Habitat and Movement Ecology of Grizzly Bears in the Mackenzie Delta, NWT

by Mark A. Edwards

In the 1960s and 1970s, the Mackenzie Delta region of the Northwest Territories in Canada's Western Arctic was on the brink of an oil and gas "boom"; however, pipeline construction was delayed following Thomas Berger's recommendation for a 10-year moratorium so that Native land claims could be settled. Today, the Mackenzie Delta is the proposed site for the new Mackenzie Gas Project, which will include an increase in the number of exploration and production wells and the construction of a pipeline and gathering system with associated facilities, as well as airfields and winter and all-weather roads, and result in landscape-level changes (Imperial Oil Resources Ventures Limited, 2004; Cizek and Montgomery, 2005). Wildlife managers and the affected communities are concerned that sensitive species like the barren-ground grizzly bear (*Ursus arctos*) could be adversely affected by increasing oil and gas development. Historically, grizzly bear declines in North America have resulted from the fragmentation of habitats by human settlements, roads, agriculture, human intolerance, and inadequate planning in the early stages that precede development (Servheen et al., 1999). Wildlife managers lack the current information on the ecology of this Arctic population of grizzlies needed for effective mitigation of the effects of disturbance caused by hydrocarbon development.

Low density, high mobility, and large home ranges describe Arctic grizzly bear populations (Ferguson and McLoughlin, 2000). When compared to other large carnivores, grizzlies are considered to have a lower ecological resilience, which is characterized by low population density, low fecundity, and low dispersal ability through developed areas (Weaver et al., 1996). Low resilience suggests that grizzlies are especially vulnerable to development-related disturbance. The sensitivity of the species makes it difficult for population numbers to increase in multi-use landscapes where the cumulative impacts of industry, subsistence and sport hunting, problem and defence kills, and recreational activities are the norm. The Mackenzie Gas Project will transect areas occupied by grizzly bears within the Inuvialuit Settlement Region, which is also at the northernmost edge of their geographical range. At these northern latitudes, grizzly bears must accumulate enough energy reserves to last the 6–7 months of winter dormancy (Nagy et al., 1983). We do not know what effects a pipeline will have on the grizzlies of the Mackenzie Delta, but it could make it more difficult for them to meet their resource needs given a short active 5–6 month period (Nagy et al., 1983). Harding and Nagy (1980) predicted that hydrocarbon development in the region could be detrimental to grizzly bears because of the loss of available resources, and that mortality from problem bear-human interaction could result in population decline.

The primary goals of my project are to collect baseline information on grizzly bear ecology before pipeline construction begins, to describe annual and seasonal home range size and distribution, and to identify important habitats. The information gained will form the foundation for model development to assess the affect of oil and gas–related activities on grizzly bears. Major project objectives are 1) to describe habitat selection patterns, 2) to quantify movement patterns, and 3) to incorporate these patterns into a scenario-based modelling approach to assess the response of grizzly bears to pipeline-related development.

STUDY AREA

My research is being conducted in the Mackenzie Delta region north of Inuvik to the Beaufort Sea (ca. 28 000 km^2). Human populations are centered in Aklavik, Inuvik, Paulatuk, and Tuktoyaktuk. The region is characterized by long, cold winters and short, cool summers, with temperatures ranging from -57˚C to 32˚C (Black and Fehr, 2002). Numerous lakes and rivers are found in the area, and broad habitat features include boreal forest dominated by spruce (*Picea glauca* and *P. mariana*) in southern areas, which grades into tundra with scattered trees and shrubs (Black and Fehr, 2002).

METHODS AND PRELIMINARY RESULTS

Getting the Sample

From mid-May to early June in 2003–06, 130 bears were captured and immobilized by aerial darting using Telezol®, and 41 were fitted with Global Positioning System (GPS)/Argos-linked satellite radio-collars (Telonics Inc., Mesa, AZ, Service Argos Inc., Lynnwood, WA) programmed to acquire location information every four hours. All collars were equipped with a collar-release mechanism with a pre-programmed "drop-off" date and time. Relocation information was imported into a Geographic Information System (GIS), ArcGIS 9.1 (Environment Systems Research Institute, Redlands, California, USA) for home range delineation and analysis of bear distribution and movements. Over 30 000 locations have been recorded.

The home range is the area that an animal uses within a specified period of time to provide the necessary resources for survival and successful reproduction (Burt, 1943). Individuals inhabiting regions where habitat quality is high will require smaller areas to secure their life requisites (Gill and Wolf, 1975).

Annual home range sizes based on 100% minimum convex polygons were created to delineate the overall space use and general distribution for male (range: 1475–6735 km^2) and female (range: 80–4965 km^2) grizzly bears. Fixed-kernel home range estimates (95%: male range, 553–4306 km^2; female range, 108–3064 km^2; and 50%: male range, 36–333 km^2; female range, 8–404 km^2) allowed core areas of activity to be identified.

Home ranges for grizzlies in the Mackenzie Delta were greater than those reported for both coastal and interior North American populations. These results suggest that habitat quality, defined as the abundance and predictability of foods, is low in the Mackenzie Delta region, so that bears must cover greater areas to meet their resource needs. Distance and speed of travel were similar for male and female grizzly bears.

Much research on home range delineation and use of core areas has been done using telemetry, but relatively few studies link location data and associated habitats to investigate behaviour (Kernohan et al., 2001). The attributes of a particular patch may result in a change in an individual's rate or direction of travel, or both (Boone and Hunter, 1996). Incorporating movement rates and patterns in habitat selection models provides an explanatory medium with robust predictive abilities to determine how environmental features influence the way animals navigate the landscape (Fortin et al., 2005). For grizzly bears in the Mackenzie Delta, disturbance from development and increased risk of mortality could alter movement and dispersal patterns, which could affect population dynamics. More research is needed on the role of seasonal patch distribution and habitat quality in shaping movement patterns of grizzly bears in non-fragmented landscapes.

FIG. 1. Vernon Amos (left) and Mark Edwards make final adjustments to the GPS/Argos satellite-linked collar. Photo: Andrew Derocher.

Identifying Important Grizzly Bear Habitat

To describe habitat selection patterns and identify important habitats for grizzly bears in the Mackenzie Delta, I am using resource selection function (RSF) analysis (Manly et al., 2002). The RSF can provide insights with predictive properties for understanding species-habitat relationships and is proportional to the probability that an animal will use a resource (Boyce and McDonald, 1999; Boyce et al., 2002). Areas used by bears will be determined from telemetry locations, and available sites will be randomly generated. Important seasonal habitats for grizzly bears will be determined at three scales: the individual home range, the subpopulation, and the regional population.

Development of habitat selection models for grizzly bears requires that environmental and anthropogenic components of the study area be accurately represented and quantified. Where possible, this information was acquired from pre-existing sources; however, the resolution of the analyses required that the vegetation characteristics of the landscape be quantified at a level and classification accuracy not presently available. Over 550 sites have been surveyed across the study area for use in the development of the vegetation classification model. When completed in autumn 2006, the vegetation classification model will have the highest possible classification accuracy available and will be applicable to studies of other wildlife species in the area, such as barren-ground caribou (*Rangifer tarandus*), wolves (*Canis lupus*), wolverines (*Gulo gulo*), and waterfowl.

Risk Assessment for Grizzly Bears

Historically, in the absence of field data, assessment of risk to wildlife from natural or human-based events has largely been based on expert biological opinion (McDonald and McDonald, 2002). RSF models provide an objective medium to quantitatively and objectively evaluate the risk of habitat change on animals or populations (Manly et al., 2002; McDonald and McDonald, 2002). Results from the habitat selection analysis for grizzly bears will be used to attribute a relative value or risk from pipeline-related development. McDonald and McDonald (2002) define risk assessment as the evaluation of anthropogenic actions relative to their capacity to harm or benefit the ability of individuals or populations to preferentially choose resources. The RSF provides a response value to a set of

FIG. 2. Female grizzly bear with three two-year-old cubs in the Mackenzie Delta, N.W.T. Photo: Andrew Derocher.

environmental attributes that is the probability that an animal will use an area (Manly et al., 2002). The risk index is the change in response value from before to after the hypothetical intervention (McDonald and McDonald, 2002). Using a factorial-based approach, we will evaluate competing development scenarios to assess which one will cause the least harm to grizzly bears. Within a GIS, the proposed locations of alternative development plans will be superimposed on the landscape, and the relative probability of use will be estimated under both pre-manipulation and post-manipulation conditions. The risk indices induced by alternative actions will be compared.

Diet Composition and Trophic Position

Understanding the foraging patterns of a species is fundamental for effective management (Fuller and Sievert, 2001). Unlike other populations, the northern boundary for Mackenzie Delta grizzly bears is the Beaufort Sea. The north coast offers a potential alternative marine food source not available to more interior populations (Roth, 2002). To examine the diet of Arctic grizzly bears, I am comparing the carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) stable isotope ratios of hair and claw samples collected from research bears with those of bear foods found in the region. Stable isotope analysis can be used to increase our understanding of the proportional contribution of different dietary groups and their nutritional value and to determine the trophic position of this Arctic population in the food web (Jacoby et al., 1999). Since the isotopic signature found in the sampled tissue represents not only what the animal has ingested but also what the animal has assimilated, we can estimate the proportional contribution and nutritional importance of terrestrial plant and animal proteins as well as marine food types (Hobson et al., 2000).

Hair and claws are metabolically inert; therefore, the stable-isotope signature represents the diet of an individual during the specific growth period (Jacoby et al., 1999; Roth, 2002). Grizzlies moult once a year (in June or July), and hair collected before the moult represents the feeding history for the previous active season (Jacoby et al., 1999; Hobson et al., 2000).

Sixty-three hair and longitudinal claw samples have been collected from bears as part of the 2003–06 capture programs. Since stable isotope signatures vary geographically, I am creating a regionally distinct isotopic baseline of bear foods for the Mackenzie Delta area. Development of the baseline model required that a representative sample of bear foods be collected and their isotopic values determined (Hilderbrand et al., 1999; Jacoby et al., 1999). Samples were collected of the 33 different grizzly bear food types identified in the region.

SIGNIFICANCE OF RESEARCH

This study will provide managers with baseline information on grizzly bear ecology in the Mackenzie Delta region so that bear response to development can be anticipated before the hydrocarbon exploration and extraction activities begin to increase. McLoughlin et al. (2003) predicted that Central Arctic grizzlies could be in danger of population decline if human activity proceeded at an increasing rate. My research will identify seasonally important habitats so that access to these areas can be maintained. Grizzly bears in the open tundra, where there is limited hiding cover, are more likely to be displaced than bears inhabiting forested landscapes (Gibeau et al., 2002; Wielgus et al., 2002). Therefore, maintaining secure foraging areas where bears can accumulate the necessary energy reserves is important for survival and reproduction. These limiting factors become even more important for Arctic grizzly bear populations because of the short active period and low habitat quality compared to regions occupied by southern and coastal populations. With increasing resource-extraction activities and the associated disturbance, grizzly bears in the North could face situations similar to those found in multi-use landscapes farther south, such as habitat fragmentation and increased mortality due to habituation. More human activity on the landscape could result in grizzly bears' expending more energy through avoidance behaviour and increased movement. The results of this project will allow wildlife managers to develop protocols for improving grizzly bear management and sustainable harvest and preventing regional grizzly bear declines in the face of increasing resource extraction and human activity.

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REFERENCES

BLACK, S., and FEHR, A. 2002. Natural history of the Western Arctic. Inuvik: Western Arctic Handbook Committee.

BOONE, R.B., and HUNTER, M.L. 1996. Using diffusion models to simulate the effects of land use on grizzly bear dispersal in the Rocky Mountains. Landscape Ecology 11:51 – 64.

BOYCE, M.S., and McDONALD, L.L. 1999. Relating populations to habitats using resource selection functions. Trends in Ecology & Evolution 14:268 – 272.

BOYCE, M.S., VERNIER, P.R., NIELSEN, S.E., and SCHMIEGELOW, F.K.A. 2002. Evaluating resource selection functions. Ecological Modelling 157:281 – 300.

BURT, W.H. 1943. Territoriality and home range concepts as applied to mammals. Journal of Mammalogy 24:346 – 352.

CIZEK, P., and MONTGOMERY, S. 2005. Cumulative effects modeling of the Mackenzie Gas Project — scoping and development. Yellowknife: Canadian Arctic Resource Committee.

FERGUSON, S.H., and McLOUGHLIN, P.D. 2000. Effect of energy availability, seasonality, and geographic range on brown bear life history. Ecography 23:193 – 200.

FORTIN, D., BEYER, H.L., BOYCE, M.S., SMITH, D.W., DUCHESNE, T., and MAO, J.S. 2005. Wolves influence elk movements: Behavior shapes a trophic cascade in Yellowstone National Park. Ecology 86:1320 – 1330.

FULLER, T.K., and SIEVERT, P.R. 2001. Carnivore demography and the consequences of changes in prey availability. In: Gittleman J.L., Funk, S.M., and Macdonald, D.W.R.K., eds. Carnivore conservation. New York: Cambridge University Press. 163 – 178.

GIBEAU, M.L., CLEVENGER, A.P., HERRERO, S., and WIERZCHOWSKI, J. 2002. Grizzly bear response to human development and activities in the Bow River watershed, Alberta, Canada. Biological Conservation 103:227 – 236.

GILL, F.B., and WOLF, L.L. 1975. Economics of feeding territoriality in golden-winged sunbird. Ecology 56:333 – 345.

HARDING, L., and NAGY, J.A. 1980. Responses of grizzly bears to hydrocarbon exploration on Richards Island, Northwest Territories, Canada. International Conference on Bear Management and Research 4:277 – 280.

HILDERBRAND, G.V., JENKINS, S.G., SCHWARTZ, C.C., HANLEY, T.A., and ROBBINS, C.T. 1999. Effect of seasonal differences in dietary meat intake on changes in body mass and composition in wild and captive brown bears. Canadian Journal of Zoology 77:1623 – 1630.

HOBSON, K.A., McLELLAN, B.N., and WOODS, J.G. 2000. Using stable carbon (δ13C) and nitrogen (δ15N) isotopes to infer trophic relationships among black and grizzly bears in the upper Columbia River Basin, British Columbia. Canadian Journal of Zoology 78:1332 – 1339.

IMPERIAL OIL RESOURCES VENTURES LIMITED. 2004. Environmental impact statement. Calgary: Imperial Oil Resources Ventures Limited.

JACOBY, M.E., HILDERBRAND, G.V., SERVHEEN, C., SCHWARTZ, C.C., ARTHUR, S.M., HANLEY, T.A., ROBBINS, C.T., and MICHENER, R. 1999. Trophic relations of brown and black bears in several western North American ecosystems. Journal of Wildlife Management 63:921 – 929.

KERNOHAN, B.J., GITZEN, R.A., and MILLSPAUGH, J.J. 2001. Analysis of animal space use and movements. In: Millspaugh, J.J., and Marzluff, J.M., eds. Radio tracking and animal populations. San Diego: Academic Press. 126 – 164.

MANLY, B.F.J., McDONALD, L.L., THOMAS, D.L., McDONALD, T.L., and ERICKSON, W.P. 2002. Resource selection by animals: Statistical design and analysis for field studies. Norwell, Massachusetts: Kluwer Academic Publishers.

McDONALD, T.L., and McDONALD, L.L. 2002. A new ecological risk assessment procedure using resource selection models and geographic information systems. Wildlife Society Bulletin 30:1015 – 1021.

McLOUGHLIN, P.D., TAYLOR, M.K., CLUFF, H.D., GAU, R.J., MULDERS, R., CASE, R.L., and MESSIER, F. 2003. Population viability of barren-ground grizzly bears in Nunavut and the Northwest Territories. Arctic 56(2):185 – 190.

NAGY, J.A., RUSSELL, R.H., PEARSON, A.M., KINGSLEY, M.C.S., and LARSEN, C.B. 1983. A study of grizzly bears on the barren grounds of Tuktoyaktuk Peninsula and Richards Island, Northwest Territories, 1974 to 1978. Edmonton: Canadian Wildlife Service.

ROTH, J.D. 2002. Temporal variability in arctic fox diet as reflected in stable-carbon isotopes; the importance of sea ice. Oecologia 133:70–77.

SERVHEEN, C., HERRERO, S., and PEYTON, B. 1999. Bears. Status survey and conservation action plan. IUCN/SSC Bear and Polar Bear Specialist Groups. Gland, Switzerland and Cambridge, U.K.: IUCN.

WEAVER, J.L., PAQUET, P.C., and RUGGIERO, L.F. 1996. Resilience and conservation of large carnivores in the Rocky Mountains. Conservation Biology 10:964 – 976.

WIELGUS, R.B., VERNIER, P.R., and SCHIVATCHEVA, T. 2002. Grizzly bear use of open, closed, and restricted forestry roads. Canadian Journal of Forest Research 32:1597 – 1606.

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