Western Arctic Caribou Herd Bibliography

Climate

Joly, K., P. A. Duffy, and T. S. Rupp. 2012. Simulating the effects of climate change on fire regimes in Arctic biomes: implications for caribou and moose habitat. Ecosphere 3 (5): 1-18. Article 36.
Summary: The amount of area burned in northwest Alaska was modeled using different climate warming scenarios. It is forecasted that fire will increase in the region, which will reduce the amount of high-quality habitat by up to 30% within the herd's core winter range. Conversely, moose habitat is forecasted to increase by 20-65%.

Joly, K., R. R. Jandt, C. R. Meyers, and M. J. Cole. 2007. Changes in vegetative cover on Western Arctic Herd winter range from 1981-2005: potential effects of grazing and climate change. Rangifer Special Issue 17: 199-207.
Summary: Analysis of Western Arctic Caribou Herd winter habitat between 1981 and 2005 revealed a decline in lichens and an increase in grasses overall. These changes are likely to be the result of caribou grazing, fire and possibly climate change.

Joly, K., D. R. Klein, et al. 2011. Linkages between large-scale climate patterns and the dynamics of Arctic caribou populations. Ecography 34(2): 345-352.
Summary: Comparison of caribou herd populations with large-scale climate patterns suggest that the Western Arctic Caribou Herd may be showing positive response to the Pacific Decadal Oscillation, which has brought warmer temperatures and wetter conditions in western Alaska and decreased precipitation in the Arctic.

Joly, K. and D. R. Klein. 2011. Complexity of caribou population dynamics in a changing climate. Alaska Park Science 10 (1): 26-31.
Summary: Caribou have survived previous changes in climate, although may have experienced some localized extinctions. While some effects of climate change may benefit caribou, large changes could be detrimental. This might include changes in habitat that attract other wildlife and more predators. We can expect that caribou populations will change in the future.

Management

Callaway, D. (2005). ANILCA and the Western Arctic Caribou Herd Cooperative Management Plan. In: Alaska Park Science, December 2005, Vol. 4, No. 2, pp. 22-26.
Summary: Those who wrote ANILCA appeared to have an awareness of the necessity to integrate local knowledge, values, and cooperation in the framing of a wildlife management regime. When the ADF&G believed the Western Arctic Caribou Herd had dropped to 75,000 caribou in the mid-1970's, local hunters felt these estimates were too low and had missed a lot of animals, so they continued to hunt and exceeded the quota. Employees John Trent and John Cody of ADFG and Dave Spirtes of NPS decided that a new management plan was needed and thus laid the foundation for the Western Arctic Caribou Herd Cooperative Management Plan.

Dau, J. 2000. Managing reindeer and wildlife on Alaska's Seward Peninsula. Polar Research 19(1):57–62.
Summary: When reindeer were introduced to the Seward Peninsula in the late 1890's, the Western Arctic Caribou were largely missing from the landscape. As caribou began to return to this area, they have contributed to reduced number of reindeer in herds as reindeer leave and join the migrating caribou or caribou disrupt the reindeer herds and through competition for food and trampling of habitat. The attraction of predators like wolves and brown bears as the number of caribou has increased has had an impact on the reindeer industry. Cooperative management groups have formed recently to try to come up with local solutions to meet the needs of diverse users, including reindeer herders, subsistence and sport hunters and management agencies.

Fullman, T.J., Joly, K., Ackerman, A. 2017. Effects of environmental features and sport hunting on caribou migration in northwestern Alaska. Movement Ecology 5:4.
Summary: Influence of physical features (terrain ruggedness, river width, land cover) and sport hunting (hunter camps and transporter aircraft landing sites) on Western Arctic Caribou Herd migration was analyzed for Noatak National Preserve. Caribou avoided rugged terrain and areas with more river, forest, and tall shrubs while selecting for areas dominated by tussock tundra and dwarf shrubs. Migration of caribou through Noatak does not appear to be inhibited by sport hunting activity, though this does not preclude the possibility of temporary effects altering availability of caribou for individual hunters. Caribou exhibited exploratory movement, following predictions of a random walk model. This behavior may facilitate utilization of high-quality forage prior to the onset of winter, especially during mild autumns.

Joly, K. and M. D. Cameron. 2018. Use of Selawik National Wildlife Refuge by Western Arctic Caribou Herd, 2009-2017. Natural Resource Report NPS/ARCN/NRR—2018/1681. National Park Service, Fort Collins, Colorado.
Summary: Analysis of caribou movements and distribution in Selawik National Wildlife Refuge, northwest Alaska.

Klein, D. R., L. Moorehead, et al. (1999). Contrasts in use and perceptions of biological data for caribou management. Wildlife Society Bulletin 27(2): 488-498.
Summary: Attitudes and perceptions of hunters and managers of the Western Arctic Caribou Herd were interviewed. Alaskan managers felt that monitoring caribou population dynamics and ranges was their highest priority. Hunters indicated willingness to accept hunting restrictions to help sustain the herd, and accepted the use of radiocollaring and aerial surveys as acceptable methods.

Rattenbury, K., K. Kielland, et al. (2009). A reindeer herder's perspective on caribou, weather and socio-economic change on the Seward Peninsula, Alaska. Polar Research 28(1): 71-88.
Summary: Herder James Noyakuk helped to delineate some of the key factors affecting herders. Weather is more critical now than it may have been 20 years ago, and a single weather event, like delayed freeze-up, early break-up or storms, can have had dramatic effects on herd access and retention. It is difficult to quantify the weather conditions that most affect daily herding plans (visibility, timing of freeze-up and break-up, and snow conditions), whereas air temperature, wind speed and wind direction affect herding indirectly, and did not correlate with how Noyakuk rated weather conditions on herding trips. Responses to extreme weather events are linked to other environmental (caribou, predators, reindeer and range health), economic

(depressed international antler prices, low meat and antler sales from small herds, rising fuel and equipment costs, need for non-herding employment) and social (inability to hire crews, inefficiency/dangers of solo herding) stresses) factors.

Spaeder J., D. Callaway and D. Johnson. 2003. The Western Arctic herd: barriers and bridges to cooperative management. NPS Technical Report NPS/CCSO/UW-2003-01.
Summary: This report investigated how a cooperative caribou harvest assessment program might contribute to greater trust among Native hunters and federal and state managers. The report detailed a number of case studies and also described and analyzed how cooperative management approaches might be devised to deal with the four general functions of wildlife resource management—research, allocation, regulation, and enforcement.

Ecology

Ballard, W. B., L. A. Ayres, et al. (1997). Ecology of wolves in relation to a migratory caribou herd in northwest Alaska. Wildlife Monographs (135): 5-47.
Summary: Studies of wolves and the Western Arctic Caribou Herd during 1987 to 1992 suggested that caribou comprised approximately 51% of wolf diets. Caribou appeared to be the preferred diet of wolves until caribou densities fell below 200 head per ~600 mi2, when wolves would switch to predating more moose. Wolves within the range of the Western Arctic Caribou Herd killed 6-7% of this caribou population annually. Wolf predation levels during this period did not appear to strongly limit caribou population growth.

Baltensperger, A. P., and K. Joly. 2019. Using seasonal landscape models to predict space use and migratory patterns of an arctic ungulate. Movement Ecology 7 (18). DOI: 10.1186/s40462-019-0162-8.
Summary: Caribou are a critical subsistence resource in northwest Alaska. How close caribou come to villages affects subsistence harvests. Using eight years of GPS data from over 200 collared Western Arctic Herd caribou cows, researchers investigated what factors may influence caribou distribution and use of migratory routes. Caribou were predicted to use areas of shallower snow in winter. During the spring migration, caribou were predicted to travel along routes when the snow tends to melt out earlier or where conditions, such as greater wind, produced harder snow, which is easier to travel on. Forested habitats were avoided both on spring and fall migrations. Caribou were predicted to be closer to the coast during insect relief period probably because of the cooler temperatures and higher winds which reduce insect harassment. Caribou tended to be >20 km away from roads, villages, and other human infrastructure. Commonly used migration routes, including on the east and west side of Kobuk Valley National Park and through Cape Krusenstern National Monument, were also identified. This information could prove useful in conservation planning as a number of developments have been proposed within the herd's range.

Cameron, M. D., et al. 2018. Movement-based methods to infer parturition events in migratory ungulates. Canadian Journal of Zoology 96: 1187-1195.
Summary: Using GPS collar data from 2010 to 2015 for the Western Arctic Herd, researchers used two different movement models to detect calving events specifically designed for woodland caribou, a relative of the migratory caribou in Alaska. These models test for a significant drop of

the movement rate of the female caribou during calving, which indicates that she delivered a calf. Researchers compared these results from the GPS collar data to aerial observations taken each year by ADF&G personnel to determine how well the methods worked. They found that by using the two models together, they could be approximately 90% confident in the GPS-based result indicating a female caribou did or didn't have a calf. This finding helps managers of caribou herds by providing a tool with which to identify if, when, and where a female has a calf in a given year.

Cameron, M. D., et al. 2020. Pronounced fidelity and selection for average conditions of calving area suggestive of spatial memory in a highly migratory ungulate. Frontiers in Ecology and Evolution 8:564567. doi: 10.3389/fevo.2020.564567.
Summary: This research documented where the calving grounds of the Western Arctic Herd are and why caribou might be using this area. Fidelity to the calving grounds was high, with a core calving ground being used in all years of the study. Green-up has not occurred while caribou migrate in spring to reach the calving ground, so they need to rely upon their memory to return to this area. The calving grounds are located where green-up is the most consistent and provides the most high-quality forage for caribou, which help them meet the energetic demands of feeding the newborn calves and replenishing their body reserves after the long winter.

Cameron, M. D., et al. 2021. Mechanistic movement models identify continuously updated autumn migration cues in Arctic caribou. Movement Ecology 9 (54). DOI: 10.1186/s40462-021-00288-0.
Summary: The drivers of autumn migration in caribou have been far less studied than those for spring. This work documented that caribou respond to snow fall and decreasing temperatures in deciding when to migrate in autumn. It also revealed that migration is not an "on or off" process; caribou would continually assess conditions along their migration route and adjust their movements if conditions improved along the way. With snow fall coming later and autumn temperatures increasing in recent years in northwest Alaska, climate change may play a role in delayed migration in the Western Arctic Herd. These delays have critical impacts on subsistence hunters.

Dale, B. W., L. G. Adams, et al. (1994). Functional response of wolves preying on barren-ground caribou in a multiple prey ecosystem. Journal of Animal Ecology 63(3): 644-652.
Summary: Studies during March 1989, & 1990 and November 1990 provided some understanding on how the number and density of caribou on the landscape was affected by wolf predation. From analysis of wolf kill rates, prey selection and prey availability for four wolf packs that overlap with the Western Arctic Caribou Herd, it did not appear that wolves had a regulatory effect on caribou. This was based on mathematical analysis that showed that wolf:caribou ratios were high at low prey densities and that wolves did not increase predation as caribou density increased. Nevertheless, reduction in both wolves and bears would be expected to result in increases in caribou density.

Dalerum, F., K. Kunkel, et al. (2009). Diet of wolverines (Gulo gulo) in the western Brooks Range, Alaska. Polar Research 28(2): 246-253.
Summary: The diet of approximately 148 wolverine were determined for the period of 1996 to 2002 through stomach and colon content analysis for animals hunted or trapped by locals within the migratory range of the Western Arctic Caribou Herd. Wolverines mostly ate caribou during the winter, many of which may have been killed by other predators and then scavenged by

wolverine. When caribou were scarce, wolverine switched to eating mostly moose and were able to stay at a similar fitness level on either diet.

Dau, J. 2005. Two caribou mortality events in northwest Alaska: possible causes and management implications. Rangifer Special Issue 16: 37-50.
Summary: After receiving reports from hunters of small numbers of dead caribou near Pt. Hope during the winters of 1994-1995 and 1999-2000, a search was done to count carcasses and sample them to determine what had happened. It appeared that many caribou were malnourished and a high number of calves had died. There was no clear evidence of toxins, but analysis of weather data suggested that wind may have produced hardened snow that could have made it hard for caribou to feed and very low temperatures further stressed the caribou. These deaths did not appear to affect the overall population of the herd but had an impact on local groups.

Dau, J. 2009.Western Arctic Caribou Herd. – In Harper, P. (ed.). Caribou management_ report_ of survey –inventory activities, 1 July 2006–30 June 2008. Alaska Department of Fish and Game. Juneau, Alaska, USA
Summary: Censuses of the WAH were conducted in 2007 and 2009. The July 2007 photos census produced a minimum estimate of 377,000 caribou, but may have been underestimated due to poor lighting and unaccounted for small groups. In 2009, the herd was more completely aggregated and overall good conditions for the census provide confidence in an estimate of approximately 401,000 caribou. During June calving surveys, we observed 65 calves:100 cows in 2006; 73:100 in 2007 and 70:100 in 2008. June, fall and spring calf:cow ratios have declined at similar rates during 1982-2008. Pregnant cows and some nonmaternal caribou begin migrating toward the calving grounds in the Utukok River uplands in April.

Gerlach, S. C., L. K. Duffy, et al. 2006. An exploratory study of total mercury levels in archaeological caribou hair from northwest Alaska. Chemosphere 65(11): 1909-1914.
Summary: Examination of caribou hair from an archaeological site near Deering from about 860 years ago suggest similar levels of mercury then as is found now. These historical data will be important to look for changes as we monitor levels of mercury in subsistence foods in the future.

Gurarie, E., et al. 2019. Tactical departures and strategic arrivals: Divergent effects of climate and weather on caribou spring migrations. Ecosphere 10 (12): e02971. DOI: 10.1002/ecs2.2971.
Summary: In a large study of North America's tundra caribou, including the Western Arctic Herd, researchers found synchronicity of spring migration departure dates from Hudson Bay to the Chukchi Sea. Timing was linked to current conditions that caribou faced: deep, wet snow delayed departures, whereas snow-free areas were associated with early departures. Early migrations tended to go slow, whereas late migrations tended to be quick. The date of the end of spring migration, which culminates in calving, was associated with the conditions caribou faced the summer before, perhaps linking summer forage quality, body condition, and the timing of calving.

Gurarie, E., et al. 2020. For everything there is a season: estimating periodic hazard functions with the cyclomort R package. Methods in Ecology and Evolution 11 (1): 129-138. DOI: 10.1111/2041-210X.13305.
Summary: This paper provides a new tool to analyze seasonal patterns of mortality. It uses data from the Western Arctic Herd to show how it can be used. The analyses showed that mortality

risk is greatest during spring migration until green-up and fall migration and the rut, in a typical year. During the difficult (deep snow) winter of 2017-2018, mortality rates doubled and spiked in November.

Hong, G. H., M. Baskaran, et al. 2011. Anthropogenic and natural radionuclides in caribou and muskoxen in the Western Alaskan Arctic and marine fish in the Aleutian Islands in the first half of 2000s. Science of the Total Environment 409(19): 3638-3648.
Summary: Caribou samples from the Western Arctic Caribou Herd collected between 1998 and 2006 were analyzed for radionuclides from natural and human-activity related sources. Levels found in caribou were similar to those found in the plants they eat, and levels were low and did not appear to pose a health threat to subsistence communities during this time.

Joly, K., and M. D. Cameron. 2018. Early fall and late winter diets of migratory caribou in northwest Alaska. Rangifer 38 (1): 27-38.
Summary: Lichens are the primary winter forage for large herds of migratory caribou (*Rangifer tarandus*). Caribou select for lichens more than they are available across the landscape and they generally avoid, during winter, habitat that has been burned by wildfires for decades while lichen abundance recovers. However, the relative importance of lichens in the diet is subject to debate. From 2010-2013, we conducted one of the largest microhistological studies of the early fall (58 samples from 1 site) and late winter (338 samples from 58 sites) diets of barren-ground caribou. Lichens constituted ~ 71% of the late winter diets of caribou in northwest Alaska, whereas moss (11%) and shrubs (9%) were the next most common forage items. Early fall diets were very similar to late winter, perhaps because deciduous vegetation is senescent during both periods. Diets of males, non-pregnant females and pregnant females were not significantly different. Pregnancy was not associated with the abundance of any forage type during winter, but was associated with higher physiological stress. This result was expected as fall body condition dictates conception, caribou are 'capital' breeders, and gestation can be energetically demanding. Caribou that migrated south (i.e., wintered south of 67.1^{o}N) had lower levels of nutritional stress, higher levels of lichen in the diet, and lower levels of moss and shrubs compared to caribou that did not migrate south.

Joly, K., et al. 2021. Seasonal patterns of spatial fidelity and temporal consistency in the distribution and movements of a migratory ungulate. Ecology and Evolution 11 (12): 8183-8200. DOI: 10.1002/ece3.7650.
Summary: Western Arctic Herd caribou display strong fidelity to their calving grounds and insect relief areas, returning to same general area year after year. On average, females calved within 4 days of when they calved the previous year. The timing and location of fall migration was more variable than spring migration. One key driver of fidelity may be how predictable resources are from year to year. Fidelity was lowest during winter as snow conditions can be highly variable from year to year.

Joly, K., et al. 2021. Caribou and reindeer migrations in the changing Arctic. Animal Migrations 8: 156-167. DOI: 10.1515/ami-2020-0110.
Summary: Migration is the key to having large populations of barrenground caribou, like the Western Arctic Herd. The key to preserving caribou migration is to allow the animals free passage. This paper reviews factors influencing caribou migrations and how climate change may alter them and their influence on migrations.

Joly, K., et al. 2019. Longest terrestrial migrations and movements around the world. Scientific Reports 9: 1-10. Article 15333. DOI: 10.1038/s41598-019-51884-5.
Summary: Arctic caribou display some of the longest terrestrial migrations in the world. The Western Arctic Herd is among the longest of any caribou herd and, at its population peak, displayed the longest terrestrial migration of them all. Interesting, the caribou's main predator, the gray wolf, travels more in a year than even the caribou.

Joly, K., et al. 2020. Behavioral, physiological, demographic and ecological impacts of hematophagous and endoparasitic insects on an arctic ungulate. Toxins 12 (5) 334. DOI:10.3390/toxins12050334.
Summary: Insects, like mosquitoes, warble flies and bot flies, strongly impact caribou. Initially, caribou change their behavior in response to insect harassment. They form large aggregation and their movement rates spike to the highest for the entire year – even higher than during migration. High levels of harassment can impact the body condition of animals as they spend less time eating. Ultimately, this can lower pregnancy rates and affect population growth.

Joly, K., R. R. Jandt, et al. 2009. Decrease of lichens in Arctic ecosystems: the role of wildfire, caribou, reindeer, competition and climate in north-western Alaska. Polar Research 28(3): 433-442.
Summary: A review of research reveals signs of change in Arctic tundra ecosystems. Factors known to be affecting these changes include wildfire, disturbance by caribou and reindeer, differential growth responses of vascular plants and lichens, and associated competition under climate warming scenarios. These factors suggest a reduction in lichen during recent decades.

Joly, K., S. K. Wasser, and R. Booth. 2015 Non-invasive assessment of the interrelationships of diet, pregnancy rate, group composition, and physiological and nutritional stress of barren-ground caribou in late winter. PLoS One 10 (6): e0127586. doi:10.1371/journalpone.0127586.
Summary: Fecal samples were collected and analyzed to assess the late winter diets, rates of pregnancy, sex ratios and condition of Western Arctic Herd caribou. Diets were dominated by lichens. Pregnancy rates fell within the expected range for a declining here.

Prichard, A. K., et al. 2020. Interchange and overlap among four adjacent arctic caribou herd. Journal of Wildlife Management 84 (8): 1500-1514. doi: 10.1002/jwmg.21934.
Summary: Historically, caribou moving from one herd to another has thought to have been fairly uncommon, especially among females. This study looked at how many caribou were moving among the four large Arctic Alaska herds. The researchers documented higher interchange rates than had been previously thought occurring in this region. The smaller herds were more likely to have caribou go to bigger herds than the other way around. Interchange has many management implications, which are also discussed.

Winter

Joly, K. 2011. Modeling influences on winter distribution of caribou in northwestern Alaska through use of satellite telemetry. Rangifer Special Issue 19: 75-85.

Summary: Satellite collars fitted to caribou revealed that that caribou moved significantly less during mid-winter than early- or late-winter and that cows moved significantly more in April than bulls due to their earlier departure on their spring migration. Cows avoided forested areas, highlighting the importance of tundra habitats, and selected for dwarf shrub, with relatively high lichen cover, and sedge habitat types. Bulls selected for dryas, coniferous forest and dwarf shrub habitats but against lowland sedge, upland shrub and burned tundra.

Joly, K., P. Bente, et al. 2007. Response of overwintering caribou to burned habitat in northwest Alaska. Arctic 60(4): 401-410.
Summary: Satellite collars fitted to caribou revealed that caribou were more likely to select burned areas in the late fall and early spring than midwinter. They appear to particularly avoid burns estimated to be 26-55 years old, likely due to the reduction in lichen in burned areas.

Joly, K., F. S. Chapin, et al. 2010. Winter habitat selection by caribou in relation to lichen abundance, wildfires, grazing, and landscape characteristics in northwest Alaska. Ecoscience 17(3): 321-333.
Summary: We found that lichen abundance was more than 3 times greater at locations used by caribou than found at random. The current winter range does not appear to be overgrazed as a whole, but continued high grazing pressure and consequences of climate change on plant community structure might degrade its condition. Within the current winter range, lichen abundance was more than 4 times greater at unburned locations than at recently (< 58 y) burned locations. The historic winter range has low lichen abundance, likely due to sustained grazing pressure exerted by the herd, which suggests that range deterioration can lead to range shifts.

Joly, K., M. J. Cole, et al. 2007. Diets of Overwintering Caribou, Rangifer tarandus, Track Decadal Changes in Arctic Tundra Vegetation. Canadian Field-Naturalist 121(4): 379-383.
Summary: Winter diets of the Western Arctic Caribou Herd from 1995/1996 and 2005 were determined based on fecal analysis. Diets tracked changes in vegetation observed across 10 years, with decreased lichen and increased sedges and shrubs.

Joly, K., P. A. Duffy, and T. S. Rupp. 2012. Simulating the effects of climate change on fire regimes in Arctic biomes: implications for caribou and moose habitat. Ecosphere 3 (5): 1-18. Article 36.
Summary: The amount of area burned in northwest Alaska was modeled using different climate warming scenarios. It is forecasted that fire will increase in the region, which will reduce the amount of high-quality habitat by up to 30% within the herd's core winter range. Conversely, moose habitat is forecasted to increase by 20-65%.

Saperstein, L. B., 1996. Winter forage selection by barren-ground caribou: Effects of fire and snow. Rangifer Special Issue 9:237–238.
Summary: Both long- and short-term consequences should be considered when examining the effects of fire on the foraging behavior of caribou. Post-fire increases in protein content, digestibility, and availability of cotton grass, E. vaginatum, make burned tussock tundra an attractive feeding area for caribou in late winter. These benefits are likely short-lived, however. Lowered availability of lichens and increased relative frequency of bryophytes will persist for a much longer period.

Skoog, R.O., 1968. Ecology of the caribou (Rangifer tarandus granti) in Alaska. Ph.D. dissertation. University California, Berkeley. 699 pp., RO. 1968. Ecology of the caribou (Rangifer tarandus granti) in Alaska. Ph.D. dissertation. University California, Berkeley. 699pp.
Summary: Alaska's caribou population consists of six regional sub-populations and eleven herds, typically centered around high-quality habitat. As the number of caribou in an area increase, they begin to move into areas of lower quality habitat and some may eventually leave the herd and go into other regions. A historical view of caribou herds shows that many animals moved between regions, especially when there were more than 5 to 10 animals per square mile. It appears that there was enough forage in many regions to support more caribou when this study was completed in the 1960's.

Resource Development

Fullman, T. J., et al. 2021. Simulation modeling accounts for uncertainty while quantifying ecological effects of development alternatives. Ecosphere 12(5): e03530. DOI: 10.1002/ecs2.3530.
Summary: How can we evaluate impacts of management alternatives before specific development proposals are submitted? This paper modeled potential impacts to the calving grounds of both the Western Arctic Herd and Teshekpuk Herd from various development scenarios for the NPR-A. Recommendations for adjusting scenarios were provided that may better conserve the calving areas without substantially affecting development options.

Fullman, T. J., et al. 2021. Mapping potential effects of proposed roads on migratory connectivity for a highly mobile herbivore using circuit theory. Ecological Applications 31(1): e02207. doi: 10.1002/eap.2207.
Summary: There are a number of development proposals within the range of the Western Arctic Herd. This work assesses the impacts of one proposed road system, looking at how caribou movements and distribution could be impacted by them. Migration of caribou is critical to the region as these movements bring caribou within range of subsistence hunters in nearly 40 villages in northwest Alaska. Caribou avoided dense vegetation, rugged terrain, major rivers, and existing roads in both spring and fall. If the roads were developed, some villages could see less caribou coming near to their village.

Magdanz, James S., Joshua Greenberg, Joseph M. Little, and David S. Koster. 2016. The Persistence of Subsistence: Wild Food Harvests in Rural Alaska, 1983-2013. *Social Science Research Network* 2779464. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2779464
Summary: Explores Alaska's subsistence economy using community-level demographic, economic, and harvest data from a large sample of rural households, evaluating trends over time, identifying factors associated with harvests and personal incomes, and modeling productivity. With time as the only factor, models suggest community populations and wild food harvests are not changing, while real personal incomes are gradually declining, contradicting popular narratives of burgeoning rural indigenous populations, diminishing subsistence and growing cash-dependence. Multiple regression models find evidence of modest harvest declines over time in remote areas; geographic location and accessibility are highly influential. Using propensity score matching, models show that road building is expected to result in significant declines in harvests, but no significant changes in incomes, contradicting state narratives of positive rural development impacts.

Wilson, R.R., D.D. Gustine, and K. Joly. 2014. Evaluating Potential Effects of an Industrial Road on Winter Habitat of Caribou in North-Central Alaska. Arctic 67(4): 472-482.
Summary: Worldwide, some caribou (*Rangifer tarandus*) populations are experiencing declines due partially to the expansion of industrial development. Caribou can exhibit behavioral avoidance of development, leading to indirect habitat loss, even if the actual footprint is small. Thus, it is important to understand before construction begins how much habitat might be affected by proposed development. In northern Alaska, an industrial road that has been proposed to facilitate mining transects a portion of the Western Arctic caribou herd's winter range. To understand how winter habitat use might be affected by the road, we estimated resource selection patterns during winter for caribou in a study area surrounding the proposed road. We assessed the reductions of habitat value associated with three proposed routes at three distance thresholds for disturbance. High-value winter habitat tended to occur in locally rugged areas that have not burned recently and have a high density of lichen and early dates of spring snowmelt. We found that 1.5% to 8.5% (146–848 km2) of existing high-value winter habitat in our study area might be reduced in quality. The three alternative routes were only marginally different. Our results suggest that the road would have minimal direct effects on high-value winter habitat; however, additional cumulative impacts to caribou (e.g., increased access by recreationists and hunters) should be considered before the full effects of the road can be estimated.

Wilson, R.R., L.S. Parrett, K. Joly, and J.R. Dau. 2016. Effects of roads on individual caribou movements during migration. Biological Conservation 195: 2-8.
Summary: Long distance migrations by large mammals are increasingly imperiled by human development. We studied autumn migratory patterns of caribou (*Rangifer tarandus*) in relation to an industrial road in northwestern Alaska. We built null movement models to determine the expected time to cross the road if caribou movements were not affected by the road. We then identified individuals that took longer to cross than expected (slow crossers) and those that did not differ from that expected from the null model (normal crossers). We identified eight as slow and 20 as normal crossers. Slow crossers took an average of 33.3±17.0 (±SD) days to cross the road compared to 3.1± 5.5 days for normal crossers. Slow crossers had an average crossing date of 8 Nov. ± 7.7 days versus 25 Oct. ± 20.6 days for normal crossers. Movement rates of the two classes did not differ before crossing the road, but slow crossers moved N1.5 times as fast as normal crossers after crossing the road. Movement patterns were partially explained by environmental attributes but were most strongly affected by how far a caribou was from the road and whether it was classified as slow or normal crosser. While avoidance is an important aspect of the effects of roads on populations, our results show the importance of other factors, such as how long individuals are delayed in crossing when assessing the influence of development on wildlife.

Wolfe, R.J. and R.J. Walker. 1986. *Impacts of roads and settlement entry on subsistence in Alaska*. Proceedings of the Annual Meeting of Alaska Anthropological Association: Fairbanks.

Wolfe, R.J. and R.J. Walker. 1987. *Subsistence economies in Alaska: productivity, geography, and development impacts*. Arctic Anthropology 24(2): 56–81.

Subsistence Use

Andersen, David B., Caroline Brown, Robert Walker, and Gretchen Jennings. 2004. The 2001–2002 Harvest of Moose, Caribou, and Bear in Middle Yukon and Koyukuk River Communities. Alaska Department of Fish and Game, Division of Subsistence, Technical Paper No. 278.

Andersen, David B., Charles J. Utermohle, and Louis Brown. 1998. The 1997– 1998 Harvest of Moose, Caribou, and Bear in Middle Yukon and Koyukuk River Communities, Alaska. Alaska Department of Fish and Game, Division of Subsistence, Technical Paper No. 245.

Andersen, David B., Charles J. Utermohle, and Louis Brown. 2000. The 1998–1999 Harvest of Moose, Caribou, and Bear in Ten Middle Yukon and Koyukuk River Communities. Alaska Department of Fish and Game, Division of Subsistence, Technical Paper No. 251.

Andersen, David B., Charles J. Utermohle, and Gretchen Jennings. 2001. The 1999–2000 Harvest of Moose, Caribou, and Bear in Ten Middle Yukon and Koyukuk River Communities. Alaska Department of Fish and Game, Division of Subsistence Technical Paper No. 262.

Atkinson, H. Mobilizing Indigenous Knowledge through the Caribou Hunter Success Working Group. *Land* 2020, *9*, 423.
Summary: The caribou stewardship practices of the Iñupiat have persisted through cycles of abundance and decline for the Western Arctic Caribou Herd (WACH). This research seeks to address the challenges and opportunities faced when mobilizing Indigenous Knowledge in the National Park Service (NPS) management of the herd. Motivated by Indigenous stewardship concerns, NPS staff facilitate and participate in an informal working group focused on caribou hunter success. Using Indigenous Knowledge methods, this study examined the outcomes of the working group and the use of "rules of thumb" to identify and share stewardship practices. In the two cases, the Caribou Hunter Success Working Group created space for subsistence hunters to develop educational materials based on Indigenous Knowledge to address specific hunter success issues. Subsistence users participate in the federal subsistence programs and related subsistence forums, and it is the work of the NPS to mobilize the knowledge they contribute to improve subsistence management for both the users and the resource. There are two additional benefits for the NPS: (1) a better understanding of the use of the resource, and (2) when regulations are informed by Indigenous Knowledge, there is a greater likelihood of adherence. The mobilization of Indigenous Knowledge leads to more effective management.

Braund, Steven R., Karen Brewster, Lisa Moorehead, Timothy P. Holmes, and John A. Kruse. 1993. The North Slope Subsistence Study: Barrow, 1987, 1988, 1989. Anchorage: Technical Report No. 149, OCS Study, MMS 91-0086, submitted to U.S. Department of the Interior Minerals Management Service, for contract no. 14-12-0001-30284. Stephen R. Braund & Associates with University of Alaska Anchorage Institute of Social and Economic Research.

Braund, Steven R., Eric Loring, Lisa Moorehead, David C. Burnham, and John A. Kruse. 1993. The North Slope Subsistence Study: Wainwright, 1988, 1989. Submitted to the US Department of Interior, Minerals Management Service, Alaska OCS Region, Anchorage, Alaska. Anchorage: Stephen R. Braund & Associates with Institute of Social and Economic Research, University of Alaska Anchorage.

Braem, N.M., S. Pedersen, J. Simon, D.S. Koster, T. Kaleak, P. Leavitt, J. Patkotak, and P. Neakok. 2011. Monitoring of caribou harvests in the National Petroleum Reserve in Alaska: Atqasuk, Barrow, and Nuiqsut, 2003–2007. Alaska Department of Fish and Game, Division of Subsistence Technical Paper No. 361, Fairbanks.

Braem, N.M., 2011. Subsistence wildlife harvests in Deering, Alaska, 2007-2008. Alaska Department of Fish and Game Division of Subsistence, Special Publication No. SP2010-002, Anchorage.

Braem, N.M., 2011. Subsistence wildlife harvests in Noorvik, Shungnak and White Mountain, Alaska, 2008-2009. Alaska Department of Fish and Game Division of Subsistence, Special Publication No. SP2011-003, Fairbanks.

Braem, N.M., 2012. Subsistence wildlife harvests in Ambler, Buckland, Kiana, Kobuk, Shaktoolik and Shishmaref, Alaska, 2009-2010. Alaska Department of Fish and Game Division of Subsistence, Special Publication No. SP2012-003, Fairbanks.

Braem, N.M.; James S. Magdanz; David S. Koster; Patricia Fox. 2013. Subsistence harvests in Northwest Alaska: Selawik, 2010–2011. ADF&G Division of Subsistence, Technical Paper No. 389.

Braem, N.M. and M. Kostick. 2014. Subsistence wildlife harvests in Elim, Golovin, Kivalina, Koyuk, Noatak, and Wales, Alaska, 2010-2011. Alaska Department of Fish and Game Division of Subsistence, Special Publication No. SP2012-004, Fairbanks.

Braem, N.M., E.H. Mikow, S.J. Wilson, and M.L. Kostick. 2015. Wild Food Harvests in 3 Upper Kobuk River Communities: Ambler, Shungnak, and Kobuk, 2012–2013. Alaska Department of Fish and Game Division of Subsistence, Technical Paper No. 402, Fairbanks.

Braem, N.M., E.H. Mikow,and M.L. Kostick, editors. 2017. Chukchi Sea and Norton Sound Observation Network: Harvest and Use of Wild Resources in 9 Communities in Arctic Alaska, 2012–2014. Alaska Department of Fish and Game Division of Subsistence, Technical Paper No. 403, Fairbanks.

Braem, Nicole M. 2017. Revised Options for Amounts Reasonably Necessary for Subsistence Uses of the Teshekpuk Caribou Herd. Alaska Department of Fish and Game Division of Subsistence, Special Publication No. BOG 2017-02, Fairbanks.

Brower, R., and T. Opie. 1996. North Slope Borough Subsistence Harvest Documentation Project: Data for Anaktuvuk Pass, Alaska for the Period July 1, 1994 to June 30, 1995. Barrow: North Slope Borough, Department of Wildlife Management.

Brower, R., and T. Opie. 1997. North Slope Borough Subsistence Harvest Documentation Project: Data for Atqasuk, Alaska for the Period July 1, 1994 to June 30, 1995. Barrow: North Slope Borough, Department of Wildlife Management.

Brower, R., and T. Opie. 1998. North Slope Borough Subsistence Harvest Documentation Project: Data for Nuiqsut, Alaska for the Period July 1, 1994 to June 30, 1995. Barrow: North Slope Borough, Department of Wildlife Management.

Brown, Caroline L., Robert Walker, and Susan B. Vanek. 2004. The 2002-2003 Harvest of Moose, Caribou, and Bear in Middle Yukon and Koyukuk River Communities. Alaska Department of Fish and Game, Division of Subsistence, Technical Paper No. 280.

Brown, C.L., N.M. Braem, M.L. Kostick, A. Trainor, L.J. Slayton, D.M. Runfola, E.H. Mikow, H. Ikuta, C.R. McDevitt, J. Park, and J.J. Simon. 2016. Harvests and uses of wild resources in 4 Interior Alaska communities and 3 Arctic Alaska communities. Alaska Department of Fish and Game Division of Subsistence, Technical Paper No. 426, Fairbanks.

Fuller, Allen, S., and John George C. 1997. "Evaluation of Subsistence Harvest Data from the North Slope Borough 1993 Census for Eight North Slope Villages: For the Calendar Year 1992." Barrow: North Slope Borough, Department of Wildlife Management.

Galginaitis, Michael C. 1990. Subsistence Resource Harvest Patterns: Nuiqsut. Anchorage: Submitted to the US Department of Interior, Minerals Management Service, Alaska OCS Region.

Galginaitis, Michael C., Claudia Chang, Kathleen M. MacQueen, Albert A. Dekin Jr., and David Zipkin. 1984. Ethnographic Study and Monitoring Methodology of Contemporary Economic Growth, Sociocultural Change and Community Development in Nuiqsut, Alaska. Anchorage: Social and Economic Studies Program Technical Report No. 96. Submitted to the US Department of Interior, Minerals Management Service, Alaska OCS Region.

Georgette, S. 1994. Summary of Western Arctic Caribou herd overlays (1984–92) and comparison with harvest data from other sources. Alaska Department of Fish and Game, Division of Subsistence: Juneau.

Georgette, S. 1999. Subsistence harvests in Northwest Alaska: Caribou, Moose, Bear, Wolf, and Wolverine May 1998 through April 1999. Alaska Department of Fish and Game, Division of Subsistence: Kotzebue.

Georgette, S. and H. Loon 1988. *The Noatak River: Fall caribou hunting and airplane use.* Alaska Department of Fish and Game Division of Subsistence, Technical Paper No. 162.

Georgette, S. and H. Loon. 1993. *Subsistence use of fish and wildlife in Kotzebue, a Northwest Alaska regional center*. Alaska Department of Fish and Game Division of Subsistence, Technical Paper No. 167: Juneau.

Georgette, S., K. Persons, and A. Ahmasuk. 2002. Subsistence Wildlife Harvests in Four Communities on the Western Seward Peninsula, Alaska 2000-2001. Alaska Department of Fish and Game Division of Subsistence and Kawerak, Inc.: Kotzebue.

Georgette, S., K. Persons, E. Shiedt, and S. Tahbone. 2004. *Subsistence wildlife harvests in five northwest Alaska communities, 2001–2003*. Alaska Department of Fish and Game, Maniilaq

Association, and Kawerak, Inc.

Georgette, S., A. Ahmasuk, K. Persons, E. Shiedt, and E. Trigg. 2005. *Subsistence wildlife harvests in three northwest Alaska communities, 2003–2004*. Alaska Department of Fish and Game, Maniilaq Association, and Kawerak, Inc.

Godduhn, A.R., N.M. Braem, and M.L. Kostick 2014. *Subsistence Wildlife Harvests in Kotzebue, Alaska, 2012–2013*. Alaska Department of Fish and Game Division of Subsistence, Special Publication No. SP2014-03: Fairbanks

Guettabi, M., J. Greenberg, J. Little, and K. Joly. 2016. Evaluating potential economic effects of an industrial road on subsistence in north-central Alaska. Arctic 69 (3): 305-317. A new road has been proposed to provide access to this region and the Ambler Mining District from north-central Alaska. To evaluate how it might affect subsistence harvest, we used models to identify factors related to subsistence production at the household level. We found substantial differences in these factors between communities near the proposed road and a comparable set of road accessible communities outside the region. Total subsistence production of study area communities was 1.8 to 2.5 times greater than those outside it. If the road was opened to the public and subsistence harvest patterns for study area communities changed to mirror existing communities on the existing road system as a result of the road, the financial cost would be $6,900 – $10,500 per household (assuming a $8/lb "replacement" cost for subsistence harvests). Taken together, our results suggest that the proposed road should be expected to substantially impact subsistence production in communities that are not currently connected to the road system.

Halas, G, and G. Kofinas. 2015. Community Report: Caribou Migration, Subsistence Hunting, and User Group Conflicts in Northwest Alaska. UAF School of Natural Resources & Extension, AFES Miscellaneous Report 2015-06.
Summary: This community report presents key findings of a research project of the University of Alaska Fairbanks, the National Park Service, and the Native Village of Noatak that studied the links between caribou, interactions of local and non-local hunters, and changes to subsistence caribou hunting. (http://www.uaf.edu/snre/research/publications/miscellaneous-publication/)

Halas, Gabriela. 2015. Caribou migration, subsistence hunting, and user group conflicts in northwest Alaska: A traditional knowledge perspective. School of Natural Resources and Extension, University of Alaska Fairbanks.
Summary: In the last decade there has been an increase in caribou hunting activities by non-local hunters and commercial operators in Noatak's traditional hunting lands, including the Noatak National Preserve.
This thesis acts as the full report from a research project of the University of Alaska Fairbanks, the National Park Service, and the Native Village of Noatak that studied the links between caribou, interactions of local and non-local hunters and transports, and changes to subsistence caribou hunting.

Heller, C.A. and E.M. Scott 1967. *The Alaska dietary survey, 1956–1961*. U. S. Department of Health: Education, and Welfare Nutrition and Metabolic Disease Section, Arctic Health Research Center: Anchorage

Loon, Hannah Paniyavluk and Selawik Elders 2007. Uqausriptigun: In Our Own Words, Selawik elders speak about caribou, reindeer and life as they knew it. U.S. Fish & Wildlife Service, Selawik National Wildlife Refuge: Kotzebue, Alaska.

Magdanz, J.S., N.S. Braem, B.C. Robbins, and D.S. Koster 2010. *Subsistence harvests in Northwest Alaska, Kivalina and Noatak, 2007*. Alaska Department of Fish and Game Division of Subsistence, Technical Paper No. 354: Kotzebue.

Magdanz, J.S., C.J. Utermohle, and R.J. Wolfe 2002. *The production and distribution of wild food in Wales and Deering, Alaska*. Alaska Department of Fish and Game Division of Subsistence, Technical Paper No. 259: Kotzebue.

Magdanz, J.S., R.J. Walker, and R.R. Paciorek 2004. The subsistence harvests of wild foods by residents of Shungnak, Alaska, 2002. Alaska Department of Fish and Game Division of Subsistence, Technical Paper No. 279: Juneau

Marcotte, James R., and Terry L. Haynes. 1985. "Contemporary Resource Use Patterns in the Upper Koyukuk Region, Alaska." Technical paper 93. Fairbanks: Alaska Department of Fish and Game, Division of Subsistence. http://www.adfg.alaska.gov/techpap/tp093.pdf.

Mikow, E., Nicole M. Braem, Marylynne Kostick. 2014. Subsistence Wildlife Harvests in Brevig Mission, Deering, Noatak, and Teller, Alaska, 2011–2012. Alaska Department of Fish and Game Division of Subsistence, Special Publication No. -002.

Mikow, E.H. and M.L. Kostick 2016. *Subsistence wildlife harvests in Kotzebue, Alaska, 2013–2014*. Alaska Department of Fish and Game Division of Subsistence, Special Publication No. 2016-2: Fairbanks

Patterson, A. 1974. *Subsistence harvests in five native regions: for the Joint Federal-State Land Use Planning Commission for Alaska.* Resource Planning Team: Anchorage.