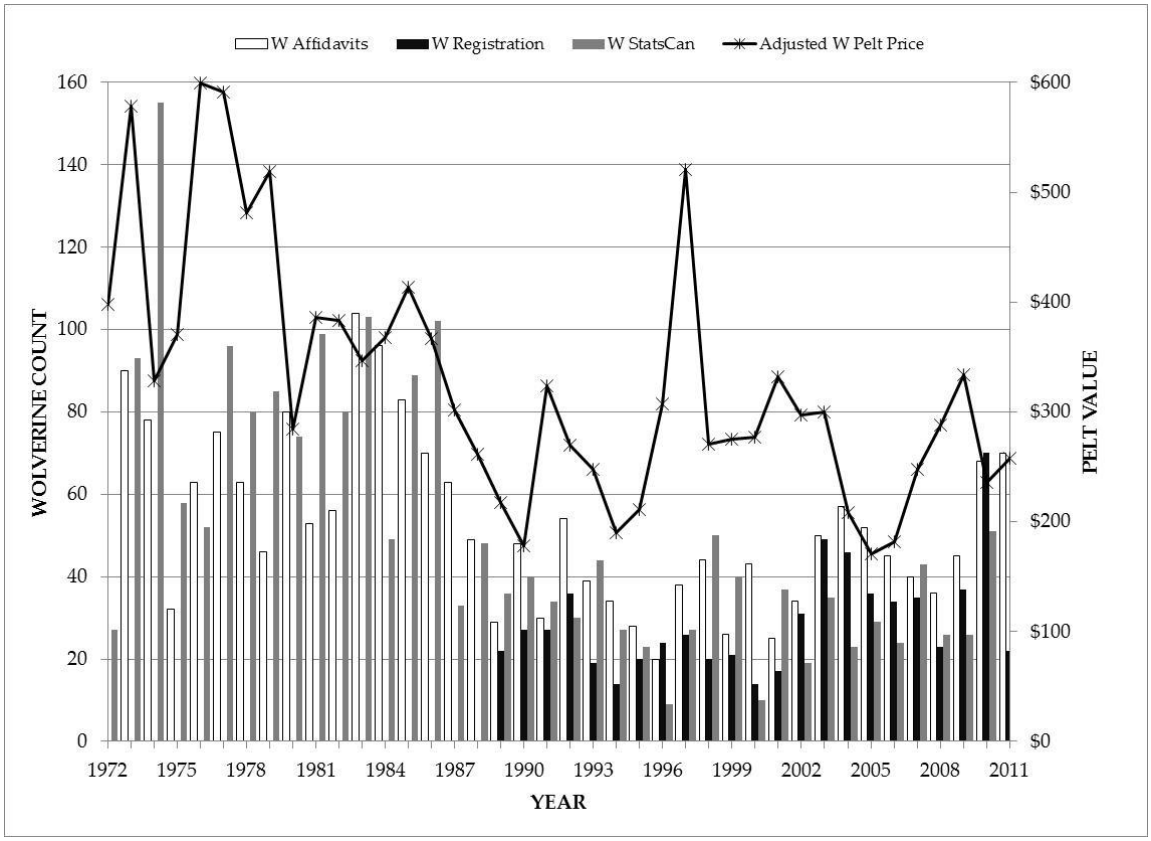

Figure 2. Wolverine (W) harvests reported on fur affidavits, fur registrations, and Statistics Canada fur exports, and average wolverine pelt price adjusted for inflation, in Alberta from 1972-2011. Year represents the trapping season end date (1990 indicates harvests made from 31 August 1989 – 31 August 1990).

4.2 Wolverine distribution

The distribution of wolverines, as determined from harvests reported on fur affidavits (Figure 1), show wolverines primarily occurring in the Rocky Mountain, Foothills, Boreal Forest and Canadian Shield natural regions. This distribution has remained fairly consistent over time, with the possible expansion of wolverine into the Boreal Forest of northeastern Alberta (Figure 3; Appendices 2-7). When trapping records were grouped by natural region, the data shows a potential increase and expansion of wolverine harvests occurring in northeastern Alberta, particularly in the Fort McMurray area (Figure 3). For example, the average number of wolverines harvested in the NE Boreal from 1985-1989 was 5 wolverines, as compared to 13 wolverines from 2005-2011. The majority of the total wolverine harvests (1985-2011) occurred in the NW Boreal (63%), followed by NE Boreal (includes Canadian Shield) (20%), Rocky Mountains (9%), and Foothills (8%). The distribution of wolverines is roughly proportional to the percent area of each natural region, with the exception of the NW Boreal and Foothills. Approximately 58% of wolverines were harvested in the NW Boreal, which comprises only 41% of the total trapline area (RFMAs). The Foothills comprise 23% of the trapline area, but only 10% of the total wolverine harvest (Figure 3; Table 1).

Wolverine harvests reported on fur registrations were also summarized by natural region to determine changes over space and time. The fur registrations showed a similar spatio-temporal trend as the affidavits. When comparing two time periods (1989-1999; 2000-2011; Table 1), wolverine harvests have more than doubled in the NW Boreal (105%), and also increased by 47% and 33% in the NE Boreal and Foothills, respectively. During the same time periods, wolverine harvests declined by 40% and 32% in the Canadian Shield and Rocky Mountains, respectively.

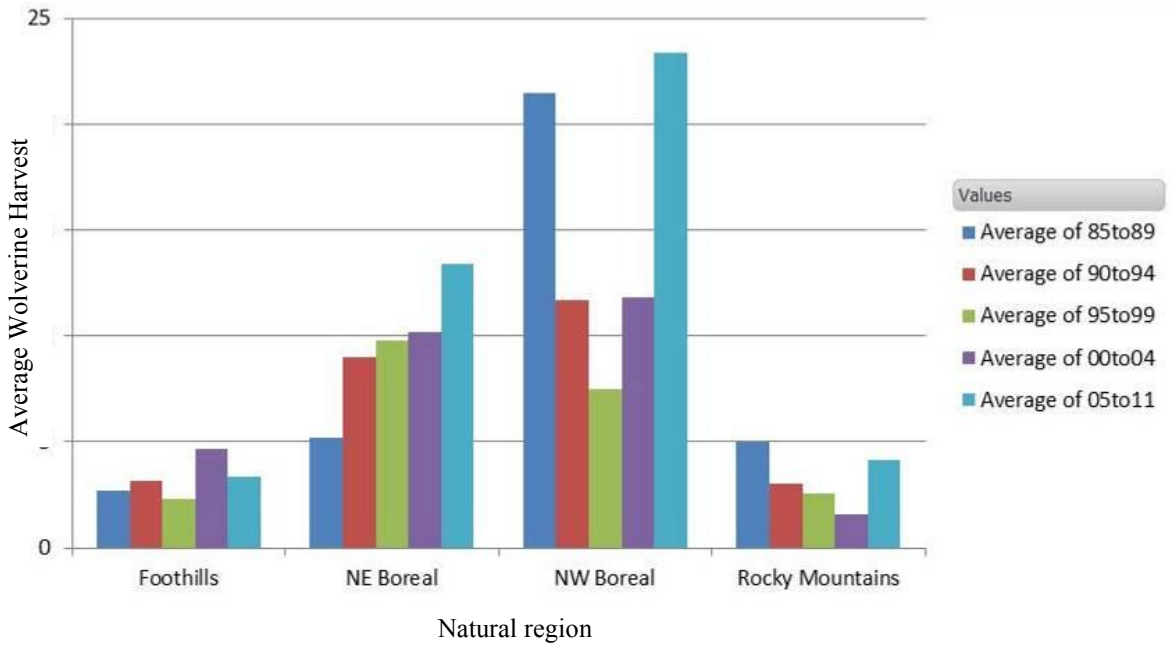

Figure 3. Average wolverine harvest reported on fur affidavits, by natural region, across different time intervals in Alberta. Harvests from the Canadian Shield were included with the NE Boreal natural region.

Table 1. Percent of total trapline area, total wolverine harvests, and harvest density, summarized by natural region, for two time periods in Alberta.

Natural region	Percent of total trapline area	Total harvests 1989-1999 (#/km^2)	Total harvests 2000-2011 (#/km^2)
Canadian Shield	2.6%	13 (0.0014)	8 (0.0009)
Rocky Mountains	6.9%	35 (0.0004)	24 (0.0003)
Foothills	23.4%	28 (0.0011)	37 (0.0015)
NE Boreal	25.8%	49 (0.0005)	72 (0.0008)
NW Boreal	41.4%	121 (0.0008)	249 (0.0016)

FWMIS locations for wolverine occurrences demonstrate that registered traplines could have wolverines present without a harvest taking place, so we use caution when interpreting the distribution of wolverines from harvest data alone (Figure 4). Although our maps do not indicate wolverine harvests in National Parks, wolverines likely occur there (Waterton Lakes, Banff, Jasper, and Wood Buffalo National Parks). In addition to harvests on registered traplines, other mortality events are recorded on fur registrations, including road kill, harvests on Indian Reserves, Metis colonies or Wood Buffalo National Park, as well as accidental harvest by resident trappers (Table 2). These mortality events are challenging to map because they often have no specific location information. No wolverine mortalities were registered prior to 1995, indicating an increase in non-trapline mortalities after that point, and particularly in 2012. However, it's difficult to determine if the more recent reporting of wolverine mortalities on fur registrations simply reflects an increased effort (Fish and Wildlife staff, general public) to report them.

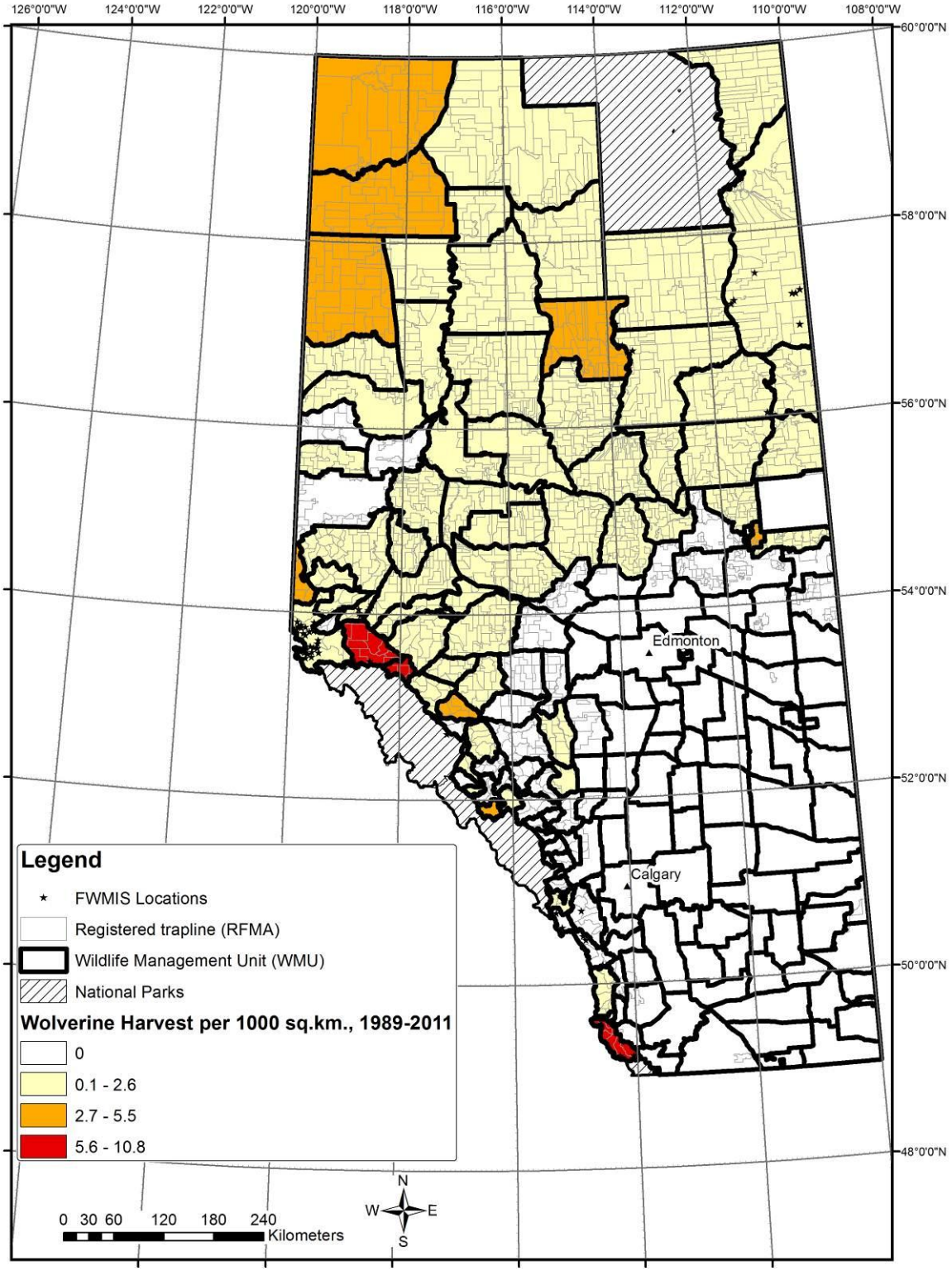

Figure 4. Wolverine harvest densities in relation to RFMA and WMU, as reported on fur registrations from 1989-2011, and FWMIS locations from 2002-2011.

Table 2. Wolverine mortalities on registered traplines (RFMA) and non-trapline locations (roadkill, trapping in Indian Reserve/Wood Buffalo National Park, accidental harvest by resident trapper), reported on fur registrations from 1995-2012. [2012] data is incomplete since all registrations had not been received.

Year	Non-trapline mortalities	Registered trapline mortalities
1995	1	20
1996	1	24
1997	0	26
1998	0	20
1999	1	21
2000	1	14
2001	0	17
2002	0	31
2003	2	49
2004	3	46
2005	1	36
2006	2	34
2007	4	35
2008	1	23
2009	1	36
2010	1	70
2011	1	22
[2012]	8	39

It is not surprising that approximately 80% of the wolverine harvests occur in the Boreal Forest in northern Alberta, given that's where the majority (67%) of the available trapping area occurs (Table 1). However, when wolverine harvest densities are corrected by WMU area, the highest densities occur within the Rocky Mountains (Figure 4). According to fur registrations, the highest wolverine harvest densities (>5.5 wolverines/1000 km^2) over time (1989-2011) have occurred in the Rocky Mountains: Castle-Carbondale (WMU 400), Solomon (WMU 439) and Adams Creek (WMU 440). Medium wolverine harvest densities (2.7-5.5 wolverines/1000 km^2) have been reported in both the Boreal Forest and Rocky Mountains: Siffleur Wilderness (WMU 736), Red Cap (WMU 437), Narraway (WMU 445), Lakeland Provincial Recreation Area (WMU 841), Panny River (WMU 541), Chinchaga River (WMU 524), Rainbow Lake (WMU 536) and Bistcho Lake (WMU 539). However, some of these higher densities may be the

result of a small number of wolverine harvests reported in a small WMU. Therefore, harvest density at the scale of a WMU may not be a robust indication of population numbers.

The total number of years with a wolverine harvest may indicate where a more stable trapper effort and wolverine population occurs. Since 1989, the registered traplines that had five or more years with a wolverine harvest are located in the Rocky Mountains (WMU 400*, 440*, 445*), Foothills (WMU 353), and Boreal Forest (WMU 524*, 527, 530, 532, 534, 535, 536*, 539*, 541*); * indicates WMUs that also had medium to high wolverine harvest densities (2.7-10.8 wolverines/1000 km^2; Figure 5; Appendix 1). Although, some of the mountain areas had the highest wolverine harvest densities, places where wolverines have been harvested the highest number of years (12-23 years) occurred in the Boreal Forest, primarily north of 58 degrees latitude (WMU 530, 536, 539; Figure 5). Coincidentally, some of these WMUs in the Boreal Forest (WMU 524, 532, 534, 536, 539) have a wolverine trapping season extended by two weeks (1 November – 15 February; Government of Alberta 2012).

In general, the harvest data indicates that the core distribution of wolverine spans along the Rocky Mountains and across the northern Boreal Forest of Alberta. Some of this distribution is consistent with our predictions of where wolverines should occur, assuming spring snowpack is important for recruitment and long term population persistence (Copeland et al. 2010; Figure 6): Caribou Mountains (WMU 534, NW Boreal), Chipewyan (WMU 532, Canadian Shield), Bistcho Lake (WMU 539, NW Boreal) (Figure 1; Appendix 1). The spring snow distribution is relatively continuous throughout the Boreal Forest of Canada, with the exception of Alberta, which tends to have a more cold and dry climate (The Wolverine Foundation 2012). The snow cover map indicates more consistent spring snowpack in the Rocky Mountains and a patchy distribution, with large areas devoid of spring snow cover, throughout most of northern Alberta (north of 56 degrees latitude; Figure 6). And yet, we have evidence of fairly consistent long term wolverine harvest from many areas that appear to lack large areas of spring snow cover (WMU 524, 527, 530, 541; Figure 6; Appendix 1). The relationship between wolverine occurrence and spring snowpack was strongest when considering female dens, where 98% of dens found across the wolverine's circumpolar range overlapped places where snow persisted one or more years into spring (2000-2006; Copeland et al. 2010). In Alberta, we found that approximately 63% of traplines that reported female harvest had

at least 1 year (n=86 of 138 traplines) with spring snowpack, and 13% of traplines had 5 or more years (n=18 of 138 traplines) (Figure 6). The majority of traplines that caught a female wolverine and had spring snowpack for 5 or more years were in the Rocky Mountains (61%; n=11 traplines), followed by NW Boreal (28%; n=5), and Canadian Shield (11%; n=2). However, there are other areas in the Rocky Mountains that have persistent spring snow coverage but lack wolverine harvest (Kananaskis country, WMUs 410-414; Figure 6; Appendix 1), indicating that other factors must be considered when determining wolverine distribution (trapping effort, prey, human activity, development, etc.).

Global Forest Watch Canada indicated that larger patches of continuous, intact forests occurred in the Rocky Mountains, Boreal Forest and Canadian Shield (Lee et al. 2010) (Figure 5). The landscapes of the Boreal Forest tend to be more fragmented south of 57 degrees latitude. The areas of the northern Boreal Forest of Alberta that support higher wolverine harvests appear to be less fragmented; a greater proportion of traplines that harvested a wolverine for five or more years overlapped with intact forest (WMU 400, 440, 530, 531, 532, 534, 536, 539, 540). However, some areas with large, intact landscapes in the mountains have low or zero wolverine harvest (Happy Valley (WMU 308), Upper Saskatchewan (WMU 426), Bighorn (WMU 430), White Goat (WMU 432), Cardinal (WMU 436), White Goat Wilderness (WMU 738)). Despite a lack of intact forests in the Foothills, the number of wolverine harvests has increased by 32%, while harvests in the more intact Rocky Mountain landscape have declined by 31% (Table 1).

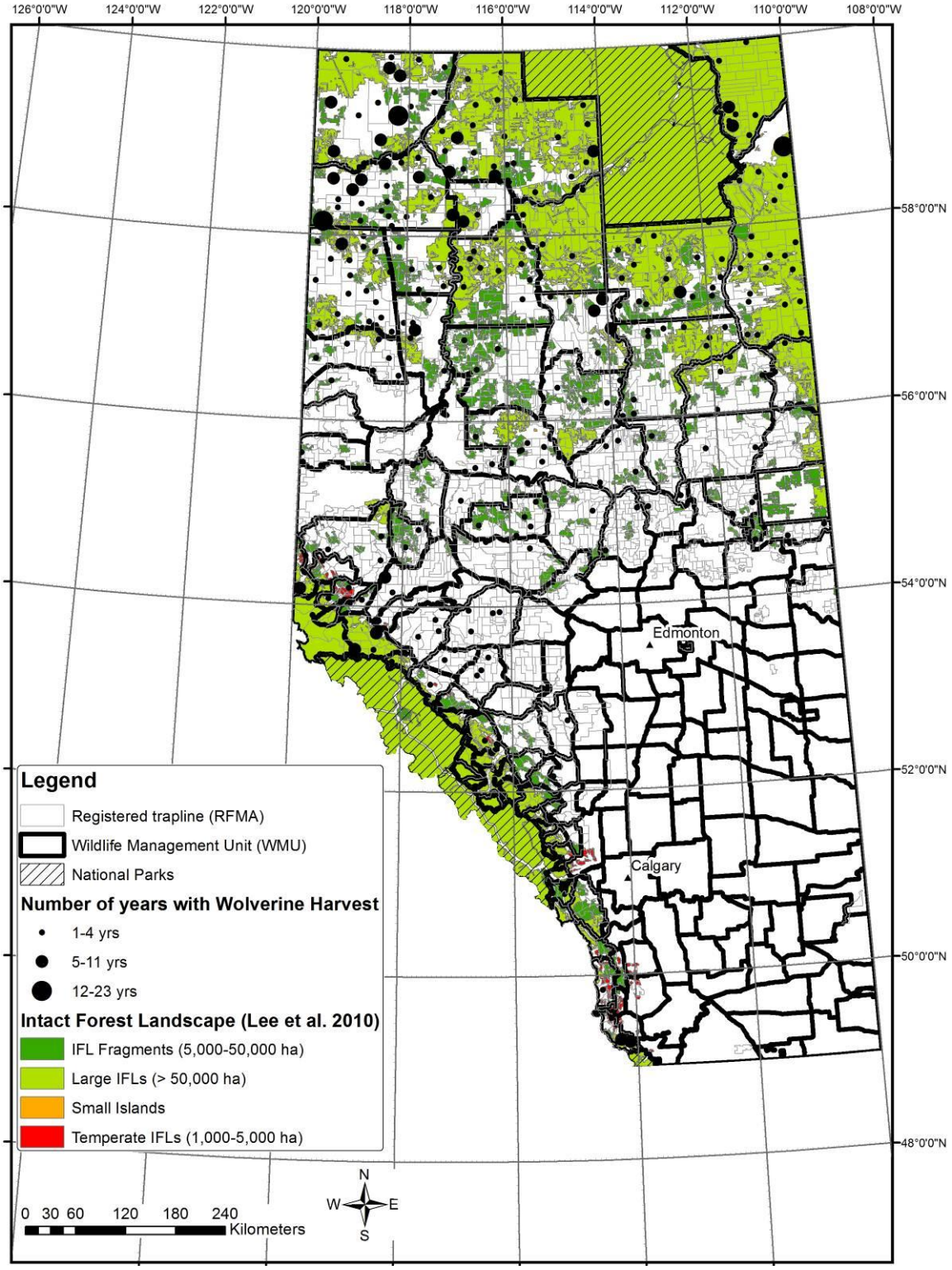

Figure 5. Number of years with a wolverine harvest (dot is centered on RFMA polygon) in relation to Intact Forest Landscapes, from 1989-2012 in Alberta.

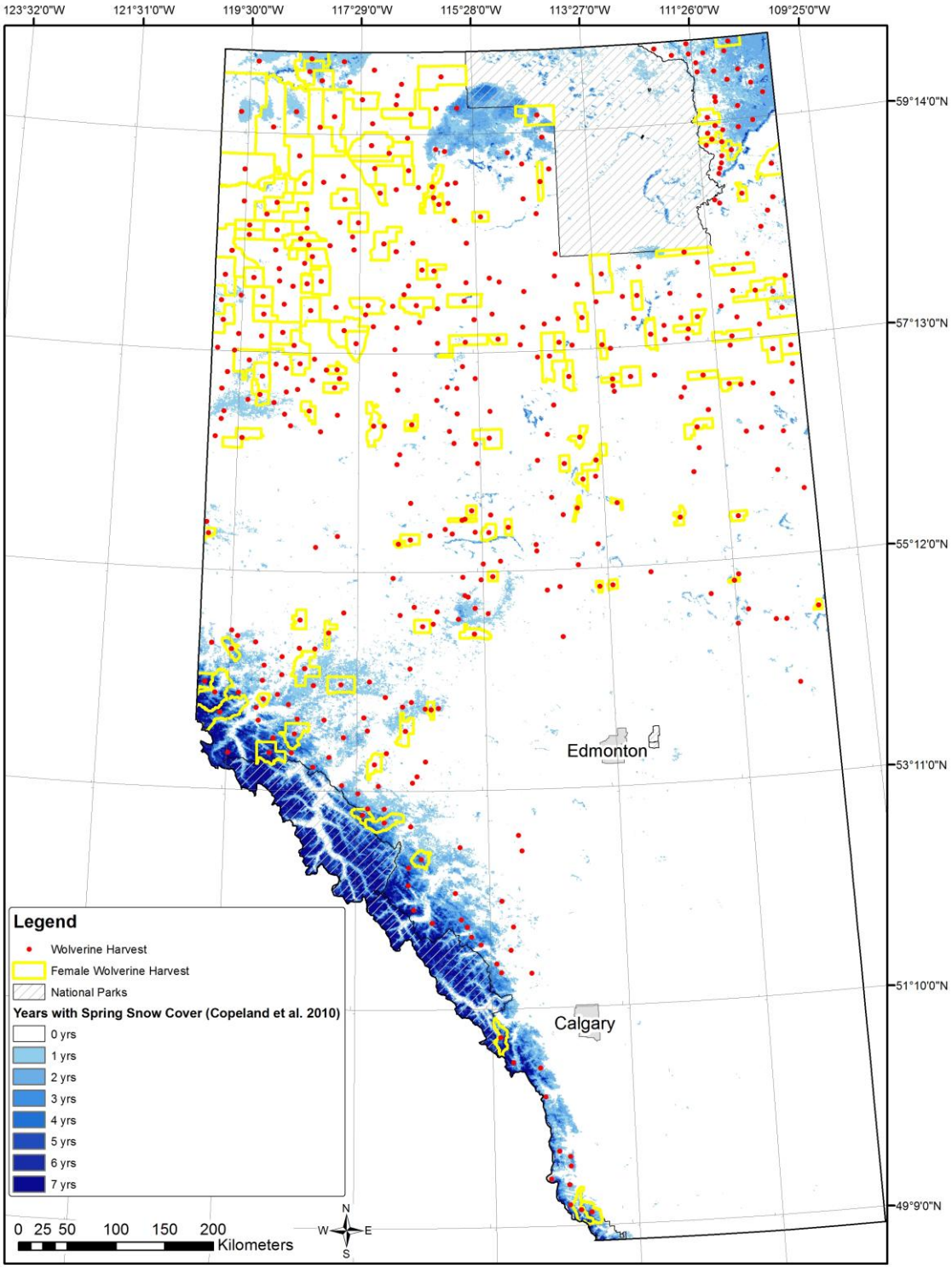

Figure 6. Distribution of female wolverine harvests reported on fur registrations from 1989-2011, and total wolverine harvest from fur registrations and affidavits from 1985-2011 (red dots centered on RFMA), relative to years with spring snow cover from 2000-2006 in Alberta.

4.3 Wolverine harvest success

4.3.1 Statistics Canada

Wolverine pelt exports have fluctuated over time with the peak export recorded in 1927 (350 wolverines exported) and the lowest number recorded in 1954 (0 wolverines) (Figure 7), which likely reflects the effects of intense poisoning efforts from 1952-1956 to control a rabies outbreak (Pybus 2005). The initiation of a quota in 1989 of one wolverine harvest per year per registered trapline, makes it difficult to compare harvest data as a reflection of potential population change over pre- and post-quota time periods. Trapping effort may have changed as a result of the quota, although harvest numbers are within a similar range during different time periods (1960-1970 vs. 1997–2010; Figure 7).

Wolverine pelt values have also varied over time (range: $170 in 2005 to $600 in 1976) and appear to have a positive relationship to wolverine harvest from 1972-2011 (r_s=0.495, *d.f.*=38, *p*=0.001; Figure 8). In addition, unadjusted (for inflation) average lynx pelt values also had a positive relationship to wolverine harvests recorded by Statistics Canada from 1972-2010 (r_s=0.422, *d.f.*=38, *p*=0.007), fur affidavits from 1972-2010 (r_s=0.544, *d.f.*=37, *p*=0.0003), and fur registrations from 1989-2010 (r_s=0.499, *d.f.*=20, *p*=0.02). The strength of the relationship between lynx pelt values and wolverine harvests is even stronger as they both increase from 1995-2010 (r_s=0.72, *d.f.*=14, *p*=0.002). Discrepancies exist between the Statistics Canada, fur affidavit, and fur registration records on an annual basis, but the general increasing trend across data sources is apparent from 2000-2010 (Figure 2).

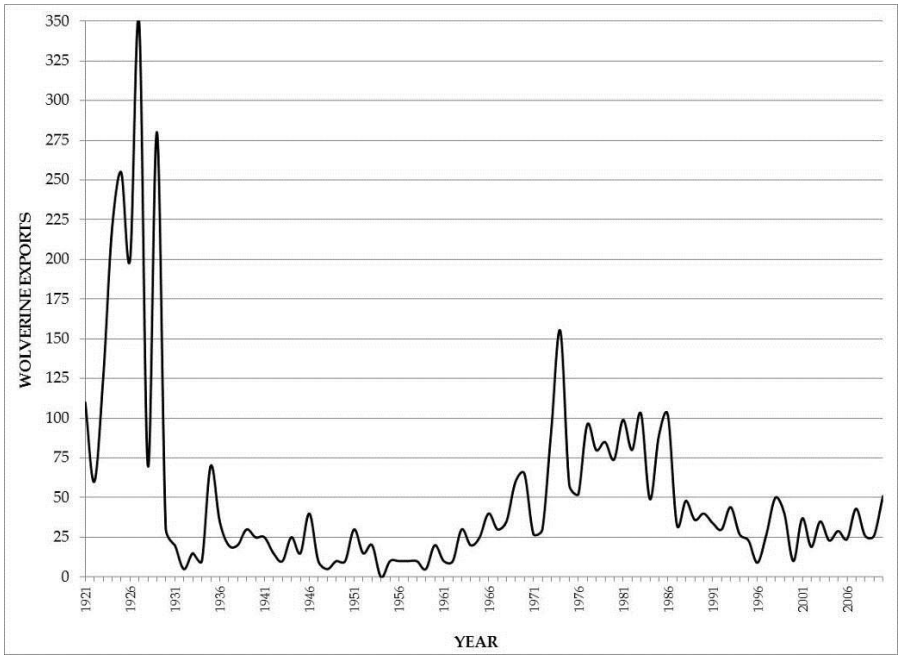

Figure 7. Total wolverine pelts exported from Alberta from 1921-2010. Export records from 1921-1970 were estimated from Todd and Geisbrecht (1979) and records from 1971-2010 were derived from Statistics Canada (2012). Year represents the trapping season end date.

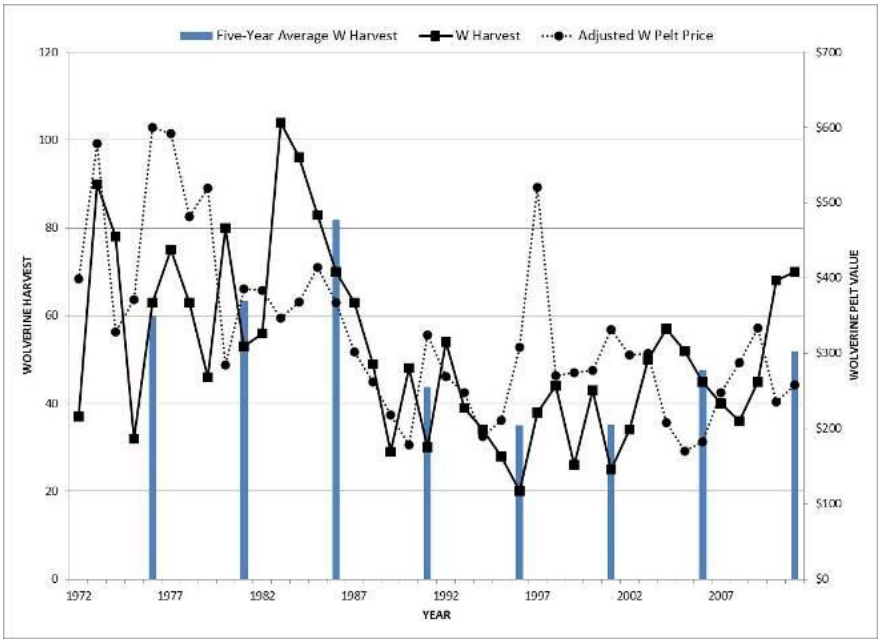

Figure 8. Five-year average wolverine harvest, and total wolverine harvest reported on fur affidavits, and wolverine pelt price for Alberta from 1972-2011. Wolverine affidavit data from 1972-1984 were estimated from Alberta Fish and Wildlife (1990). Year represents the trapping season end date. Five-year time periods are 1972-1976, 1977-1981, etc.

4.3.2 Fur affidavits and registrations

Data from fur affidavits show variable wolverine harvests over time, with noticeably greater numbers prior to 1989 when there was no quota in place (Figure 8). Wolverine harvests from affidavits (1972-2011) have ranged from a low of 20 wolverines in 1996 to a high of 104 wolverines in 1983. Wolverine harvests were on a downward trend from 1984-1996, but harvests have shown an increasing trend from 1997-2011. In fact, wolverine harvests have increased by 1.5 fold when comparing the five-year averages of 1992-1996 to 2007-2011 (Figure 8). Similarly, the average number of traplines reporting a wolverine harvest has risen, with a 1.6 times increase from the 1990-1994 time period to the 2005-2011 time period (Figure 9). On average, approximately 3% of all traplines (n=46, range: 33-61) harvested wolverine in the most recent time period (2005-2011). Approximately 25% of all traplines (n=418) have reported a wolverine harvest on fur affidavits at least once in the past 27 years (1985-2011). The number of traplines that have reported more than one wolverine harvests on an affidavit is ≤1% of the total traplines (range: 1-12) from 1985-2011; the vast majority of which are located in the Rocky Mountains and NW Boreal. So despite the increasing trend in the number of traplines catching wolverine, the proportion of traplines catching more than one wolverine per year does not appear to be increasing.

Wolverine harvests reported on fur registrations do not match fur affidavits precisely, but do follow similar trends from 1989-2011 (r_s=0.591, *d.f.*=21, p=0.003). In general, the number of wolverine harvests registered tends to be lower than affidavit reports, on an annual basis (Figure 2). The annual number of wolverine harvests from registrations (1989–2011) has ranged between 14 (1994, 2000) and 70 (2010) (Figure 10). The average number of wolverines registered has increased 1.5 fold from the 1989-1992 time period to the 2009-2012 time period (Figure 10). Approximately 18% of traplines (n=305) have registered a wolverine harvest at least once during the past 23 years (1989-2011). December (43%) and January (40%) were the primary months when trappers caught wolverine, as compared to 9% in November and 8% in February. The proportion of males and females harvested was surprisingly consistent across months; roughly 66% of the total registered wolverine harvests were male and 32% were female (n=467; range: male=54-86%, female=14-46%) (Figure 11). Although greater numbers of males were harvested in all months, the ratio of males to females increased by approximately 20% in February as compared to the other months (Figure 11). The sex ratio of the Alberta

harvest was comparable to wolverines harvested in British Columbia, where females comprised less than 50% of the total harvest (Lofroth and Ott 2007).

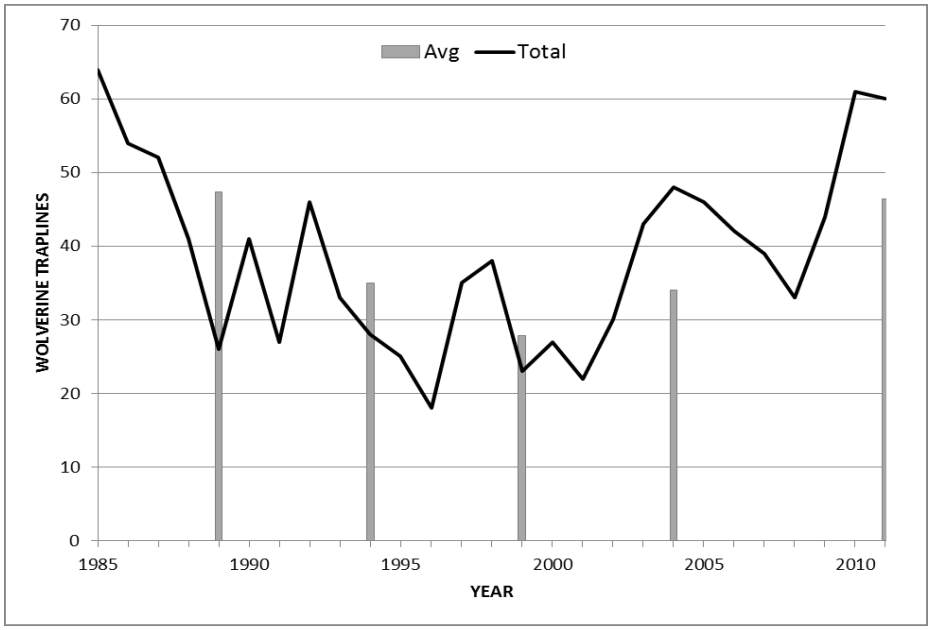

Figure 9. Total and average number of traplines that reported a wolverine harvest on fur affidavits from 1985-2011 in Alberta. Time periods are 1985-1989, 1990-1994, 1995-1999, 2000-2004, and 2005-2011.

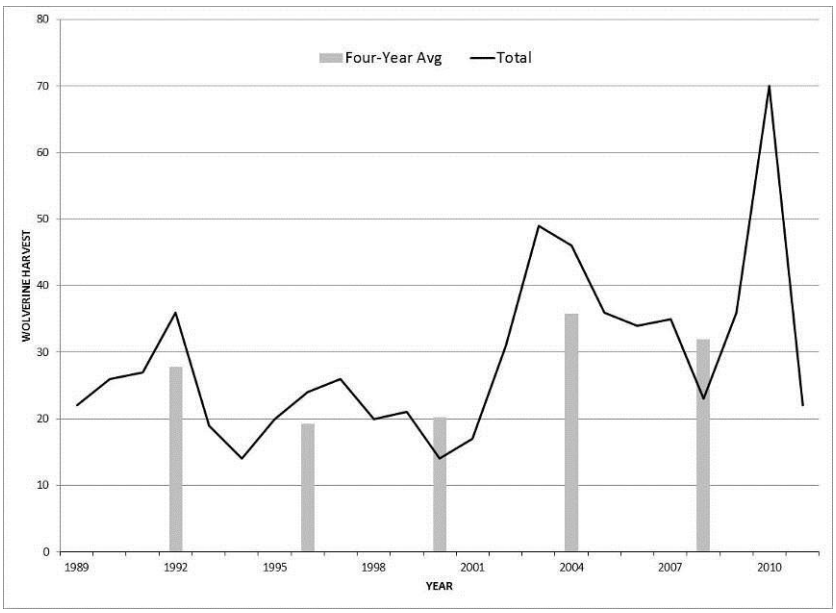

Figure 10. Total and four-year average of wolverine harvests reported on fur registrations from 1989-2012 in Alberta. 2012 data is incomplete since all records had not been received. Year represents the trapping season end date. Four-year time periods are 1989-1992, 1993-1996, etc.

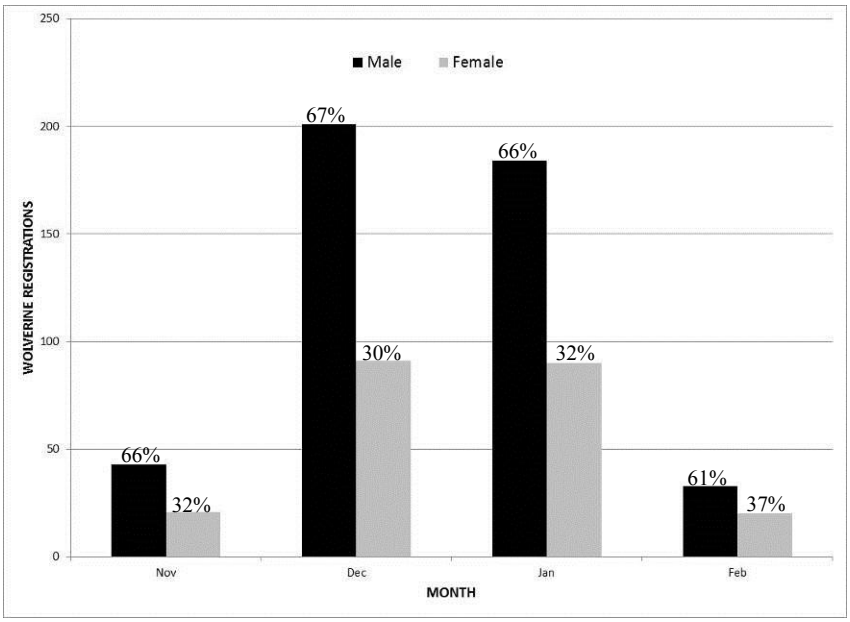

Figure 11. Total and percent of wolverine harvests by gender, reported on registered traplines by month, from 1989-2012 in Alberta. Wolverines with unknown gender were excluded.

4.3.3 Wolverine and lynx

Wolverine and lynx both had harvest quotas initiated in the late 1980s (1988 for Lynx; 1989 for wolverine). Trapping records reflect the well-known 10-year lynx cyclic pattern with harvest peaks occurring around 1982, 1992, 2002 and suspected in 2012 (Figure 12). Although wolverine harvests did not fluctuate at the same magnitude as lynx, we found that wolverine harvests seemed to track the ups and downs in the lynx harvest data strikingly well from 1985-2010 (r_s=0.372, d.f.=24, p=0.06; Figure 12). Interestingly, this trend holds up for both fur affidavits (Figure 12) and fur registrations (Figure 13), but less well for the longer-term Statistics Canada records, where lynx harvests were much greater in magnitude prior to 1980 (Figure 14). The distribution of lynx, as determined from fur affidavits from 1985-2010, indicate that lynx are broadly distributed with harvest densities highest in the NE/East-central Boreal (north of 54 degrees latitude), the NW Boreal (north of 56 degrees latitude), and to a lesser degree in the Foothills and Rocky Mountains (Appendix 7). We found a high spatial and temporal overlap of wolverine and lynx harvests; approximately 67% of traplines that had a wolverine harvest also reported a lynx harvest in the same year (1985-2011).

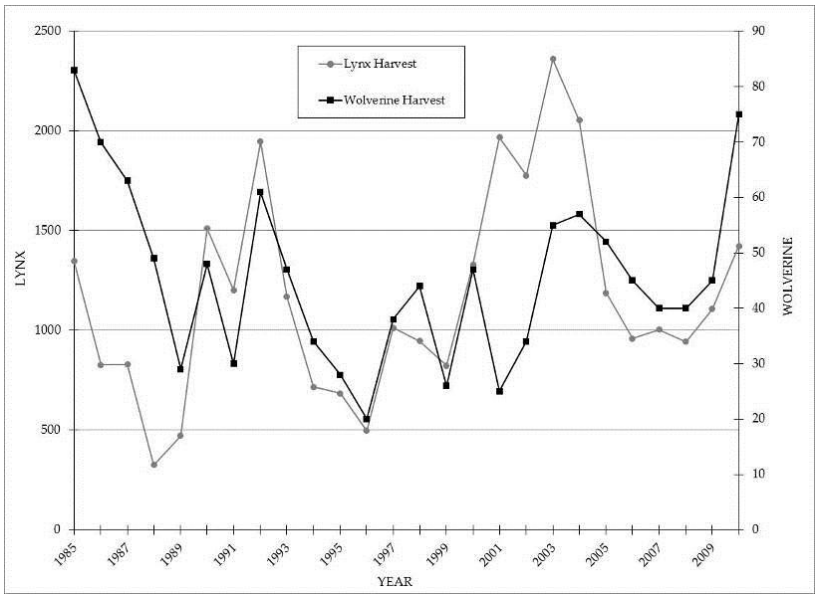

Figure 12. Total lynx (n=30,438) and wolverine (n=1,185) harvests reported on fur affidavits from 1985–2010 in Alberta. Year represents trapping season end date.

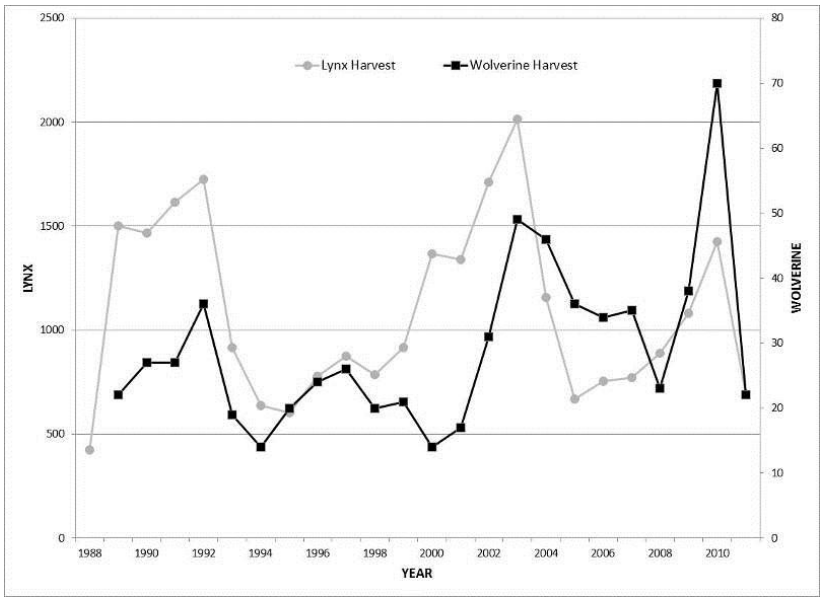

Figure 13. Total lynx (n=25,697) and wolverine (n=671) harvests reported on fur registrations from 1989-2010 in Alberta. Year represents trapping season end date.

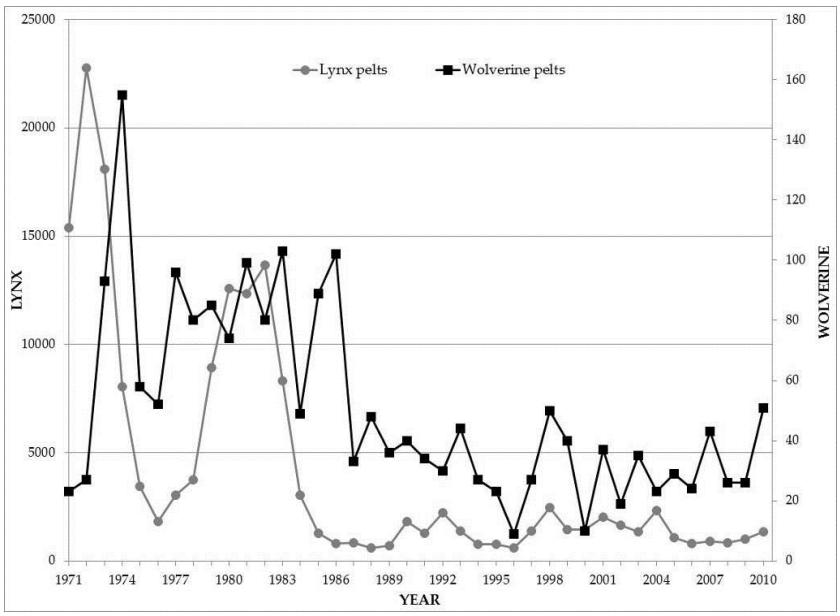

Figure 14. Total number of lynx (n=168,457) and wolverine (n=2,029) pelts exported from 1971–2010 in Alberta, as reported by Statistics Canada (2012). Year represents trapping season end date.

5.0 DISCUSSION

We provide the most recent and comprehensive summary of wolverine harvest data for Alberta. In contrast with previous analyses on wolverine data prior to 1999 (Petersen 1997; Poole and Mowat 2001), we show evidence of an expansion in wolverine harvest distribution (Table 1), which also coincides with an increase in the total number of wolverine harvests reported on fur affidavits and fur registrations from 1997-2011 (Figures 8, 10). The mean annual number of wolverine harvests reported on affidavits, as well as the number of traplines reporting a wolverine harvest, has increased since the mid-1990s. However, there has been no trend in the frequency of traplines reporting >1 wolverine/year over this time period. The locations where more than one wolverine were caught were very similar to the locations with higher harvest densities and greater number of years reporting a harvest (NW Boreal and Rocky Mountains). Although wolverines continue to be harvested in the Rocky Mountains, the traplines where more than one wolverine was harvested is shifting away from this region (n=7 traplines (1985-1989), n=5 (1990-1994), n=0 (1995-1999), n=2 (2000-2004), n=2 (2005-2011); total harvest from the Rocky Mountains has also declined over time (Table 1; Figure 3), and may indicate a change in trapper effort.

It is not surprising that the vast majority of wolverine harvests (82%) occurred in the Boreal Forest in northern Alberta given that most of the available trapping area occurs there (67%). It is not clear whether the increase in wolverine harvests in the NE Boreal is related to an increase in the wolverine population or simply to trapper effort. Skinner and Todd (1988) used a trapper questionnaire to estimate that wolverines had a sparse distribution in NE Alberta, approximately between 53-56 degrees latitude and east of 115 degrees longitude; harvest data also suggested a sparse distribution in this area. However, the more recent harvest data shows a potential expansion in wolverine distribution into parts of the Foothills (Slave Lake area) and the NE Boreal (Fort McMurray area). It is possible that increases in human population and industrial development, particularly in the Fort McMurray area, have resulted in previously remote registered traplines now becoming more accessible to trappers.

Although harvest data is useful for plotting wolverine occurrence on a map, we do not know whether or not wolverines are present on traplines that have not reported a harvest. While the majority of the FWMIS locations overlapped areas that had

wolverine harvests, there were a few FWMIS locations where wolverine harvests had not occurred (Highwood (WMU 404), Elbow (WMU 406)). This suggests that multiple sources beyond harvest data can provide a more informed picture of wolverine distribution. FWMIS locations are useful in determining wolverine range and distribution even though they are often opportunistic observations recorded by recreationalists, research scientists, or consultants performing tasks for industry. This is evidenced by the increase in FWMIS locations in the oilsands area near Fort McMurray, Willmore Wilderness and some parts of Kananaskis country.

We were surprised to find that large areas of the Boreal Forest lacked persistent spring snow cover, yet had consistent wolverine harvests through time (1985-2011). Studies have suggested that wolverines have an obligate need for persistent spring snowpack which is linked to successful denning recruitment (Copeland et al. 2010). Exploring other metrics, such as distance to the nearest spring snow cover, would help in determining whether wolverines tend to occur closer to places with spring snowpack.

New research has shown evidence for a food-based hypothesis to help explain why wolverines occur in cold, low-productivity environments (Inman et al. 2012). Areas with deep snow provide wolverines with an ideal place to cache prey and den. Areas that lack snow during the denning period may still have suitable cover for dens (hollow trees, woody debris, etc.), prey availability, and microsites to refrigerate cached items for extended time periods (sphagnum moss). Also, the snow cover map is not 100% accurate and wolverines may have snow dens that occur outside the snow coverage map. Investigating wolverine dens in the Boreal Forest of Alberta would give better information on the characteristics of dens and how they differ from other studies.

Temperature has also been suggested as an important predictor of wolverine occurrence, so further research could explore how temperature, particularly soil temperature or mean August temperature differs across Alberta (Copeland et al. 2010). Although elevation is likely related to both spring snowpack and temperature, it is also an important variable to consider given that wolverines may exhibit thermal avoidance (Copeland et al. 2010). Prey availability is another important consideration to wolverine distribution but it is difficult to quantify; trappers could provide information based on their experiences, as well as wolverine specimens for further study (stable isotope analysis). Anecdotal observations from the Boreal Forest suggest that wolverines may

benefit from ungulate roadkill near roads, but wolverines can also become victims themselves; commercial fisheries can also provide an important food source (Bistcho Lake; J. Gerwing pers. comm.), as well as snowshoe hare populations.

Other research has found that wolverines tend to occur in places further away from people (Banci 1994). This certainly would seem to be the case when considering the wolverine harvest distribution in Alberta, with the majority of the harvest occurring in the less populated and less developed areas of the Boreal Forest and Rocky Mountains. Large, intact forests are fairly continuous among traplines in the mountain region but they have a narrow width, while larger, more patchy intact forests occur in the Boreal Forest (Lee et al. 2010). We anticipated more consistent wolverine harvest among traplines in the mountain region given the low human footprint.

Further research should include areas where wolverine harvests seem to be discontinuous, such as the areas northwest of Porcupine Hills, southwest of Chain Lakes, west of Highway 22, Kananaskis country, the lower foothills west of Drayton Valley and north to Swan Hills, and the area on the east side of the Athabasca River, northeast of Wabasca and west of Fort McMurray. Coincidentally, many of these areas have undergone intense human development and/or have heavy levels of recreational activity (Herrero 2005; Schneider 2002). As a result, grizzly bear conflicts and/or mortality are also high in the areas around Swan Hills and Kananaskis country (Alberta Grizzly Bear Recovery Team 2008). An increased human footprint could be discouraging trapper effort in some of these areas (Webb et al. 2008), and/or be reflective of a true lack of wolverine occurrence.

Conversely, the lack of wolverine harvest in some areas may be caused by remote, inaccessible areas located far away from towns (northeast of Wabasca along the Athabasca River, some mountain traplines). Without further investigation, we cannot determine wolverine status in these areas, although discussions with trappers would be a good place to start. Despite the evidence that wolverines don't generally occur near concentrated human activities or development, apparently wolverines can travel through these areas occasionally. A wolverine was photographed running through a new subdivision in Airdrie, just north of Calgary in March 2012, and a wolverine was videotaped eating dog food in a backyard in St. Albert, just north of Edmonton in June

2012 (R. Corrigan pers. comm.). A family group of wolverines were also observed living at the dump in High Level (J. Gerwing pers. comm.).

It is interesting that wolverine harvests would closely track lynx harvests, both at the provincial and trapline scale. The high degree of spatial and temporal overlap of wolverine and lynx suggest the two are closely linked. Lynx are considered a "bread and butter" furbearer species with a wide distribution, relatively high densities when populations are increasing, and they tend to have valuable pelts. We hypothesize that the close relationship between lynx and wolverine is likely caused by a combination of factors including trapper effort, and natural population fluctuations. Trappers likely adjust their effort in relation to furbearer abundance, and so as lynx numbers increase, trapper effort increases. As more lynx are caught, the encounter and catch rate of wolverine (bycatch) also increases, as they can be incidentally caught in lynx traps.

As a scavenger, it is also possible that wolverines are attracted to active traplines to steal bait and/or trapped lynx, making the trapper more likely to target wolverines. In addition, we cannot rule out the importance of the snowshoe hare and lynx population fluctuations. Previous researchers have documented the importance of the snowshoe hare, particularly when they are very abundant, in the diet of wolverines (Banci 1994). As the lynx population declines in concert with snowshoe hare numbers, wolverines may benefit from scavenging lynx that struggle to find an alternate prey source. Changes to trapping regulations for lynx may affect wolverine harvest, since the former appears to have some close link to the latter. We will be looking into lynx and wolverine relationships in future studies.

Although long-term furbearer harvest data is valuable, we use caution in interpreting these results as a direct reflection of actual wolverine population trends. Trapper effort is a complex process that is influenced by a wide variety of factors in Alberta including: furbearer abundance, weather, rising average income, health, work schedule, fur prices, improved recreational access, and increasing industrial development (Mullen 2006). To better tease apart the effect of trapper effort from population effects, trapping records would be more valuable if trappers recorded the number of trapnights per species. Trapper questionnaires have been used in the past to get a snapshot of furbearer abundance and continue to be an important source of traditional knowledge. As part of a larger wolverine project, we will be using a trapper questionnaire, in conjunction with

the collection of field data, to measure wolverine occurrence and gene flow in order to better understand the status of wolverines in Alberta. This updated wolverine harvest summary gives us good baseline information to work from.

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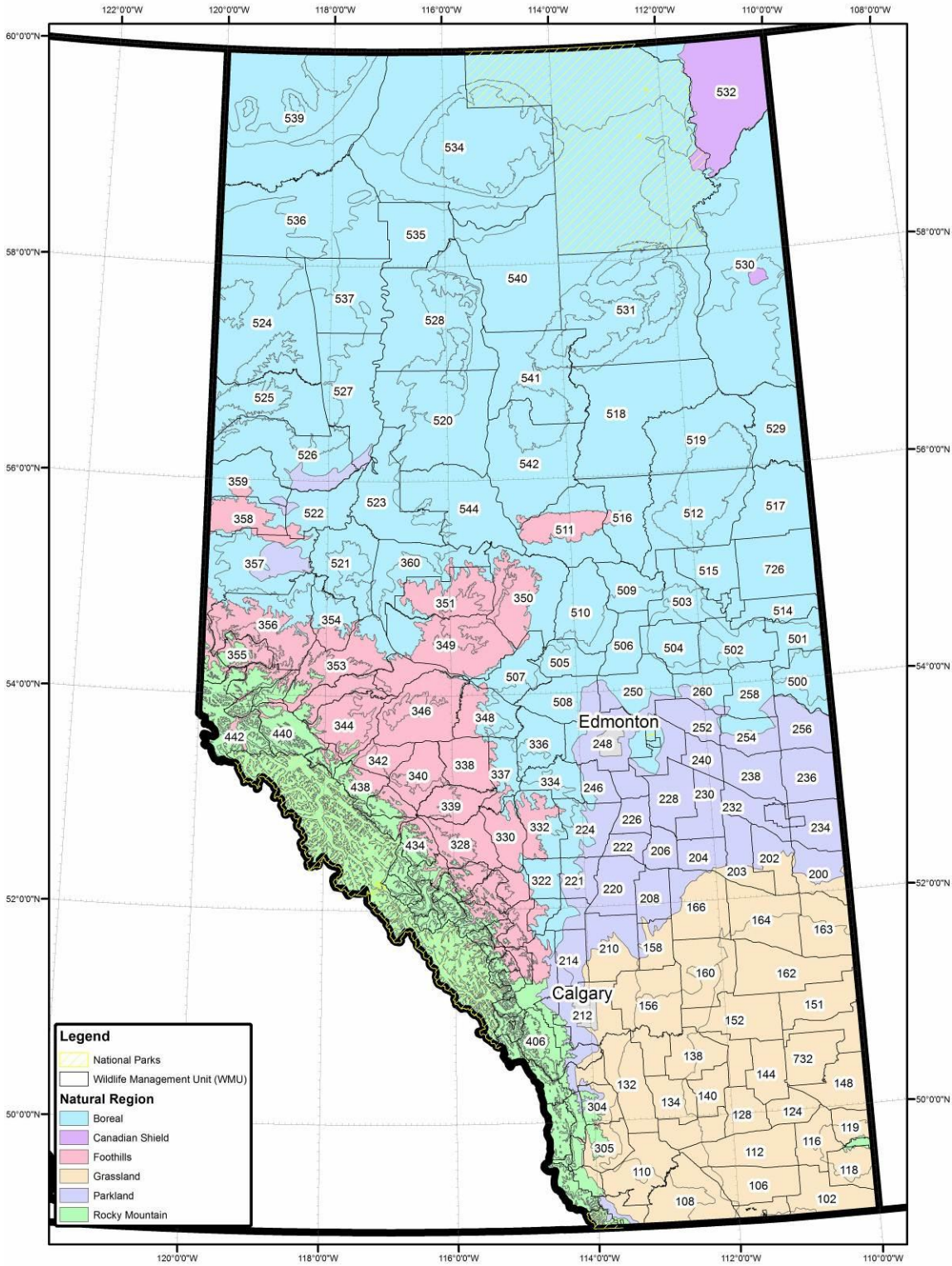
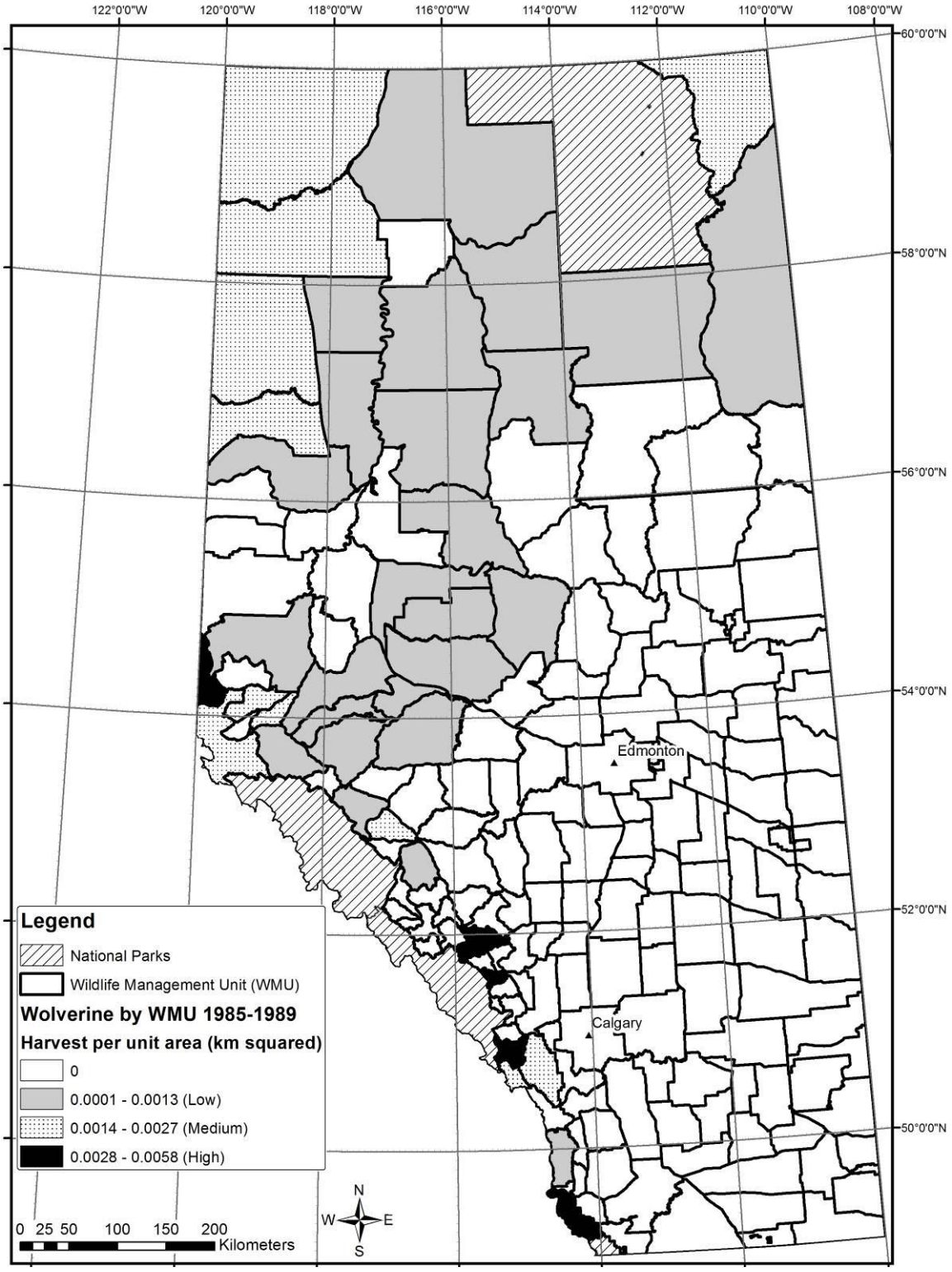
7.0 APPENDICES

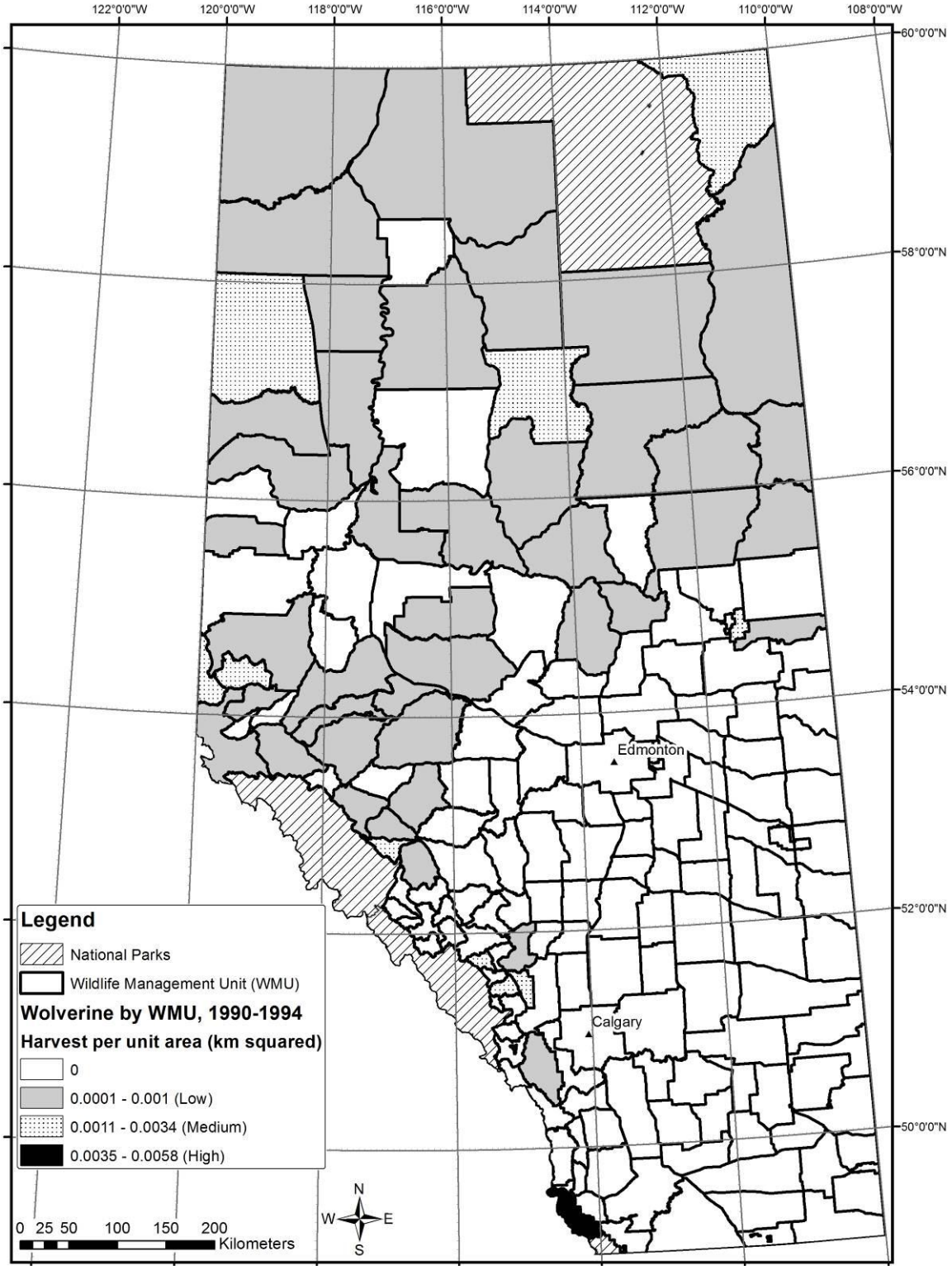
Appendix 1. Wildlife Management Units (WMU) and Natural Regions in Alberta.



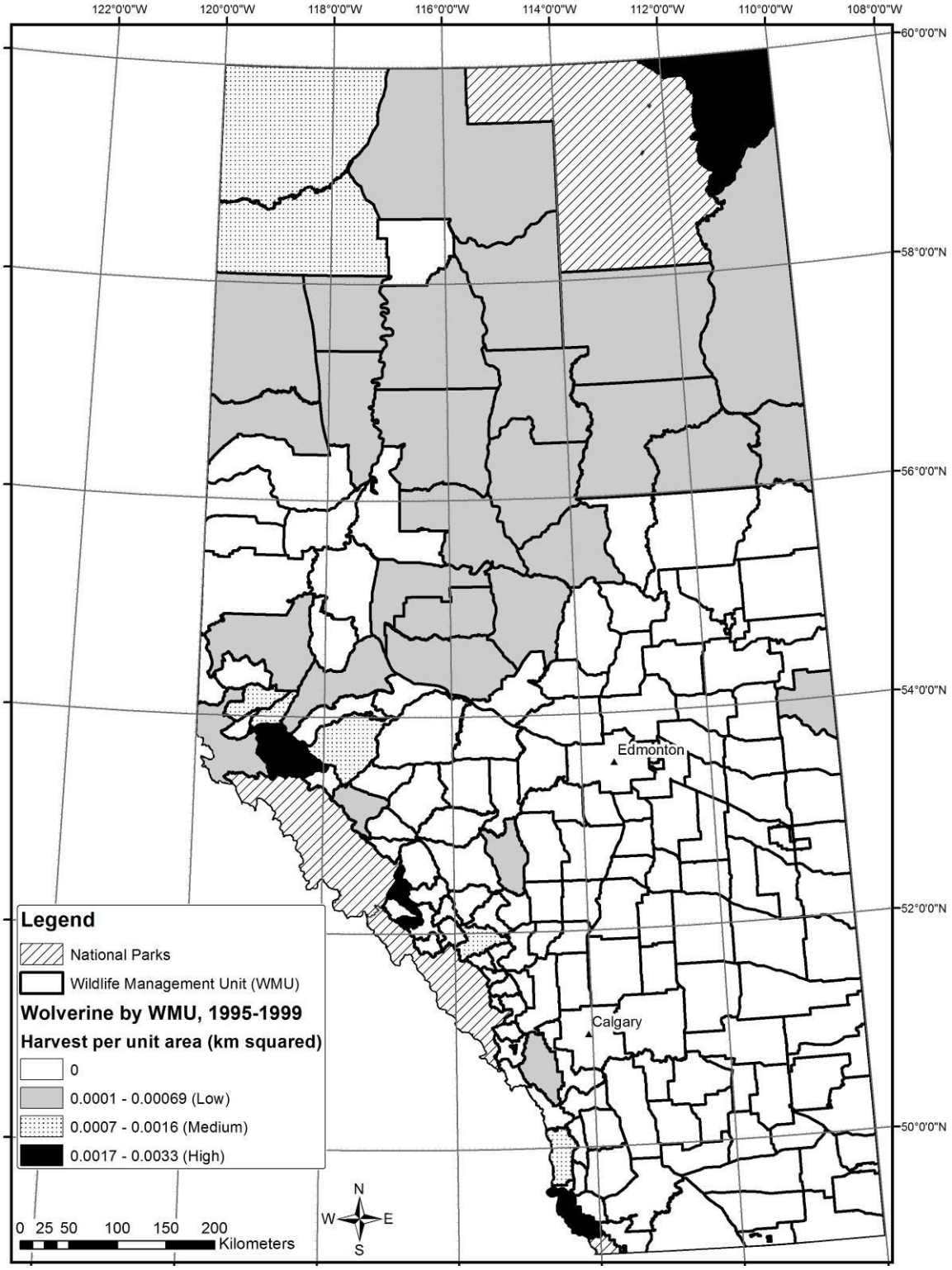
Appendix 2. Wolverine harvest density (# wolverine per km^2) by WMU reported on fur affidavits from 1985-1989 in Alberta. National Parks and non-trapline areas were excluded.



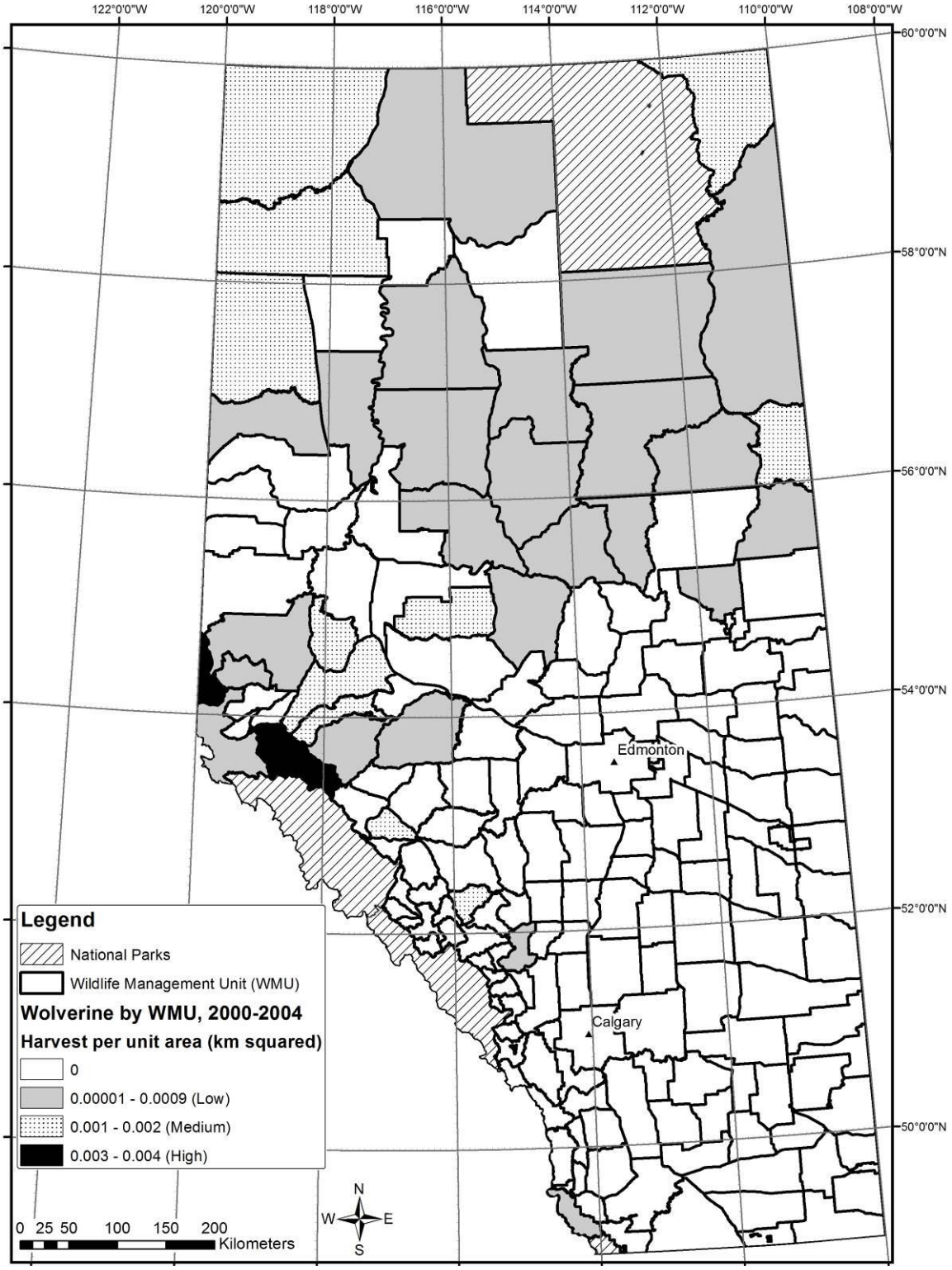
Appendix 3. Wolverine harvest density (# wolverine per km^2) by WMU reported on fur affidavits from 1990-1994 in Alberta. National Parks and non-trapline areas were excluded.



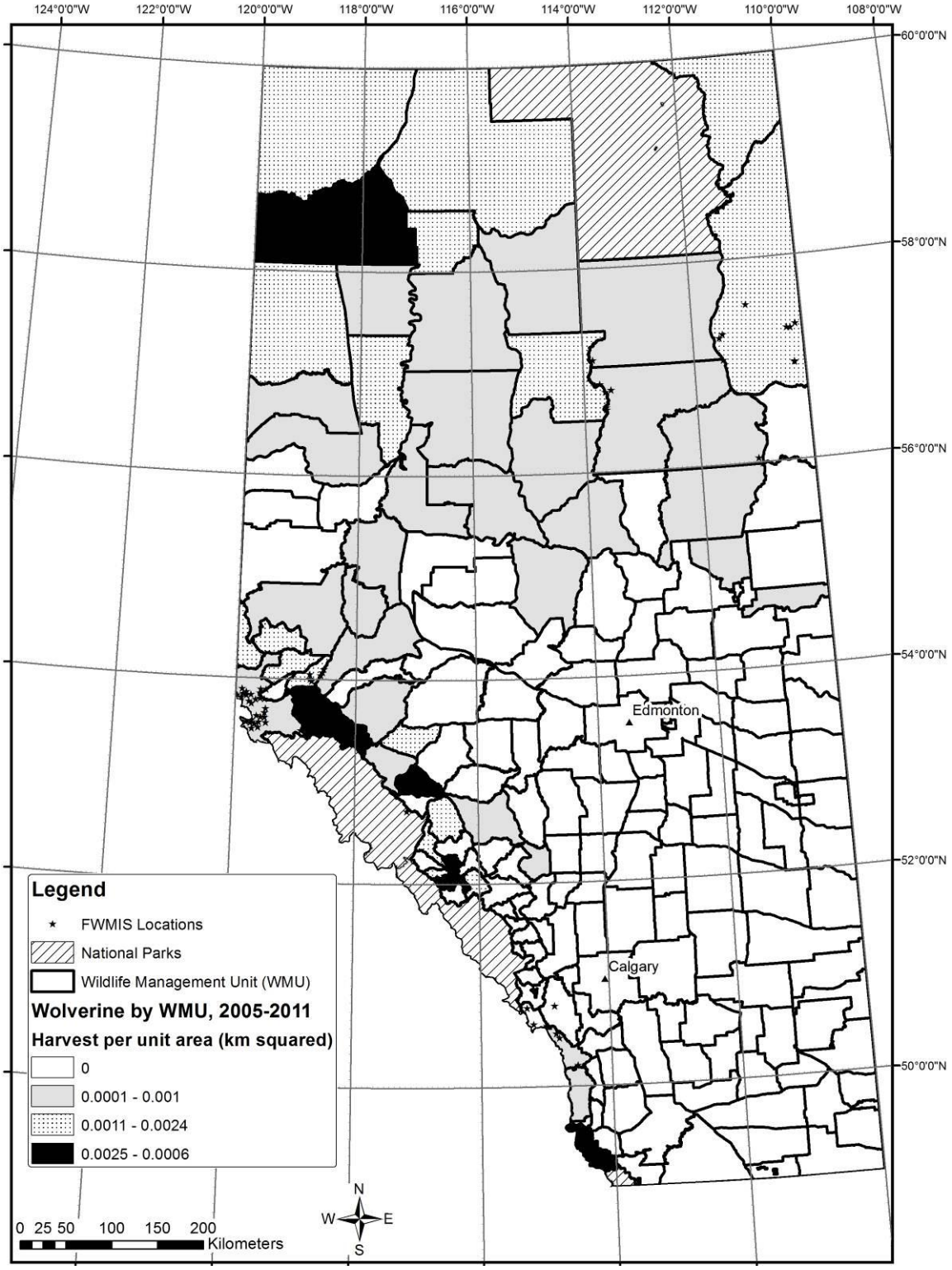
Appendix 4. Wolverine harvest density (# wolverine per km^2) by WMU reported on fur affidavits from 1995-1999 in Alberta. National Parks and non-trapline areas were excluded.



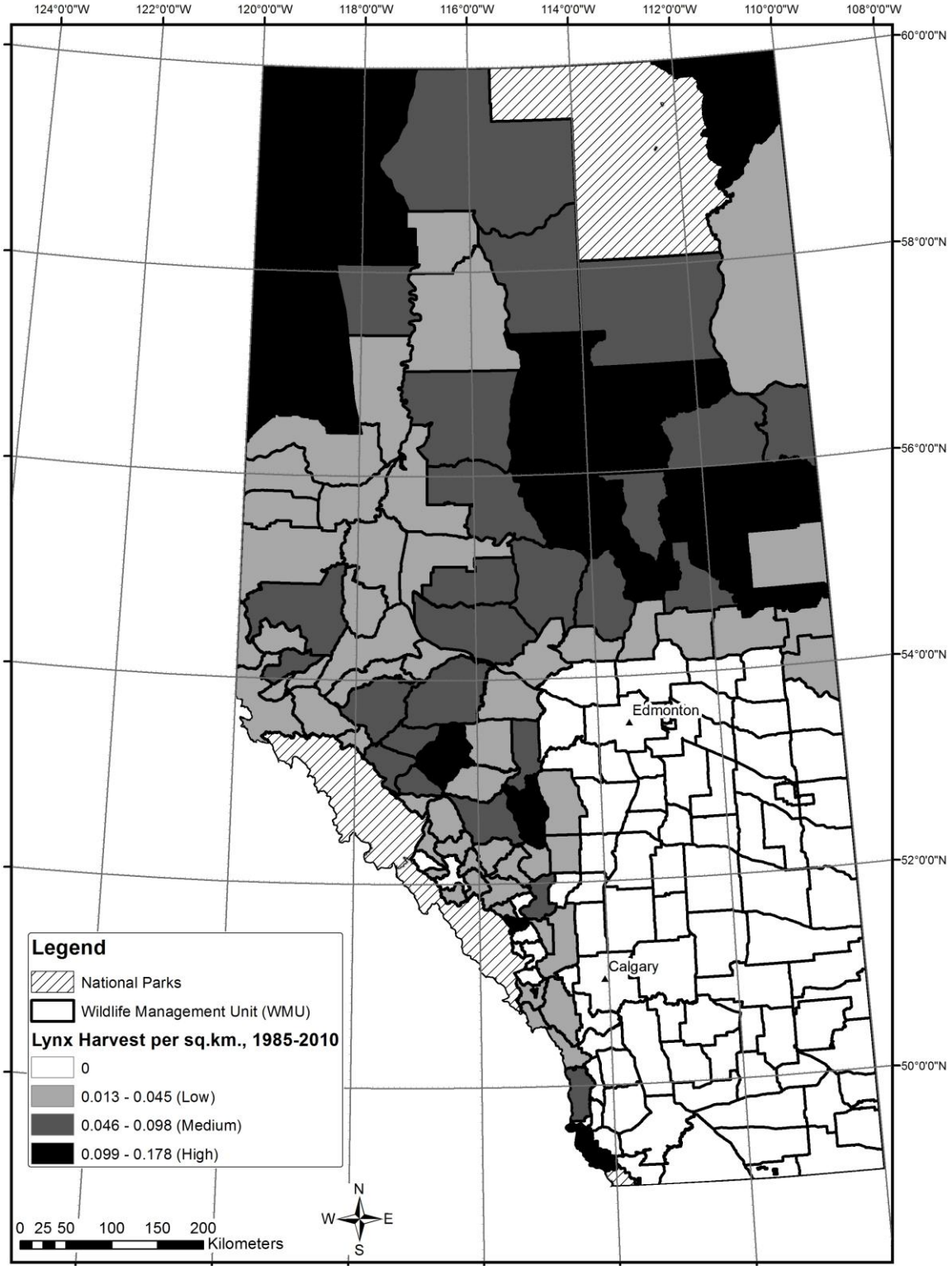
Appendix 5. Wolverine harvest density (# wolverine per km^2) by WMU reported on fur affidavits from 2000-2004 in Alberta. National Parks and non-trapline areas were excluded.



Appendix 6. Wolverine harvest density (# wolverine per km^2) by WMU reported on fur affidavits from 2005-2011 in Alberta. National Parks and non-trapline areas were excluded. FWMIS locations are from 2002-2011.



Appendix 7. Lynx harvest density (corrected by area) in relation to RFMA and WMU reported on fur affidavits from 1985-2010 in Alberta. National Parks and non-trapline areas were excluded.



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