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WILDLIFE CONSERVATION SOCIETY CANADA

CONSERVING CARIBOU LANDSCAPES IN THE NAHANNI TRANS-BORDER REGION

USING FIDELITY TO SEASONAL RANGES AND MIGRATION ROUTES

John L. Weaver

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SUMMARY

The trans-border region encompassing the watershed of the legendary South Nahanni River in the Northwest Territories and adjacent areas in southeast Yukon Territory comprises some of the last, large wildlands in North America. Across these boreal forests and mountains roams one of the most iconic but vulnerable wildlife species of Canada: the woodland caribou (*Rangifer tarandus caribou*). In this context, a chronicle of caribou travels in a relatively pristine landscape can provide a valuable basis and benchmark for conservation. Accordingly, I analyzed 3493 satellite (PTT) locations of 24 adult female caribou obtained during 2000-2007 to discern their seasonal ranges and migration routes.

I distinguished 2 local populations – the 'Coal River' and 'La Biche' groups – based on spatial separation during multiple seasons. Coal River caribou occupied an annual range (100% MCP) of 29,815 km^2 with 44% on the Nahanni side and 56% on the Yukon side; La Biche caribou ranged across 9,568 km^2 with 68% on the Nahanni side and 32% on the Yukon side.

Both caribou groups spent late winter (Feb 1 – Apr 15) in montane spruce forests (with lichen understorey) along the lower South Nahanni River inside Nahanni National Park Reserve. In spring, caribou migrated west and south along major river valleys and across the Territorial border to mountain plateaus in southeast Yukon. From the beginning of calving in late May until the end of the rut or breeding period in mid-October, members of the Coal River group were spread out across 15,000 km^2 of alpine plateaus and subalpine basins in the Coal River and Hyland River watersheds in southeast Yukon. After the rut, they moved eastward back into the Nahanni region through a section along the Territorial divide known as Caribou Pass. Later in fall, Coal River caribou wandered around a large expanse of boreal forest in the Caribou and Meilleur River basins. As snowfall typically increased in early winter, these caribou moved further north toward and into Nahanni National Park Reserve to complete their yearly round of travels.

Caribou of the La Biche group confined their range during the calving, summer, and rut periods to 2,000 km^2 of mountain plateaus in the upper basins of the La Biche and Whitefish Rivers in southeast Yukon (close to the Territory border). In years of heavier snowfall, they also moved northward by late winter toward and into Nahanni National Park Reserve.

Overall, these caribou exhibited a remarkable degree of *fidelity* (return to within 10 km of previous centre of activity) to calving (86% of individuals/

78% of cases) and summer (July) sites (81%/ 70%) and lesser fidelity to rut (56%/ 48%) and late-winter (March) sites (53%/ 40%). This pattern of strong fidelity to calving and summer sites, moderate fidelity to rut sites, and weaker fidelity to winter ranges appears consistent across many studies of woodland caribou in mountainous landscapes of western Canada and some caribou studies in boreal forests of eastern Canada.

Caribou in each group migrated along several specific routes to which they exhibited varying degrees of fidelity, depending upon the season. During spring migration, 12 (80%) of 15 individuals used the same entire route in 2 or more years; for 35 cases, they followed the entire route (54%) or at least a certain segment (26%). In the return migration during fall and early winter, however, only 5 (36%) of 14 individuals used the same entire route in 2 or more years; for 34 cases, they followed the entire route (24%) or at least a certain section (41%).

Woodland caribou typically are relatively sedentary; by contrast, these trans-border groups of woodland caribou traveled exceptional distances during migration. In spring, members of the Coal River group moved with strong directionality an average distance of 168 km (longest 253 km) at a rate of 4.7 km/day. La Biche caribou migrated a shorter average distance of 95 km (longest 121 km) at a rate of 3.7 km/day. In fall, Coal River caribou moved (with variable directionality) an average distance of 221 km (longest 327 km). Again, members of the La Biche group migrated a shorter distance of 95 km (longest 121 km). In the Nahanni trans-border region, alpine habitats on the Nahanni side are few, isolated, and narrow. Thus, the broad-scale pattern of the landscape suggests that caribou migrate in spring to distant alpine sites in the Yukon to position themselves for the calving and post-calving periods; in winters with deep snow, they migrate all the way back to low-elevation forests in the South Nahanni River valley. In terms of round-trip distances, Coal River caribou traveled an average of 392 km (longest 551 km); La Biche caribou moved an average of 178 km (longest 211 km). The only reported migrations that match or exceed distances traveled by the Coal River animals are those of caribou in northern Alaska and Canada and a few populations of antelope species in grasslands of Africa, Mongolia, and Wyoming (USA).

Due to their exceptional travels and remarkable fidelity to seasonal ranges and migration routes, caribou in this intact Nahanni trans-border region represent a unique biological asset. Yet caribou are vulnerable to various impacts from human developments and activities. Hence, large intact landscapes where caribou can move widely to select seasonal ranges and minimize contact with predators appear crucial for their long-term persistence.

Therefore, I propose a trans-border conservation area to maintain the integrity of this intact landscape for caribou. Nahanni National Park Reserve is too small and too narrow to provide for wide-ranging caribou. Scientific findings from this study substantiate Parks Canada's final recommendation for new boundaries that would protect the range of these caribou groups within the South Nahanni River watershed in Dehcho territory. On the Yukon side, land-use plans can incorporate these findings to safeguard important summer ranges (calving and post-calving) and migration routes. Successful conservation of trans-border landscapes for these caribou will require a high level of interjurisdictional collaboration and commitment.

SOMMAIRE

La région transfrontalière qui englobe le bassin versant de la légendaire rivière Nahanni Sud dans les Territoires du Nord-Ouest et les zones attenantes dans le sud-est du Yukon abrite quelques-unes des dernières vastes étendues de nature sauvage de l'Amérique du Nord. À la grandeur de ce paysage boréal où s'étendent des forêts et s'élèvent des montagnes erre une des espèces fauniques les plus iconiques et vulnérables à la fois : le caribou des bois (*Rangifer tarandus caribou*). Dans un tel contexte, suivre les déplacements de caribous sur un territoire relativement vierge peut servir de base et de référence utiles à des objectifs de conservation. En conséquence, j'ai procédé à l'analyse de 3493 localisations par satellite (PTT) de 24 caribous femelles adultes, dont les données avaient été collectées entre 2000 et 2007, et ce, dans l'optique d'établir leurs aires de distribution et routes de migration saisonnières.

J'ai repéré deux populations locales distinctes – celles de la rivière Coal et de la rivière La Biche – sur la base d'une séparation spatiale effectuée au fils de plusieurs saisons. Les caribous de la rivière Coal occupaient une aire annuelle (MCP de 100 %) de 29 815 km^2 (44 % du côté de la Nahanni et 56 % du côté du Yukon) tandis que l'aire de distribution des caribous de la rivière La Biche s'étendait sur 9568 km^2 (68 % du côté de la Nahanni et 32 % du côté du Yukon).

Les deux populations de caribous ont passé la fin de l'hiver (du 1er février au 15 avril) dans les forêts d'épinettes alpestres (avec des lichens en sous-étage) qui longent la rivière Nahanni Sud dans la partie inférieure de la réserve de parc national Nahanni. Au printemps, les caribous ont migré vers l'ouest et le sud en empruntant les principales vallées fluviales et ont franchi la frontière interterritoriale jusqu'aux plateaux montagneux dans le sud-est du Yukon. Entre le début de la période de la mise bas à la fin de mai et la fin de la période de rut ou de reproduction à la mi-octobre, la population de la rivière Coal s'est étalée sur 15 000 km^2 de plateaux alpins et de bassins subalpins des bassins versants des rivières Coal et Hyland dans le sud-est du Yukon. Après les chaleurs, les caribous sont retournés dans l'est jusqu'à la région Nahanni en empruntant un sentier le long de la ligne de partage territoriale qu'on nomme le col Caribou. Plus tard à l'automne, les caribous de la rivière Coal ont erré sur un grand territoire de forêt boréale dans les bassins versants des rivières Caribou et Meilleur. Lors de l'arrivée typique des chutes de neige abondantes en début d'hiver, ces caribous se sont déplacés plus au nord, pour terminer enfin leur aller-retour annuel dans la réserve de parc national Nahanni.

La population de caribous de la rivière La Biche a occupé une aire de distribution limitée durant la mise bas, l'été et la période de rut, soit une superficie de 2000 km^2 de plateaux montagneux dans la partie supérieure des bassins versants des rivières La Biche et Whitefish dans le sud-est du Yukon (près de la frontière du territoire). Les années où les chutes de neige ont été plus abondantes, les caribous se sont aussi déplacés vers le nord jusqu'à la réserve de parc national Nahanni avant la fin de l'hiver.

Somme toute, ces caribous ont manifesté un niveau remarquable de *fidélité* (retour au centre d'activité précédent dans un rayon de 10 kilomètres) aux sites de mise bas (86 % des caribous/78 % des cas) et aux sites d'été (juillet, 81 %/70 %). Ils ont été moins fidèles aux sites de rut (56 %/48 %) et de fin d'hiver (mars, 53 %/40 %). Cette tendance vers un niveau de fidélité élevé aux sites de mise bas et d'été, un niveau de fidélité modéré aux sites de rut, et un niveau de fidélité plus faible aux aires de distribution hivernales figure dans les conclusions de plusieurs autres études sur le caribou des bois habitant les montagnes de l'Ouest canadien et sur le caribou des forêts boréales de l'Est du Canada.

Les caribous de chaque population ont emprunté plusieurs routes de migration spécifiques et les niveaux de fidélité ont varié selon la saison. Durant la migration du printemps, 12 caribous sur 15 (80 %) ont emprunté la même route en totalité deux années consécutives ou plus; dans 35 cas, les caribous ont emprunté la même route en totalité (54 %) ou en partie (26 %). Lors de la migration de retour à l'automne et au début de l'hiver, toutefois, seulement 5 caribous sur 14 (36 %) ont emprunté la même route en totalité deux années consécutives ou plus; dans 34 cas, les caribous ont emprunté la même route en totalité (24 %) ou en partie (41 %).

Généralement, le caribou des bois est un mammifère relativement sédentaire. Par contre, ces deux groupes de caribou des bois transfrontaliers ont franchi des distances exceptionnellement longues.

Au printemps, le groupe de la rivière Coal s'est déplacé avec une forte orientation sur une distance moyenne de 168 kilomètres (jusqu'à un maximum de 253 kilomètres) à une vitesse de 4,7 km/jour. Les caribous de la rivière La Biche ont migré sur une plus courte distance moyenne de 95 kilomètres (jusqu'à un maximum de 121 kilomètres) à une vitesse de 3,7 km/jour. À l'automne, les caribous de la rivière Coal se sont déplacés (avec une orientation variable) sur une distance moyenne de 221 kilomètres (jusqu'à un maximum de 327 kilomètres). Encore une fois, le groupe de la rivière La Biche a franchi une plus courte distance de 95 kilomètres (jusqu'à un maximum de 121 kilomètres). Dans la région transfrontalière du bassin de la rivière Nahanni, les habitats alpins du bassin sont rares, isolés et étroits. Ainsi, la configuration du paysage à large échelle suggère que les caribous migrent au printemps vers des sites alpins lointains du Yukon en préparation de la période de la mise bas et du stade suivant immédiatement la mise bas; les hivers où les chutes de neige sont abondantes, les caribous s'en retournent sur les routes migratoires jusqu'aux forêts de basse altitude de la vallée de la rivière Nahanni Sud. Pour ce qui est des distances du parcours aller-retour, les caribous de la rivière Coal ont parcouru une distance moyenne de 392 kilomètres (jusqu'à un maximum de 551 kilomètres); dans le

cas des caribous de la rivière La Biche, la distance moyenne parcourue s'est chiffrée à 178 kilomètres (jusqu'à un maximum de 211 kilomètres). On ne rapporte des migrations dont les distances égalent ou dépassent les distances parcourues par le groupe de la rivière Coal que pour les caribous dans le nord de l'Alaska et le Nord canadien et quelques populations d'antilopes dans les prairies de l'Afrique, de la Mongolie et de l'État américain du Wyoming.

En raison de leurs déplacements exceptionnels et de leur niveau de fidélité remarquable à leurs aires de distribution et routes de migration saisonnières, les caribous dans cette région transfrontalière intacte de la Nahanni représentent un actif biologique unique. Pourtant, le caribou est vulnérable aux divers impacts des développements et des activités anthropiques. Il appert donc que les grands territoires intacts où les caribous peuvent se déplacer librement à la recherche d'aires saisonnières et minimiser les contacts avec les prédateurs soient cruciaux pour assurer leur pérennité à long terme.

Je propose donc l'aménagement d'une aire de conservation transfrontalière afin de maintenir l'intégrité de ce territoire intact au bénéfice du caribou. La réserve de parc national Nahanni est trop petite et trop étroite pour soutenir le caribou à distribution étendue. Les conclusions scientifiques de cette étude valident les nouvelles frontières recommandées par Parcs Canada pour protéger l'aire de distribution de ces groupes de caribous à l'intérieur du bassin versant de la rivière Nahanni Sud sur le territoire Deh Cho. Du côté du Yukon, ces conclusions peuvent être intégrées dans les plans d'aménagement du territoire afin de protéger d'importantes aires de distribution (période de la mise bas et stade suivant immédiatement la mise bas) et routes de migration utilisées durant la saison estivale. La conservation efficace des territoires transfrontaliers au bénéfice de ces caribous exigera un niveau accru de collaboration et d'engagement entre les gouvernements.

1. INTRODUCTION

Conservation Context and Background

The trans-border region encompassing the watershed of the legendary South Nahanni River in the Northwest Territories and adjacent lands in southeast Yukon Territory comprises some of the last, large wildlands in North America (Sanderson et al. 2002a). Such relatively pristine landscapes afford crucial but vanishing opportunities to provide scientific benchmarks of ecological integrity.

Nahanni National Park Reserve (NNPR) was established in 1972 to protect the spectacular waterfalls and canyons of the South Nahanni River. In 1978, the United Nations (UNESCO) recognized Nahanni National Park Reserve as a World Heritage Site (UNESCO 1978). Under the Canada National Parks Act, Parks Canada has mandated responsibility for ensuring the ecological integrity of national parks (Statutes of Canada 2000). The people of the Dehcho First Nation also have a strong interest in conserving the integrity of the land and waters of Nahæâ Dehé (South Slavey name for the South Nahanni River watershed) in their traditional territory (Dehcho LUP Committee 2006). Much of the southeast Yukon adjacent to Nahanni is still remote and also contains outstanding ecological features, including unique biological diversity and productive forests (CPAWS-Yukon 2002). It lies within the traditional territory of the Kaska Dena First Nation whose people have a strong respect for the land and waters.

Across these boreal forests and mountains roams one of the most iconic but vulnerable wildlife species of Canada: the woodland caribou (*Rangifer tarandus caribou*). Woodland caribou that occur in the northern mountains of western Canada are considered the 'mountain ecotype' as they migrate various distances to calve at higher elevations in the mountains. This 'Northern Mountain population' is listed by COSEWIC as one of 'special concern' (COSEWIC 2002). This status is conferred upon a species whose 'characteristics make it particularly sensitive to human activities or natural events'.

Caribou range widely across landscapes and use a variety of strategies to garner important food resources and to reduce the risk of predation (Bergerud 2000, Rettie and Messier 2000, Johnson et al. 2001, McLoughlin et al. 2005, Gustine and Parker In Press). They are particularly vulnerable, however, where

human activities, developments and access (1) result in the direct loss and fragmentation of habitat, (2) alter habitat conditions that result in greater abundance of moose and wolves, and (3) increase the likelihood of predation, excessive hunting and poaching, and vehicular collisions (see review and citations *in* Thomas and Gray 2002 and Vistnes and Nellemann 2008, also Apps and McLellan 2006, Courtois et al. 2007). The range of woodland caribou in Ontario, for example, has receded over the past 100 years coincident with the expanding 'footprint' of industrial logging and other human activities (Schaefer 2003, Vors et al. 2007).

Nahanni National Park Reserve represents a classic example of the 'boundary problem' that confronts many national parks and other protected areas across the world (Newmark 1985): it is too small and too narrow to provide Park protection for wide-ranging animals such as woodland caribou. At present, the Park Reserve is <8 km wide in some sections while encompassing only 4765 km^2 (about 14%) of the South Nahanni River watershed. Parks Canada has engaged in a thoughtful and public process to determine new boundaries for Nahanni National Park (Reserve) that would enable the Park to better meet its legislative charge for ecological integrity. In the Yukon, various land-planning efforts have been initiated as interest increases to develop mines, expand logging operations in more productive forests, and build new roads for transportation infrastructure. Because caribou are 'landscape' species that use large, ecologically diverse areas, they likely serve as useful 'umbrella' species in conservation planning (Sanderson et al. 2002b).

It is in this context of intact wildlands, species vulnerability, and planning initiatives that designing landscapes for caribou conservation has become important. Lack of spatial information on seasonal ranges and movements of caribou in this remote trans-border region has been a major limitation to planning for their conservation.

During the late 1970s, Nahanni Park wardens made aerial surveys of the principal ungulate species in the Park, including woodland caribou (Comin et al. 1981). They reported that, in winter, caribou occurred primarily along the South Nahanni River valley, both above and below Virginia Falls, as far downriver as its confluence with the Mary River coming in from the west. In the absence of radio-collared animals, though, Park wardens could only guess where these caribou might spend the rest of the year. Although subsequent radio-tracking revealed the seasonal ranges and movements of caribou using the upper South Nahanni watershed (Gullickson and Manseau 2000), the yearly range and routes of caribou from the lower Nahanni remained unknown.

Across the border in the southeast sector of the Yukon Territory, biologists counted 348 caribou in the upper reaches of the La Biche River (Florkiewicz 1993) and 383 caribou in the headwaters of the Coal River further to the west (Florkiewicz 1997) (note: both surveys represented minimum numbers of caribou due to incomplete coverage). Yukon biologists labeled caribou in these two areas as the La Biche and Coal River 'herds'. Where the animals spent the winter remained unknown.

So, in March 2000 and October 2001, biologists with the Territorial governments (with support from Parks Canada) captured 7 adult female caribou in southeast Yukon and 2 near the South Nahanni River south of the Flat River

and fitted them with satellite (PTT) radio-collars. Subsequent locations indicated that these animals wintered in Nahanni National Park Reserve and traveled into southeast Yukon for the summer (Jan Adamczewski, *personal communication*). Parks Canada contracted the Yukon team to capture an additional 18 female caribou in the vicinity of the Yukon Territory-Northwest Territories border in October 2004.

Under a cooperative agreement between Parks Canada, the Territorial governments, and Wildlife Conservation Society (WCS) Canada, I compiled and analyzed locations of these caribou up to December 31, 2005. In an earlier report (Weaver 2006), I mapped and discussed their seasonal ranges and movements under the term of 'Lower Nahanni caribou herd'. As that report focused exclusively on providing information regarding proposed expansion of Nahanni National Park Reserve, however, data analysis and presentation was restricted to the Northwest Territories side of the border. To develop a more complete understanding of caribou movements across their entire trans-border range, I have continued to collect locations from caribou whose collars are still transmitting data.

Nahanni Trans-Border Study Region

The study region encompassed the trans-border range used by caribou during 2000-2007: the lower section of the South Nahanni River watershed in the southwest corner of the Northwest Territories and adjacent lands in the southeast corner of the Yukon Territory (Figure 1). Nahanni National Park Reserve is located within the traditional territory of the Dehcho First Nation. Virginia Falls [Náɻlɻcho], in the center of the Park Reserve, lies 240 km (160 mi) west of Park headquarters in Ft. Simpson [Líídlɻɻ Kǜé] on the Mackenzie River. There are no roads within the Park and only short trails at Rabbitkettle Lake and Virginia Falls; access to the area is only possible by aircraft. The Park Reserve is 4765 km^2 in size, encompassing about 14% of the South Nahanni River watershed. Large areas important to the caribou (Caribou, Flat, and Meilleur River basins) lie outside the present Park to the south and west. An expanse of boreal forest with few alpine areas characterized much of the Nahanni portion up to the Territorial border.

The southeast corner of the Yukon, framed by the British Columbia border on the south and the Campbell Highway (Hwy 4) on the west, includes the traditional territory of the Kaska First Nation (Figure 1). The small community of Watson Lake, Yukon, on the Alaska Highway also lies 240 km southwest of Virginia Falls. The Nahanni Range road (Yukon Hwy 10) is a gravel road built in the early 1960s for access to the mining site of Tungsten (or Cantung), which lies just inside the Northwest Territories about 210 km northeast of Watson Lake. It receives light traffic during the summer and fall. The upper reaches of important watersheds such as the Coal River and La Biche River currently receive little human use. Landscapes in the southeast Yukon consisted of alpine plateaus, subalpine basins, and boreal forests.

Moose (*Alces alces*) and Dall's sheep (*Ovis dalli dalli*) are other common ungulates in the study area. Potential predators of caribou include wolves (*Canis lupus*), grizzly bears (*Ursus arctos*) and black bears (*U. americanus*), wolverines (*Gulo gulo*), and lynx (*Lynx canadensis*).

This trans-border region has a continental climate: long, cold, rather dry winters and short, mild summers with moderate amounts of precipitation. Average temperatures at the Tungsten mine site (edge of study area) ranged from -24° C in January to 11° C in July for the period 1951-1980 (only period of available data for site closest to caribou range). Average levels of monthly precipitation varied from 12 mm in February to 90 mm in July. Snowfall at Watson Lake (the nearest weather station with consistent data on recent snowfall) averaged 196 cm per winter (range 141 – 268 cm) during the decade 1997-2006 (Environment Canada) (Table 1). Snowfall was particularly heavy in the winters of 2004-05 and 2006-07. Precipitation decreases along a gradient from the Yukon-NT divide on the west to the South Nahanni River valley on the east. Elevations across the study area range from 2100 m on mountaintops in the Selwyn Range in the Yukon to 400 m along the lower end of the South Nahanni River.

Table 1. Total snowfall (cm) by month, Watson Lake, Yukon Territory, winters 1997-98 through 2006-07.

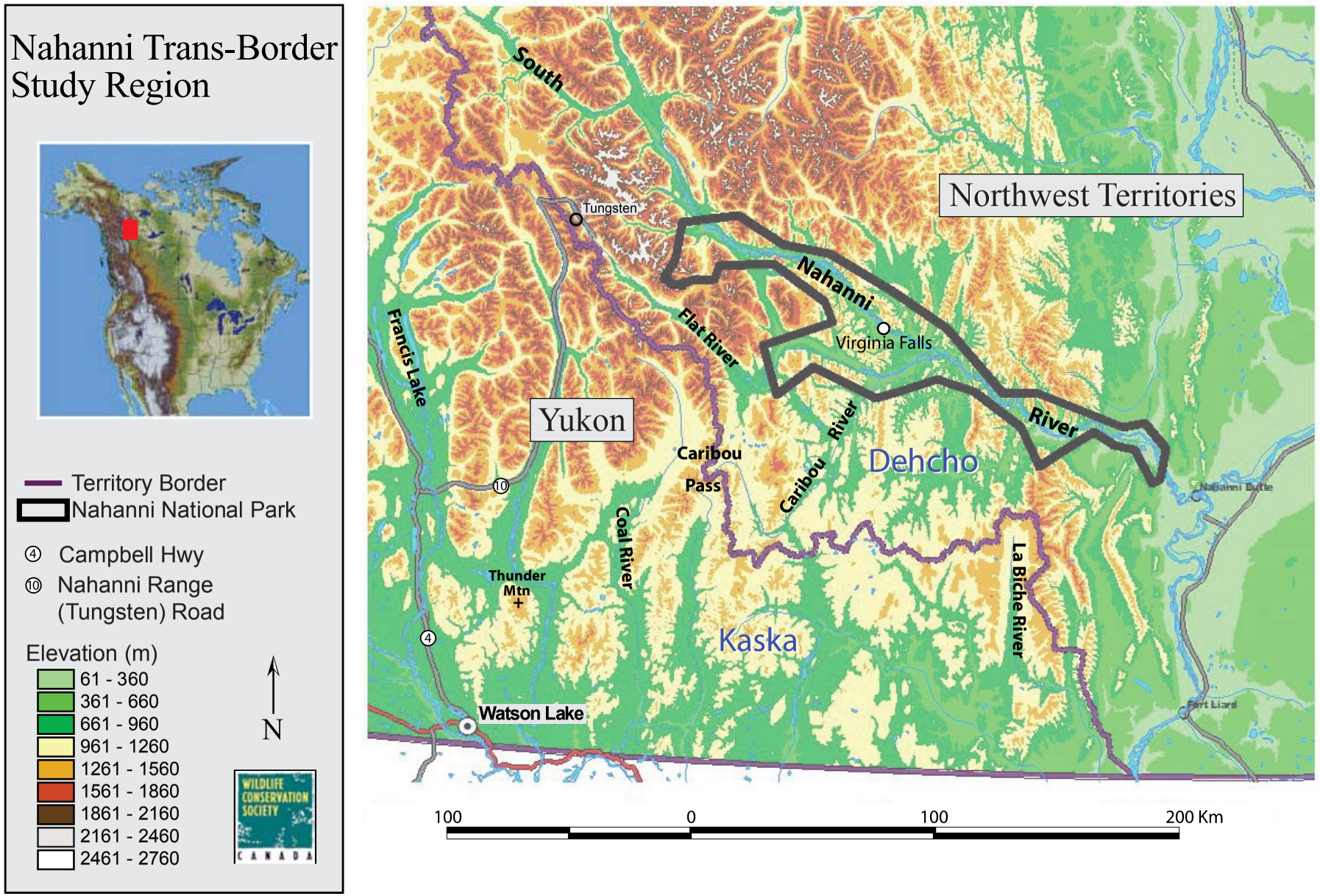
Month	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07
Oct	40.2	31.4	14.2	29.7	34.9	2.8	10.4	23.4	5.4	9.1
Nov	24.4	17.0	45.8	26.8	45.1	55.4	32.0	32.2	35.7	41.6
Dec	31.7	21.0	36.1	29.5	44.3	19.3	47.7	52.5	27.7	37.9
Jan	22.5	34.4	21.6	26.9	39.9	55.5	60.6	100.2	54.5	30.5
Feb	18.8	17.8	15.1	16.3	27.2	19.1	7.1	39.9	27.7	74.5
Mar	13.2	4.1	7.9	14.3	15.1	35.5	20.5	13.6	18.0	60.9
Apr	19.8	15.1	34.3	1.4	4.5	7.8	10.0	5.8	38.5	1.4
Total	**170.6**	**140.8**	**175.0**	**144.9**	**211.0**	**195.4**	**188.3**	**267.6**	**207.5**	**255.9**
Rating	**Low**	**Low**	**Low**	**Low**	**Mod**	**Mod**	**Mod**	**High**	**Mod**	**High**

For the trans-border area, different classifications of land cover types have been developed on the Nahanni side and the southeast Yukon side. Because each administrative jurisdiction is likely to use its own classification for resource management, I retained the respective coverages but pieced them together along the Territorial border (Figure 2).

For the South Nahanni River watershed, Stow and Wilson (2006) developed a new classification and map from imagery of 6 Landsat ETM+ scenes by the Canada Centre for Remote Sensing (CCRS) (Orazietti and Fraser 2005). They conducted a cluster analysis using terrain features (elevation, slope, aspect) and several vegetation variables (e.g., percent conifer cover). They modified the clusters based upon previous descriptions and comments by researchers with field experience in the Nahanni area.

On the Nahanni side, 15 land cover types were classified and mapped (adapted from Stow and Wilson 2006) (Table 2a) (Figure 2). The most common and widespread type within the range of caribou in the lower Nahanni country was the 'montane spruce-lichen woodland' (65%). Other types with a terrestrial

Figure 1. Location of study region for Nahanni trans-border caribou, Northwest Territories and Yukon Territory, Canada.



lichen (*Cladina* and *Cladonia* spp. fed upon by caribou) understory occurred on another 12% of the land. Past fires were evident across much of the landscape, resulting in mosaics of variable-sized patches of different cover types including pine and aspen (8%). A shrub savannah composed of scrub birch (*Betula glandulosa*), dwarf willow (*Salix* ssp.), and scattered white spruce (*Picea glauca*) and subalpine fir (*Abies lasiocarpa*) occupied the subalpine area. Compared to ranges of other caribou within the Greater Nahanni Ecosystem (Weaver 2006), the lower Nahanni sector contained more boreal forest ('Montane Spruce-Lichen Forest' type) and less of the alpine types ('Subalpine Low Vegetation', 'Rock', and 'Snow/Ice' types).

For the southeast Yukon, I was advised to use the EOSD classification (Earth Observation for Sustainable Development) developed by Natural Resources Canada (2000). This classification was derived from enhanced Thematic Mapper (ETM+) Landsat 7 remote sensing data ca. 2000 with a minimum mapping unit resolution of 1 ha (Wulder et al. 2004). I collapsed the original 24 classes into 15 classes by aggregating some of the minor variations in wetland types and by making 2 classes of crown closure (rather than 3) for the three principal forest types.

In this section of the trans-border region, 15 land cover types were classified and mapped (Table 2b) (Figure 2). The most common type within the Yukon section was the 'open conifer forest' (52%), likely similar to the 'Montane Spruce-Lichen Forest' type on the Nahanni side. It was difficult to determine which other types also had a lichen understorey because only one type was recognized as such – a 'moss/lichen' type with 0.5% coverage. Because the Yukon portion had higher mountains, alpine types such as low shrub (13.6%) and rock (likely with low vegetation) (8.6%) covered more of the landscape occupied by caribou. In addition, there appeared to be a finer-grained diversity of cover types mapped on the Yukon side. In comparing the two classifications and maps, the Nahanni map appeared to have a more refined classification specific to the Nahanni area, whereas the EOSD classification for the southeast Yukon was more general but with greater spatial resolution.

Figure 2. Land cover types in Nahanni trans-border study region, Northwest Territories and Yukon Territory, Canada.

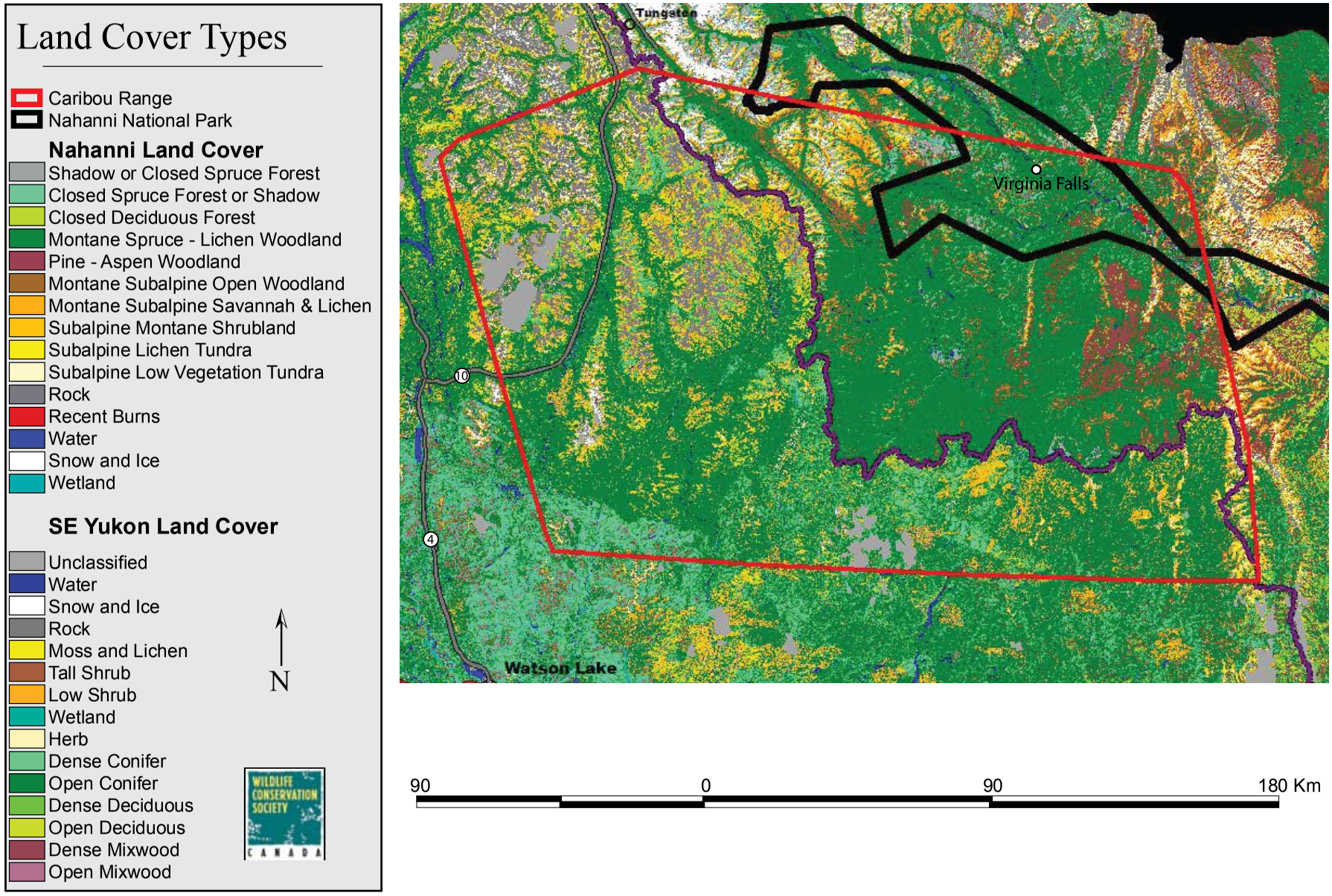


Table 2a. Description and extent of land cover types in Nahanni portion of trans-border region, Northwest Territories. Adapted from classification developed by Stow and Wilson (2006).

Land Cover Type	Area		Description
	Km^2	%	
Shadow or Closed Spruce Forest	365	2.7	shadowed areas on steep northern slopes that may be closed forests of white spruce (see below) or adjacent to it
Closed Spruce Forest	448	3.3	mature, closed and open forests of white spruce, mostly on northern slopes in the valleys of the northern GNE
Closed Deciduous Forest	44	0.3	closed deciduous forests of aspen and poplar, interspersed with white spruce, on moderate terrain in valleys and bottomlands, particularly in the southeast end of the GNE
Montane Spruce-Lichen Forest	8679	64.6	moderately dense woodland of mature white or black spruce (depending upon drainage and elevation) in valley bottoms and on lower slopes, patchy at higher elevations and interspersed with open woodland and savannah/ abundant lichens in the understory/ most common land cover in the GNE
Pine-Aspen Woodland	1127	8.4	mixed open woodland of lodgepole or jack pine – aspen with some spruce (depending on aspect) regenerating from old burns
Montane Subalpine Open Woodland	834	6.2	open woodland of white spruce on steep slopes of southerly aspect at mid elevation, lichen in understory
Montane Subalpine Savannah and Lichen	674	5.0	savannah with sparse density of spruce and ground cover dominated by lichens, primarily in high montane and subalpine areas on steep slopes with a southerly aspect
Subalpine Montane Shrubland	139	1.0	open and sparse shrubland, interspersed with tundra, in very high montane and subalpine areas on steep slopes with southerly aspect
Subalpine Lichen Tundra	137	1.0	tundra and lichen barrens, interspersed with bare rock, alpine-subalpine areas on steep slopes with southerly aspect
Subalpine Low Vegetation Tundra	222	1.7	low tundra vegetation, bare soil and rock in alpine areas
Rock	328	2.5	rock outcrops interspersed with small patches of various plant communities (e.g., low vegetation tundra)
Recent Burns	106	0.8	either patchy burns interspersed with spruce woodland at lower elevations or shadowed northern slopes at higher elevations (similar spectral responses)
Water	105	0.8	larger water features
Snow and Ice	145	1.1	permanent snow or ice
Wetland	82	0.6	smaller lakes, ponds, bogs
Total	**13,435**	**100.0**	

Table 2a. Description and extent of land cover types in Yukon portion of trans-border region, Northwest Territories. Adapted from EOSD classification by Natural Resources Canada (2000).

Land Cover Type	Area		Description
	Km^2	%	
Unclassified	830	4.4	no data, clouds, or shadow
Lakes and Rivers	98	0.5	larger water features
Snow/ice	54	0.3	permanent snow or ice
Rock	1614	8.6	rock outcrops likely interspersed with small patches of alpine vegetation
Moss/lichen	94	0.5	>20% ground cover and at least 1/3 moss or lichen
Tall Shrub	257	1.4	>20% ground cover and at least 1/3 shrub >2 m in height (tall willow)
Low Shrub	2549	13.6	>20% ground cover and at least 1/3shrub <2 m in height (scrub birch/dwarf willow)
Wetland	144	0.8	ponds, bogs, marshes
Herb	457	2.4	>20% ground cover grass/forb
Dense Conifer	1483	7.9	conifer trees >75% basal area, >60% crown closure
Open Conifer	9763	52.1	conifer trees >75% basal area, <60% crown closure
Dense Deciduous	50	0.3	deciduous trees >75% basal area, >60% crown closure
Open Deciduous	1118	6.0	deciduous trees >75% basal area, <60% crown closure
Dense Mixwood	68	0.4	mix of conifer and deciduous each <75% basal area, >60% crown closure
Open Mixwood	157	0.8	mix of conifer and deciduous each <75% basal area, <60% crown closure
Total	**18736**	**100.0**	

Research: Approach, Goals, and Objectives

How caribou distribute themselves across a landscape has emerged as an organizing principle for understanding their ecology (Bergerud and Page 1987, Johnson et al. 2002) and devising conservation strategies (Seip and Cichowski 1996, Bergerud 2000). Caribou confront choices at various spatial and temporal scales that impinge upon their survival and reproduction (Rettie and Messier 2000). Their spatial resolution of these choices results in a home range composed of seasonal ranges and various movement routes. There are different approaches to identify areas or attributes deemed important to caribou. One reductionist approach is compare 'use *v*. availability' data (e.g., resource selection functions: RSFs) acquired at fine-scale from animals collared with GPS transmitters (Johnson et al. 2002, Gustine et al. 2006b). Such studies typically have been short-term (1-2 years).

For location data that are more coarse-scale but collected over a longer period, an alternative approach is to examine fidelity of individuals to certain areas or sites. Fidelity has been defined as "the tendency of animals to return to or remain in a particular place" (White and Garrott 1990). Fidelity is one of several strategies that an individual may deploy to enhance its fitness, particularly for long-lived animals whose continued survival provides multiple opportunities for reproduction and recruitment (McLoughlin et al. 2005). Fidelity represents a choice by the animal that integrates information regarding a diverse set of ecological factors (e.g., habitat suitability, minimizing risk of predation, etc.). Presumably, it reflects a satisfactory solution in terms of trade-offs. The fact that an animal has survived multiple years to provide requisite data for an analysis of fidelity provides tacit evidence that the place has value. This study offered a unique opportunity to examine fidelity of caribou because multi-year locations existed for 17 individuals (mean = 3.2 years, range 2.0-5.4 years).

The purpose of this conservation report is to provide spatially-explicit, scientific data about caribou ranges and movements that can inform decisions regarding expansion of Nahanni National Park Reserve and land use planning in southeast Yukon. The research goal was to assess fidelity of caribou to seasonal ranges and migration routes as a robust approach to mapping ecologically important areas for caribou conservation. The specific objectives were to: (1) map and describe seasonal ranges, assess site fidelity, and describe habitats; (2) map and describe seasonal migration routes and distances, and assess fidelity to routes; and (3) provide a conservation map for caribou that integrates key ranges and migration routes in this trans-border region. Such maps can inform land/resource planning decisions in a simple but powerful way (Groves 2003). The maps and descriptions presented in this report supersede those in the caribou chapter of my earlier report (Weaver 2006).

2. RANGES, SITE FIDELITY, AND HABITATS

In this chapter, I describe and map caribou distribution during various seasons. Such maps represent a visual record of animal occurrence that can provide specific, practical information to land planners (Sanderson et al. 2002b, see Berger 2004 for cogent example). Next, I assay the degree of site fidelity exhibited by individual caribou during specific seasons. Lastly, I describe habitats used by caribou during those seasons.

Methods

Caribou Capture and Collaring

Biologists from the Northwest Territories (2000) and Yukon Territory (2001, 2004) captured and collared a sample of adult/sub-adult female caribou across a 250-km-wide swath of this trans-border region. Upon finding caribou, the highly-experienced crew pursued the first available cow that could be separated from the group (i.e., 'opportunistic' selection). Chase times were usually less than a minute. The crew captured caribou using the standard technique of firing nets from the helicopter and physically restraining the animal without drugs once on the ground (Barrett et al. 1982). Capture operations were carried out in accordance with wildlife handling protocols and capture permits from each Territorial government.

Participating agencies jointly agreed to use earlier-generation satellite collars (Platform Terminal Transmitters or PTTs) through the Argos Service system because the transmitters were judged to have greater reliability (on average) than GPS-type transmitters, and the lesser accuracy was deemed still adequate for study purposes. Each captured caribou was fitted with a satellite collar manufactured by Telonics, Inc. Satellite transmitters were programmed to transmit locations for an 8-hour period every 5 days and thus to have an expected lifetime of >5 years. Each collar also carried a VHF transmitter in the 152.030 – 152.570 range. For data analysis, I continued the earlier protocol developed by Territorial biologists of selecting the last, best-quality location during a

transmission period. Service Argos advertised the following accuracy for location classes (LC) of varying quality: LC 3: <150 m, LC 2: 150-350 m, and LC 1: 350-1000 m (Service Argos 2005).

Data Analysis

The spatial structure of caribou populations is sometimes 'fuzzy' (Schaefer et al. 2001). Biologists have used various definitions for 'herds' that differ in their seasonal criterion (separation during calving or rut *v.* winter). In this report, I define a 'local population or group' of caribou as "caribou occupying a common range that can be distinguished spatially from other groups over the course of multiple seasons (especially calving and rut) and have limited exchange of individuals". I recognized 2 local populations or groups on the basis of their separation on seasonal ranges from calving until rut; I refer to these as the 'Coal River' and 'La Biche' groups. Subsequent radio-tracking revealed that caribou assigned to the Coal River and La Biche groups were separated by a minimum distance of 125 km at peak of calving and during summer and by 72 km during the rut. Nonetheless, it should be noted that collared caribou from each group shared their late-winter range in or near Nahanni National Park Reserve.

Annual and Seasonal Ranges: I delineated caribou ranges for the period 2000-2007 using the 100% Minimum Convex Polygon (MCP) method in animal movement extension (Hooge and Eichenlaub 1997) of ArcView.

To describe the seasonal movements of caribou, I divided the year into 7 seasons based upon (a) biological events (e.g., calving and rut), and (b) sharp differences in the average rate of daily movement (Ferguson and Elkie 2004) (Table 3). I charted successive distances traveled by caribou between locations and examined the graph for substantial changes in movement rates. I defined the calving season (May 26 - June 5) based upon (a) the 2-3 successive dates in which movements were quite restricted, and (b) direct observations of newborn calves in other, proximal study areas (Bergerud et al. 1984, Farnell and McDonald 1990, Wood 1996, Gustine at al. 2006a). The rut period (September 26 - October 10) was defined based upon timing of aggregations of caribou in the study region (Florkiewicz 1993, 1998; Jan Adamczewski, *personal communication*). After the rut, most caribou did not migrate in one continuous movement all the way to their late-winter range in Nahanni National Park Reserve. Rather, this 'migration' occurred in a spasmodic series of rapid movements interspersed with periods of localized movements. Accordingly, I defined three seasons for that period: fall, early winter, and late winter. Of course, not all caribou adhered tightly to these dates, yet the breakout seemed to represent the general patterns of movement.

Table 3. Inclusive dates of defined seasons for caribou in the Nahanni trans-border region, Northwest Territories and Yukon Territory.

Season	Start Date	End Date
Late Winter	Feb 1	Apr 15
Spring	Apr 16	May 25
Calving	May 26	Jun 5
Summer	Jun 6	Sep 25
Rut	Sep 26	Oct 10
Fall	Oct 11	Nov 30
Early Winter	Dec 1	Jan 31

Site Fidelity: A metric for quantifying site fidelity widely used in bird and mammal studies is the inter-year distance between the geometric centres of locations for the defined period or season. Some studies have advocated estimating the probability distribution of the animal's use of space ('utilization distribution' or UD) to quantify the degree of overlap over time (Fieberg and Kochanny 2005). Such estimation procedures, however, can be problematic due to their statistical assumptions and may perform poorly when locations are clumped (Hemson et al. 2005). Accordingly, I determined the geometric average of the locations for a defined period and measured the distance between centre points for successive years (Ferguson and Elkie 2004). I chose this approach rather than comparing locations at the same time in successive years (Schaefer et al. 2000) because that method would confound time with space.

For calving and rut, I used all 3-4 locations accrued during those shorter periods. For the longer seasons, I sub-sampled 4-6 consecutive locations to have a similar number of locations for comparison with shorter seasons. I chose the month of March to represent 'late winter' and the month of July to represent 'summer' (Wood 1996). Because the available set of locations usually spanned 3 years and thus generated 3 average points in space, I calculated the site-fidelity index not only between successive years but also between year 3 and year 1. In light of the finding that these trans-border caribou traveled 100-200 km in seasonal migrations, I considered inter-year distances between centres ≤10 km to be indicative of fidelity. Other caribou researchers have also used that distance as an index of fidelity (Brown and Theberge 1985, Ferguson and Elkie 2004).

I characterized fidelity using: (1) the mean and median distance and variation (SD), which quantifies the spatial proximity, (2) the proportion of individuals that returned within 10 km, which indicates prevalence of fidelity among sampled animals, and (3) the proportion of years in which animals returned within 10 km, which indicates frequency of fidelity.

Habitats: To assess caribou use of habitats, I selected only the most accurate (≤150 m error) of the three classes of satellite locations. I buffered the caribou locations by this distance and assigned the dominant (≥75%) land cover type to that location. For locations where 2 land cover types each comprised ≥25% but ≤75% dominance, I assigned equal occurrence (0.5) to both types. This

situation arose occasionally on the Yukon side due to the greater spatial resolution and perhaps the finer juxtaposition of certain cover types on the summer range.

Because nearly all of the suitable caribou locations during late winter occurred on the Nahanni side, I used the land cover classification for Nahanni to assign and assess caribou occurrence for those seasons (Table 2a). Also, because nearly all of the locations during calving, summer, and rut periods occurred on the Yukon side, I used the EOSD classification to assign and assess caribou occurrence during those periods (Table 2b). The spring and fall locations occurred on both sides, which made the assessment more problematic without assumptions about the similarity between the corresponding classifications.

Results

Biologists from the Territorial governments captured and collared 27 female caribou across a wide area in southeast Yukon and adjacent area in the lower South Nahanni River watershed: 4 during February 28-29 2000, 5 during October 15-16 2001, and 18 during October 10-16 2004 (Figure 3). Three of the 18 caribou captured in October 2004 turned out to be members of the Finlayson herd that ranged further to the north and west. Of the remaining 24 collared caribou, 4 animals were assigned to the La Biche group; the other 20 to the Coal River group.

Systematic radio-tracking of these caribou yielded 3493 locations representing 57.3 'caribou-years' (1 caribou x 12 months). Individuals averaged 146 locations (range 7-304) and 2.4 years of operation (range 0.1-5.4 years) (Table 4). As of October 11, 2007, 8 caribou still had functioning collars. The estimated accuracy of satellite locations for caribou was relatively good. For all of the 3493 locations obtained during 2000-2007, 60% were Class 3 (<150m), 26% Class 2 (150-350m), and 14% Class 1 (350-1000m).

Annual Range of Trans-border Caribou

Approximately 55% of the 3493 locations occurred on the Nahanni (Northwest Territories) side and 45% on the Yukon side (Figure 4). Caribou from the Coal River group accounted for about 78% of the locations, whereas caribou from the La Biche group provided 22% of the locations. Connecting the outer-most locations to form a minimum convex polygon (100% MCP) yielded an estimated range of 29,815 km^2 for the Coal River group with about 44% of the area on the Nahanni side and 56% on the Yukon side. For the La Biche group, about 68% of its range of 9,568 km^2 was on the Nahanni side and 32% on the Yukon side. The distribution of these caribou spanned some 325 km of the Territorial border.

Collared caribou from the two groups overlapped primarily on late-winter range during March-April in and adjacent to Nahanni National Park Reserve, with some additional overlap near the Territorial border during fall and early winter (Figure 4). Of the 22 radio-collared caribou that provided >10 locations during this study, every one was located inside the present boundaries of Nahanni National Park Reserve (NNPR) sometime during late winter. During the 2000-2007 period, collared caribou occurred at least once inside NNPR

in 75% of 60 caribou-years; another 8% occurred within 5 km of the Park boundary at least once during the winter or early spring. This substantiates use of Nahanni National Park Reserve by these caribou during a critical period in most years.

Table 4. Chronology of satellite (PTT) locations for 24 adult female caribou of the trans-border Nahanni region, Northwest Territories and Yukon Territory, 2000-2007. Group affiliation refers to Coal River (CR) and La Biche (LB).

PTT Number	Map Number	Group	Start Date	End Date	Duration years)	n Locs
10802	19	CR	Mar 3, 2000	Jul 25, 2005	5.4	304
10803	20	CR	Mar 3, 2000	Jun 20, 2004	4.3	162
10805	21	CR	Mar 3, 2000	Aug 20, 2002	2.5	69
12190	22	CR	Mar 3, 2000	Jun 21, 2000	0.3	22
15037	23	CR	Oct 19, 2001	Nov 27, 2005	4.1	98
15040	24	CR	Oct 24, 2001	Nov 23, 2001	0.1	7
15042	25	CR	Oct 19, 2001	Aug 29, 2005	3.9	239
15043	26	LB	Oct 19, 2001	May 21, 2004	2.6	166
15044	27	LB	Oct 19, 2001	Jun 20, 2004	2.7	156
53585	1	CR	Oct 16, 2004	Oct 11, 2007	3.0	217
53587	3	CR	Oct 16, 2004	Oct 11, 2007	3.0	217
53588	4	CR	Oct 16, 2004	Oct 11, 2007	3.0	216
53589	5	CR	Oct 16, 2004	Mar 5, 2005	0.4	29
53590	6	CR	Oct 16, 2004	Oct 11, 2007	3.0	212
53591	7	CR	Oct 16, 2004	Nov 20, 2004	0.1	8
53592	8	LB	Oct 16, 2004	Oct 11, 2007	3.0	219
53593	9	CR	Oct 16, 2004	Jun 13, 2005	0.7	47
53594	10	CR	Oct 16, 2004	Nov 5, 2006	2.0	149
53595	11	LB	Oct 16, 2004	Jun 28, 2007	2.7	195
53596	12	CR	Oct 16, 2004	Oct 11, 2007	3.0	219
53597	13	CR	Oct 16, 2004	Oct 11, 2007	3.0	217
53599	15	CR	Oct 16, 2004	Oct 1, 2005	1.0	67
53600	16	CR	Oct 16, 2004	Oct 11, 2007	3.0	218
53601	17	CR	Oct 16, 2004	Apr 24, 2005	0.5	39
Totals					**57.3**	**3493**

Figure 3. Location of caribou captures, Nahanni trans-border study region, Northwest Territories and Yukon Territory, Canada. Caribou numbers correspond to those in Table 4.

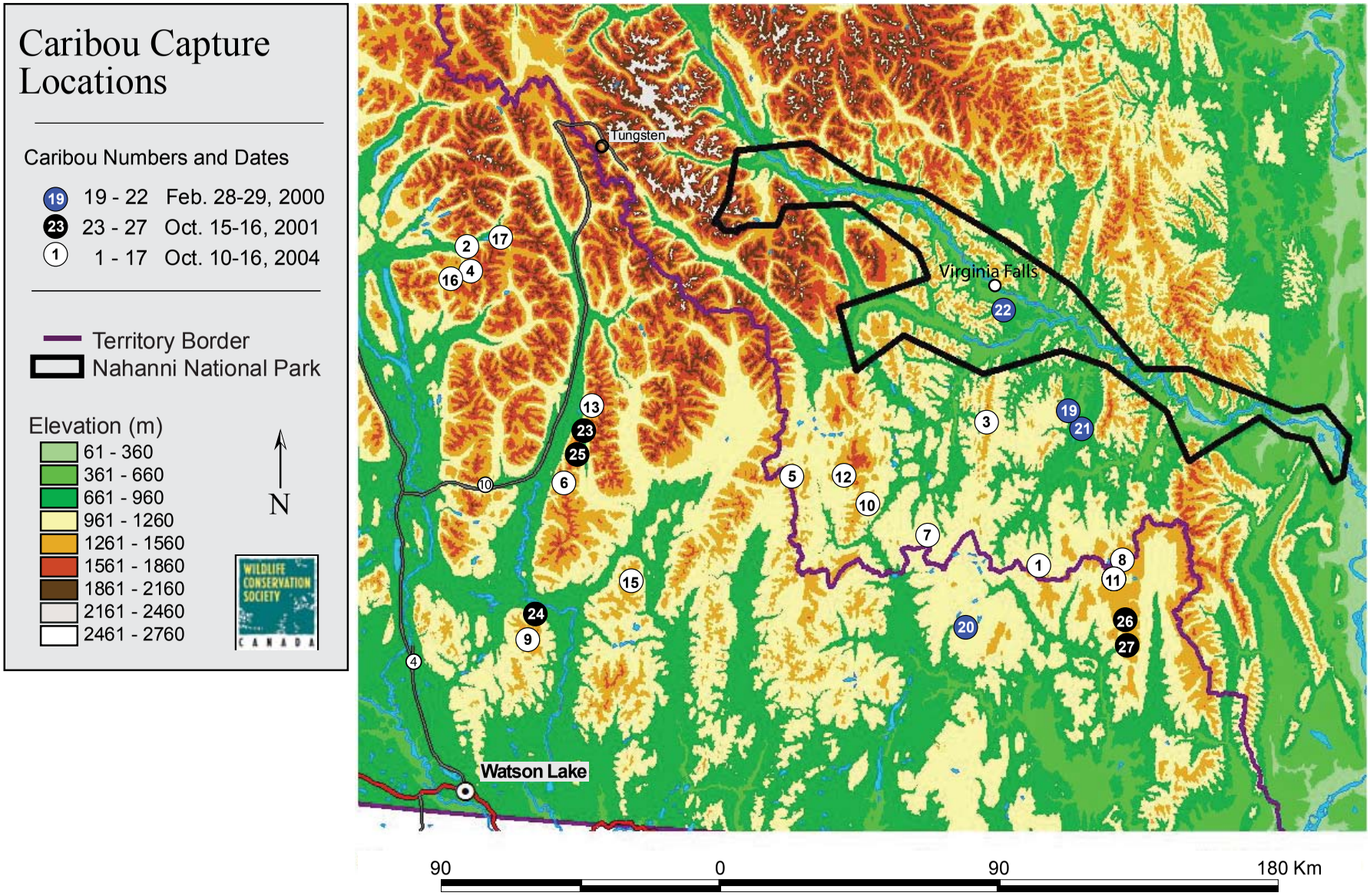
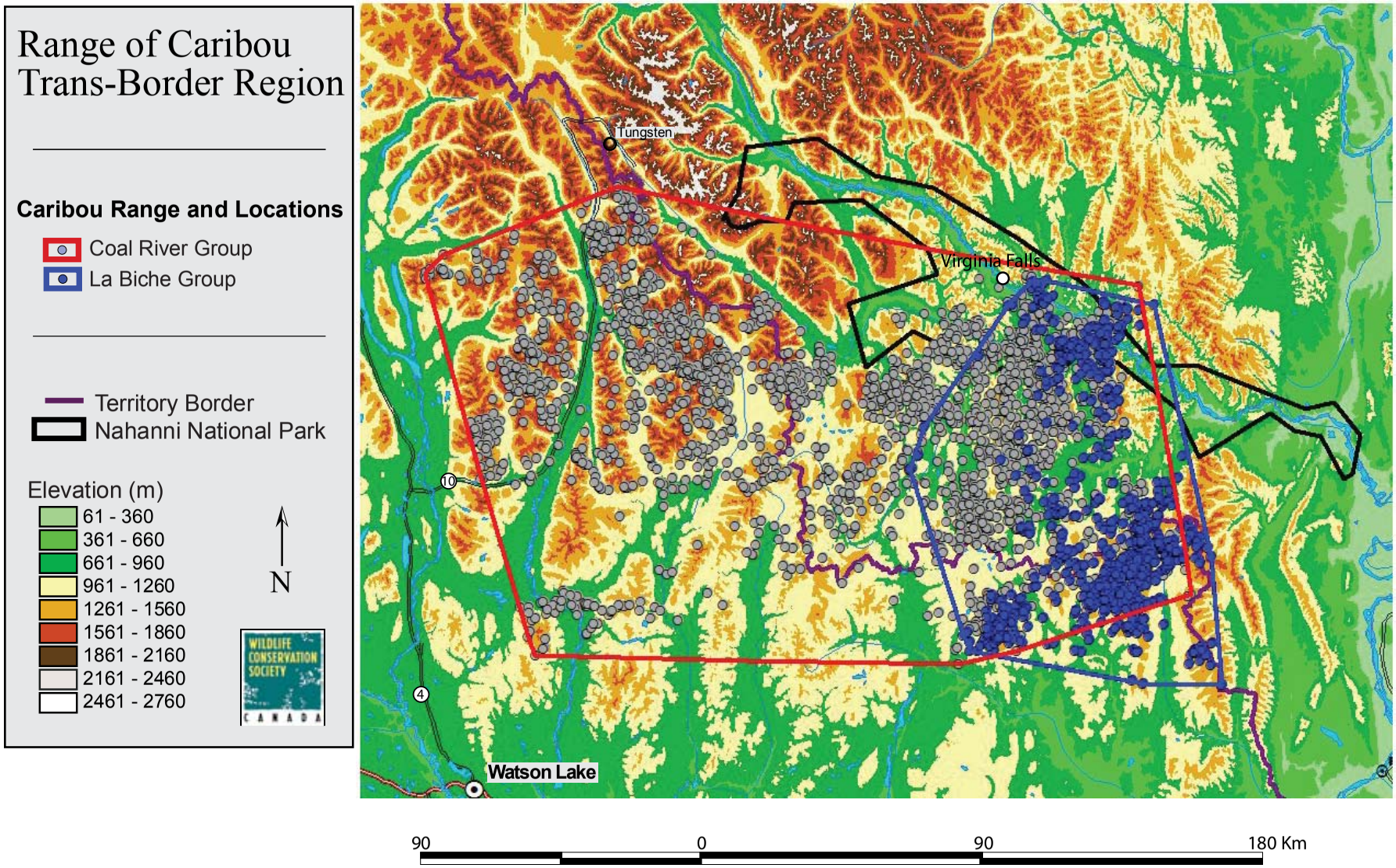


Figure 4. Locations and range of caribou in the Coal River and La Biche groups across the Nahanni trans-border region, Northwest Territories and Yukon Territory, 2000-2007.



Seasonal Ranges

In this section, I describe key areas used by caribou during each of the seven seasons. I plotted locations of caribou on seasonal maps separately for the Coal River (Figures 5-11) and La Biche groups (Figures 12-18) to facilitate refined management, as necessary. Each map is scaled to show locations for that season relative to both the annual ranges and Nahanni National Park Reserve. In addition, each map displays locations color-coded by year to facilitate visual comparisons of site fidelity. I begin this description of the yearly round of caribou travels in *late winter* because that was a period of geographic concentration inside or adjacent to Nahanni National Park Reserve when the distribution of Coal River and La Biche individuals overlapped the most.

Coal River group

Late Winter: During late winter (February 1 – April 15), the primary area for the Coal River group centered on the confluence of the Flat River and the South Nahanni River in Nahanni National Park Reserve (Figure 5). It extended from the Funeral Range on the east to Clark Lake and up to the Flat River on the west; and from Virginia Falls on the north to the headwaters of May Creek and the Mary River on the south. Sites of notable concentration in multiple years included:

- bench west of Direction Mountain between Flat River and the South Nahanni River,
- along the west side of South Nahanni River valley between Mary River and Flat River and bench adjacent to the west,
- area east of May Creek to the base of the Funeral Range (south of Mary River),
- a tributary valley to the Flat River (below confluence with Caribou River) that provides efficient passage south to the Mary River valley,
- along the Flat River between Jorgensen Creek and Caribou River,
- terraces on the west side of lower section of Caribou River, and
- between McMillan Lake and Clark Lake, primarily on the north side of the Diamond Creek valley.

Elevations ranged from 400-500 m along the Flat and South Nahanni Rivers to 700-900 m on slopes and benches. In years with low snowfall (e.g., 2001), two collared caribou spent the late winter in the upper reaches of major watersheds near the Territorial divide: head of Marten Creek and south branches of Meilleur River on the Northwest Territories side, and head of Whitefish River on the Yukon side. These sites ranged between 1250 and 1400 m in elevation.

Spring: Spring (April 16 – May 25) was a period of rapid movement by caribou as they migrated from late-winter range to their calving sites. In the next chapter, I present a detailed description and map of the complex of migration routes used by caribou during both spring and fall. Here, I provide a general description and map of caribou locations during spring.

Members of the Coal River group migrated generally westward (NW→ SW) across the Territorial divide to mountain plateaus in southeast Yukon (Figure 6). At this time, they traveled the major river valleys, presumably because the higher country held deeper snow. Most of the Coal River caribou migrated 175 - 225 km distance in 15-30 days during late April and the first three weeks of May to reach their calving sites.

Calving: During the calving period (May 26 – June 5), members of the Coal River group spread out across a wide stretch of mountain plateaus in the Coal River and Hyland River watersheds in southeast Yukon (Figure 7). Notable sites in multiple years included:

- plateaus between lower Hyland and Coal Rivers east of Thunder Mountain,
- the Mount Laporte plateau between the main Coal Creek and West Coal Creek valleys,
- valleys and plateaus in the upper Hyland River between the Nahanni Range road and Caesar Lakes and north toward Bear Pass, and head of the Rock River,
- west of the Nahanni Range road in the high valleys and plateaus of Dolly Varden, Conglomerate Creek, and Flood Creek basins.

Summer: During the summer period (June 6 – September 25), Coal River caribou occupied much of the same range in the Coal River and Hyland River watersheds and extended north to Anderson Creek (Figure 8). Many remained within a small summer range until September, a few weeks before the onset of the breeding period (rut). Key sites included:

- Territorial divide between Borden Creek (NT) and upper branch of Coal River (YT),
- extensive mountain plateaus between branches of Coal River from south end near Mount Laporte going north to Little Hyland River,
- extensive mountain plateaus west of Hyland River/Nahanni Range road from west of Dolly Varden Creek on the south end going north to Anderson Creek, then over to Anderson Lake and west to Mount Hunt near the East Arm of Francis Lake, and
- lower Hyland River and Thunder Mountain area 45 km northeast of Watson Lake, YT.

Rut: During the rut or breeding period (September 26 – October 10), members of the Coal River group still used the mountain plateaus in the Coal River and Hyland River watersheds and back into the Nahanni sector (Figure 9). In many cases, caribou remained during the rut on the same plateau where they had spent the summer; however, some moved 20-50 km across major valleys in mid-September to other alpine plateaus for the rut. Key sites in multiple years included:

- mountain plateaus west of Hyland River/Nahanni Range road in vicinity of Dolly Varden Creek and Conglomerate Creek,
- mountain plateaus east of Hyland River/Nahanni Range road from Upper Hyland River south past Caesar Lakes and both sides of West Coal River,
- lower Hyland River and Thunder Mountain area,
- Territorial divide between upper Coal River (YT) and Borden Creek (NT), and
- an isolated mountain plateau southeast of Skinboat Lakes on the Nahanni side.

Fall: After the rut, most members of the Coal River group moved rapidly eastward across the Territorial divide into the Nahanni country during the fall period (October 11 – November 30). Interestingly, once some of the Coal

River caribou left the rugged Selwyn Mountains on the Yukon side, they moved eastward along the more subdued section of the Territorial divide area (Figure 10). Individuals that summered in such disparate places as the headwaters of the Coal River and Thunder Mountain traveled in fall to the head of the La Biche River where they intermingled with members of the La Biche group. In most years, these Coal River caribou would then 'double-back' westward to the upper Meilleur River area.

Although caribou were scattered widely across the Liard Plateau section of the Nahanni region during fall, some sites of notable concentration in multiple years included:

- the Territorial divide from the headwaters of Marten Creek (NT) eastward to the headwaters of the La Biche River (YT),
- middle section of Caribou River west of Stonemarten Lakes; also, the area between Marten Creek and Meilleur River extending north along east side of the Caribou Range,
- northeast of McMillan Lake, and
- on the Yukon side, the forested plateau between the headwaters of Whitefish and Beaver Rivers (southeast of Jackpine Lake).

During this fall period, many of the Coal River caribou moved often in seemingly random fashion across this vast boreal forest interspersed with muskeg.

Early Winter: As snowfall typically increased in late fall, Coal River caribou would move further north toward Nahanni National Park Reserve. During the early-winter period (December 1 – January 31), they coalesced in a tighter distribution south of and inside the Park (Figure 11). Notable sites in multiple years included:

- between Marten Creek and Meilleur River extending north along both sides of the Caribou Range and into the Mary River basin, and
- northeast of McMillan Lake and south to Clark Lake.

In years of lighter snowfall, some Coal River caribou would linger along the Territorial border in December but usually push on northward into lower country in January.

Thus having migrated upwards of 250 km from their low-elevation winter range inside Nahanni National Park Reserve across the Territorial border and onward to summer sites on high plateaus and rugged mountains in the Yukon and then returning with the deepening snow, caribou of the Coal River group completed their yearly round of traditional travels.

Figure 5. Locations of the Coal River caribou during late winter, Northwest Territories and Yukon Territory, 2000-2007.

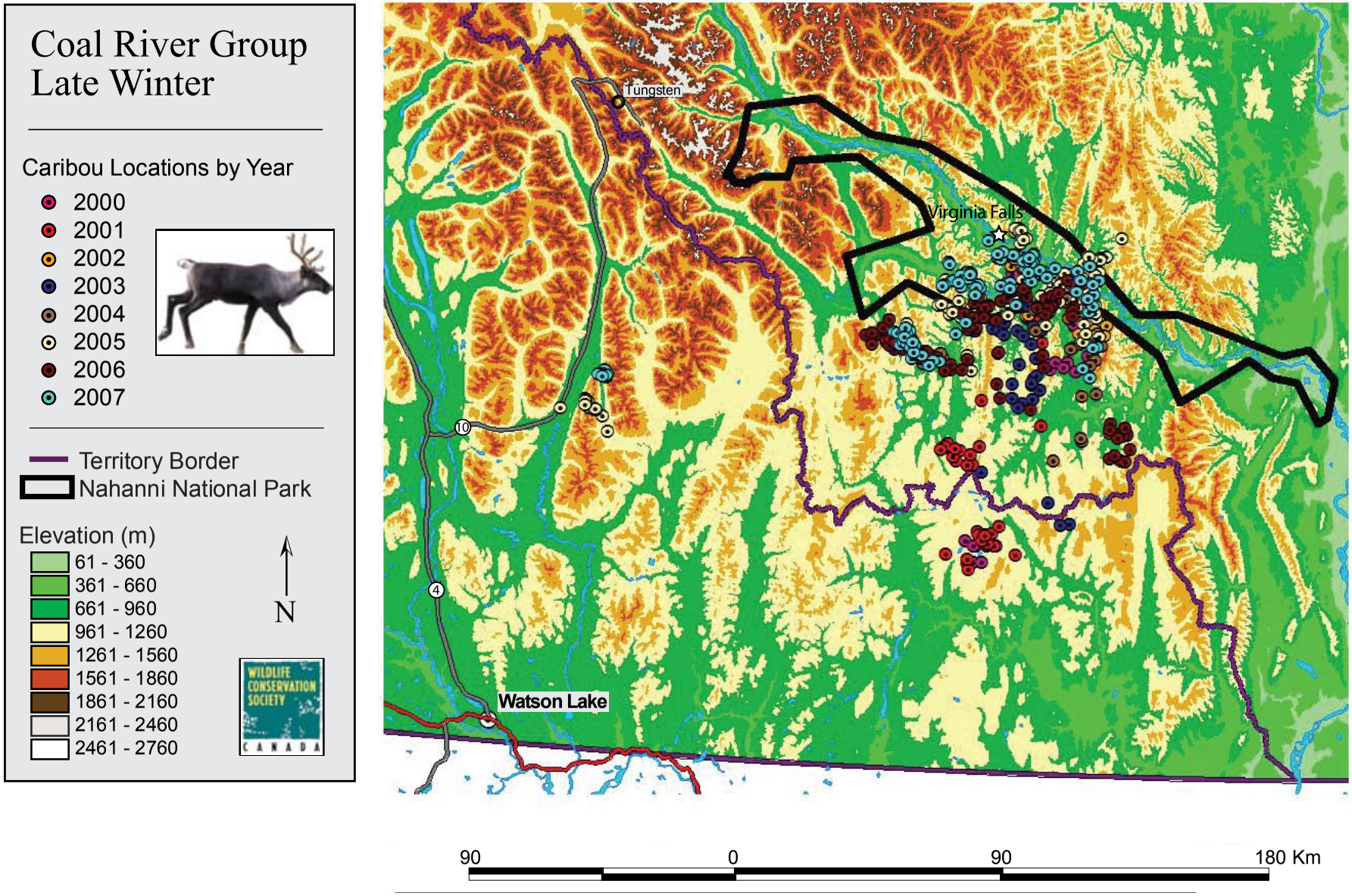


Figure 6. Locations of the Coal River caribou during spring, Northwest Territories and Yukon Territory, 2000-2007.

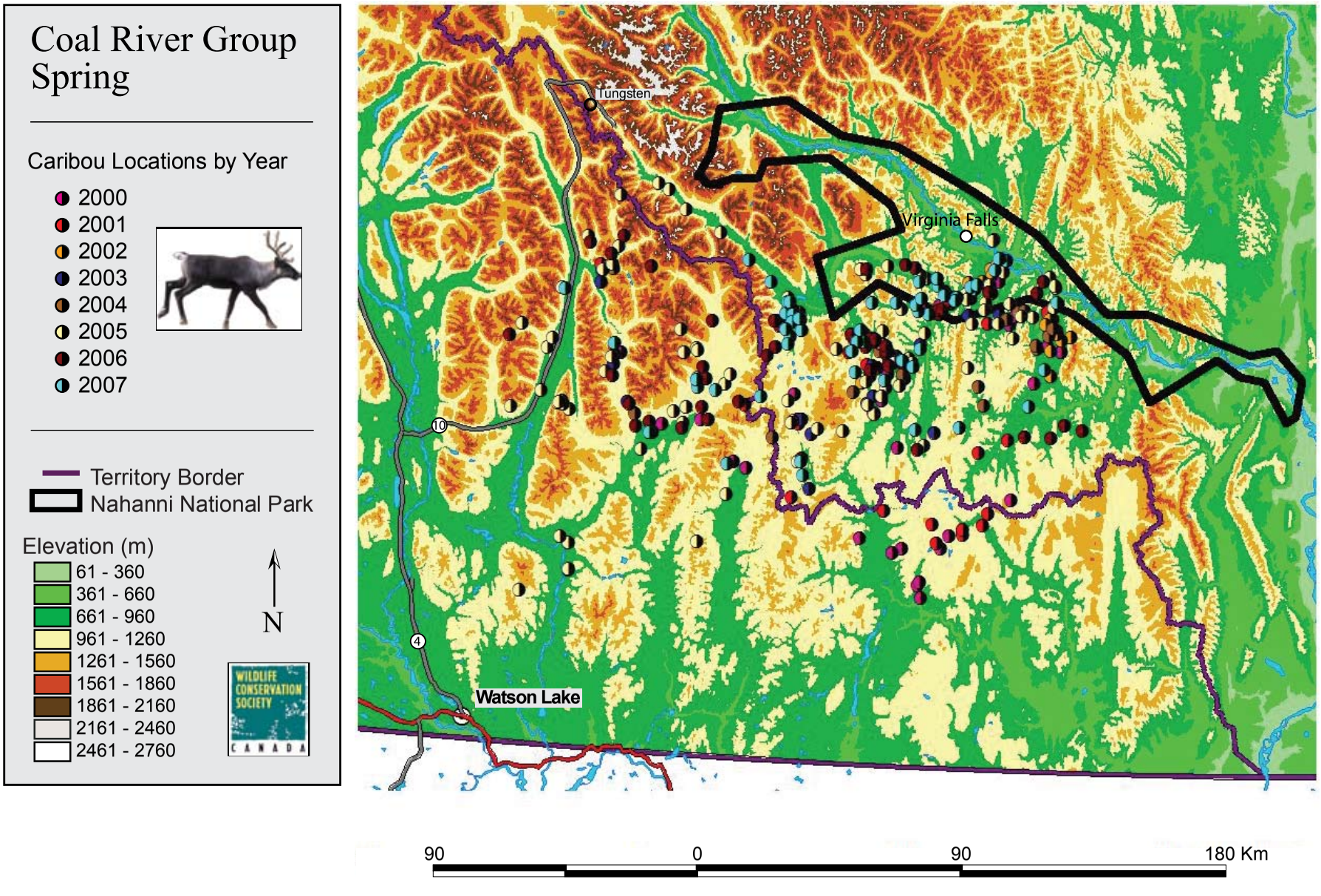


Figure 7. Locations of the Coal River caribou during calving period, Northwest Territories and Yukon Territory, 2000-2007.

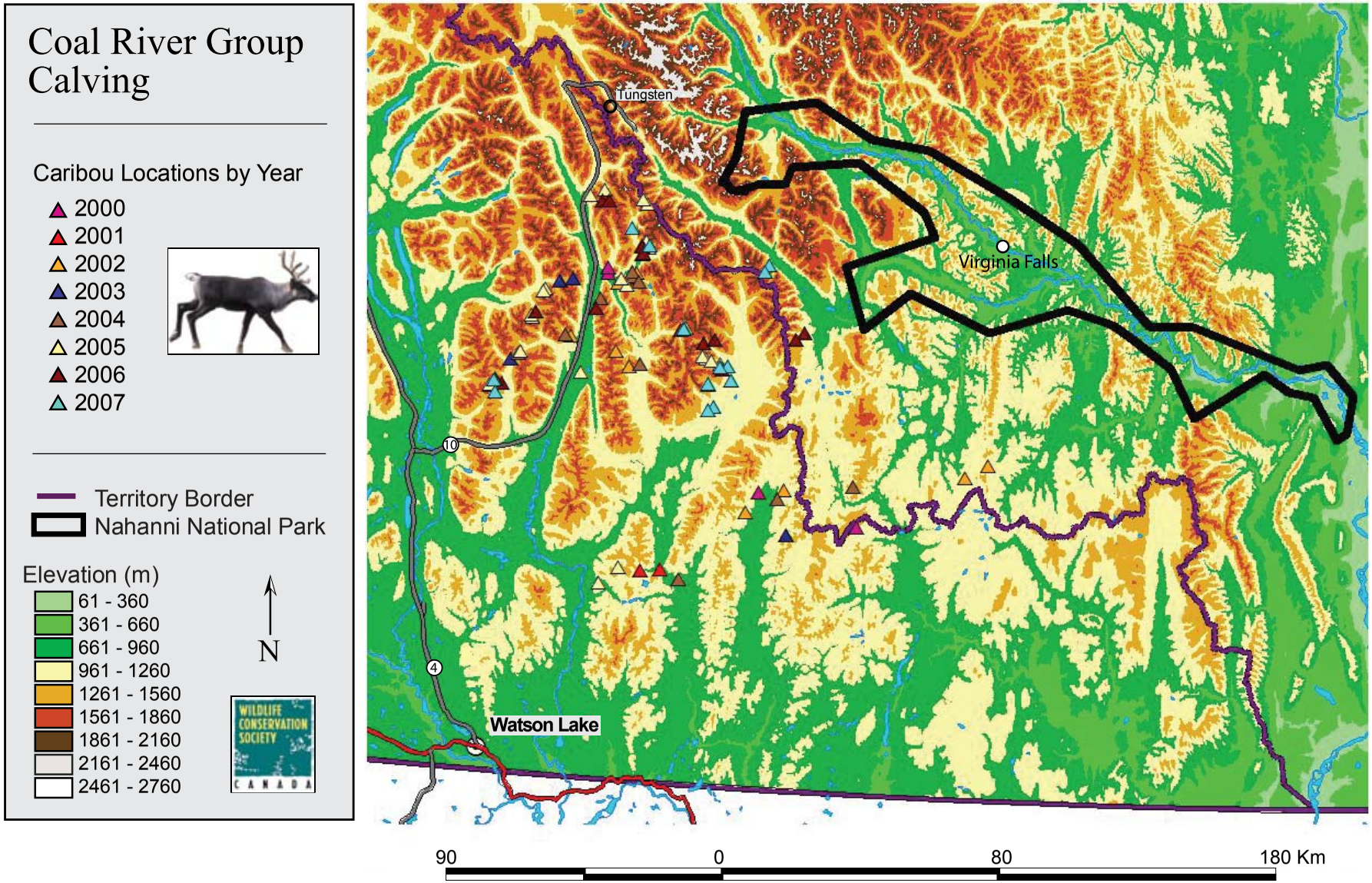


Figure 8. Locations of the Coal River caribou during summer, Northwest Territories and Yukon Territory, 2000-2007.

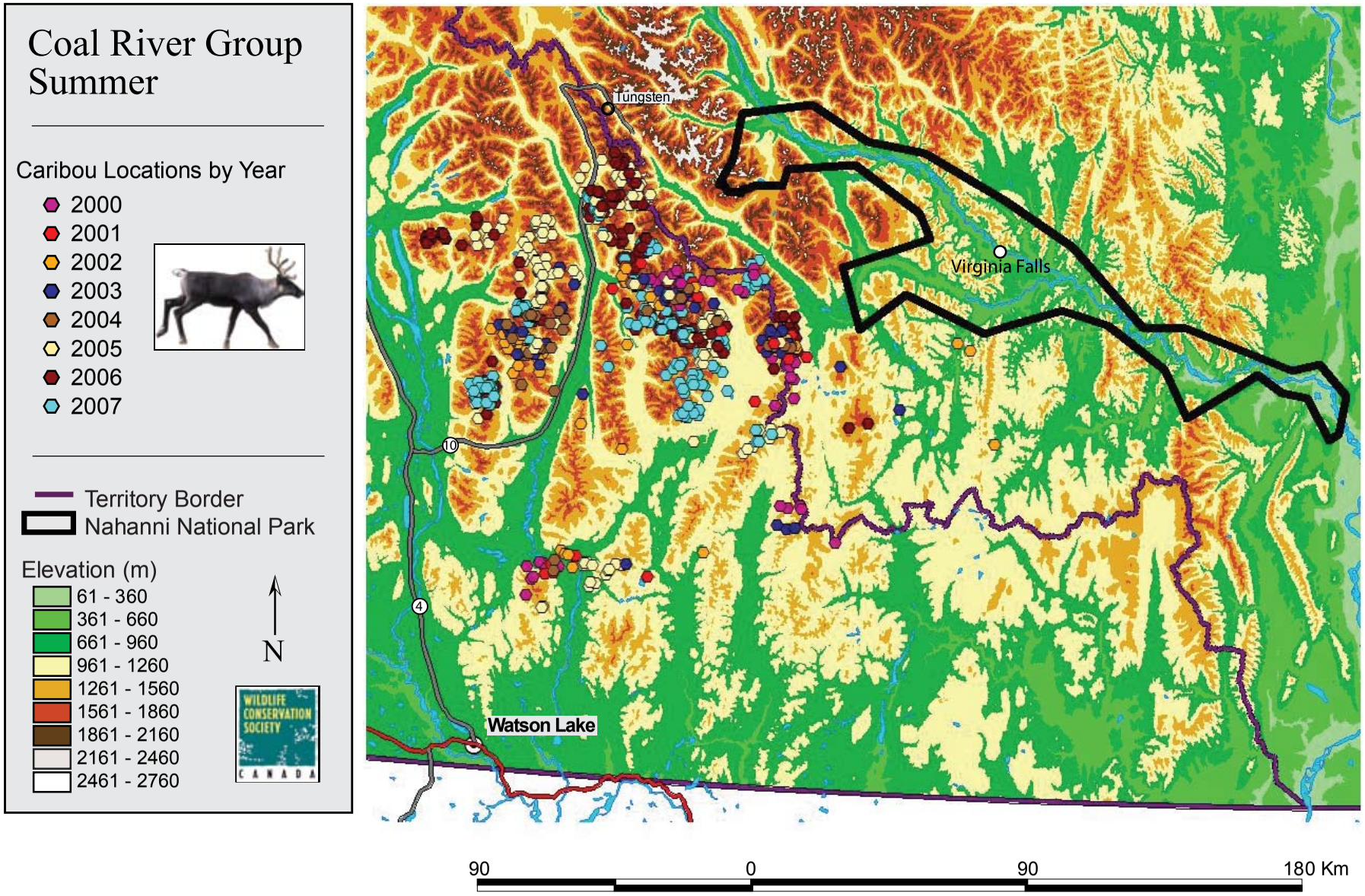


Figure 9. Locations of the Coal River caribou during rut period, Northwest Territories and Yukon Territory, 2000-2007.

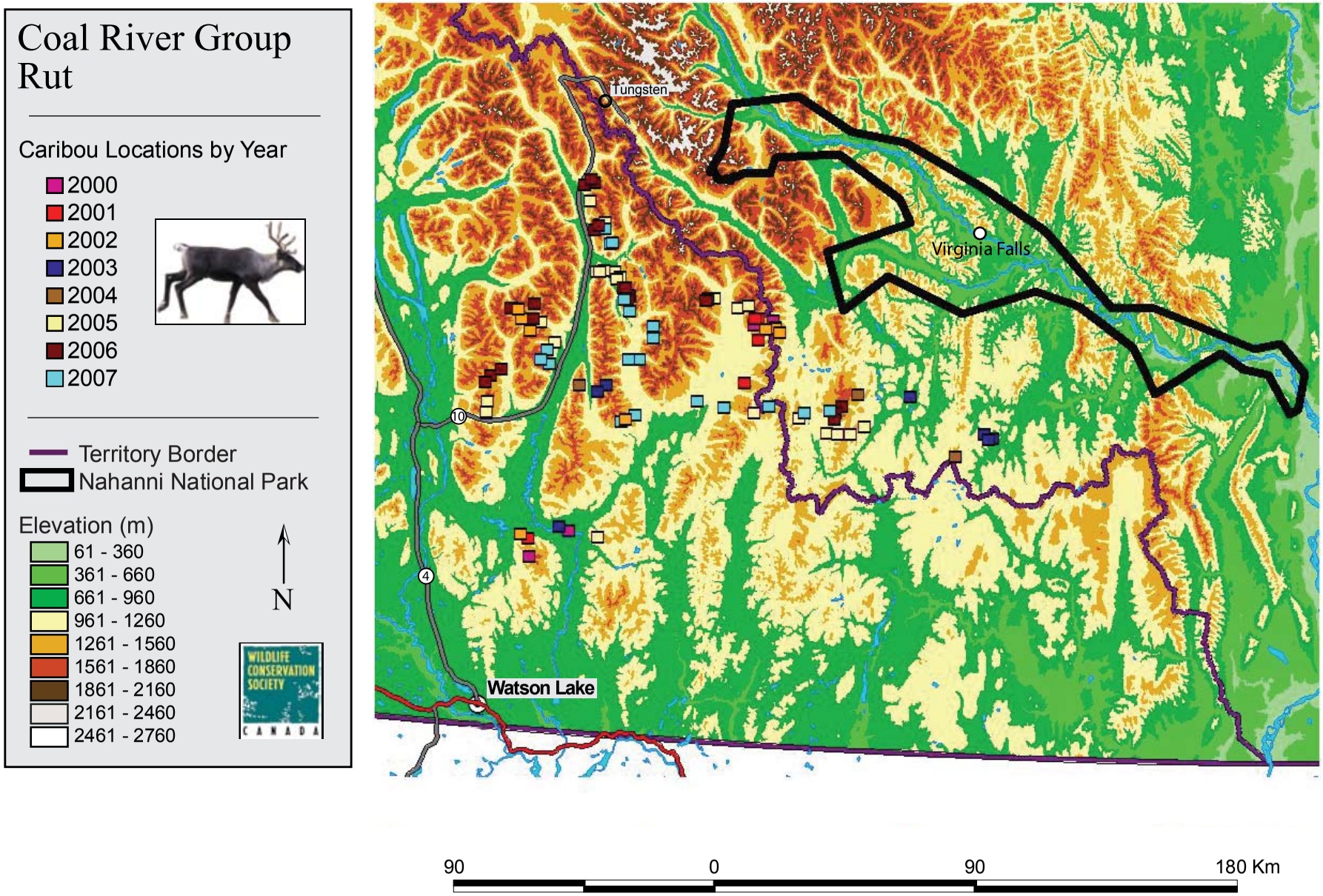


Figure 10. Locations of the Coal River caribou during fall, Northwest Territories and Yukon Territory, 2000-2006.

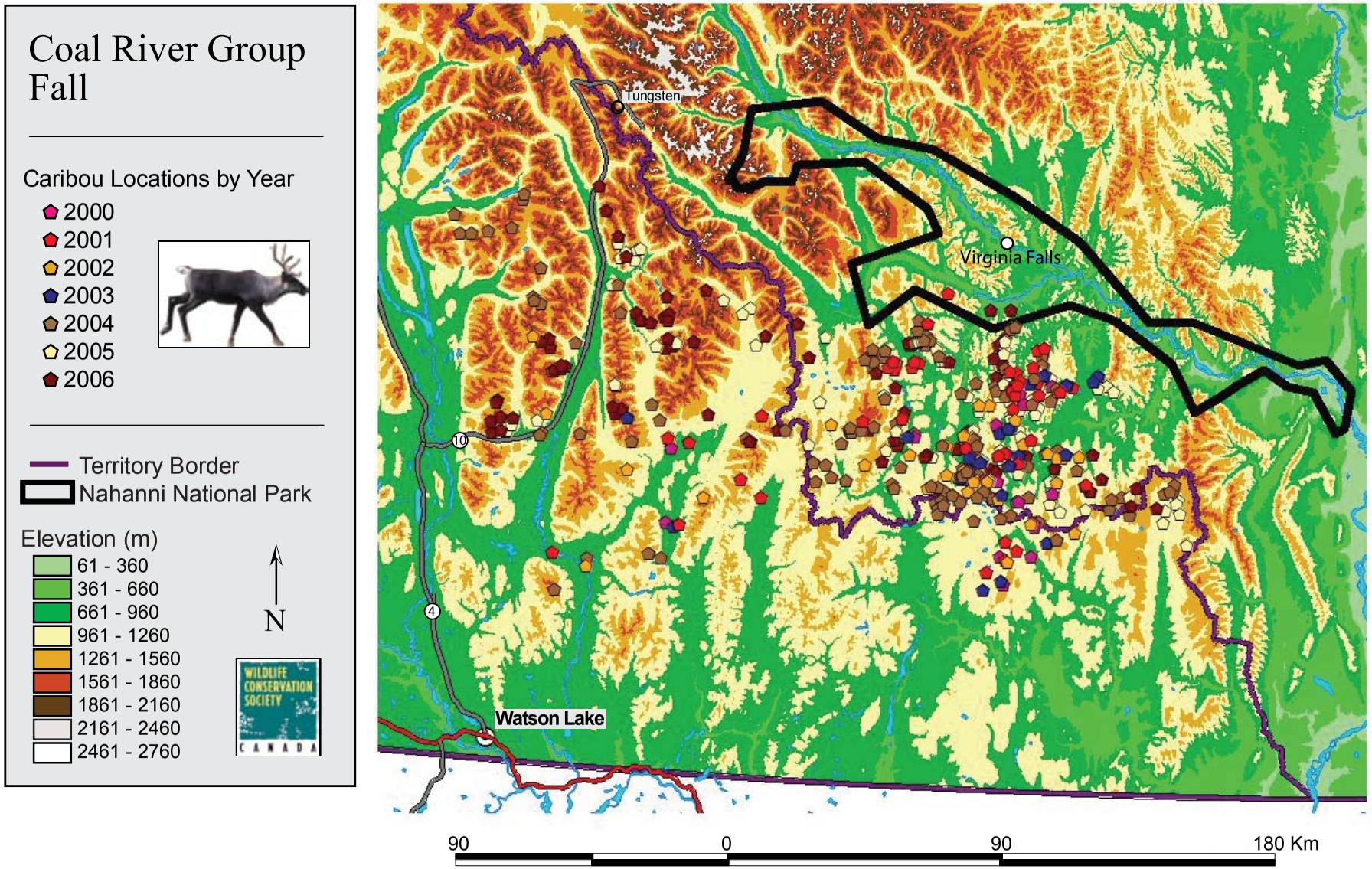
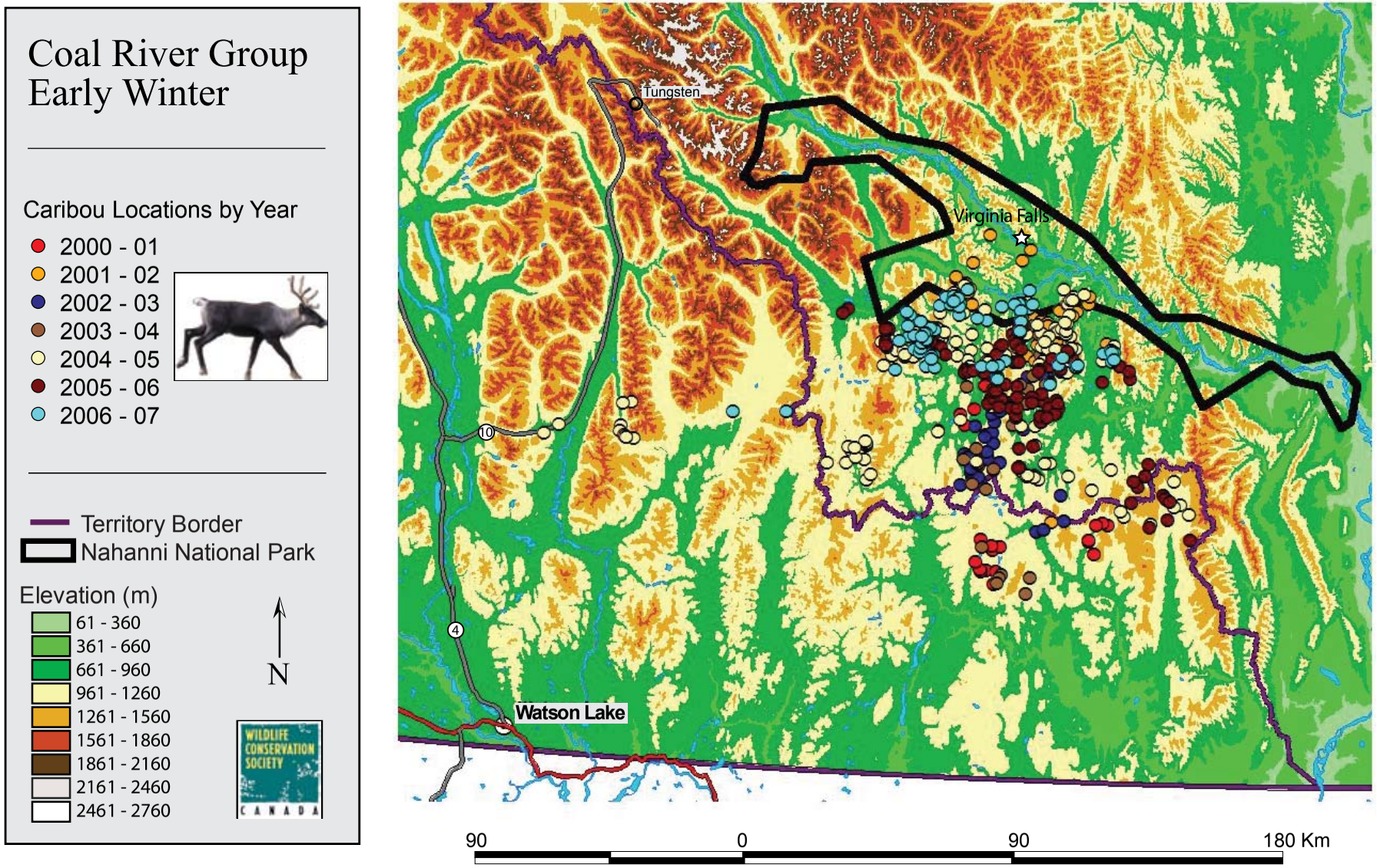


Figure 11. Locations of the Coal River caribou during early winter, Northwest Territories and Yukon Territory, 2000-2007.



La Biche group

Late Winter: The late-winter range of the La Biche group centered the confluence of the Mary River and the South Nahanni River in Nahanni National Park Reserve and the bench adjacent to the west and north of the Mary River (Figure 12). The area east of May Creek to the base of the Funeral Range (south of Mary River) was a center of activity as well. In a year of moderate snowfall (2002), one of the La Biche caribou ranged north of the South Nahanni River in lower Clearwater Creek valley and across from the Mary River confluence during March and early April. On one occasion (February 26, 2002), it was located about 8 km west of the Prairie Creek mine. Locations varied in elevation from 400-500 m along the South Nahanni River to 700-900 m on slopes and benches. In a year with lighter snowfall (2006), both of the La Biche collared caribou spent late winter near the Territorial divide: head of south branches of Meilleur River on the Northwest Territories side, and head of Whitefish River on the Yukon Territory side. These sites ranged between 1250 and 1400 m in elevation.

During late winter, collared caribou of the Coal River and La Biche groups overlapped in their distribution in lower May Creek and Mary River and the plateau to the west; they also occurred in close proximity in some of the peripheral winter ranges (cf. Figures 5 and 12).

Spring: In spring, members of the La Biche group migrated southward up the May Creek and Meilleur River valleys across the Territorial divide to mountain plateaus on the Yukon side (Figure 13). These animals migrated a shorter distance of 90-100 km in 25-30 days to reach their calving sites. During spring migration, there was some overlap between the two groups as animals headed south up May Creek and over into the Meilleur River valley. At that point, however, the Coal River caribou turned west and crossed the divide near the head of the Caribou River, while the La Biche caribou continued southward.

Calving: During the calving period, La Biche caribou occupied a limited area of mountain plateaus at the head of the La Biche River and Whitefish River basins in southeast Yukon (Figure 14). Sites of notable concentration in multiple years included:

- head of the La Biche River,
- string of plateaus between upper La Biche and upper Whitefish Rivers south of Dendale Lake, and
- a plateau southeast of Jackpine Lake near head of the Whitefish River.

Summer: During the summer period, La Biche caribou stayed essentially in the calving areas (Figure 15). Sites of notable concentration in multiple years included:

- head of the La Biche River,
- string of plateaus between upper La Biche and upper Whitefish Rivers south of Dendale Lake, and
- the plateau southeast of Jackpine Lake near head of the Whitefish River.

One notable difference, however, was that some caribou in the headwaters of the La Biche River basin moved during July from the west side across the valley to the more rugged, alpine mountains on the east side along the Territorial divide. Later in the summer, they would return to the west side. Perhaps these caribou sought relief from insect harassment.

Rut: During the rut period, members of the La Biche group remained in their summer range (Figure 16). The primary site of notable concentration in multiple years was the plateau between upper La Biche and upper Whitefish Rivers south of Dendale Lake and north to the border.

Fall: La Biche caribou stayed during the fall in the same areas where they had spent the summer and the rut (Figure 17). They were concentrated primarily in the plateau area between the upper La Biche and upper Whitefish Rivers, north to the Territorial border.

Early Winter: During the early-winter period, members of the La Biche group continued to occupy the area along the Territorial border – especially during years with light to moderate snowfall. However, in years of heavier snowfall, they too would move northward toward and into the Nahanni National Park Reserve in late December or January (Figure 18). During this period, caribou from the Coal River and La Biche groups overlapped in occurrence in several areas:

- along the Territorial border in the upper Whitefish and La Biche River basins on the Yukon side and the upper Meilleur River area on the Northwest Territories side, and
- in the lower sections of May Creek and Mary River near the Park boundary.

Compared to the Coal River group, caribou of the La Biche group spent the entire period from calving until early winter in a relatively small area near the Territorial divide. It's important to note that within the range of this group, the extent of land above timberline is limited.

Figure 12. Locations of the La Biche caribou during late winter, Northwest Territories and Yukon Territory, 2002-2007.

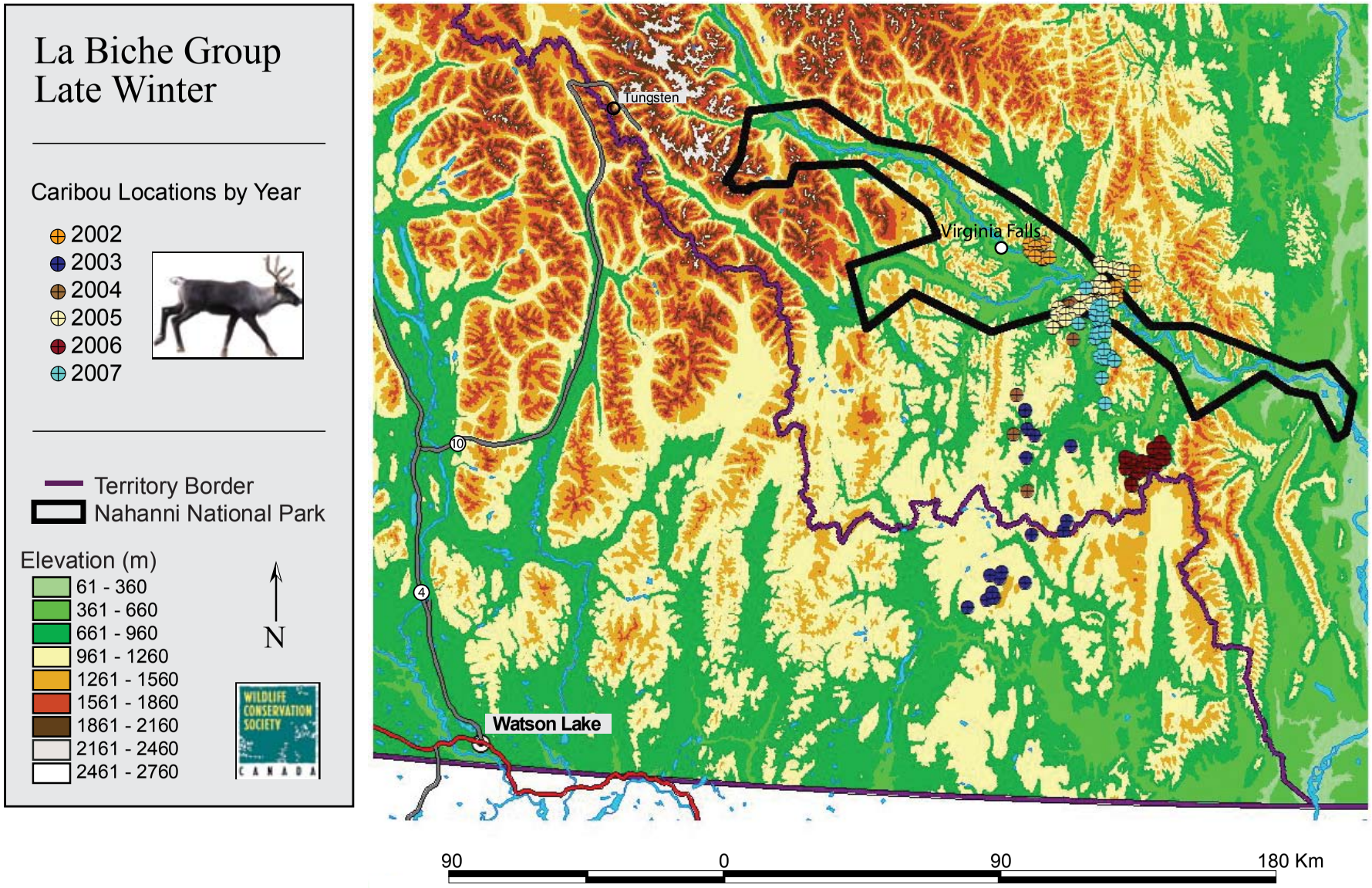


Figure 13. Locations of the La Biche caribou during spring, Northwest Territories and Yukon Territory, 2002-2007.

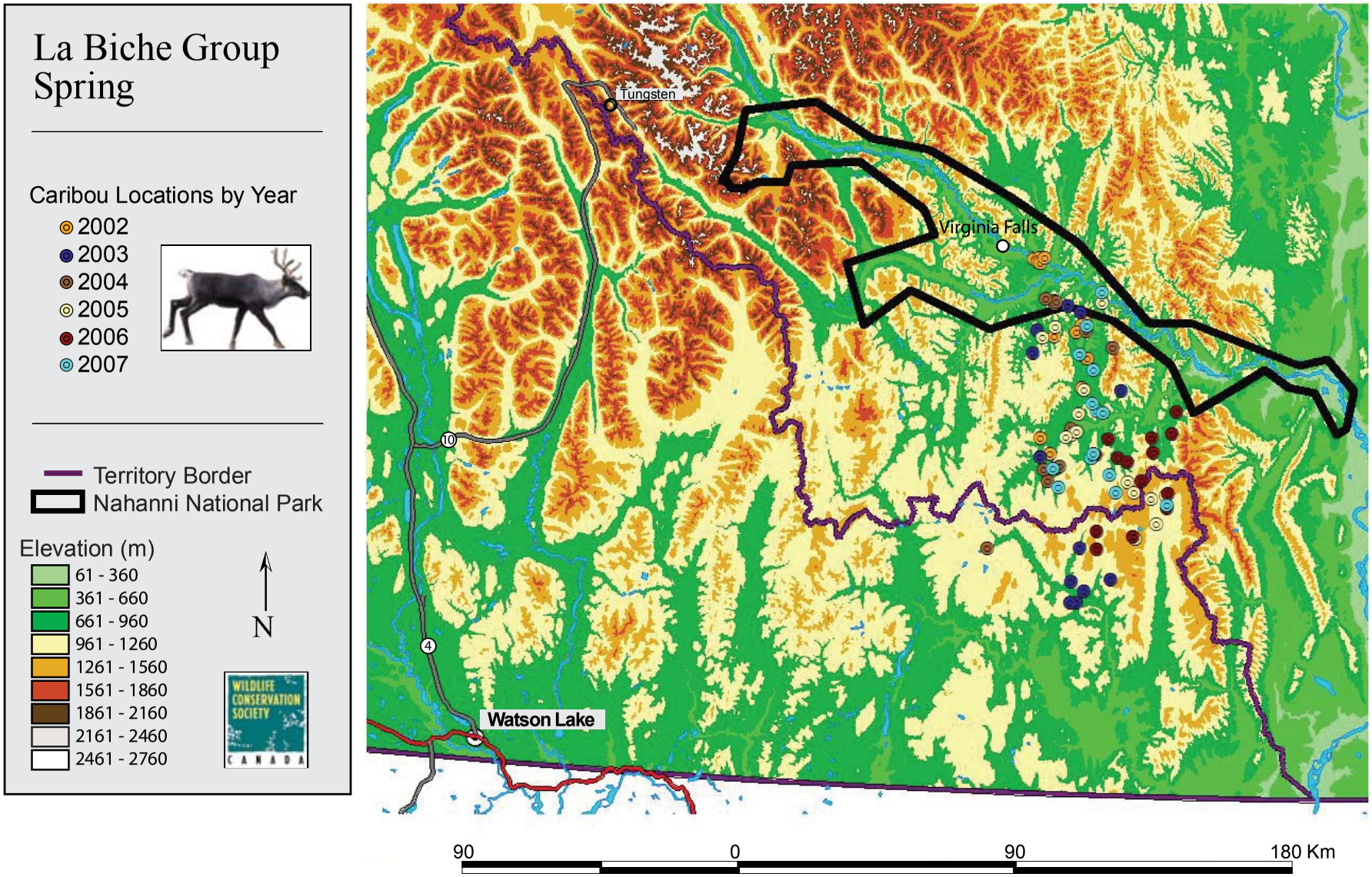


Figure 14. Locations of the La Biche caribou during the calving period, Northwest Territories and Yukon Territory, 2002-2007.

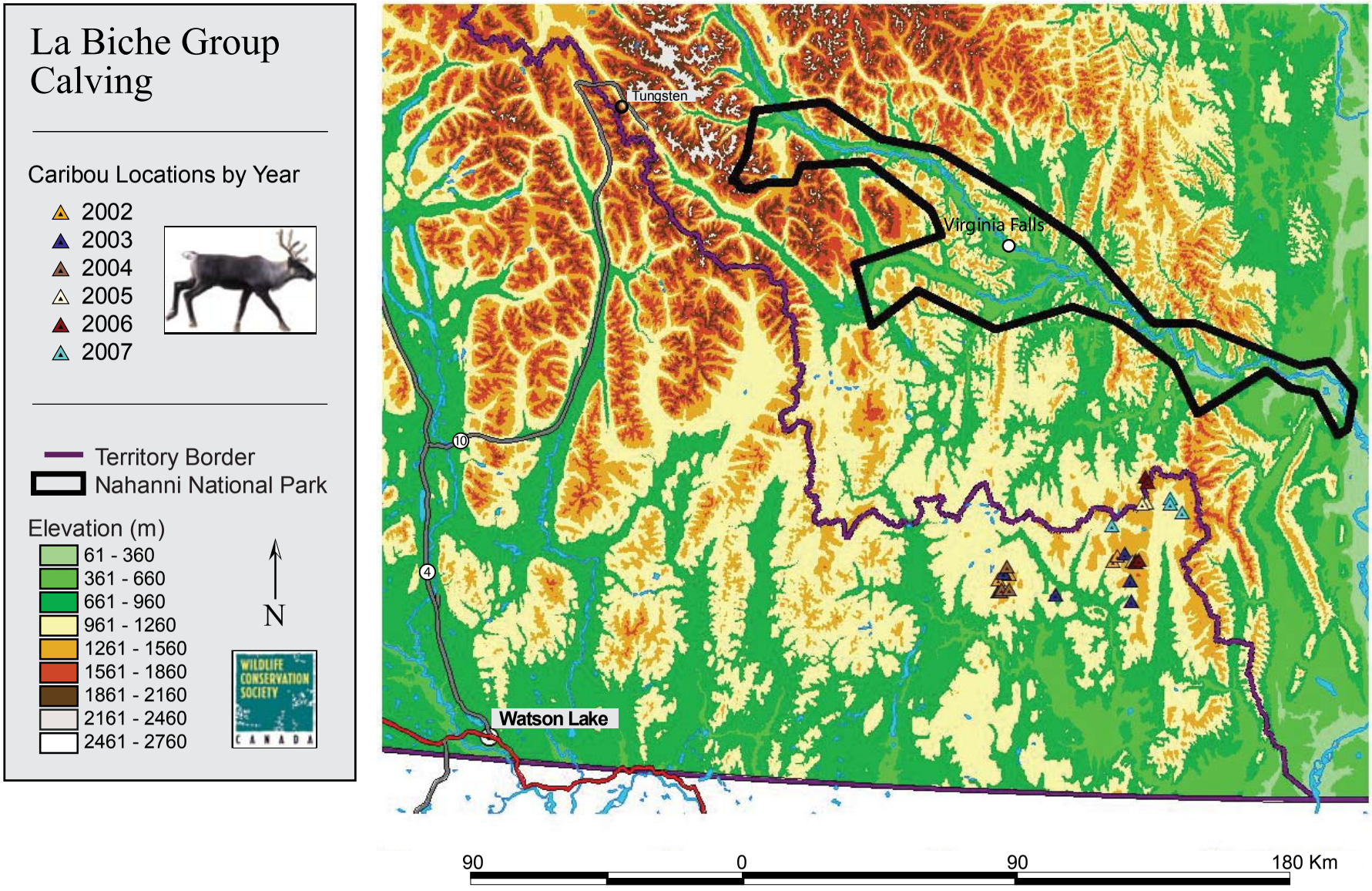


Figure 15. Locations of the La Biche caribou during summer, Northwest Territories and Yukon Territory, 2002-2007.

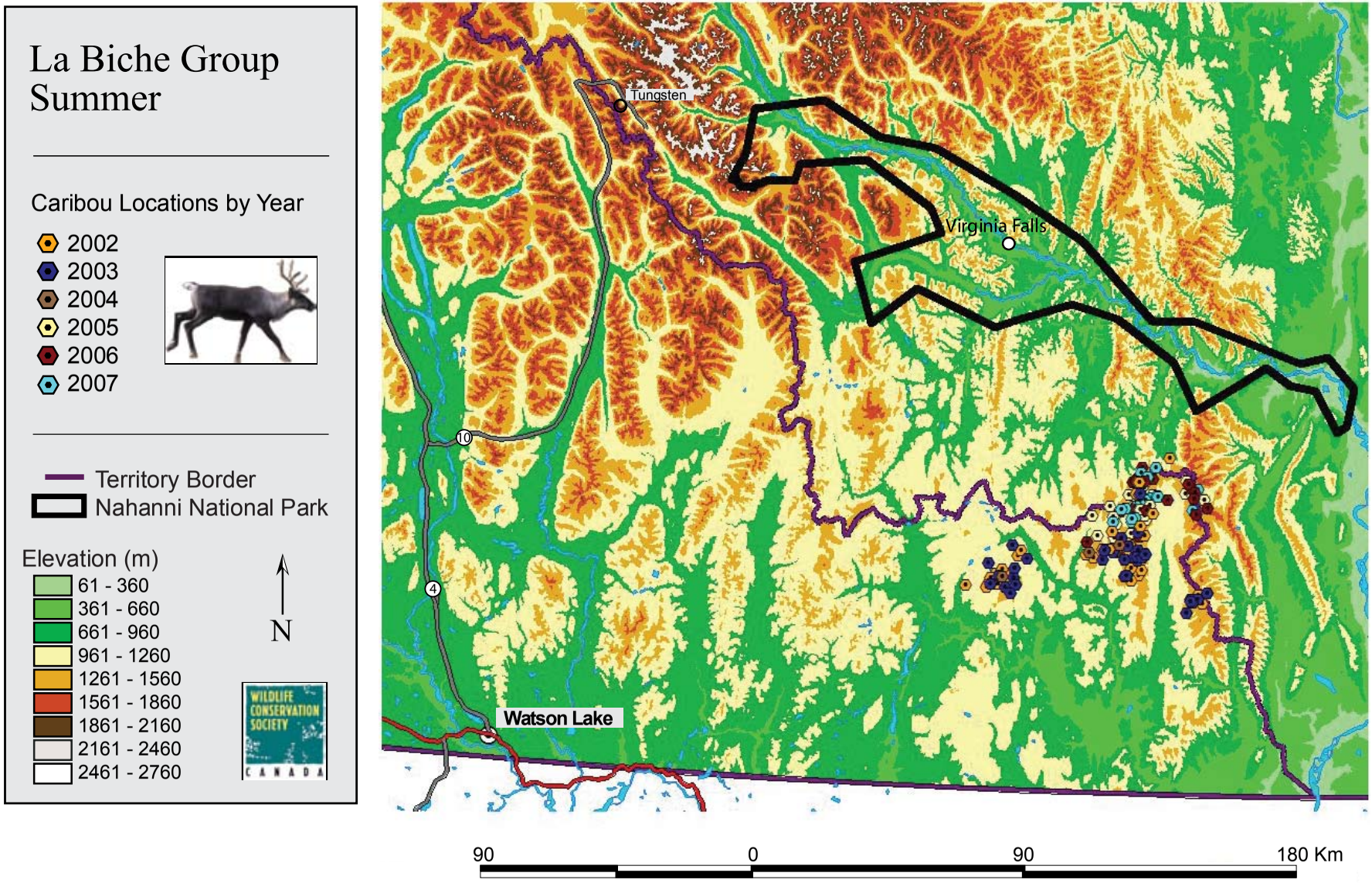


Figure 16. Locations of the La Biche caribou during the rut period, Northwest Territories and Yukon Territory, 2002-2007.

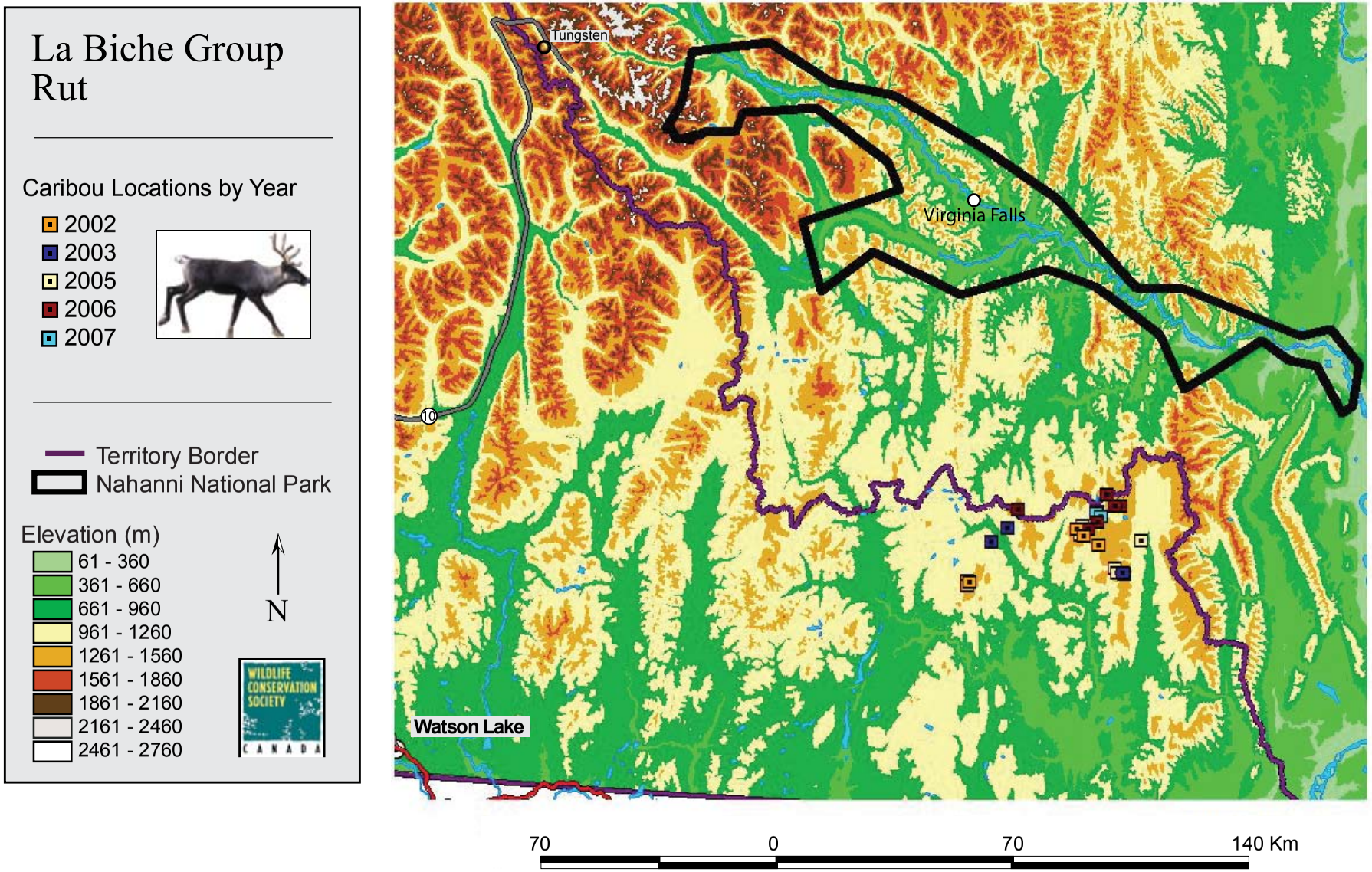


Figure 17. Locations of the La Biche caribou during fall, Northwest Territories and Yukon Territory, 2001-2006.

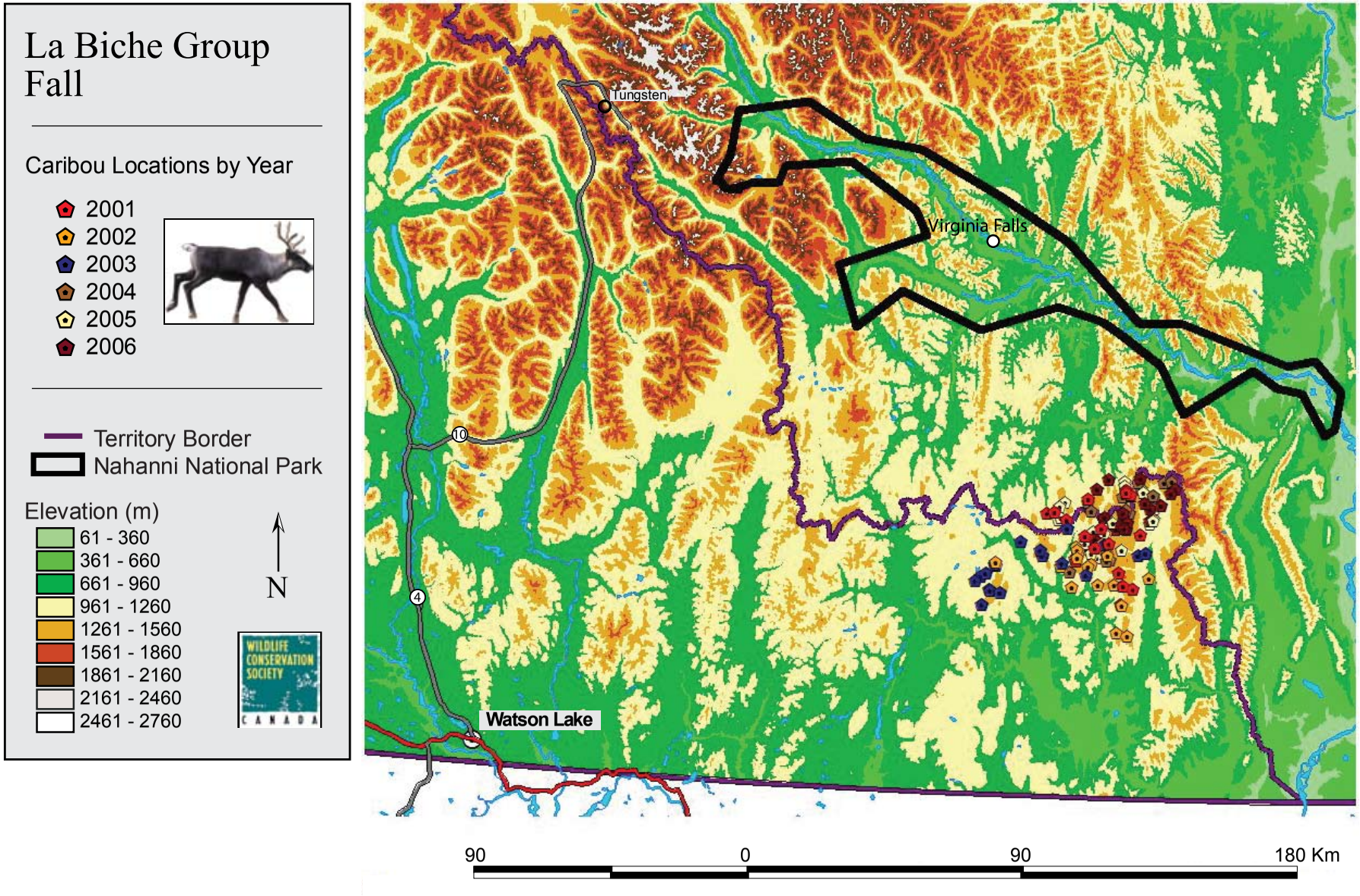
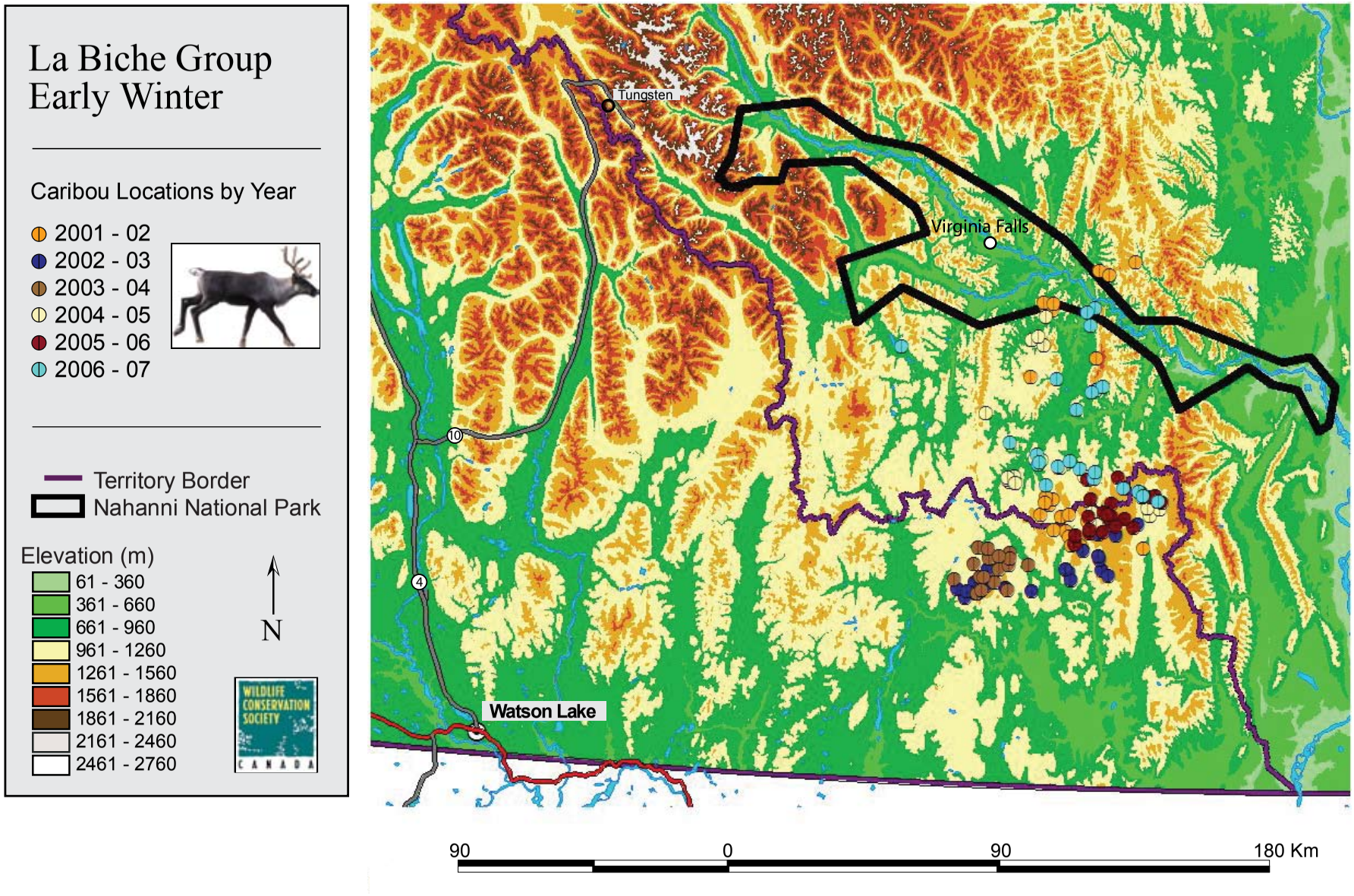


Figure 18. Locations of the La Biche caribou during early winter, Northwest Territories and Yukon Territory, 2001-2007.



Site Fidelity

Here, I assay the degree of fidelity to seasonal sites using three metrics. It's important to note at the outset that, under certain circumstances, the metric of inter-year distances between centres of activity can obscure the real degree of fidelity. Consider the example of an individual that occupies sites 5 km apart in years 1 and 3 but uses a site 50 km away in the middle year. The inter-year distance averaged across all 3 years would be about 35 km. Yet, she demonstrated strong fidelity in 2 of 3 years. Under such variable distribution, the other metrics relating to prevalence and frequency of fidelity may be more revealing.

Late Winter

Caribou of the Coal River group exhibited varying fidelity to late-winter sites that seemed to be influenced by amount of snowfall. During March, the mean inter-year distance for individuals of the Coal River group was 29.1 km (median = 24.5 km) (Table 5). Seven of 13 individuals exhibited fidelity to their late-winter range; overall, caribou exhibited fidelity in 14 (40%) of 35 cases. La Biche caribou also displayed varying fidelity to late-winter sites that seemed to be influenced by snowfall, too. The average inter-year distance was 40.5 km (median = 38.8 km) (Table 5). Two of the 4 individuals exhibited fidelity to their late-winter range; overall, caribou from this group exhibited fidelity in 4 (33%) of 12 cases. This reflected the fact that La Biche caribou had two wintering strategies: (1) in years of high snowfall (2005 and 2007), they spent late winter at lower elevations of the Mary River and South Nahanni River in or near Nahanni National Park Reserve, and (2) in years of low to moderate snowfall (2006), they wintered near the Territorial divide about 70-90 km away.

Table 5. Fidelity of caribou from the Coal River and La Biche groups to sites during late-winter period (March), Nahanni trans-border region, Yukon Territory and Northwest Territories, 2000-2007. Inter-year distance (km) (± SD) was measured between geometric centres of locations; proportion refers to number when inter-year distance was ≤ 10 km.

Fidelity Metric	Coal River	La Biche
Mean Inter-Year Distance	29.1 (± 16.7)	40.5 (± 21.8)
Proportion of Individuals	7 / 13	2 / 4
Proportion of Cases	14 / 35	4 / 12

Calving

Many individual caribou from the Coal River group exhibited remarkable fidelity to calving sites. The average inter-year distance was 13.8 km (median = 5.3 km) (Table 6). Eight of 10 individuals returned to within 10 km of their calving site; overall, caribou from this group exhibited fidelity in 22 (73%) of 30 cases. In 15 cases, the distance was ≤3.2 km from a site in another year. The La Biche collared caribou also exhibited remarkable fidelity to calving sites. Average inter-year distance was 6.9 km (median = 7.0 km) (Table 9). All four individuals returned to within 10 km of their calving site in consecutive years; overall, caribou from this group exhibited fidelity in 10 (91%) of 11 cases.

Table 6. Fidelity of caribou from the Coal River and La Biche groups to sites during calving period, Nahanni trans-border region, Yukon Territory and Northwest Territories, 2000-2007. Inter-year distance (km) (± SD) was measured between geometric centres of locations; proportion refers to number when inter-year distance was ≤ 10 km.

Fidelity Metric	Coal River	La Biche
Mean Inter-Year Distance	13.8 (± 15.3)	6.9 (± 3.2)
Proportion of Individuals	8 / 10	4 / 4
Proportion of Cases	22 / 30	10 / 11

Summer

Caribou continued to show strong fidelity to their favorite sites in summer (July). Average inter-year distance was 15.1 km (median = 7.3 km) for members of the Coal River group (Table 7). Nine of 12 individuals returned to within 10 km of their summer site; overall, caribou from this group exhibited fidelity in 21 (62%) of 34 cases. In 13 cases, the inter-year distance was ≤3.2 km. In other cases, individual caribou returned essentially to the same site for 2 years but then shifted 40-60 km to another mountain plateau in the third year.

Caribou from the La Biche group also exhibited high level of fidelity to summer sites. Average inter-year distance was 9.3 km (median = 7.7 km) (Table 7). Three of 4 individuals returned to within 10 km of their calving site in consecutive years; overall, caribou from this group exhibited fidelity in 7 of 9 cases (78%). In 2 cases, though, individuals returned essentially to the same site for at least 2 locations during July but then moved across the valley during other days of the month. If those cases are included, then average distance drops to 4.7 km (median = 4.4), all four individuals exhibited fidelity, and frequency of fidelity increases to 100% (Table 7).

Table 7. Fidelity of caribou from the Coal River and La Biche groups to sites during summer period (July), Nahanni trans-border region, Yukon Territory and Northwest Territories, 2000-2007. Inter-year distance (km) (± SD) was measured between geometric centres of locations; proportion refers to number when inter-year distance was ≤ 10 km.

Fidelity Metric	Coal River	La Biche
Mean Inter-Year Distance	15.1 (± 15.7)	9.3 (± 3.9)
Proportion of Individuals	9 / 12	3 / 4
Proportion of Cases	21 / 34	7 / 9

Rut

Caribou exhibited moderate but variable fidelity to rut or breeding sites. For Coal River caribou, average inter-year distance was 18.3 km (median = 12.7 km) (Table 8). Eight of 12 individuals returned to within 10 km of their rut site; overall, these caribou showed fidelity in 18 (55%) of 33 cases. If the distance threshold criterion for fidelity was relaxed slightly from 10 km to 12 km, however, the number of individuals increases to 10 and the frequency increases to

25 (76%) of 33 cases. Thus, many of the Coal River caribou exhibited at least moderate fidelity to their rut sites, whereas a few individuals shifted substantially to new rut areas.

Caribou from the La Biche group also exhibited slightly less fidelity to rut sites compared to the calving and summer sites. Average inter-year distance was 14.3 km (median = 14.6 km) (Table 8). Only one of 4 individuals returned to within 10 km of its rut site in different years; overall, caribou exhibited fidelity in 2 of 9 cases (22%).

Table 8. Fidelity of caribou from the Coal River and La Biche groups to sites during rut period, Nahanni trans-border region, Yukon Territory and Northwest Territories, 2000-2007. Inter-year distance (km) (± SD) was measured between geometric centres of locations; proportion refers to number when inter-year distance was ≤ 10 km.

Fidelity Metric	Coal River	La Biche
Mean Inter-Year Distance	18.3 (± 16.5)	14.3 (± 4.8)
Proportion of Individuals	8 / 12	1 / 4
Proportion of Cases	18 / 33	2 / 9

To summarize: These caribou exhibited: (1) a remarkable degree of fidelity (return to within 10 km of previous centre of activity) to calving (86% of individuals/ 78% of cases) and summer (July) sites (81%/ 70%), and (2) lesser fidelity to rut (56%/ 48%) and late-winter (March) sites (53%/ 40%).

Habitats

During late winter, 81% of 371 caribou locations occurred in the 'Montane Spruce-Lichen Forest' type, which accounted for about 65% of the landscape (Table 9, Figure 2). Interestingly, caribou had fewer locations in the Pine-Aspen type (3.8%) than its distribution (8.4%); they clearly avoided a large patch of this type in upper May Creek - middle Meilleur River basin that likely resulted from a fire. Relatively few caribou locations occurred in the alpine cover types during late winter.

During the short calving period, caribou occurred mostly in open conifer types (43% of 58 locations) and dense conifer types (16%) that were proximal to rocky, alpine types (38%). Later in summer, caribou shifted more to exposed alpine types ('rock'/'low shrub', and 'herb') (57% of 497 locations), including patches of snowfields (2.3%).

During the rut, caribou occurred less often in the most exposed alpine types (22% of 68 locations) and mostly on the edge of plateaus and subalpine basins where 'low shrub' (scrub birch and willows) (24%) and 'open conifer' (42%) occurred in close proximity.

In early winter, 85% of 365 locations of these caribou occurred again in the 'Montane Spruce-Lichen Forest' type, which accounted for about 65% of the landscape. Caribou were located less often in the Pine-Aspen type (3.7%) than its distribution (8.4%); again, they avoided the large patch in upper May Creek - middle Meilleur River basin.

Table 9. Occurrence (% of locations) of caribou in land cover types in different seasons, Northwest Territories and Yukon Territory, 2000-2007. Sample size of available locations is shown in parentheses. See Tables 2a and 2b for description of land cover types.

Land Cover	Pct Cover	Calving (58)	Summer (497)	Rut (68)	Early Winter (365)	Late Winter (371)
Unclassified	2.7				-	1.5
Closed Spruce Forest (Dense Conifer)	3.3				5.7	7.5
Closed Deciduous Forest	0.3				-	0.1
Montane Spruce-Lichen (Open Conifer)	64.6				84.8	81.1
Pine-Aspen	8.4				3.7	3.8
Montane Subalpine Open Woodland	6.2				3.0	1.9
Montane Subalpine Savannah Lichen	5.0				1.0	1.1
Subalpine Shrubland	1.0				-	-
Subalpine Lichen Tundra/ Subalpine Low Veg Tundra	2.7				0.5	0.8
Rock	2.5				0.7	0.3
Recent Burns	0.8				0.3	0.8
Lakes and Rivers	0.8				0.1	1.1
Snow and Ice	1.1				-	-
Wetlands	0.6				0.1	-
Subtotal	**100.0**				**99.9**	**100.0**
Unclassified	4.4	-	5.8	2.9		
Lakes and Rivers	0.5	-	-	1.5		
Snow and Ice	0.3	-	2.3	-		
Rock/Tundra	8.6	24.1	27.0	11.8		
Moss/Lichen	0.5	-	0.2	0.7		
Tall Shrub	1.4	-	0.7	0.7		
Low Shrub	13.6	9.5	20.4	24.3		
Wetland	0.8	-	0.1	-		
Herb	2.4	4.3	9.6	10.3		
Dense Conifer	7.9	16.4	4.0	2.2		
Open Conifer	52.1	43.1	24.9	41.9		
Dense Deciduous	0.3	-	-	-		
Open Deciduous	6.0	2.6	4.7	2.9		
Dense Mixwood	0.4	-	-	-		
Open Mixwood	0.8	-	0.3	0.7		
Subtotal	**100.0**	**100.0**	**100.0**	**99.9**		

Discussion

Seasonal Ranges

These caribou spent late winter in boreal forests inside the narrow boundaries of Nahanni National Park Reserve in the Northwest Territories. In spring, they migrated 90-240 km westward across the Territorial divide to alpine plateaus in the mountains of southeast Yukon for calving, summer, and the rut before returning in the fall to the lower Nahanni country. (When snow and/or wind conditions permit effective foraging on alpine ridges, those sites can also be used by caribou in winter.) A similar pattern of movements from lowland forests in winter to alpine/sub-alpine ranges in summer has been reported for caribou in several mountainous locales (Oosenbrug and Theberge 1980, Bergerud et al. 1984, Edmonds 1988, Farnell and McDonald 1990, Wood 1996, Gustine and Parker In Press, among others). It is widely thought that this represents one strategy in mountainous landscapes to 'space away' from summer habitats of moose and associated travel routes of wolves searching for moose (Bergerud and Page 1987, Seip 1991, Seip 1992, Barten et al. 2001, Gustine et al. 2006a) in a 'predator-prey shell game' (Mitchell and Lima 2002). The implication is that caribou populations may persist with greater likelihood in large, diverse landscapes that offer multiple choices for refugia from predation and for energetically-efficient foraging in winter (Seip and Cichowski 1996, Gustine and Parker In Press).

In the trans-border region used by the Coal River and La Biche groups of caribou, alpine habitats on the Nahanni side are few, isolated, and narrow. Thus, the broad-scale pattern of the landscape suggests that caribou move to distant sites in the Yukon to position themselves for the calving and post-calving periods. This has resulted in a large annual range (collectively >32,000 km^2) that spans the border of both jurisdictions. Clearly, conservation of caribou populations and habitats in this trans-border region must reflect that ecological context.

Site Fidelity

In the Nahanni trans-border region, female caribou exhibited remarkable fidelity to calving and mid-summer sites in terms of inter-year proximity, prevalence, and frequency. This fidelity held even when they occupied different winter ranges. Numerous studies have also documented very strong fidelity by woodland caribou at these seasons, in both Northern Mountain populations in western Canada (Edmonds 1988, Farnell and McDonald 1990, Cichowski 1993, Wood 1996, Weaver 2006) and Boreal populations in eastern Canada (Shoesmith and Storey 1977, Brown and Theberge 1985, Schaefer et al. 2000, Rettie and Messier 2001, Ferguson and Elkie 2004). Strong fidelity to calving and summer sites could enhance an individual's fitness if it resulted in higher reproductive success in terms of recruitment of young. For fidelity to a specific site to become traditional, the site must be relatively stable through time in terms of key attributes (e.g., availability of quality forage and/or low likelihood of predator encounter). Alpine sites likely are stable in terms of forage availability during an individual's lifetime.

Many of the female caribou in the Nahanni trans-border region displayed at least moderate fidelity to sites for breeding (rut), whereas a few individuals shifted substantially to new areas. Other studies also noted moderately strong fidelity by caribou to rut sites in the mountains of western Canada (Edmonds 1988, Farnell and McDonald 1990, Wood 1996, Weaver 2006). Nonetheless, some individuals used a different area in different years. Such occasional shifts in rut location and group affiliation may account for the lack of genetic structure in woodland caribou across the intact landscapes of the Mackenzie Mountains (Zittlau 2004). Fidelity to breeding sites has been reported for some Boreal populations (Schaefer et al. 2000, Ferguson and Elkie 2004) but not others (Shoesmith and Storey 1977, Fuller and Keith 1981).

Female caribou in the Nahanni trans-border region exhibited their least fidelity to late-winter sites, which seemed to be influenced at a coarse scale by amount of snowfall. The depth and hardness of snow could mediate choices at various spatial scales both in terms of foraging efficiency and risk of predation (Gustine et al. 2006b). Several other studies of woodland caribou in western and eastern Canada also have recorded much weaker fidelity by woodland caribou to sites in late winter (Wood 1996, Schaefer et al. 2000, Ferguson and Elkie 2004). By contrast, the Little Rancheria caribou showed strong fidelity to its winter range near Watson Lake, Yukon (Florkiewicz et al. 2004). Caribou distribution in late winter may be determined more by selection of environmental *conditions* (depth and hardness of snow) rather than a specific site. Plasticity in site selection would likely enhance winter survivorship as conditions vary through time.

Finally, researchers reported that they could not simulate the seasonal distribution patterns of boreal caribou in a Manitoba field study using habitat preference alone but had to include home range fidelity in the model (Metsaranta and Babek 2006). They suggested that such traditional areas represented implicit refugia from predators.

Habitats

During the calving period, Coal River and La Biche caribou were located most frequently in open spruce forests near timberline and in rocky, alpine types. For the post-calving period during summer, they shifted more to alpine sites with low shrub and herb cover. During the rut, they occurred most often where alpine plateaus were juxtaposed close to subalpine basins with open forests or shrub types. Several studies in northern British Columbia (Bergerud et al. 1984, Cichowski 1993, Wood 1996, Poole et al. 2000, Gustine et al. 2006a), southwest Yukon (Oosenbrug and Theberge 1980), and western Alberta (Edmonds 1988) have reported similar patterns of habitat use.

During early winter, caribou were located in spruce forests at low-elevations or occasionally at higher elevations in years with lighter snowfall. By late winter, however, caribou usually were restricted to low-elevation spruce forests with shallower snow depth. Across the larger region, woodland caribou have over-wintered in windswept alpine sites (Cichowski 1993, Wood 1996), open stands of lodgepole pine (or mixed with spruce) at low elevations (Johnson et al. 2001, Florkiewicz et al. 2004), or in spruce-fir forests at intermediate elevations (Cichowski 1993, Poole et al. 2000). Gustine and Parker (In Press) have pointed out the considerable plasticity of woodland caribou in seasonal selection of resources.

3. SEASONAL MIGRATION ROUTES

Migration can be defined as "seasonal round-trip movements between discrete areas not used by that individual at other times of the year" (adapted from Berger 2004). The ecological impetus for migration in large herbivores is to: (1) exploit seasonally-available resources in separate locales, and/or (2) reduce the risk of predation by spacing away from predators (Sinclair 1983, Fryxell and Sinclair 1988, Alerstam et al. 2003). Migration is a common strategy that may be mixed with a residential strategy, which may reflect density-dependent responses to changing environmental conditions across space and time (Sinclair 1983, Hedenström 2003).

Several populations of barren-ground caribou are well-known for long-distance migrations up to 5000 km round-trip (e.g., Porcupine herd: Fancy et al. 1988). Woodland caribou also migrate, albeit over shorter distances (50-300 km) (e.g., Edmonds 1988). Although maintaining connectivity between summer and winter areas can be an important consideration for caribou conservation (especially in mountainous landscapes), it has received scant attention (Saher and Schmiegelow 2005).

Woodland caribou in the Nahanni trans-border region migrated from their late-winter range within Nahanni National Park Reserve westward across the Territorial border to summer ranges in southeast Yukon. In this chapter, I describe and map the routes that caribou followed in spring and fall migrations and assess the degree of individual fidelity to those routes. I also calculated one-way and round-trip distances for comparison with a global synthesis of long-distance migration in mammals (Berger 2004).

Methods

To discern the directional routes used by caribou in their seasonal migrations, I processed the location data in several steps. First, for each caribou, I plotted all locations beginning with its departure from late-winter range to arrival on its calving range ('spring migration') and – conversely – beginning with departure from its rut range (or pre-rut range, in some cases) to arrival

on late-winter range ('fall migration'). Next, I deleted extraneous locations that were irrelevant to determining the direction of movement (e.g., when the animal restricted its movements in a small locale for several days or even weeks which occurred mostly during 'fall' migration). Then, I repeated this procedure for that particular caribou in all subsequent years and mapped those locations. In many cases, locations from different years occurred along the same route and helped to delineate the route with more precision. In other cases, it revealed a different route taken by that individual in different years. In some cases, caribou moved rapidly and covered 30-60 km between available locations (5-10 days), and I did not feel as confident about inferring the exact route.

I assessed route fidelity of individual caribou by making pair-wise comparisons between routes taken in various years. If yearly locations occurred ≤10 km of each other at three separate (≥20 km apart) sections of a route, I considered that to indicate fidelity to the entire route. In practice, this pattern emerged when an individual followed a river valley (in spring) along the entire way. In some cases, caribou followed certain sections in different years but not the entire route. For example, this occurred when an animal followed a river valley to a major 'junction' and took a different river valley one year and ended at the same or different destination. In other cases, caribou did not exhibit fidelity for either the section or the route as they took a completely different path. Given this landscape pattern, I tabulated the outcomes categorically by R (*route* fidelity), S (*section* fidelity), or N (*no* fidelity).

In a set of Appendix maps, I have provided maps showing the locations by which I inferred the migration routes. Locations are coded by *color* to identify the individual caribou and by *symbol* to denote the year. This facilitated inspection of route fidelity by individual caribou. I denote the route with dashes to convey that – given the nature of the available data – these mapped routes represent an inferred but useful approximation. For the Coal River group which had the larger number of collared animals and the more complicated movement routes, I 'bundled' various sets of caribou who shared common starting sites and destinations, and often similar migration routes. Finally, I synthesized information from those Appendix maps (all individuals across all years) to derive the general migration maps shown below. On these maps, arrows indicate the location and direction of various routes used by the Coal River and La Biche groups during seasonal migrations. Appendix maps are available upon request to WCS Canada.

To estimate migration distances, I calculated one-way distances based upon the starting and ending locations as described above for spring and fall migrations. Because these caribou crossed over the Territorial divide into different watersheds, I made one calculation of the 'actual' route from the censored locations and another calculation based on a straight-line route. I summed the distances traveled in the 2 migrations of each year to obtain the round-trip distance. Rate of travel was simply the distance/number of days.

Results

Spring and Fall Migration Routes of Coal River and La Biche Groups

Coal River Group

Caribou usually left their late-winter range around the middle of April to begin spring migration. During this spring migration, caribou typically traveled quickly and with strong directionality toward their calving areas.

Coal River caribou proceeded westward from their late-winter range in Nahanni National Park Reserve via a variety of routes and 'junctions' (Figure 19). One route followed the Flat River westward past the Cascade of 13 Steps to the confluence of Borden Creek (south of Seaplane Lake) where the valley broadens. An alternative route brought animals to the same site by coming southwest up the Caribou River, turning northwest past Clark Lake and McMillan Lake (where caribou wintered in some years), and over to the confluence area. This seemed to be a junction where (a) most animals followed Borden Creek to the southwest and crossed the Territorial divide north of Caribou Pass, thereby skirting the south end of the rugged Ragged Range, or (b) some animals continued for a considerable distance up the Flat River before crossing a more rugged section of the divide through a minor pass to reach a summer site at the headwaters of the Hyland River.

For animals that moved up the Caribou River, another junction occurred at the confluence of Diamond Creek (out of Clark Lake) and Canyon Creek with Caribou River. Instead of turning up the Clark Lake valley, some caribou continued southwest up along the north side of the Caribou River, past the south end of an isolated mountain mass, and crossed the Territorial divide on the south side of Caribou Pass. Some caribou that started from the south end of the core winter range moved south up May Creek and the middle section of Meilleur River, and then turned west to the upper reaches of Caribou River and Caribou Pass.

It's important to note that nearly all of these various routes converged at the Territorial divide in the vicinity of Caribou Pass. The southern terminus of the Ragged Range buttressed the north end of this crossing, whereas the head of the Caribou River appeared to mark the south end.

On the Yukon side of the divide, migration routes diverged again (Figure 19). One route led north up the main Coal River valley to traditional calving and summer sites around Mount Laporte and in the alpine plateaus and mountains at the headwaters of the Coal River. Another route continued west from Caribou Pass, then proceeded northwest up the West Coal River valley past its headwaters and on into the upper reaches of the Hyland River basin. At the upper end of the West Coal River valley, some animals turned west to cross the Nahanni Range road in the vicinity of Conglomerate Creek. Others proceeded further north before turning west to cross the road near Flood Creek, south of the Hyland airstrip. (I provide more detail on road crossings in a later section.) Lastly, another route led westward from the south end of the Caribou Pass to traditional calving and summer sites in the lower Hyland River valley and Thunder Mountain.

Coal River caribou typically began their autumn migration by mid-October. Some animals had already moved 10-20 km from their summer range in mid-September to another area to begin rutting later that month. Others remained on or close to summer sites for rutting, then began the fall migration in earnest.

On the Yukon side, caribou moved eastward on the return trip following some of the same general routes used during spring migration (Figure 20). They did not appear to be as restricted by snow at this time, however, and traveled more across the higher country rather than along the valley bottoms. Caribou that summered on the west side of the Hyland River crossed the Nahanni Range road in the fall again near Conglomerate Creek but more often further south around Jackpine Creek and Dolly Varden Creek. These animals moved directly eastward, across the broad valley above the confluence of the two main branches of the Coal River, and on toward the north side of Caribou Pass. Caribou that spent the rut around Thunder Mountain returned eastward along the same general route used in the spring to cross the divide south of Caribou Pass. As in spring, these return routes converged in the vicinity of Caribou Pass.

On the Northwest Territories side, caribou using the more northerly route would cut across Borden Creek and proceed more directly eastward to the McMillan Lake area, rather than following the Flat River as they did in the spring. In some years, these caribou would linger for weeks in the McMillan Lake area during early winter. Later, these animals would move northeasterly to spend late winter along the lower Flat River inside Nahanni National Park Reserve.

Other caribou traveled eastward across the U-bend in the upper Caribou River and then along the more subdued section of the Territorial divide over to the Lookout Mountain/Spruce Lake area. Some moved eastward at slightly lower elevations across the upper branches of the Meilleur River, some going as far east as the headwaters of the La Biche River. There, they overlapped with members of the La Biche group. The Coal River caribou would then 'double-back' westward to the upper Meilleur River area. In most years, these caribou seemed to wander around the large area of boreal forest between the Meilleur River and Marten Creek during late fall and early winter. By late January, though, they typically resumed a more directional movement north toward Nahanni National Park Reserve. They traveled across the forested plateaus at moderate elevations, rather than following the river courses as they did during the spring migration. Hence, their movement routes through this terrain were less narrowly defined. By February, they would finally reach their late-winter range inside Nahanni National Park Reserve. In this spasmodic manner of migration, Coal River caribou completed their yearly round.

La Biche Group

In spring, the La Biche group of caribou proceeded straight south from their late-winter range in Nahanni National Park Reserve to their calving and summer sites on the Yukon side of the Territorial divide (Figure 21). Initially, these caribou moved south up May Creek and through a low, forested divide into the middle section of the Meilleur River valley. Here, three major branches of

the Meilleur River come together that drain a large basin of boreal forest, and caribou movements appeared to diverge at this point into two or three routes. Because the streams are rather incised in this area, caribou likely moved along gradual slopes and low ridges up to the Territorial divide. There, caribou moved to their calving and summer sites along the divide and just inside the Yukon border.

After the rut, La Biche caribou remained along the Territorial divide through fall and sometimes early winter. In years with heavier snowfall, they would leave the divide in December and begin migrating north. Sometimes, they would linger in the upper Meilleur River basin for a couple of weeks in early January before resuming their migration. On this return trip, La Biche caribou picked routes along the forested plateaus flanking either side of the Meilleur and Mary Rivers (Figure 22), rather than tracking through the middle of the valley as during the spring migration. These routes would converge in the lower Mary River inside Nahanni National Park Reserve where the La Biche group would usually arrive by early February to complete their yearly round.

Fidelity to Migration Routes

Caribou in the Nahanni trans-border region exhibited a stronger degree of fidelity to the entire route during spring migration compared to fall migration (Table 10). In spring, 12 (80%) of 15 individuals used the same entire route in 2 or more years; in 35 cases, they appeared to follow the entire route (54%) or at least a certain section (26%). In fall, 5 (36%) of 14 individuals used the same entire route in 2 or more years; in 34 cases, they followed the entire route (24%) or at least a certain section (41%).

Table 10. Categorical scale of fidelity by caribou of the Coal River and La Biche Groups during spring and fall migration, Nahanni trans-border region, Yukon Territory and Northwest Territories, 2000-2007.

Season/Category	Coal River	La Biche	Total
Spring			
Entire Route	16	3	19
Section	7	2	9
None	6	1	7
Fall			
Entire Route	8	0	8
Section	12	2	14
None	10	2	12

Migration Distances

In spring, members of the Coal River group migrated an average of 168 km (longest 253 km) along actual routes at an average travel rate of 4.7 km/day. La Biche caribou migrated an average of 95 km (longest 121 km) at an average rate of 3.7 km/day (Table 11).

In fall, Coal River caribou migrated an average of 221 km (longest 327 km), whereas caribou from the La Biche group traveled an average of 89 km (longest 115 km) (Table 12).

On average, Coal River caribou made a round-trip of 392 km (longest 551 km) during their migrations, whereas the La Biche caribou traveled an average of 178 km (longest 211 km) in their round-trips (Table 13).

Table 11. Mean (± SD) and maximum distance (km) and travel rate (km/day) of spring migration by caribou of the Coal River and La Biche groups, Nahanni trans-border region, Yukon Territory and Northwest Territories, 2000-2007.

Migration Metric	Coal River (n=14)			La Biche (n=4)		
	× (± SD)	Max	Rate	× (± SD)	Max	Rate
Actual Route	168 (39.8)	253	4.7 (1.1)	95 (13.5)	121	3.7 (1.0)
Straight-Line	135 (33.1)	187	3.8 (1.1)	81 (12.4)	102	3.1 (1.0)

Table 12. Mean (± SD) and maximum distance (km) traveled during fall migration by caribou of the Coal River and La Biche groups, Nahanni trans-border region, Yukon Territory and Northwest Territories, 2000-2007.

Migration Metric	Coal River (n=11)		La Biche (n=4)	
	× (± SD)	Max	× (± SD)	max
Actual Route	221 (51.1)	327	89 (15.0)	115
Straight-Line	141 (25.9)	190	73 (15.8)	89

Table 13. Mean (± SD) and maximum distance (km) of round-trip migration by caribou of the Coal River and La Biche groups, Nahanni trans-border region, Yukon Territory and Northwest Territories, 2000-2007.

Migration Metric	Coal River (n=11)		La Biche (n=4)	
	× (± SD)	Max	× (± SD)	max
Actual Route	392 (96.3)	551	178 (27.8)	211
Straight-Line	274 (55.8)	365	151 (29.3)	182

Figure 19. Spring migration routes of the Coal River caribou, Northwest Territories and Yukon Territory, 2001-2007.

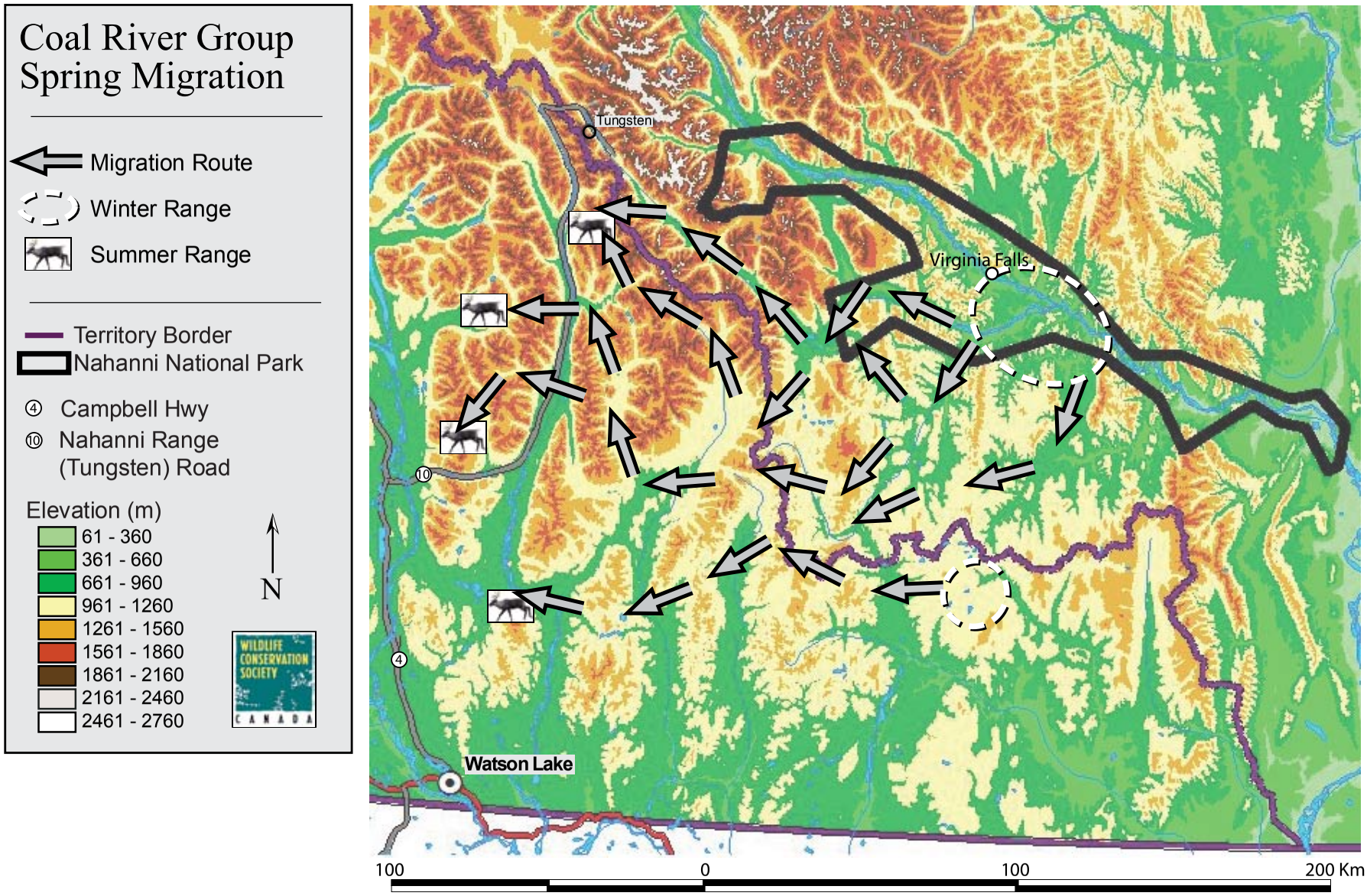


Figure 20. Fall migration routes of the Coal River caribou, Northwest Territories and Yukon Territory, 2001-2007.

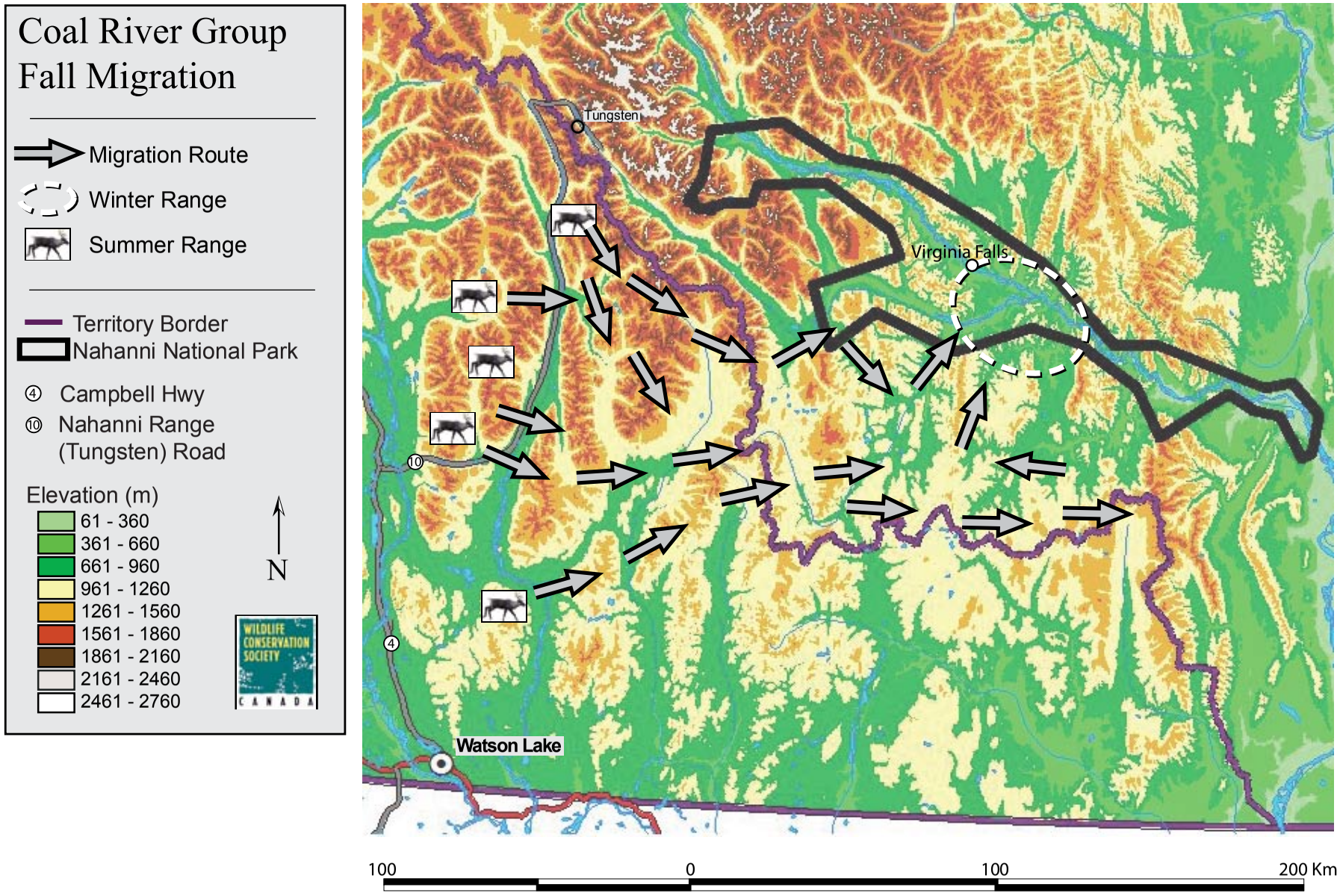


Figure 21. Spring migration routes of the La Biche caribou, Northwest Territories and Yukon Territory, 2002-2007.

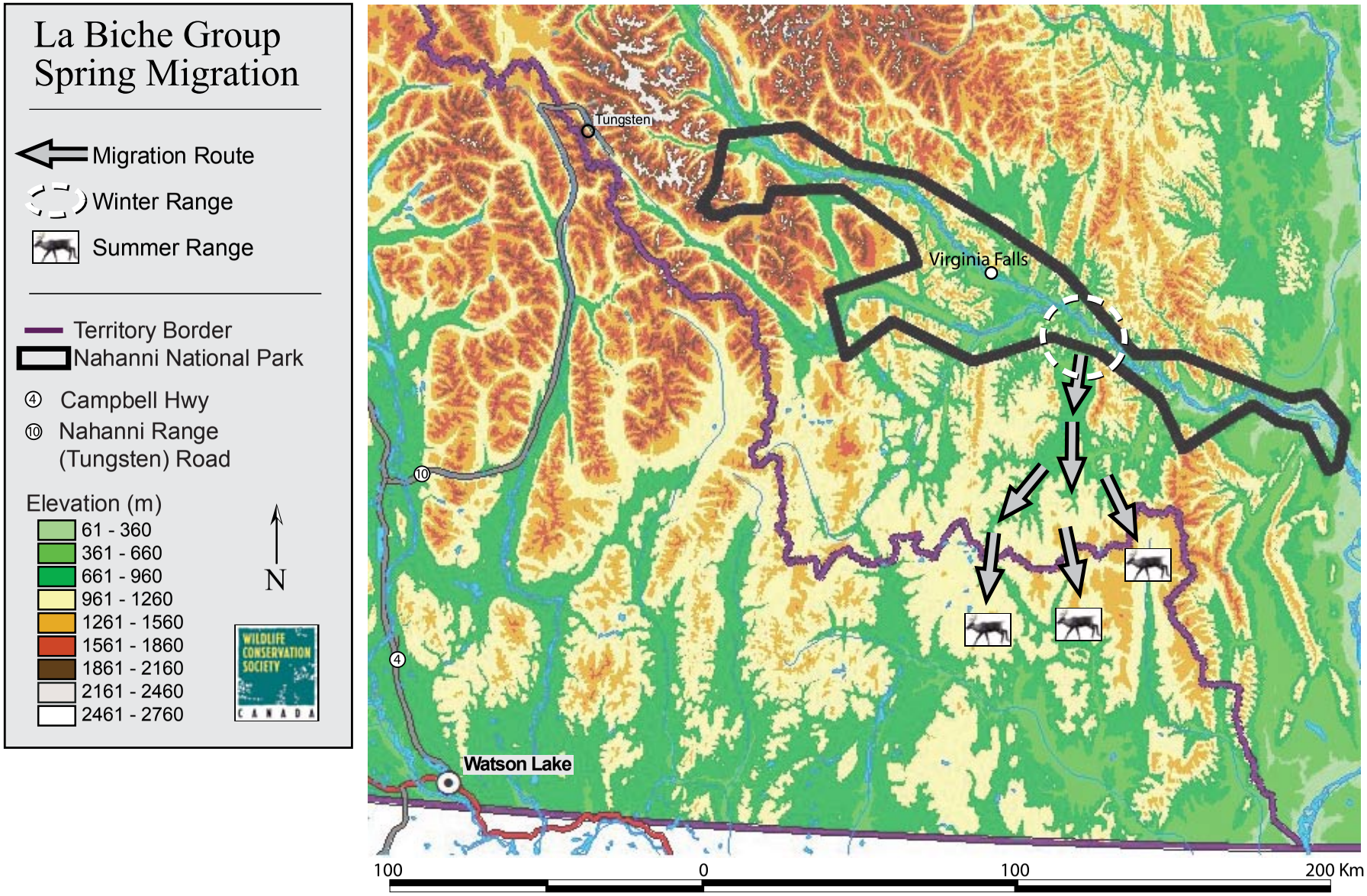
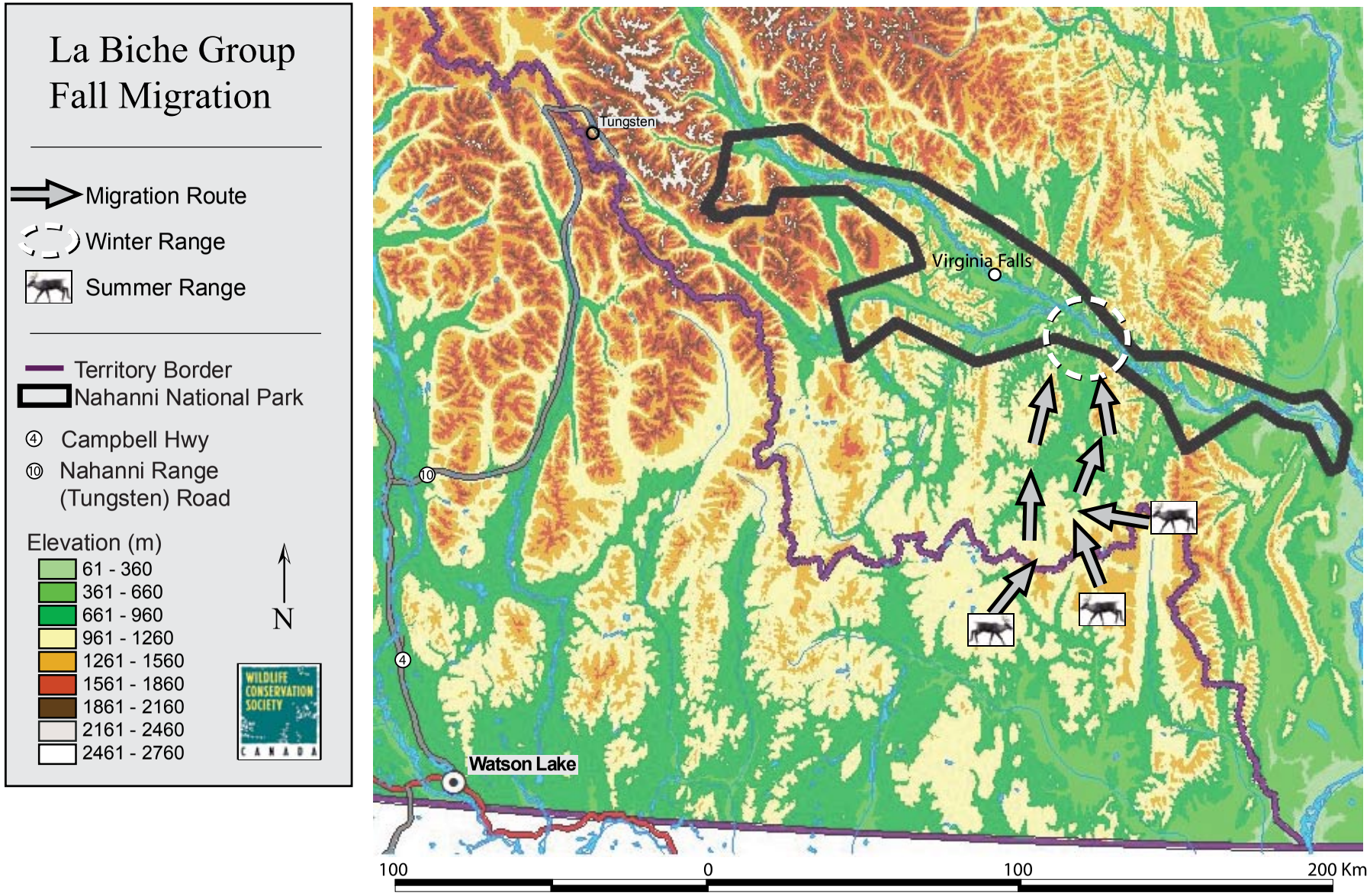


Figure 22. Fall migration routes of the La Biche caribou, Northwest Territories and Yukon Territory, 2002-2007.



Crossing of the Nahanni Range Road

The Nahanni Range road (Yukon Hwy 10) is a gravel road built in the early 1960s for access to the mining site of Tungsten (or Cantung). When the mine is operational, workers use the road; otherwise, it receives light traffic except during the fall hunting season. Several radio-collared members of the Coal River caribou group crossed the Nahanni Range road in spring and fall. Because this road provides the only highway (gravel) access anywhere in the trans-border range of these caribou, I present data here on the timing and location of caribou crossings. For these individuals, I have mapped pairs of locations that straddle the road (Figures 23a - 23b). I coded locations by *color* to identify the individual caribou and by *symbol* to denote the year. In many cases, the coarse time interval between data collection (5 days) and rapid movements did not enable precise delineation of crossing sites. Nonetheless, some useful insights can be gleaned, especially where some locations were close to the road. Additional observations of caribou/ caribou tracks by district Conservation Officers over the past 20 years supplemented the telemetry information (data courtesy of M. Brodhagen, Yukon Department of Environment).

In spring, caribou crossed the Nahanni Range road usually during late May (mean date = May 27, median date = May 24, range May 16 – June 14). Most crossings likely occurred between Jackpine Creek and near Flood Creek; several occurred near Conglomerate Creek (Figure 23a). Along the road near Flood Creek and above the confluence of the Little Hyland and Hyland Rivers, Conservation Officers have noted caribou tracks throughout spring, summer and fall in proximity to mineral licks (M. Brodhagen, *personal communication*).

In fall, caribou crossed the Nahanni Range road usually during early October (mean date = Oct 10, median date = Oct 7, range Sep 1 – Nov 13). Most crossings likely occurred between near Dolly Varden Creek and Spruce Creek; several occurred again near Conglomerate Creek (Map 23b). Conservation Officers have noted caribou tracks across the road in these areas in the fall, as well as further west below Dolly Varden Creek (M. Brodhagen, *personal communication*).

In terms of fidelity to crossing sites, individual animals appeared to cross the road in the fall within 2-20 km of sites in the previous spring. Both telemetry and track observations by Conservation Officers indicate that caribou crossed the road further north in the spring, perhaps drawn by mineral licks in those areas. Between years, individual animals appeared to cross within 10-20 km of sites where they crossed in previous years. In conclusion, the section of the Nahanni Range road between Dolly Varden Creek and Conglomerate Creek has been especially important for seasonal crossings by female caribou of the Coal River group.

Figure 23a. Caribou crossings of Nahanni Range road during spring, Yukon Territory, 2002-2007.

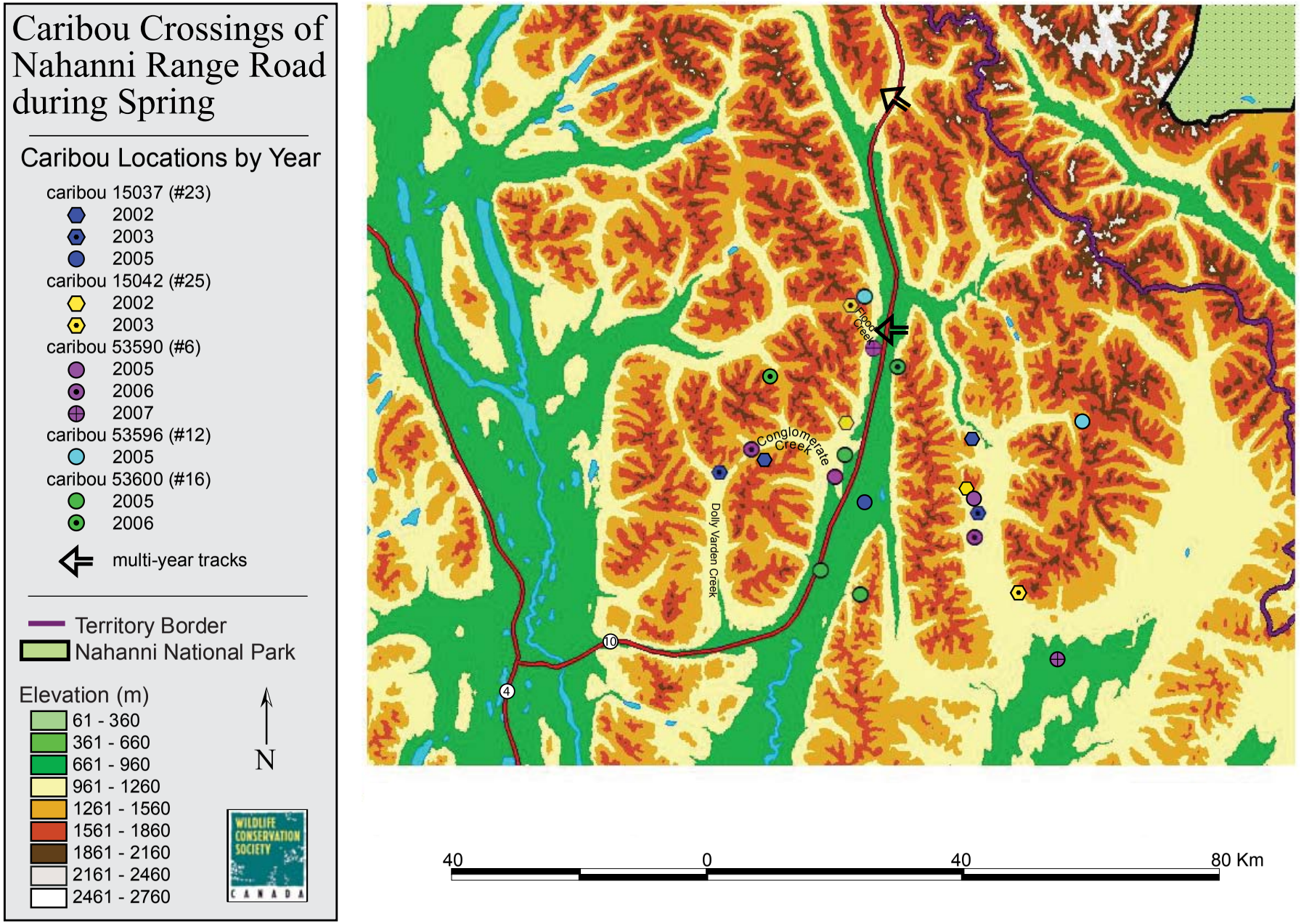
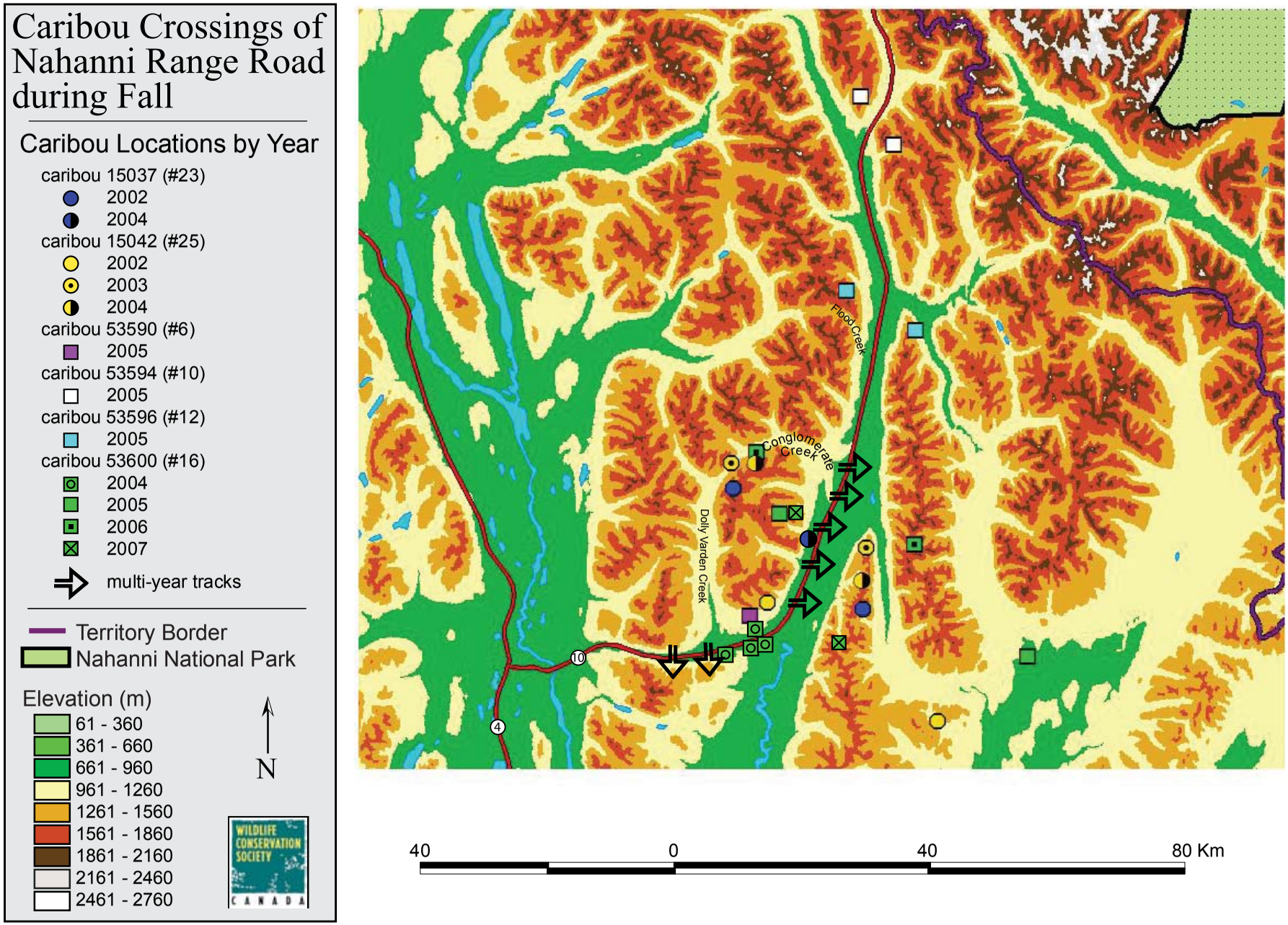


Figure 23b. Caribou crossings of Nahanni Range road during fall, Yukon Territory, 2002-2007.



Discussion

Route Selection

The pattern of caribou migrations in the Nahanni trans-border region varied slightly between groups and by season. In spring, members of the Coal River group used 4-5 primary routes on the Nahanni side as they moved westward from their late-winter range. All but one of these routes broadly converged at the Territorial divide in the vicinity of Caribou Pass. Once across the divide, Coal River caribou used 3-4 primary routes in the Yukon to reach their calving areas. Upon their departure from late-winter range, La Biche caribou followed a single, primary route south up May Creek and middle Meilleur River valley, then split into three routes as they approached the Territorial divide. Saher and Schmiegelow (2005) noted variation between caribou in route selection during spring migration as some animals branched off to go around mountains or connect to other drainages.

During spring migration, caribou in the mountain landscape of the Nahanni trans-border region proceeded directly and rapidly (4-5 km/day) along the main river valleys and/or adjacent benches. By choosing such routes, caribou avoided rugged terrain and deeper snow at higher elevations. Presumably, this allowed them to expend less energy in their movements, which is consistent with the notion of traveling the path of least resistance (Hedenström 2003). Moreover, moose were common in some of these valleys; perhaps caribou were migrating quickly and steadily to minimize time spent in likely travel zones for wolves (Huggard 1993). Saher and Schmiegelow (2005) also found that caribou in a mountainous landscape followed along major river valleys during spring migration.

After the rut in fall, caribou of the Coal River group moved relatively quickly out of the rugged mountains eastward toward the Territorial border. At this time, they traveled more across higher terrain rather than strictly along the river valleys. They used four primary routes on the return trip but did not appear to follow the same exact pathways as during spring. Nonetheless, these return routes again converged at the Territorial divide in the vicinity of Caribou Pass. Once across the divide into the Nahanni country, members of the Coal River group would meander across the vast boreal forest there; after a few weeks, they would resume some directional movement toward Nahanni National Park Reserve. After the rut, the La Biche caribou would remain along the Territorial divide or slightly north on the Nahanni side. In years with moderate to deep snow, they would begin migrating in January and move directly along upland slopes to their late-winter range in the Park.

Route Fidelity

Only a few published studies have reported on caribou fidelity to seasonal migration routes. In an earlier study of caribou using the upper portion of the South Nahanni River watershed, the only caribou with a satellite radio-collar (#22120) appeared to follow the same migration route along the river corridor during both spring (2 consecutive years) and fall migration (3 consecutive years) (Weaver 2006). For caribou in the mountains of west-central Alberta north of

Jasper National Park, Edmonds (1988:819) stated that "based on radio locations [VHF] and visual sightings, routes of seasonal movements were similar each year." In a 2-year study, Saher and Schmiegelow (2005:145) noted that 2 caribou "tended to use the same route" in both years.

Migration Distances

Caribou in the Nahanni trans-border region migrated longer distances than reported in any other published study of movements by woodland caribou. Other studies have measured length of seasonal migrations as straight-line distances, which is a reasonable approximation when movements do not involve major 'dog-legs'. To facilitate comparisons of migration distance across studies, I use straight-line distance as the common metric. I would note, however, that the migration routes used by the Coal River caribou did have a major turn in direction, which caused straight-line measures to be 20-40% shorter than actual route on the ground.

Length of spring migration averaged 135 km (187 km max) for Coal River caribou and 81 km (102 km max) for La Biche caribou in this study. A female caribou from another group in the upper South Nahanni River country likely averaged approximately 123 km (128 km max) (Weaver 2006). Caribou in northern BC averaged 68 km (84 km max) (measured from maps in Farnell and McDonald 1990) and 58 km (88 km maximum) (Wood 1996). In two areas along the border of west-central Alberta and east-central British Columbia, caribou averaged 87 km (150 km max) (Edmonds 1988) and 73 km (119 km max) (Saher and Schmiegelow 2005).

For female caribou in the Coal River group, I recorded an average round-trip distance (actual route) of 392 km (straight line = 274 km), with a maximum distance of 551 km (straight line = 365 km). The only reported migrations that match or exceed round-trip distances traveled by the Coal River animals are those of barren-ground caribou in northern Alaska and Canada and a few populations of antelope species in grasslands of Africa, Mongolia, and Wyoming (Berger 2004). Long-distance migrations represent an ecological phenomenon and legacy that is at risk in the modern world due to the expanding 'wheelprint' of humans (Berger 2004).

4. CONSERVING LANDSCAPES FOR CARIBOU

A Trans-Border Conservation Area for Caribou

Recent studies across Canada have underscored the vulnerability of woodland caribou populations to human activities that (1) result in the direct loss and fragmentation of habitat, and (2) lead to excessive mortality (especially of adult females) from predation due to greater abundance of moose and wolves and/or from over-hunting, poaching, and vehicular collisions (McLoughlin et al. 2003, Apps and McLellan 2006, Courtois et al. 2007, Vors et al. 2007, Wittmer et al. 2007).

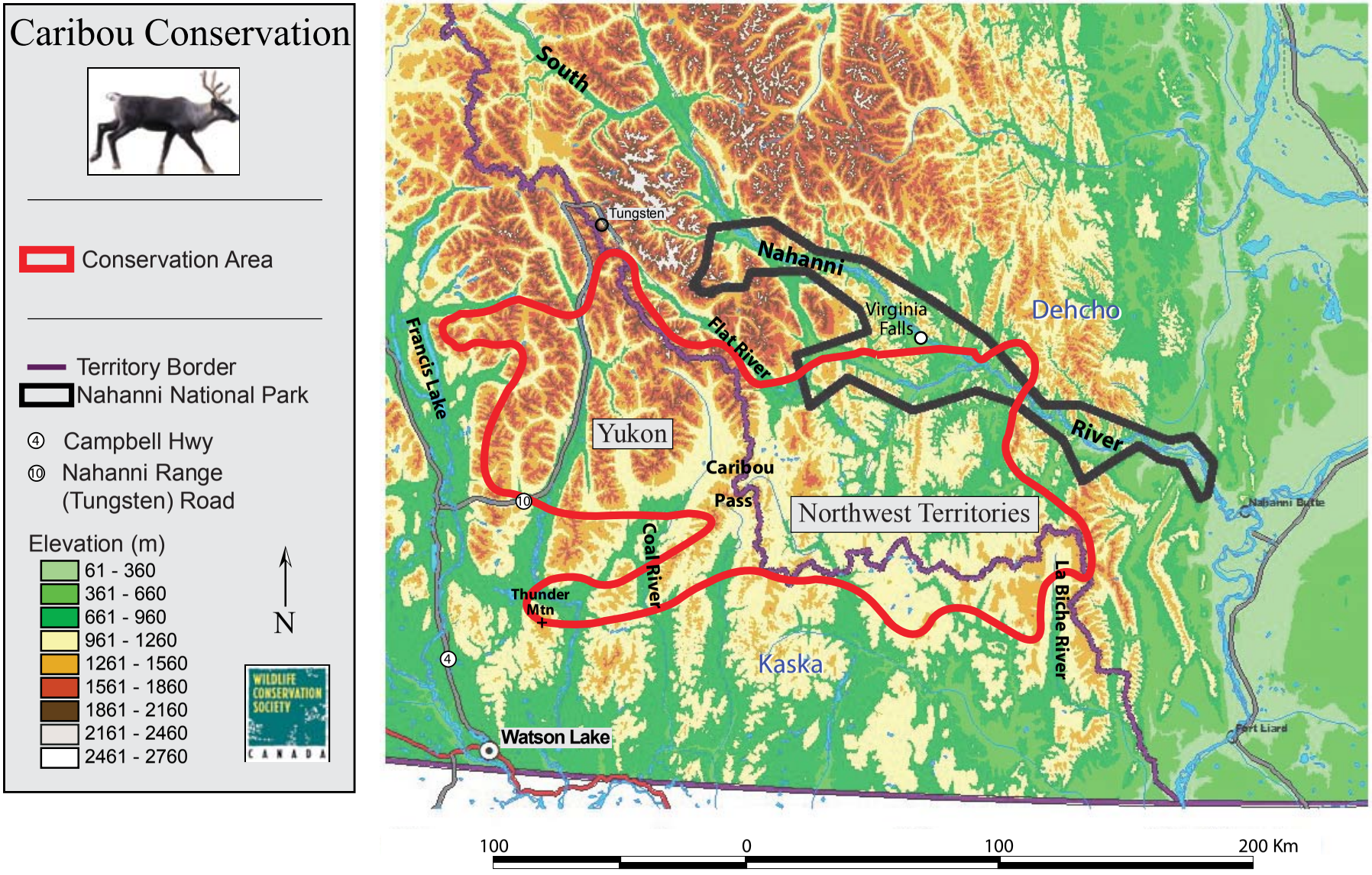
A common strategy among managers of precious assets is to minimize risk by providing secure havens or refugia. Indeed, the powerful role of refugia in population persistence has emerged as one of the most robust concepts in modern ecology (Fahrig 1988). Both the historical record and empirical studies attest to the need by caribou for refugia from pervasive human activities (Seip and Cichowski 1996, Vors et al. 2007, Courtois et al. 2007). Hence, large intact landscapes where caribou can move widely to select seasonal ranges and minimize contact with predators appear crucial for their long-term persistence.

Incorporating spatial information about species distribution and movements is essential to effective conservation planning for vulnerable species like woodland caribou (Abbitt et al. 2000). In earlier chapters, I mapped and described the seasonal ranges and migration routes of caribou in the trans-border region and documented their strong fidelity to certain locales (especially for calving and summer) and routes. Here, I have synthesized that information to map a trans-border caribou conservation area (Figure 24). This caribou conservation area includes the core area of seasonal ranges and migration routes that received traditional use by caribou of the Coal River and La Biche groups during the period 2000-2007.

Expansion of Nahanni National Park Reserve

Under the Canada National Parks Act, Parks Canada has mandated responsibility for ensuring the ecological integrity of national parks. Clearly, Nahanni National Park Reserve is too small and too narrow to provide for wide-ranging

Figure 24. Caribou conservation area for the Nahanni trans-border region, Northwest Territories and Yukon Territory



caribou. Over the past few years, Parks Canada has undertaken a thoughtful and public process to determine new boundaries for Nahanni National Park (Reserve) that would enable the Park to better meet its legislative charge for ecological integrity.

In an earlier report, I recommended new boundaries for Nahanni National Park Reserve that would encompass the range of various caribou groups within the South Nahanni River watershed (Weaver 2006). Parks Canada developed initial options that included much of the South Nahanni River watershed within the Dehcho territory (Parks Canada 2007). Each of the initial options for boundary expansion, however, excluded areas of variable sizes in the headwaters of the upper Caribou River near the Territorial border (labeled as the 'Selena Creek mining area').

Findings of this present report demonstrate even more clearly the vital importance of that area. Nearly all of the migration routes used by the Coal River group during spring and fall converge along the Territorial divide both north and south of Caribou Pass (see Figures 19-20 for migration routes, Figure 24 for location of Caribou Pass). In addition, some of the larger exclusions would impinge upon areas used by caribou from fall through the late-winter period (Figure 5). Intensive development in the upper Caribou River basin ('Selena Creek mining area') could sever crucial connectivity between areas used for calving, post-calving, and breeding in the Yukon and winter ranges in Nahanni. Moreover, any roads would 'open up' a large area subject to human access because potential mining lies near the center of a remote region; consequently, penetration by new roads could have disproportionately large, negative effects.

Based upon this continuing caribou research and public consultation, Parks Canada recently made a final recommendation on Park boundaries that would include all of the upper Caribou River. The scientific findings presented here in this report amply substantiate the soundness of that final recommendation. Any outstanding mineral claims, however, should be resolved to ensure full protection of this area.

Conservation of Caribou Landscapes in Southeast Yukon

Virtually all of the calving, post-calving, and breeding areas and several migration routes of the Coal River and La Biche caribou groups occurred on the Yukon side of the trans-border region in Kaska territory. Caribou exhibited strong fidelity to spring migration routes and summer sites on alpine plateaus and sub-alpine basins. Maintaining the functional integrity of these traditional sites and routes is important because displacement could impact caribou populations. Hence, it is essential to incorporate the findings from this report into regional land planning, especially in terms of managing roads and human access. Conserving wide-ranging wildlife species like caribou in a trans-border context can be challenging in practice (e.g., Schmiegelow 2006). Conservation of woodland caribou in this trans-border region will require a high level of inter-jurisdictional communication, collaboration and commitment.

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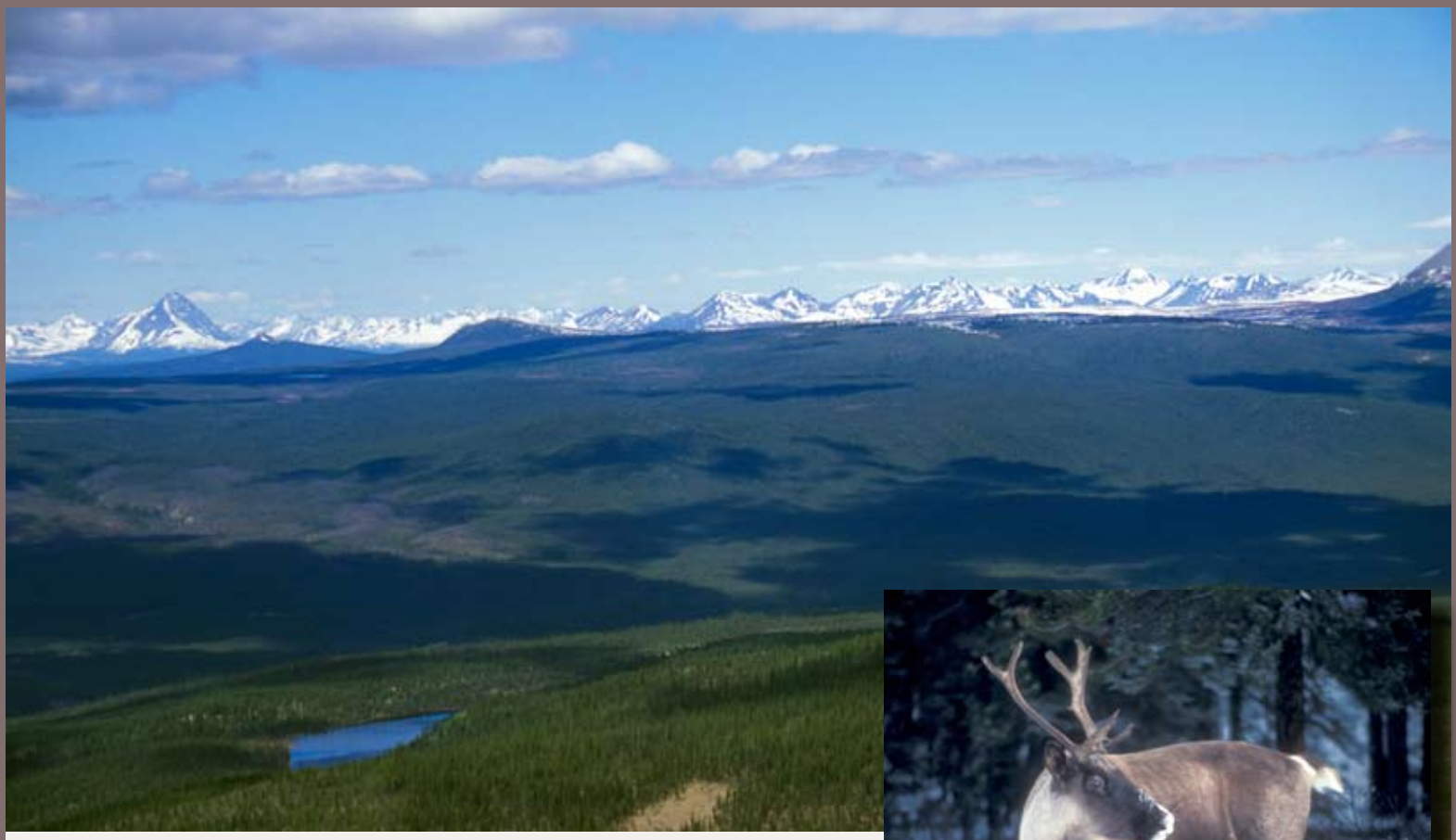

Across a remote region along the NWT-Yukon border roams one of the most iconic but vulnerable wildlife species in Canada: the woodland caribou. These caribou spend late winter in boreal forests inside the narrow boundaries of Nahanni National Park Reserve. In spring, they migrate 90 - 240 km westward across the Territorial divide to alpine plateaus in the mountains of southeast Yukon. There, they birth their calves, spend the summer, and breed in the fall before migrating back to the Nahanni country.

Many of these caribou return to the same seasonal places each year via the same migration routes. This 'fidelity' — tendency to return to the same place each year — underscores the importance of such places for conservation of caribou landscapes.

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