EXTRAPOLATIVE METHODS FOR ASSESSING BARREN-GROUND GRIZZLY BEAR DENNING HABITAT AND PRELIMINARY MAPPING OF DENNING HABITAT IN THE MACKENZIE DELTA AREA

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ABSTRACT

Methods for identifying and mapping grizzly bear (*Ursus arctos*) denning habitat in the Mackenzie Delta area and adjacent mainland were examined. The physical and biotic properties of den sites, for which there are valid ground truth data, were extrapolated to assess denning suitability in other areas. Inputs for the procedure consist of Landsat imagery, aerial photographs, soil maps, vegetation maps and the geographic information in the data files of Canada Land Data System. Environmental factors that contribute to the suitability of a site for denning consist of a favourable arrangement of the variables at a given location. For this reason, denning ecology of grizzly bears does not neatly fit into any habitat typology based on regional biophysical properties. Our maps denoting grizzly bear habitat, have not been field tested and must therefore be regarded as preliminary. Definitive mapping of denning habitat cannot be carried out solely from zonal descriptors of environmental factors recognized as being important for denning success.

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INTRODUCTION

The objective of this project was to examine methods for identifying and mapping areas on Richards Island, Tuktoyaktuk Peninsula and the adjacent mainland having terrain attributes associated with barren-ground grizzly bear denning habitat.

Nagy et al. (1983) documented the location of 101 grizzly bear dens and commented about the ecological characteristics of dens on Richards Island and Tuktoyaktuk Peninsula. Reports published by companies involved in hydrocarbon development as part of the Mackenzie Delta environmental program (Slaney 1973, 1974a, 1974b, 1975), describe the interrelationships between grizzly bears and habitat elements in the region. Harding (1976) examined 23 grizzly bear dens on Richards Island to assess the ecological importance of den site characteristics. Den site preferences of grizzly bears on Richards Island and Tuktoyaktuk Peninsula were reported by Nagy et al. (1977).

Confirmed den locations and den site characteristics reported in the literature point to the importance of specific physical and vegetative features, which provide grizzly bear denning habitat. The occupied denning habitat is characterized by strong to very strong slopes, southerly exposure, shrubs and unfrozen substrate of friable consistence[1]. These characteristics appear to reflect desirable habitat elements because they contribute to the ease of excavating dens as well as other factors that may have survival

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1 Terminology for describing soils and landforms follows the Canada System of Soil Classification (1973).

value. Shrub-covered, south-facing slopes are areas of heavier than normal snow deposition because, being to the leeward of prevailing winds, such sites tend to accumulate and retain wind driven snow (Harding 1976, Vroom et al. 1977). Insulative value of snow cover, depth of thaw, soil consistency, and ease of digging denote habitat relationships that could be powerful selective factors for barren-ground grizzly bears.

Concepts of Extrapolation

A good indicator of similar ecological conditions is sameness of vegetation (Ratcliff and Pieper 1982). Since remote sensing (Landsat) habitat surveys embrace interpreting environmental factors that are reflected in the vegetation, habitat potential may be assessed on the basis of vegetation being similar or dissimilar from specific locations where there are valid ground truth data. A map generated by such extrapolation would show the distribution of areas having analogous reflectance and it could be inferred that the areas have similar habitat types. Employing the extrapolative method, environmentl properties of known den sites can be used to prepare thematic maps denoting environmentally similar areas. Medium scale aerial photographs may be used as proximate ground truth during area classification by reflectance type.

Inasmuch as den sites are frequently described in terms of soil and vegetation, delineation of these variables might also be extrapolated to denote favourable habitat conditions. One method for testing this relationship could involve plotting den sites in relation to designated soil and vegetation polygons. Large area classification, taking into account existing soil and vegetation maps, could be feasible if specificity for certain soil and vegetation types can be shown.

Employing the Canada Land Data System (CLDS), geographic information can be processed by computer to classify the area according to suitability for denning. Areas classified and ranked in this way could be designated for special consideration with respect to land use proposals.

This report documents the results of extrapolating environmental factors from observed den sites to derive a classification of denning habitat in a region where physical and biological variables are described in general terms.

PROJECT AREA

The project area is entirely within the Mackenzie Delta (107C) and Stanton (107D) map sheets, it is bounded on the north by $70^{\circ}20'$N latitude, on the east by $128^{\circ}00'$W longitude, on the south by $69^{\circ}00'$N and on the west by $136^{\circ}00'$W (Fig. 1). Anderson River is the eastern limit of mapping within the project area, the northern limit is 70°N.

Physiographic Regions

Mackay (1974) describes the physical geography of the Mackenzie Delta area. Seven of the 10 physiographic regions identified by him occur in the project area (Fig. 2). Of these, the Pleistocene Coastlands region encompassing Richards Island, Tuktoyaktuk Peninsula and Eskimo Lakes contains most of the known den sites (Fig. 1). Fifty percent of this area has elevations less than 30 m asl and 72 m asl on Richards Island marks the highest reported spot elevation in the Pleistocene Coastlands region. The surface expression of the Pleistocene Coastlands region is characterized by hummocky moraine and other glacial features.

The Fluted Plains and Anderson River Uplands regions are characterized by glacial drift of varying thickness. Elevations in the Anderson Uplands region occasionally exceed 305 m asl. Zoltai et al. (1979) describe the Anderson River Uplands as an area of irregular topography due to 15-60 m of ground moraine deposited in large hummocky hills. There are numerous lakes with short streams draining from lake to lake throughout the area.

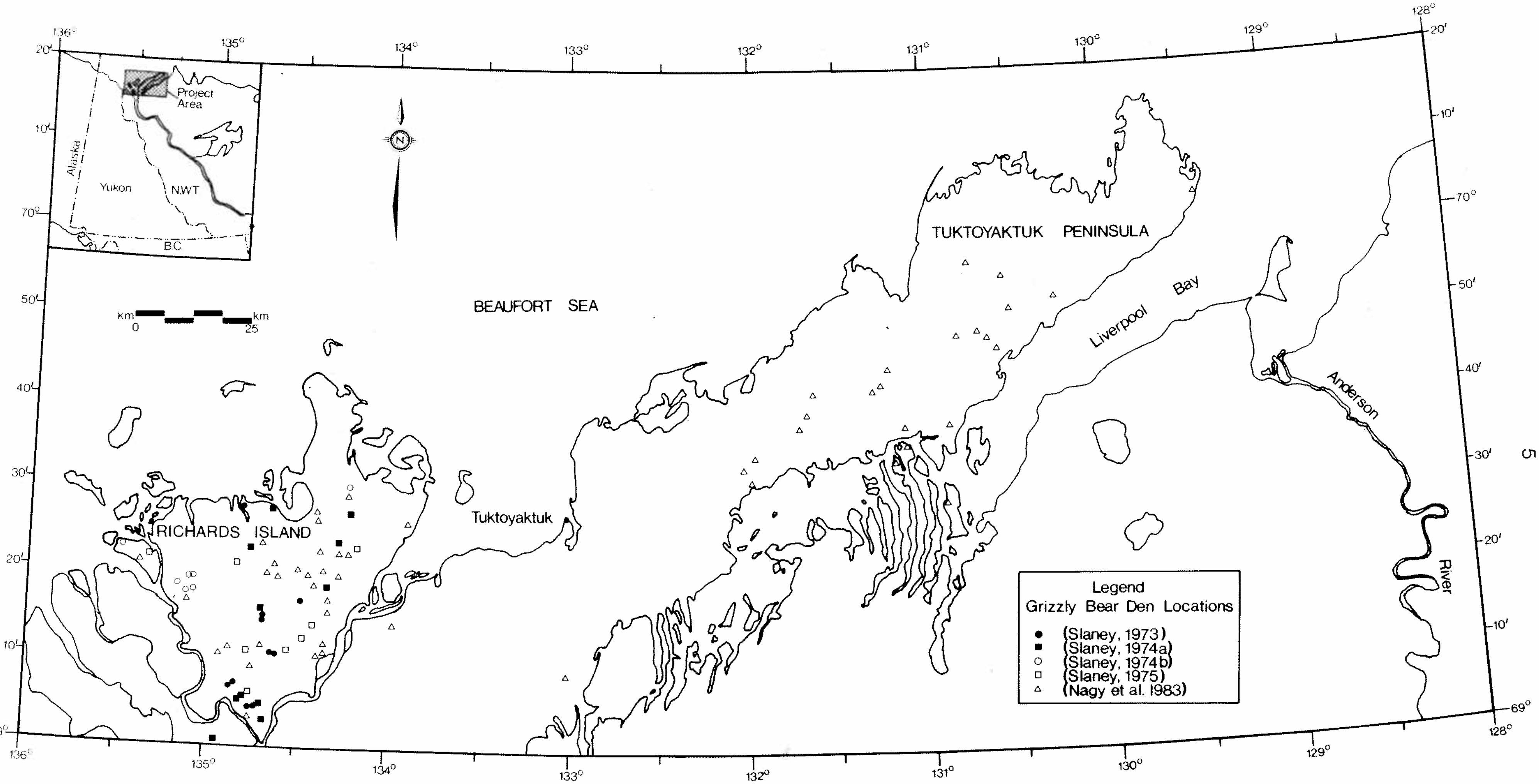

Figure 1. Map of the project area showing den locations on Richards Island and Tuktoyaktuk Peninsula.

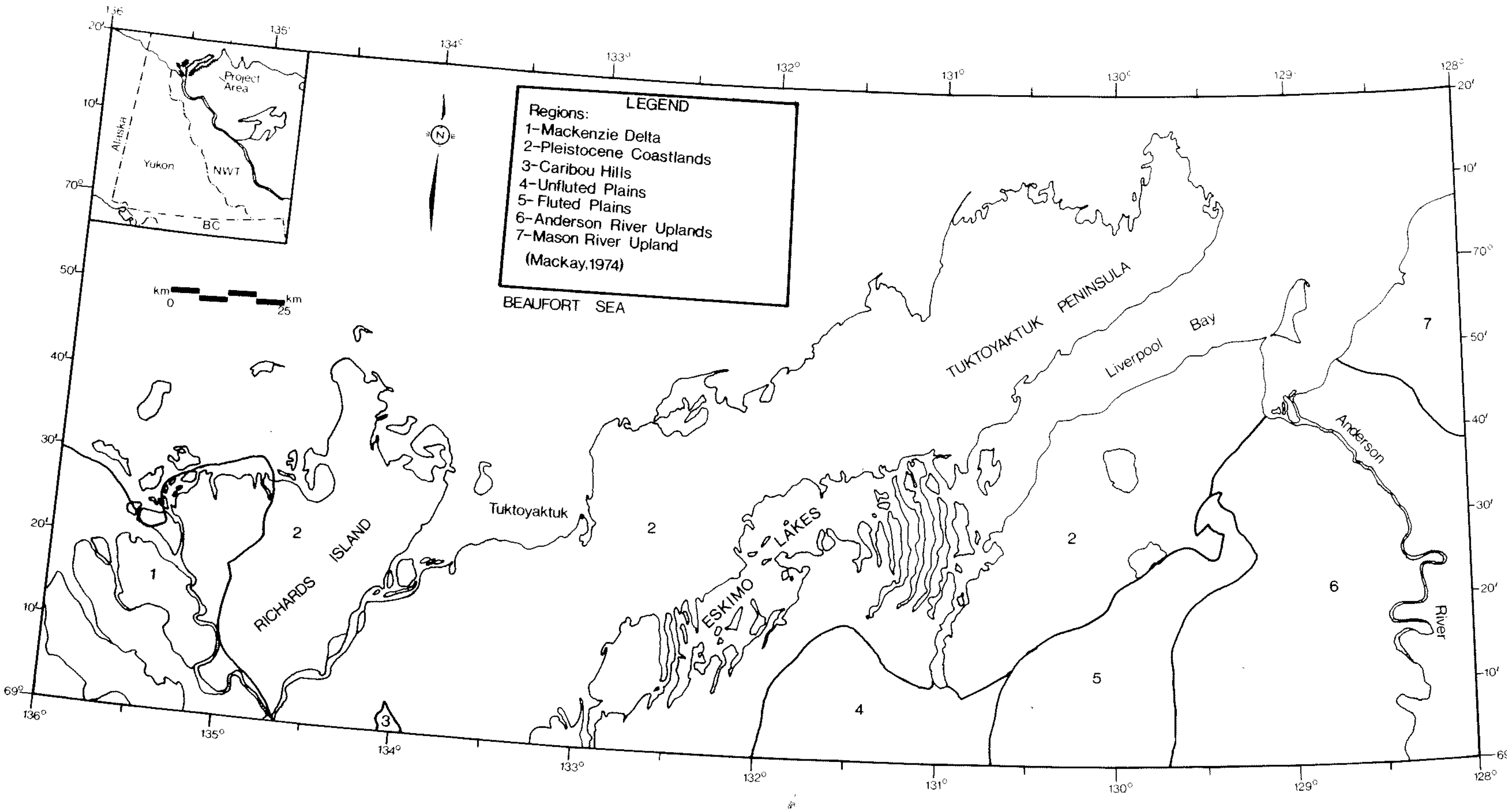

Figure 2. Physiographic regions of the project area.

Drift is thin and patchy over the Fluted Plains with local relief generally less than 30 m.

The Mackenzie Delta physiographic region consists mainly of recent river sediment. Precise definition of the boundary between this region and the Pleistocene Coastlands is difficult because of outliers of Pleistocene deposits west of the main area of contact between the regions (Mackay 1974). Surface expression associated with the Mackenzie Delta reflects the primary depositional form, fluvial processes. The area is level and subject to flooding during spring thaw and periodically by storm surges (Slaney 1974c).

In the Unfluted Plains region, major glacial features are conspicuously rare. The terrain is inclined, sloping from an elevation of 305 m asl in the south to 30 m asl in the north. Glacially formed flutings occur in some small areas, and other topographic features of glacial origin are meager (Mackay 1974).

The Mason River Uplands region is mainly flat with many drained lakes and poorly drained flats (Mackay 1974). Zoltai et al. (1979) describe surface expression in that region as broadly undulating with a mantle of colluvial and aeolian-like materials, patchy till and glacier transported stones.

Only the northernmost section of the Caribou Hills region extends into the project area. This section is transitional between the Pleistocene Coastlands to the north and the hillier sections of the Caribou Hills in the south. Broad melt-water channels cut through the region, lakes are few (Mackay 1974).

Soils and Vegetation

Provisional soil maps of the project area were prepared by Soil Resources, Agriculture Canada (Tarnocai and Veldhuis, in prep.). Slaney (1974c) described vegetation mapping units and associated soils on Richards Island and Tuktoyaktuk Peninsula. Soils and vegetation in the easternmost part of the project area (east of 131°W longitude) are described by Zoltai et al. (1979).

Soils are differentiated according to major soil forming processes which operate on a regional, rather than local basis. Slope classes are given as relief criteria for the mapped soil polygons. The properties of parent materials are described for zonal soils represented in the mapped polygons.

Permafrost conditions occur throughout the area. The thickness of the active layer varies from about 25 cm to 130 cm depending upon parent material, drainage, peat accumulation and aspect (Zoltai et al. 1979).

Vegetation types on Richards Island and Tuktoyaktuk Peninsula are described by the Forest Management Institute (1975) as four major groups (Shrubs, Moss-lichen, Monocotyledonic, and Tundra-pond fields). Within the hierarchial system there are subclasses differentiated on the basis of stem height for shrubs, elevation and soil moisture condition. Zoltai et al. (1979) used similar diagnostic criteria to classify vegetation in their Horton-Anderson Rivers study area.

METHODS

Reported den sites on Richards Island and Tuktoyaktuk Peninsula were plotted on a topographic map of the area. Zonal soil and vegetation characteristics of each site were noted and the reflectance of those areas was visually identified on Landsat colour transparencies in bands 4, 5, and 7 at a scale of 1:1,000,000.

The reflectance of areas where bear dens were known to occur was used as an interpretive category to delineate adjacent areas having similar reflectance. Areas that were identified as having analogous reflectance were transferred to our mapping scale of 1:250,000 with a Bauch and Lomb zoom transfer scope. Aerial photographs at 1:60,000 scale were used for mapping control by ensuring that the physiographic properties associated with den sites were present in areas identified by Landsat interpretation.

LUPLAN

LUPLAN is the acronym for a land use planning program developed by the Division of Water and Land Resources at the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Canberra, Australia (Ive 1980). The program employs micro-computers for processing data to analyze land use options. It was developed during the course of land use planning studies on the South Coast of New South Wales (Austin and Cocks 1978). Lands Directorate, Environment Canada, have adopted LUPLAN for analysing land resource data complied as part of the Canada Land Data System (CLDS).

CLDS data for part of the Beaufort Sea Planning Region were analyzed to rate denning suitability in 21 ecodistricts. Eight of the ecodistricts are represented in the project area. The data set used in the program describes the following characteristics of each ecodistrict: terrain/water ratio, average mean macro relief range, local relief range, mode of origin - parent material, surface expression, depth of thaw - active layer, soil surface texture and plant association variables. Variables for the last five terrain characteristics are expressed as primary, secondary and tertiary occurrences within each ecodistrict. This is a partial listing of the terrain characteristics compiled in the CLDS data file. In all, as many as 27 biophysical features may be used to describe an ecodistrict. Each CLDS descriptor in the data set was assigned a numerical designation and given a rating between 0 and 1 which reflects its importance as a property satisfying grizzly denning habitat requirements. The CLDS data satisfied the input requirement of LUPLAN, we provided ratings and weights for generating denning suitability scores.

RESULTS

Documented grizzly bear denning habitat in the project area is characterized by morainal geomorphology and shrub vegetation communities. Figure 3 depicts a cross section through the Pleistocene Coastlands region and adjacent recent alluvial areas near 69°19'N latitude on Richards Island. Area 1 in Figure 3 is representative of the recent delta area where pleistocene outliers are present (Slaney 1974c). Area 2 is representaive of the area in east-central Richards Island were known denning sites occur (Fig. 1). This is an area of hummocky moraine with complex slopes of varying steepness and aspect. Ecological information compiled by Environment Canada indicates that the terrain/water ratio on Richards Island is 25-50% (Morrison et al. 1982). These factors add to the variability of the area, and the stream and lake banks can also serve as den sites (Slaney 1974a, Harding 1976).

Landsat Interpretation

Reflectance of vegetation in the Pleistocene Coastlands region contrasts distinctly with that of vegetation on recent alluvium in the Mackenzie Delta region. Given the known distribution of dens in the respective areas, the extrapolative technique of categorizing areas by differentiation of reflectance types enabled mapping of moraine covered areas. Areas delineated by this method were accorded status as denning habitat and plotted on 1:250,000 scale maps of the project area. Aerial photographs were viewed steroscopically to validate the accuracy of Landsat interpetation.

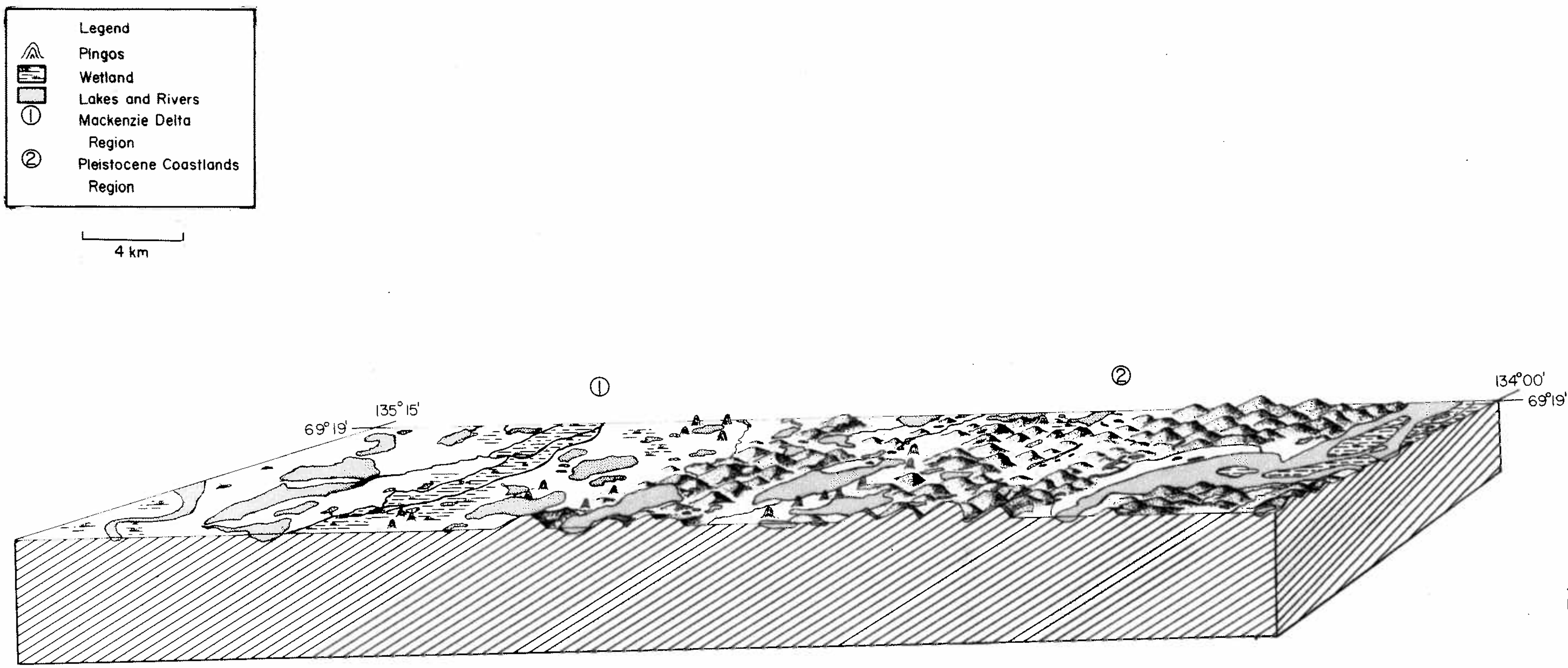

Figure 3. Simple representation of topography in the Mackenzie Delta and Pleistocene coastlands of Richards Island. Local relief features are not drawn to scale.

The validation technique involved identification of morainic features in the mapped units. A grid overlay was employed to specify the representativeness of areas relative to denning sites on Richards Island. By extending known data into areas less well known, preliminary maps showing denning habitat in the project area were produced. We selected 1:250,000 as the mapping scale to retain topographic detail for recognition of terrain elements in the field. Because of their size, the maps are attached to the report as in-pocket appendices.

Soil and Vegetation

Den locations were tabulated according to their occurrence in each of the soil categories shown on provisional soil maps prepared by Tarnocai (in prep.). Table 1 shows the number of dens that occurred in each soil association on Richards Island and Tuktoyaktuk Peninsula. Soil associations are described according to parent materials and the areal extent of each association is expressed as percentage of the total known denning area.

Table 1 provides eight comparisons between soil types and distribution of denning sites. Glacial till and sandy alluvium covered 13% and 18% of the area respectively; yet together, these sites contained 70% of the dens. A strong preference for alluvial soils could be inferred, but the concept that a given regional soil type is favoured is questionable because properties of soils described at the zonal category do not accurately reflect conditions at more specific levels. Den sites occurring in pleistocene outliers within soils classified zonally as alluvium

Table 1. Number of dens occurring in soil associations on Richards Island and Tuktoyaktuk Peninsula.

Soil association[1]	% of area	Parent material	% of dens
Kittigazuit (Kt)	13	fine clayey and fine loamy glacial till	37(n=20)
Shallow Bay (Sb)[2]	18	fine loamy and sandy alluvial	33(n=18)
Naporotalik (Np)	4	fine clayey and fine silt, marine deposit	11(n=6)
Kiktoreak/Kidluit (Ki/Ku)	22	mesic fen peat/fine eolian sand	1(n=4)
Tibjak (Tb)	7	glaciofluvial sand and gravel	4(n=2)
Kittigazuit/Kiktoreak (Kt/Ki)	26	fine clayey and fine loamy glacial till/ mesic peat fen	4(n=2)
Naporotalik/Kiktoreak (No/Ki)	2	fine clayey and fine silt of marine deposit/ mesic fen peat	2(n=1)
Tibjak/Kiktoreak (Tb/Ki)	8	glaciofluvial sand and gravel/ mesic peat fen	2(n=1)

1 Soil associations mapped and described by Tarnocai (in prep.).

2 Pleistocene outliers are believed to occur in this association, see text.

(Table 1) could lead to erroneus assumptions about the importance of deltaic soils for denning habitat. Den locations plotted by Slaney (1974c) and Harding (1976) in the Mackenzie Delta physiographic region (Figs. 1 and 2) suggest denning in pleistocene outliers within the zone of alluvial soils.

Den occurrence according to vegetation type is summarized in Table 2. Shrubs were represented in 84% of the sites. The importance of shrubs for stabalizing the soil at den sites, and for improving thermal efficiency by retaining snow is frequently cited (Vroom et al. 1977). This should not be interpreted to mean that all den sites will be in areas shown on vegetation maps as shrub covered because just one clump of willows will suffice if other environmental factors are favourable.

LUPLAN

Denning suitability scores calculated from CLDS data by LUPLAN identify ecodistricts containing morainal topography as being important in terms of denning habitat. However, ecodistricts in the project area range in size[1] from 380 km^2 to 16,441 km^2, thus, estimating denning suitability at specific locations by means of this technique holds little promise of success. It is acknowledged that most of the descriptors are expressed as having primary, secondary, and tertiary occurrences; however, this does not improve specificity of the information because the areas of occurrence cannot be differentiated. LUPLAN demonstrates that zonal data are not appropriate for entering into the truth of a

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1 Ecodistrict statistics compiled by Lands Directorate, Environment Canada.

Table 2. Number of dens occurring in broad vegetation types on Richards Island and Tuktoyaktuk Peninsula.

Vegetation type	% of area	% of den
High shrub	5	5(n=5)
Low shrub	59	79(n=81)
Monocotyledon (non-woody type)	36	16(n=17)

situation where site specific phenomena need to be explained. Consequently, a high suitability score does not aid in the anlaysis of habitat quality in a specific location within an ecodistrict.

DISCUSSION

Denning ecology of grizzly bears does not neatly fit into any habitat typology framework based on regional biophysical properties. Ecological land units have been described and rated as grizzly bear habitat according to abundance of food plants (Craighead et al. 1982) but denning preference has consistantly been described in terms of site characteristics. The environmental factors that contribute to the suitability of a site for denning consist of numerous combinations of soil, terrain and vegetation. For this reason, it is to be expected that denning habitat is widely distributed throughout occupied grizzly range. If denning habitat is rare in the project area, there should be a tendancy for a bear to return to the same site from year to year. Such site tenacity has not been reported. We do not known what cues a bear to select the appropriate combination of physical and biotic factors that contribute to its denning success but it is logical to believe that time and energy costs associated with searching are implicated. If this premise is valid, a bear should select an adequate den site near the foraging area instead of seeking a land unit with special qualities for denning habitat.

Habitat areas plotted on our maps are based on extrapolation of data from reported denning sites to an area for which there was no such information. This instance of extrapolation must be considered exploratory and tentative because the maps have not been validated by ground truthing. Aside from being inferential, the transition of data from reports to our base maps incurred the risk of plotting errors because of differences in scale. The representation of den sites as points on soil maps was especially difficult and some sites were rejected because of uncertainty about where they should be placed. It should not be overlooked that there is great potential for error when reflectance types are extrapolated beyond the place for which there are valid ground observations. We attempted to decrease the risk for error by referring to aerial photography but, in the absence of ground truth information, the uncertainty persists. Adopting inaccurate maps raises the spectre of bears being excavated from their dens by earth moving operations in an area that had not been designated as "denning habitat".

All of the den sites examined by Harding (1976) were characterized by pleistocene parent material and shrubs. Taking into account that pleistocene geomorphology and shrub vegetation can be identified on air photographs, photo interpretation techniques may be used to evaluate local habitat conditions. Habitat evaluation in discrete target areas by these methods may prove more useful for habitat management than large area classifications that rely on multi-level sampling or extraction of zonal data on vegetation and other biophysical variables.

RECOMMENDATIONS

Generalizations about the importance of the mapped areas in terms of denning habitat should be field tested. This can be accomplished by carrying out an aerial survey of the extrapolated area soon after emergence of bears from their winter dens. Emergence from dens in this region occurs from the latter part of April to about mid-May. In 1974, Harding (1976) observed that emergence extended from April 27 to May 22.

Maps depicting habitat areas should not be accepted as the final word for prescribing how land resources should be used. Large area classifications have a great margin for error which can only be resolved through evaluating habitat conditions at the actual location where a land use operation is scheduled to take place. Reconnaissance level information and zonal data do not adequately reflect local conditions. When the impact of an activity on denning habitat is called into question, the matter should be resolved by direct rather than extrapolative methods. Habitat maps are not definitive enough for us to make rational decisions about the consequence to denning habitat of development at a given location.

A standardized system for recording site specific properties should be developed and its use encouraged. A site described according to its UTM coordinates can be accurately plotted, sites shown as points on report sized maps cannot.

A study should be carried out to develop an understanding of the interrelationahips between various aspects of grizzly bear habitat. In particular, the influences of food distribution and abundance in relation to denning behaviour need to be examined. Denning activity may be better explained in relation to the food resources and seasonal activity centres of a bear's range, rather than in terms of environmental factors which simply contribute to denning success.

ACKNOWLEDGEMENTS

This project was funded under the NOGAP funding agreement. Dr. Graham Yapp adapted LUPLAN for use of CLDS geographic information to estimate denning suitability of ecodistricts in the project area. P. Gray, B. Stephenson, and R. Bell reviewed this report. E. Irvine typed the manuscript.

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