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Department of Environment
Avatiliqiyikkut
Ministère de l'Environnement

SPATIAL AND TEMPORAL PATTERNS OF WOLF HARVEST IN RELATION TO CARIBOU HERD MOVEMENTS IN NUNAVUT

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Summary

Enhanced wolf (*Canis lupus*) management actions are often employed to support recovery of declining caribou (*Rangifer tarandus*) herds. Most herds of migratory tundra caribou (*R. t. groenlandicus*) in Nunavut and adjacent Northwest Territories (NWT) are either in decline or at historically low population levels. Beginning in 2018-19 in the Kitikmeot Region and expanding to all of Nunavut in 2019-20, the Government of Nunavut (GN) Department of Environment (ENV) offered compensation through the Support for Active Harvesters program to local hunters to harvest wolves and provide sample and location data. We examined wolf harvest data from 1,500 wolves killed by hunters within Nunavut between 2018-19 and 2020-21 to describe the spatial and temporal patterns of the Nunavut wolf harvest in relation to caribou densities based on collared individuals. We examined the age and sex structure of the wolf harvest, and the spatial and temporal clustering of the harvest (i.e., whether hunting is effective at removing entire packs). We also provided rough estimates of the number of wolves associated with the Qamanirjuaq caribou herd and of the proportion of these wolves harvested by Nunavut hunters.

During 2018-19, 146 wolves were recorded harvested by 52 hunters within the Kitikmeot, primarily by hunters from Kugluktuk. Harvest numbers peaked in December and February–May, with a high proportion of the harvest during October–December comprised of juveniles and a wider distribution of ages harvested as the season progressed.

During 2019-20, 658 wolves were recorded harvested across Nunavut, with 64% of the harvest from Arviat, Baker Lake and Kugluktuk hunters. Harvest peaked in November and March–May. During 2020-21, 699 wolves were recorded harvested, with 68% of the harvest from Arviat, Baker Lake and Kugluktuk hunters. In both years, the proportion of juveniles in the harvest declined over time and a relatively small number of hunters contributed a large portion of the harvest. Nearly all (99%) of the wolves were shot and the remainder were trapped.

Although patterns differed among communities, wolves were generally harvested closer to communities prior to Christmas (generally within 75 km) and further from communities later in the winter, with peak distances in April and May (up to 500 km). Thus, even though the hunters were far from their communities, necessitating camping over day-trips, they were effective at harvesting larger numbers of wolves. Arviat hunters harvested wolves over a broad distance later in the winter, including over 450 km from the hamlet in 2019-20, but the distribution of harvest was higher closer to higher densities of caribou. The distribution of high densities of Qamanirjuaq caribou and hence the wolf harvest differed between years. The proportion of packs harvested differed among communities and generally decreased as pack size increased and increased as the season progressed.

Rough estimates of the number of wolves associated with the Qamanirjuaq caribou herd suggest that hunters annually removed approximately 12–25% of the wolves associated with the late winter and spring movements of the Qamanirjuaq herd. Estimates of wolf numbers and proportion of wolves harvested are based on assumed rather than observed relationships between caribou and wolf numbers and therefore should be interpreted very cautiously. More work is required to better estimate how many wolves may be associated with the migratory herds, especially the Qamanirjuaq herd, during winter and spring, but given high harvests of wolves south and southwest of Arviat during March, April and May, it is likely that

numbers of wolves and wolf-killed caribou are greatly reduced as the herd migrates to their calving grounds west of the coast of Hudson Bay, resulting in low numbers of wolves and reduced wolf predation on the calving and early post-calving grounds.

Wolf harvesting is a traditional part of the culture of Nunavut hunters, as well as a source of seasonal income. The effectiveness of Nunavut wolf hunters appears high, with large annual harvests from some communities, especially Arviat, Baker Lake and Kugluktuk. Nunavut wolf hunters appear able to target older and presumably potentially breeding portions of the population later in the winter after most natural losses would have occurred, increasing the additive impacts of these ground-based harvest efforts. In some areas wolf harvest during spring migration result in low numbers of wolves and reduced wolf predation on the calving and post-calving grounds. Since wolf populations can quickly rebound when treatment is removed due to immigration from surrounding areas and high reproductive rates, the incentive program should be continued.

ᐃᓂᒦᖃᑦᑕᕐᓂᖏᓐᓄᑦ ᐊᒻᒪᓗ ᖃᓄᑎᒋ ᐊᑯᓂᐅᑎᒋᓂᖏᓐᓄᑦ ᖃᓄᐃᓕᐅᖅᐸᓪᓕᐊᓃᑦ ᐊᒪᕈᖅᑕᐅᔪᑦ ᐱᔾᔪᑎᖃᖅᑐᑦ ᑐᒃᑐᐃᑦ ᐊᒥᕐᕋᐃᑦ ᐊᐅᓪᓚᓐᓂᖏᓐᓂᒃ ᓄᓇᕗᒻᒥᑦ

ᐊᐅᓚᑦᑎᔨᓂᖖᓘᖅᑐᑦ ᓇᐃᓈᖅᓯᔪᑦ

ᐱᐅᓯᒋᐊᖅᓯᒪᔪᖅ ᐊᒪᖅᖁᓂᒃ (*Canis lupus*) ᐊᐅᓚᑦᑎᓃᑦ ᖃᓄᐃᓕᐅᕈᑕᐅᔪᑦ ᐃᑲᔪᕐᓂᐊᕐᓗᒋᑦ ᐊᒥᓲᔪᖕᓃᖅᐸᓪᓕᐊᓂᖏᑦ ᐅᑎᖅᑎᑦᑐᒪᑉᓗᒋᑦ ᑕᒃᑐᐃᑦ (*Rangifer tarandus*) ᐊᒥᕐᕋᐃᑦ. ᑕᒪᓗᒃᑖᕐᓚᒃ ᐊᒥᕐᕋᐃᑦ ᐅᑎᖅᑕᖃᑦᑕᖅᑐᑦ (*R. t. groenlandicus*) ᓄᓇᒧᑦ ᓄᓇᕗᒻᒥᑦ ᐊᒻᒪᓗ ᖃᓂᑖᓂᑦ ᓄᓇᑦᑎᐊᕐᒥᑦ ᐊᒥᓲᔪᖕᓃᖅᐸᓪᓕᐊᔪᑦ ᐅᕝᕙᓘᓐᓃᑦ ᑕᐃᒪᙵᓂᒥᑦ ᐊᒥᓲᑎᒋᓂᖏᑦ ᐊᑦᑎᓛᖑᓯᒪᓕᖅᑐᑦ. ᐱᒋᐊᓵᖅᑎᓪᓗᒍ 2018-19 ᕿᑎᕐᒥᐅᓂᑦ ᐊᒻᒪᓗ ᑎᑭᐅᑎᕙᓪᓕᐊᑉᓗᓂ ᓄᓇᕗᒃᑖᕐᒧᑦ 2019-20-ᒥᑦ, ᓄᓇᕗᒻᒥ ᒐᕙᒪᒃᑯᑦ ᐊᕙᑎᓕᕆᔨᒃᑯᖏᑦ ᐅᑎᖅᑎᑦᑎᖃᑦᑕᕈᒪᓕᓕᓚᐅᖅᑐᑦ ᐃᑲᔪᕐᓗᒍ ᒪᖃᐃᖃᑦᑕᖅᑐᓄᑦ ᑐᕌᖓᔪᒥᒃ ᓄᓇᓕᖕᒥᐅᑕᐃᑦ ᒪᖃᐃᑏᑦ ᐊᒪᕈᕌᖓᑕ ᐊᒻᒪᓗ ᑐᓂᓯᓗᑎᒃ ᐆᒃᑐᕋᓚᒃᓴᒥᒃ ᓲᕐᓗ ᓂᕿᖓᓂᑦ ᐊᒪᕉᑉ ᐊᒻᒪᓗ ᓈᓴᐅᑎᓂᒃ/ᑎᑎᖅᖃᓂᒃ. ᕿᒥᕐᕈᓚᐅᖅᑕᕗᑦ ᐊᒪᕈᖅᑕᐅᓯᒪᔪᓂᑦ ᓈᓴᐅᑏᑦ/ᑎᑎᖅᖃᐃᑦ 1,500-ᖑᔪᓂᑦ ᐊᒪᕈᐃᑦ ᑐᖁᑕᐅᔪᓂᒃ ᒪᖃᐃᑎᓄᑦ ᓄᓇᕗᒻᒥᑦ ᐊᑯᓐᓂᖓᓂᑦ 2018-29 ᐊᒻᒪᓗ 2020-21 ᐅᖃᐅᓯᕆᓂᐊᕐᓗᒋᑦ ᐃᓂᒦᖃᑦᑕᕐᓂᖏᓐᓄᑦ ᐊᒻᒪᓗ ᖃᓄᑎᒋ ᐊᑯᓂᐅᑎᒋᓂᖏᓐᓄᑦ ᖃᓄᐃᓕᐅᖅᐸᓪᓕᐊᓃᑦ ᓄᓇᕗᒻᒥ ᐊᒪᕈᖅᓯᐅᖅᑎᓂᑦ ᐱᔾᔪᑎᖃᖅᑐᓂᒃ ᑐᒃᑐᐃᑦ ᐊᒥᓲᑎᒋᓂᖏᓐᓄᑦ ᐊᑐᖅᓱᒥᑦ ᖁᖓᓯᑭᓯᖅᑕᐅᓯᒪᔪᑦ. ᕿᒥᕐᕈᓚᐅᖅᑕᕗᑦ ᐅᑭᐅᖏᑦ ᐊᒻᒪᓗ ᐊᖑᓴᓪᓗᐃᑦ ᐊᕐᓇᓪᓗᐃᑦ ᐋᖅᑭᐅᒪᓂᓇᔭᖏᑦ ᐊᒪᕈᖅᑕᐅᔪᓂᑦ, ᐊᒻᒪᓗ ᐃᓂᒦᖃᑦᑕᕐᓂᖏᓐᓄᑦ ᐊᒻᒪᓗ ᖃᓄᑎᒋ ᐊᑯᓂᐅᑎᒋᓂᖏᓐᓄᑦ ᑲᑎᓯᒪᔪᑦ ᐊᒪᕈᖅᑕᐅᔪᓂᑦ (ᐆᒃᑑᑎᒋᓗᒍ, ᐊᒪᕈᖅᑕᐅᖃᑦᑕᕐᓂᖏᑦ ᐃᑲᔪᐃᓂᖃᕐᒪᖔᑦ ᐲᕐᓂᐊᕐᓗᒋᑦ ᑕᒪᕐᒥᓗᒃᑖᑦ ᐊᒪᕈᐃᑦ ᑲᑎᓯᒪᔪᑦ). ᑐᓂᓯᓚᐅᕐᒥᔪᒍᑦ ᓇᓚᐅᑦᑖᖅᓯᒪᔪᓂᒃ ᖃᑉᓯᐅᓂᖏᓐᓄᑦ ᐊᒪᕈᐃᑦ ᐊᒃᑐᐊᓂᖃᖅᑐᑦ ᖃᒪᓂᕐᔪᐊᖅ ᑐᒃᑐᐃᑦ ᐊᒥᕐᕋᓂᑦ ᐊᒻᒪᓗ ᐃᓚᖏᓐᓂᑦ ᐊᒪᕈᖅᑕᐅᔪᓂᑦ ᓄᓇᕗᒻᒥ ᒪᖃᐃᑎᓄᑦ.

2018-19-ᒥᑦ, 146 ᐊᒪᕈᖅᑕᐅᔪᑦ ᑎᑎᕋᐅᓯᐅᓚᐅᖅᑐᑦ 52 ᒪᖃᐃᑎᓄᑦ ᕿᑎᕐᒥᐅᓂᑦ, ᐱᓗᐊᖅᑐᕐᒥᑦ ᒪᖃᐃᑎᓂᑦ ᖁᕐᓗᖅᑐᕐᒥᑦ. ᐊᒪᕈᖅᑕᐅᔪᑦ ᖃᑉᓯᐅᓂᖏᑦ ᐊᒥᓲᓐᖑᓇᐊᓚᐅᖅᑐᑦ ᐋᓪᔪᓕᕐᕕᖕᒥᑦ ᐊᒻᒪᓗ ᐊᐳᖕᓂᕕᖕᒥᑦ ᓄᕐᕋᐃᑦ-ᒧᑦ, ᐊᒥᓱᑦ ᐃᓚᖏᑦ ᐊᒪᕈᖅᑕᐅᔪᑦ ᐃᓐᓇᕈᖅᐸᓪᓕᐊᓕᓵᖅᓱᑎᒃ ᐅᑭᐅᓖᑦᒥᑦ ᐋᓪᔪᓕᕐᕕᖕᒧᑦ ᐊᒻᒪᓗ ᐊᔾᔨᒌᙱᑦᑐᓂᒃ ᐅᑭᐅᖃᖅᑐᓂᒃ ᐊᒪᕈᖅᑕᐅᖃᑦᑕᖅᐳᑎᒃ ᐱᕙᓪᓕᐊᑎᓪᓗᒋᑦ ᑕᖅᖀᑦ ᒪᖃᐃᕝᕙᐅᖃᑦᑕᖅᑐᑦ.

2019-20, 658 ᐊᒪᕈᖅᑕᐅᔪᑦ ᑎᑎᕋᐅᓯᐅᓚᐅᖅᑐᑦ ᓄᓇᕗᒻᒥᑦ, 64% ᐊᒪᕈᖅᑕᐅᑉᓗᑎᒃ ᐊᕐᕕᐊᓂᑦ, ᖃᒪᓂᑦᑐᐊᕐᒥᑦ ᐊᒻᒪᓗ ᖁᕐᓗᖅᑐᕐᒥᑦ ᒪᖃᐃᑎᓄᑦ. ᐊᒪᕈᕋᔪᓐᓂᖅᓴᐅᑉᓗᑎᒃ ᑲᑕᒑᓇᕝᕕᖕᒥᑦ ᐊᒻᒪᓗ ᓇᑦᑎᐊᕐᒥᑦ ᓄᕐᕋᐃᑦ-ᒧᑦ. 2020-21-ᒥᑦ, 699 ᐊᒪᕈᖅᑕᐅᔪᑦ ᑎᑎᕋᐅᓯᐅᓚᐅᖅᑐᑦ, 68% ᐊᒪᕈᖅᑕᐅᑉᓗᑎᒃ ᐊᕐᕕᐊᓂᑦ, ᖃᒪᓂᑦᑐᐊᕐᒥᑦ ᐊᒻᒪᓗ ᖁᕐᓗᖅᑐᕐᒥᑦ ᒪᖃᐃᑎᓄᑦ. ᑕᒪᐃᓐᓂᑦ ᐅᑭᐅᓂᑦ, ᐃᓚᖏᑦ ᐃᓐᓇᕈᖅᐸᓪᓕᐊᓕᓵᖅᑐᑦ ᐊᒪᕈᖅᑕᐅᔪᓂᑦ ᐊᒥᓲᔪᖕᓃᖅᐸᓪᓕᐊᓚᐅᖅᑐᑦ ᐊᒻᒪᓗ ᐊᒥᓲᖏᑦᑐᑦ ᐊᒪᕈᓚᐅᖅᑐᑦ ᐊᖏᓂᖅᓴᐅᔪᒥᑦ ᐃᓚᖓᓂᑦ ᐊᒪᕈᖅᑕᐅᔪᓂᑦ. ᑕᒪᕐᒥᓗᒃᑖᖅᖃᔭᖅ (99%) ᐊᒪᕈᐃᑦ ᓯᖅᖁᖅᑎᑕᐅᓚᐅᖅᑐᑦ ᐊᒻᒪᓗ ᐊᒥᐊᒃᑯᖏᑦ ᐲᔭᖃᑦᑕᒥᒃ ᐊᑐᖅᓱᑎᒃ.

ᓄᓇᖁᑦ ᐊᑯᓐᓂᖓᓂᑦ ᖃᓄᐃᓕᐅᖅᐸᓪᓕᐊᓂᖏᑦ ᐊᔾᔨᒋᓇᐅᙱᑦᑑᓗᐃᑦ, ᐊᒪᕈᖅᑕᐅᖃᑦᑕᖅᑐᑦ ᓄᓇᓕᖕᒧᑦ ᖃᓐᓂᖅᓴᐅᔪᒥᖃᑦᑕᓚᐅᖅᑐᑦ ᐊᓂᕝᕙᐊ ᖃᓪᓕᓕᕚᖓᑦ (75 ᑭᓛᒥᑕᓂᒃ ᖃᓂᑎᒋᔪᒥᑦ) ᐊᒻᒪᓗ ᓄᓇᓕᖕᓂᑦ ᐅᖓᓯᖕᓂᖅᓴᐅᔪᓂᑦ ᐅᑭᐅᖅᑎᓪᓗᒍ, ᐅᖓᓯᒃᓯᓂᖅᓴᐅᓕᖅᓱᑎᒃ ᑎᕆᒡᒍᐃᑦ-ᒥᑦ ᐊᒻᒪᓗ ᓄᕋᐃᑦ-ᒥᑦ (500 ᑭᓛᒥᑕᓄᑦ ᑎᑭᑦᓱᒍ). ᑕᐃᒪᓐᓇᒎᑦ, ᒪᖃᐃᓐᑦ ᐅᖓᓯᒃᑲᓗᐊᖅᓱᑎᒃ ᓄᓇᓕᖕᒋᓐᓂᑦ, ᑕᖕᒫᓇᐊᖃᖃᑦᑕᖅᓱᑎᒃ, ᑕᐃᒪᓐᓇ ᐊᒥᓲᓂᖅᓴᓂᒃ ᐊᒪᕈᖃᑦᑕᓚᐅᖅᑐᑦ. ᐊᕝᕙᐊᓂᑦ ᒪᖃᐃᓐᑦ ᐊᒪᕈᓚᐅᖅᑐᑦ ᐅᖓᓯᒃᑐᑲᓪᓚᖓᒥᑦ ᐅᑭᐅᖑᓕᖅᑎᓪᓗᒍ, 450 ᑭᓛᒥᑕᓂᒃ ᐅᖓᓯᒃᑎᒋᔪᒥᑦ ᐊᕝᕙᐊᓂᑦ 2019-20-ᒥᑦ, ᑭᓯᐊᓂ ᓇᒻᒪᒋᐅᓯᒪᓂᖏᑦ ᐊᒪᕈᖅᑕᐅᔪᑦ ᖁᑦᑎᖕᓂᖅᓴᐅᓚᐅᖅᑐᖅ ᖃᓂᓐᓂᖅᓴᐅᔪᑦ ᐊᒥᓲᑎᒋᓂᐅᔪᓂᑦ ᑐᒃᑐᓂᑦ. ᓇᒻᒪᒋᐅᖃᑦᑕᕐᓂᖏᑦ ᐊᒥᓲᑲᓪᓚᐅᕐᓱᑎᒃ ᖃᒪᓂᕐᔪᐊᖅ ᑐᒃᑐᖏᑦ ᐊᒻᒪᓗ ᐊᒪᕈᖅᑕᐅᔪᑦ ᐊᔾᔨᒋᙱᒋᖃᑦᑕᖅᑐᑦ ᐅᑭᐅᑦ ᐊᑯᓐᓂᖓᓂᑦ. ᐃᓚᖏᑦ ᑲᑎᒪᔪᑦ ᐊᒪᕈᖅᑕᐅᔪᑦ ᐊᔾᔨᒋᙱᒋᖃᑦᑕᖅᑐᑦ ᓄᓇᖁᑦ ᐊᑯᓐᓂᖓᓂᑦ ᐊᒻᒪᓗ ᐊᒥᓲᔪᙳᖅᐸᓪᓕᐊᐸᓱᑦ ᑲᑎᒪᔪᑦ ᐊᖏᑎᒋᓂᖏᑦ ᐊᖏᒡᓕᒋᐊᖅᓱᓂ ᐊᒻᒪᓗ ᐊᖏᒡᓕᒋᐊᖅᐸᓪᓕᐊᖏᓐᓇᖅᓱᓂ ᐅᑭᐅᑉ ᐃᓗᐊᓂᑦ.

ᓇᓚᐅᑦᑖᖅᑕᐅᔪᑦ ᖃᐅᔨᐅᓂᖏᑦ ᐊᒪᕈᐃᑦ ᐱᔾᔪᑎᒋᐸᓗᒋᑦ ᖃᒪᓂᕐᔪᐊᖅ ᑐᒃᑐᐃᑦ ᐊᒥᕋᐃᑦ ᐅᖃᖅᑐᑦ ᒪᖃᐃᓐᑦ ᐊᕐᕌᒍᑕᒫᒃᑯᑦ 12-25%-ᓗᐊᓂᒃ ᐊᒪᕈᖃᑦᑕᖅᑐᑦ ᐅᑭᐅᖑᓕᖅᑎᓪᓗᒍ ᐊᒻᒪᓗ ᐅᐱᕐᖓᖅᐸᓪᓕᐊᓕᖅᑎᓪᓗᒍ ᐊᐅᓚᓂᖏᓐᓂᑦ ᖃᒪᓂᕐᔪᐊᖅ ᐊᒥᕋᖏᑦ. ᓇᓚᐅᑦᑖᖅᑕᐅᔪᑦ ᖃᐅᔨᐅᓂᖏᑦ ᐊᒪᕈᐃᑦ ᐊᒻᒪᓗ ᐃᓚᖏᑦ ᐊᒪᕈᖅᑕᐅᔪᑦ ᐊᑐᖅᑐᑦ ᐃᓱᒪᒋᔭᐅᔪᒥᒃ ᑕᑯᔭᐅᔪᓂᐅᖏᓛᖅᑐᖅ ᐱᔾᔪᑎᖃᖅᑐᓂᒃ ᐊᑯᓐᓂᖓᓂᑦ ᑐᒃᑐᐃᑦ ᐊᒻᒪᓗ ᐊᒪᕈᐃᑦ ᖃᐅᔨᐅᓂᖏᑦ ᑕᐃᒪᓐᓇᒎᑦ ᑐᑭᓕᐅᖅᑕᐅᔭᕆᐊᓕᒃ ᐅᔾᔨᖅᑐᕐᓱᑎᒃ. ᐱᓕᕆᐊᖑᒃᑲᓂᕆᐊᖃᖅᑐᑦ ᓇᓚᐅᑦᑖᕆᑦᑎᐊᕐᓂᖅᓴᐅᓂᐊᕐᓗᓂ ᖃᐅᓯᑦ ᐊᒪᕈᐃᑦ ᐊᒃᑐᐊᓂᖃᕐᒪᖖᑕ ᐅᑎᖅᑕᖃᑦᑕᖅᑐᑦ ᐊᒥᕋᓂᒃ, ᐱᓗᐊᖅᑐᒥᑦ ᖃᒪᓂᕐᔪᐊᖅ ᐊᒥᕋᓂᒃ, ᐅᑭᐅᖑᑎᓪᓗᒍ ᐊᒻᒪᓗ ᐅᐱᕐᖠᖑᑎᓪᓗᒍ, ᑭᓯᐊᓂ ᐊᒥᓯᐃᑦ ᐊᒪᕈᖅᑕᐅᖃᑦᑕᕐᓂᖏᐅᑎᓪᓗᒋᑦ ᓂᕆᐊᓂᑦ ᐊᒻᒪᓗ ᓂᕆᖅᐸᓯᐊᓂᑦ ᐱᖓᖓᖅᐸᓯᐊᓂᑦ ᐊᕝᕙᐊᓂᑦ ᓇᑎᐊᑦ-ᒥᑦ, ᑎᕆᒡᒍᐃᑦ-ᒥᑦ ᐊᒻᒪᓗ ᓄᕋᐃᑦ-ᒥᑦ, ᐊᒥᓲᑎᒋᓂᖏᑦ ᐊᒪᕈᐃᑦ ᐊᒻᒪᓗ ᐊᒪᕈᖅᑕᐅᔪᑦ ᒥᒃᓵᓂᐊᕐᔪᐊᖃᑦᑕᖅᑐᑦ ᐊᒥᕋᐃᑦ ᓄᕆᐅᕝᕕᖓᓄᙵᐅᔭᕚᓚᑦ ᐱᖓᖓᒥᑦ ᓯᕐᔭᖓᓂᑦ ᑕᓯᐅᔭᕐᔪᐊᑉ, ᑕᐃᒪᓐᓇᒎᑦ ᐊᒥᓲᙱᖃᑦᑕᖅᑐᑦ ᐊᒪᕈᐃᑦ ᐊᒻᒪᓗ ᐊᒪᕈᐃᑦ ᓂᕆᔭᒃᓴᖅᓯᐅᖅᑐᑦ ᓄᕆᐅᖅᑎᓪᓗᒋᑦ ᐊᒻᒪᓗ ᓄᕆᐅᕙᓂᕙᖅᑎᓪᓗᒋᑦ ᐃᓂᒋᔭᐅᔪᓂᑦ.

ᐊᒪᕈᖃᑦᑕᕐᓃᑦ ᐱᖅᑯᓯᑐᖃᕆᔭᐅᔪᖅ ᓄᓇᕗᒻᒥ ᒪᖃᐃᑎᓄᑦ, ᐊᒻᒪᓗ ᐅᑭᐅᑉ ᐃᓚᖓᓂᑦ ᑮᓇᐅᔭᓕᐅᕈᑕᐅᖃᑦᑕᖅᐳᑎᒃ. ᐊᑑᑎᖃᕐᓂᖓ ᓄᓇᕗᒻᒥ ᐊᒪᖅᓯᐅᖅᑏᑦ ᖁᑦᑎᒃᑑᔭᖅᑐᖅ, ᐊᒥᓯᐃᑦ ᐊᕐᕌᒍᑕᓖᑦ ᐊᒪᕐᑕᐅᖃᑦᑕᖅᐳᑎᒃ ᐃᓚᖏᓐᓂᑦ ᓄᓇᓕᖕᓂᑦ, ᐱᓗᐊᖅᑐᒥᑦ ᐊᕝᕙᐊᓂᑦ, ᖃᓂᑦᑐᐊᕐᒥᑦ ᐊᒻᒪᓗ ᖁᕐᓗᖅᑐᒥᑦ. ᓄᓇᕗᒻᒥ ᐊᒪᖅᓯᐅᖅᑏᑦ ᐃᓐᓇᐅᓂᖅᓴᐅᔪᓂᒃ ᐊᒪᖅᓯᐅᖃᑦᑕᖅᑑᔭᖅᑐᑦ ᐊᒻᒪᓗ ᐱᐊᓛᓕᐅᖃᑦᑕᖅᑐᓂᒃ ᐃᓚᖏᓐᓂᒃ ᐊᒪᕐᓂᑦ ᐅᑭᐅᖑᓕᕋᓛᑦ ᑭᖑᓂᐊᒍᑦ ᑕᒪᑯᑖᕐᓚᒃ ᐃᖏᓂᑦ ᑐᖁᔪᑦ ᐱᖅᖀᖅᑎᓪᓗᒋᑦ, ᐊᖏᕐᓕᒋᐊᖅᓯᔪᖅ ᐃᓚᓯᓂᕐᒃ ᐊᒃᑐᖅᓯᓂᐅᔪᓂᒃ ᒪᖃᐃᖃᑦᑕᕐᓂᐅᔪᓂᒃ. ᐃᓚᖏᓐᓂᑦ ᐃᓂᐅᔪᓂᑦ ᐊᒪᕈᑕᐅᔪᑦ ᐅᐱᕐᕈᓛᒃᑯᑦ ᐅᑎᖅᐸᓪᓕᐊᑎᓪᓗᒋᑦ ᐊᒥᓲᖏᖃᑦᑕᖅᑐᑦ ᐊᒪᕈᐃᑦ ᐊᒻᒪᓗ ᐊᒪᕈᐃᑦ ᓂᕆᔭᒃᓴᖅᓯᐅᖅᑐᑦ ᓄᕆᐅᕝᕕᐅᔪᓂᑦ ᐊᒻᒪᓗ ᓄᕆᐅᕌᓂᒃᑎᓪᓗᒋᑦ ᐃᓂᒋᔭᐅᔪᓂᑦ. ᐊᒪᕈᐃᑦ ᐊᒥᒃᑎᒋᓂᖏᑦ ᐅᑎᒃᑲᓂᑲᐅᑎᒋᔭᓇᕐᒪᑕ ᐱᓕᕆᐊᖑᓂᖅ ᐄᖅᑕᐅᒃᐸᑕ ᐱᔾᔪᑎᒋᐸᓪᓗᒋᑦ ᐅᑎᖅᑕᖅᑐᑦ ᖃᓂᑦᑐᓂᑦ ᐃᓂᐅᔪᓂᑦ ᐊᒻᒪᓗ ᖁᑦᑎᒃᑑᐸᓗᓂ ᐱᐊᓛᓕᐅᖃᑦᑕᕐᓂᕐᒥᑦ, ᐱᓕᕆᐊᖑᓂᖏᓄᑦ ᑐᕌᖓᔪᖅ ᑲᔪᓯᑎᑕᐅᓯᒪᔭᕆᐊᖃᖅᑐᖅ.

ININGINNI TADJALU QANURILIURUTAIT AMARUNI ANGUNIARNIRNI PIDJUTIKKUT TUKTUT INGILRADJUTAINNI NUNAVUNMI

Aulapkaijini Naittuq Naunaijaruti

Pijuummiqtiqhimajunik amaruni (*Canis lupus*) munaridjutainni qanuriliurutait atuqtauvaktut ikajurnirmun ikikliliqtunun tuktuni (*Rangifer tarandus*). Amigaitqijaujun ingilrainnaqtuni ukiuqtaqtumi tuktuit (*R. t. groenlandicus*) Nunavunmi haniliriiktumilu Nunatsiami (NWT) naliani ikilivallialiqtun imaaluunniit ingilraarnitamin ikikliqpiaqtun amihuarjuutainni. Aullaqtiqhuni 2018-19mi Kitikmeoni pivaliqhunilu tamaat Nunavunmun 2019-20mi, Nunavut Kavamanga (GN) Avatiliqijikkut Havagvia (ENV) hailihimapkaijun manikhanik talvuuna Ikajuutikkut Anguniaqtinun pinhuarutimimi ukununga nunallaami anguniaqtinun anguniarnirnun amarunik tunilutiklu timaanin ihivriuqtakhamik humiinniinnilu naunaitkutainnik. Ihivriuqtavun amaruit angujauhimajun naunaitkutainnik ukunanga 1,500 amarunin anguniaqtinin Nunavunmi uvani 2018-19min uvanilu 2020-21mun naunaijariami humiinninginnik qangalu qanuriliurutait Nunavunmin amarunik angujaujunin pidjutaitigun tuktunun amigainniinnik tunnganiqarhuni qunguhirmiaqaqtunin tuktuinnin. Ihivriuqtavun ukiungit anguhaluujaakhaita arnarluujaakhaita amaruni angujauhimajuni, ukuallu humiittaakhaitat qangalu katihimadjutait anguniaqtaujuni (imaa, naliak anguniarniit ihuarutaukpat nungupkarutainnik tamainnik amaruqatigiingnik). Tunihimajugullu nalautinniarhimalugin qaffiujaakhainnik amaruit pidjutilgit uvani Qamanirjuaq tuktuinni avvainnilu hapkunani amaruni angujauhimajunik Nunavunmin anguniaqtiinnin.

Atuqtilugu 2018-19, 146 amarut titiraqtaujut angujaujut 52nik anguniaqtinin Kitikmeonin, taapkunanngalluarlu anguniaqtinin Kugluktumin. Anguniarnikkut qaffiuniit amigaitqijaujun Tisaipami Fibjualimi–Maymilu, amigaitqijaupluni anguniarniq uvani Aktuupami–Tisaipami ilaujut amaruat aallatqiillu ukiuqarutait angujaujun anguniarvik hivumuutillugu.

Talvani 2019-20, 658 amarut titiraqtauhimajun angujaujun tamaani Nunavunmi, pipluni 64% avvaanik anguniarutinin Arvianin, Qamanittuamin Kugluktuminlu anguniaqtiinnin. Anguniarniit amigaitqijaujun Nuvaipami uvanilu Maatsimi–Maymilu. Talvani 2020-21mi, 699 amarut titiraqhimajun angujaujun, pipluni 68% avvaanik anguniaqtaujun Arvianin, Qamanittuamin Kugluktumillu anguniaqtinin. Taapkuangni ukiuni, amigainniit amaruani angujaujuni ikiklilaaqtuq hivitunirmi taimaalu ikitqijaujullu anguniaqtiit pidjutijun amigaitqijaujumik avvaanik anguhinirmi. Tamatqiutivjaktun (99%) amarunik hiquqtauhimajun ilaquillu naniriaqtauhimajun.

Taimaitkaluaqhuni qanurinniit aallangajun naliinni nunallaani, amarut angujauvaktun qanitqijaujumik nunallaanun hivuagun Quviahukvingmi (imaakiaq iluani 75ni km) ungahitqijaujunilu nunallaanin atukhaarniani ukiup, piqarhuni ungahitqijaujunik Aprilmi Maymilu (talvunga 500nik km). Taimaatun, taapkuat anguniaqtiit ungahikkaluaqhutik nunallaamingin, piplutik tangmaaqpakhutik, nakuujumik anguniaqtun amigaitqijaujunik amarunik. Arvianin anguniaqtiit angujun amarunik ungahiktuni atukhaaqtumi ukiumi, ilaujuqlu avatquhimajumik 450 km haamlanganin 2019-20mi, kihimi pidjutaa anguniarniup amigaitqijauvaktuq qanitiqjaani amigaitqijauniqarnirni tuktuni. Una pidjutaa amigaitqijauniqarnirni uvani Qamanirjuaq tuktuni taimaidjutaa uvani amaruni angujaujuni aallakkiiktun ukiuni. Amigainniit amaruqatiinni angujaujuni aallangajuq nunallaani taimaalu ikiklijuummiqtun amaruqatiit amigairaangata amigaiqhutiklu ukiup hivumuuniani.

Nalautinniaqhimajun qaffiujaakhaita amaruit pidjutilgit uvani Qamanirjuaq tuktuni ihumagijun anguniaqtiit ukiuq tamaat anguvaktait imaakiaq 12-25% avvaani amaruni pidjutilgit atukhaarniani ukiumi upingaamilu ingilradjutainni uvani Qamanirjuaq tuktuinni. Nalautinniarhimajun amaruni qaffiujaakhainni ukunanilu qaffiujuni amarut angujauvaktun tunnganiqaqtun ihumagijaujuni kihiani tautukhimanikkut pidjutainni tuktuni amarunilu qaffiunirni taimaalu uqaqtaujukhat ihumagidjutiinnakkut. Havagjuummirniit ihariagijaujun nakuutqijaujumik qaffiujun amarut pidjutiqarniinni ukunani ingilrainnaqtuni tuktuinni, ukuallaunilu Qamanirjuaq tuktuinni, talvani ukiumi upinnaamilu, kihimi pidjutaani amigaittuni angudjutini amaruni hivuraani uvanilu hivuraani-ualliani Arviani Maatsimi, Aprilmi Maymilu, pijungnaqhijuq qaffiuniit amaruni ukunanilu amarunin-tuqutauvaktun tuktuit ikiklijuummiqpiaqpaktun taimaatun tuktui ingilradjutainni nuriviinnun nunanun ualliani hinaani Kangiqsualuup, pidjutingani qaffiunirnik ikittunik amarunik uvanilu ikittunik amarunin tuqutirutainnik nurrivingni uvanlu pilihaaliqtuni nurrihuirutimi nunainni.

Amarunik anguniarniit pitquhikkut ilaujuq pitquhiinni Nunavunmin anguniaqtiinnin, pidjutiujuqlu qakunguraanga maniliurutait. Nakuuniqarniit uvani Nunavunmin amarunik anguniaqtiinnin qulvahiktutun ittuq, amigaittuni ukiuq tamaat anguniarutinin ilanginnin nunallaanin, ukualluanin Arvianin, Qamanittuamin Kugluktumillu. Nunavunmin amarunik anguniaqtiit tautungnarniqaqtun turaangajait angajukhitqijanik najjijaaqtuni ilainni amaruni atukhaaqniani ukiumi kinguagun amigaitqijanik aularaanginnaqtukkut tuqudjutainnik pikpata, amigaiqjuummiqtiqhugin hapkuat ilaudjutaujun hulqutit hapkunani nunami-tunnganiqaqtun anguniarnikkut havagutit. Ilanginni nunani amaruni anguniarniit upingaami ingilradjutainni pidjutivaktun ikittunik amarunik imaalu ikiklijunik amarunin tuqutirutinik uvani nurrivingni uvanlu nurrihuirutimi nunainni. Taimaatun amaruit amigairniit qilamik amigaiqtaaqmata hanaqidjuti nutqaqtitaugaangat pidjutipluni qaidjutainnik hanianiittunin nunanin ukunangalu amigaittunin najjijunin aktilaanginnin, una pilaqhuutikkut pinahuaruti aulapkaqtitauhimmaaqtukhaq.

TENDANCES SPATIALES ET TEMPORELLES DE LA CHASSE DU LOUP PAR RAPPORT AUX DÉPLACEMENTS DES HARDES DE CARIBOUS AU NUNAVUT

Résumé

Des mesures de gestion du loup (*Canis lupus*) améliorées sont souvent utilisées pour appuyer la restauration des hardes de caribous (*Rangifer tarandus*) en déclin. La plupart des hardes de caribous migrateurs de la toundra (*R. t. groenlandicus)* au Nunavut et dans les Territoires du Nord-Ouest (T.N.-O.) sont en déclin ou à des niveaux de population historiquement bas. Depuis 2018-2019 dans la région de Kitikmeot, et depuis 2019-2020 dans l'ensemble du Nunavut, le ministère de l'Environnement du gouvernement du Nunavut (GN) offre une incitation dans le cadre du programme de soutien aux chasseurs actifs aux chasseurs locaux pour chasser le loup et fournir des échantillons et des données de localisation. Nous avons examiné les données de 1 500 loups tués par des chasseurs au Nunavut entre 2018-2019 et 2020-2021 afin de décrire les tendances spatiales et temporelles de la chasse du loup au Nunavut par rapport aux densités de caribous, fondées sur les animaux munis d'un collier. Nous avons examiné la structure par âge et par genre des loups chassés, ainsi que le regroupement spatial et temporel de la récolte (c.-à-d. si la chasse peut efficacement éliminer des meutes entières). Nous avons également fourni des estimations approximatives du nombre de loups associés à la harde de caribous de Qamanirjuaq et de la proportion de ces loups récoltés par les chasseurs du Nunavut.

En 2018-2019, 146 loups ont été récoltés par 52 chasseurs dans le Kitikmeot, principalement par des chasseurs de Kugluktuk. Le nombre de prises a atteint un sommet en décembre et en février-mai, avec une forte proportion de la récolte d'octobre à décembre ayant étant composée de jeunes loups. La distribution des âges des prises s'est élargie au fur et à mesure que la saison a avancé.

En 2019-2020, 658 loups ont été récoltés dans l'ensemble du Nunavut, dont 64 % par des chasseurs d'Arviat, de Baker Lake et de Kugluktuk. La récolte a atteint un sommet en novembre et en mars-mai. En 2020-2021, 699 loups ont été récoltés dans l'ensemble du Nunavut, dont 68 % par des chasseurs d'Arviat, de Baker Lake et de Kugluktuk. Au cours de ces deux années, la proportion de jeunes loups dans la récolte a diminué au fil du temps et un nombre relativement faible de chasseurs a contribué à une majorité de la récolte. Presque tous les loups (99 %) ont été abattus et le reste a été piégé.

Les tendances diffèrent d'une collectivité à l'autre, mais avant Noël, les loups étaient généralement récoltés près des collectivités (dans un rayon d'environ 75 km) et plus tard en hiver, ils l'étaient loin des collectivités, les plus grandes distances ayant été en avril et en mai (jusqu'à 500 km). Ainsi, même si les chasseurs étaient loin de leurs collectivités, nécessitant de camper sur site lors d'excursions de plus d'une journée, ils pouvaient efficacement récolter un plus grand nombre de loups. Les chasseurs d'Arviat ont chassé les loups sur une grande distance plus tard au cours de l'hiver, y compris à plus de 450 km du hameau en 2019-2020, mais la distribution des prises était supérieure plus près des densités élevées de caribous. La distribution des fortes densités de caribou de Qamanirjuaq et, par conséquent, la récolte de loups, a différé d'une année à l'autre. La proportion de meutes récoltées variait d'une collectivité à l'autre et diminuait généralement à mesure que la taille des meutes augmentait, et augmentait au fur et à mesure que la saison avançait.

Des estimations approximatives du nombre de loups associés à la harde de caribous de Qamanirjuaq suggèrent que les chasseurs ont éliminé annuellement environ 12 à 25 % des loups associés aux déplacements de la harde de Qamanirjuaq à la fin de l'hiver et au printemps. Les estimations du nombre de loups et de la proportion de loups récoltés sont fondées sur des relations présumées plutôt qu'observées entre le nombre de caribous et de loups et doivent donc être interprétées avec beaucoup de prudence. Du travail supplémentaire est nécessaire pour mieux estimer le nombre de loups qui pourraient être associés aux hardes migratrices, en particulier la harde de Qamanirjuaq, en hiver et au printemps, mais compte tenu des prises élevées de loups au sud et au sud-ouest d'Arviat en mars, en avril et en mai, il est probable que le nombre de loups et de caribous tués par les loups diminue considérablement à mesure que la harde migre vers ses aires de mise bas à l'ouest de la côte de la baie d'Hudson, entrainant ainsi un faible nombre de loups et une réduction de la prédation des loups dans les aires de mise bas et de début de la période postvêlage.

La chasse du loup fait partie intégrante de la culture des chasseurs du Nunavut et constitue une source de revenus saisonniers. L'efficacité des chasseurs de loups du Nunavut semble élevée, compte tenu des récoltes annuelles importantes dans certaines collectivités, en particulier Arviat, Baker Lake et Kugluktuk. Les chasseurs de loups du Nunavut semblent être en mesure de cibler les parties plus âgées et vraisemblablement reproductrices de la population plus tard au cours de l'hiver, après que la plupart des pertes naturelles se soient produites, ce qui augmente les effets cumulatifs de ces efforts de récolte au sol. Dans certaines régions, la récolte du loup pendant la migration printanière réduit le nombre de loups ainsi que la prédation des loups dans les aires de mise bas et de postvêlage. En raison du fait que les populations de loups peuvent rapidement rebondir lorsque le traitement est retiré en raison de l'immigration en provenance des régions environnantes et des taux de reproduction élevés, le programme d'incitation devrait être poursuivi.

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Introduction

Enhanced wolf (*Canis lupus*) management actions are often employed to support recovery of declining caribou (*Rangifer tarandus*) herds. These actions may include hunter training, support or incentives for ground-based harvesting, sterilization, poisoning, and aerial shooting, among other wolf removal options (Adams et al. 2008, Farnell 2009, Russell 2010, Hayes 2013, McLaren 2016, Boertje et al. 2017, WFATWG 2017). Experience in many jurisdictions suggests that wolf removal must be greater than 55–60% of the population annually for ≥4 years and carried out over a large area to maintain reduced wolf densities sufficiently to elicit a demographic response in an ungulate population (National Research Council 1997, McLaren 2016, Nishi et al. 2020). These levels of wolf harvest are often difficult for ground-based harvesting efforts to attain (Webb et al. 2011, McLaren 2016). Aerial shooting (often coupled with collaring of ≥1 member of a pack) has been effective in some areas (Russell 2010, Hayes 2013, McLaren 2016), but can be compromised by comparatively low wolf densities and difficulties in locating wolves, and high costs (WFATWG 2017, Nishi et al. 2020). Predator management strategies on migratory wolves following migratory herds are even more challenging (McLaren 2016). By late fall when young wolves are large and strong enough to travel with the pack, most wolves within the range of migratory caribou herds resume their close association with the migratory caribou and maintain it throughout winter (Musiani et al. 2007, Clark et al. 2021).

Most herds of migratory tundra caribou (*R. t. groenlandicus*) in Nunavut and adjacent Northwest Territories (NWT) are either in decline or at historically low population levels (COSEWIC 2016). Evidence from traditional and scientific sources indicates that caribou herds periodically increase and decrease at some interval (COSEWIC 2016, Bongelli et al. 2020). Although not fully understood, cyclical changes are likely largely due to trends in range quality, habitat disturbance (i.e., forest fires), climate, predation, disease and anthropogenic influences (COSEWIC 2016). Wolf predation is often singled out as a significant contributing factor (Hayes and Russell 2000, Russell 2010). Wolves are known to predate both adults and calves (Bergerud et al. 2008), and managing the wolf populations to reduce wolf predation on caribou is one of the few management levers available.

To support recovery of the Bathurst and Bluenose-East caribou herds, the Government of the NWT (GNWT) Environment and Climate Change (ECC) and Tłı̨chǫ Government (TG) began an aerial shooting program to supplement community wolf harvest incentive programs in late winter 2019-20, but the effectiveness of this program to reach wolf reduction targets (60–80% removal levels) within winter range has yet to be clarified (Nishi et al. 2020). Beginning in 2018-19 in the Kitikmeot Region and expanding to all of Nunavut in 2019-20, the Government of Nunavut (GN) Department of Environment (ENV) through the Support for Active Harvesters program offered compensation to local hunters to harvest wolves and provide samples and location data. Nearly 150 wolves were harvested by local hunters in the Kitikmeot in 2018-19, and over 650 and about 700 wolves were harvested Nunavut-wide during 2019-20 and 2020-21, respectively, the vast majority from within the Kitikmeot and Kivalliq regions. Through sample collection forms, carcass examination, and age analysis, we determined the location, date, sex and age of these harvested wolves. These data, coupled with GN and GNWT collar data of caribou herds in Nunavut, provide an opportunity to examine the spatial and temporal patterns of the wolf harvest in relation to caribou herd movements and distance from communities. Nunavut hunters are in a unique position as they are able to effectively hunt wolves on good snow conditions in the open tundra, as opposed to within the treeline where soft snow and forests often hamper hunter travel and effectiveness.

Although most migratory caribou herds within mainland NWT and Nunavut have shown steep rates of decline and low abundance, for example the Bathurst and Bluenose-East herds (Adamczewski et al. 2022, Boulanger et al. 2022), the Qamanirjuaq herd in the Kivalliq Region of Nunavut has instead demonstrated a moderate rate of decline of 2% based on the 2017 calving ground survey (Boulanger et al. 2018). Of key interest is whether relative stability of the Qamanirjuaq herd can be correlated to the more intensive wolf harvest measures undertaken on this herds' range.

The objectives of this analysis were:

1. Using GIS, describe the spatial and temporal patterns of the wolf harvest in Nunavut in relation to inferences of caribou herd locations/densities from collared caribou and distance from communities;
2. Temporally document the age and sex structure of the wolf harvest, including examination of spatial and temporal clustering of the harvest (i.e., whether hunting is effective at removing entire packs); and
3. Estimate shifts in age structure of wolves harvested as an index of the effectiveness of the ground-based wolf control program.

Study Area

While the Support for Active Harvesters program applied to all of Nunavut, our analysis of wolf harvest locations in relation to caribou distribution focussed on the Kitikmeot and Kivalliq regions within Nunavut, primarily mainland Nunavut and Victoria Island (Fig. 1). Other islands and peninsulas adjacent to and north of the Nunavut mainland (e.g., King William Island and Boothia Peninsula) had no supporting caribou collar data. Comparatively few wolves were harvested in the Qikiqtaaluk region during the study and there was no reported harvest on Baffin Island.

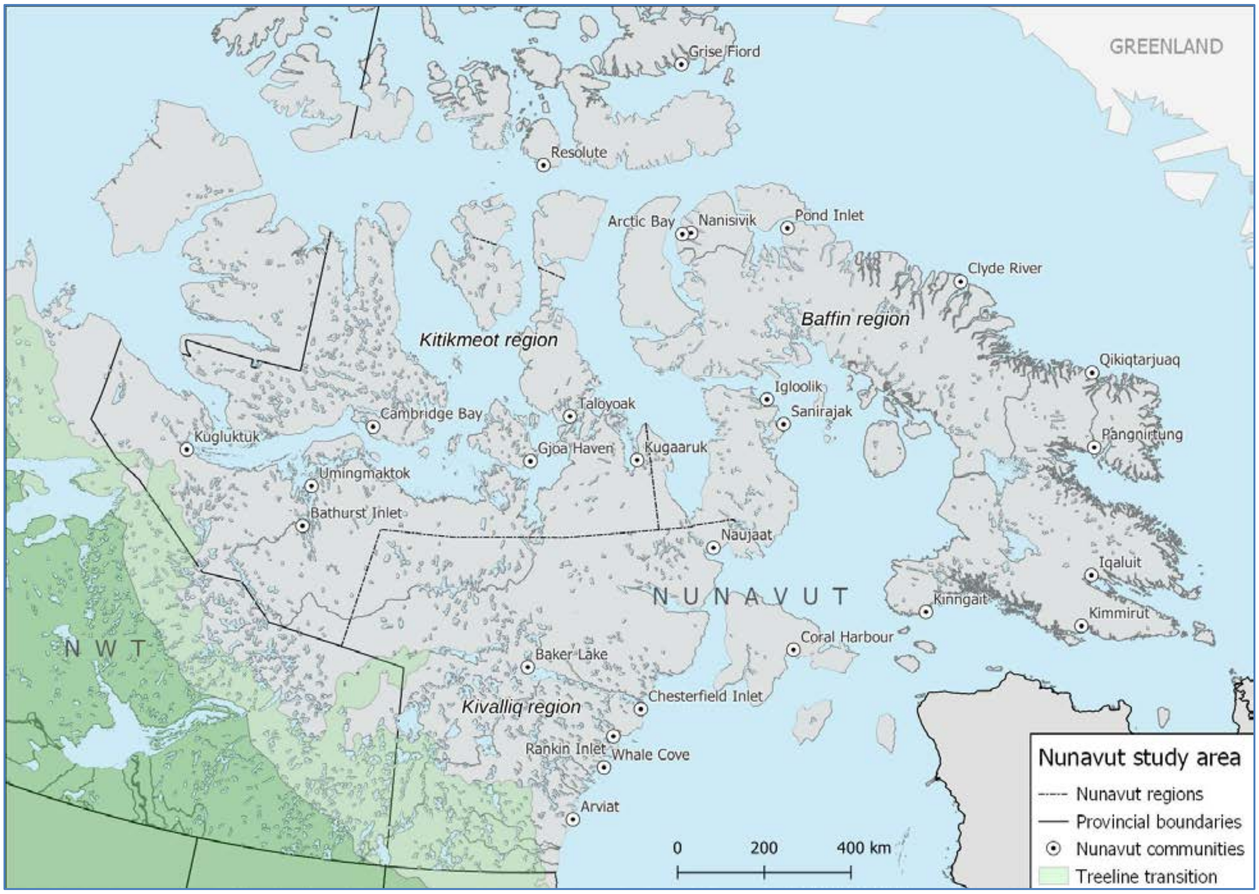

Figure 1. Map of Nunavut and communities; the Support for Active Harvesters program applies to the entire territory.

Study Design and Methodology

Spatial data acquisition

Wolf harvest data

Wolves occupy almost all of Nunavut, and are classified as both a furbearer and a big game mammal under the Nunavut Agreement (https://www.tc.canada.ca/sites/default/files/migrated/nunavut_land_claims_agreement.pdf). Under the Nunavut Agreement, furbearer harvest privileges are held by Inuit beneficiaries, non-Inuit who harvested furbearers legally in the Nunavut settlement area prior to 1981, and non-Inuit whose application has been approved by local Hunters and Trappers Organizations (HTOs). Unlike most provinces, hunters and trappers in Nunavut do not have registered or traditionally exclusive family trap lines or hunting areas.

Wolf hunting in Nunavut is mainly by firearms from snowmobiles, with few wolves trapped. With a very limited road network in the territory, snowmobiles are a vital form of transportation which hunters use to harvest wolves because it is the only practical method given the wide-open spaces of the Nunavut tundra. Early in the season (October to February) most hunters harvest wolves on day or weekend trips while harvesting caribou or muskoxen (*Ovibos moschatus*). From March onward hunter groups generally take trips 1–2 weeks in length specifically for wolf hunting.

There are no estimates of wolf numbers within Nunavut. Both migratory and resident wolves occur within the territory, with most individuals moving with migrating caribou herds. Additional large prey for wolves includes populations of muskoxen which are expanding throughout most of the mainland (with lower densities further east and northeast within Nunavut; Campbell and Lee 2019) and moose (*Alces alces*) around Bathurst Inlet and along the treeline, areas supporting quantities of shrubs. Other carnivores in the area include Arctic fox (*Vulpes lagopus*), red fox (*V. vulpes*), wolverine (*Gulo gulo*), grizzly bear (*Ursus arctos*) and black bear (*U. americanus*) along the treeline. Polar bears (*U. maritimus*) occur along coastal areas.

Each year we obtained the skull and a small piece of skin (~2.5 x 2.5 cm) with fur from hunters with the assistance of HTOs and Conservation Officers (CO). A $300 subsidy was provided to hunters for each skull brought back to their wildlife office to encourage the reporting and return of samples. For each wolf sample collected during the course of this study, COs filled out sample collection forms with information from hunters about their name (known only to the senior author) and home community, the harvest date, location, wolf sex, and method of harvest, and their opinion about the current abundance trend of the local wolf population: “Do you think the wolf population is decreasing, stable or increasing”. The skinned skulls were stored frozen, and were thawed at room temperature for examination in early May each year. We sent the first premolar to Matson’s Laboratory LLC (Milltown, MT, USA) for age estimation using cementum analysis. This technique is based on the cyclic nature of cementum growth in teeth forming annular patterns of different darkness depending on the season (Matson 1981). Following Mech (1970) and Gese and Mech (1991), individuals were then grouped into three age classes: juvenile (0-year-old), yearling (1-year-old) and adult (≥2 years).

Kitikmeot 2018-19: To support harvesting activities and contribute to the knowledge of wolf ecology and species management in Nunavut, ENV launched a pilot project of skull collections within the Kitikmeot Region as part of the Support for Active Harvesters Program and in response to community concerns, to provide samples for scientific research and examine wolf harvest effort and use of wolf harvest as a management tool in caribou recovery. There was no limit to the number of wolves submitted.

Nunavut 2019-20 and 2020-21: The Kitikmeot program was expanded Nunavut-wide in September 2019, again with no limit to the number of skulls submitted. Nunavut hunters killing wolves within the NWT North Slave Wolf Harvest Incentive Area received an additional $900 payment from the GNWT.

Caribou collar data

Caribou collar locations from October 2018 to June 2021 from collars deployed by ENV were obtained for the Qamanirjuaq (QM), Lorillard (LR), Wager Bay (WB), Ahiak (AH) and Dolphin and Union (DU) herds within Nunavut (Caslys Consulting Ltd., Saanichton, BC). Collar data from the DU herd ran from April 2015 to early December 2020, and resumed in April 2021 with additional collaring. Collars were deployed by ECC on the Bluenose-East (BE), Bathurst (BA) and Beverly/Ahiak (BV) herds (ENR 2021). Here we consider the Beverly and Beverly/Ahiak herds to be synonymous. Within the Nunavut data set all animals with Herd = UK designation were visually confirmed as QM caribou. Within the ECC data set, 13 of 18 caribou with

Herd = NA (not available) were assigned to herd based on movement paths or association with other collared caribou. Both sexes were represented in the collar data, with increasing numbers of bulls collared after 2015.

Collar fix rate varied, with most collars providing from 1 to several GPS locations daily. Over 1.5 million caribou collar locations were obtained. To facilitate GIS computations, to prevent more frequent fixes from skewing (unduly weighting) collar density maps, and because we did not require fine-scale temporal resolution to the data, we thinned/rarefied the data sets to one location daily and subset the collar data sets to cover the period from October 2018 to June 2021 (covering the 3 years of wolf harvest data). The ECC collar data had time and datetime stamp but Nunavut and DU data did not have a time component.

Data preparation

We conducted spatial analysis in QGIS (QGIS Development Team 2020), GRASS (GRASS Development Team 2020) and MapInfo (MapInfo 2000) using the Canada Lambert Conformal Conic (LCC) projection. We first conducted telemetry density (heat) mapping (kernel density estimation; Downs and Horner 2012) to display monthly patterns of caribou distribution. To determine heat map kernel radius, we estimated the median daily movements among the Nunavut and ECC data sets by month:

1. We added LLC coordinates to the files.
2. We sorted the data sets by caribou identification and date, and calculated the distance (in metres) between successive locations.
3. We calculated the number of days between successive fixes and applied a filter to remove all times >1 day, which accounts for missed fixes where a daily location was not obtained.
4. We calculated the mean distance moved per day by animal and month.
5. We calculated the animal sample size and median distance moved by month. Not unexpectedly, the median daily movement distances differed somewhat between the Nunavut and ECC data sets, and we used the average between data sets for heat mapping (Fig. 2).

Caribou herds often overlapped spatially and temporally; thus, the caribou heat map was run on the combined collar data set from all herds. However, sample sizes of collars varied among herds and over time as does the recent population estimate for each herd. For example, in December 2018 there were 27 collars on BA caribou, out of a population of approximately 8,200 (Adamczewski et al. 2019), thus each collar “represented” about 300 caribou. In contrast, there were 49 collars on QM caribou out of an estimated 288,000 caribou (Boulanger et al. 2018) – roughly one collar for every 5,900 caribou. To account for these differences, we weighted each caribou collar location by a relative factor of representativeness, ranging from 1 (DU or BA herds) to a high of 87 for the QM herd, based on the number of collared individuals and the most recent herd estimate (Appendix 1).

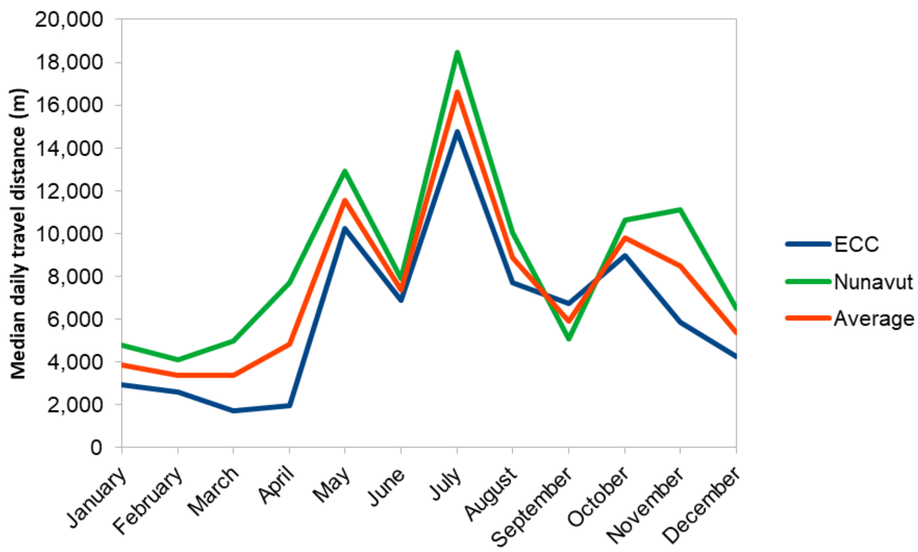

Figure 2. Median daily movement distances (m) by caribou for the GNWT Environment and Climate Change (ECC), and Government of Nunavut Department of Environment (Nunavut) data sets.

We used heat mapping to demonstrate the relative distribution of caribou collars on a monthly basis using the monthly median for kernel radius and Epanechnikov kernel shape (QGIS Heatmap plugin). To highlight areas where caribou collar density (and presumably caribou distribution) was greatest we mapped centers of activity as collar density above the mean map average (the average density across all mapped caribou distribution).

We produced monthly maps showing caribou distribution and the distribution of reported wolf harvests. Given the scale of mapping, adjacent wolf kill locations within ~25 km were shown on the maps as a single dot representing the cumulative number of wolves harvested.

For each reported wolf kill location we calculated:

1. The distance to the nearest caribou heat map boundary (the mapped boundary between caribou distribution and no caribou);
2. The distance to the nearest caribou center of activity (collar densities greater than the map average); and
3. Distance to the community from the kill data, where the hunting party originated.

To demonstrate the distribution of caribou herds in relation to the wolf harvest we also produced a single month's map from all seasons (March 2019, April 2020 and April 2021) using un-weighted heat mapping for each herd. We used a 10-km kernel for each herd.

Proportion of wolf packs harvested

We examined the spatial and temporal clustering of the harvest in an effort to assess whether hunting was effective at removing entire packs. We used two methods to examine this question. In the "QGIS assessment" method we examined the locations and dates of wolf harvest by community. Within the database we used reported data on whether the harvested wolf was alone, the number of individual wolves observed and comments to determine what proportion of entire groups were removed, as well as spatial and temporal associations to better interpret the data. For example, if two different wolf harvests on the same day within reasonable proximity to each other (often <5 km to a maximum of 15 km) both said pack size was two, we assumed the entire pack of two was removed. To a large extent this depended on accurate reporting of wolf harvest locations and whether the number of individual wolves in the pack was recorded. If no pack size was recorded the number of wolves in the pack prior to harvest was unknown.

In addition to the visual grouping, we also conducted a "rules-based" date and distance data assessment to 'assign' pack size using a hierarchical approach to group observations, initially grouping by community, date and location, assigning 6 apparent lone wolves to pairs (same date and latitude-longitude). We found some issues with the data where observed pack size and whether more than a lone wolf was observed and harvested were not consistently recorded. In addition, observations of harvest on the same day within a 5–10 km were considered a pack. If no observations of pack size were noted then the number observed was set equal to the number harvested for a given group. This may underestimate the number observed, however, again, it was not possible to evaluate this potential bias with the information available. We acknowledge that this approach might not classify packs or all harvest events correctly. For example, if a pack was hunted over a long distance with different latitude-longitude for each kill then it is possible that the pack would be divided into multiple harvest groups. As discussed later, to mitigate these issues we suggest that future data collection should include a "pack ID" of similar on each set of records in the database to delineate whether the same group of wolves was targeted among records.

Logistic regression (Hosmer and Lemeshow 2000) was used to test for factors that affected harvest success, with harvest success estimated as wolves harvested divided by wolves observed. An event/trials input format was used (i.e., wolves harvested/wolves observed) for logistic regression models, therefore accounting for different sample sizes of wolves observed in the estimation of percent harvested. Logistic regression analysis was conducted using the *glm* function included in program R (R Development Core Team 2009). Results from all analyses were plotted using the *ggplot2* package (Wickham 2009) with GIS analyses conducted using the *sf* package (Pebesma 2018) in *R.* Data manipulation was conducted using the *dplyr* (Wickham 2011) and *lubridate* (Grolemund and Wickham 2011) *R* packages.

Results

Wolf harvest

Seasonal caribou movements generally matched known patterns of calving in northern and eastern mainland Nunavut followed by movements south and west away from calving areas towards and into treeline for the winter (see monthly heat maps in Appendix 2). Collared DU caribou mostly calved and summered on Victoria Island and wintered on the Nunavut mainland.

Kitikmeot 2018-19

During 2018-19, 146 wolves were recorded harvested within the Kitikmeot, primarily by hunters from Kugluktuk (69% of the regional harvest; Table 1). Two main concentrations of harvest were detected from Kugluktuk hunters, around Napaktulik (Takijuq) Lake (*n* = 41) and around the northern portion of Contwoyto Lake (*n* = 44; Fig. 3). Cambridge Bay hunters primarily harvested wolves on the south coast of Victoria Island <100 km from the community and on Kent Peninsula. All wolves were reported as shot.

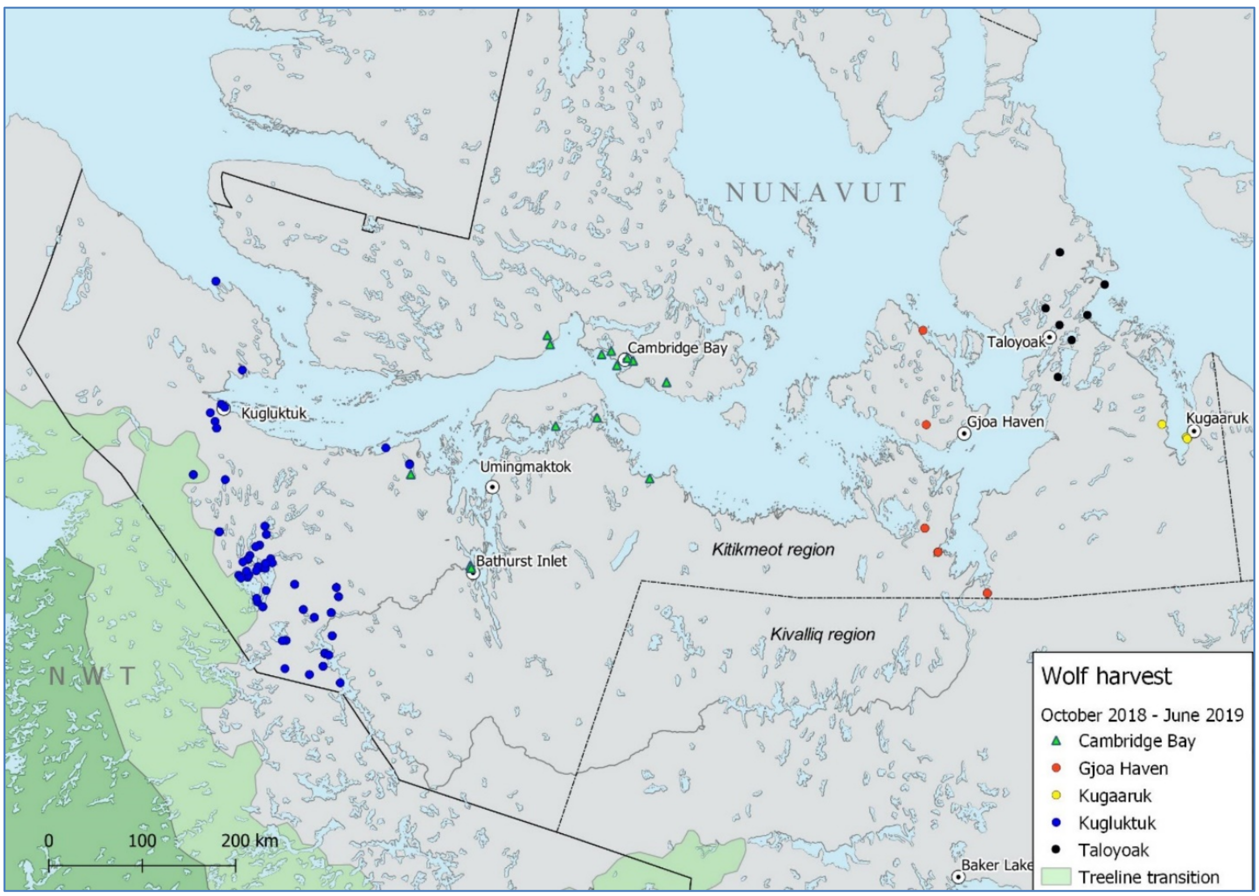

Figure 3. Distribution of reported wolf harvest in the Kitikmeot Region, 2018-19. Symbols may represent >1 wolf harvested at that location.

Table 1. Number and sex of recorded wolf harvests by community, Kitikmeot Region, 2018-19.

Community	Female	Male	Unknown	Total
Kugluktuk	36	50	15	101
Cambridge Bay	10	11	0	21
Gjoa Haven	2	11	0	13
Taloyoak	1	5	2	8
Kugaaruk	2	1	0	3
Total	51	78	17	146

A total of 52 hunters reported harvesting wolves. A single hunter from Kugluktuk (resident of an outpost camp) accounted for 32% of the regions' harvest (Table 2).

Table 2. Distribution of wolf harvest by individual hunters, Kitikmeot Region, 2018-19.

Number of wolves	1	2	3	4	5	6	12	46
Number of hunters	31	11	2	2	3	1	1	1
% of harvest	21	15	4	6	10	4	8	32

Four wolves were recorded as harvested in October and November 2018 (all relatively closes to communities), with increased harvest in December (Table 3). Nearly three-quarters (71%) of the regional harvest occurred during February to May.

Table 3. Distribution (*n* = 146), mean age (*n* = 139) and proportion of males (*n* = 128) in the monthly wolf harvest, Kitikmeot Region, 2018-19.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Number	2	2	21	11	31	25	27	21	6
Age (yrs)									
Mean	0.5	1.0	1.7	2.8	3.5	3.6	1.5	3.0	2.2
SE	0.49		0.52	0.60	0.47	0.52	0.35	0.48	0.90
n	2	1	21	10	29	25	25	20	6
Sex									
% males	100	100	67	55	52	60	52	68	100
n	2	2	6	11	31	25	27	19	5

Males comprised 60% of the harvest, with a slight peak in males in the harvest early and late in the season (Table 3). The age distribution of harvested wolves (*n* = 139) changed as the season progressed with juveniles comprising 54% of the harvest during October to December, with higher proportions of 1–3-

year-olds later in the season (Table 3, Fig. 4). Juveniles were heavily harvested early in the season and a wider distribution of ages harvested as the season progressed. The mean age of harvested wolves peaked in February and March (Table 3).

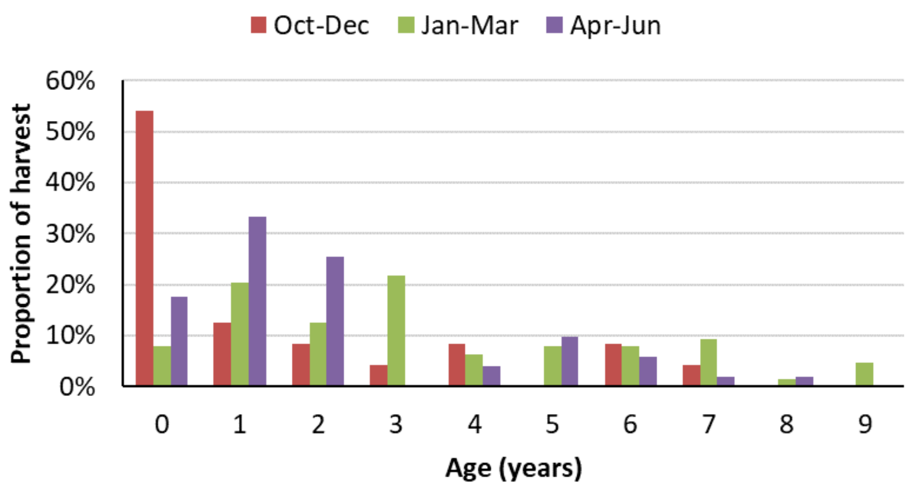

Figure 4. Distribution of age of harvested wolves by 3-month period, Kitikmeot Region, 2018-19 (*n* = 139).

Nunavut 2019-20

During 2019-20, 658 wolves were recorded harvested within Nunavut, with 64% of the harvest from Arviat, Baker Lake and Kugluktuk hunters (Fig. 5; Table 4). Only 34 wolves were reported harvested within the Qikiqtaaluk region (within the High Arctic), 5% of the Nunavut collection. Concentrations of harvested wolves included west and southwest of Arviat, near Dubawnt Lake, about 350 km west of Arviat, 50 km north of Baker Lake, and north of Aberdeen Lake. Rankin Inlet hunters occasionally travelled to meet the returning QM herd in late spring, to areas traditionally hunted by Arviat hunters. The distribution of peak harvest was bi-modal, with a small peak in November and a higher peak in March-May (Table 5). Six of the wolves (1%) were reported as trapped (4 of these from Baker Lake) and the remainder were shot.

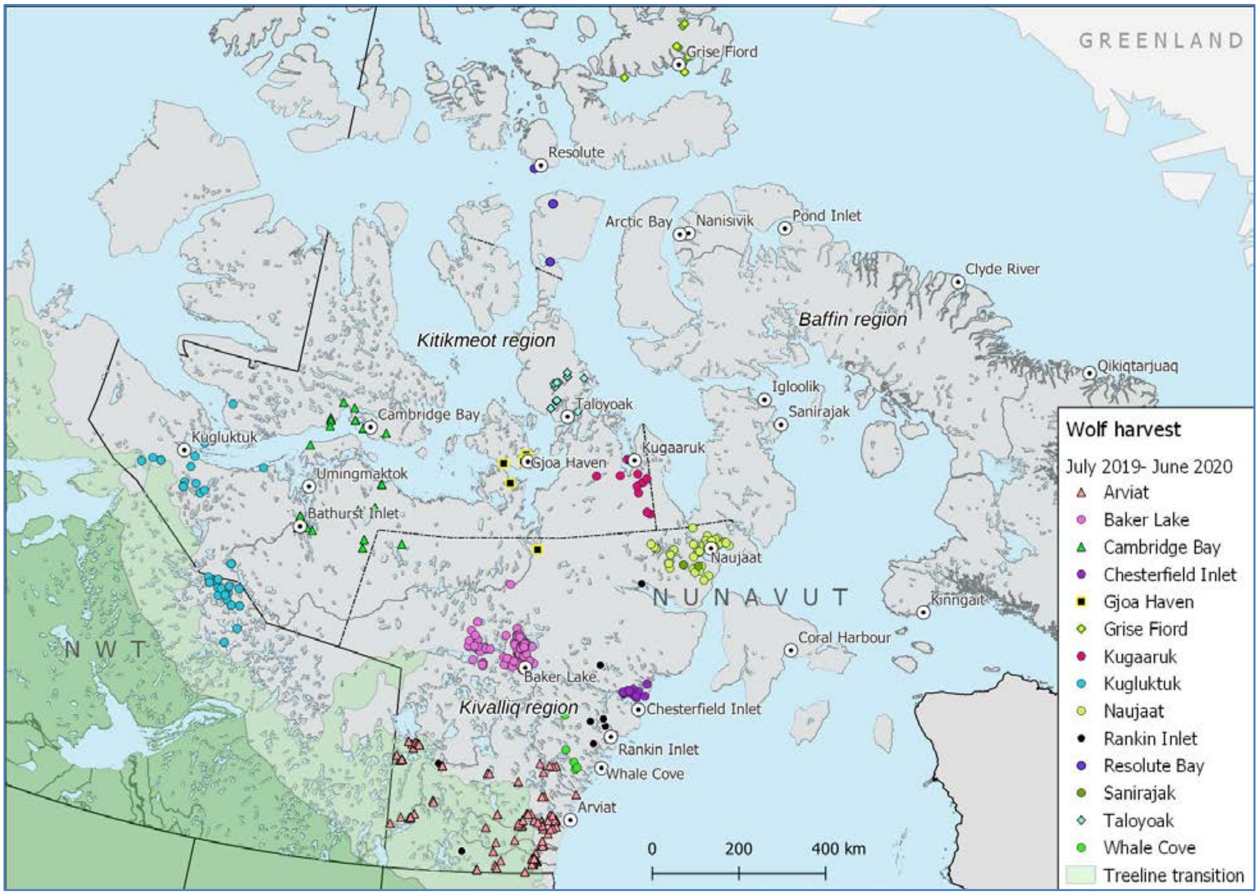

Figure 5. Distribution of reported wolf harvest in Nunavut, 2019-20. Symbols may represent >1 wolf harvested at that location.

Table 4. Number and sex of recorded wolf harvests by community, Nunavut, 2019-20.

Region	Community	Female	Male	Unknown	Total
Kitikmeot		**69**	**83**	**1**	**155**
	Cambridge Bay	10	25		35
	Gjoa Haven	4	5	1	10
	Kugaaruk	2	13		15
	Kugluktuk	29	35		64
	Taloyoak	24	5		29
Kivalliq		**188**	**226**	**57**	**471**
	Arviat	70	97	57	224
	Baker Lake	63	67		130
	Chesterfield Inlet	10	8		18
	Naujaat	28	30		58
	Rankin Inlet	13	23		36
	Whale Cove	4	1		5
Qikiqtaaluk		**13**	**18**	**3**	**34**
	Grise Fiord	1	7	3	11
	Sanirajak	2	1		3
	Resolute Bay	10	10		20
	Total	**270**	**327**	**61**	**658**

Table 5. Distribution (*n* = 653), mean age (*n* = 604) and proportion of males (*n* = 592) in the monthly wolf harvest, Nunavut, 2019-20.

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
No.	2	2	7	17	95	41	39	53	128	182	83	4
Age (yrs)												
Mean	4.0	0.5	0.5	1.7	1.3	1.3	0.9	1.5	1.5	1.4	1.8	1.0
SE	3.00	0.50	0.50	0.55	0.24	0.27	0.24	0.27	0.18	0.15	0.19	0.00
n	2	2	4	17	93	40	39	52	116	174	63	2
Sex												
% males	100	100	86	47	54	34	69	51	54	60	55	25
n	1	2	7	17	95	41	39	53	113	145	75	4

Male wolves comprised 55% of the Nunavut harvest in 2019-20, with higher proportions of the males in the harvest from January to May (Table 5). The age distribution of younger harvested wolves changed as the season progressed with juveniles comprising 53% of the harvest during October to December and declining, and yearlings comprising 23% of the harvest and increasing (Fig. 6). The proportion of harvested adult wolves changed little as the season progressed. The mean age of harvested wolves peaked early and late in the winter (Table 5).

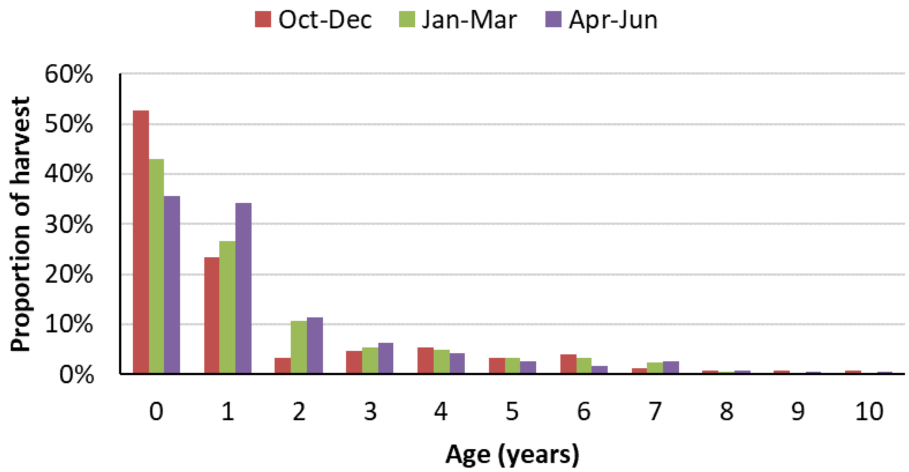

Figure 6. Distribution of age of harvested wolves by 3-month period, Nunavut, October 2019 – June 2020 (*n* = 596).

A total of 471 wolves were harvested by 123 hunters in the Kivalliq region during the 2019-20 season. (Table 6). Ten hunters (8%) each harvested over 10 wolves, contributing 38% of the wolf harvest, and 18 hunters (15%) took just over 50% of the wolves. A similar pattern was evident in the Kitikmeot region, with 8 (13%) of the 60 hunters harvesting 44% of the 153 wolves. Seven of the 21 hunters (33%) contributed nearly 60% of the 34 wolves harvested in the Qikiqtaaluk region.

Table 6. Distribution of wolf harvest by individual hunters by region, Nunavut, 2019-20.

Kitikmeot Region											
Number of wolves	1	2	3	4	5	6	7	8	11	18	
Number of hunters	36	6	4	5	1	4	1	1	1	1	
% of harvest	23	8	8	11	3	16	5	6	8	12	
Kivalliq Region											
Number of wolves	1	2	3	4	5	6	7	8	9	10	11-26
Number of hunters	49	22	16	5	13	2	1	1	2	2	10
% of harvest	10	9	10	4	14	3	1	2	4	4	38
Qikiqtaaluk Region											
Number of wolves	1	2	3	5							
Number of hunters	14	3	3	1							
% of harvest	41	18	26	15							

Nunavut 2020-21

During 2020-21, 699 wolves were recorded harvested within Nunavut, with 68% of the harvest from Arviat, Baker Lake and Kugluktuk hunters (Fig. 7; Table 7). Eight wolves were reported harvested within the Qikiqtaaluk region, 1% of the Nunavut total. Concentrations of harvested wolves included southwest of Arviat (but not as far west as in 2019-20), north, west and south of Baker Lake, and north of Point Lake in the NWT. Seven of the wolves (1%) were reported as trapped and the remainder were shot.

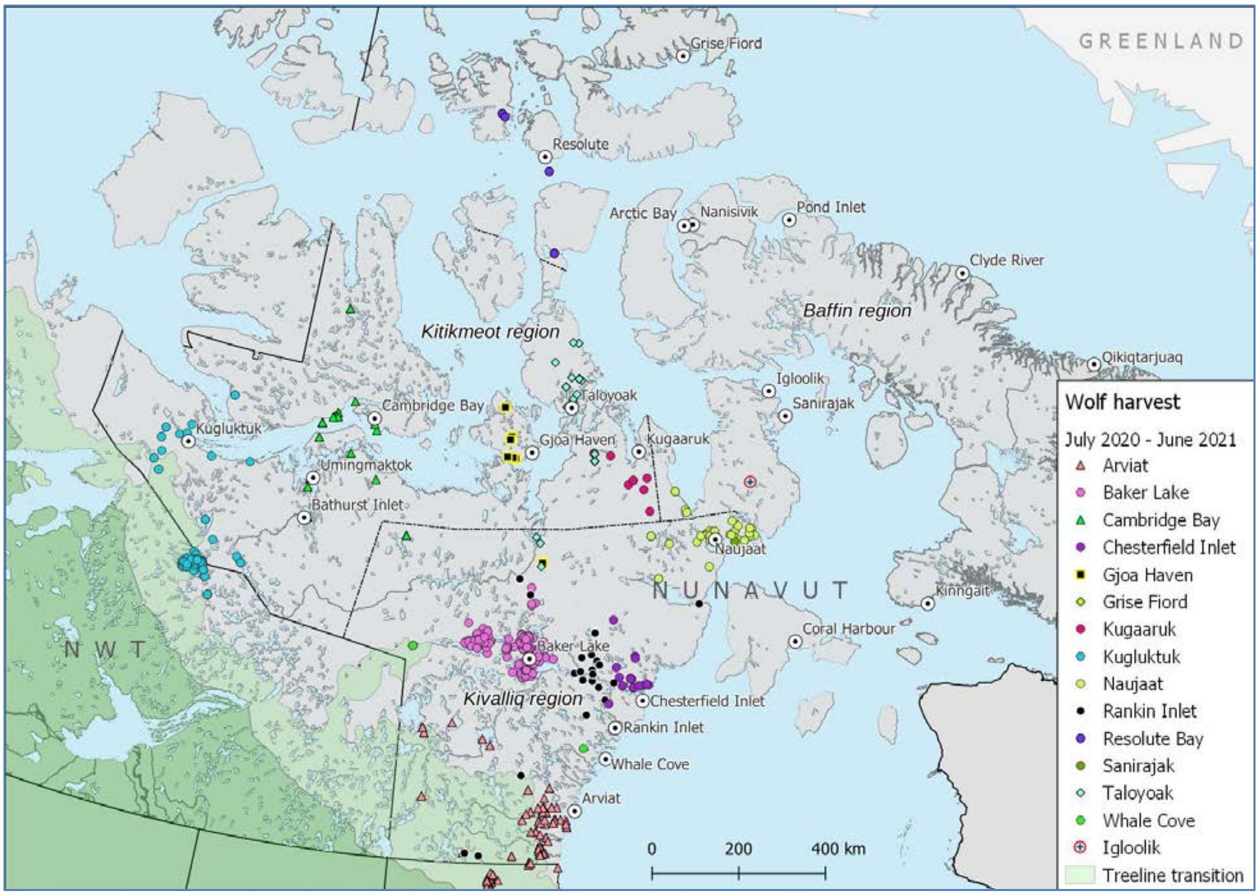

Figure 7. Distribution of reported wolf harvest in Nunavut, 2020-21. Symbols may represent >1 wolf harvested at that location.

Male wolves comprised 56% of the Nunavut harvest in 2020-21 (Table 7), with higher proportions of the males in the harvest in December and March (Table 8). The age distribution of younger harvested wolves changed as the season progressed with juveniles comprising 56% of the harvest during October to December and declining, and yearlings comprising 26% of the harvest and increasing (Fig. 8). The proportion of harvested 2-year-olds increased as the season progressed, and more 3–5-year-olds were harvested mid-winter. The mean age of harvested wolves peaked early and late in the winter (Table 8).

Table 7. Number and sex of recorded wolf harvests by community, Nunavut, 2020-21.

Region	Community	Female	Male	Unknown	Total
Kitikmeot		**84**	**120**	**10**	**214**
	Cambridge Bay	15	21		36
	Gjoa Haven	4	5		9
	Kugaaruk	5	7		12
	Kugluktuk	48	67	10	125
	Taloyoak	12	20		32
Kivalliq		**215**	**261**	**1**	**477**
	Arviat	58	74		132
	Baker Lake	108	113		221
	Chesterfield Inlet	8	15		23
	Naujaat	20	29	1	50
	Rankin Inlet	21	26		47
	Whale Cove		4		4
Qikiqtaaluk		**6**	**2**		**8**
	Sanirajak	1			1
	Igloolik		1		1
	Resolute Bay	5	1		6
	Total	**305**	**383**	**11**	**699**

Table 8. Distribution (n = 699), mean age (n = 599) and proportion of males (n = 685) in the monthly wolf harvest, Nunavut, 2020-21.

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
No.	4	1	5	7	113	81	85	78	142	113	60	6
Age (yrs)												
Mean	1.3	8.0	1.8	0.4	1.1	1.3	0.8	0.9	1.4	0.8	2.1	0.8
SE	0.33	0.00	1.18	0.20	0.19	0.22	0.17	0.18	0.16	0.18	0.28	0.17
n	3	1	4	7	113	80	79	53	114	81	58	6
Sex												
% males	50	100	60	86	53	59	46	54	64	55	47	83
n	4	1	5	7	113	81	85	78	141	104	60	6

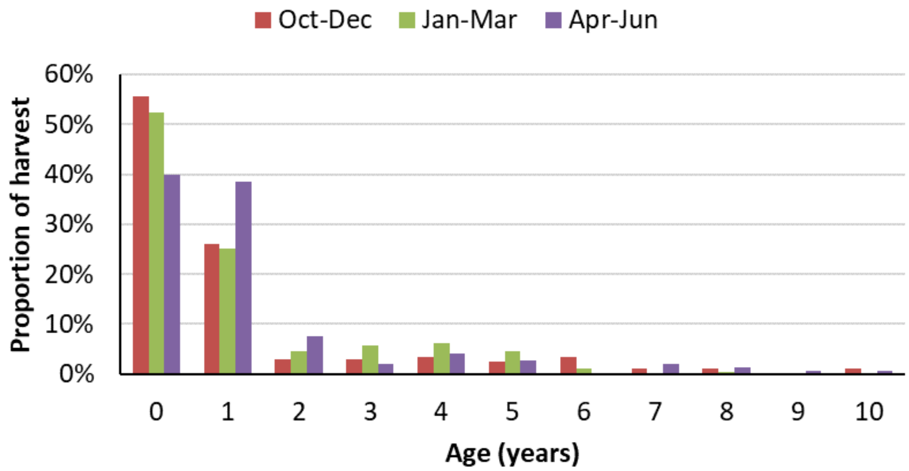

Figure 8. Distribution of age of harvested wolves by 3-month period, Nunavut, October 2020 – June 2021 (n = 591).

Summing among years, young wolves (aged 0–1 years) comprised 70–80% of the annual harvest in the Kitikmeot and Kivalliq regions in 2019-20 and 2020-21, increasing from 43% of the Kitikmeot harvest in 2018-19 (Fig. 9).

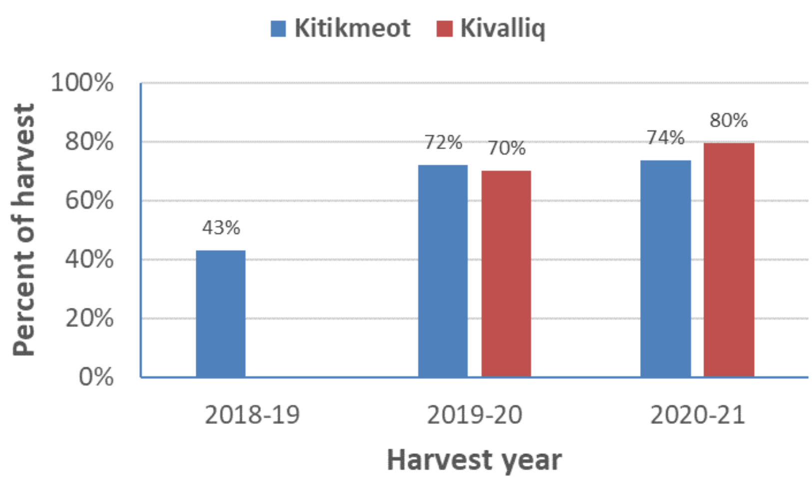

Figure 9. Proportion of young wolves within the annual harvest by Nunavut region, 2019-21.

A total of 477 wolves were harvested by 122 hunters in the Kivalliq region during the 2020-21 season. (Table 9). Nine hunters (7%) each harvested from 11-54 wolves, contributing 38% of the wolf harvest. One hunter from Baker Lake harvested 54 wolves, fully 11% of the regions harvest. In the Kitikmeot region, 4 (6%) of the 64 hunters harvesting 39% of the 214 wolves harvested, and one hunter accounted for 12% of the regions harvest.

Table 9. Distribution of wolf harvest by individual hunters by region, Nunavut, 2020-21.

Kitikmeot Region											
Number of wolves	1	2	3	4	5	6	8	10	11	26	
Number of hunters	31	7	13	3	1	2	2	1	2	1	
% of harvest	14	7	18	6	2	6	7	5	10	12	
Kivalliq Region											
Number of wolves	1	2	3	4	5	6	7	8	9	10	11-54
Number of hunters	51	22	16	8	1	8	1	4	2	0	9
% of harvest	11	9	10	7	1	10	1	7	4	0	38
Qikiqtaaluk Region											
Number of wolves	1	2									
Number of hunters	4	1									
% of harvest	67	33									

Harvesters' perception of wolf population trends

Harvesters' perception about trends in wolf populations differed among regions (χ^2 $P < 0.001$), but almost all believed that numbers were either stable or increasing (Table 10). About 16% more respondents believed wolf numbers were increasing in the Kitikmeot compared with the Kivalliq region. Note that the sample size does not reflect individual hunters, since a hunter may provide >1 harvested wolf to the program within and among years.

Table 10. Perception of wolf population trend (%) of wolf hunters providing carcasses for the Support for Active Harvesters program, 2018-19 – 2020-21.

Region	*n*	Decreasing	Stable	Increasing
Kitikmeot	504	0	40	60
Kivalliq	921	3	53	44
Qikiqtaaluk	24	0	33	67

Wolf harvest relative to distance from communities and caribou

Wolves were generally harvested closer to communities prior to Christmas (generally within 75 km) and further from communities later in the winter, with peak distances in April and May (Fig. 10). This pattern was less evident in 2018-19 within the Kitikmeot, where the harvest came predominantly from Kugluktuk hunters. However, in 2018-19 much of the Kugluktuk wolf harvest came from an outpost camp hunting near caribou concentrations around Napaktulik and Contwoyto lakes (M. Awan, unpubl. data).

Spatial and temporal patterns of wolf harvest differed among communities. Arviat hunters harvested wolves close to the community during October–December, and over a broad distance later in the winter, including over 450 km from the hamlet in 2019-20. Baker Lake showed a similar pattern at a reduced scale, harvesting within 100 km prior to Christmas (largely along the Meadowbank all-weather access road north of the hamlet), and further away during mid to late winter. Hunters from Kugluktuk largely harvested wolves further from the hamlet during the winter, depending on the winter distribution of caribou herds.

These patterns of harvest generally reflected the patterns of movement of higher densities of caribou (Appendix 2) and the restricted travel conditions early in the year.

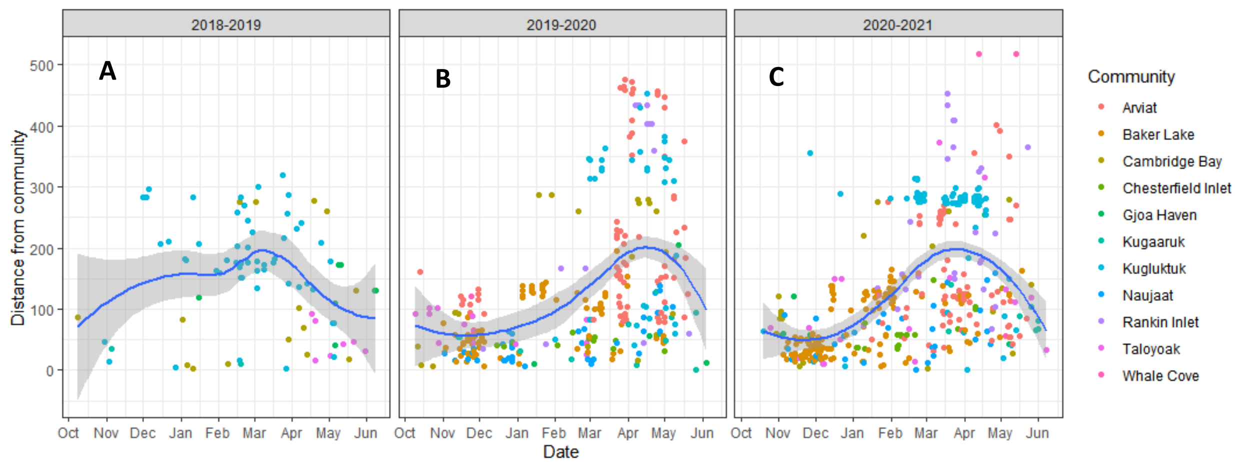

Figure 10. Wolf harvest locations plotted by distance from communities (km) during the A) 2018-19 (Kitikmeot), B) 2019-20 (Nunavut) and C) 2020-21 (Nunavut) harvest seasons. Smoothed lines provide an estimate of overall trend in the data set.

Hunters travelled up to 500 km from their communities to harvest wolves, but generally harvested wolves within 200 km of higher densities of collared caribou (Fig. 11). The communities that harvested wolves >200 km from higher density caribou occurrence were located where caribou collaring and hence caribou distribution within Nunavut were likely incomplete, mainly within the northeast Nunavut mainland: Kugaaruk, Naujaat, Taloyoak and Gjoa Haven, and to a lesser extent Cambridge Bay.

Estimated pack size and numbers of wolves harvested were higher closer to higher densities of caribou (Figs. 12, 13). Thus, even though the hunters were far from their communities, necessitating camping over day-trips, they encountered larger packs of wolves and were effective at harvesting larger number of wolves. Hunters from the communities of Kugaaruk, Naujaat, and Taloyoak did not follow this pattern, again likely related to limited collaring of caribou in those areas.

Communities such as Arviat and Kugluktuk, whose hunters move to areas with higher densities of caribou, were able to harvest large numbers of wolves close to those caribou. A spatial plot of this data set by year and distance from higher densities of caribou showed that areas of higher wolf harvest were often further from communities (Fig. 14). An exception appeared to be Baker Lake where most wolf harvest occurred within 150 km of the community.

In many cases the harvested wolves could be reliably “assigned” to a particular caribou herd when herd overlap was limited, but in some cases overlap of collared caribou from different herds meant assigning caribou herds to the wolf harvest was uncertain and problematic (Figs. 15, 16, 17).

Hunters appeared to focus their wolf harvest efforts where caribou densities were high. For example, the QM caribou herd was further from Arviat in April 2020 compared to April 2021, and the distribution of the wolf harvest mirrored this pattern (Figs. 16, 17).

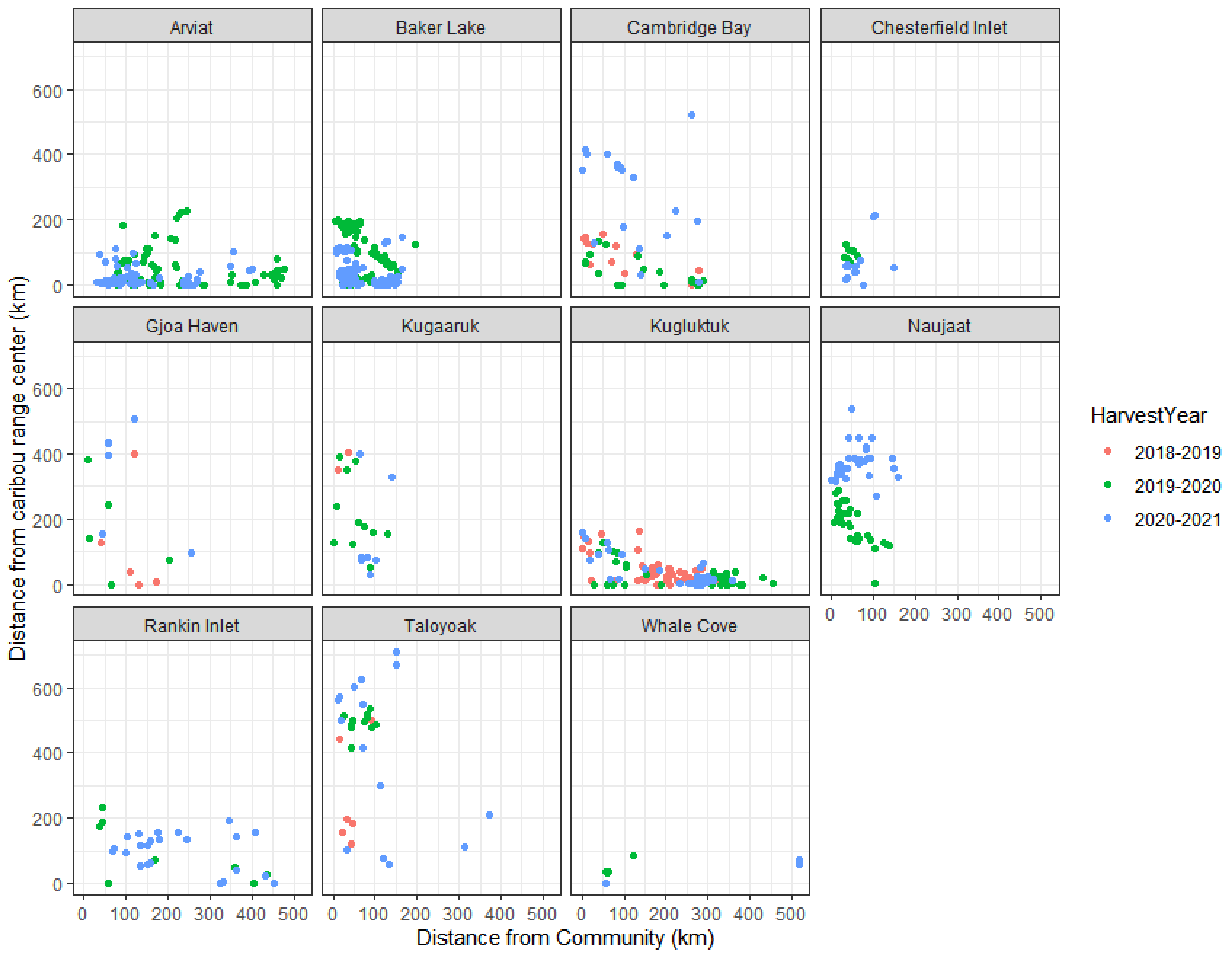

Figure 11. Relationship between wolf harvest distance from caribou centers of activity (higher densities) and communities, Kitikmeot 2018-19 and Nunavut 2019-20 and 2020-21.

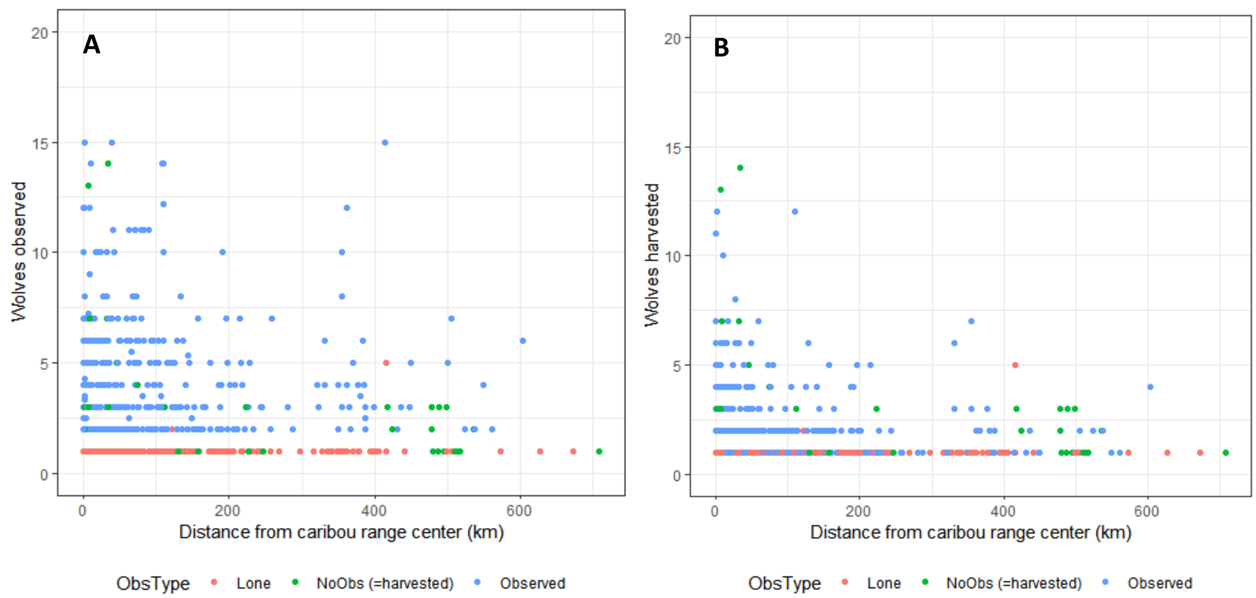

Figure 12. Number of wolves observed (A) and number of wolves harvested (B) relative to the distance from caribou centers of activity (higher densities), Kitikmeot 2018-19 and Nunavut 2019-20 and 2020-21 data combined. "Lone" = no group size reported but harvested at the same location on the same date; "NoObs" = no group size reported but harvested ≤5 km apart on the same date; "Observed" = pack size observation.

Figure 13. Number of wolves harvested related to distance from community and binned distances from higher densities of caribou, Kitikmeot 2018-19 and Nunavut 2019-20 and 2020-21.

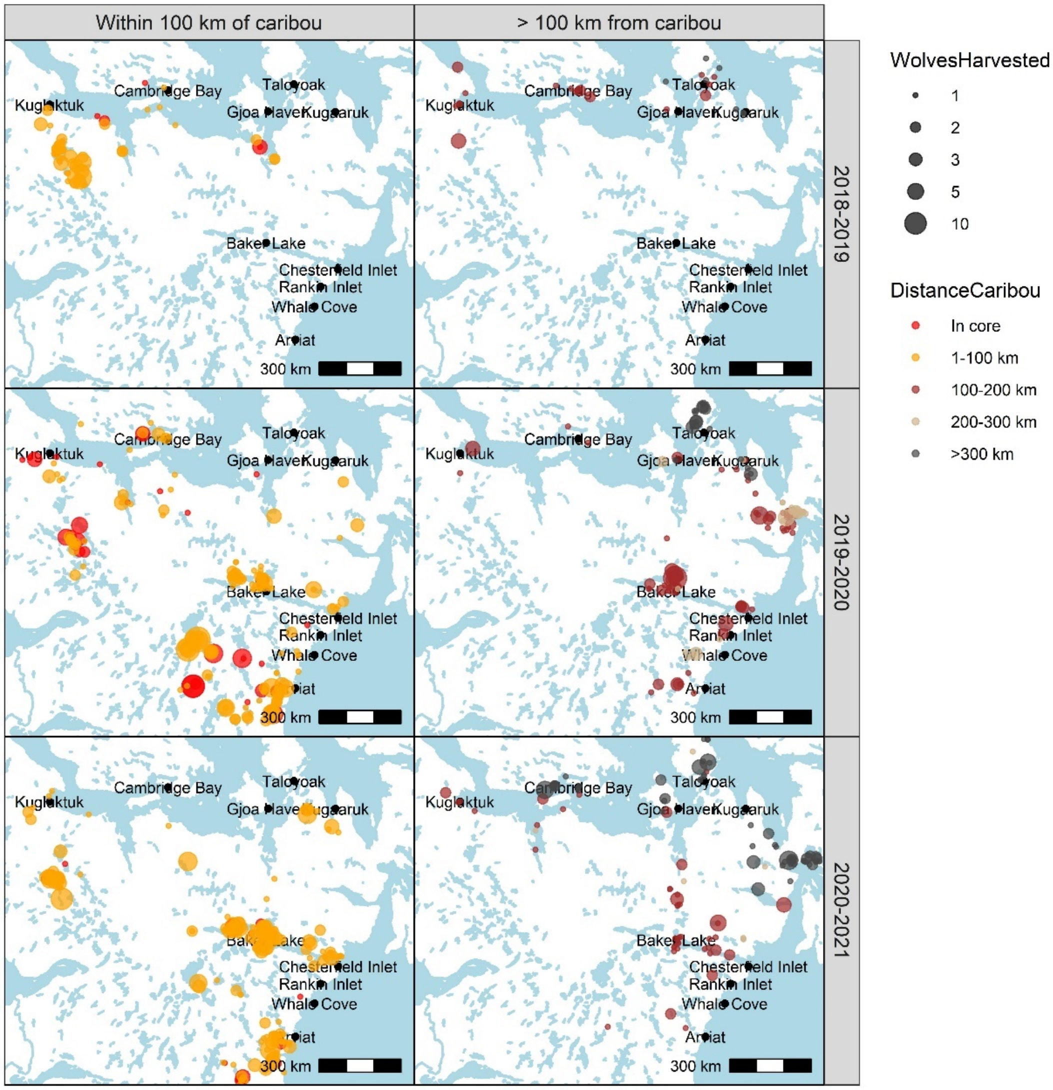

Figure 14. Locations of wolves harvested grouped by distance from areas of higher caribou density (DistanceCaribou), Kitikmeot 2018-19 and Nunavut 2019-20 and 2020-21.

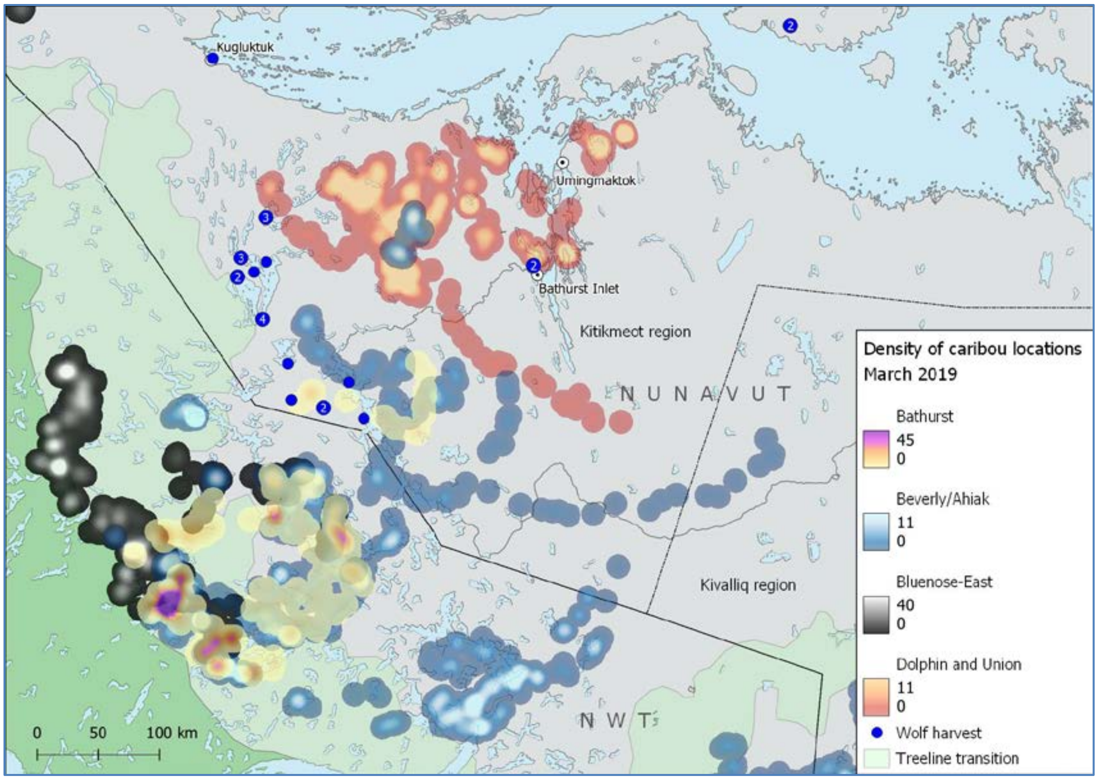

Figure 15. Collared caribou distribution by herd and wolf harvest collection locations, March 2019.

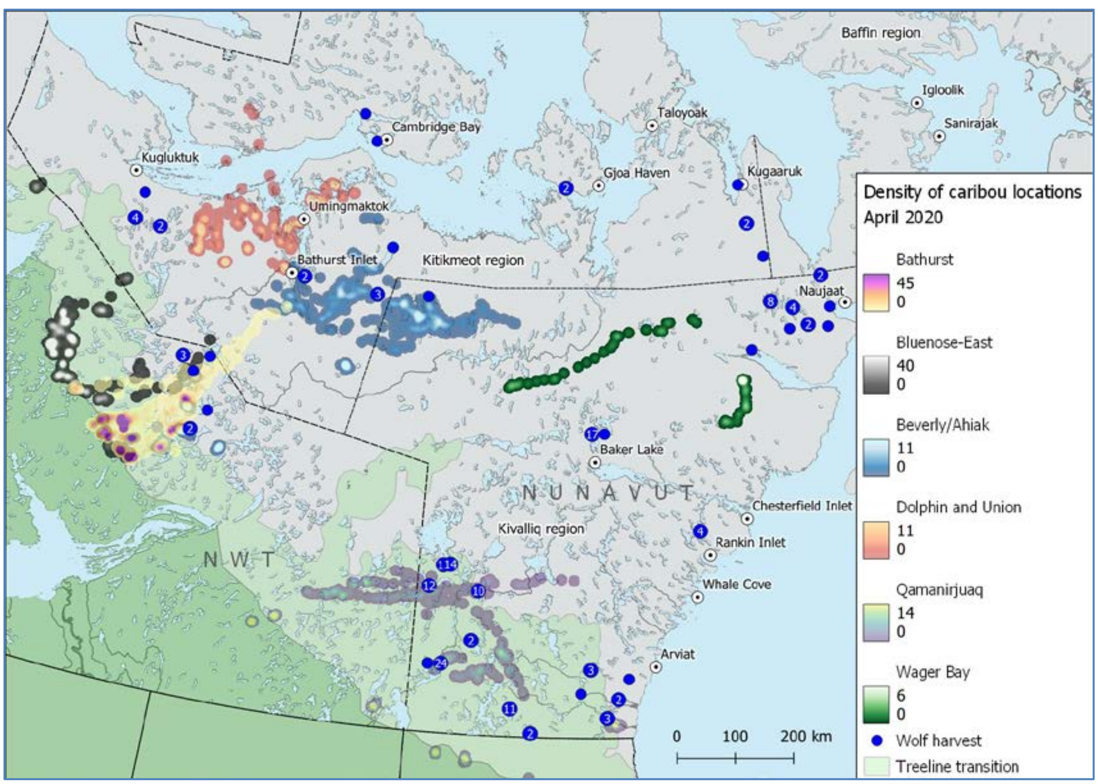

Figure 16. Collared caribou distribution by herd and wolf harvest collection locations, April 2020.

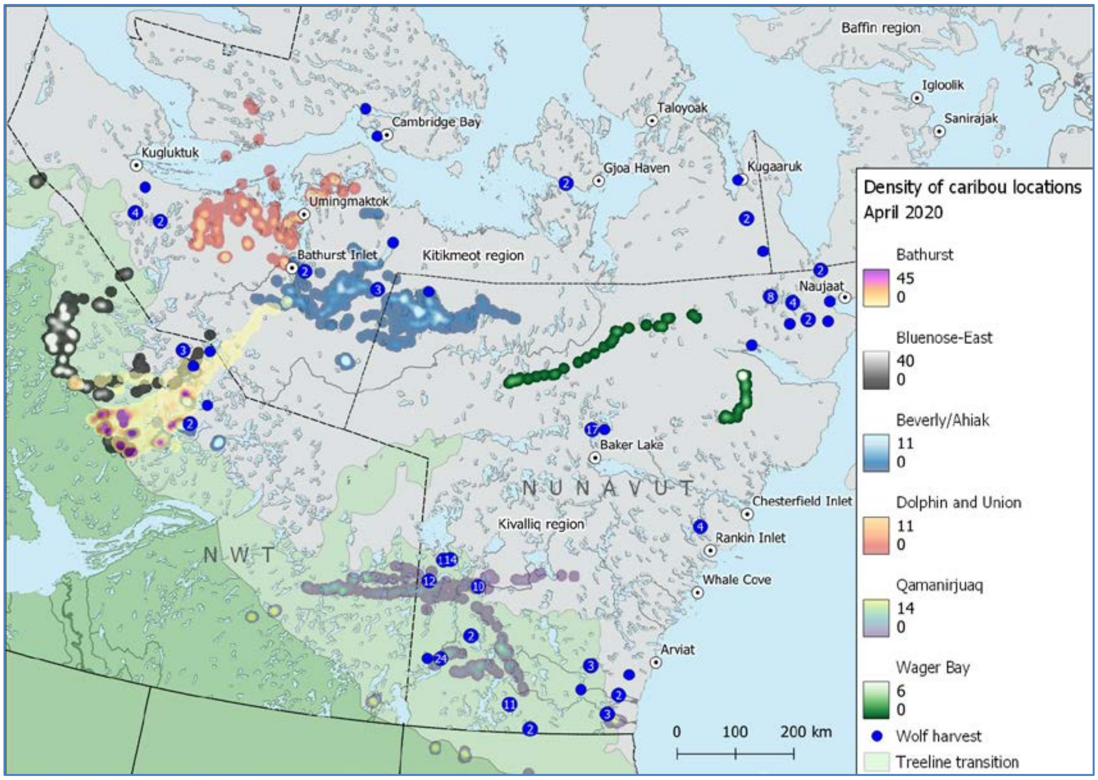

Figure 17. Collared caribou distribution by herd and wolf harvest collection locations, April 2021.

Proportion of wolf packs harvested

Kitikmeot 2018-19

Within the Kitikmeot in 2018-19 only Kugluktuk had sufficient samples sizes to examine the proportion of wolves harvested from packs observed (94% overall; *n* = 23 packs). The mean proportion of each pack harvested was high and trended higher across the winter, but monthly sample sizes were low (Fig. 18). Full packs were harvested on 87% of occasions.

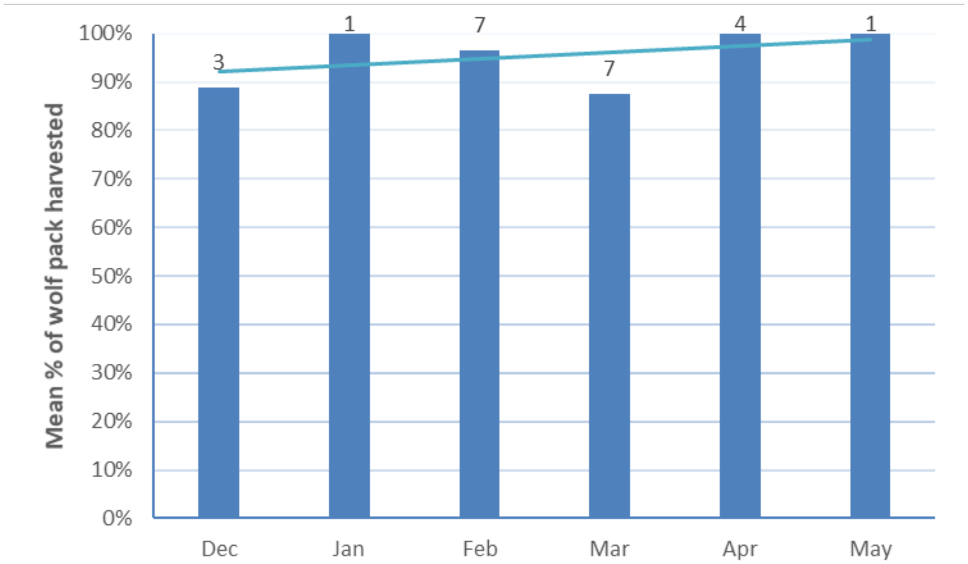

Figure 18. Mean proportion of wolf packs (≥2 wolves) harvested by month generated by QGIS assessment, Kitikmeot, 2018-19. Sample sizes shown above bars. Linear trendline added.

Nunavut 2019-20

Hunters from Arviat and Kugluktuk reported harvesting the greatest proportion of wolves from packs observed during 2019-20, roughly 75% (Fig. 19). Across Nunavut, the mean proportion of each pack harvested increased as the winter progressed from 50% in November to 75% in May (Fig. 20). Full packs were harvested on 35% of occasions across the season, with an increasing trend as the season progressed: 16% during October–December (n = 63), 39% during January–March (n = 76), and 50% during April and May (n = 68). It is likely that wolf packs in a given area were collectively harvested over time by different hunting parties until there were none left, but it is difficult to verify this assumption.

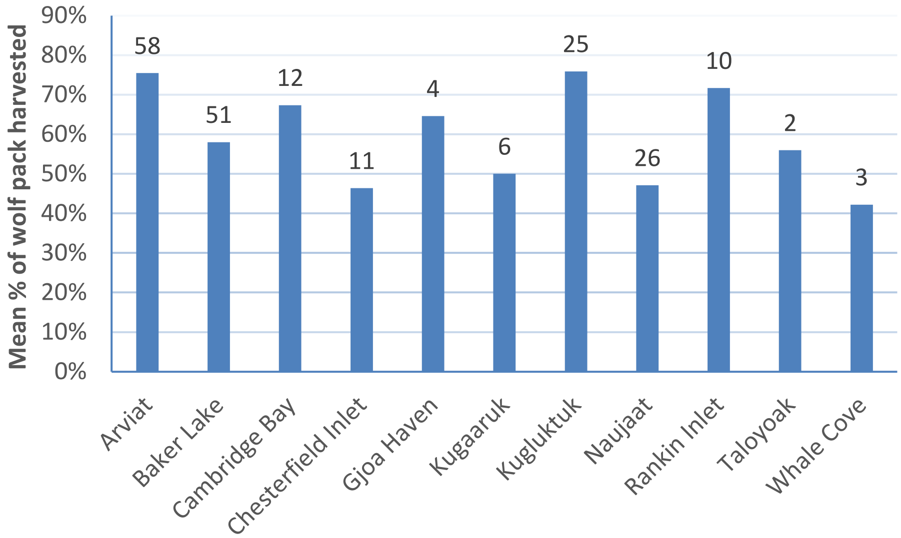

Figure 19. Mean proportion of wolf packs (≥2 wolves) harvested by community generated by QGIS assessment, Nunavut, 2019-20. Sample sizes shown above bars.

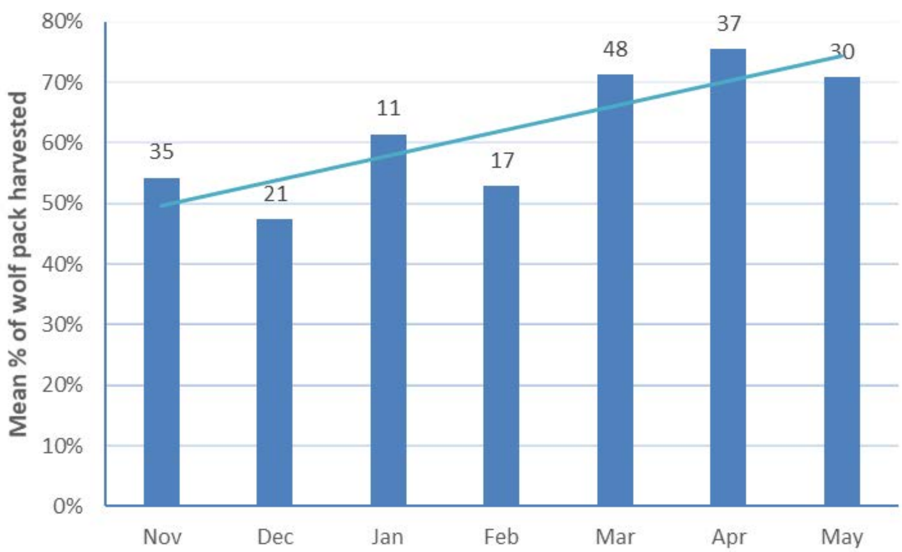

Figure 20. Mean proportion of wolf packs (≥2 wolves) harvested by month generated by QGIS assessment, Nunavut, 2019-20. Sample sizes shown above bars. Linear trendline added.

Nunavut 2020-21

Hunters from Arviat reported harvesting the greatest proportion of wolves from packs observed during 2020-21 (85%), with most harvesting 50–70% of packs (Fig. 21). Across Nunavut, the mean proportion of each pack harvested again increased as the winter progressed (Fig. 22). Full packs were harvested on 40%

of occasions across the season, with an increasing trend as the season progressed: 22% during October–December (n = 64), 42% during January–March (n = 102), and 56% during April and May (n = 54). Arviat hunters harvested full packs 73% the time overall.

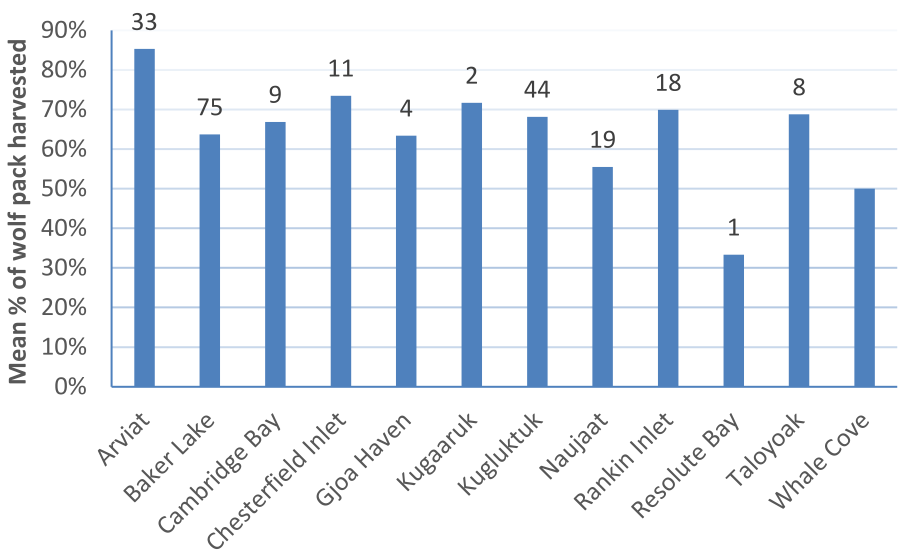

Figure 21. Mean proportion of wolf packs (≥2 wolves) harvested by community generated by QGIS assessment, Nunavut, 2020-21. Sample sizes shown above bars.

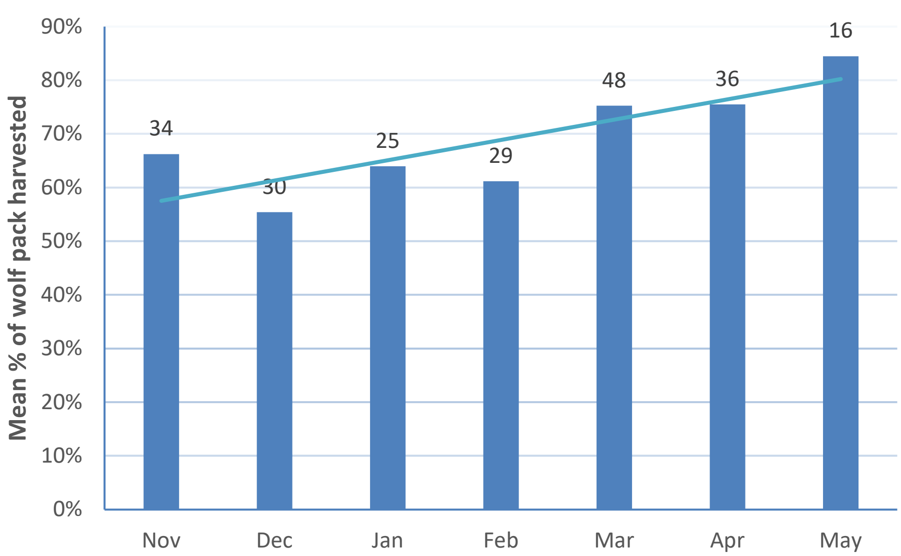

Figure 22. Mean proportion of wolf packs (≥2 wolves) harvested by month generated by QGIS assessment, Nunavut, 2020-21. Sample sizes shown above bars. Linear trendline added.

All data combined

Combining all data and using the rules-based assessment we tested the effect of the number of wolves observed, an index of pack size, on percent harvested. The resulting data set had 841 packs or individuals defined, 301 of which were single wolf observations and could not be used to define percent of pack or group harvested, leaving 540 groups of ≥2 wolves to assess harvest success. Wolves observed (log-transformed) was a significant predictor of percent harvested (Z = -5.7, $P < 0.0001$), with lower percentage of wolf packs harvested as pack size increased (Fig. 23). This result is likely because it is easier to harvest most or all of small packs than large packs.

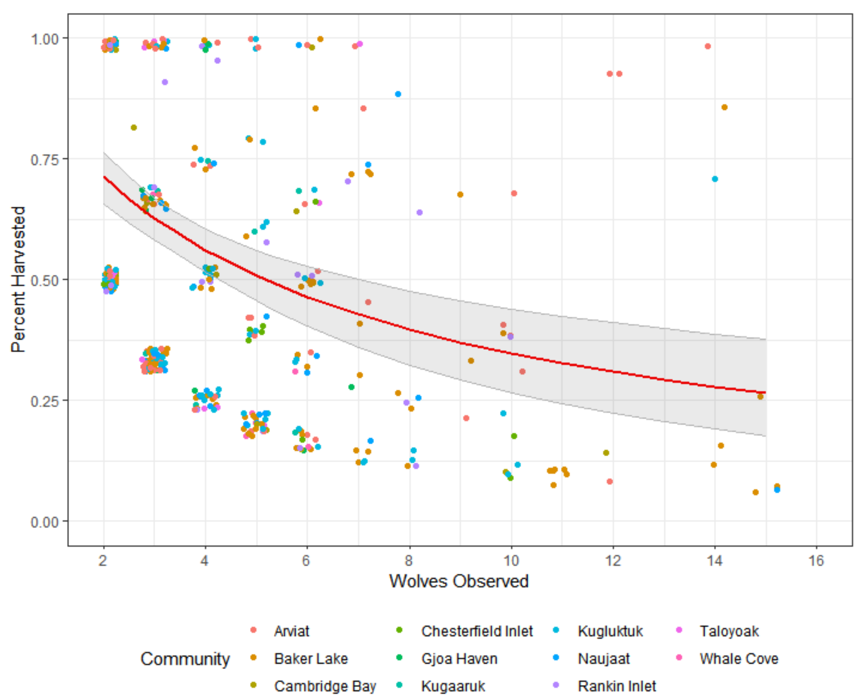

Figure 23. The proportion of wolf packs harvested by pack size (wolves observed) using a rules-based assessment, data combined for 2018-21. Points are jittered to increase interpretation. Predictions of mean percent harvested from logistic regression analysis with log(wolves observed) as a predictor are shown (red line). Confidence intervals are shaded around the prediction line.

Of additional interest was whether a temporal trend in harvest could be detected. For this analysis the data set was reduced to the 3 communities with the most harvest data – Arviat, Baker Lake, and Kugluktuk. Models were considered with community, wolves observed, and date for each harvest year. A model with harvest year, date of harvest, and wolves observed was used to control for harvest year and the effect of the number of wolves on harvest rate. Interactions between community and date of harvest were tested with no significant differences detected. A model with an additive effect of date across all communities had some support with date of harvest being significant (Z = 2.2, $P = 0.02$) in addition to pack size (Z = -

4.1, *P* < 0.0001; Fig. 24). A plot of predictions (standardized for a mean pack size of 4 wolves) revealed a weak trend with harvest rate increasing as the season progressed.

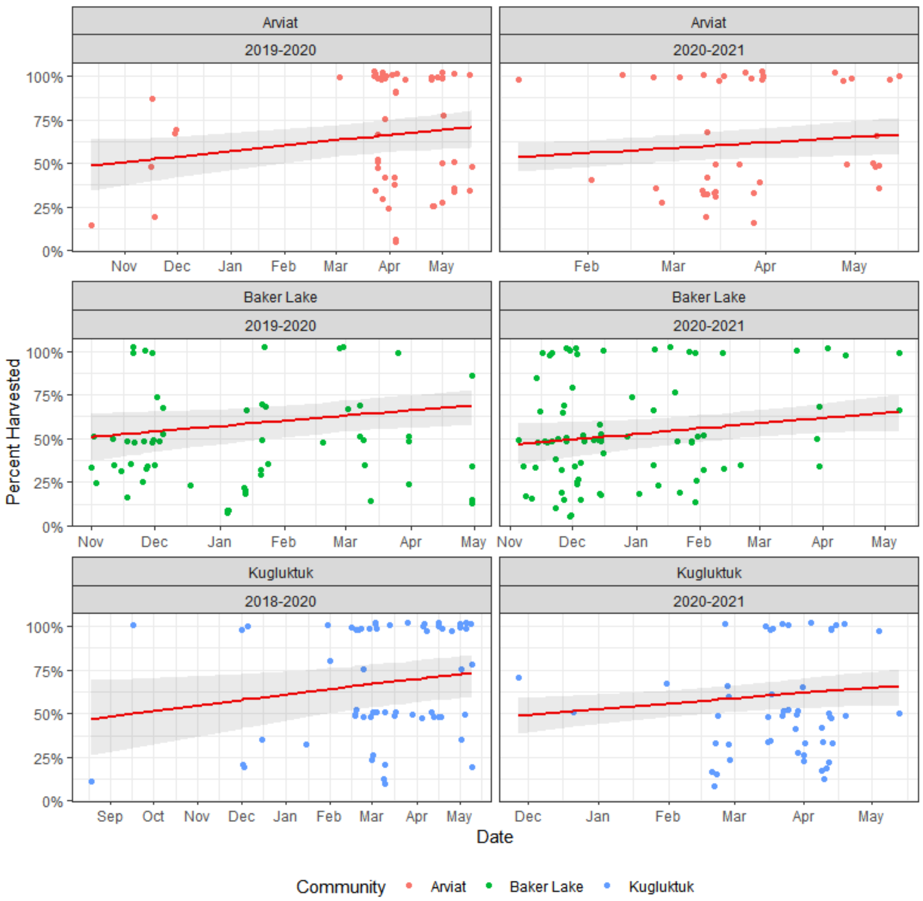

Figure 24. The proportion of wolf packs harvested by date using a rules-based assessment for 3 communities across different harvest periods. Points are jittered to increase interpretation. Predictions of mean percent harvested from logistic regression analysis with date as a predictor with log(wolves observed) set at mean values (4 wolves; red lines). Confidence intervals are shaded around the prediction line.

Wolf numbers and proportion harvested

One of our objectives was to attempt to estimate how many wolves may be associated with the migratory QM herd during winter, and thus what proportion of the wolves is being harvested by community hunters. We focussed on the QM herd because recent estimates of herd size were available (Boulanger et al. 2018) and there was little overlap with adjacent herds. No field-based estimates of wolf numbers in Nunavut are available. Methods to estimate wolf numbers using ungulate biomass (Kuzyk and Hatter 2014, Nishi et al. 2020) are complicated by the need to calculate wolf density over the massive range of the migratory

QM caribou herd, as well as to consider the substantial number of muskoxen present in portions of the range. The ungulate biomass method makes numerous assumptions and therefore this estimate may not pertain to the current wolf population in migratory caribou ranges. Ungulate biomass could be used to explore wolf numbers; however, we strongly caution against using these estimates to define management targets.

Nishi et al. (2020) used a 'ungulate biomass index' (UBI) regression equation (Kuzyk and Hatter 2014) to derive wolf density estimates applied to 95% utilization distribution of caribou winter range size.

$Y = 5.4x - 0.166x^2$

where y = wolf density (wolves/1,000 km^2) and x = ungulate biomass index/km^2. Barren-ground caribou were assigned a relative biomass value of 2, therefore estimates of caribou density (caribou/km^2) were multiplied by a factor of 2 to generate the UBI biomass index. Muskoxen and moose were not considered in this current 'back of the envelope' calculation.

Assuming approximately 250,000 QM caribou within a winter range covering about 70,000 km^2 (mean annual 95% utilization distribution from 2017-18 to 2021-22; Caslys Consulting, unpubl. data), the UBI calculation estimated approximately 2,100 wolves in total associated with the QM herd during winter. Alternatively, ECC used a ratio of roughly 10 wolves/1,000 caribou on winter range (Nishi et al. 2020: Tables 24–26), which means (assuming ~250,000 QM caribou) there would be ~2,500 wolves in total associated with the winter range of the QM herd. Parker (1972) estimated a ratio of 1 wolf per 114 caribou, equating to an estimate of approximately 2,200 wolves associated with the herd. This approach also assumes availability of caribou to wolves at all times and does not consider the impact of predator control or other measures on wolf abundance. All these factors likely will cause variation in actual wolf abundance and for this reason the UBI index and other ratios should be interpreted cautiously.

These rough calculations of wolf abundance associated with the QM caribou winter range suggest that, assuming the communities of Whale Cove, Arviat and Rankin Inlet hunt wolves associated with the QM herd and that the wolf harvest levels from 2019-20 (265 wolves) and 2020-21 (183 wolves) are usually attained, Nunavut hunters are harvesting ~9–13% of the wolf population associated with the QM herd during winter and spring each year. However, these calculations overlook that a portion of the wolf population will not follow the QM herd onto the tundra and become potentially available to NU hunters. The proportion of the wolf population associated with the QM herd that is available to NU harvesters is unknown, but based on movements of a limited number of collared wolves in the NWT and data from Russia, perhaps 50–70% of wolves migrate with herds in spring (Kolpaschikov et al. 2015, Clark et al. 2021), meaning that NU hunters are taking a larger proportion of the wolves associated with the QM and available to harvesting on the tundra, perhaps in the 12–25% range.

Discussion

Wolf harvesting is a traditional part of the culture of Nunavut hunters, as well as a source of seasonal income. During 2018-19 to 2020-21, the number of harvested wolves fluctuated but the number of hunters remain more or less the same. Some hunters hunt wolves occasionally while hunting caribou and/or muskoxen, and some hunt wolves on a more regular basis. Almost all wolves (~99%) were shot with few animals trapped. The effectiveness of Nunavut wolf hunters appears high, with large annual harvests from some communities, especially Arviat, Baker Lake and Kugluktuk. Within the North Slave region of the NWT, the catch per unit effort by Nunavut harvesters was 2 magnitudes higher than that of NWT harvesters (based on harvester questionnaires; Nishi et al. 2020). Nunavut hunters travel long distances to harvest wolves, often later in the winter and generally towards higher densities of caribou (as indexed by collared individuals), similar to other Arctic areas (Hayes et al. 2016).

The proportion of packs harvested differed among communities, but generally decreased as pack size increased and increased as the season progressed. Effectiveness of harvesting small packs of wolves was high, with roughly 50–60% harvest of packs with ≥3 individuals; the proportion of each pack removed increased as winter progresses, possibly related to longer daylight and better travel conditions. Removal of entire wolf packs may reduce caribou predation rates since partial removal can cause pack splitting and formation of more numerous packs (number of packs is a strong determinant on predation rates) and smaller packs (per capita kill rates are higher in smaller packs; Ballard et al. 1997, Hayes et al. 2000).

The proportion of immature individuals in a harvest is a valuable indicator of the impact of removal programs on carnivore populations (Kelsall 1968, Robinson et al. 2008). Largely based on the intensive wolf control programs (primarily wide-spread poisoning) conducted in the NWT during the mid-1950s to early 1960s, Kelsall (1968) and Fuller and Novakowski (1955) suggested that the proportion of young wolves in the harvest would shift from 10–20% in unexploited wolf populations, to 65–75% in heavily exploited populations. The age structure observed in both the Kitikmeot and Kivalliq regions in 2019-20 and 2020-21 (70–80% young wolves) indicate high levels of exploitation of the segment of the wolf population accessible to harvesters.

Many caribou herds within mainland NWT/Nunavut overlap during portions of the year, making it difficult to “assign” a harvested wolf to a particular herd. In recent years there has been extensive overlap north of Yellowknife among the BA, BE and BV herds (ECC, unpubl. data). ECC used an elaborate approach to assign harvested wolves to caribou herds when examining ground and aerial wolf harvest conducted in late winter 2019-20 (Nishi et al. 2020). However, hunters from Arviat, Whale Cove and Rankin Inlet target only what could be considered QM wolves, harvesting 265 and 183 wolves from the QM caribou herds’ range in 2019-20 and 2020-21, respectively. Although not a large proportion of the total number of wolves associated with the entire QM herd, assuming each wolf may consume approximately 29 caribou annually (Hayes and Russell 2000, WFATWG 2017: Appendix F), this represents about 5,300–7,700 caribou not predated or approximately 2–3% of the current QM population estimate.

For the QM herd where “assigning” harvested wolves to a particular herd is possible, approximately 12–25% of wolves associated with the herd during spring migration and pre-calving movements may be harvested by Nunavut hunters each year. These values, while impressive, are still far lower than the >55–

60% annual harvest required to maintain reduced wolf densities sufficiently to illicit a demographic response in an ungulate population (National Research Council 1997, McLaren 2016, Nishi et al. 2020). Regardless, given high harvests of wolves south and southwest of Arviat during March, April and May, it is likely that both the numbers of wolves and number of wolf-killed QM caribou are greatly reduced as the herd migrates during late winter and spring to their calving grounds west of the coast of Hudson Bay. This results in hunters targeting wolves following migrating caribou to their calving grounds and the removal of most resident wolves from the calving grounds, and therefore low numbers of wolves and reduced wolf predation on the calving and post-calving grounds. Low predation rates of new-born QM calves in the early 2010s were attributed to high harvest rates of wolves during pre-calving migration (Szor et al. 2014).

This level of harvest pressure requires annual effort since adjacent wolf populations can quickly respond to reduced wolf density by long-distance dispersal and increasing natality rates (Schmidt et al. 2017). It is possible that the traditional harvest of large numbers of wolves by coastal communities may have influenced demographic trends in the QM herd. Demographic analysis of the QM herd is being conducted in unison with the 2022 calving ground survey (J. Boulanger, pers. comm.). Results from this survey should provide further inference on QM status and associated demographic trends.

From 1995 to 1998, an average of 146 wolves were harvested annually in the Qikiqtaaluk Region, with about 80% taken from Baffin Island (Krizan 1999, unpubl. data). Caribou numbers on Baffin Island were likely high to declining during the 1990s (Campbell et al. 2015). These wolf harvests are minimum counts; a hunter survey in the Qikiqtaaluk region in 1998 showed that approximately one half of the harvest was used privately for clothing or sold locally (and hence not enumerated in the system), with the other half was sent to fur auctions (Krizan 1999). No wolves harvested from Baffin Island were detected by the Nunavut-wide Support for Active Harvesters program over 2 years, during a period of very low caribou numbers (Campbell et al. 2015, Ringrose 2018) and no significant secondary prey to maintain wolf populations. Where alternative large prey is absent, such as on Baffin Island, wolf populations will generally decline with declining primary prey (Mech 2005). Despite low and/or declining populations of caribou within the central mainland Nunavut (Kitikmeot Region), high wolf abundance can be sustained by alternative large prey, such as muskoxen and moose.

Except for hunters from Baker Lake, from October to late February Nunavut hunters mainly harvested wolves while hunting other game, leading to similar hunting effort from early to mid-winter among years. The number of wolves harvested appears to fluctuate depending on caribou numbers (and hence wolf numbers) in the area. Beginning in early March, hunters generally travelled to specifically hunt wolves, resulting in higher hunting effort and harvests.

Ground-based harvest efforts often remove the most naïve and vulnerable segments of the population (Adams et al. 2008), whereas control programs are thought to remove wolves more randomly since lethal control is less selective and breeders are more likely to be killed than they would be otherwise (Webb et al. 2011, Schmidt et al. 2017). If young or dispersing individuals make up a large portion of the harvest, harvest mortality may be compensatory because young naïve wolves exhibit the highest rates of natural mortality and dispersal (Boyd and Pletscher 1999; Hayes and Harestad 2000; Fuller et al. 2003; Smith et al. 2010). However, Nunavut wolf hunters appear able to target older and presumably potentially breeding portions of the population later in the winter after most natural losses would have occurred, increasing the additive impacts of these ground-based harvest efforts.

Hunters in the Kitikmeot Region, mainly from Kugluktuk, harvested wolves primarily from winter ranges. The high proportion of young in the Kitikmeot sample during 2019-20 and 2020-21 indicate relatively intense harvest within the areas accessed by hunters. However, few wolves were harvested in April and May during caribou spring migrations to the mainland calving grounds of the BA and BE herds (Appendix 2). Logistics and access may be limiting the ability of Kitikmeot harvesters to reduce wolf numbers as caribou approach the calving grounds.

Wolf populations can quickly rebound when treatment is removed due to immigration from surrounding areas and high reproductive rates (National Research Council 1997, Schmidt et al. 2017). Within Nunavut, wolves are an annual resource for hunters, and wolf harvest for clothing and for income is a seasonal and traditional activity. For example, in the range of the BE, BA and BV caribou herds, migratory wolves generally den around and below treeline (Heard and Williams 1992). Although this likely also occurs on QM range where these wolves would be distant and unharvestable by hunters from coastal communities on Hudson Bay, many wolves associated with the QM herd also den above treeline closer and within the calving grounds (Heard and Williams 1992). Either way, “crops” of wolves therefore follow caribou residing or moving onto the tundra where they are accessible to coastal hunters on an annual basis.

Limitations

Our analyses were of course limited by numbers and distribution of collared caribou among herds. It was evident that collar distribution was thin to non-existent in some areas, especially in the northeast Nunavut mainland (Appendix 2). In other areas, the attrition in collars was evident, for example collar sample size on the Lorillard and Wager Bay herds was greatly reduced by April 2020 when extensive wolf harvest associated with these two herds occurred north of Baker Lake (Fig. 5, Appendix 2).

Portions of our analyses and summaries were dependent on assumptions made on the wolf harvest data, largely related to the definition of pack size and numbers harvested. In some cases, it was easy to determine that, for example, 6 wolves were harvested from a pack of 6 wolves at the same location. Many other groupings were not so obvious. These data could be rendered clearer, facilitating more robust analyses, if the database were able to clarify which harvested wolves belonged to which recorded pack size and the number of wolves harvested from that particular pack -cross-referencing harvest ID numbers would be helpful. Also, harvest of individual wolves needs to be clarified that they were indeed lone wolves, and not associated with other individuals. In some cases, the database observations did not agree with the spatial records. In general, we consider the proportion of wolf pack harvested to be a crude measure of harvest effectiveness.

A measure of catch per unit effort (CPUE) by Nunavut wolf hunters would provide another indication of the effectiveness of harvest within the territory. The challenge with the current wolf harvest data set is that annual harvest effort is unknown and therefore it is difficult to ascertain if annual harvest success for some communities is due to greater harvest effort or higher harvest effectiveness. However, there are many variables that may affect measures of harvest effort: for example, effort likely varies with snow conditions and the winter distribution of caribou and hence the associated wolves; wolves are harvested during harvest trips for other species (e.g., caribou, muskoxen) as well as trips primarily focussed on hunting wolves; unsuccessful wolf harvest trips are not recorded; and harvest effectiveness likely varies between experienced and young hunters. Regardless, a data set that provides even a crude measure of effort, possibly the number of excursions and number of days of hunting and the number of kilometres travelled (and possibly details of routes taken) could provide a better overall estimate of harvest effectiveness (Clake et al. 2021).

More work is required to estimate how many wolves may be associated with the migratory QM herd (and possibly other herds) during winter. We suggest that using the UBI equation to estimate wolf numbers may be problematic for migratory barren-ground caribou for a number of reasons (Kuzyk and Hatter 2014). This equation was developed for wolf populations in British Columbia that prey on a variety of relatively stationary southern ungulate species, rather than northern wolves that primarily prey upon more ephemeral prey sources like populations of caribou and muskoxen. An inherent issue with the UBI calculation is that it does not consider that wolves do not have access to caribou across winter or seasonal ranges especially during the denning season (late winter) when movements by wolves are more restricted. Therefore, it is likely that only a proportion of caribou populations are "available" to wolves at any one time. Annually variable overlap among adjacent herds on winter ranges further complicates this relationship. Due to migratory caribou movements and restrictions of wolves to denning sites, the year-round availability of caribou to wolves is lower in northern populations and therefore the inherent relationship between wolf abundance and caribou biomass is different. Studies on functional response of predators to varying levels of prey density have shown that various relationships are possible, all of which have implications on the underlying relationship between prey and predator density (Zimmerman et al. 2005). Therefore, this likely produces an over-estimate of wolves given that only a proportion of caribou are available to wolves across the large seasonal range. We attempted to partially correct for this using crude estimates of the proportion of wolves that may be following the QM herd during spring migration. The UBI method also likely overestimates wolf abundance by assuming that the effectiveness of wolves in preying upon northern caribou is similar to the multitude of ungulate species available to southern wolves. It also assumes human-caused mortality rates do not exceed sustainable limits and wolf numbers have had time to adjust to prey biomass. For all these reasons we suggest estimates from this index are very crude, are likely overestimates, and should be treated cautiously.

Recommendations

1. The Support for Active Harvesters program facilitates harvest of wolves associated with concentrations of caribou within Nunavut, and appears to be an effective wolf management tool to remove a large proportion of accessible wolves while simultaneously providing additional support to hunters. Since wolf populations can quickly rebound when treatment is removed due to immigration from surrounding areas and high reproductive rates, the incentive program should be continued.
2. The Support for Active Harvesters program should ensure prompt payment to harvesters that submit skulls. The faster harvesters are paid, the more likely they will restock fuel and supplies and return to the land to hunt additional wolves.

3. Although challenging to obtain, we recommend that some form of hunter effort should be collected to supplement the wolf harvest data currently collected. The NWT program considers distance travelled for hunting and time spent hunting to estimate hunter effort (Clark et al. 2021). A data set that provides effort, possibly the number of excursions and number of days of hunting (and possibly details of routes taken) would provide a better overall estimate of harvest effectiveness.

4. The effectiveness of the wolf harvest program could be better examined by conducting a demographic analysis of caribou survival using the collar data. This would give a relative indication of how survival rates of the QM herd, where the proportion of wolves harvested during late winter and spring is thought to be comparatively high, compared to other herds.

5. Within the mainland Kitikmeot Region, much of the focus of wolf harvest incentives current target the winter ranges of the BE and BA herds. The effectiveness of harvest and resulting impacts on the demography of these herds would likely be enhanced by increased logistical support to harvesters from both sides of the border. Support and incentives to harvesters to continue to hunt wolves during migration from BE and BA winter ranges to calving ranges would enhance the effectiveness of the overall program; establishing forward operating camps and fuel caches may be useful. Expansion of the NWT Wolf Management Incentive Area into the Kitikmeot Region would provide additional incentives to Nunavut harvesters, further increasing the harvest of wolves associated with the BE and BA herds. It may be beneficial to engage and support experienced wolf hunters to set up harvester camps and focus on areas not normally accessible during spring caribou migration (*cf* Kolpaschikov et al. 2015, Clark et al. 2021).

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Appendix 1: Caribou collar sample size

Table 11. Collar sample size by caribou herd and month, December 2018 to June 2021, and most recent caribou herd estimates.

Year-Month	BA	BE	BV	QM	LR	WB	AH	DU
2018-Oct	27	43	42	49	16	9		3
2018-Nov	27	43	42	49	16	9		3
2018-Dec	27	43	42	49	16	9		33
2019-Jan	27	42	41	49	15	8		31
2019-Feb	28	42	40	48	13	8		31
2019-Mar	38	56	60	52	6	4		30
2019-Apr	39	57	59	55	3	4		28
2019-May	37	55	58	51	3	4		28
2019-Jun	36	51	53	44	2	4		24
2019-Jul	35	50	52	42	2	4		24
2019-Aug	35	49	51	29	1	3		24
2019-Sep	29	40	43	26	1	3		23
2019-Oct	26	39	33	23	1	3		21
2019-Nov	25	38	32	23	1	3		21
2019-Dec	25	36	31	23	1	3		20
2020-Jan	25	36	30	23	1	3		20
2020-Feb	31	32	29	24	1	3		21
2020-Mar	70	71	32	29	1	2		18
2020-Apr	71	67	26	23	1	2		16
2020-May	59	59	22	16	1	2		13
2020-Jun	57	55	22	12	1	2		12
2020-Jul								8
2020-Aug								7
2020-Sep	45	53	25	38	6	5	4	4
2020-Oct	43	53	25	38	6	5	4	4
2020-Nov	42	50	25	36	6	4	4	4
2020-Dec	41	49	25	36	5	4		3
2021-Jan	40	47	24	36	5	4		
2021-Feb	44	47	26	34	5	3	1	
2021-Mar	55	82	61	33	5	3	2	
2021-Apr	55	78	61	33	4	3	4	36
2021-May	55	78	60	32	5	3	4	35
2021-Jun	53	78	59	30	5	3	4	35
Herd size	8,200	22,350	103,400	288,250	41,000	41,000	71,340	3,800

Year of estimate and source of herd size estimates:

Bathurst (BA): 2018; Adamczewski et al. 2019.

Bluenose East (BE): 2018; Boulanger et al. 2019.

Beverly (BV): 2018; Campbell et al. 2019.

Qamanirjuaq (QM): 2017; Boulanger et al. 2018.

Lorillard (LR): 2002; COSEWIC 2016.

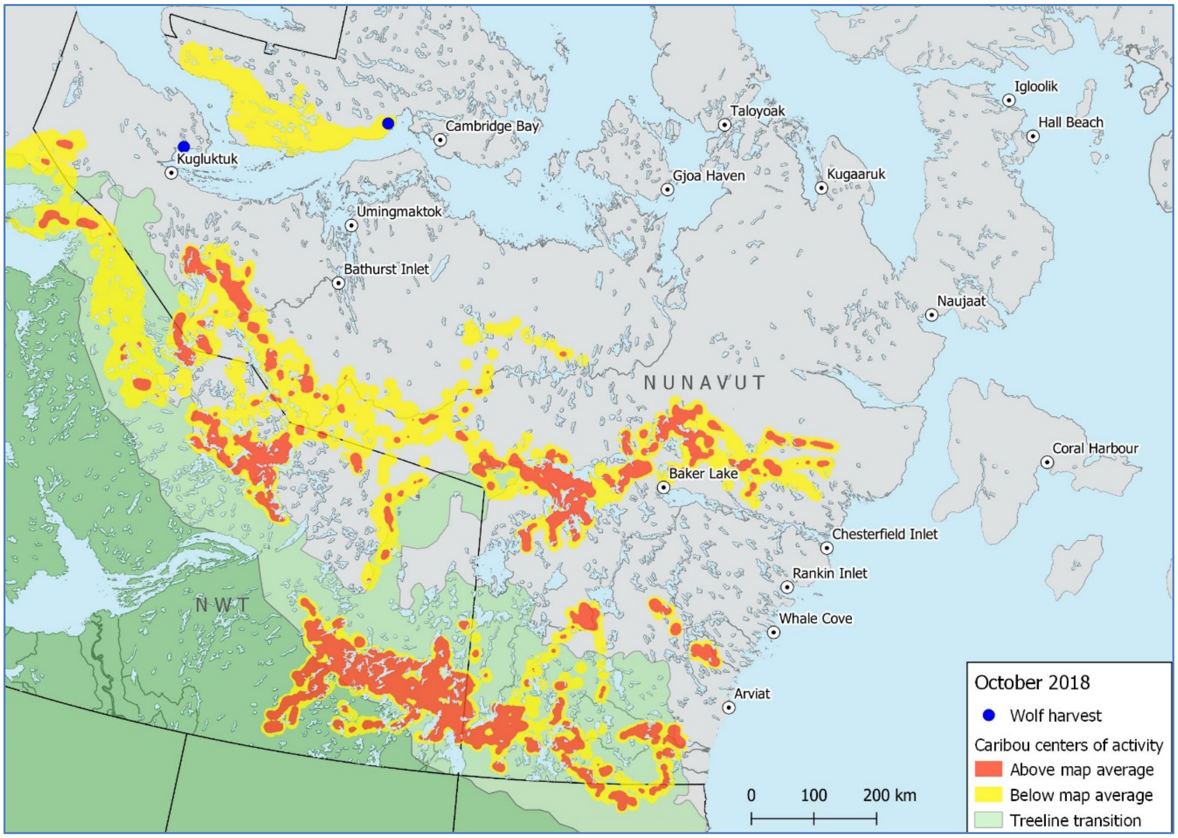
Wager Bay (WB): 2002; COSEWIC 2016.

Ahiak (AH): 2011; Campbell et al. 2014.

Dolphin and Union (DU): 2020; Campbell et al. 2021.

Appendix 2: Monthly caribou and wolf harvest maps October 2018 – June 2021

Figure 25. Collared caribou distribution and centers of activity, and wolf harvest collection locations, October 2018 to June 2021 (see legends for month and year).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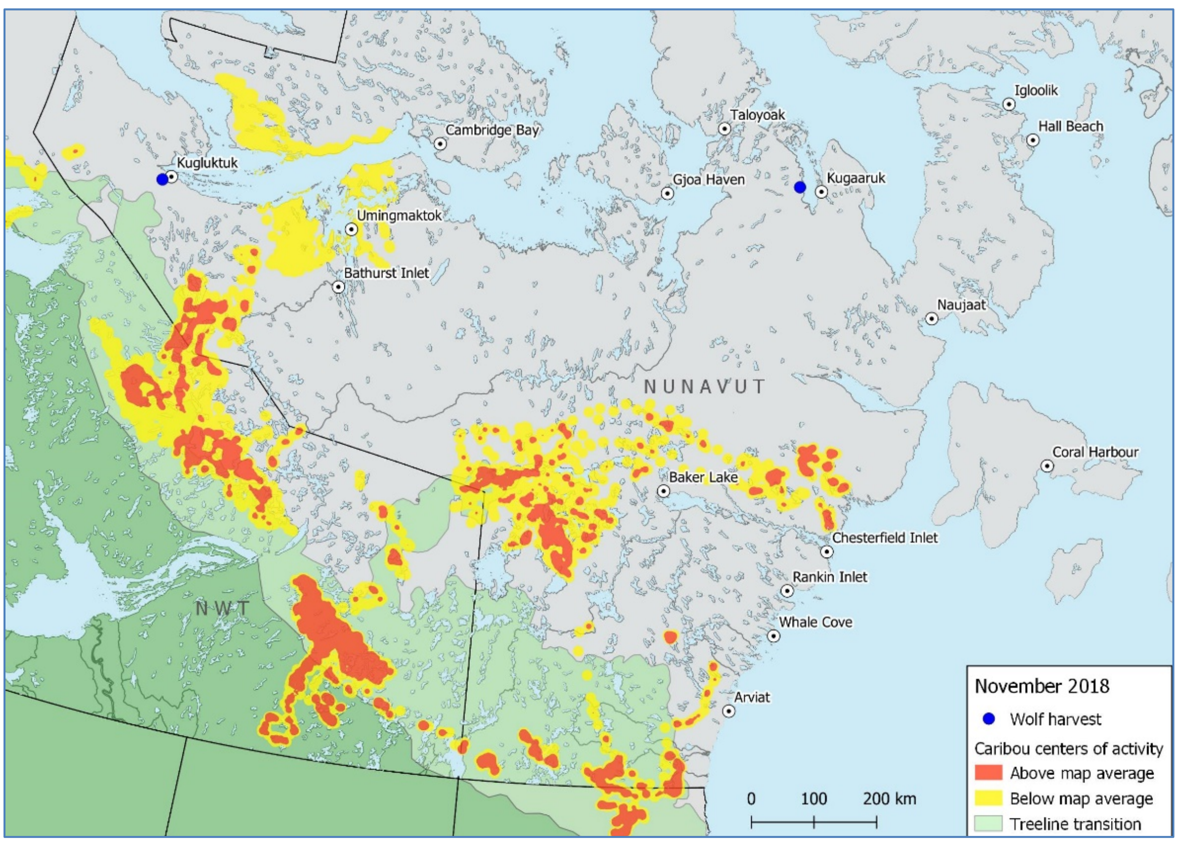
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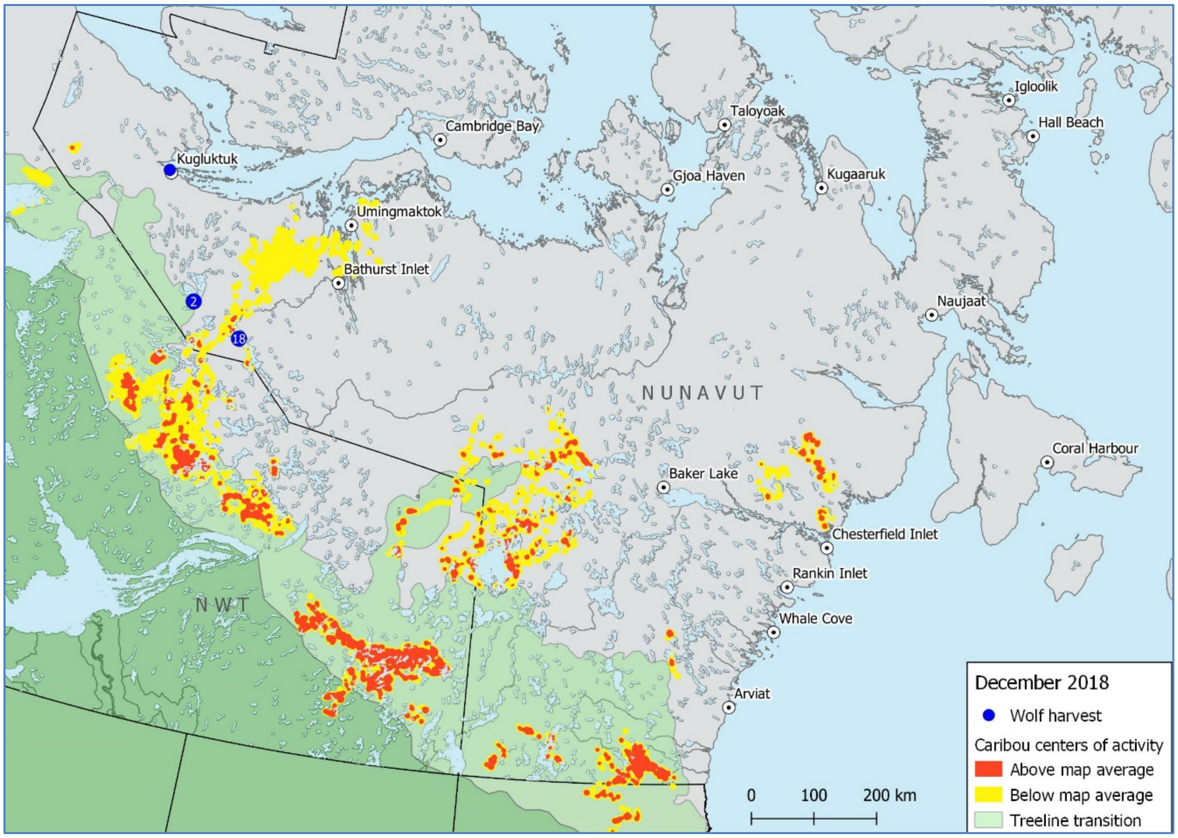
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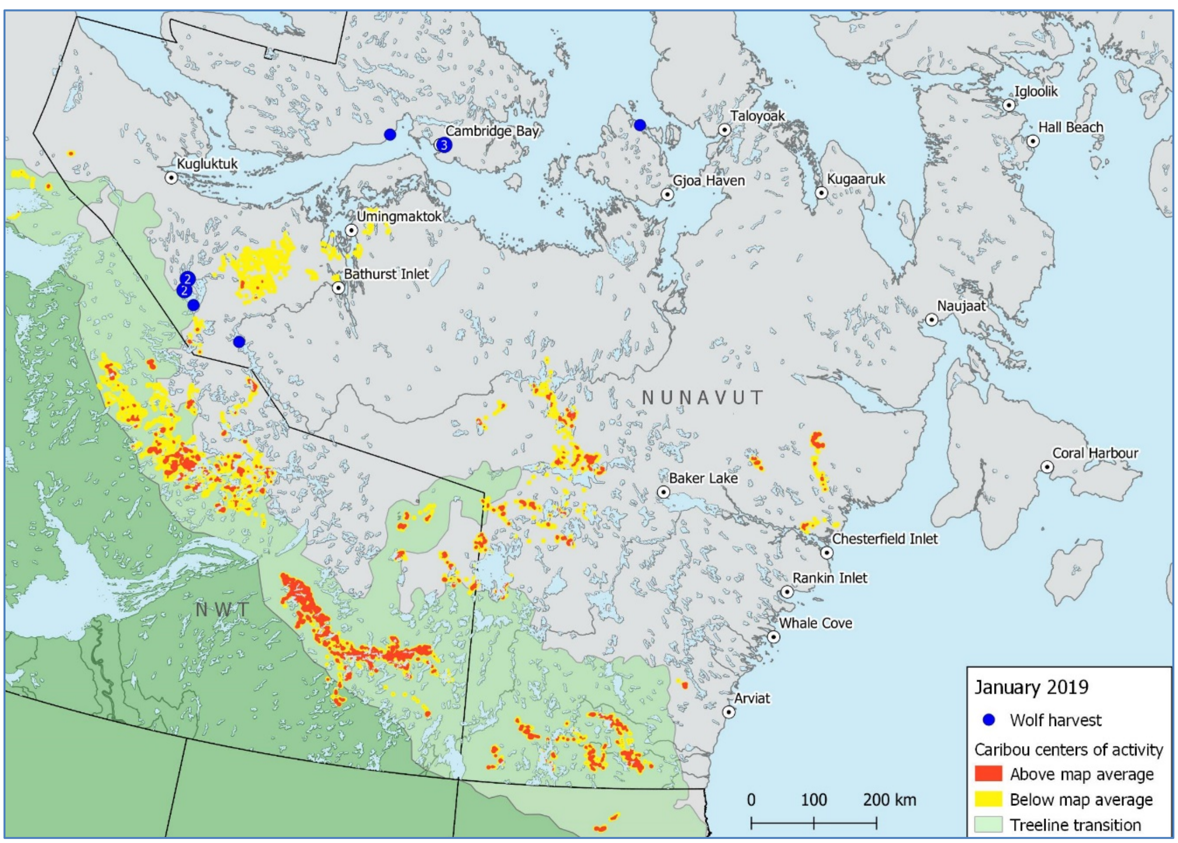
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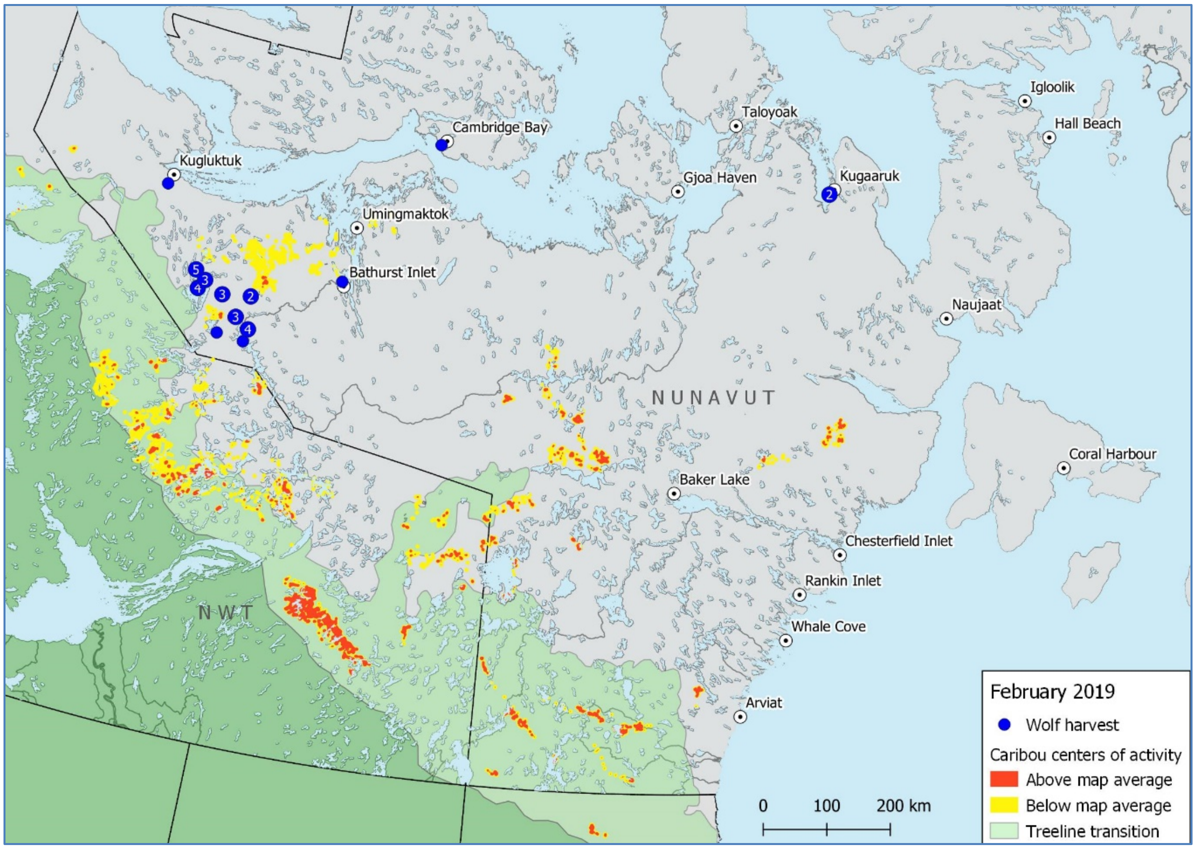
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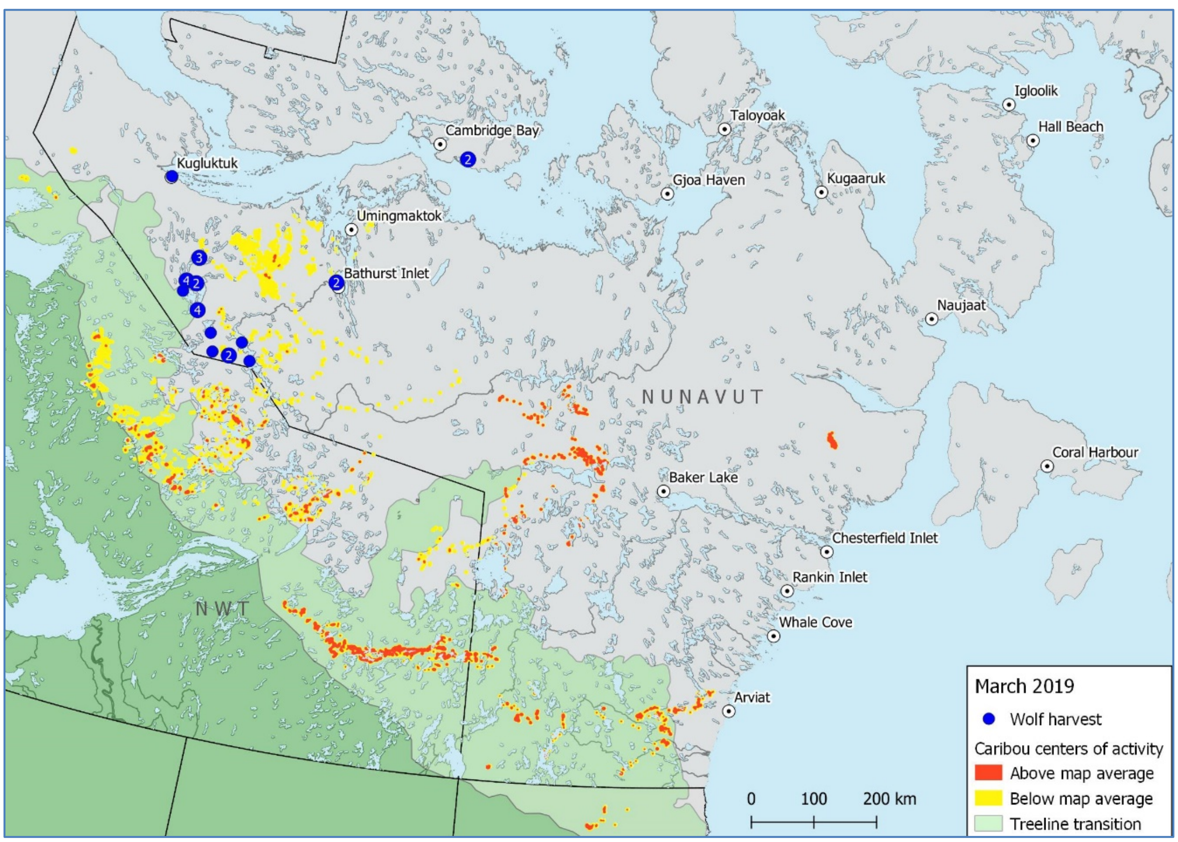
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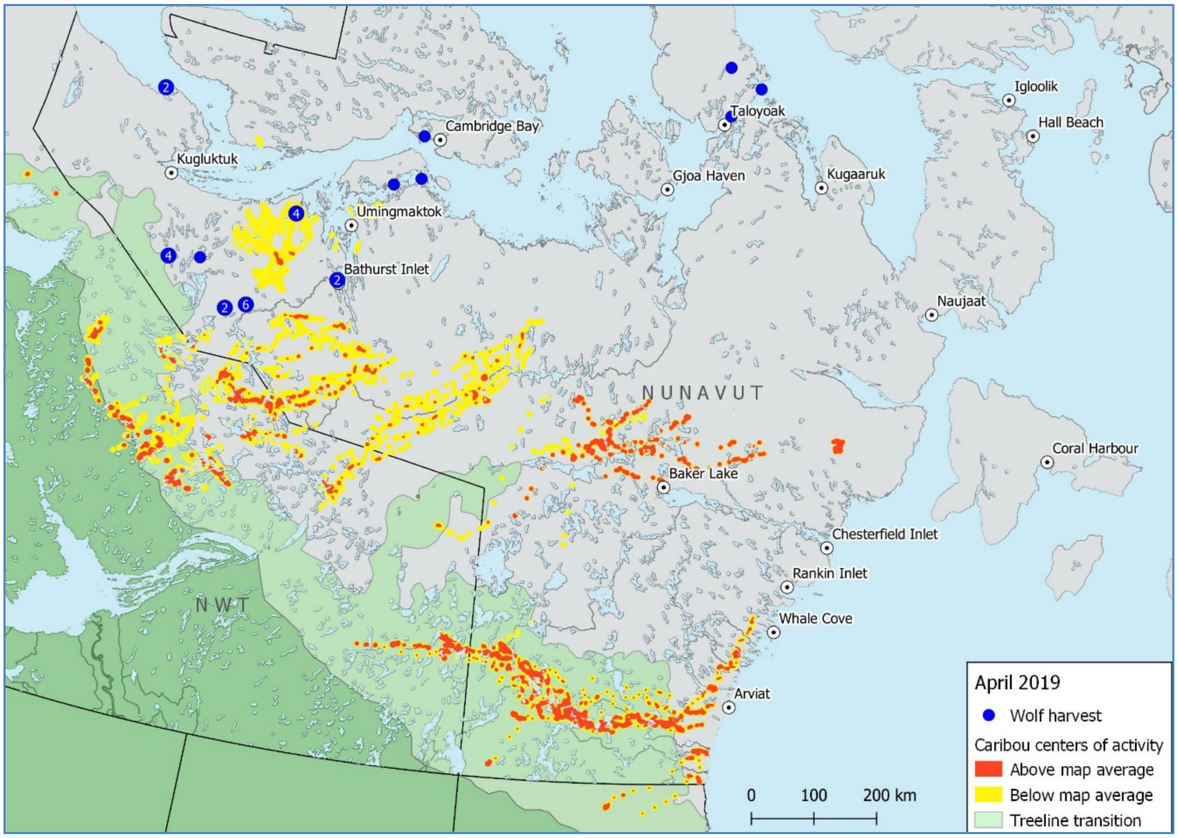
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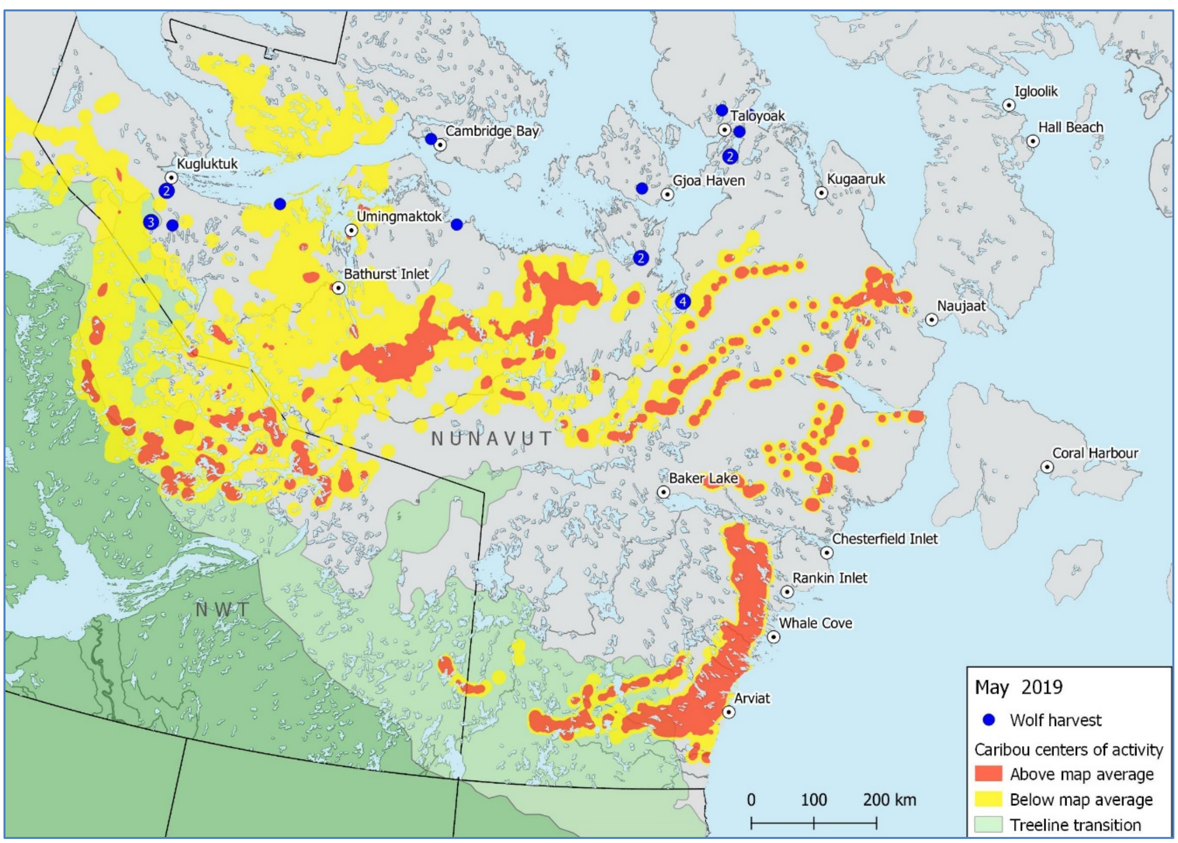
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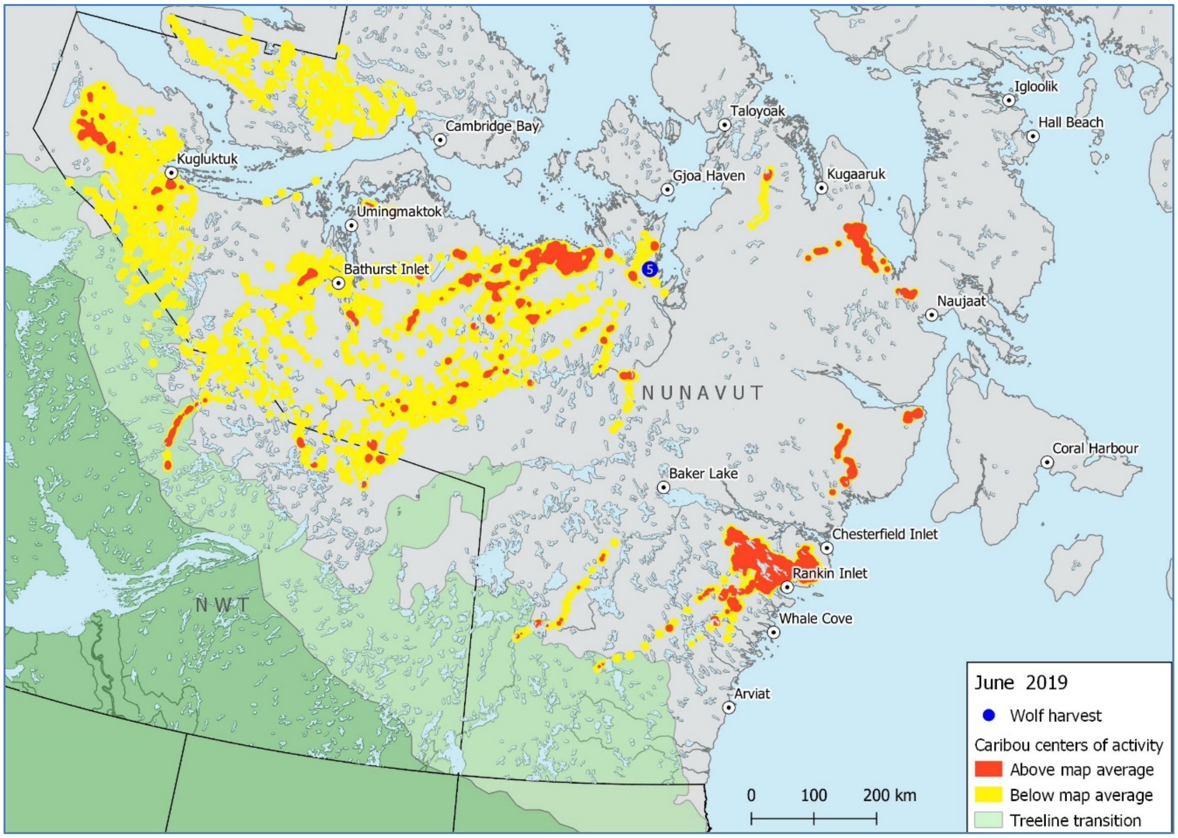
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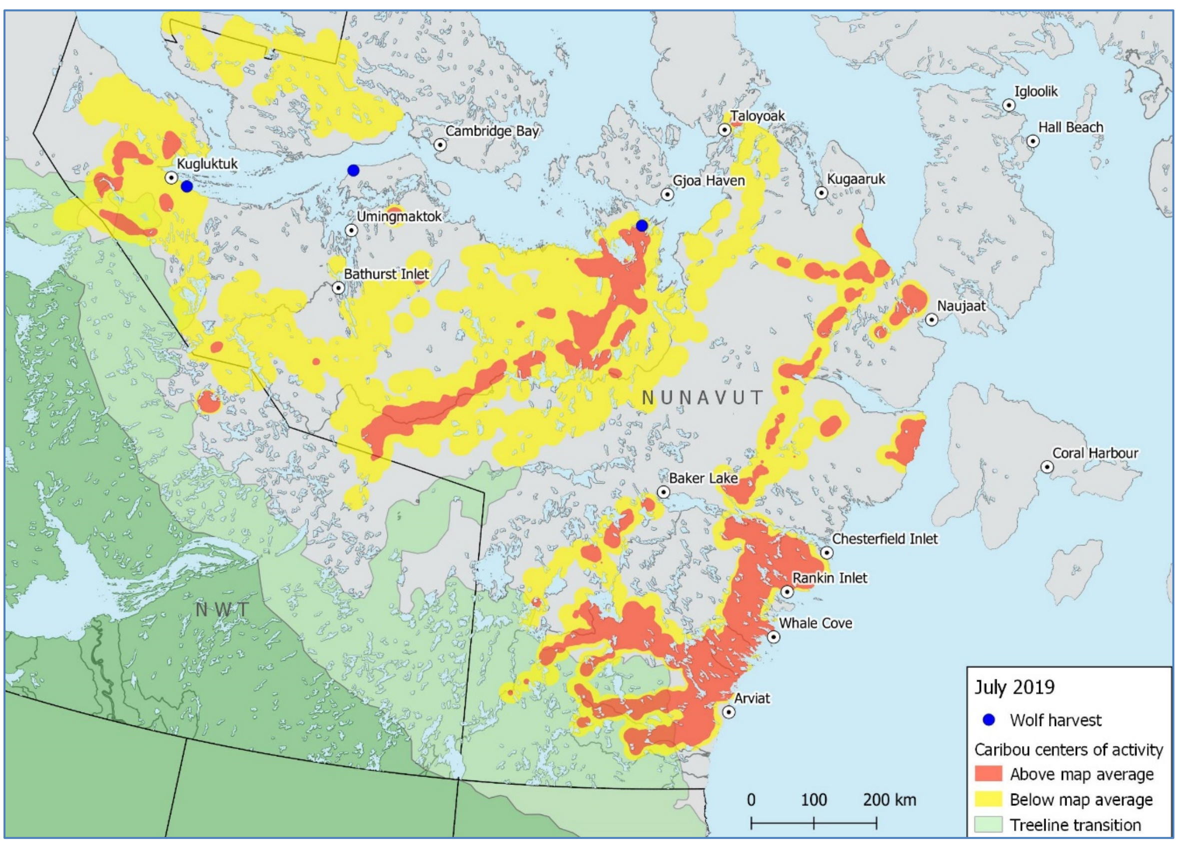
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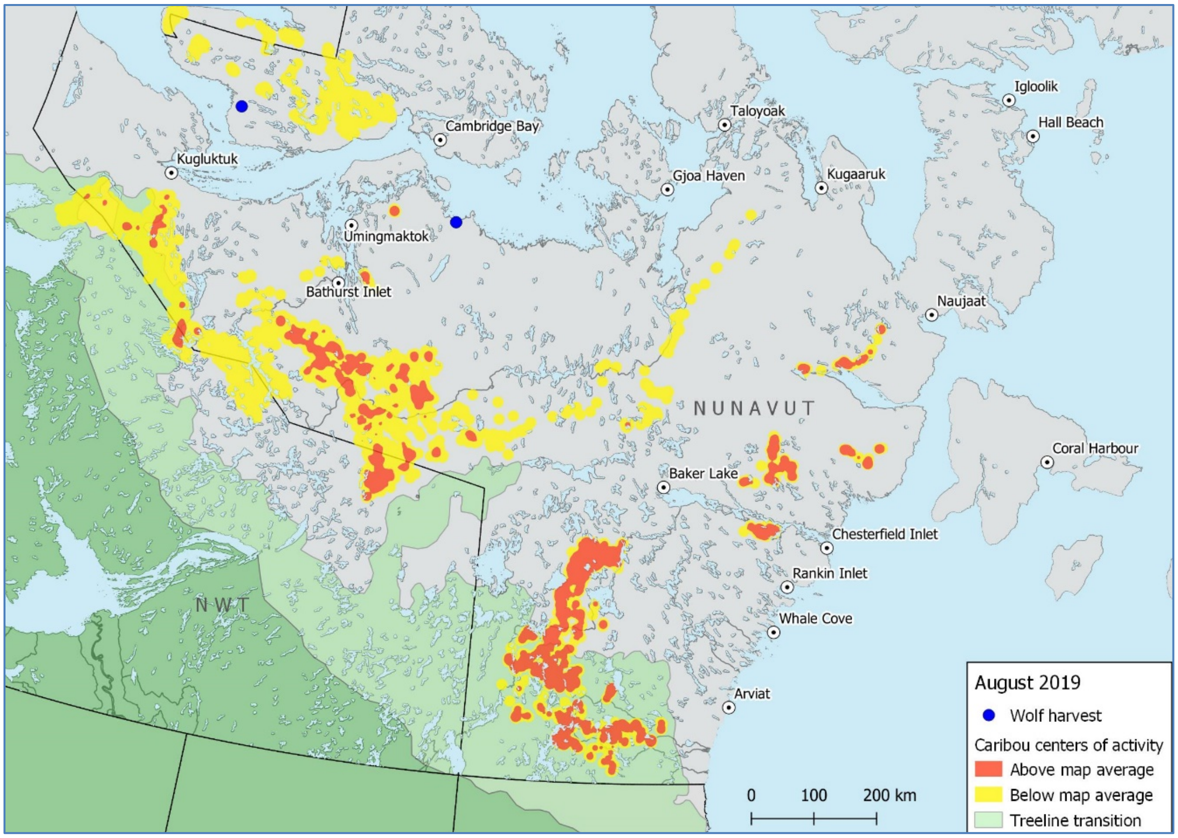
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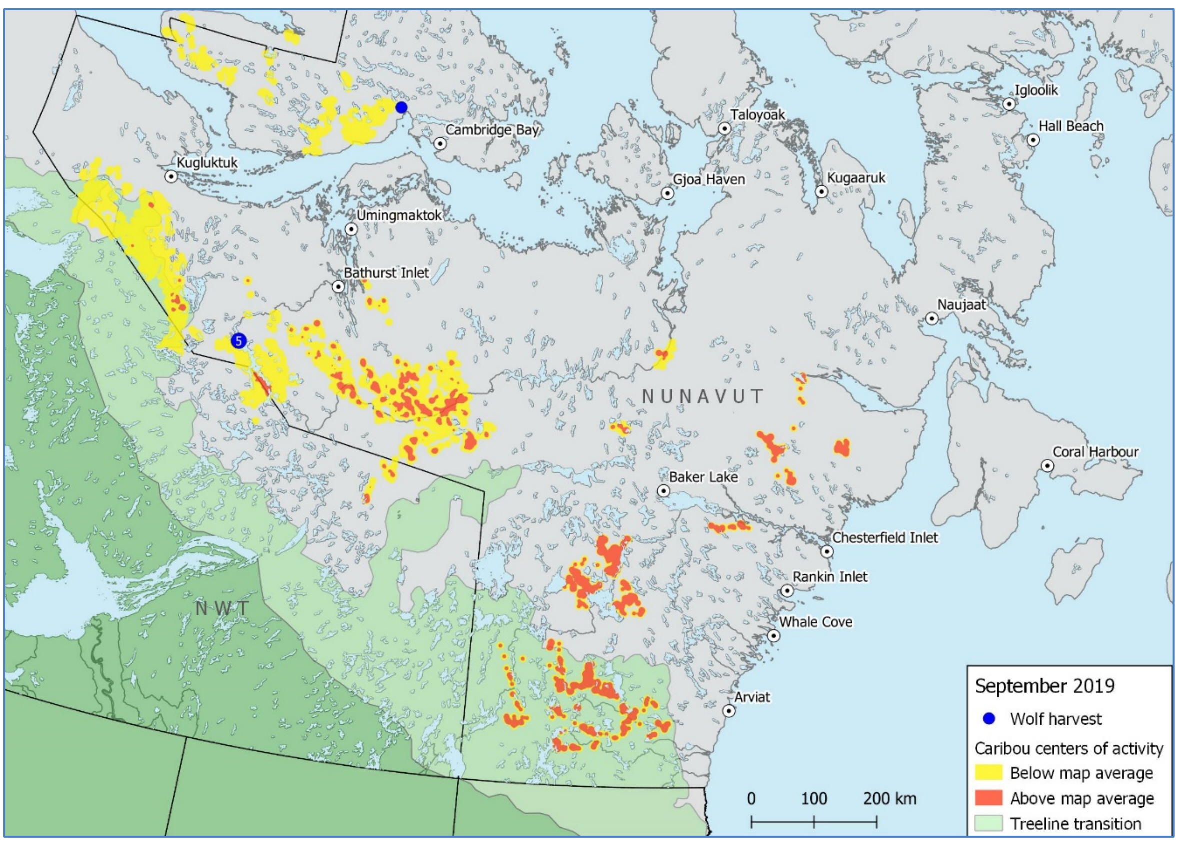
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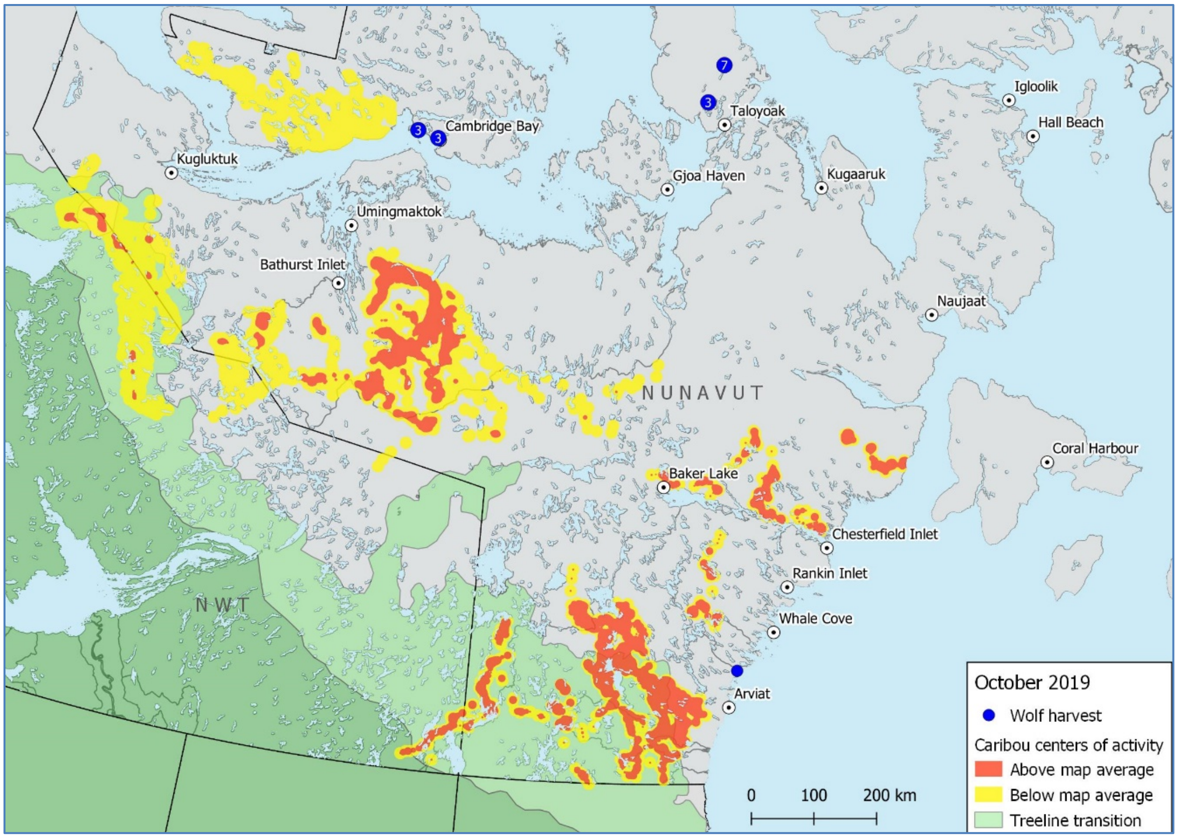
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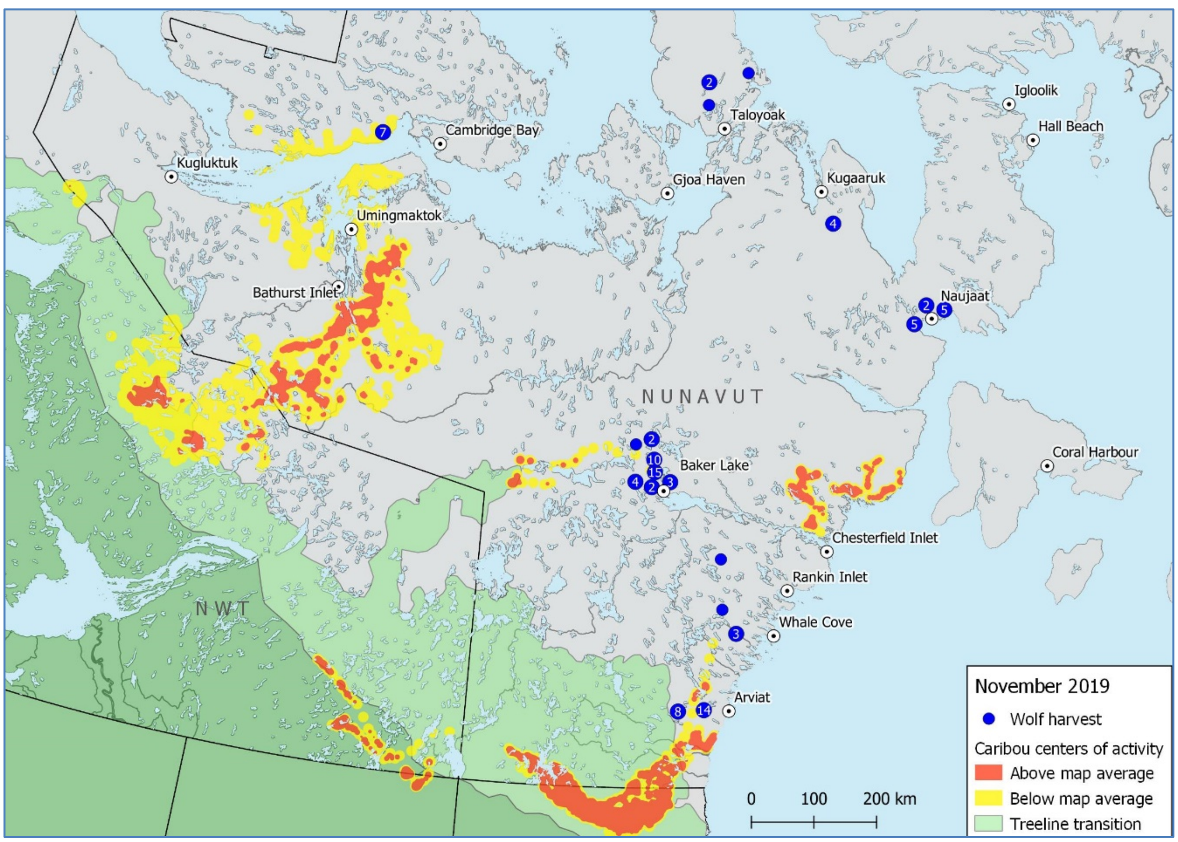
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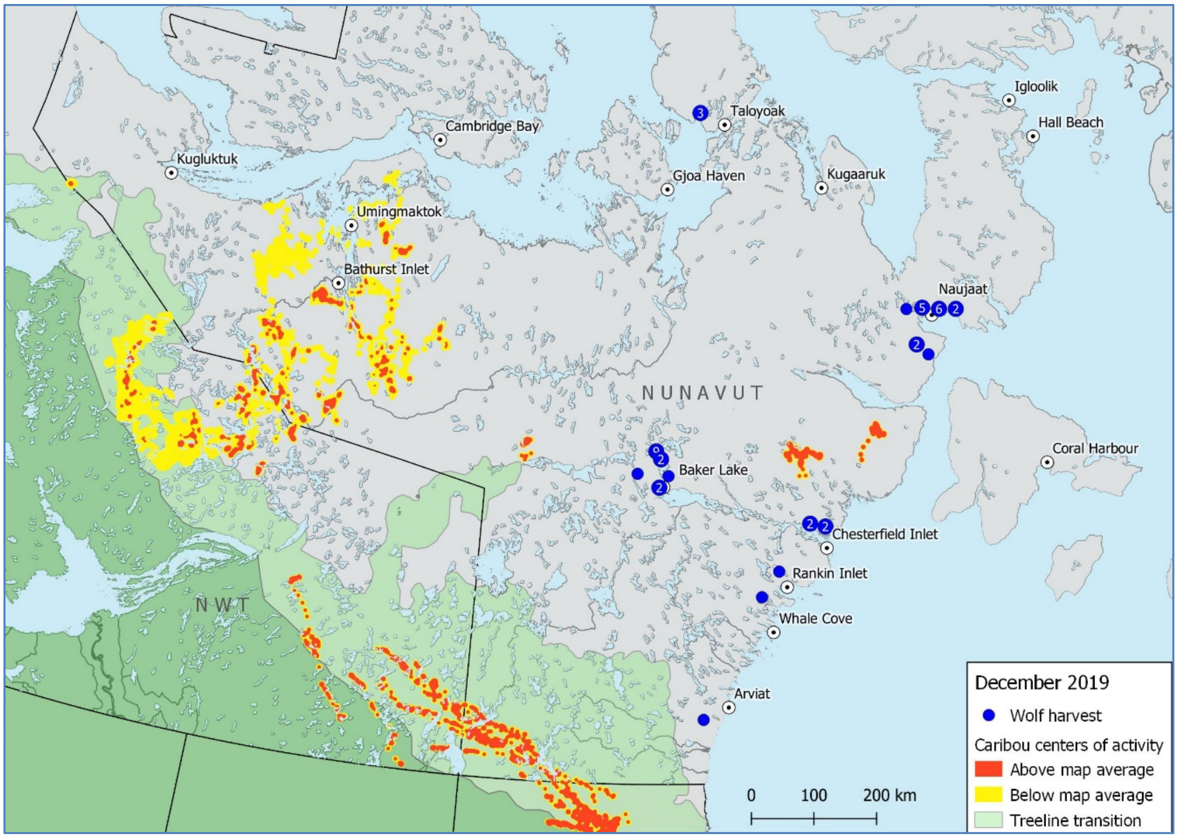
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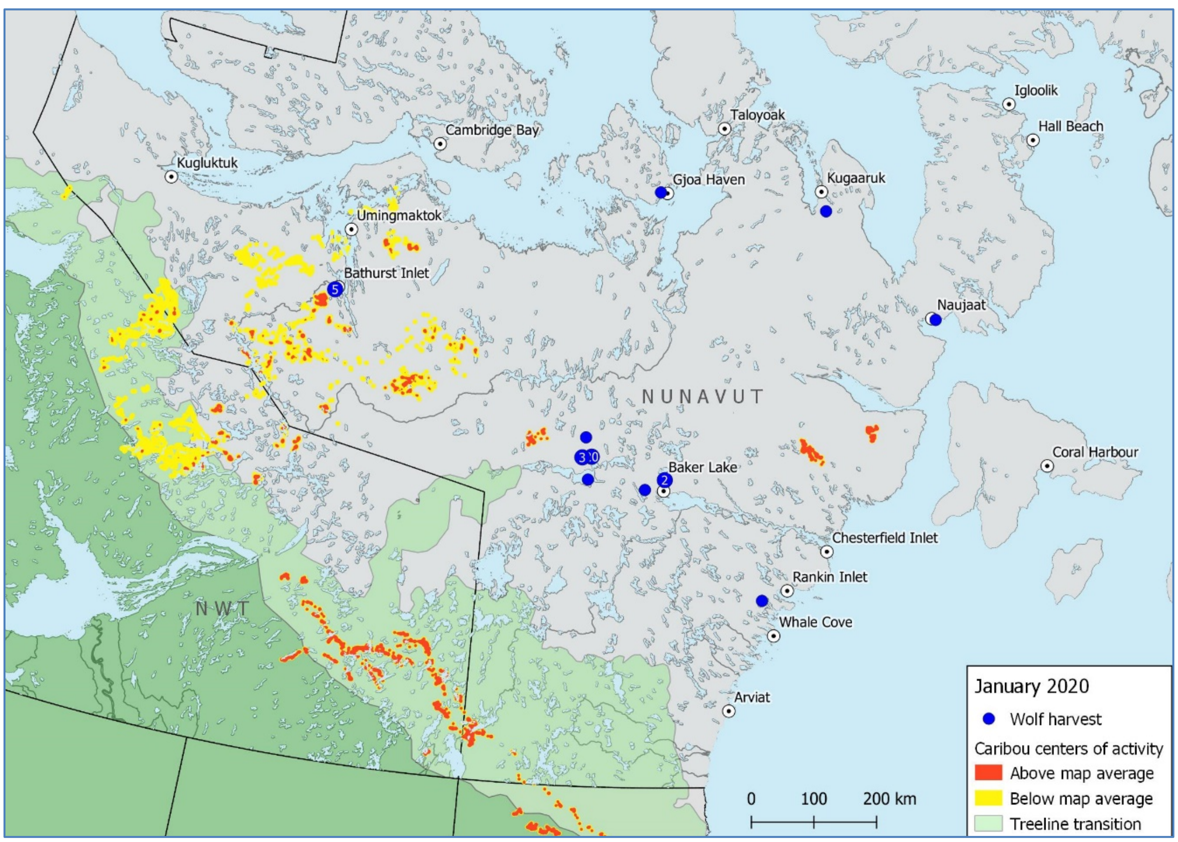
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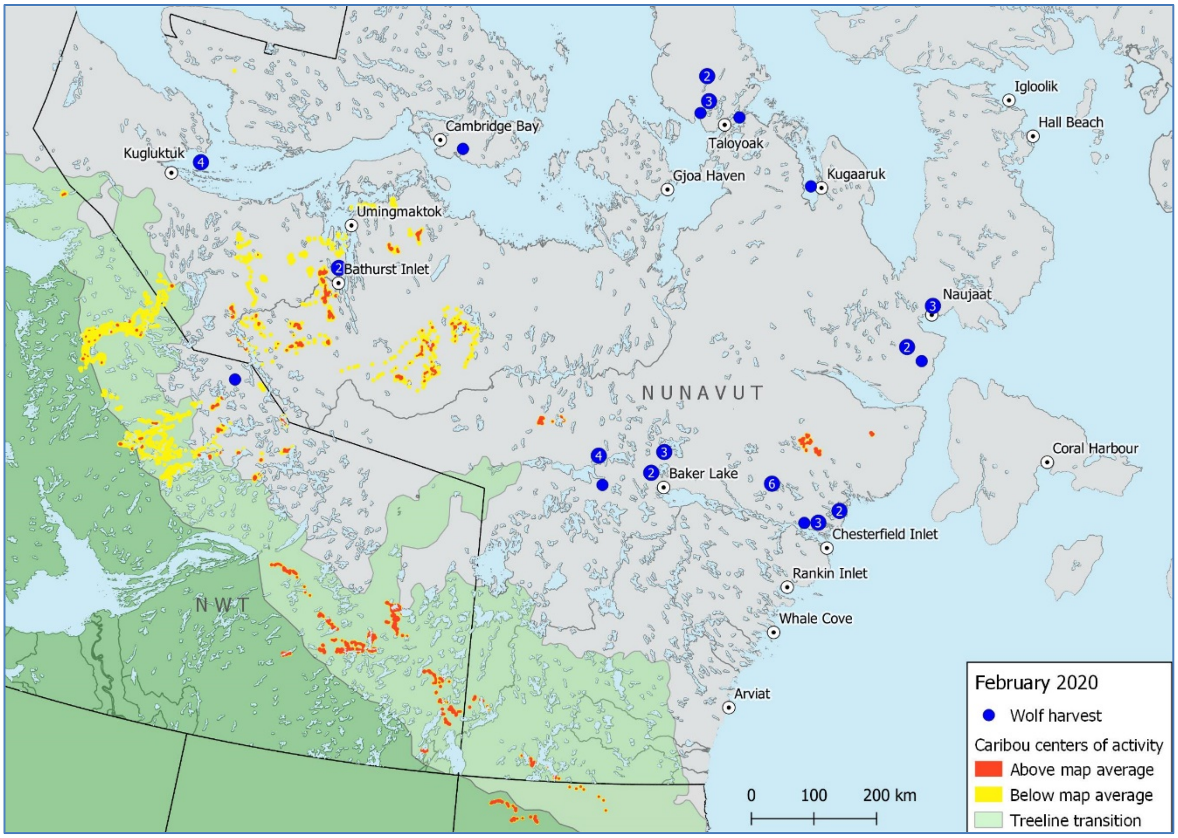
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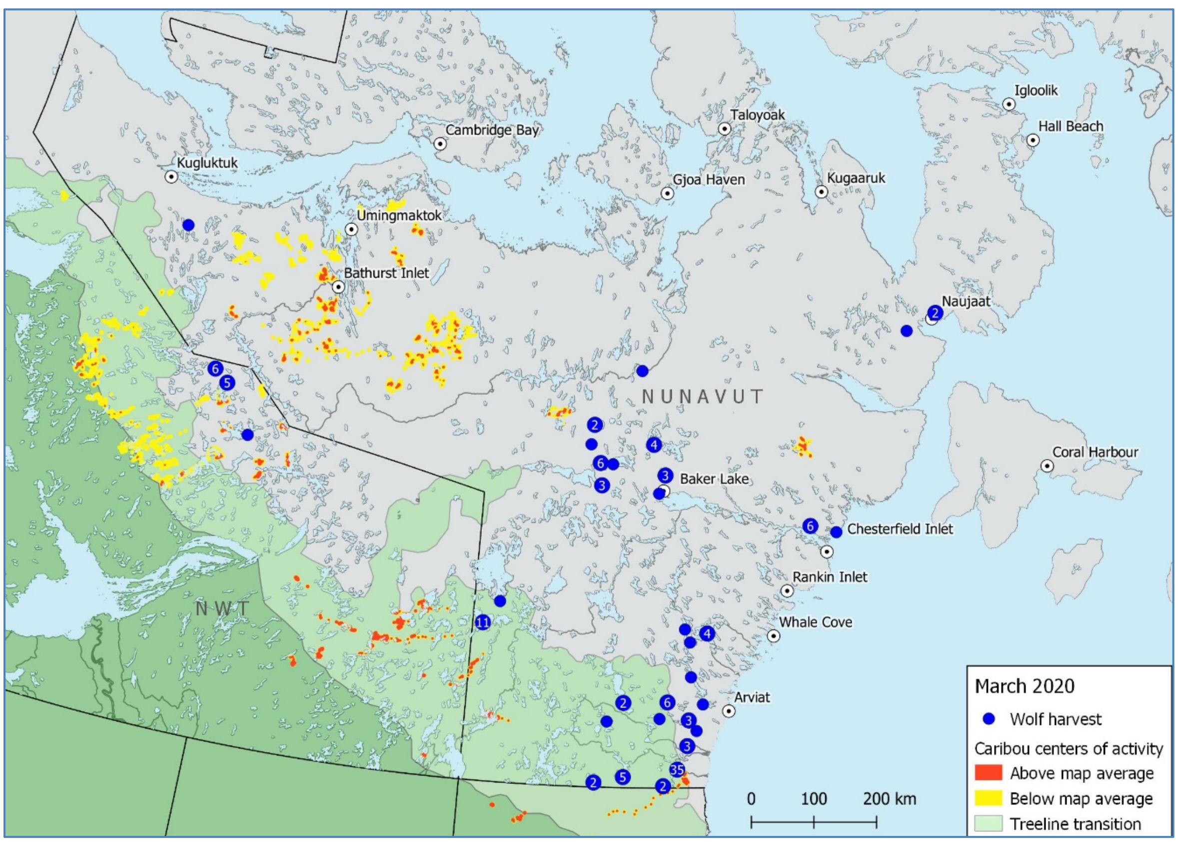
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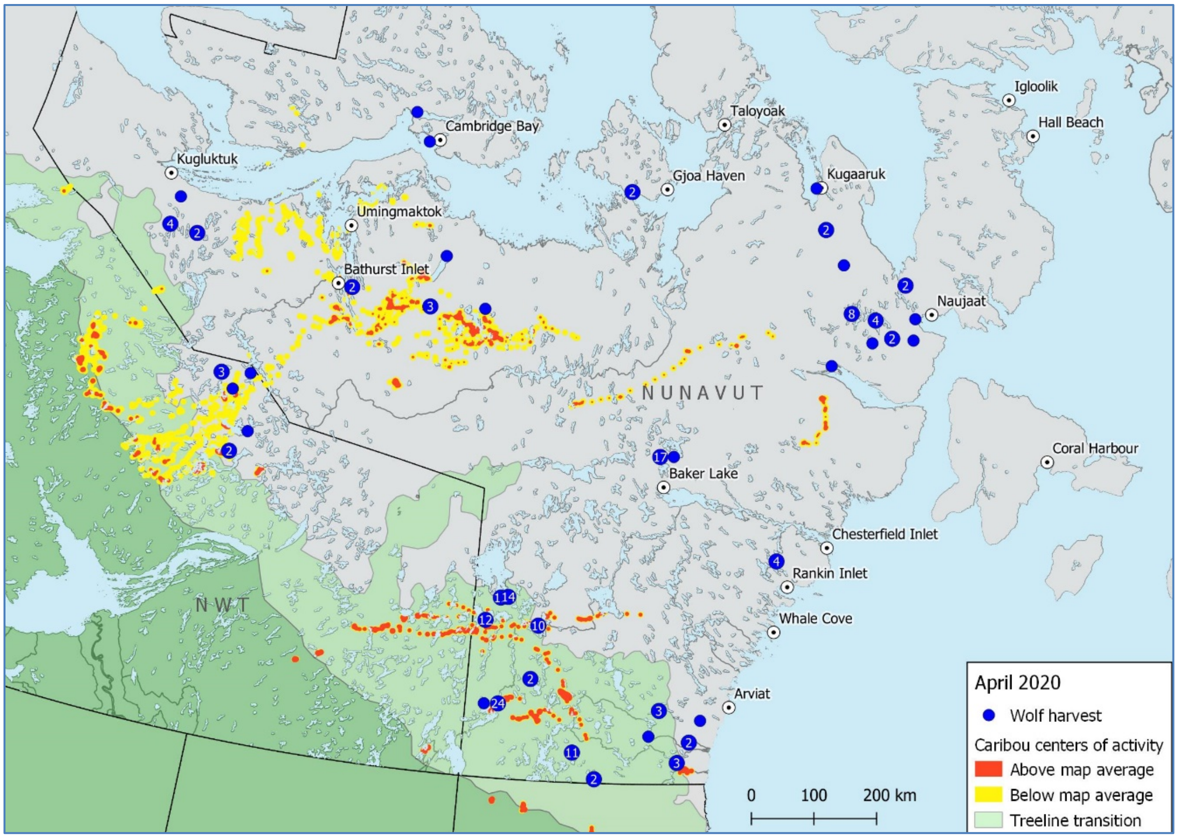
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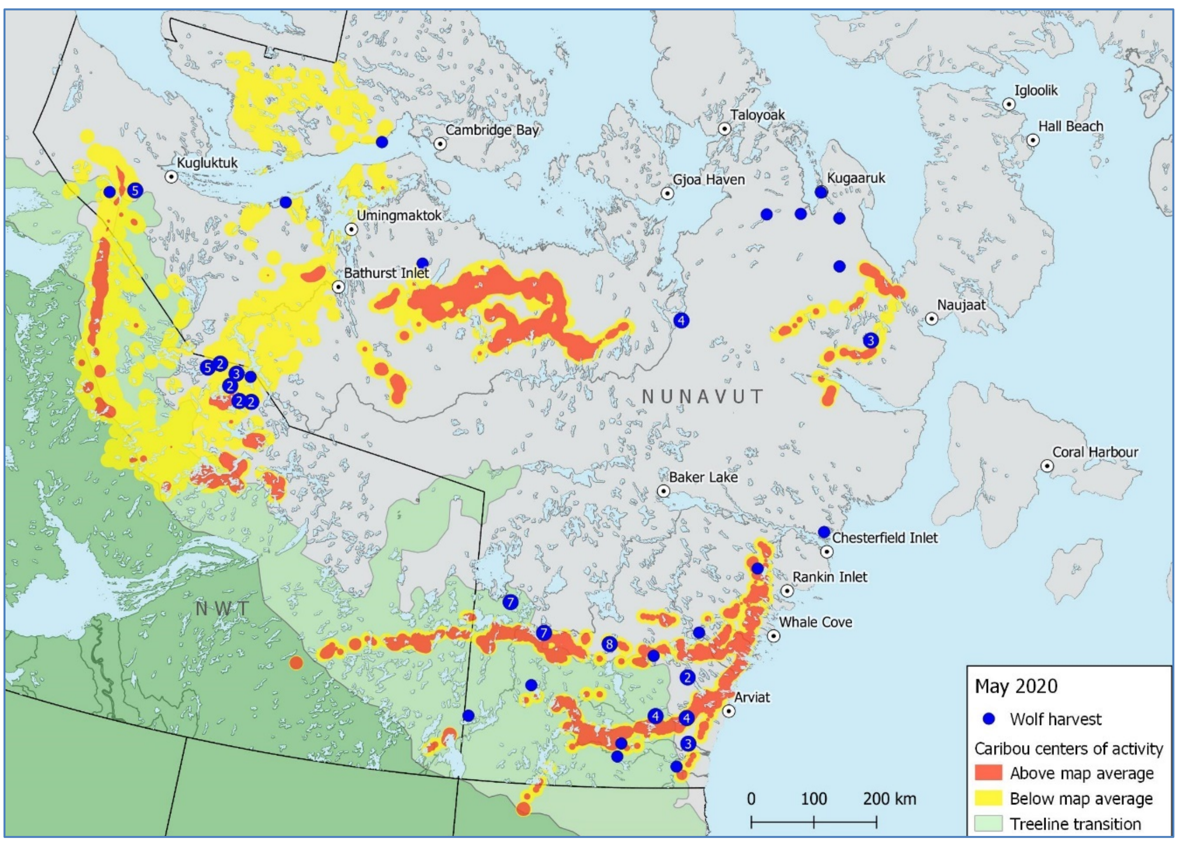
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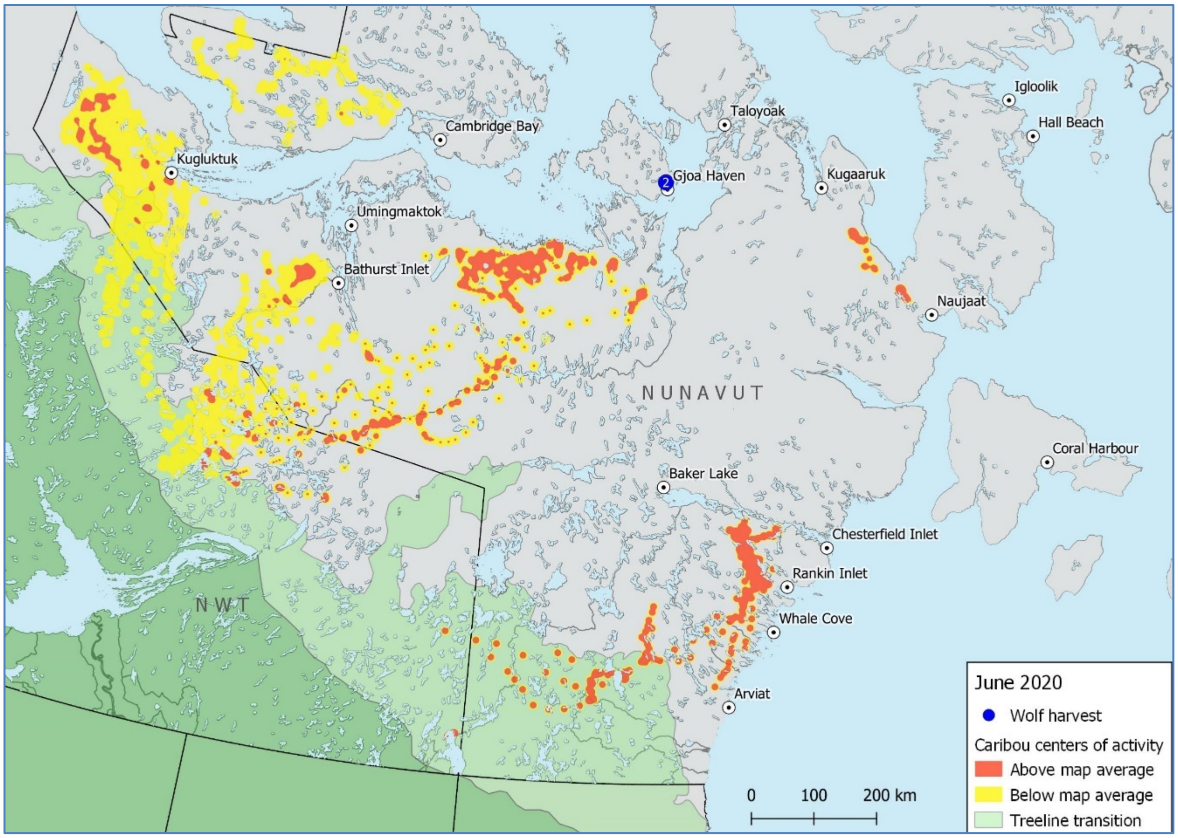
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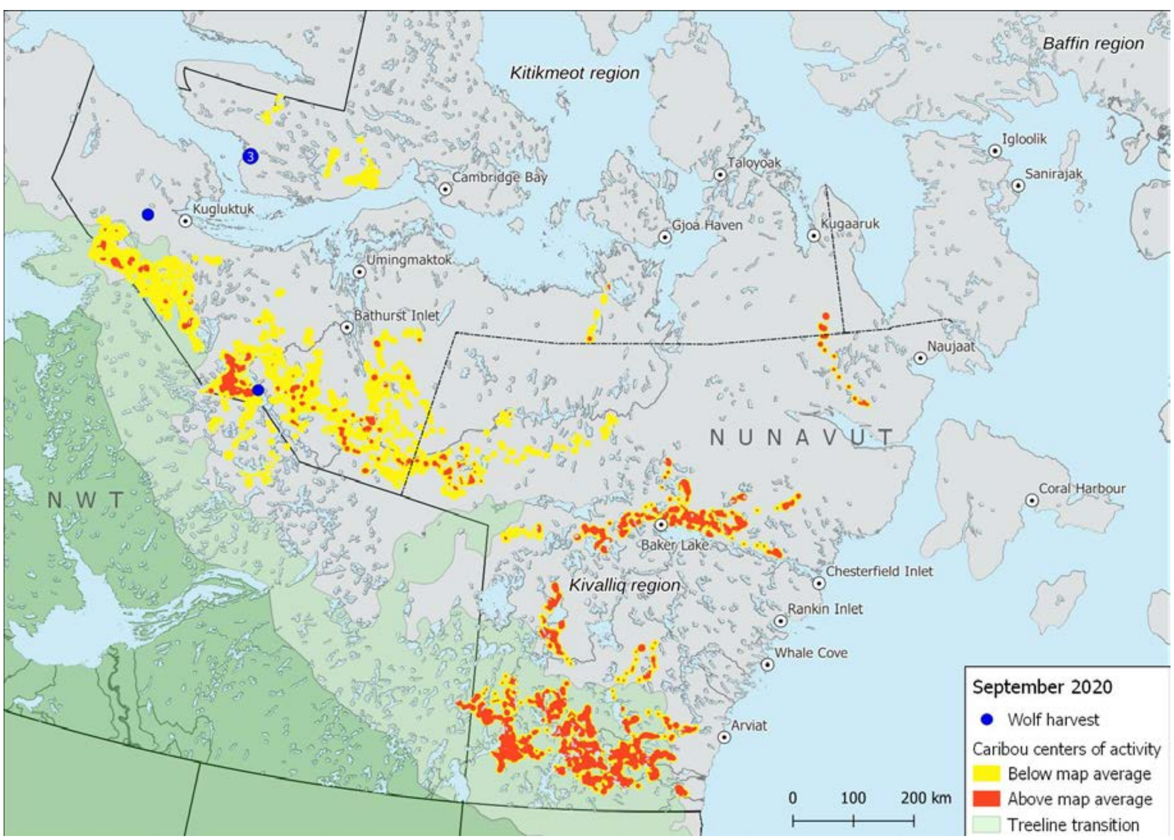
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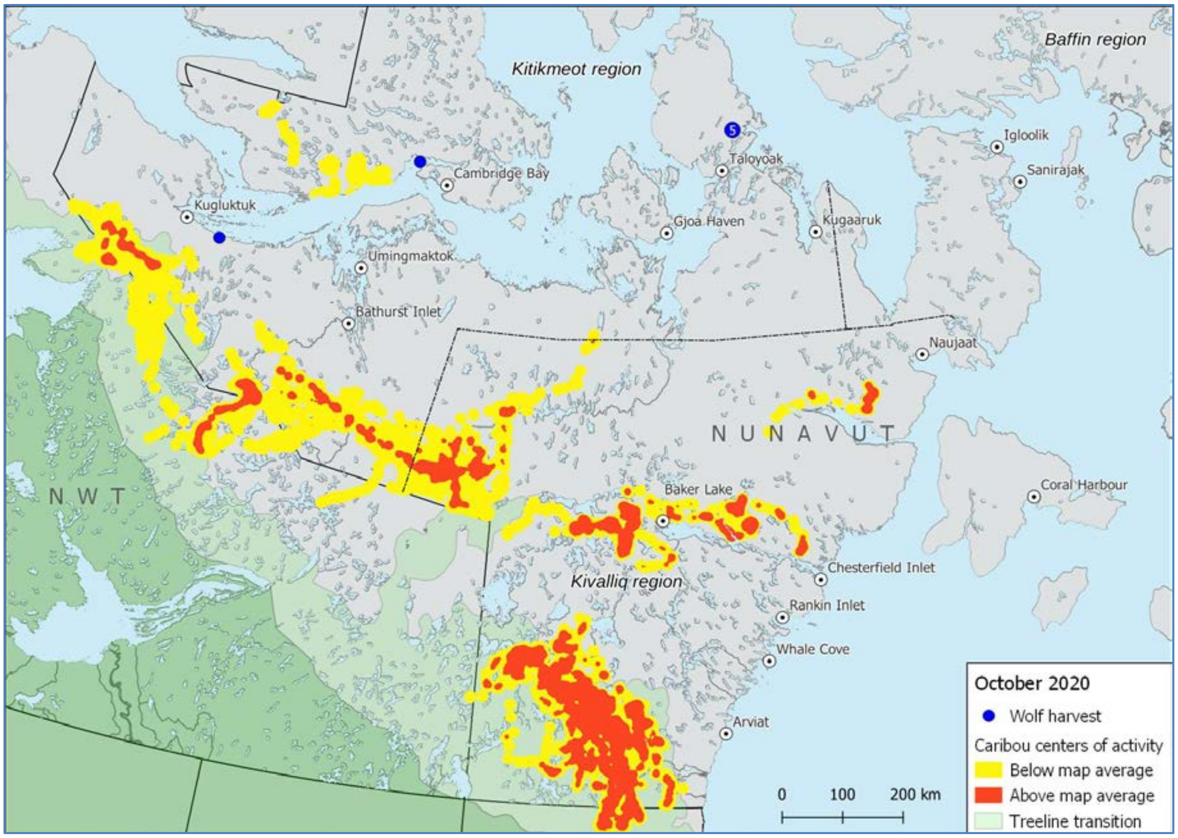
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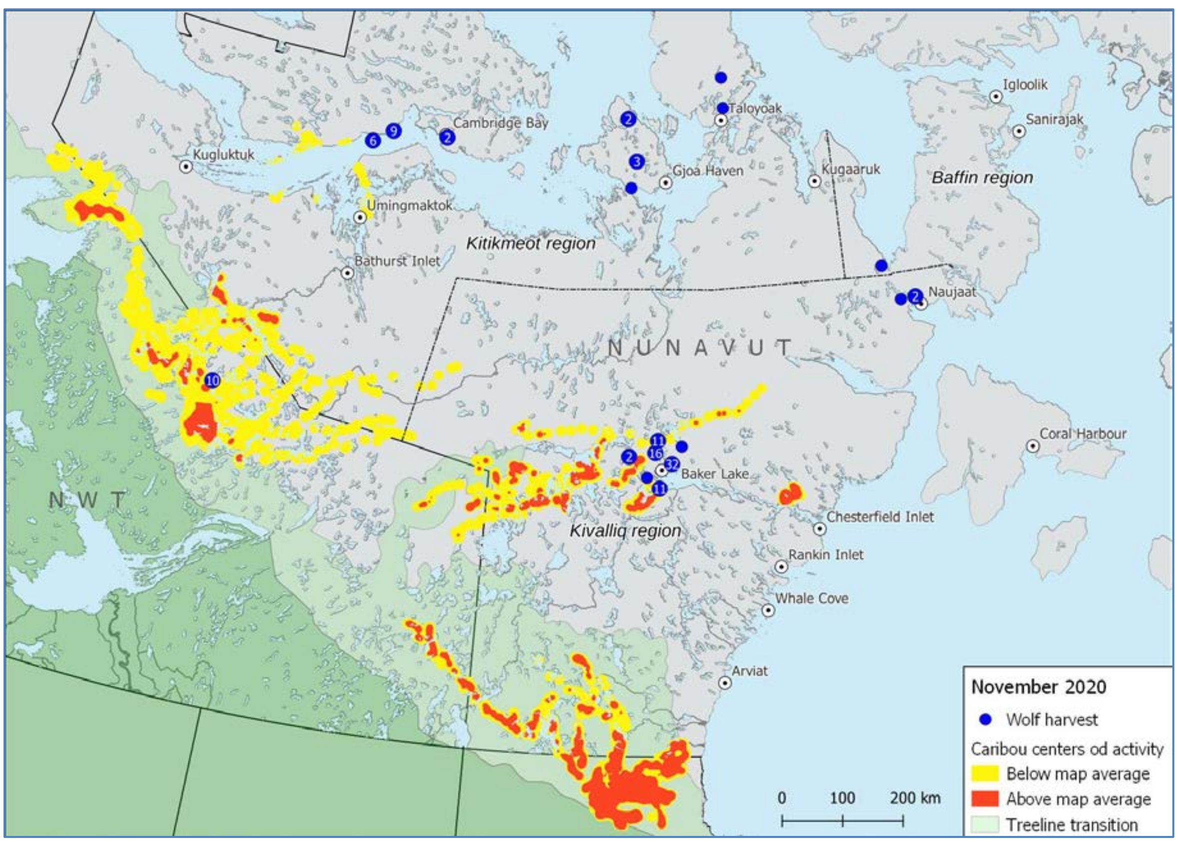
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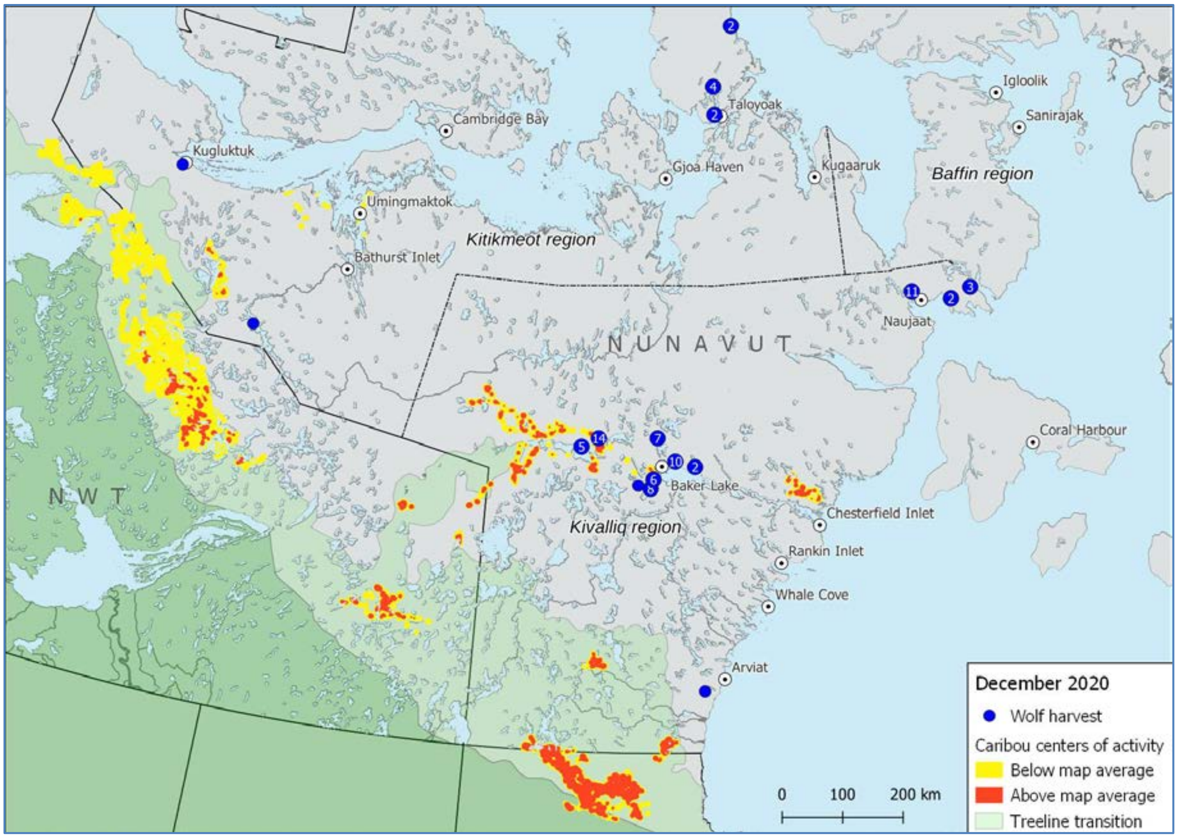
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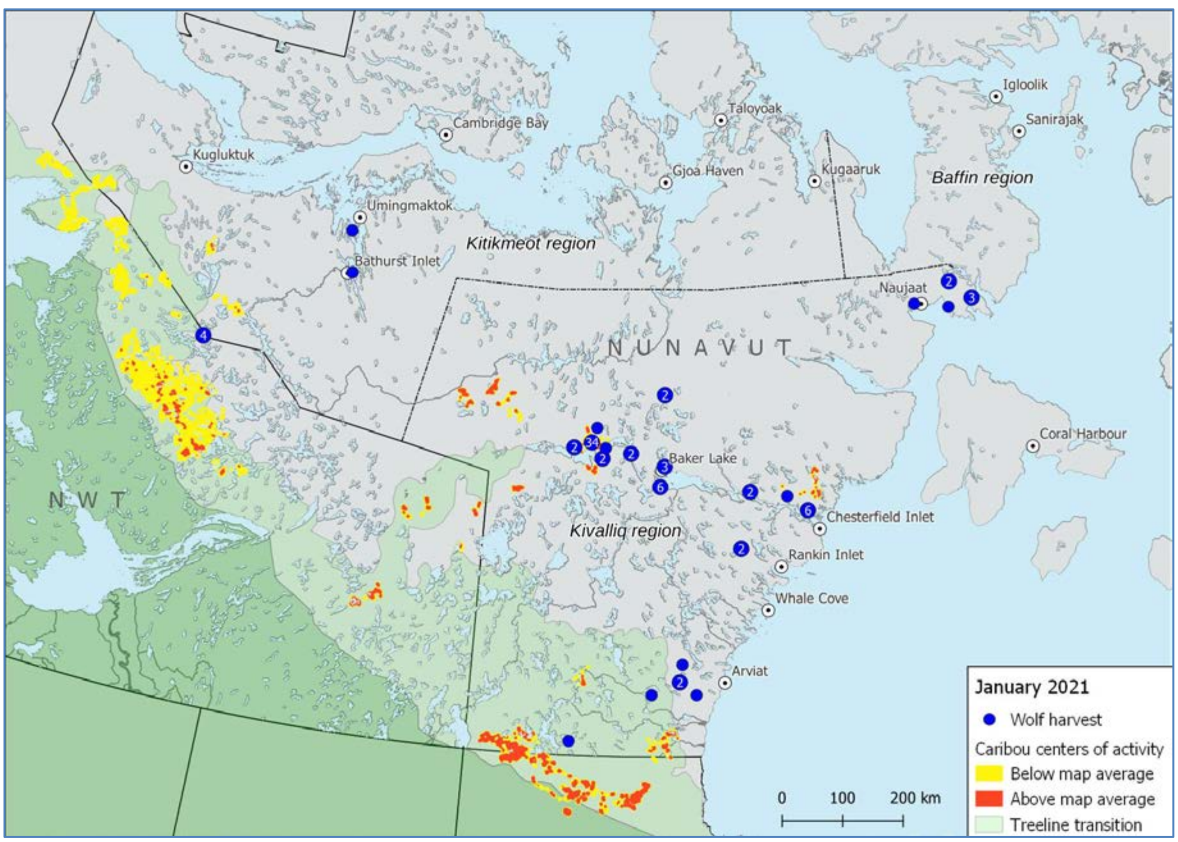
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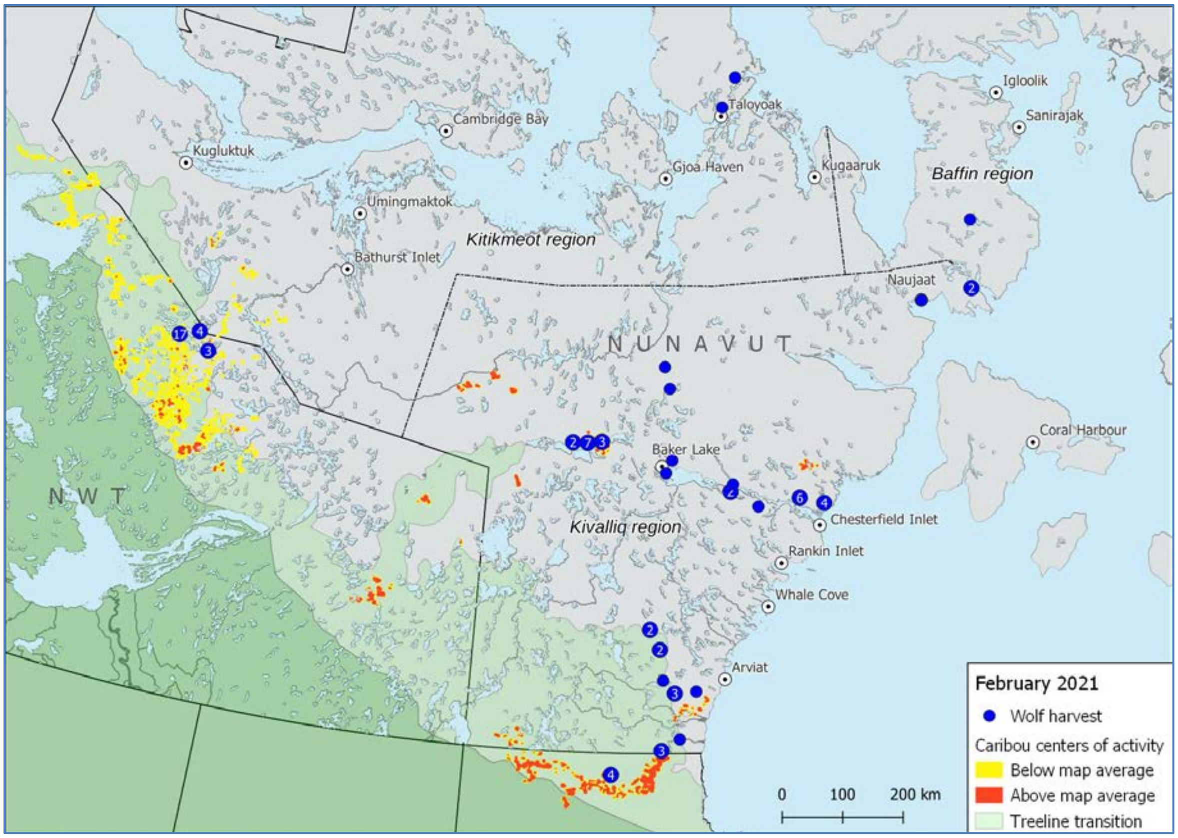
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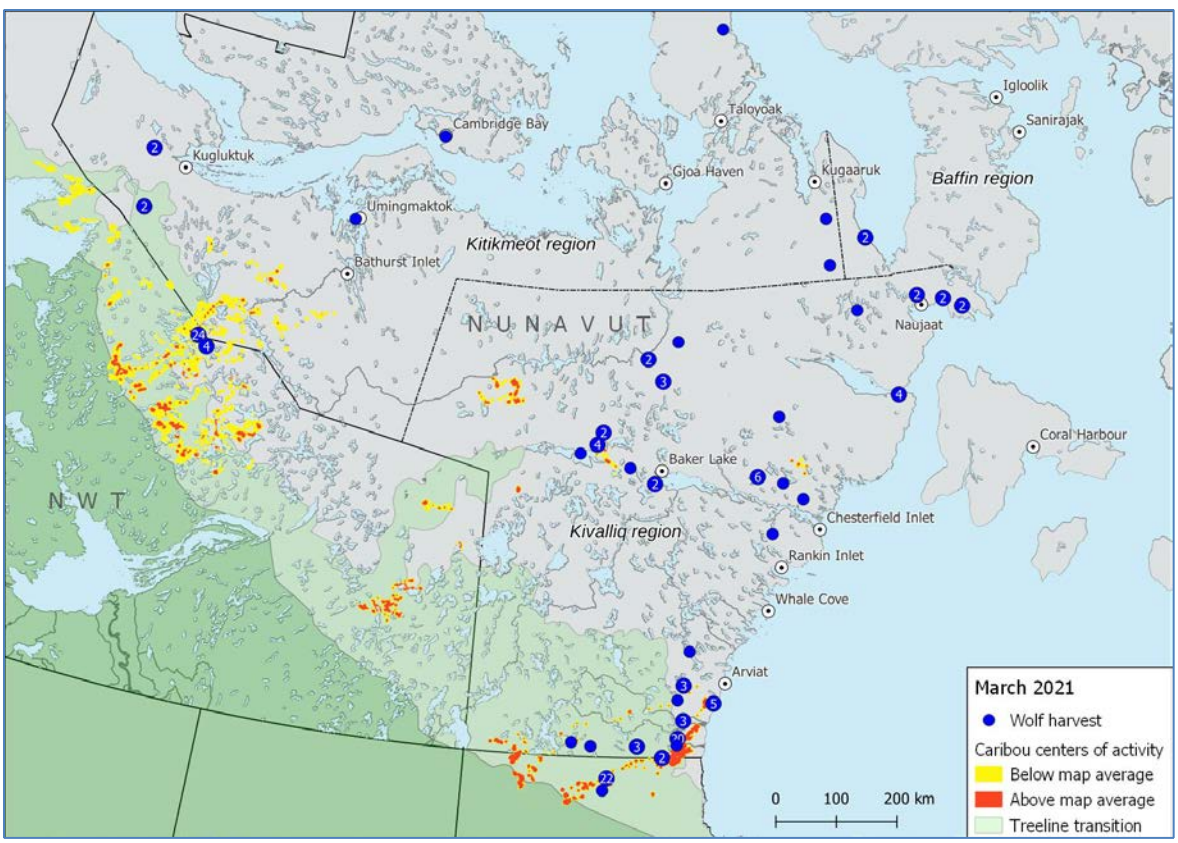
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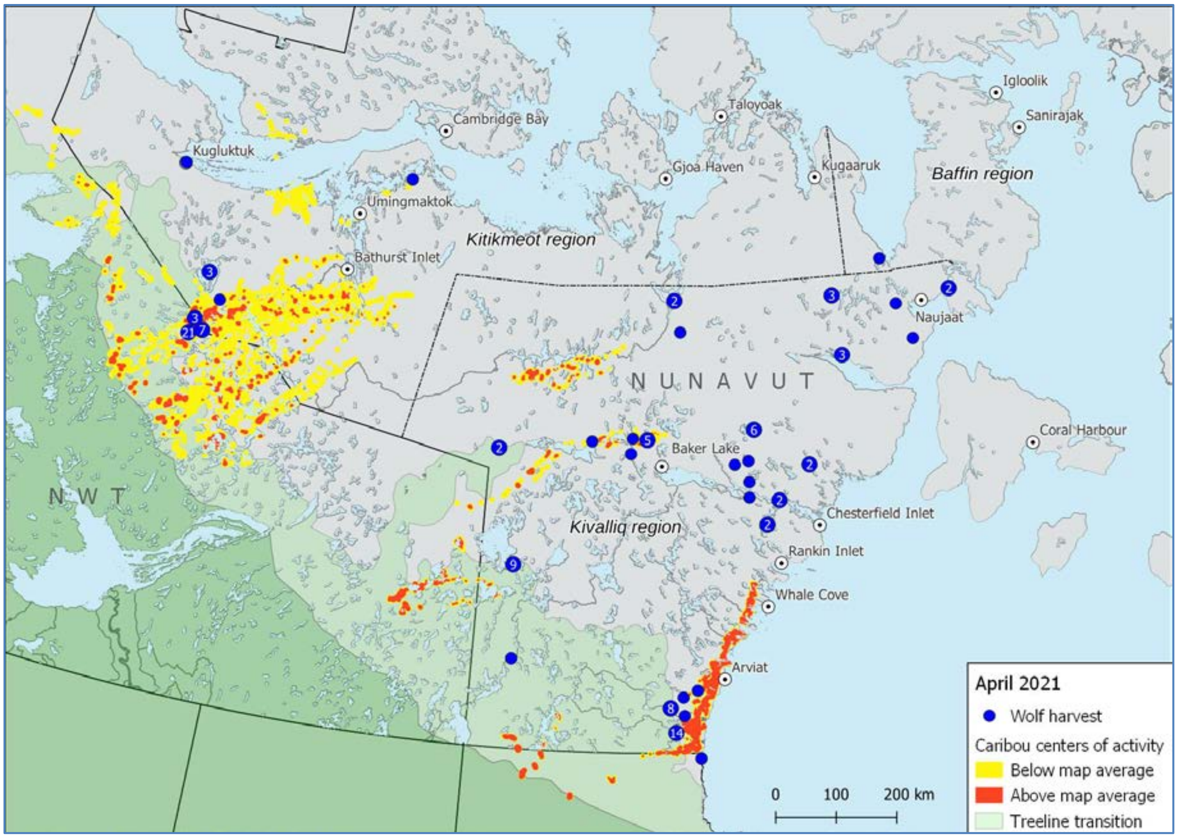
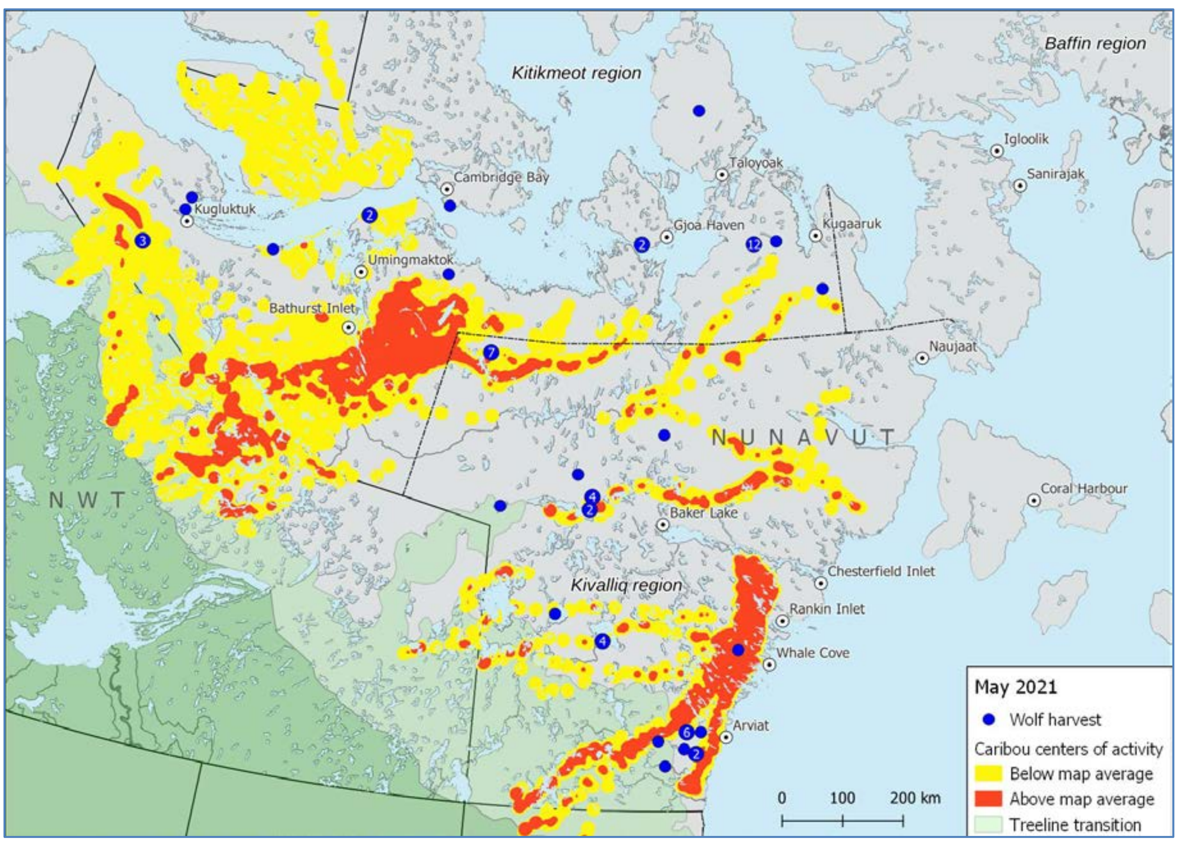
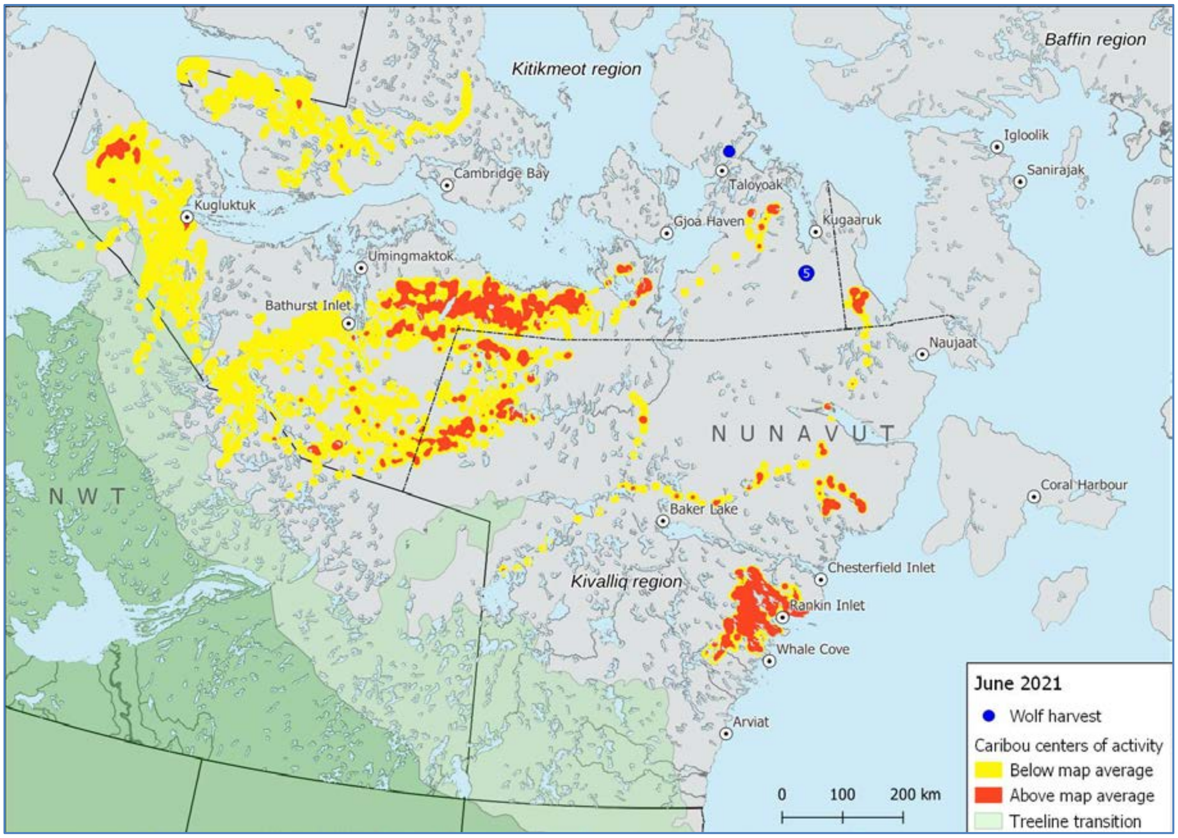
Bathurst Inlet
Naujaat
N U N A V U T
Coral Harbour
Baker Lake
N W T
Kivalliq region
Chesterfield Inlet
Rankin Inlet
Whale Cove
Arviat
March 2021
Wolf harvest
Caribou centers of activity
Below map average
Above map average
Treeline transition
0 100 200 km


Igloolik
Sanirajak
Taloyoak
Cambridge Bay
Kugluktuk
Gjoa Haven
Kugaaruk
Baffin region
Umingmaktok
Kitikmeot region
Bathurst Inlet
Naujaat
NUNAVUT
Coral Harbour
Baker Lake
NWT
Chesterfield Inlet
Kivalliq region
Rankin Inlet
Whale Cove
Arviat
April 2021
Wolf harvest
Caribou centers of activity
Below map average
Above map average
Treeline transition
0 100 200 km


Baffin region
Kitikmeot region
Igloolik
Sanirajak
Taloyoak
Cambridge Bay
Kugluktuk
Gjoa Haven
Kugaaruk
Umingmaktok
Bathurst Inlet
Naujaat
NUNAVUT
Coral Harbour
NWT
Baker Lake
Chesterfield Inlet
Kivalliq region
Rankin Inlet
Whale Cove
Arviat
May 2021
Wolf harvest
Caribou centers of activity
Below map average
Above map average
Treeline transition
0 100 200 km



Kitikmeot region
Baffin region
Igloolik
Sanirajak
Cambridge Bay
Taloyoak
Kugluktuk
Gjoa Haven
Kugaaruk
Umingmaktok
Bathurst Inlet
Naujaat
NUNAVUT
Coral Harbour
NWT
Baker Lake
Chesterfield Inlet
Kivalliq region
Rankin Inlet
Whale Cove
Arviat
0
100
200 km
June 2021
Wolf harvest
Caribou centers of activity
Below map average
Above map average
Treeline transition