PRELIMINARY ANALYSIS OF REPRESENTATIVE CORE AREAS

for the

NORTHWEST TERRITORIES PROTECTED AREAS STRATEGY

Volume I

Final Report

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FOREWORD

This study provides a basis for dialogue and debate around the placement of Protected Areas for the Northwest Territories (NWT) Protected Areas Strategy (NWT-PAS). More specifically, this study focuses on just *one* set of criteria for the selection process—namely, the representation of an ecological coarse filter as described by the NWT-PAS Goal 2. It is critical to note, that in no way, should this study stand on its own as a means for selecting protected areas. The NWT-PAS clearly articulates a wide range of values that need be incorporated into these decisions. Prominent among these are cultural and/or traditional values, which have explicitly *not* been considered in this study, as per the terms of reference.

This study represents an opportunity to experiment with available ecological information in such a way that allows decision-makers to test assumptions about how proposed and existing protected areas might fulfill the *ecological goals* of the NWT-PAS. This short-term study should not drive site selection, but rather should be used as a guide, a catalyst for exploring new conservation opportunities, and finally, as *one* measure of success as the NWT-PAS develops over time.

Further, it is important to clarify this study's preliminary nature. At the time of undertaking, available information is severely limited, and what information is available, is being reviewed and adjusted. Thus, we emphasize that the strength of the study lies not as much in its specific mapped results, but in the strength of the approach. This study is meant to be open and adaptable, and is designed to encourage iterative improvements over time. Those results that are presented here, particularly in map form, must be viewed as initial experiments, worthy of exploration, questioning, further testing, and validation.

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EXECUTIVE SUMMARY

INTRODUCTION

The Mackenzie Valley Five-Year Action Plan (Action Plan) for the Northwest Territories Protected Areas Strategy (NWT-PAS) calls for the identification, review and evaluation of a network of protected areas in those ecoregions of the Mackenzie Valley that will be directly intersected by the proposed Mackenzie Valley gas pipeline or hydrocarbon development areas. There are many important criteria for selecting potential protected areas, and the first goal of the NWT-PAS is to select areas of special natural and cultural values. A second goal of the NWT-PAS ('Goal 2') is to protect 'representative core areas' within each ecoregion of the NWT. These core areas are meant to protect the biological diversity of the NWT and to ensure that the variety and abundance of ecological values (e.g. fish and wildlife habitat) are captured or 'represented' within the protected areas network.

In February of 2005, Round River Canada was contracted to conduct a short-term (2 month), preliminary assessment of how existing data might be used to inform the selection of protected areas to meet this second goal of the NWT-PAS. The preliminary, and specific nature of the analysis is important to emphasize given the limitation of existing data (in particular we note the absence of information on landcover, and species habitat requirements), and given that this study focuses on just one set of values (ecological) in assessing representative core areas. As part of this exercise, we were also asked to provide a recommended workplan for a second, more in depth phase of study. The workplan does not assume that there will be a second phase of work; it is provided as a separate but companion product to this report.

APPROACHES TO REGIONAL-SCALE CONSERVATION PLANNING

Conservation planning is an applied science that is meant to help guide management for protecting biological diversity. At a regional scale (e.g. the scale of the NWT), this planning typically relies upon three types of information:

- **Focal species analyses** –describing and evaluating species habitat requirements for important wildlife species
- **Coarse-filter ecosystem representation analyses** – an analysis that looks at representing broad landscape variations in terms of topography, soils, water, climate, and vegetation
- **Special elements analyses** – mapping and analysis of unique, rare, or sensitive occurrences of species, habitats, and features such as hot springs, mineral licks.

In addition, other analyses may further our ability to capture important ecological processes such as fire regimes, and the dynamic relationship between predator and prey populations. Each of these analyses would also be enhanced through the incorporation of Tradition Knowledge.

The combination of these analyses is important, as they provide complementary information that should increase the robustness of conservation plans. However, the Northwest Territories is a vast region for which information and data on ecological values are limited. For this study, rudimentary information on a coarse filter and on special elements drives the analysis. The Phase 2 workplan places a priority on increasing the information base so that a wider array of data can be included in the analysis.

STUDY AREA DESCRIPTION

This study focuses on 15 of the 16 ecoregions that would be directly impacted by the planned Mackenzie Valley gas pipeline corridor and associated hydrocarbon development areas[1]. Twelve of the Study Area ecoregions are within the Taiga Plains ecozone, 2 are within the Southern Artic ecozone, and one is part of the Boreal Cordillera ecozone. These ecoregions make up a Study Area that is over 52 million hectares in size (Map 2). It is important to note that these ecoregion boundaries are currently under revision.

Within the study area are several existing and proposed protected areas (Map 1). These include,

- **Existing Legislated** Protected Areas-- Wood Buffalo National Park, Nahanni National Park Reserve, Kendall Island and Anderson River Delta Migratory Bird Sanctuaries
- **NWT-PAS Initiatives**
    - **Areas of Interest** -- Pehdzeh Ki Deh and Sambaa K'e
    - **Candidate Protected Areas --** Tsodehniline Tuyat'ah
    - **Candidate Areas with Interim Protection--** i Sahoyúé and ?edacho and Edéhzhie
- **Other Protected Area Proposals**
    - Tuktut Nogait National Park proposed expansion

UNDERLYING DATA

The strength of any study such as this is founded on the underlying data and information that can be used in an analysis. Unfortunately, while the efforts of dedicated government staff and the scientific community at large continue to build a base of conservation information for the NWT, a great deal of raw data collection, synthesis and analysis is still needed to build a solid scientific foundation for informing NWT-PAS decision-making. In this study we have attempted to accumulate as many spatially explicit data sets as possible in the form of a GIS database. These data include geo-physical, biological and human use information. Examples include,

- **Landscape Units** -- The Landscape Unit classification created by the NWT's Department of Resources, Wildlife and Economic Development (RWED) (Map 3). These are used as a surrogate for biodiversity representation.
- **Biological Information** -- Limited and sporadic information was available on biological elements for the study area. Data that was supplied included rare plant locations, raptor nesting sites, critical habitat for some species of interest, important bird areas, key migratory bird habitat, wildlife areas of special interest, and sensitive areas identified by the Mackenzie Basin Committee (Maps 4a,b,c,d,e).
- **Human Use and 3rd Party Interests** – These data sets included a variety of point and linear features relating to existing human use/impacts in the Study Area (Map 5) and existing third party interests.

[1] The Yukon Plains ecoregion, of which only a small fraction (less than 100,000 ha) is located in the NWT, was not included in this analysis.

ANALYTICAL COMPONENTS

We used the underlying data discussed above to create a number of descriptive maps and data layers for the Study Area. These maps and information are meant to serve as both stand-alone information products for guiding NWT-PAS decision-making, and also as direct inputs (analytical components) into the process of selecting core representative areas. These components include,

- **Human Use Model** – This component (Map 6) describes the relative zone of influence of human activity. The information is used in the core area selection process to help identify conservation areas where there are the fewest potential conflicts between conservation values and human use.
- **Development Interest Model** – This component (Map 7d) helps to describe the probability of future development by summarizing third party interests in the Study Area. The information can serve as a stand alone product that provides a relative measure of vulnerability and conservation urgency. It is also used in this study in combination with measurements of conservation value to help prioritize areas for attention from the NWT-PAS.
- **Landscape Unit Coarse Filter** -- Landscape Units provide us with a surrogate for biological diversity, around which we can set representation goals. The selection of representative core areas is then informed by how well the areas can contribute toward meeting those goals. And while even the boundaries of Landscape Units are currently under review and likely to change, the short-term assessment of this data lays the groundwork for future incorporation of new, more refined, and ecologically-based information.
- **Special Elements Analysis** – In the short time frame available for the study, identifying and collecting available data on occurrences of species of concern, unique or special habitats, or other features and areas that may be important to capture within a protected areas network, has proved challenging. Additionally, few data sets are sufficiently extant for setting representation goals around. However, these data have been used to create a Special Element Index or 'hotspot' analysis.

EXPRIMENTAL CORE AREA SELECTION

Using the maps and models (analytical components) described above, this study created several scenarios that tested a variety of NWT-PAS criteria for mapping potential representative core areas. These scenarios are experiments using the limited data that was available, but they may prove useful in helping the NWT-PAS decide on *how* it would best go about measuring success against Goal 2.

For conducting these experiments, we used a computer software tool known as MARXAN. Using this tool allowed us to experiment with representing the coarse filter Landscape Units 'efficiently' i.e. with core areas that were big enough to support healthy and viable examples of species and ecological systems, but which in total, covered as little total area within the Mackenzie Valley as possible. Use of the MARXAN tool also assisted in designing and analyzing alternative core area selection scenarios in a quick and repeatable manner. In this

study we used MARXAN to explore 2 different goal options, and for each of those, we tested two different protected area scenarios as follows:

Goal Options

1. **Conservation Area Size** – Using recommendations from the GNWT for the NWT-PAS, a goal of selecting at least one core area with a minimum size of 400,000 ha in each ecoregion was set. All options met this goal first.
2. **Baseline Goals** -- In this option, proportional goals for representing Landscape Units (the amount/proportion that needs to be captured in a protected areas network)were based on recommendations from the GNWT for the NWT-PAS as follows:

Goal	Landscape Unit Size:
10%	>500,000 ha
15%	100,000 to 500,000 ha
20%	30,000 to 100,000 ha
25%	10,000ha to 30,000 ha
100%	<10,000 ha

3. **Precautionary Goals** – In this option, baseline goals for representing Landscape Units were increased 3-fold such that the most common Landscape Units would have at least 30% representation, a benchmark sometimes used in other regional studies. These translate as follows:

Goal	Landscape Unit Size:
30%	>500,000 ha
45%	100,000 to 500,000 ha
60%	30,000 to 100,000 ha
75%	10,000ha to 30,000 ha
100%	<10,000 ha

Protected Areas Scenarios

1. **Open Scenario –** In this analysis, existing protected areas were assumed to contribute toward representation goals for Landscape Units i.e. the amount of each landscape unit in each park was counted as protected, and therefore counted toward meeting conservation goals. Conversely, the Landscape Units represented in NWT-PAS proposals were *not* counted as being represented. The 'open' analysis is useful for exploring the current overlap of NWT-PAS proposals with areas of high conservation value.
2. **Closed Scenario** -- In this analysis, all existing and NWT-PAS proposed protected areas were assumed to contribute toward representation goals for Landscape Units i.e. the amount of each landscape unit in each park and NWT-PAS proposal was counted as protected, and therefore counted toward meeting conservation goals. The closed analysis is useful for exploring where the NWT-PAS might need to identify additional areas to meet representation goals, if current NWT-PAS proposals were approved.

We employed a stepwise approach using MARXAN to evaluate combinations of these scenarios and options. For each of 'Open' and 'Closed' scenarios we created experimental conservation rankings or tiers that described potential core areas through the following steps:

1. Tier 1 areas were created by selecting minimum 400,000 ha core areas for each ecoregion.

2. Additional areas were then selected in order to meet the remaining *baseline* goals for Landscape Unit representation that were not met in Tier 1 areas. These additional areas were labeled Tier 2.
3. Finally, areas were selected in order to meet the remaining *precautionary* goals for Landscape Units that were not met in Tier 1 areas. These additional areas were labeled Tier 3.

We then compared results from these analyses in order to evaluate how the various options and scenarios affected the total area required to meet goals, and how well these areas represented Landscape Units. In experiments using the baseline goals and existing protected areas locked in (open scenario), 30% of the Study Area was required to satisfy all representation goals for Landscape Units. In comparison, 39% of the Study Area was required to meet representation goals when NWT-PAS proposals were also locked in (closed scenario). When precautionary goals were applied, the open scenario required 46% of the Study Area, while the locked scenario required 50%.

CONSERVATION PRIORITY

It is important to note that software tools like MARXAN alone should not be depended on to generate a map of representative core areas for the NWT-PAS. Rather, these are effective tools for exploring the spatial implications of decisions made about biodiversity values (be they species, or surrogates such as the Landscape Units), goals (how much of the values need to be represented or conserved), and costs (meeting goals with a minimum amount of area, and a minimum conflict with existing human uses). In fact, the outputs of these MARXAN experiments form just one part of our results, and are improved upon by an analysis of special elements and conservation priorities.

In order to explore priority setting, we compared known conservation values for an area with the potential for economic development and activity. We expect that the NWT-PAS will want to focus its energy on proposals where areas have known high ecological value, but greater or lesser priority may be placed on areas depending on the degree to which they might conflict with existing or proposed human uses.

Conservation Value

In this study, conservation value refers to the potential of an area to represent specified conservation goals and/or features. For comparative purposes, we described conservation value using several measures. The first measure of conservation value is drawn from the MARXAN representation analysis itself. For each of the options and scenarios mentioned above, MARXAN explored over 100 different possibilities of where areas might most efficiently meet representation goals for Landscape Units. From this range of 100 possibilities, we mapped the frequency with which areas were identified for meeting goals; those areas that were selected most often were ranked as having a higher conservation value than those less often selected (Maps 8a,b, 9a,b).

As a second measure of conservation value we used the Special Elements Index (SEI) described in Section 5.5 (Map [10]). This measured the relative abundance for each planning unit, of each special element we had available for the study.

Finally, both the conservation value score from representation analysis and Special Elements Index were summarized to create a third, combined measure of conservation value (Map 10a).

Prioritization

Using the conservation value scores from the MARXAN representation experiments (Maps 8a,b,9a,b) we mapped the areas of high conservation value relative to the development interest score as shown in Map 7d. The combination of these scores describes a range of priorities from high conservation value/ high development interest to high conservation value/low development interest. In maps 11a,b,12a,b, we illustrate these prioritization results for each option and scenario combination.

We repeated the prioritization exercise using the Special Element Index or 'hotspot' analysis. As above, the hotspots were contrasted to development interest, and again the combination of scores describes a range of priorities from high conservation value/ high development interest to high conservation value/low development interest. These results are presented in Map 13.

Finally, the combined conservation value scores were mapped in relation to development interests (Map 14). The resulting map displays the overlap of combined conservation value scores as described in Map 10a, with development interests (Map 7d). The NWT-PAS will likely want to focus its energy on proposals where areas have known high ecological value, but greater or lesser priority may be placed on areas depending on the degree to which they might conflict with existing or proposed human uses.

CONCLUSIONS AND RECOMMENDATIONS

We recognize that the variety of these results and the number of options for exploring ecological values presented here can make it difficult to settle on one single solution for delineating core areas. However, we are convinced that given the extremely preliminary data available for analysis, and the short time frame available for this phase of analysis, delineating a single solution for the NWT-PAS would be misleading. This is particularly true given that decisions around protected areas demand the integration of many more values than those explored in this report, not the least of which are cultural or traditional values.

Despite these limitations, we believe that the methods, tools and results discussed in this study provide an important starting point from which further investments in research and analysis can be framed. The results themselves should allow for exploring assumptions about current protected areas, alternative goal settings, and the relationship between representation, 'hotspots', human uses, and third party interests.

While this preliminary study has helped to provide an important framework for the NWT-PAS, we were also explicitly asked to begin drafting a workplan for a second phase of analytical work. This workplan outlines a number of important priorities for ongoing analyses including recommendations that specifically seek to improve upon some of the most obvious information gaps in the current study. Of these, the need for information on vegetation and land cover, and modeling of focal species habitats are perhaps the most pressing. While we trust the methods and results presented here are informative, we strongly recommend that efforts be focused on improving the underlying data, analytical components, and methodological approaches used for selecting representative core area in the NWT.

Table of Contents

1 INTRODUCTION 1
1.1 The Northwest Territories Protected Areas Strategy 1
1.2 Representative Core Areas: Short-term Objectives 1
1.3 Organization of this Report and Supplemental Materials 2
2 RATIONALE AND APPROACHES FOR REGIONAL-SCALE CONSERVATION PLANNING 3
2.1 Purpose and Goals 3
2.2 Elements of Conservation Area Design 3
2.2.1 Special Elements 4
2.2.2 Representation 4
2.2.3 Focal Species 4
2.2.4 Connectivity 5
2.3 New Directions in Boreal Planning 5
3 STUDY AREA DESCRIPTION 7
3.1 Study Area 7
3.1.1 Profile of Study Area Ecoregions 7
3.2 Conservation Status/ Land Use Designations 8
3.2.1 Existing Legislated Protected Areas 8
3.2.2 Proposed National Park Expansion 8
3.2.3 NWT-PAS Initiatives 8
4 UNDERLYING DATA and GIS DATABASE 10
4.1 Landscape Units 10
4.2 Biological Information 10
4.3 Human Use Information 12
4.4 Third Party Interests 12
5 ANALYTICAL COMPONENTS 13
5.1 Planning Units 13
5.2 Human Use Model 13
5.2.1 Background 13
5.2.2 Methodology 14
5.2.3 Results and Discussion 16
5.3 Development Interest Index: Quantifying Third Party development interests 17
5.3.1 Background 17
5.3.2 Methods 17
5.3.3 Results and Discussion 18
5.4 Coarse Filter Analysis 19
5.4.1 Background 19
5.4.2 Methods 19
5.4.3 Results 20

5.5 Special Elements Analysis 20
5.5.1 Background 20
5.5.2 Special Elements Index 22
6 EXPERIMENTAL CORE AREA SELECTION 23
6.1 Background 23
6.2 Site Selection Algorithms: MARXAN 23
6.3 Goals 24
6.3.1 Minimum Conservation Area Size 24
6.3.2 Minimum Representation of Coarse Filter Targets 25
6.4 Iterative Approach to Selecting Core Representative Areas 27
6.4.1 Selection Step 1 27
6.4.2 Selection Step 2 27
6.4.3 Selection Step 3 27
6.5 Comparative scenarios 28
6.5.1 Open Scenario 28
6.5.2 Locked Scenario 28
6.6 Core Area Selection Results: Scenario Experiments 29
6.6.1 Scenario Overview results 29
6.7 Comparison of Special Features vs. Conservation Tiers 31
6.7.1 GAP analysis: Conservation tiers vs. Special Elements 31
7 CONSERVATION PRIORITY 34
7.1 Conservation Value 34
7.1.1 Frequency of Selection by Representation Analysis 34
7.1.2 Special Elements Index 34
7.1.3 Combined Conservation Value Score 34
7.2 Prioritization 34
8 RECOMMENDATIONS and CONCLUSIONS 36
8.1 Appropriate uses and limitations of this analysis 36
8.2 A Second Phase of Analysis 36
LITERATURE CITED 38

LIST of MAPS - Volume II

Map1. Study Area, Existing Protected Areas, and NWT-PAS Initiatives
Map 2. Priority Ecoregions of the Mackenzie Valley 5-Year Action Plan
Map 3. Landscape Units Within the Study Area
Map 4a. Special Features and Elements: Northern Land Use Information Series, Critical Habitats
Map 4b. Special Features and Elements: Areas of Ecological Interest
Map 4c. Special Features and Elements: Raptor Nest, Rae Plant Locations and Important Bird Areas
Map 4d. Special Features and Elements: High Value Caribou Habitat
Map 4e. All Special Features and Elements
Map 5. Human Uses Data:
Map 6. Human Use Footprint
Map 7a. Mining Interest
Map 7b. Oil and Gas Interest
Map 7c. Road Length by Analysis Unit
Map 7d. Development Interest

Map 8a. Relative Conservation Value: Baseline Goals, Open Scenario
Map 8b. Relative Conservation Value: Precautionary Goals, Open Scenario
Map 9a. Relative Conservation Value: Baseline Goals, Closed Scenario
Map 9a. Relative Conservation Value: Precautionary Goals, Closed Scenario
Map 10. Special Elements Index
Map 10a. Combined Conservation Value Score
Map 11a. Relative Conservation Priorities: Baseline Goals, Open Scenario
Map 11b. Relative Conservation Priority: Precautionary Goals, Open Scenario
Map 12a. Relative Conservation Priority: Baseline Goals, Closed Scenario
Map 12b. Relative Conservation Priority: Precautionary Goals, Closed Scenario
Map 13. Relative Conservation Priority: Special Elements Index and Development Interest
Map 14. Relative Conservation Priority: Combined Conservation Value Scores and Development Interest

LIST of APPENDICES - Volume III

A. Rationales and approaches to Regional-scale Conservation Planning
B. Profiles of Ecoregions in the Study Area
C. Data Used in the Study
D. Landscape Units Classification
E. Expanded methods for Development Interest Index
F. Ecoregion Distribution of Landscape Units by and Protection Type
G. Landscape Unit Representation by Individual Legislated Protected/NWT-Pas Proposal Area
H. Representation of special elements by Individual Legislated Protected/NWT-Pas Proposal Area
I. Conservation Goals Background
J. Comparison of Conservation Tiers from Landscape Unit Representation Analysis

1 INTRODUCTION

1.1 The Northwest Territories Protected Areas Strategy

The Mackenzie Valley Five-Year Action Plan (Action Plan) for the Northwest Territories Protected Areas Strategy (NWT-PAS) calls for the identification, review and evaluation of a network of protected areas in those ecoregions of the Mackenzie Valley that will be directly intersected by the proposed Mackenzie Valley gas pipeline or hydrocarbon development areas. There are many important criteria for selecting potential protected areas, and the first goal of the NWT-PAS is to select areas of special natural and cultural values. A second goal of the NWT-PAS ('Goal 2') is to protect 'representative core areas' within each ecoregion of the NWT. These core areas are meant to protect the biological diversity of the NWT and to ensure that the variety and abundance of ecological values (e.g. fish and wildlife habitat) are captured or 'represented' within the protected areas network.

Task 1 of the Action Plan focuses specifically on preliminary mapping of both ecologically representative areas and non-renewable resource potential. It is hoped that a general ecological and non-renewable resource potential evaluation can be completed in order to facilitate identification of potential areas of high ecological value and areas of high economic value. This information could then be applied in the preliminary design of a protected areas network, with particular attention being paid to avoiding conflicts between resource development and high conservation values where possible.

Task 1A of the Action Plan articulates the objective of mapping ecologically representative areas for the Mackenzie Valley, and it is Task 1A that is the focus of this study. As stated in the Action Plan, representation of the NWT's biodiversity is to be based on biophysical land units defined within the National Ecological Framework for Canada (1996), a Canada-wide ecological land classification framework. Lacking more complete information on species and communities, experts have agreed that applying a coarse filter approach based on elements of the landscape (landforms, soils, water and climate) can be used to approximate biodiversity. However, the Action Plan also clearly states that final area selection should not rely entirely on a coarse filter approach (landscape unit representation). Where other ecological data layers are available or can be generated or purchased at a reasonable cost, they will be analyzed to supplement the coarse filter approach.[2].

1.2 Representative Core Areas: Short-term Objectives

In a geography as broad as that of the NWT, the NWT-PAS goals represent a significant, if not daunting undertaking, and one best addressed in several phases. In order to address immediate information needs related to the development of the Mackenzie Valley pipeline, an initial phase (Phase 1) of work was proposed.

In response to this proposal, in February of 2005, Round River Canada was contracted to conduct a short-term (2 month), preliminary assessment of how existing data might be used to inform the selection of protected areas to meet Goal 2 of the NWT-PAS. The preliminary, and specific nature of the analysis is important to emphasize given the limitation of existing data (in particular we note the absence of information on landcover, and species habitat requirements),

[2] Please see the Mackenzie Valley Five-Year Action Plan (Oct. 2003) for a detailed description of objectives, goals, and tasks.

and given that this study focuses on just one set of values (ecological) in assessing representative core areas.

The potential limitations of this Phase 1 product were recognized early in the project, but nevertheless, this initial work provides a platform for scoping further required work that would more completely fulfill Task 1A. While the first phase of analysis will provide an important framework for the NWT-PAS, there is a common understanding among experts, managers and planning partners that substantially more analytical work will be required in the coming 12 to 24 months in order to better fill that framework. A detailed workplan for Phase 2 has been proposed and is described in a companion product for the NWT-PAS.

1.3 Organization of this Report and Supplemental Materials

This report is divided into eight sections. Section 1 is intended to provide basic background information on the NWT-PAS and the purpose and organization of this study. Section 2 sets the scientific context for the study by supplying some background on regional-scale conservation planning. Section 3 provides a brief description of the study area. Section 4 outlines the underlying data that has been accumulated during the study, while Section 5 describes how this data was used to derive a set of analytical components (models and classifications). Section 6 explains how analytical components can be used in a variety of scenarios for representation analysis. An approach to setting conservation priorities using each of the analytical components and the representation analysis is described in Section 7. Finally Section 8 contains recommendations about the limitations of these short-term products and outlines the need for further study and analysis. All maps referenced in this report are presented in Volume II.

This report is also accompanied by Appendices (Volume III) that among other things catalogue the data layers that were made available for the study, and this catalogue is also part of a GIS data base that holds the underlying data, analytical components, and results of the study.

Two other companion pieces include a recommended workplan for a second phase of study for meeting the objectives of Goal 2, of the NWT-PAS, and Task 1A of the Action Plan. This workplan consists of both an Excel workbook and descriptive narrative. As of April 22, 2005, the workplan is still in draft form as a series of meetings between partners in May 2005 is expected to further shape the proposed scope of work. Finally, at the request of the NWT-PAS, we have supplied as a separate product, a peer review of WWF's "Conservation Suitability Analysis of The Northwest Territories: An Exploratory Approach" (Cizek, 2004).

2 RATIONALE AND APPROACHES FOR REGIONAL-SCALE CONSERVATION PLANNING

Despite the more limited objectives of this Phase 1 study, it is important to set the context in which the general planning approach for this study is set. An expanded discussion of rationales and approaches to regional-scale conservation planning is presented in Appendix A.

2.1 Purpose and Goals

Worldwide, conservation scientists have become increasingly engaged in assisting conservation organizations and governments striving to meet their regional conservation missions. Measuring success at maintaining long term ecological functions and biodiversity in any region has proven difficult and elusive. Therefore, to provide more tangible measures of success scientists have proposed sets of conservation and management goals. Noss (1992) and Noss and Cooperrider (1994) stated four goals of regional conservation to be satisfied to achieve the overarching mission of maintaining biodiversity and ecological integrity, into perpetuity. These goals are:

- Represent, in a system of protected areas, all native ecosystem types and seral stages across their natural range of variation.
- Maintain viable populations of all native species in natural patterns of abundance and distribution.
- Maintain ecological and evolutionary processes, such as disturbance regimes, hydrological processes, nutrient cycles, and biotic interactions.
- Design and manage the system to be resilient to short-term and long-term environmental change and to maintain the evolutionary potential of lineages.

These four goals are often cited and have become central to most regional conservation strategies and conservation area designs endorsed and/or developed by government agencies and conservation organizations.

2.2 Elements of Conservation Area Design

A number of increasingly sophisticated techniques are being applied to regional conservation area designs. Many represent technological or theoretical advancements in our attempts to model and predict the fundamental dynamics and diversity of the landscapes; most attempt to optimize the amount of information gleaned from sparse data, and rely on computer-intensive and GIS-based approaches. Regardless of the techniques, many recent regional conservation planning efforts rely upon three types of information to provide the foundation of the design: focal species analyses, coarse-filter ecosystem representation analyses and fine-filter targets (special elements), as described by Noss et al. (1999). The combination of these analyses provides complementary information sources that should increase the robustness of the design as compared to the use of a single information source. A critical addition to this suite is the explicit consideration of connectivity across landscapes, for the maintenance of demographic and genetic exchange between populations, as well as the maintenance of ecosystem and landscape processes (Dobson 1999; Hoctor et al. 2000; Taylor et al. 1993). Other analyses may

further our ability to capture important dynamic processes, including spatial population viability analyses (advancing focal species analyses), and ecological process modeling (e.g., fire modeling).

2.2.1 Special Elements

The special elements approach typically results in the mapping of hotspots and other biologically or ecologically important areas that are recommended for protection above other areas. Hotspots usually are based on concentrations of species (usually rare or endemic taxa) and can be recognized on a variety of spatial scales, from local to global (e.g., see Myers et al. 2000). Identified hotspots of species richness or endemism, and any other priorities based on special elements, are only as reliable as the underlying data. In most cases, including the majority of the NWT and the rest of Canada, biological surveys are spotty at best. Areas that show up as "cold spots" could either be areas where species richness or endemism is truly low or they could simply be areas that were never surveyed.

In all cases, the fine filter is dependent on reasonably comprehensive, or at least well-distributed, biological surveys to be most useful. But, despite the fact that surveys are not comprehensive for most of Canada, to neglect areas known to be rich in special element occurrences or other ecological values simply because survey data across the region in question are incomplete would be foolhardy. A precautionary approach would protect known hotspots. Hence, the fine filter remains valuable (indeed necessary, if not sufficient) even in relatively poorly surveyed regions.

2.2.2 Representation

Given that species distributions are determined largely by environmental factors, such as climate and substrate, and that vegetation and other species assemblages respond to gradients of these factors across the landscape, protecting examples of all types of vegetation or physical environmental classes ought to capture the vast majority of species without having to consider those taxa individually (Noss and Cooperrider 1994). It has been estimated that 85-90% of all species can be protected by the coarse filter (Noss 1987). Testing this optimistic assumption empirically is difficult, as doing so would require a reasonably complete inventory of all taxa, including cryptic organisms such as bacteria and small invertebrates, sampled over a broad area. In regions with relatively low endemism, such as most of Canada, the coarse filter is predicted to perform better than in regions with high endemism, where species populations are highly localized (Noss and Cooperrider 1994).

Representation assessments typically rely on vegetation (often based on remote sensing, as in the U.S. Gap Analysis Program; Scott et al. 1993), surrogate taxa (e.g., vertebrate species richness, also used in the U.S. Gap Analysis Program), abiotic environmental classes (e.g., landforms, habitat classes defined by soils or geology), or some combination of biological and physical factors (e.g., ecological land units) as proposed coarse filters. Increasing evidence suggests that a combination of biological and abiotic data, as in ecological land units, provides a more secure basis for representation than either class alone (Kirkpatrick and Brown 1994; Kintsch and Urban 2002; Noss et al. 2002a; Groves 2003; Lombard et al. 2003).

2.2.3 Focal Species

Although conservation planning for all biodiversity is desirable, it would be impossible (and possibly counterproductive) to determine and manage for the ecological needs of every species

in a region (Franklin 1993; Poiani et al. 2000). As an alternative, researchers have suggested the identification of a suite of focal species to guide conservation planning (Lambeck 1997; Miller et al. 1998). Focal species are selected such that their protection, as a group, would concurrently protect all or at least most remaining native species. Planning for the maintenance or restoration of healthy populations of multiple focal species can provide a manageable set of objectives for identifying and prioritizing areas, and for determining the necessary size, location and configuration of conservation areas. Focal species monitoring can also be a useful tool in judging the effectiveness of the conservation plan once implemented.

2.2.4 Connectivity

Explicit consideration of connectivity is required when considering large study areas that will likely support multiple core conservation areas. Maintenance of ecological linkages is critical to the long term viability of all species, as well as key ecological processes. The value of connectivity is reviewed in several publications (e.g., Andreassen et al. 1995; Beier & Noss 1998; Collinge 1996). Regional connectivity can be represented through predictions of potential generalized wildlife movements across the study area. These predictions should capture wildlife movements that tend to be determined by energetic considerations related to topography modified by security concerns; they will not capture the movements of species such as sheep or goats which use topography for security.

2.3 New Directions in Boreal Planning

With the advent of a partnership between the Canadian Boreal Initiative and the Canadian Boreal Ecosystems Analysis for Conservation Networks (BEACONs) Project, advances for conservation planning in Canada's Boreal region are being realized. Efforts by BEACONs include confirming appropriate levels of protection required to maintain the ecological integrity of the boreal region. Research also focuses on proactive conservation planning, maintenance of ecological integrity, and demonstration of ecological sustainability. Part of the BEACONs approach is directed at identifying anchor sites for a regional protected areas network through the identification of criteria for benchmark areas. These benchmarks can provide important reference areas against which resource development activities can be evaluated. As reference areas, benchmark areas should be large enough to maintain ecological processes, such as natural disturbance regimes and predator-prey dynamics.

The BEACONs Project makes the important case that for the Canadian Boreal, uncertainty around management decisions, as well as ecosystem processes and condition, demand a science-based approach that integrates the disciplines of resource management and conservation planning. BEACONs has proposed several avenues for this integration, including the application of a reverse-matrix model. This model focuses on the matrix, or areas between protected areas, as the supportive environment in which limited development occurs and activities compatible with ecological sustainability are identified through an adaptive management framework.

The Northwest Territories could provide an important opportunity for testing and implementing the reverse matrix approach. In particular, the goals of the NWT-PAS should fit well with its conceptual foundation, as it likely has broad applicability in the design of ecological networks that facilitate biodiversity conservation and sustainable use. Given the short time frames of this study, a thorough exploration of how these concepts and principles might be applied was not possible. However, a number of key elements of the BEACONs

model are incorporated into the approach discussed in this study, including the identification of minimum size area requirements for core or anchor sites. Further, as part of this study, we have been asked to help convene a visioning workshop, and to build a workplan for a second phase of analysis, both of which would specifically address application of the reverse-matrix model.

3 STUDY AREA DESCRIPTION

3.1 Study Area

The decision by the NWT-PAS to use ecoregional boundaries to define the Action Plan's TASK 1A objectives fits well with current thinking behind the need to conduct ecological analysis within ecologically defined boundaries (Groves 2002). The advantage of an ecoregional approach includes the ability to place any landscape feature in a local, regional or global context. This study focuses on 15 of the 16 ecoregions that would be directly impacted by the planned Mackenzie Valley gas pipeline corridor and associated hydrocarbon development areas[3]. Twelve of these are nested within the Taiga Plains ecozone, 2 are within the Southern Artic ecozone, and one is part of the Boreal Cordillera ecozone. It is this more discrete set of ecoregions, totaling over 52 million hectares in size, which is the focus of our study (Map 2, Table 3.1). It is important to note that these ecoregional boundaries are currently being revised.

Table 3.1. Total area within the 15 ecoregions of the Study Area[3].

Ecozone	Ecoregion	Hectares
Southern Artic	Tuktoyuktuk Coastal Plains	4,218,695
Southern Artic	Dease Arm Plain	5,710,665
Taiga Plains	Mackenzie Delta	916,593
Taiga Plains	Peel River Plateau	4,547,861
Taiga Plains	Great Bear Lake Plain	10,755,626
Taiga Plains	Fort MacPherson Plain	2,738,243
Taiga Plains	Colville Hills	2,019,711
Taiga Plains	Norman Range	4,207,905
Taiga Plains	Mackenzie River Plain	1,640,908
Taiga Plains	Franklin Mountains	652,066
Taiga Plains	Sibbeston Lake Plain	1,371,318
Taiga Plains	Horn Plateau	2,492,716
Taiga Plains	Hay River Lowland	7,580,324
Taiga Plains	Northern Alberta Uplands	3,002,401
Boreal Cordillera	Hyland Highland	460,555
Total Study Area		52,315,585

3.1.1 Profile of Study Area Ecoregions

A full description of each of the ecoregions in the Study Area is found in Appendix B. These descriptions are taken directly from the Government of Canada's "Narrative Descriptions of Terrestrial Ecozones and Ecoregions of Canada", which can be located at,

http://www.ec.gc.ca/soer-ree/English/Framework/Nardesc/default.cfm

[3] The Yukon Plains ecoregion, of which only a small fraction (less than 100,000 ha land area) is located in the NWT, was not included in this analysis.

3.2 Conservation Status/ Land Use Designations

3.2.1 Existing Legislated Protected Areas

Included in this category are areas of land or sea specially dedicated to the protection and maintenance of biological diversity and its associated natural and cultural resources (Table 3.2). Presently, only four existing protected areas partially overlap with the Study Area—Wood Buffalo National Park and Nahanni National Park Reserve, Kendall Island and Anderson River Delta Migratory Bird Sanctuaries. The Pingo Canadian Landmark (national landmark) also falls within the study area.

3.2.2 Proposed National Park Expansion

Part of the proposed National Park expansion, Tuktut Nogait, also overlaps with the Study Area.

3.2.3 NWT-PAS Initiatives

In addition to these existing protected areas, several important areas have been proposed by communities for protection through the NWT-PAS process (Table 3.2).

3.2.3.1 Areas of Interest

Areas of Interest are special natural areas or sites of cultural importance that have been identified by communities in the first two steps of the NWT PAS planning process[4]. These areas do not yet have definitive boundaries and have no restrictions on land use or access. Candidate Protected Areas can be selected from an Area of Interest. Two large Areas of Interest, Pehdzeh Ki Deh and Smbaa K'e are found within the study area.

3.2.3.2 Candidate Protected Areas

Candidate Protected Areas have been selected from an Area of Interest, undergone proposal development and have been accepted for further evaluation. Candidate Protected Areas have the support of the appropriate communities, regional organizations and government agencies. Preliminary boundaries have been established but there are no restrictions on land access.

There is one Candidate Protected Area, Tsodehniline Tuyat'ah , within the study area. The Yamoga Land Corporation and the Fort Good Hope Renewable Resources Council are currently working on a proposal for interim protection for this area.

3.2.3.3 Candidate Protected Areas with Interim Protection

Interim protection refers to a time limited withdrawal of lands from new surface and/or subsurface interests within a candidate protected area to ensure that the natural and cultural values of the area are not compromised during the planning process.

Sahoyúé and ?ehdacho was the first area moved through the NWT-PAS process to attain interim protection for a five year period beginning in February 2001. The two peninsulas of Great Bear Lake are currently designated a National Historic Site.

Interim protection for Edéhzhie was granted in 2002. This initiative is supported by both the Deh Cho and Tli Cho First Nations.

[4] More details on the NWT PAS selection process can be found at http://www.enr.gov.nt.ca/pas/index.htm

While no new land access can be granted for these areas existing third party interests are not affected by the land withdrawal.

Table 3.2 Existing protected areas and NWT-PAS proposals for the Study Area, distributed by ecoregion

Protected Status	Area Name	Ecoregion Name	Hectares
National Park	Wood Buffalo	Hay River Lowland	572795
National Park Reserve	Nahanni	Hyland Highland	2080
	Nahanni	Sibbeston Lake Plain	61615
	Nahanni	Hay River Lowland	14
National Landmark	Pingo	No Boundaries Defined	
Migratory Bird Sanctuary	Kendall Island	Tuktoyuktuk Coastal Plain	61221
Proposed National Park	Tuktut Nogait	Dease Arm Plain	24588
Candidate Protected Area with Interim Protection	Edacho and Sahyoue	Great Bear Lake Plain	553330
	Edéhzhíe	Horn Plateau	1920640
	Edéhzhíe	Hay River Lowland	426614
Candidate Protected Area	Tsodehníline and Tuyat'ah	Peel River Plateau	667999
	Tsodehníline and Tuyat'ah	Fort MacPherson Plain	543959
	Tsodehníline and Tuyat'ah	Mackenzie River Plain	133489
NWT-PAS area of interest	Pehdzeh Ki Deh	Norman Range	1509662
	Pehdzeh Ki Deh	Mackenzie River Plain	17578
	Pehdzeh Ki Deh	Franklin Mountains	399851
	Sambaa K'e Area 1	Hay River Lowland	5032
	Sambaa K'e Area 1	Northern Alberta Uplands	935283
	Sambaa K'e Area 2	Hay River Lowland	104335
	Sambaa K'e Area 2	Northern Alberta Uplands	35634

4 UNDERLYING DATA and GIS DATABASE

Attempts at regional-scale conservation planning in the Northwest Territories are hampered by a lack of consistent and uniform regional data sets. This shortfall is most acute in terms of biological information. While the efforts of dedicated government staff and the scientific community at large continue to build a base of conservation information, a great deal of raw data collection, synthesis and analysis will need to be accelerated in the coming years to build a solid foundation of science to inform land-use decision-making at the territorial scale. In the interim, and for this first phase of analysis for Task 1A of the Action Plan, we have attempted to accumulate as many spatially explicit data sets as possible in the form of a GIS database. A full list of this data is described in Appendix C.

Below we describe the key data sets that were used for both driving site selection for representative core areas (see Section 6), as well as for prioritizing areas. These data include geo-physical, biological and human use information.

4.1 Landscape Units

In the absence of other ecologically based land cover classifications, the base coarse filter data set that is used to measure representation and to drive selection of core representative areas is the Landscape Unit classification created by the Government of the NWT's (GWNT) former Department of Resources, Wildlife and Economic Development (RWED), now Department of Environment and Natural Resources (ENR) (Map 3). A description of the methods used to derive this classification can be found in Appendix D.

4.2 Biological Information

Within the short time frame of this project's Phase 1, very few data sets were secured for either driving core area selection, or *post hoc* representation analysis. The effort focused on collating data used for WWF's "Conservation Suitability Analysis of The Northwest Territories: An Exploratory Approach" (Cizek, 2004) (areas previously identified as important by various agencies), as well as a select set of readily available data sets provided by the GNWT , federal government and other agencies. These data sets are described in Table 4.1 and displayed in Maps 4a, b, c, and d.

Table4.1 Biological information available for analysis of NWT representative core areas. For a complete list of sources please see Appendix C and the Literature Cited section of this report.

Data	Description
Key Migratory Bird Terrestrial Habitat	Locations of key bird terrestrial habits for migratory species, both common and rare. S.A. Alexander et al. 1991.
Wildlife Areas of Special Interest to the former GNWT Dept. of Renewable Resources	Small number of geographically broad areas identified for their value to Muskox, Peregrine Falcon, Dall Sheep, Moose, Wood Bison. R.S. Ferguson. 1987.

Data	Description
Mackenzie Basin Committee – Sensitive Areas	Sensitive areas literature review for Mackenzie River Basin Committee. 1981, and then digitized along watershed boundaries by Cizek, 2004.
Critical Habitat Areas NLUIS	Critical Habitat identified through the Northern Land Use Information Series, Department of the Environment and the Department of Indian Affairs and Northern Development between 1972 and 1983. Now compiled in WWF's NWT Digital Atlas.
International Biological Programme Sites	Describes location and habitats of threatened species, species of concern and species at risk. Also rare or unique habitat types and ecological communities. **Arctic** D.N. Nettlesmith and P.A. Smith (eds.). 1975. **Sub-Arctic** D.K.B. Beckel (ed.). 1975.
Important Bird Areas	Sites providing essential habitat for one or more species of breeding or non-breeding birds. These sites may contain threatened species, endemic species, species representative of a biome, or highly exceptional concentrations of birds.
Raptor Nest Data Set	Point locations of raptor nest sites provided by GNWT and buffered by 3 km.
Rare Plants	Draft general status ranks for vascular plants in the NWT - CAN specimen locations: subset of species that may be at risk. Data from NWT Species Monitoring Infobase, version 2005 (Government of the NWT, Yellowknife, NT), and CAN database (Canadian Museum of Nature,Ottawa), Excel file created 12/05/2004 S Carriere.
High value late winter habitat data for boreal woodland caribou	Created from the results of Anne Gunn's (GWNT ungulate biologist) habitat model for boreal woodland caribou in the Deh Cho. This is a broad-scale model that predicts boreal woodland caribou distribution in the Deh Cho region in late winter. The grid cells are 10kmx10km in size.
Boreal woodland caribou in the Lower Mackenzie River/Peel Plateau	Model shows probability of occurrence for boreal woodland caribou in the Lower Mackenzie River/Peel Plateau Area. The authors (Nagy et al.) believe this model reasonably predicts the distribution of low, moderate, and high quality late winter habitat for boreal woodland caribou. http://www.nwtwildlife.com/Publications/otherresearch.htm. The model uses vegetation cover information from the Peel River Plateau section of Ducks Unlimited Canada (DUC) land cover data
-Bluenose East and West barrenground caribou herds -Cape Bathurst barrenground caribou herd	Combined seasonal distribution of the Bluenose East and West barrenground caribou herds as well as the Cape Bathurst barrenground caribou herd. Based on probability estimates of percent utilization of the range. There are eight different seasons including calving/post calving range, early summer range, mid summer range, late summer range, fall/rutting range, fall/post rutting range, winter range, spring, spring migration, pre-calving range. http://nwtcrs.rwed-q.gov.nt.ca/pub/incoming/PAS/RRC/seasonal_ranges_paper.zip

4.3 Human Use Information

Data on human uses was provided through the GNWT and included a variety of point and linear features relating to existing human impacts on the landscape (Map 5). An accounting of how these data were used for this analysis is described below in Section 5. Data included information on,

- Roads
- Seismic Lines
- Trails
- Oil and Gas Wells
- Communities
- Lodges/camps
- Pipelines
- Winter roads

4.4 Third Party Interests

In addition to information on current human uses, data was collected regarding existing third party interests, surface land use permits and surface dispositions. The application of these data sets in this analysis is described below in Section 5. The data included information on,

- Mineral claims (active, leased, pending)
- Mineral leases (active, pending)
- Prospecting permits (active)
- Oil and Gas Pioneer (pioneer, exploration, significant discovery and production licences)
- Oil and Gas potential
- Oil and Gas call for bids
- Land Use permits
- Land Use Dispositions
- Proposed Mackenzie Valley gas pipeline and associated infrastructure

5 ANALYTICAL COMPONENTS

In this section we describe the process by which the underlying data discussed in Section 4 has been compiled and assimilated into a series of data models and classifications. These components are meant to serve as both stand-alone information products for guiding NWT-PAS decision-making, and also as direct inputs into the representation analysis described in Section 6.

5.1 Planning Units

Summarizing a diverse set of data into a single analytical framework for selection of representative areas is a challenging undertaking. One approach for resolving this challenge involved simplifying available data sets into analytical components, which in turn, we have attributed to a single, common set of planning units.

As a starting point we have selected 2000 ha hexagon-shaped units for this study. Hexagon-shaped planning units are preferred as they minimize edge: area ratio of the resulting grid of selection units. Additionally, groups of hexagons can also conform fairly well to sinuous features, such as rivers or roads. The base unit size of 2000 ha was decided upon primarily with respect to computing ability for the integration analyses. These analyses are limited in the number of planning units on which the site selection software can operate (see Section 6). We have maximized the number of planning units we could feasibly include in the site selection effort, thus minimizing the size of the individual units. The smaller the planning unit size, the more efficient the site selections tend to be with regard to total area required to meet conservation goals. Increasing the planning unit size can lead to variable results in site selection (Warman, Sinclair et al. 2004). This is partly because increasing the unit size forces inefficient selection of large units that may contain a spatially-limited amount of the conservation values being assessed.

For the purposes of this study, these 2000 ha units were further refined by intersecting the planning units with the NWT Landscape Units (see Section 4). This intersection allows for a more spatially explicit solution given the dependence on Landscape Units as the single driving data set used for site selection. In subsequent phases of analysis, when more data is brought into the site selection process, this decision to intersect should be revisited.

5.2 Human Use Model

5.2.1 Background

The NWT is often thought of as a universally intact and undisturbed landscape; certainly, when compared to most landscapes in southern Canada this perception is somewhat justified. Nonetheless, there is already a surprisingly distinct human footprint spreading with ever-increasing speed across the NWT. Fueled largely by natural resource extraction activities, most notably hard rock mining and oil and gas exploration/development, a growing network of roads, seismic lines, well pads and mine sites is extending across the region.

It can be expected that many human uses result in the direct or indirect modification and/or degradation of natural habitats and ecological processes. In fact, there is substantial consensus among biologists that anthropogenic habitat loss and degradation, including habitat fragmentation, represent the greatest threats to biodiversity worldwide (Harris 1984; Wilcove, McLellan et al. 1986; Heywood 1995; Collinge 1996; Laurance and Bierregaard 1997). It is

typically the large carnivores and habitat specialists that are most susceptible to the effects of habitat fragmentation (Newmark 1986; Harris and Gallagher 1989; Newmark 1995; Newmark 1996; Holt, Lawton et al. 1999; Gittleman and Gompper 2001; Crooks 2002; Forman, Sperling et al. 2003). Additionally, naturally rare species are particularly susceptible to habitat degradation, and to displacement by species invading these newly accessible systems. Application of the precautionary principle suggests that conservation plans should consider the ecological needs of the species that are most sensitive to the effects of habitat loss, fragmentation and degradation.

Measuring this footprint can form an important barometer of current ecological conditions, and thus be valuable in guiding site selection for core representative areas. Assessment of human impacts can also provide insights into areas where continued or increased human uses may be expected, thereby informing measures of urgency and threat for selected core areas. The human footprint analyses presented here are meant to synthesize and display available human-use data in a transparent format in order to provide an explicit framework for expert and stakeholder input and discussion. In addition, this assembly of human-use data can be used to guide site selection algorithms and predict relative development interest. We note again that this methodology has not been reviewed by local experts but is designed for modification following such input.

5.2.2 Methodology

We used existing government data sources to compile information about the distribution and types of human uses across the landscape (Map 5). Data in the form of line, point or area features were summarized into consistent units using variable width buffers and overlapping buffers were merged. The resulting areas were meant to reflect the relative zone of influence of human activity, based on relative human use intensity; these were summarized by analytical unit. We do not suggest that these buffers predict spatially accurate areas of impacts – rather they are designed to estimate relative impact, compared with the range of values found throughout the study area. We classified human use, according to relative intensity, into two classes: Major Impacts and Moderate/Low impacts. The data and approach used in this analysis are described below.

5.2.2.1 Major Impacts: Buffer by 1000m

Major impacts were defined as those human uses and activities that are characterized by continuous or high intensity human presence or human activity across the landscape. These features were buffered by 1000m – a number taken from the scientific literature as a relatively conservative 'zone of influence' – where indirect and direct human intervention influences biodiversity patterns or processes (Forman 1995; Forman and Deblinger 2000).

Features that were classified as Major Impacts included:

- Towns
- Major roads (year-round)
- Winter Roads
- Outfitter lodges & camps
- Mineral Production: producer

5.2.2.2 Moderate / Low Impacts: Buffer by 250m

Moderate or low human impacts were defined as those areas with more infrequent human presence and/or moderate to low human activity intensity. Note that it would be better to have explicit intensity attributes for each of these features (e.g. tons of materials extracted for mines, road traffic, Oil production in barrels etc.), but such data were unavailable at the time of the study. Nevertheless, we suggest that these activities, on average across the study area, reflect relatively lower intensity human uses than those classified as "Major Impacts". A buffer width of 250 meters was selected based on ecological literature describing both the direct and indirect zone of influence (Forman 1995; Forman and Deblinger 2000). Note that buffer width is likely to vary according to intensity and also for different features – we suggest that additional expert opinion be gathered to address these, and similar other, issues. Moderate / Low human uses included:

- Mineral Production: abandoned
- Mineral Production: care and maintenance
- Mineral Production: minor/renewed exploration
- Mineral Production: drilled
- Existing and proposed pipelines and pipeline facilities
- Trails, seismic lines & cutlines
- Historic Oil and Gas wells

5.2.2.3 Human Use Footprint Analysis

To create a human use footprint, the area of buffered features was summarized by planning unit and overlapping areas were merged. In this way, bias towards areas and/or features that were mapped at greater density due to mapping effort was reduced to some degree.

5.2.2.4 Human Use Intensity Analysis

A simple human use intensity map was designed specifically for use within the site-selection software used by this study (see Section 6). This map represents a continuous surface of values for the study area that is utilized in analysis to guide conservation areas towards relatively intact areas. Areas of low human use are designated as being less costly for the site selection model, and therefore are preferentially incorporated by the software for meeting representation goals. Areas of high human use have a high cost for the model, and are thus avoided where possible. The human use intensity analysis was generated by multiplying footprint area by a weighting factor--1 for low/moderate impacts, and 10 for major impacts. Weighting were established through experiments with site selection software that sought a balance between avoidance of heavily impacted areas, but only to the degree that representation goals would still be met in a spatially efficient manner. These values were then summarized by planning unit – such that each planning unit has a specific conservation cost that is correlated to relative human influence mapped within that planning unit.

5.2.3 Results and Discussion

This analysis serves to provide the NWT-PAS with a regional picture of relative levels of human use and development across the study area (see Map 6), but is not an attempt to quantify direct impacts at any given site, or the ecological significance of any existing or future impact. While the techniques used are rudimentary and limited, the assessment of regional patterns of human influence is difficult, and similar weighting additive approaches have been used for identifying areas with limited human influence elsewhere (Lesslie, Mackey et al. 1988; Lesslie 1991; Kliskey 1994; Aplet, Thomson et al. 2000; Church, Gerrard et al. 2000)

We use the human use analyses to guide the selection of ecologically representative sites that have minimal existing human uses. This allows us to select those areas in the region that have likely minimal degradation, and thus may represent the best examples of Landscape Units. Additionally, the selection of sites that avoid areas with existing uses may decrease any potential conflicts with those existing activities. Because new developments often coincide with existing infrastructure, using existing human uses to guide the selection of sites should also minimize future potential conflicts between ecological values identified in the Study Area and human use and development of those sites.

Alternatively, our use of the human development analysis does not preclude the selection of areas with existing human uses, even areas of high use. This is particularly true if a rare ecological value is located in an area of existing human uses; these sites are identified for rare values regardless of the level of human uses. In these instances, the identification may serve as an indication of the priority for conservation or restoration of the rare feature.

The data used for the human use analyses is limited to those data sets that identify existing infrastructures across the region. It is highly recommended that this summary serve as a starting point, and that a focused inventory effort be initiated to improve and update these data sets, for both improving future site selection of core areas, and also for creating a foundation for ongoing cumulative effects monitoring. Additionally, the attributes available to more fully understand the actual infrastructure or development were extremely limited, and we had to make several assumptions about feature classes, many of which are described in this report. As it stands, the lack of use intensity and current status of most features severely limits any finer classification of all features used in this analysis.

5.2.3.1 Evaluation of human uses by ecoregion

The human footprint analysis can be used for a variety of assessments to quantify relative human use and impact. For example, relative human uses can be assessed by ecoregion – which can provide the basis for cumulative effects assessments and guide conservation area designations. Table 5.1 summarizes average human footprint by ecoregions found in the study area.

Table 5.1 Summary of Human Footprint on Study Area Ecoregions

Ecoregion	Ecoregion Area (ha)	Human Footprint (ha)	% of Ecoregion
Colville Hills	2019710.50	155938.98	7.72
Dease Arm Plain	5710665.38	127137.88	2.23
Fort MacPherson Plain	2738243.10	178414.98	6.52
Franklin Mountains	652066.44	70741.46	10.85
Great Bear Lake Plain	10755625.53	277673.64	2.58
Hay River Lowland	7580323.58	496091.43	6.54
Horn Plateau	2492715.87	63069.31	2.53
Hyland Highland	460554.78	5594.41	1.21
Mackenzie Delta	916592.72	186266.75	20.32
Mackenzie River Plain	1640907.56	180351.26	10.99
Norman Range	4207904.92	190761.20	4.53
Northern Alberta Uplands	3002400.91	463903.99	15.45
Peel River Plateau	4547860.67	257629.27	5.66
Sibbeston Lake Plain	1371317.90	22265.23	1.62
Tuktoyuktuk Coastal Plain	4218694.81	1277973.55	30.29

These results illustrate relatively low levels of human influence found throughout the Northwest Territories (footprint percentages range from 1.21 percent to over 30 percent), yet many ecoregions are under substantial human influence. Better understanding patterns of human uses can help guide the NWT-PAS to take opportunities to minimize overlap of protected areas with heavily used areas. Conversely, where meeting conservation goals leaves no choice but to overlap core areas with high human activity, this information should help identify where NWT-PAS attention to resolving conflicts between proposed use and values needs urgent attention and resolution.

5.3 Development Interest Index: Quantifying Third Party development interests

5.3.1 Background

In an attempt to characterize the probability of continued and future development, third party interests in the study area were summarized into a single analytical component. This model takes into account both existing impacts as described by the human use model, as well as pending and existing claims that might influence the future developments of the landscape. This component is used as a surrogate to describe vulnerability and urgency across the study area and is used to prioritize areas following the site selection process (Sections 6 and 7). It also can serve as a stand alone product that provides a relative measure of threat, urgency or priority for the entire study area.

5.3.2 Methods

Data for each general 3rd party interest category were grouped and standardized and a composite development interest index was calculated (see table 5.2 for categories and data used, and Appendix E for detailed statistical methods). Statistical transformations reduced variance in the data and resulted in a more uniform distribution of values that reflected relative intensity of 3rd party interests.

Table 5.2 Summary of data and attributes used for Development Interest Index (pu = planning unit)

Category	Attribute	Type	Measure
Mining			
	Mine_drilled	Point	# per pu
	Mine_abandoned	Point	# per pu
	Mine_renewed	Point	# per pu
	Claim, lease, prospecting permit	Boolean	mining claim (yes or no)
Oil and Gas			
	Pipeline - proposed	Line	km per pu
	Pipeline	Polygon	ha per pu
	Pipeline – proposed facilities (point)	Point	# per pu
	Seismic Line	Line	km per pu
	Oil and Gas license	Boolean	Oil and Gas claim
Category	**Attribute**	**Type**	**Measure**
Road			
	All-season	Line	km per pu
	Winter	Line	km per pu
Towns			
	Presence	Buffered point	ha within 1km
Human Presence			
	Lodges and Camps	Buffered point	ha within 250m
	Trails	Line	km trails

5.3.2.1 Surface Land Use permits and Surface Dispositions

Surface land use permits and surface dispositions were not integrated into the Development Interest Index due to the lack of information regarding what precisely these data represented, and how, if at all, they related to the information already modeled regarding mineral, oil and gas activity and other interests.

5.3.2.2 Summary Index

A single development interest index, for each planning unit was converted to a score between zero and one-hundred (see Appendix E for details). This index provides a measure of the number of development interests – a rough measure of development likelihood or threat by planning unit. Separate indices can also be calculated for each category (Mining, Oil and Gas, Roads and Human Habitation).

5.3.3 Results and Discussion

The component inputs and combined results of the Development Interest Index are described in maps 7a, b, c, and d.

5.3.3.1 Evaluation by ecoregion

We calculated the development interest index for each planning unit in the study area and calculated the area-weighted mean value for each ecoregion (results shown in Table 5.2). Note that higher scores are a reflection of relatively greater number and diversity of 3rd party

development interests in the data. Because each category is calculated separately, we can further understand the major 3rd party interests by category for each ecoregion. For example, according to this model, the Colville Hills ecoregion had the greatest amount of 3rd party development interest data – driven largely by a concentration of mines, oil and gas wells and prospecting permits in this ecoregion.

Table 5.2 Summary of development interests in Study Area ecoregions

	Relative 3rd party Development Interests		
Ecoregion	**Oil and Gas Index**	**Mining Index**	**Development Interest Index**
Colville Hills	3.50	21.83	30.29
Dease Arm Plain	0.56	18.36	24.07
Fort MacPherson Plain	1.93	7.61	14.30
Franklin Mountains	10.15	1.02	17.45
Great Bear Lake Plain	1.15	12.50	18.28
Hay River Lowland	1.87	0.68	8.46
Horn Plateau	1.24	0.13	3.58
Hyland Highland	1.50	0.73	2.81
Mackenzie Delta	6.48	1.56	12.95
Mackenzie River Plain	8.32	1.96	14.65
Norman Range	2.67	5.52	11.85
Northern Alberta Uplands	5.43	0.00	9.77
Peel River Plateau	2.33	0.02	5.95
Sibbeston Lake Plain	1.65	0.00	2.67
Tuktoyuktuk Coastal Plain	9.32	0.09	12.19

5.4 Coarse Filter Analysis

5.4.1 Background

While the NWT-PAS had hoped to be able to create a more ecologically defined coarse filter for its short-term Task 1A effort, research by NWT-PAS partners into alternative data sources (e.g. MODIS imagery) revealed that no "quick fixes" existed. As such, classification of Landsat imagery currently underway by Ducks Unlimited Canada (DUC) remains the most viable option for developing a detailed and consistent land cover classification. In the interim, the Northwest Territory Landscape Unit classification remains the best alternative, and at least allows planners to create a coarse filter analytical framework. While it lacks the detail and definition planners would ideally like to have, the existing Landscape Units provide us with a product that can inform identification of representative core areas through goal setting. And while even the boundaries of these units are currently under review and likely to change, the short-term assessment of this coarse filter data set lays the necessary groundwork for future incorporation of new, more refined, and ecologically-based information in the future.

5.4.2 Methods

Options for modifying and improving the NWT Landscape Unit layer were initially explored. However, given that the units were under review and subject to change from other contractors,

and given the absence of any vegetation-based land cover, the decision was made to conduct the representation analysis on the existing classification. A description of the GNWT's approach to Landscape Unit classification is provided in Appendix D.

5.4.3 Results

A full accounting of the distribution and protected status of Landscape Units by ecoregion and protection type is provided in Appendix F. Appendix G details Landscape Unit representation by individual protected/proposal area.

5.5 Special Elements Analysis

5.5.1 Background

Representation of special elements and species (i.e. "fine-filter") data are often considered parallel streams of inputs that complement coarse-filter representation - all contributing towards a comprehensive protected area system. We sought to assemble available special features and species information (see Maps 4a, 4b, 4c, 4d, 4e) in order to 1) develop an analytical method for assessing sporadic special element data that can be employed by the PAS over time as new information becomes available, 2) identify "hotspots" of species and/or special features, where biodiversity values coincide using the analytical framework, and 3) to facilitate evaluation of existing species and special elements data by experts.

One of the typical and unfortunate characteristics of special feature data is that they are not consistently available across the study area and sampling bias can be a very real concern when specific goals are set for conservation elements where data collection has been extremely limited. The end result of using such data to drive site selection is that areas may be highlighted based on nothing more than degree of sampling effort as opposed to ecological value. It was beyond the scope of this study to provide a comprehensive evaluation of each special element data set. Nonetheless, the process of collecting a more comprehensive catalogue of special features for the NWT must start somewhere, and it is only with an ongoing effort to bring a variety of datasets together, can this information be vetted for appropriate use in future site selection. This assembly process, combined with a clear analytical framework, provides structure for incorporating expert judgments.

The planning team examined a variety of data sources, and in particular, those identified for WWF's Conservation Suitability Analysis of the Northwest Territories: an Exploratory Approach (Cizek, 2004), but GNWT staff were also able to supplement these with additional information. As described in Section 4, our intention was to accumulate all possible data regarding occurrences of species of concern, unique or special habitats, or other features and areas that may be important to capture within a protected areas network. We grouped the data into categories (Table 5.1) and separate analysis can be generated for overall density as well as for each category.

Few of these datasets appear to be sufficiently extant for setting goals around, however these data are potentially important guideposts and can provide a reference point for 'hot spot' analysis for the Study Area.

Table 5.1 Special Features data used for representation analysis and 'hotspot' analysis. Categories are used for summarizing representation of elements.

SE Catalogue Code	SE Feature	Category
Crithab_curlew	Critical Habitat -Curlew	bird
Crithab_raptor	Critical Habitat - Raptor	bird
Crithab_watrfwl	Critical Habitat - waterfowl	bird
Crithab_whpcrane	Critical Habitat -Whooping crane	bird
Iba	Important Bird Areas	bird
Key_migrbird_hab	Key Migratory Bird Terrestrial Habitat	bird
Raptor	Raptor Nest Sites Buffered	bird
Waosi_nesting	Wildlife Areas of Special Interest - Nesting	bird
Bluenose_east50	Bluenose Caribou Herd East 50% kernel	caribou
Bluenose_east99	Bluenose Caribou Herd East 99% kernel	caribou
Bluenose_west50	Bluenose Caribou Herd West 50% kernel	caribou
Bluenose_west99	Bluenose Caribou Herd West 99% kernel	caribou
Cape_bathurst50	Cape Bathhurst Herd 50% kernel	caribou
Cape_bathurst99	Cape Bathhurst Herd 99% kernel	caribou
Caribou_all	Critical Habitat - Caribou all	caribou
Caribou_calving	Critical Habitat - Caribou Calving	caribou
Caribou_migr	Critical Habitat - Caribou Migration	caribou
Caribou_minrl	Critical Habitat - Caribou Mineral Licks	caribou
Caribou_winter	Critical Habitat - Caribou Winter	caribou
Dehcho_bwc_hi	Dehcho Boreal Woodland Caribou, high quality habitat winter	caribou
Gwichin_bwcwin_hi	Gwichin – Boreal Woodland Caribou winter hi habitat	caribou
Crithab_grizz	Critical Habitat - Grizzly Bear	mammal
Crithab_othrmamm	Critical Habitat - other mammal	mammal
Crithab_polrbear	Critical Habitat -Polar Bear	mammal
Sheepgoat_calv	Sheep / Goal Calving Habitat	mammal
Sheepgoat_minrl	Sheep / Goat Mineral Licks	mammal
Sheepgoat_river	Sheep / Goat River Crossings	mammal
Sheepgoat_winter	Sheep / goat Winter Habitat	mammal
Waosi_calving	Wildlife Areas of Special Interest - Calving	mammal
Waosi_concentr	Wildlife Areas of Special Interest - Concentrations	mammal
Waosi_denning	Wildlife Areas of Special Interest - Denning	mammal
Waosi_feeding	Wildlife Areas of Special Interest - Feeding	mammal
Waosi_refuge	Wildlife Areas of Special Interest - Refugia	mammal
Waosi_wintering	Wildlife Areas of Special Interest - Wintering	mammal
Ibp_sites	International Biological Programme Sites	multi-purpose
Mbc_sensitive	Mackenzie Basin Committee sensitive sites	multi-purpose
Rare_plant	Rare Plant point locations	plant

5.5.2 Special Elements Index

We created a Special Elements Index (SEI) as a measure of the relative abundance of each special element for each planning unit in the study. This approach takes into account the quantity of data available, and measures abundance for each feature or element, relative to the amount described by the available data set (e.g. if a data set has 10 occurrences of an element in it, and a planning unit has 1 of those, that planning unit holds 10% of the available data for the element or feature. In this way, elements that simply have more data collected for them are not favoured over elements with fewer data points. Using this approach we created what is sometimes referred to as a 'Hotspot' map (Map [10]). For this study, the Special Elements Index was calculated as follows:

Special Elements Index (SEI) =
Amount (ha) of biodiversity feature in planning unit / total amount of biodiversity feature in study area

The advantage of this analysis is that it clearly displays where biodiversity features are distributed across the landscape and provides a clear method for adding additional data over time. In general the SEI allows us to incorporate a wider range data into the analysis; data that is not as consistent or uniform as the Landscape Units, but which has been gathered from studies on the ground, lending themselves to more 'place-based' results. The SEI is used for both comparison to, and in combination with, representation analysis, and is an important part of assessing conservation priorities for the study (Section 7). The SEI is also used as means for evaluating the current representation of special elements in legislated existing protected areas and NWT-PAS proposals (Appendix H).

6 EXPERIMENTAL CORE AREA SELECTION

6.1 Background

Using the analytical components described in the previous section, this study aims to create a map of potential core representative areas based on existing goals. These goals include representation of landscape units, identification of biodiversity hotspots and delineation of large core anchor areas, set apart from areas with human impacts where possible. This is accomplished by developing a clear and transparent analytical framework that includes the use of a site selection algorithm and other GIS and tabular analytical tools. Combining the site selection methodology and biodiversity hotspot analysis with information on human impacts and development threats, we create a number of potential options and scenarios for guiding the NWT-PAS in satisfying Goal 2.

It is critically important to note, that the data and selection criteria used are preliminary in nature and are likely to undergo substantial changes in the near future. We were thus faced with a dilemma – how to undertake site selection when available data were limited and in the process of revision? Waiting for better data was ruled out because of pressing and immediate development interests and other human pressures that may severely restrict future scenarios. As such, there was a clearly defined need to move forward with Goal 2 analysis.

Here, we focus on using available data to fully explore analytical approaches and resulting scenarios based on a set of preliminary criteria. While we recognize that such criteria are limited, we suggest that exploration of analytical tools and results can serve to focus decision-makers, partners, and stakeholders on filling gaps in information and developing a more comprehensive set of criteria. Eventually, we, and others involved in the NWT-PAS, would hope to base protected area designations on a more robust set of criteria including,

- Representation of ecological gradients (e.g. vegetation, landform, moisture, climate) for both terrestrial and freshwater ecosystems
- Incorporation of species habitat requirements
- Distribution of rare, threatened, or important special elements
- Maintenance of ecological processes over time
- Maintenance of landscape connectivity

Despite the limitations noted above, we hope that this study will form the basis for creating a solid framework around which a more complete analysis may be undertaken in subsequent phases of work.

6.2 Site Selection Algorithms: MARXAN

Recent development of spatial optimization tools such as SITES and MARXAN (Ball and Possingham 2000; http://www.ecology.uq.edu.au/marxan.htm) have advanced our ability to meet multiple conservation targets simultaneously in a spatially "efficient" manner (in this context, 'targets' refers to the elements of biodiversity we are interested in representing e.g. species, ecosystems). Using spatial optimization software provides a powerful approach to minimizing the amount of area needed to reach multiple representation goals simultaneously.

It is important to note, that site selection software should not be depended on alone to generate a conservation 'solution' for the NWT-PAS. Rather this software is an effective tool for exploring the spatial implications of decisions made about targets, goals, costs, and complimentarity. The strength of a tool such as MARXAN lies not with the certainty of its outputs (which can only be as certain as the inputs), but in the efficacy with which different scenarios can be generated and tested against established criteria. Further, we would like to emphasize that conservation planning must be adaptive over time. 'Efficient' but unimplemented site selection solutions completed now, will have increasingly reduced value over time as both ecological and socio-economic conditions change, and new opportunities for conservation action emerge and disappear.

6.3 Goals

Goals represent the end toward which conservation efforts are directed for targeted species, communities, and ecosystems and as such, are fundamental to systematic conservation planning (Margules and Pressey 2000). Goals provide the quantitative basis for identifying and prioritizing areas that contribute to a network of conservation areas. Moreover, tracking progress toward goals provides an evaluation of the performance of a conservation program, from the scale of individual projects up to province/territory or nation-wide. Tackling the question of "how much is enough?" is one of the most difficult - and most important - scientific questions in conservation planning. More background discussion of goals can be found in Appendix I.

Following on work completed to date by the GNWT regarding setting goals for the NWT-PAS (see Appendix D), for the purposes of this study, conservation goals take into consideration several key criteria,

- Minimum conservation area size
- Minimum representation of the coarse filter (Landscape Units)
- Stratification and replication across ecoregions

By no means do these criteria represent an exhaustive list of considerations to be made when establishing goals. However, given the data inputs available and the limitations of time, these represent a sufficient starting point for exploring spatial solutions to satisfying the objectives of the NWT-PAS Goal 2 as described in Task 1A of the Action Plan. Fully exploring even a limited set of goals can provide considerable insight into data and capacity needed to delineate a comprehensive, resilient and representative protected area network. Therefore, a more complete understanding human influence on a variety of elements of biodiversity is needed. We note that the site selection results presented here are secondarily driven by the presence or absence of human activities across the landscape. We made a number of assumptions related to measuring human influence – and these assumptions were again meant as a starting point, with the intent of providing a comprehensive set of example analyses; we suggest that our approach can be used to gain insight into the data and expert judgments needed to quantify human influence on the long-term viability of ecological communities and populations and also influence the sustainability of conservation actions.

6.3.1 Minimum Conservation Area Size

The size of individual conservation areas is an important consideration for the NWT-PAS. In particular, and as discussed below, a reserve system made up of fewer, but larger protected

areas is more likely to allow genes, species, populations, communities and ecosystems to persist over time when compared to a system of scattered, smaller reserves. Additionally, large reserves can better sustain natural disturbance regimes, and are more likely to protect species and habitats from exotic invasions, fragmentation and negative edge effects.

The required size of individual conservation areas can be considered relative to the natural disturbance regime. Pickett and Thompson (1978) defined a "minimum dynamic area" as the smallest area that contains patches unaffected by the largest expected disturbances. This large size is required to allow recolonization from undisturbed patches within the reserve. Further, it has been shown in several recent studies on protected areas in North America, Canada, and East Africa, that single protected areas or parks become island-like within a landscape inhospitable to biodiversity and natural processes.

Following recommendations from the GNWT (See Appendix D), for sub-arctic boreal forest regions, large reserves of **400,000 ha or more** may be required to encompass the variety of habitat changes associated with long-term fire frequency. Furthermore maintaining viable population sizes for large carnivores and migratory ungulates such as caribou requires large reserves to include those species' normal pattern of distribution.

Based on this recommendation, we have established a goal for including at least one conservation area of at least 400,000 ha in each ecoregion. The process by which this goal is achieved is discussed below in Section 6.4.

6.3.2 Minimum Representation of Coarse Filter Targets

6.3.2.1 Stratification

In order to ensure that multiple examples of Landscape Units would be captured, the Landscape Unit layer was first stratified according to ecoregions. While not all Landscape Units occur across multiple ecoregions, this stratification increased the number of Landscape Unit targets from 153 to 219.

6.3.2.2 Baseline Proportional Representation Goals

Representation goals outlined by the GNWT for the NWT_PAS (see Appendix D) took into consideration differences in prominent versus less prominent landscape units (as described by their spatial extent). The intent is to ensure that less common landscape units are represented proportionately more than larger, more common landscape units. This approach recognizes that Landscape Units with a small spatial extent may be more vulnerable to development pressures since a very small industrial effort could easily convert these areas from a natural state. Taken from recommendations by the GNWT (see Appendix D), Box 6.1 describes the proportional representation goals based on Landscape Unit size categories.

Box 6.1 Baseline Proportional Coarse Filter Representation Goals for Landscape Unit Targets in each ecoregion of the NWT

- Landscape units comprising a total area of >500,000 ha must be represented by at least **10%** of that area.
- Landscape units comprising a total area of 100,000 to 500,000 ha must be represented by at least **15%** of that area.
- Landscape units comprising a total area of 30,000 to 100,000 ha must be represented by at least **20%** of that area.
- Landscape units comprising a total area of <30,000 ha must be represented by at least **25%** of that area.
- Small landscape units, e.g.<10,000 ha, must be ***entirely*** captured (i.e. 100%epresentation)

6.3.2.3 Precautionary Coarse Filter Representation Goals

We see the NWT recommended goals as an important starting point for driving site selection in the Study Area. However, substantially more effort and information will be required in order to better answer questions regarding *how much is enough?*, particularly as more conservation targets (e.g. species, features, ecosystems) are defined through the addition of new ecological information on land cover, focal species and special features.

In the interim, we also felt it valuable to propose a supplementary and more precautionary goal set, one that would allow for exploring the spatial implications of increased goals, while also providing further input on prioritization of areas (see Section 7). In the original goal set the most common Landscape Unit types were assigned a goal of 10%. We decided to increase this goal to 30% in order to reflect minimum representation goals for coarse filter targets being applied in some other North American studies (Heinemeyer 2004, Coast Information Team 2003c, Rumsey 2003). Since this reflects a three fold increase in representation, we multiplied goals for each other goal class by the same factor. We acknowledge that these goals represent very coarse 'best guess', and encourage the NWT-PAS to invest in a more rigorous examination of appropriate coarse filter goals for the region. Box 6.2 describes the proposed precautionary representation goals based on Landscape Unit size categories.

Box 6.2 Precautionary Proportional Representation Goals for Landscape Unit Targets in each ecoregion of the NWT

- Landscape units comprising a total area of >500,000 ha must be represented by at least **30%** of that area.
- Landscape units comprising a total area of 100,000 to 500,000 ha must be represented by at least **45%** of that area.
- Landscape units comprising a total area of 30,000 to 100,000 ha must be represented by at least **60%** of that area.
- Landscape units comprising a total area of <30,000 ha must be represented by at least **75%** of that area.
- Small landscape units, e.g.<10,000 ha, must be ***entirely*** captured (i.e. 100% representation)

6.4 Iterative Approach to Selecting Core Representative Areas

We sought to make a well-informed recommendation regarding the development of a general and flexible site-selection framework. Based on the range of articulated goals, data that are currently available, data that are likely to become available for future work, *we recommend an iterative approach to delineating representative conservation areas, designed to meet multiple goals*. An iterative or stepwise approach allows for more control of the analysis and more transparency with regards to the solution outputs since each step of analysis corresponds directly with a specific set of articulated goals. A problem with many conservation designs is that improved technology has allowed users to easily delineate multiple – sometimes thousands – of conservation goals and although it is technically possible to evaluate all these goals, the resulting solutions often become impenetrable to managers and decision-makers. An iterative approach allows the use of specific and appropriate tools and parameters at each different stage of analysis.

6.4.1 Selection Step 1

The first challenge for meeting conservation goals involved the identification of core anchor sites for each ecoregion. These areas were required to be at least 400,000 ha in size, and ideally we wanted to select areas that had minimal conflicts with existing human uses. We began this selection process by determining a median impact score for each planning unit in each ecoregion. Those units with above median human impacts were screened out of the selection process in order to drive the selection model toward more intact landscape. Next, a single MARXAN goal for each ecoregion was set for 400,000 ha. In addition to screening out the highest human impact planning units, the impacts score of the remaining unit were incorporated into the algorithm's cost function, such that lower impacted units would be preferentially selected. For these MARXAN runs, a high boundary length modifier was set to ensure that large contiguous patches were selected as opposed to many smaller patches. The result is a set of large contiguous blocks of planning units in each ecoregion that we describe as Tier 1 areas.

6.4.2 Selection Step 2

The second step of site selection began with locking in the Tier 1 areas. No planning units were screened for impacts, but rather the degree of impact for each unit was incorporated into the MARXAN cost function, such that lower impacted units would be favoured for selection ahead of higher impacted units. The boundary length modifier was also reduced by half so as to give the site selection algorithm more spatial flexibility in how it met goals. This flexibility allows for more discrete smaller sites to be selected, which in turn will increase the spatial efficiency of the conservation solution (i.e. how much area is swept into the solution). MARXAN was then used to satisfy the remaining baseline Landscape Unit goals (see Section6.3.2.2) that were still outstanding after locking in of the Tier 1 areas. The additional areas selected in this step are described as Tier 2 areas.

6.4.3 Selection Step 3

The third step of analysis is identical to step two, except that instead of the baseline goals, MARXAN was used to satisfy the remaining representation goals as out lined in the precautionary goal set (see Section 6.3.2.3). Tier 2 areas were not locked into this final step so

as to allow the model maximum spatial flexibility in meeting the more precautionary representation goals. The additional areas selected in this step are described as Tier 3 areas.

6.5 Comparative scenarios

One of the advantages of using a site selection algorithm like MARXAN is the ability to quickly generate comparative conservation solutions. We compared potential solutions to meeting representation goals for two different scenarios. The first scenario, referred to as the "Open Scenario", assumed that only existing National Parks would contribute protection toward representation of Landscape Units. The second scenario, referred to as the "Locked Scenario", assumed all existing protected areas, all NWT-PAS Initiatives and Migratory Bird Sanctuaries, would contribute to Landscape Unit representation (see Section 3.2 for a full discussion of these areas).

6.5.1 Open Scenario

In the open scenario, planning units that overlapped with Nahanni National Park Reserve and Wood Buffalo National Park were automatically selected as part of each MARXAN iteration, regardless of their contribution to meeting specified representation goal sets. After some discussion with NWT-PAS staff, we decided to leave Bird Sanctuaries open, or unlocked, given that some uncertainty exists regarding the efficacy of these designations in keeping out industrial development, and due to the fact that such development is already underway in places like the Kendall Island Migratory Bird Sanctuary

Locking in the National Park planning units recognizes the reality that these protected areas will be part of the over all conservation solution, regardless of the efficiency with which they help the NWT-PAS meet its representation goals. The contribution to representation goals made by the National Parks is presented in Appendix G. By keeping site selection 'open' to all other planning units, regardless of overlap with NWT-PAS proposals, allows for observing how well an unconstrained site selection routine, seeking to meet goals while minimizing overall cost, would select sites that overlap with the areas that are currently being reviewed for incorporation into the NWT-PAS (see Figure 6.1). This evaluation of spatial complimentarity should be viewed along side of the results of the 'Locked Scenario' and the tabular results described in Section 6.6, and Appendix J. These results detail relative impacts/feasibility scores and representation contribution for each of these existing proposed protected areas.

6.5.2 Locked Scenario

In this MARXAN scenario, all planning units overlapping with existing and proposed protected areas were automatically selected for each MARXAN solution. In addition to National parks, this included all current NWT-PAS initiatives as well as Migratory Bird Sanctuaries.

By locking these planning units into the conservation solution, we can then use MARXAN to explore the question, '*if these areas were to be protected, how much more area would be required to meet conservation goals?*'

We would expect that these areas have been delineated not with optimization of ecological representation goals in mind (and we acknowledge that there are many other excellent criteria for selection of protected areas besides optimized ecological goals). Our null hypothesis would therefore state that the Locked Scenario would yield a more inefficient scenario, one that swept

in more area and more impacts than the Open Scenario in meeting representation goals. The results of this comparison can be found in Section 6.6 and are illustrated in figures 6.1 and 6.2.

6.6 Core Area Selection Results: Scenario Experiments

In order to compare results for efficiency and representation, we examined the results for each above described scenario. We recommend that scenarios – different parameters, assumptions and data sets – be treated as experiments, driven by specific questions and criteria. How would conservation area networks differ with changing parameters and goals? Designing a comprehensive and functional network will necessarily require multiple iterations and comparison of results – here we present results from a few preliminary experiments and suggest that these can be illustrative and promote additional exploration and dialogue.

In a first experiment, we compare overall area of best run solutions and also assess the average conservation cost or human impact in the resulting best run solution in order to gain insight into trade-offs between various criteria and goal setting regimes. Again, it is important to note that these results are not meant to be prescriptive – rather they provide a transparent window into a variety of different goal setting and protected area criteria and should be used to inform further discussion around similar topics. Secondly, we compare results from iterative Marxan analysis and relative biodiversity index results, by looking at the overlap, and the gaps, between the two independent approaches.

6.6.1 Scenario Overview results

Open and Locked scenarios resulted in varying amounts of areas being identified, as well as cumulative costs (Table 6.1) (Figures 6.1 and 6.2). All conservation goals were fulfilled for all Marxan runs. Not surprisingly, open scenarios resulted in more efficient solutions and there appears to be a clear trade-off between efficiency and utilization of proposed protected areas in the locked scenarios.

Table 6.1 Study Area wide comparison of spatial efficiency and human use intensity (cost) among Open and Locked scenarios in meeting baseline, and precautionary representation goals. Mean cost is calculated by taking the average human use score (Section 5.2) for each planning unit within the conservation tier.

Tier	Scenario	Solution Area (ha)	% of Study Area	Mean Cost
Tier 1	**Open**	6,152,579	12%	1.09
	Locked	11,141,586	21%	5.74
Tier 2	**Open**	15,770,304	30%	1.59
	Locked	20,361,635	39%	3.84
Tier 3	**Open**	23,891,263	46%	1.89
	Locked	26,210,869	50%	3.47

A more detailed comparison of the efficiency of these results is presented in Appendix J.

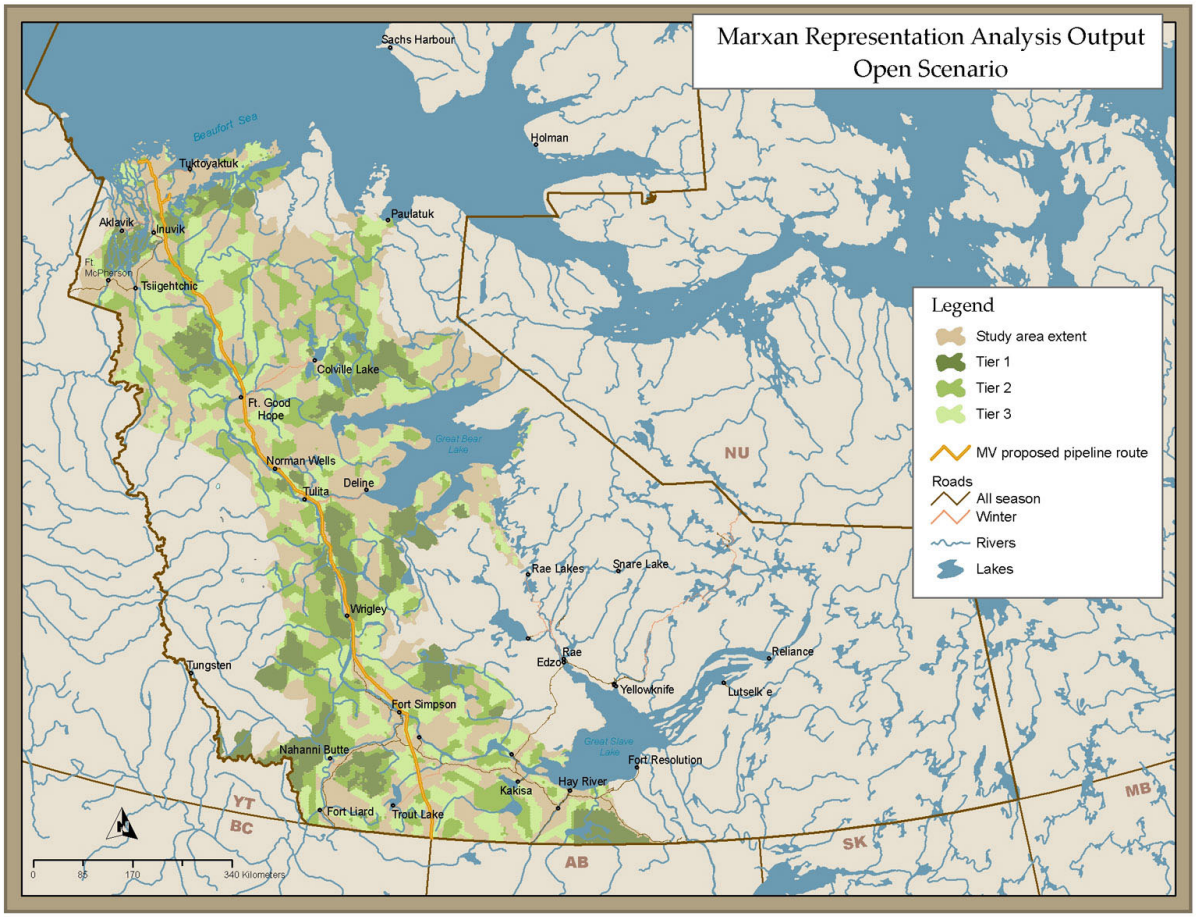

Figure 6.1 MARXAN 'Open' experiment for representing NWT Landscape Units using baseline and precautionary goals to create conservation tier classes. This was an 'Open' scenario, meaning that no NWT-PAS proposals or Migratory Bird Sanctuaries were assumed to be part of the solution, only legislated National Parks.

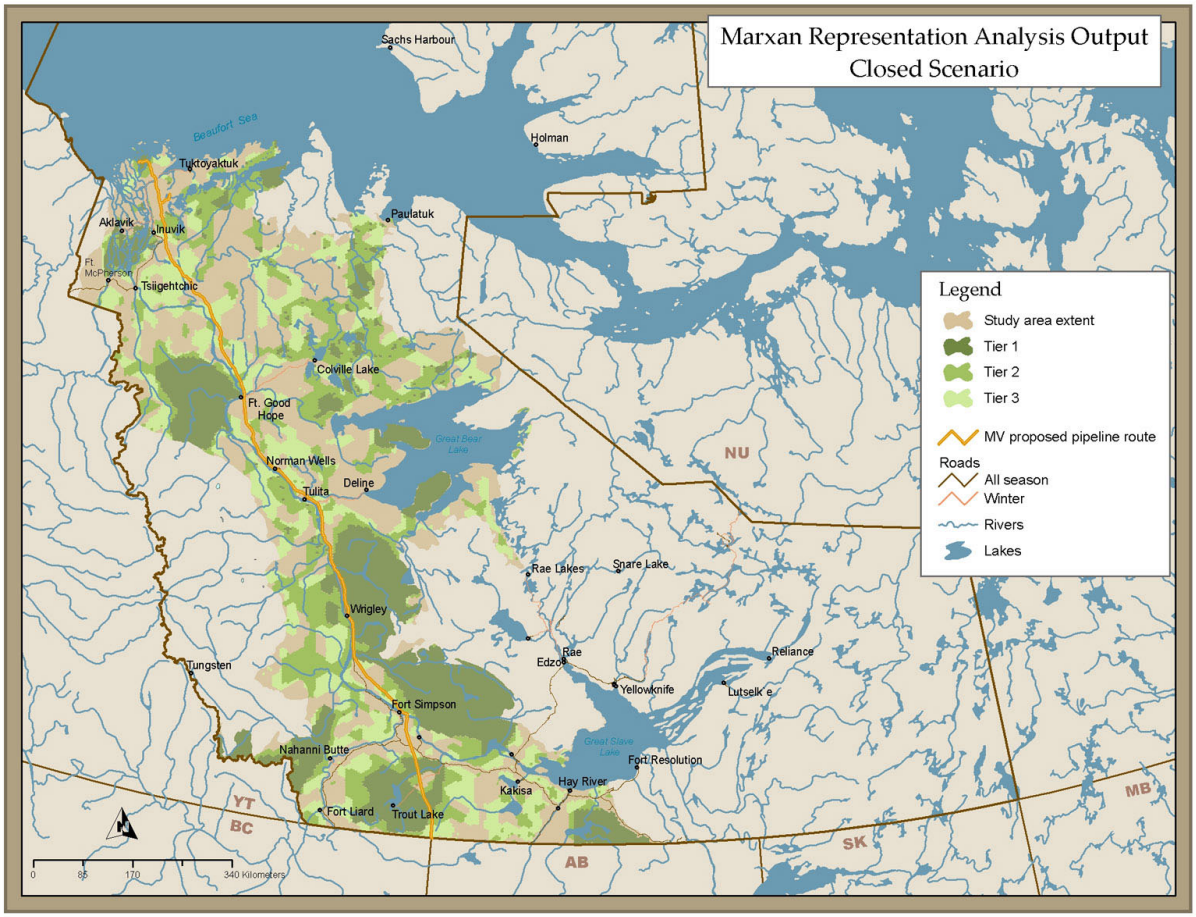

Figure 6.2 MARXAN 'Closed' experiment for representing NWT Landscape Units using baseline and precautionary goals to create conservation tier classes. This was a 'Closed' scenario, meaning that all legislated, existing, protected areas and NWT-PAS proposals were assumed to be part of the solution.

6.7 Comparison of Special Features vs. Conservation Tiers

6.7.1 GAP analysis: Conservation tiers vs. Special Elements

We could easily have set goals on and incorporated special feature data into the current MARXAN analysis; however, doing so would have precluded the following analysis: comparing Conservation Tiers with Special element distribution. In essence, exploring the degree to which the coarse filter representation of Landscape Units captures the known special elements and features of the region.

To explore these questions, for each scenario we examined representation of groups of special features (see table 5.1 for detail on the data used). Results of these analyses are displayed in table 6.8.

Table 6.8 Evaluation of the proportion of special element types captured in conservation tiers generated in Landscape Unit representation analysis. Percentage figures refer to the total percent of the element/feature type available (see table 5.1), that is captured in the tier and scenario. The index values correct the percentage scores for scenario area, and provide a measure of the spatial efficiency of each tier in capturing specials elements. High index values indicate that a particular scenario captured more of special element type with less area than those scenarios with lower index values.

	Tier 1		Tier 2		Tier 3	
	Open	**Locked**	**Open**	**Locked**	**Open**	**Locked**
Solution Area (ha)	6,152,579	11,141,586	15,770,304	20,361,635	23,891,263	26,210,869
% of Study Area	12%	21%	30%	39%	46%	50%
% of Bird Features	21.85%	28.69%	36.93%	45.38%	55.01%	57.51%
% of Caribou Features	12.13%	14.64%	30.01%	36.53%	45.27%	45.11%
% of Mammal Features	4.10%	9.80%	29.53%	37.54%	43.98%	58.31%
% of Multi-purpose Features	13.96%	34.56%	27.19%	45.94%	43.50%	51.90%
% of all biodiversity special features	12.15%	21.02%	31.69%	38.30%	43.64%	51.26%
Bird Feature Representation Index	1.82	1.37	1.23	1.16	1.20	1.15
Caribou Feature Representation Index	1.01	0.70	1.00	0.94	0.98	0.90
Mammal Feature Representation Index	0.34	0.47	0.98	0.96	0.96	1.17
Multi-Purpose Feature Representation Index	1.16	1.65	0.91	1.18	0.95	1.04
All special feature Representation Index	1.01	1.00	1.06	0.98	0.95	1.03

These results are suggestive. At first glance, it seems that protected areas (i.e. locked scenarios) provide better representation across the board for special features. For example, for tier 1, caribou features have greater representation in locked solution areas than in open scenarios (14.64% vs. 12.13%, see highlighted numbers). However, we must consider the fact that locked scenarios require more area to meet the same goals. We hypothesize that open scenarios – if our

assumptions about human impacts are correct – should represent biodiversity more efficiently. To examine this, we corrected for solution area and calculate a representation index for each category of biodiversity features. For Tier 1, the index suggests that open scenario areas are more efficiently capturing caribou features (1.01 vs. 0.70 i.e. more habitat for the same amount of area) – which provides some independent validation for our hypothesis.

However, note that especially for tiers 2 and 3, protected area locked scenarios capture special feature data more efficiently. It is possible that this is a result of the biased distribution of many of the special feature datasets – which may have been sampled in higher density in existing protected areas and NWT-PAS proposals. Although not definitive, this analysis provides some additional guidance for evaluating data sets and results.

7 CONSERVATION PRIORITY

Site selection algorithms alone should not be depended on to generate a conservation 'solution' for the NWT-PAS. Rather these are effective tools for exploring the spatial implications of decisions made about targets, goals, costs, and the efficient placement of areas. In fact, the outputs of these MARXAN experiments form just one part of our results, and are improved upon by an analysis of conservation priorities.

We approached conservation priority setting as an exercise in comparing conservation values for an area with the potential for economic development and activity. The NWT-PAS will likely want to focus its energy on proposals where areas have known high ecological value, but greater or lesser priority may be placed on areas depending on the degree to which they might conflict with existing or proposed human uses.

7.1 Conservation Value

7.1.1 Frequency of Selection by Representation Analysis

For comparative purposes, we described conservation value using two separate measures. The first measure of conservation value is drawn from the MARXAN representation analysis itself. For each of the options and scenarios mentioned above, MARXAN explored over 100 different possibilities of where areas might most efficiently meet representation goals for Landscape Units. From this range of 100 possibilities, we mapped the frequency with which planning units were identified for meeting goals, using the analysis driven by the baseline goals for the Open scenario. Those planning units that were selected most often were ranked as having a higher conservation value than those less often selected (Maps 8a,b, 9a,b).

7.1.2 Special Elements Index

As a second measure of conservation value we used the Special Elements Index (SEI) described in Section 5.5 (Map [10]). This measured the relative abundance for each planning unit, of each special element we had available for the study.

7.1.3 Combined Conservation Value Score

Finally, both the conservation value score from representation analysis and Special Elements Index were summarized to create a third, combined measure of conservation value (Map 10a).

7.2 Prioritization

Using the conservation value scores from the MARXAN representation experiments (Maps 8a,b,9a,b) we mapped the high value areas relative to the development interest score as shown in Map 7. The combination of these scores describes a range of priorities from high value/ high development interest to high value/low development interest. In maps 11a, b, 12a, b, we illustrate these prioritization results for each option and scenario.

We repeated the prioritization exercise using the Special Elements Index or 'hotspot' analysis. As above, the median the hotspots were contrasted to development interest, and again the combination of scores describes a range of priorities from high value/ high development interest to high value/low development interest. These results are presented in Map 13.

Finally, the combined conservation value scores were mapped in relation to development interests (Map 14). The resulting map displays the overlap of combined conservation value scores as described in Map 10a, with development interests (Map 7d).

8 RECOMMENDATIONS and CONCLUSIONS

8.1 Appropriate uses and limitations of this analysis

Throughout this report we have emphasized the preliminary and experimental nature of this study and its results. In our conclusions we will continue this trend since it is critically important to recognize the limitations of the work done to date. In this first phase of analysis, we have created a framework for the selection of representative core areas in order to help guide Goal 2 of the NWT-PAS. The data available for testing this framework is, to date, extremely limited, consisting of an abiotic coarse filter, or landscape units, and an assortment of information on special elements and human use for the Study Area. Unfortunately, the extent and consistency of information makes incorporation into site selection highly problematic. However, with more time more data can be attained and responsible approaches for incorporating this information can be designed.

These results should not be viewed as definitive for specific recommendations about the placement of protected areas. To begin with, decisions around protected areas demand the integration of many more values than those explored in this report, not the least of which are cultural or traditional values. Secondly, an understanding of the ecological value of the areas identified as being of high value and priority is based on a very limited set of data, and very little input from regional experts. Clearly, substantially more information on conservation elements and the regional landscape is required before our confidence can increase regarding using these results to draw definitive lines on a map.

Despite these limitations, we believe that the methods, tools and results discussed in this study provide an important starting point from which further investments in research and analysis can be built. The results themselves should allow for exploring assumptions about current protected areas, alternative goal settings, and the relationship between representation, 'hotspots', impacts, and third party interests. We hope these results stimulate dialogue and further analysis around the importance of protected area proposals for meeting representation goals, and for taking a closer look at areas within the Territory that may have high potential for meeting representation goals, but which may have been overlooked to date. The results should also lead to an ongoing evaluation of the spatial implications of representation goals. The NWT-PAS has not set specific goals around total land area to be protected, and nor does this study approach this question directly. However, we note that when this study's precautionary goals are used for the coarse filter, and when existing and proposed conservation areas are locked into the solution, that roughly half of the study area is required to meet representation goals. This is coincidental with the stated 50%total area goal for protection being advanced by the Canadian Boreal Initiative in the Boreal and Taiga regions of northern Canada.

8.2 A Second Phase of Analysis

While this Phase 1 study has helped to provide an important framework for the NWT-PAS, there is a common understanding among managers and planning partners that substantially more analytical work will be required in the coming 12 to 24 months in order to better fill that framework. For this reason, we were explicitly asked to begin drafting a workplan for a second phase of analytical work, aimed at satisfying the objectives of Goal 2. This workplan outlines a number of important priorities for ongoing work including recommendations for improving the underlying data and analytical components used for core representative area selection. Of

particular importance is the need to incorporate information on vegetation or land cover. These data are critical to the development of an ecologically defined landscape unit model, as well as for the development of focal species models—both of which are critical to improving the robustness of any study designed to inform the placement of representative core areas. The Phase 2 workplan also makes recommendations on alternative models for site selection and the incorporation of an 'ecological management' approach for NWT-PAS decision-making. There is also direction on the importance of initiating a pilot study on a sub-section of the study area in order to take advantage of areas where data already exists. Finally, one of the most important considerations for the second phase of work will be the incorporation of more thorough expert input and review.

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LIST OF MAPS - Volume II

Map1. Study Area, Existing Protected Areas, and NWT-PAS Initiatives

Map 2. Priority Ecoregions of the Mackenzie Valley 5-Year Action Plan

Map 3. Landscape Units Within the Study Area

Map 4a. Special Features and Elements: Northern Land Use Information Series, Critical Habitats

Map 4b. Special Features and Elements: Areas of Ecological Interest

Map 4c. Special Features and Elements: Raptor Nest, Rae Plant Locations and Important Bird Areas

Map 4d. Special Features and Elements: High Value Caribou Habitat

Map 4e. All Special Features and Elements

Map 5. Human Uses Data:

Map 6. Human Use Footprint

Map 7a. Mining Interest

Map 7b. Oil and Gas Interest

Map 7c. Road Length by Analysis Unit

Map 7d. Development Interest

Map 8a. Relative Conservation Value: Baseline Goals, Open Scenario

Map 8b. Relative Conservation Value: Precautionary Goals, Open Scenario

Map 9a. Relative Conservation Value: Baseline Goals, Closed Scenario

Map 9a. Relative Conservation Value: Precautionary Goals, Closed Scenario

Map 10. Special Elements Index

Map 10a. Combined Conservation Value Score

Map 11a. Relative Conservation Priorities: Baseline Goals, Open Scenario

Map 11b. Relative Conservation Priority: Precautionary Goals, Open Scenario

Map 12a. Relative Conservation Priority: Baseline Goals, Closed Scenario

Map 12b. Relative Conservation Priority: Precautionary Goals, Closed Scenario

Map 13. Relative Conservation Priority: Special Elements Index and Development Interest

Map 14. Relative Conservation Priority: Combined Conservation Value Scores and Development Interest

PRELIMINARY ANALYSIS OF REPRESENTATIVE CORE AREAS

for the

NORTHWEST TERRITORIES PROTECTED AREAS STRATEGY

Volume II

MAPS

May 1, 2005

Rick Tingey, Round River Conservation Studies
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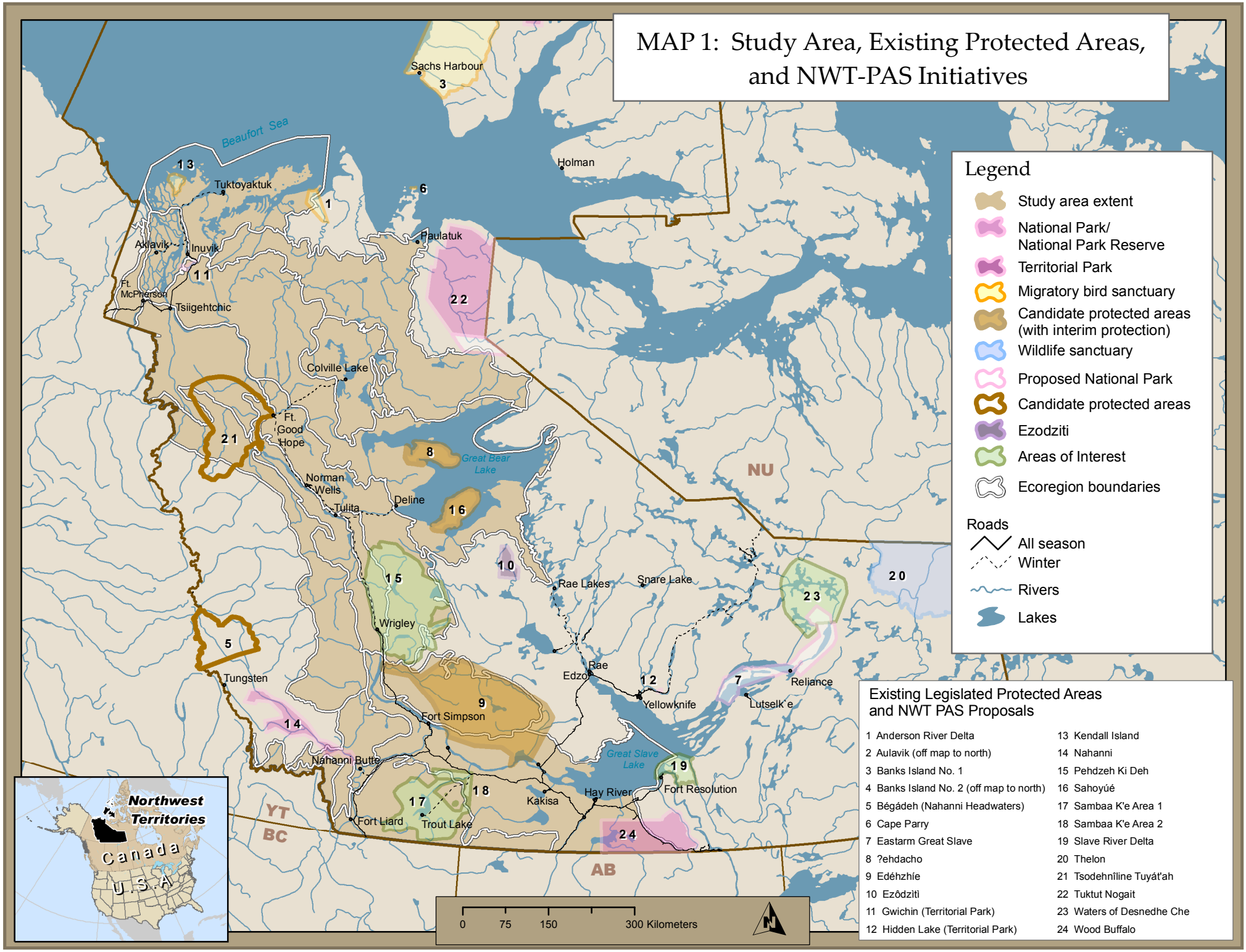
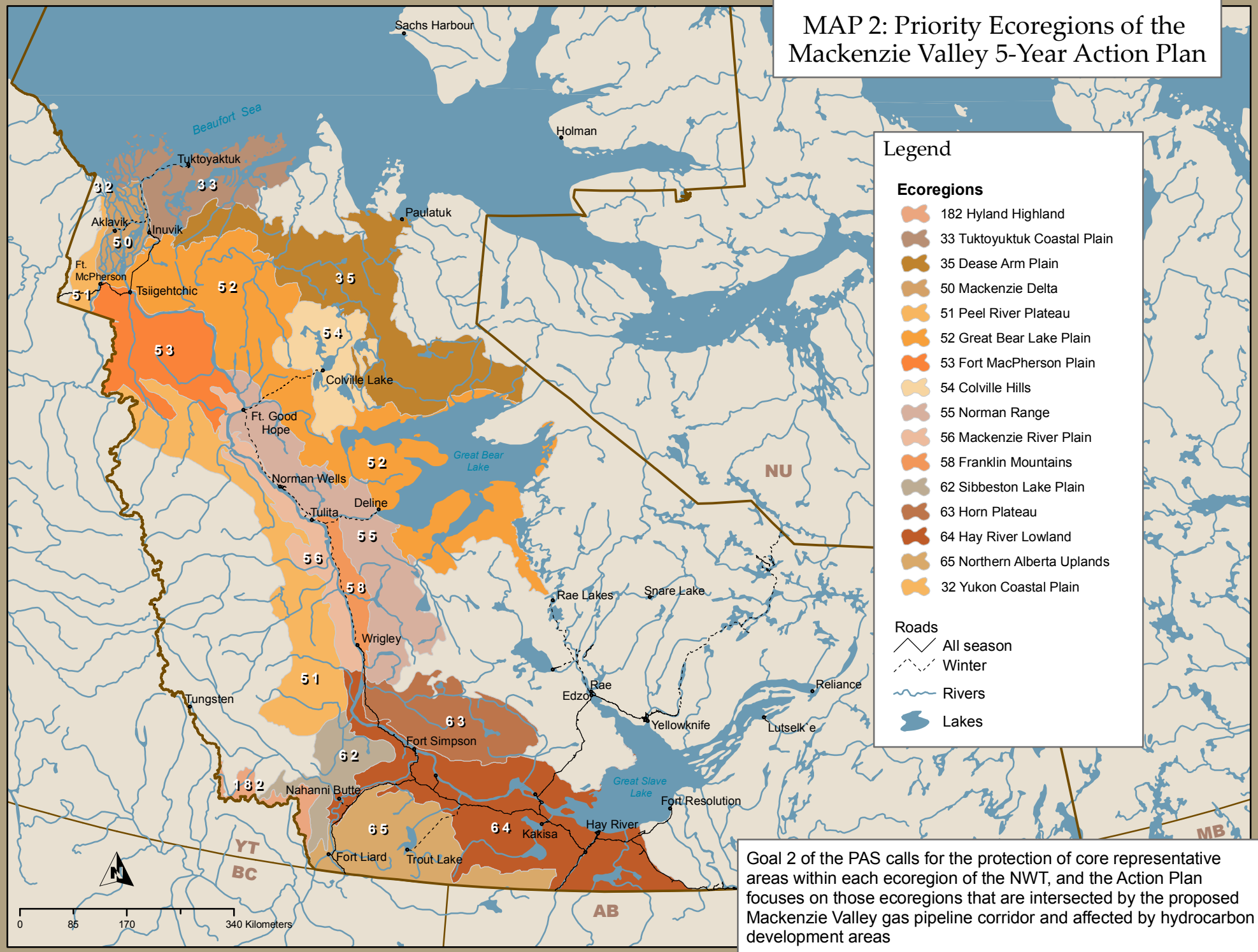

MAP 1: Study Area, Existing Protected Areas, and NWT-PAS Initiatives
Legend
Study area extent
National Park/ National Park Reserve
Territorial Park
Migratory bird sanctuary
Candidate protected areas (with interim protection)
Wildlife sanctuary
Proposed National Park
Candidate protected areas
Ezodziti
Areas of Interest
Ecoregion boundaries
Roads
All season
Winter
Rivers
Lakes
Existing Legislated Protected Areas and NWT PAS Proposals
1 Anderson River Delta
2 Aulavik (off map to north)
3 Banks Island No. 1
4 Banks Island No. 2 (off map to north)
5 Bégádeh (Nahanni Headwaters)
6 Cape Parry
7 Eastarm Great Slave
8 ?ehdacho
9 Edéhzhíe
10 Ezôdzìtì
11 Gwichin (Territorial Park)
12 Hidden Lake (Territorial Park)
13 Kendall Island
14 Nahanni
15 Pehdzeh Ki Deh
16 Sahoyúé
17 Sambaa K'e Area 1
18 Sambaa K'e Area 2
19 Slave River Delta
20 Thelon
21 Tsodehnîline Tuyát'ah
22 Tuktut Nogait
23 Waters of Desnedhe Che
24 Wood Buffalo
Sachs Harbour
Holman
Paulatuk
Tuktoyaktuk
Aklavik
Inuvik
Ft. McPherson
Tsiigehtchic
Colville Lake
Ft. Good Hope
Norman Wells
Tulita
Deline
Great Bear Lake
Wrigley
Tungsten
Nahanni Butte
Fort Simpson
Fort Liard
Trout Lake
Kakisa
Hay River
Fort Resolution
Great Slave Lake
Rae Lakes
Snare Lake
Edzo
Rae
Yellowknife
Lutselk'e
Reliance
Beaufort Sea
NU
YT
BC
AB
Northwest Territories
Canada
U.S.A.
0 75 150 300 Kilometers
N

MAP 2: Priority Ecoregions of the Mackenzie Valley 5-Year Action Plan



Legend

Ecoregions

- 182 Hyland Highland
- 33 Tuktoyuktuk Coastal Plain
- 35 Dease Arm Plain
- 50 Mackenzie Delta
- 51 Peel River Plateau
- 52 Great Bear Lake Plain
- 53 Fort MacPherson Plain
- 54 Colville Hills
- 55 Norman Range
- 56 Mackenzie River Plain
- 58 Franklin Mountains
- 62 Sibbeston Lake Plain
- 63 Horn Plateau
- 64 Hay River Lowland
- 65 Northern Alberta Uplands
- 32 Yukon Coastal Plain

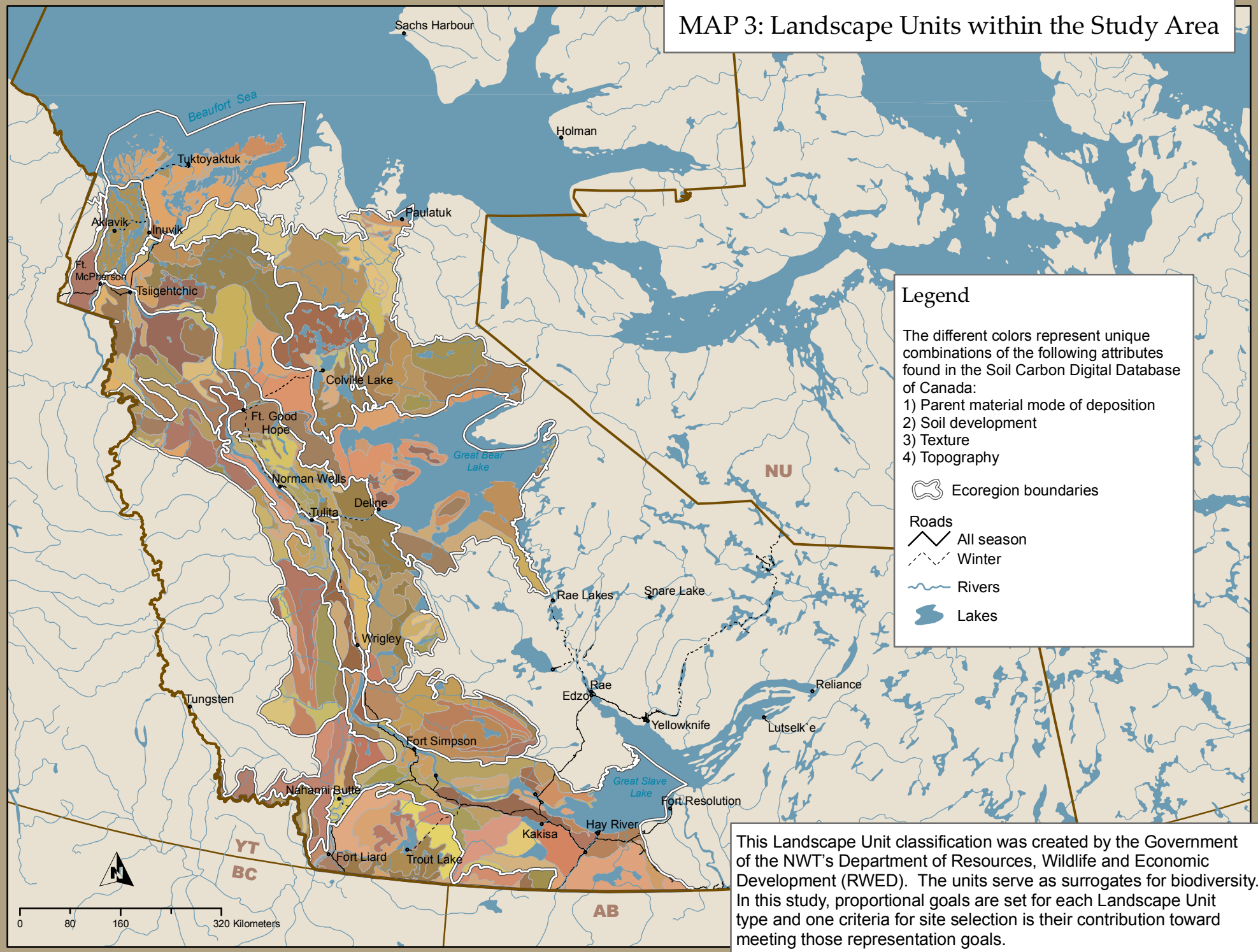
Roads
- All season
- Winter

Rivers

Lakes

Goal 2 of the PAS calls for the protection of core representative areas within each ecoregion of the NWT, and the Action Plan focuses on those ecoregions that are intersected by the proposed Mackenzie Valley gas pipeline corridor and affected by hydrocarbon development areas

MAP 3: Landscape Units within the Study Area



Legend

The different colors represent unique combinations of the following attributes found in the Soil Carbon Digital Database of Canada:

1) Parent material mode of deposition
2) Soil development
3) Texture
4) Topography

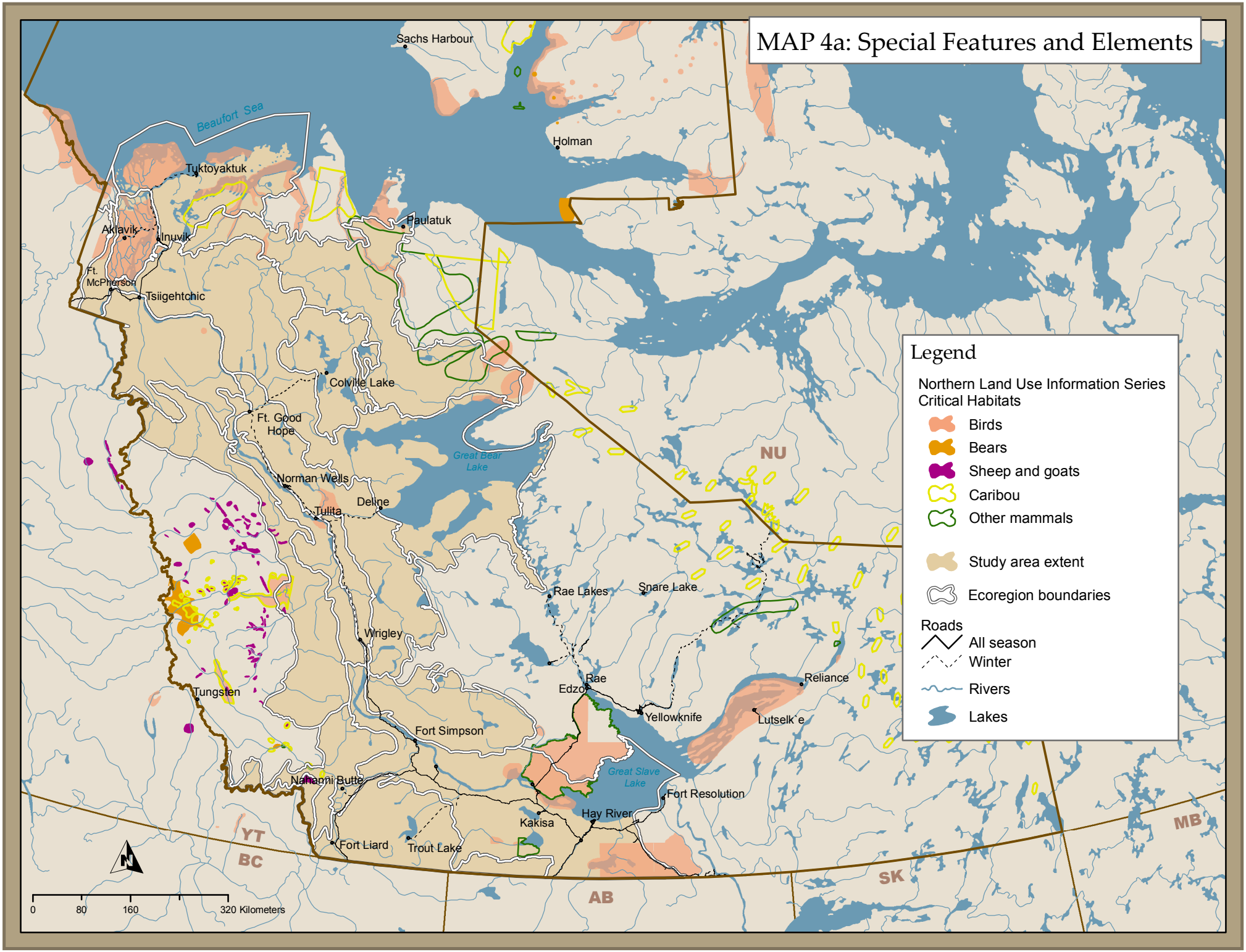
Ecoregion boundaries

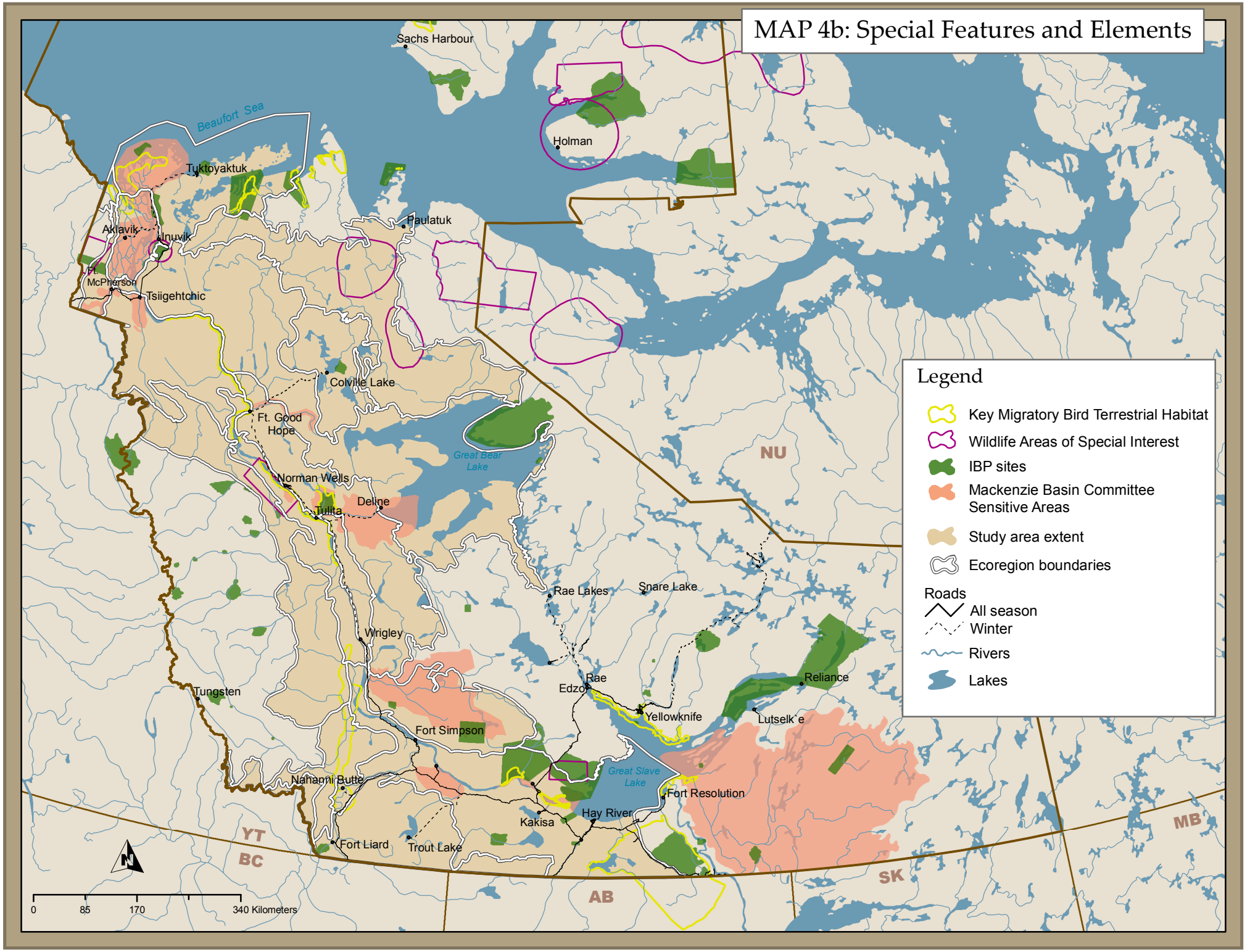
Roads
- All season
- Winter

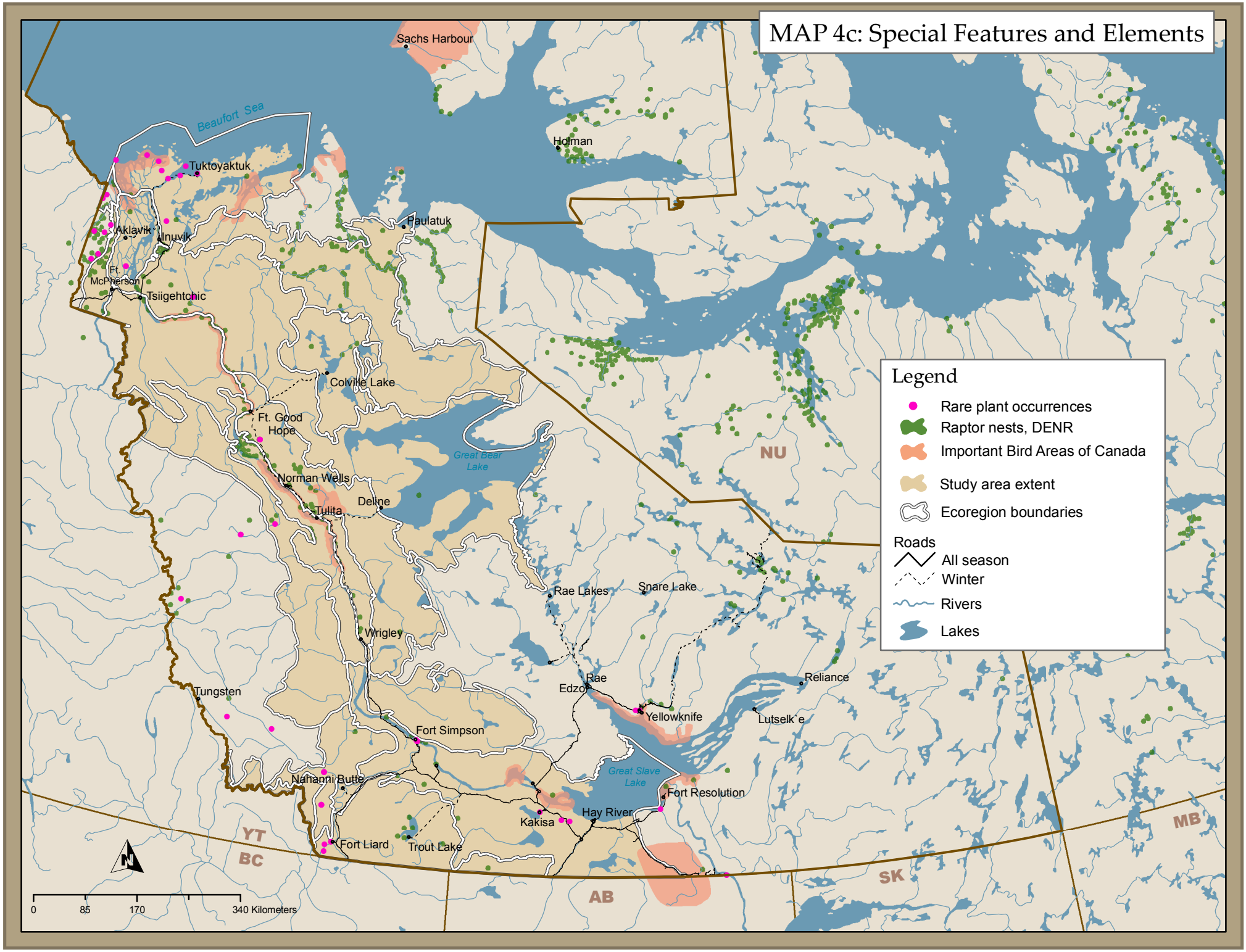
Rivers

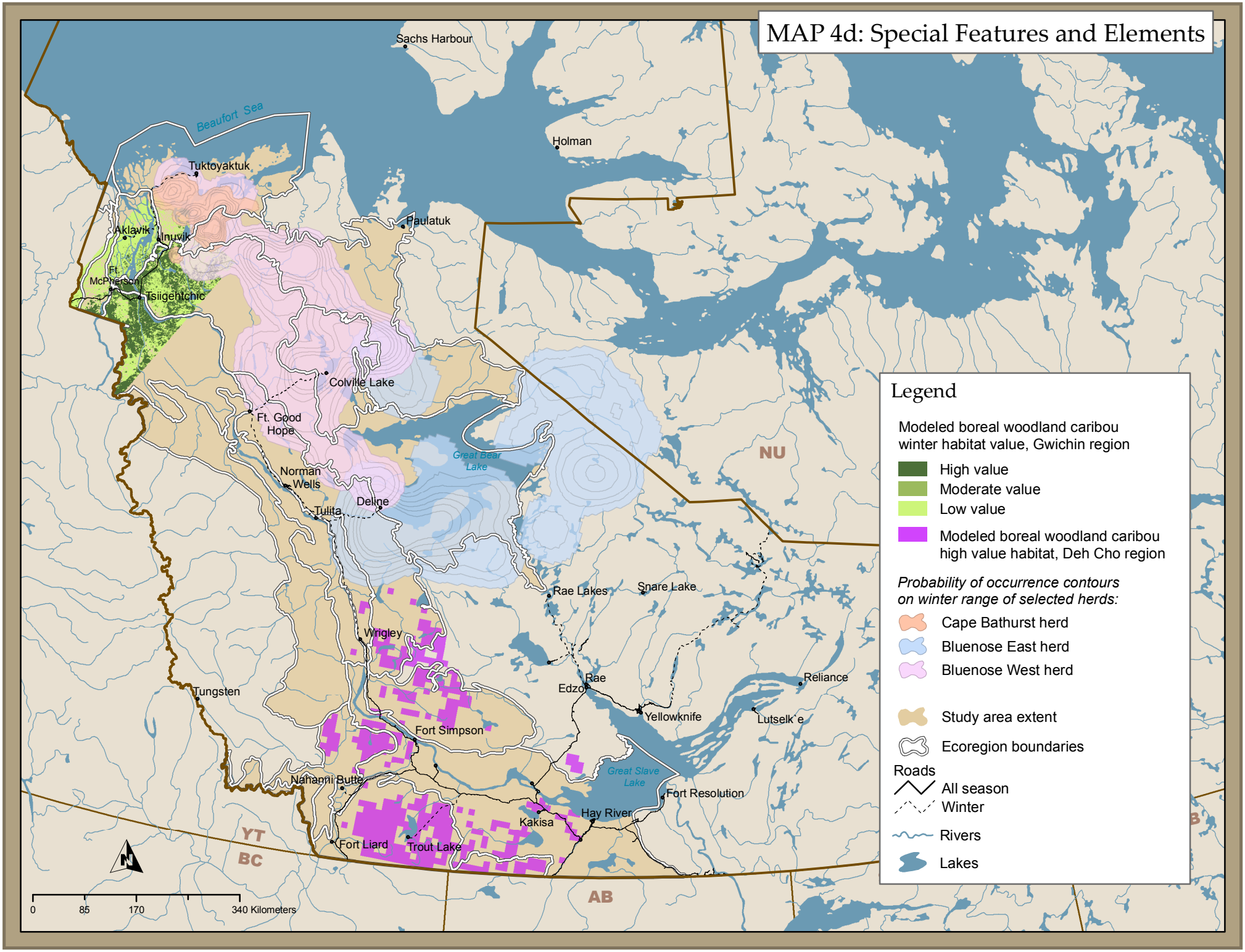
Lakes

This Landscape Unit classification was created by the Government of the NWT's Department of Resources, Wildlife and Economic Development (RWED). The units serve as surrogates for biodiversity. In this study, proportional goals are set for each Landscape Unit type and one criteria for site selection is their contribution toward meeting those representation goals.

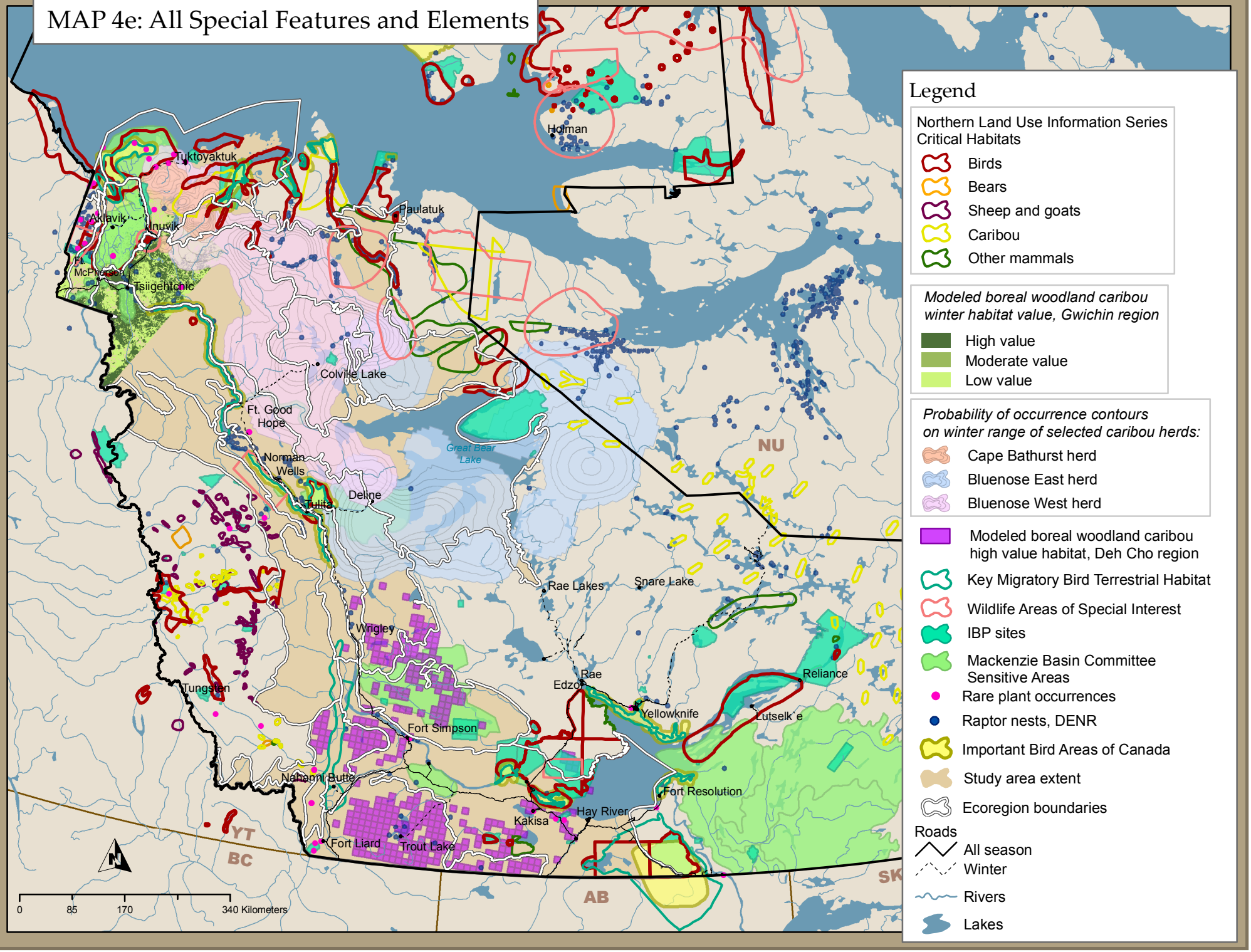

MAP 4a: Special Features and Elements
Sachs Harbour
Beaufort Sea
Holman
Tuktoyaktuk
Paulatuk
Aklavik
Inuvik
Ft. McPherson
Tsiigehtchic
Colville Lake
Ft. Good Hope
Great Bear Lake
NU
Norman Wells
Deline
Tulita
Rae Lakes
Snare Lake
Wrigley
Rae
Edzo
Reliance
Tungsten
Yellowknife
Lutselk`e
Fort Simpson
Great Slave Lake
Nahanni Butte
Fort Resolution
Hay River
Kakisa
Fort Liard
Trout Lake
YT
BC
AB
SK
MB
N
0 80 160 320 Kilometers
Legend
Northern Land Use Information Series Critical Habitats
Birds
Bears
Sheep and goats
Caribou
Other mammals
Study area extent
Ecoregion boundaries
Roads
All season
Winter
Rivers
Lakes


MAP 4b: Special Features and Elements
Sachs Harbour
Beaufort Sea
Holman
Tuktoyaktuk
Paulatuk
Aklavik
Inuvik
Ft. McPherson
Tsiigehtchic
Colville Lake
Ft. Good Hope
Great Bear Lake
NU
Norman Wells
Deline
Tulita
Rae Lakes
Snare Lake
Wrigley
Tungsten
Rae
Edzo
Reliance
Yellowknife
Lutselk`e
Fort Simpson
Great Slave Lake
Nahanni Butte
Fort Resolution
Hay River
Kakisa
Fort Liard
Trout Lake
YT
BC
AB
SK
MB
N
0
85
170
340 Kilometers
Legend
Key Migratory Bird Terrestrial Habitat
Wildlife Areas of Special Interest
IBP sites
Mackenzie Basin Committee Sensitive Areas
Study area extent
Ecoregion boundaries
Roads
All season
Winter
Rivers
Lakes


MAP 4c: Special Features and Elements
Sachs Harbour
Beaufort Sea
Holman
Tuktoyaktuk
Paulatuk
Aklavik
Inuvik
Ft. McPherson
Tsiigehtchic
Colville Lake
Ft. Good Hope
Great Bear Lake
NU
Norman Wells
Deline
Tulita
Rae Lakes
Snare Lake
Wrigley
Rae
Edzo
Reliance
Yellowknife
Lutselk`e
Tungsten
Fort Simpson
Great Slave Lake
Nahanni Butte
Fort Resolution
Hay River
Kakisa
Fort Liard
Trout Lake
YT
BC
AB
SK
MB
Legend
Rare plant occurrences
Raptor nests, DENR
Important Bird Areas of Canada
Study area extent
Ecoregion boundaries
Roads
All season
Winter
Rivers
Lakes
N
0
85
170
340 Kilometers


MAP 4d: Special Features and Elements
Sachs Harbour
Beaufort Sea
Holman
Tuktoyaktuk
Paulatuk
Aklavik
Inuvik
Ft. McPherson
Tsiigehtchic
Colville Lake
Ft. Good Hope
Great Bear Lake
NU
Norman Wells
Tulita
Deline
Rae Lakes
Snare Lake
Wrigley
Tungsten
Rae
Edzo
Reliance
Yellowknife
Lutselk'e
Fort Simpson
Great Slave Lake
Nahanni Butte
Fort Resolution
Hay River
Kakisa
Fort Liard
Trout Lake
YT
BC
AB
0
85
170
340 Kilometers
Legend
Modeled boreal woodland caribou winter habitat value, Gwichin region
High value
Moderate value
Low value
Modeled boreal woodland caribou high value habitat, Deh Cho region
Probability of occurrence contours on winter range of selected herds:
Cape Bathurst herd
Bluenose East herd
Bluenose West herd
Study area extent
Ecoregion boundaries
Roads
All season
Winter
Rivers
Lakes

MAP 4e: All Special Features and Elements



Legend

Northern Land Use Information Series Critical Habitats
- Birds
- Bears
- Sheep and goats
- Caribou
- Other mammals

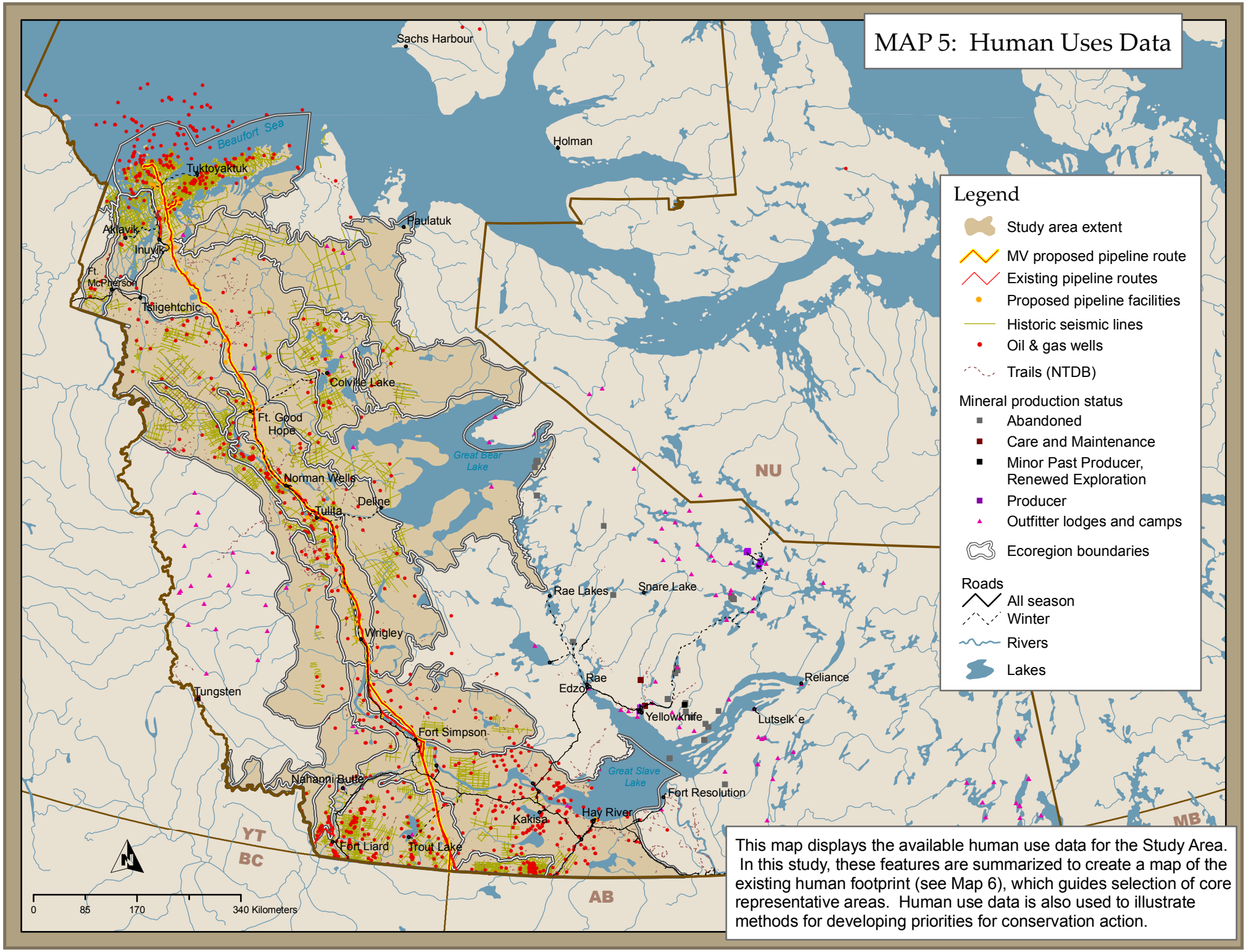
Modeled boreal woodland caribou winter habitat value, Gwichin region
- High value
- Moderate value
- Low value

Probability of occurrence contours on winter range of selected caribou herds:
- Cape Bathurst herd
- Bluenose East herd
- Bluenose West herd

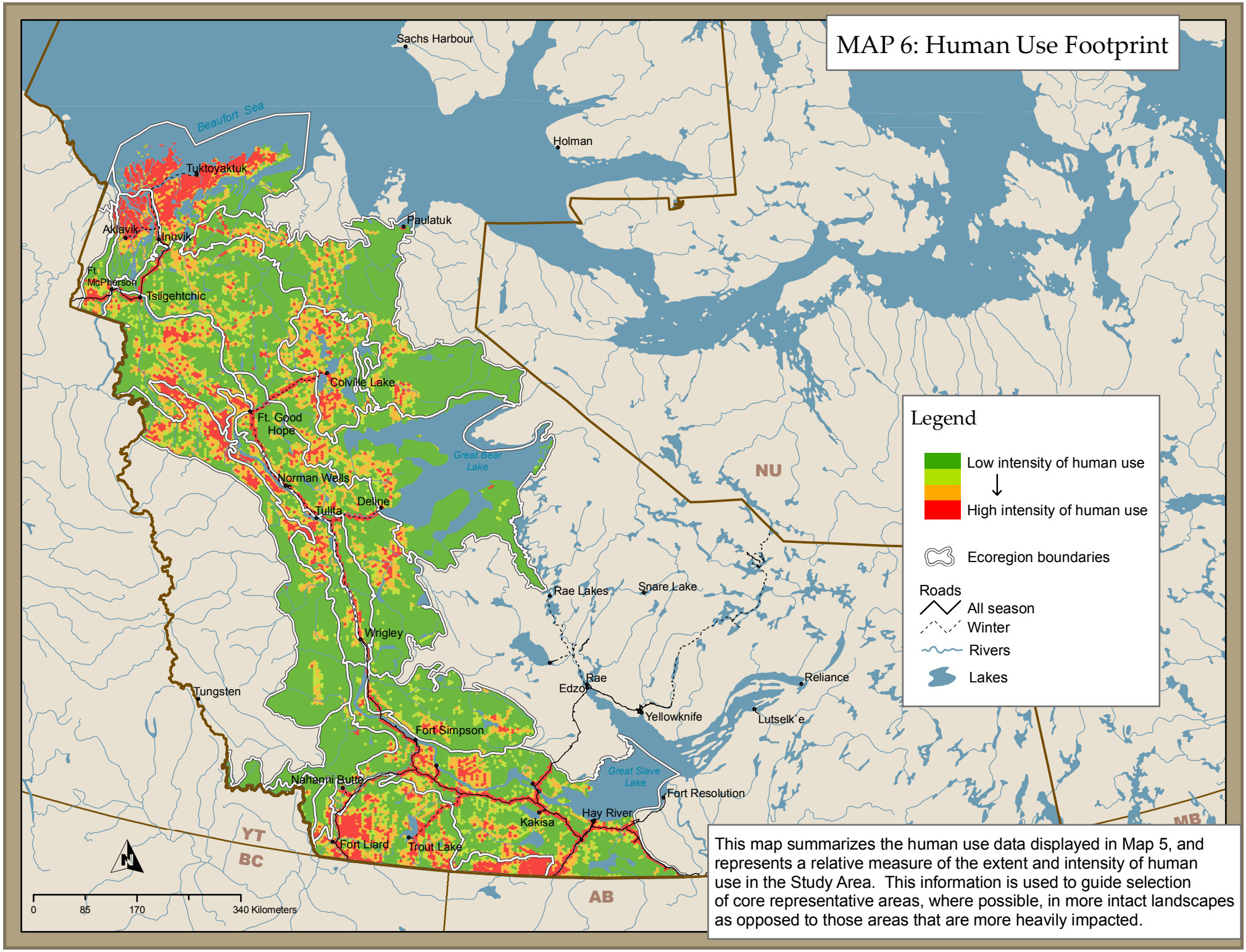
- Modeled boreal woodland caribou high value habitat, Deh Cho region
- Key Migratory Bird Terrestrial Habitat
- Wildlife Areas of Special Interest
- IBP sites
- Mackenzie Basin Committee Sensitive Areas
- Rare plant occurrences
- Raptor nests, DENR
- Important Bird Areas of Canada
- Study area extent
- Ecoregion boundaries

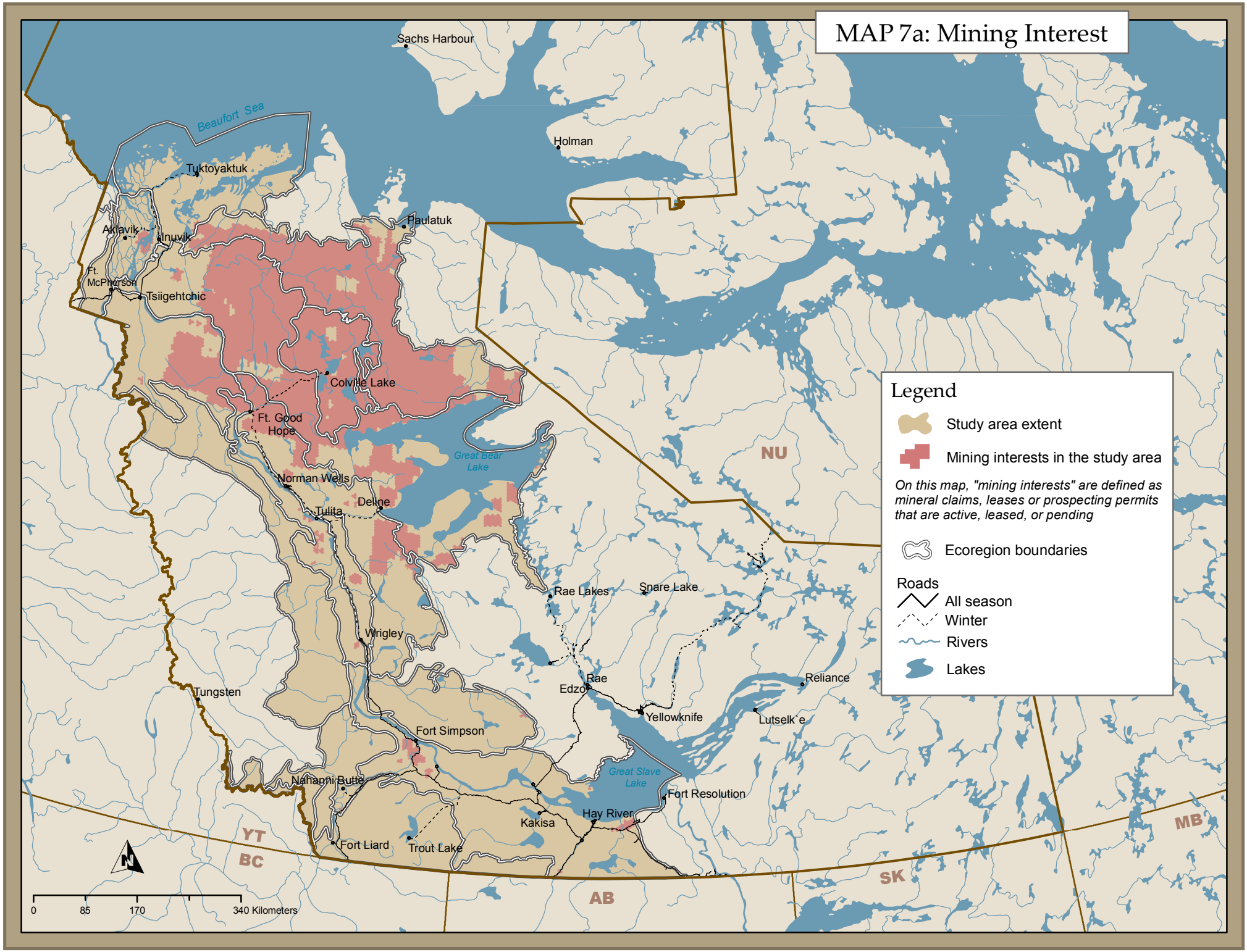
Roads
- All season
- Winter

- Rivers
- Lakes

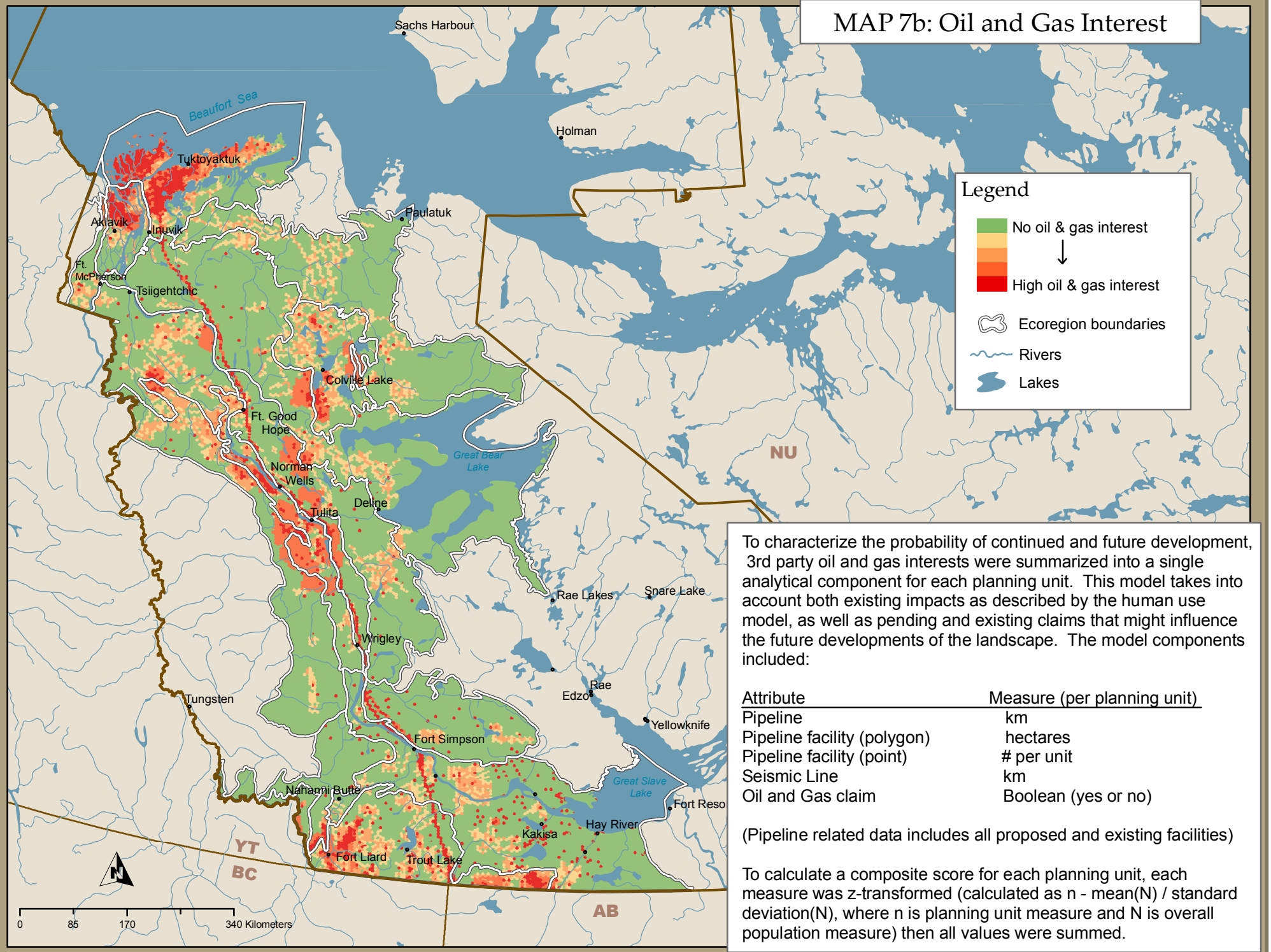


This map displays the available human use data for the Study Area. In this study, these features are summarized to create a map of the existing human footprint (see Map 6), which guides selection of core representative areas. Human use data is also used to illustrate methods for developing priorities for conservation action.


MAP 6: Human Use Footprint
Sachs Harbour
Beaufort Sea
Holman
Tuktoyaktuk
Paulatuk
Aklavik
Inuvik
Ft. McPherson
Tsiigehtchic
Colville Lake
Ft. Good Hope
Great Bear Lake
Norman Wells
Deline
Tulita
NU
Rae Lakes
Snare Lake
Wrigley
Tungsten
Rae
Edzo
Reliance
Yellowknife
Lutselk`e
Fort Simpson
Great Slave Lake
Nahanni Butte
Fort Resolution
Hay River
Kakisa
Fort Liard
Trout Lake
YT
BC
AB
MB
N
0
85
170
340 Kilometers
Legend
Low intensity of human use
High intensity of human use
Ecoregion boundaries
Roads
All season
Winter
Rivers
Lakes
This map summarizes the human use data displayed in Map 5, and represents a relative measure of the extent and intensity of human use in the Study Area. This information is used to guide selection of core representative areas, where possible, in more intact landscapes as opposed to those areas that are more heavily impacted.


MAP 7a: Mining Interest
Sachs Harbour
Beaufort Sea
Holman
Tuktoyaktuk
Aklavik
Inuvik
Paulatuk
Ft. McPherson
Tsiigehtchic
Colville Lake
Ft. Good Hope
Great Bear Lake
NU
Norman Wells
Tulita
Deline
Rae Lakes
Snare Lake
Wrigley
Tungsten
Rae
Edzo
Reliance
Yellowknife
Lutselk`e
Fort Simpson
Great Slave Lake
Nahanni Butte
Fort Resolution
Hay River
Kakisa
Fort Liard
Trout Lake
YT
BC
AB
SK
MB
N
0
85
170
340 Kilometers
Legend
Study area extent
Mining interests in the study area
On this map, "mining interests" are defined as mineral claims, leases or prospecting permits that are active, leased, or pending
Ecoregion boundaries
Roads
All season
Winter
Rivers
Lakes

MAP 7b: Oil and Gas Interest

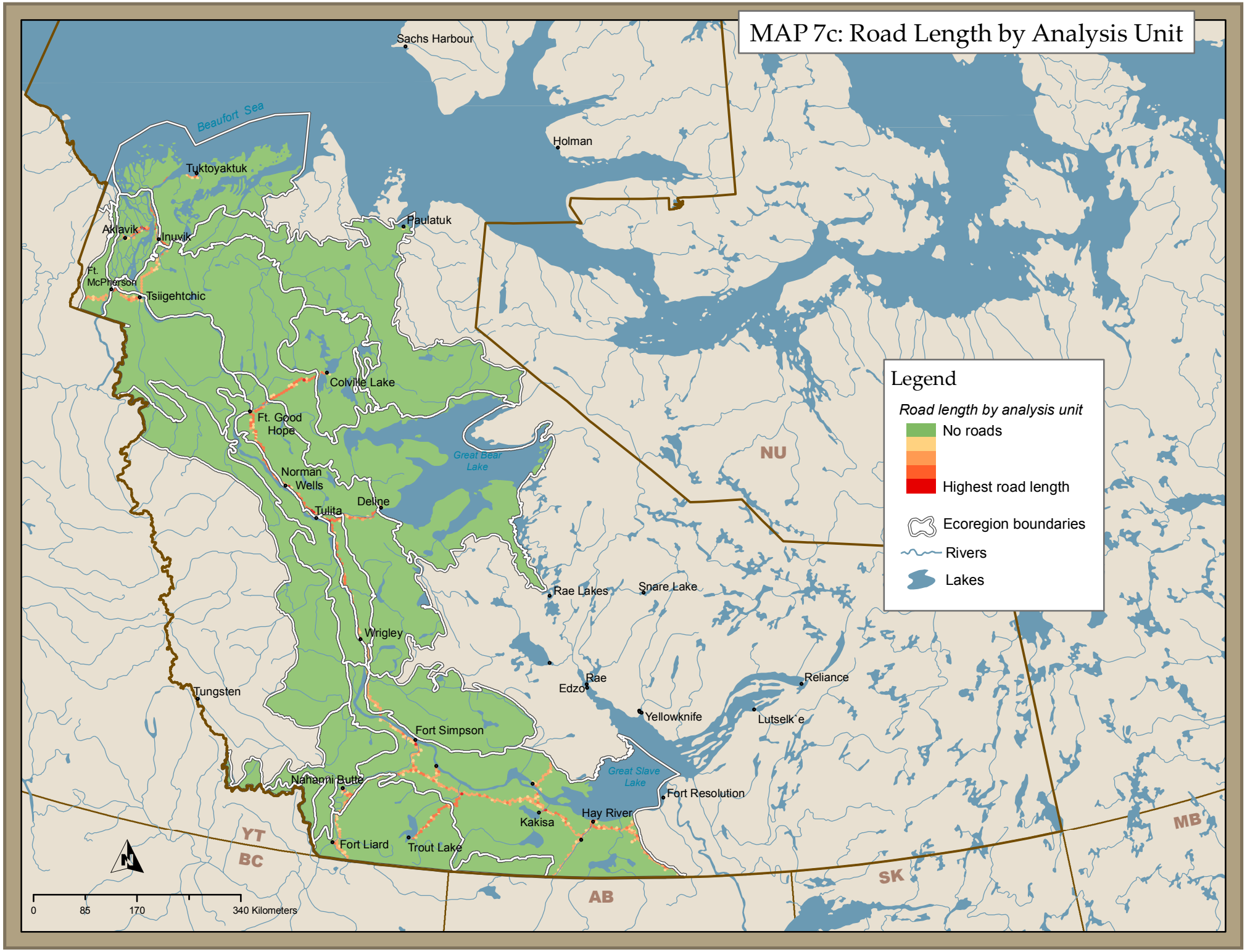


To characterize the probability of continued and future development, 3rd party oil and gas interests were summarized into a single analytical component for each planning unit. This model takes into account both existing impacts as described by the human use model, as well as pending and existing claims that might influence the future developments of the landscape. The model components included:

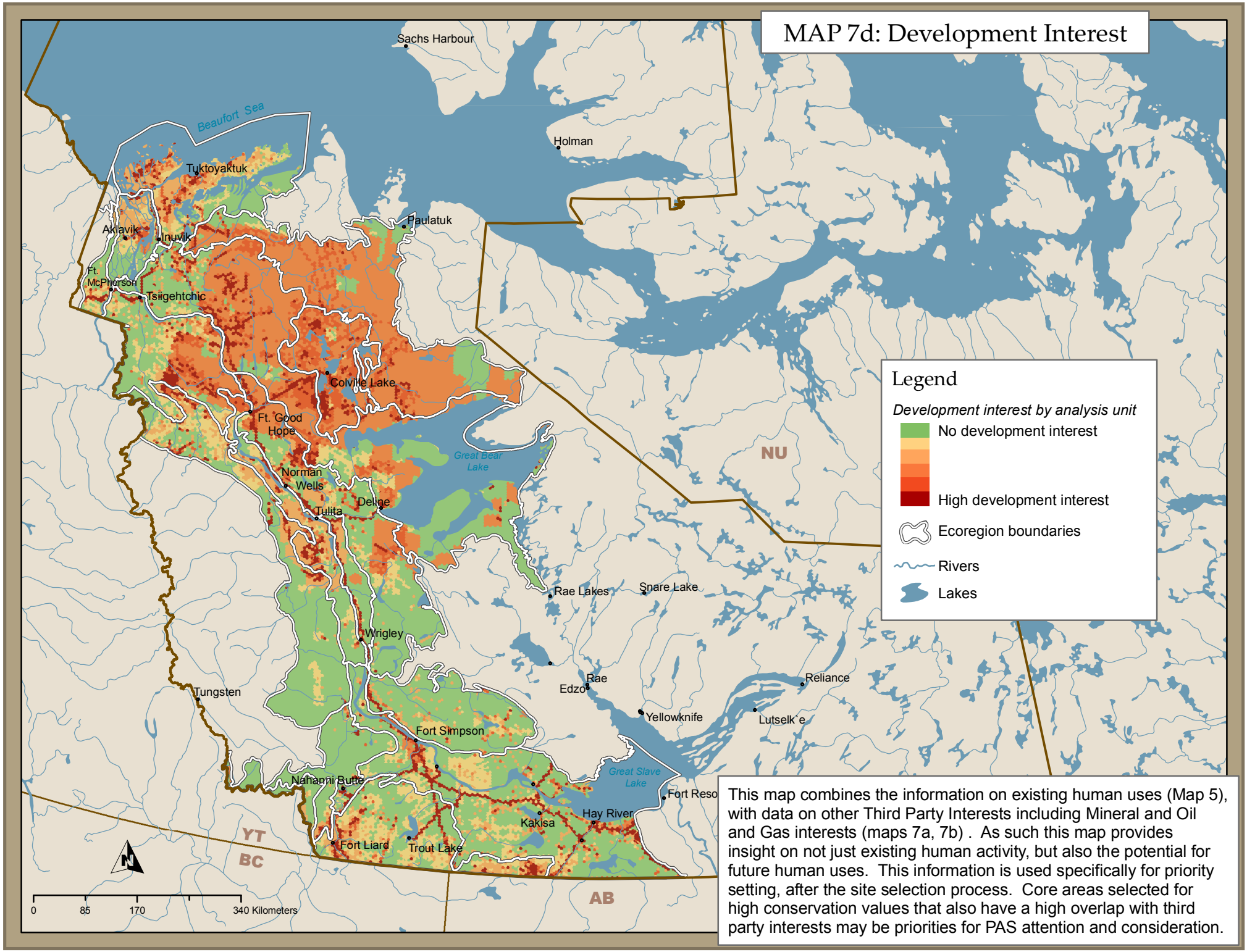
Attribute	Measure (per planning unit)
Pipeline	km
Pipeline facility (polygon)	hectares
Pipeline facility (point)	# per unit
Seismic Line	km
Oil and Gas claim	Boolean (yes or no)

(Pipeline related data includes all proposed and existing facilities)

To calculate a composite score for each planning unit, each measure was z-transformed (calculated as n - mean(N) / standard deviation(N), where n is planning unit measure and N is overall population measure) then all values were summed.

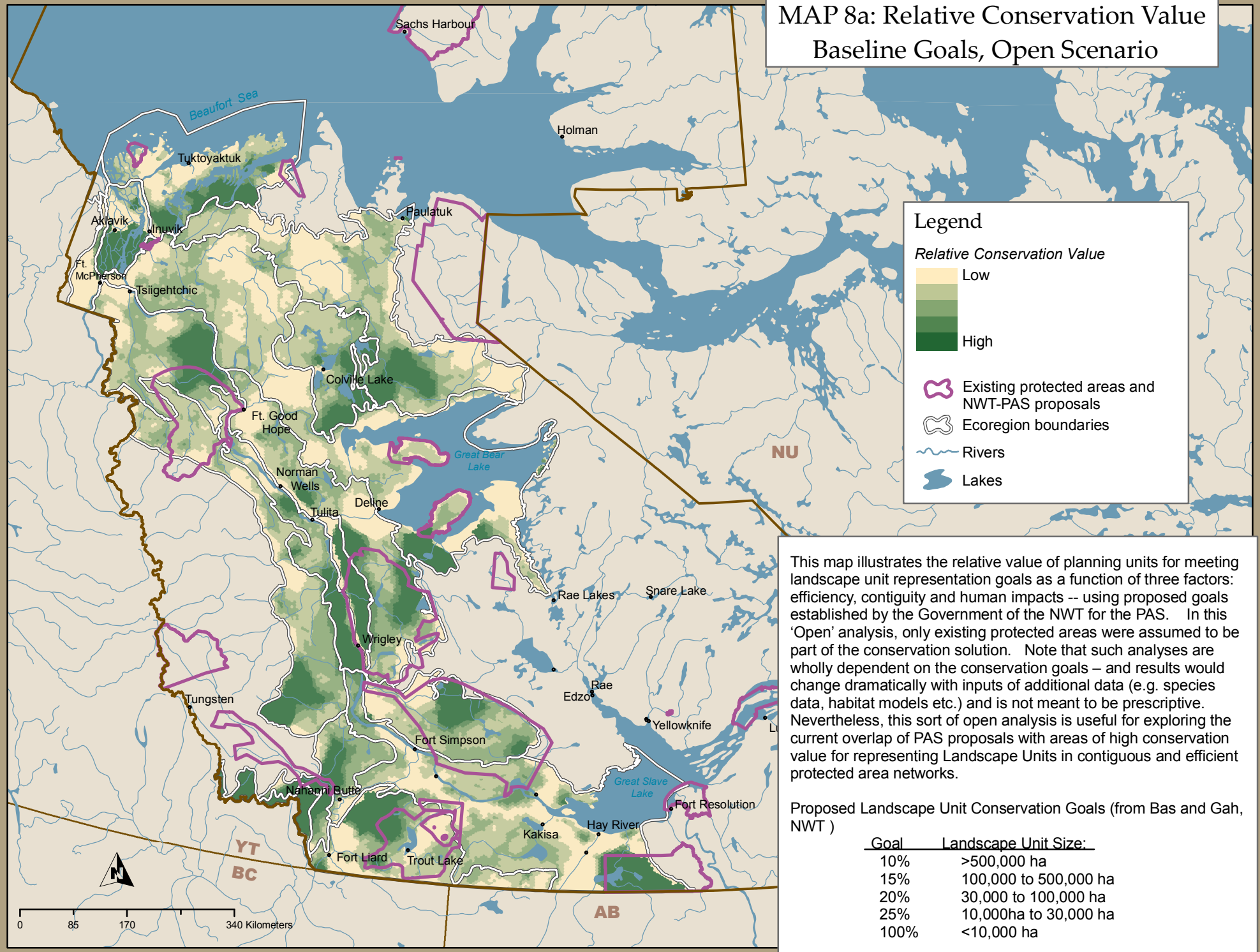

MAP 7c: Road Length by Analysis Unit
Sachs Harbour
Beaufort Sea
Holman
Tuktoyaktuk
Paulatuk
Aklavik
Inuvik
Ft. McPherson
Tsiigehtchic
Colville Lake
Ft. Good Hope
Great Bear Lake
Norman Wells
Tulita
Deline
NU
Rae Lakes
Snare Lake
Wrigley
Tungsten
Edzo
Rae
Reliance
Yellowknife
Lutselk`e
Fort Simpson
Great Slave Lake
Nahanni Butte
Fort Resolution
Hay River
Kakisa
Fort Liard
Trout Lake
YT
BC
AB
SK
MB
N
0
85
170
340 Kilometers
Legend
Road length by analysis unit
No roads
Highest road length
Ecoregion boundaries
Rivers
Lakes

MAP 7d: Development Interest



This map combines the information on existing human uses (Map 5), with data on other Third Party Interests including Mineral and Oil and Gas interests (maps 7a, 7b) . As such this map provides insight on not just existing human activity, but also the potential for future human uses. This information is used specifically for priority setting, after the site selection process. Core areas selected for high conservation values that also have a high overlap with third party interests may be priorities for PAS attention and consideration.

MAP 8a: Relative Conservation Value Baseline Goals, Open Scenario



Legend

Relative Conservation Value

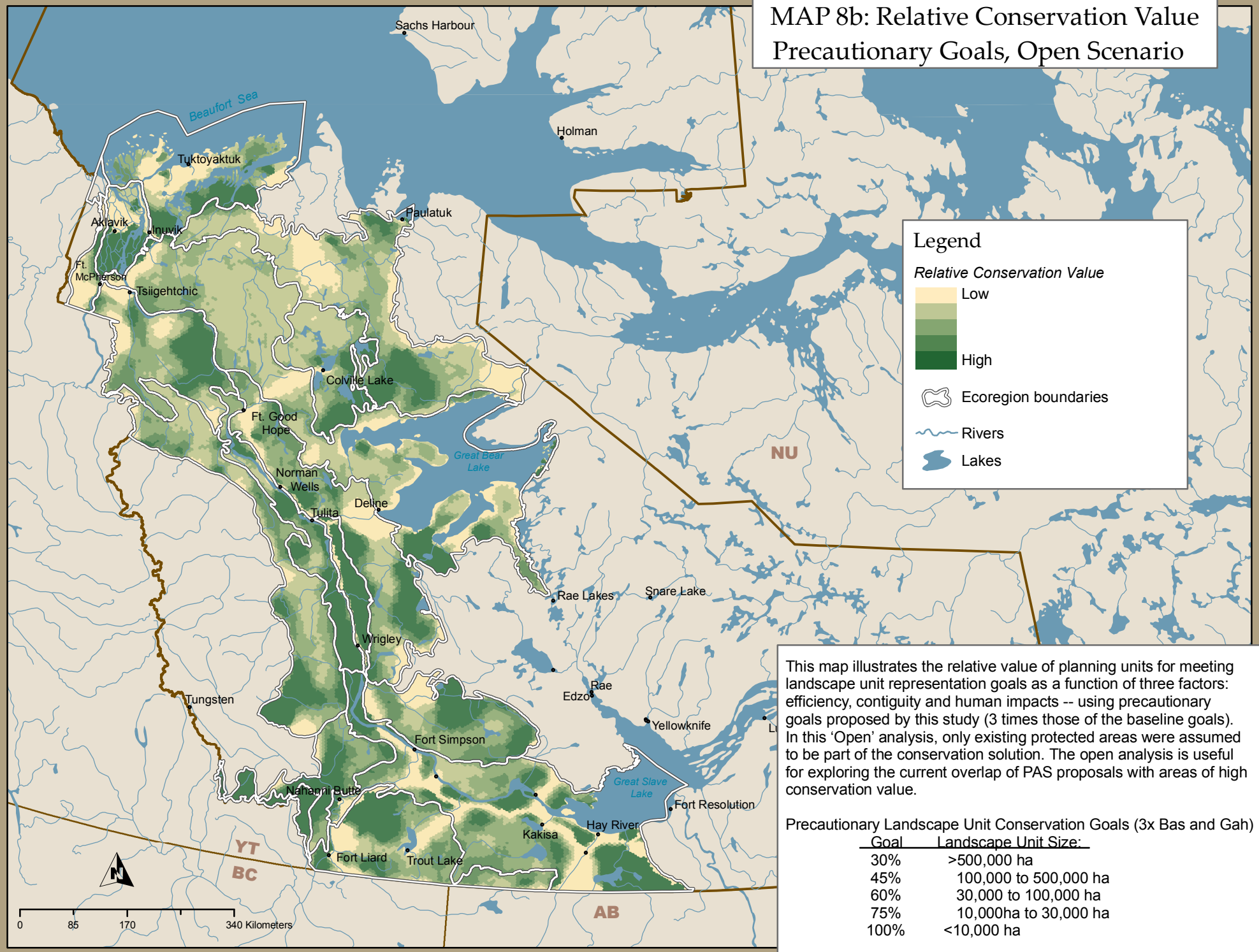
- Low
- High
- Existing protected areas and NWT-PAS proposals
- Ecoregion boundaries
- Rivers
- Lakes

This map illustrates the relative value of planning units for meeting landscape unit representation goals as a function of three factors: efficiency, contiguity and human impacts -- using proposed goals established by the Government of the NWT for the PAS. In this 'Open' analysis, only existing protected areas were assumed to be part of the conservation solution. Note that such analyses are wholly dependent on the conservation goals – and results would change dramatically with inputs of additional data (e.g. species data, habitat models etc.) and is not meant to be prescriptive. Nevertheless, this sort of open analysis is useful for exploring the current overlap of PAS proposals with areas of high conservation value for representing Landscape Units in contiguous and efficient protected area networks.

Proposed Landscape Unit Conservation Goals (from Bas and Gah, NWT)

Goal	Landscape Unit Size:
10%	>500,000 ha
15%	100,000 to 500,000 ha
20%	30,000 to 100,000 ha
25%	10,000ha to 30,000 ha
100%	<10,000 ha

MAP 8b: Relative Conservation Value Precautionary Goals, Open Scenario

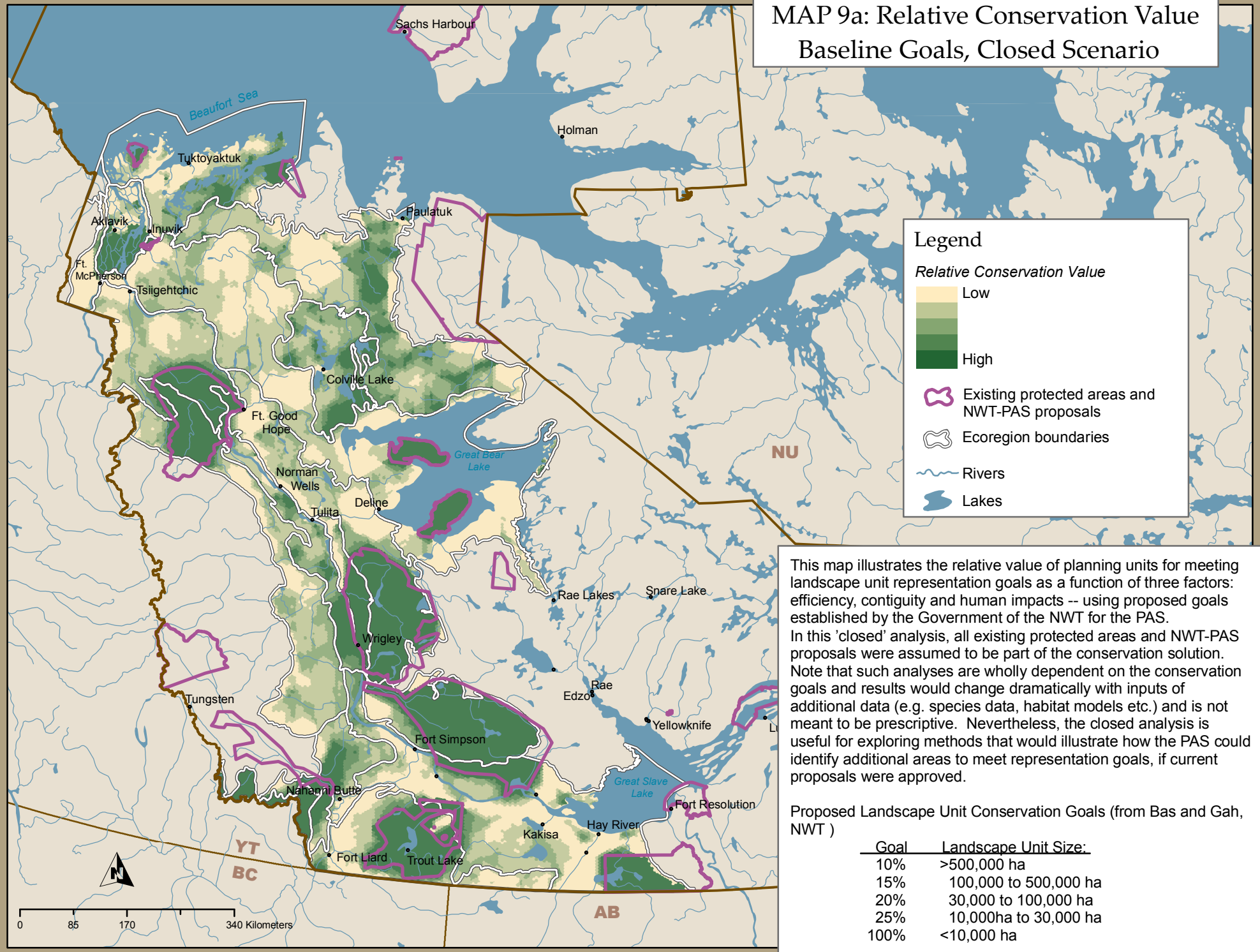


This map illustrates the relative value of planning units for meeting landscape unit representation goals as a function of three factors: efficiency, contiguity and human impacts -- using precautionary goals proposed by this study (3 times those of the baseline goals). In this 'Open' analysis, only existing protected areas were assumed to be part of the conservation solution. The open analysis is useful for exploring the current overlap of PAS proposals with areas of high conservation value.

Precautionary Landscape Unit Conservation Goals (3x Bas and Gah)

Goal	Landscape Unit Size:
30%	>500,000 ha
45%	100,000 to 500,000 ha
60%	30,000 to 100,000 ha
75%	10,000ha to 30,000 ha
100%	<10,000 ha

MAP 9a: Relative Conservation Value
Baseline Goals, Closed Scenario



Legend

Relative Conservation Value

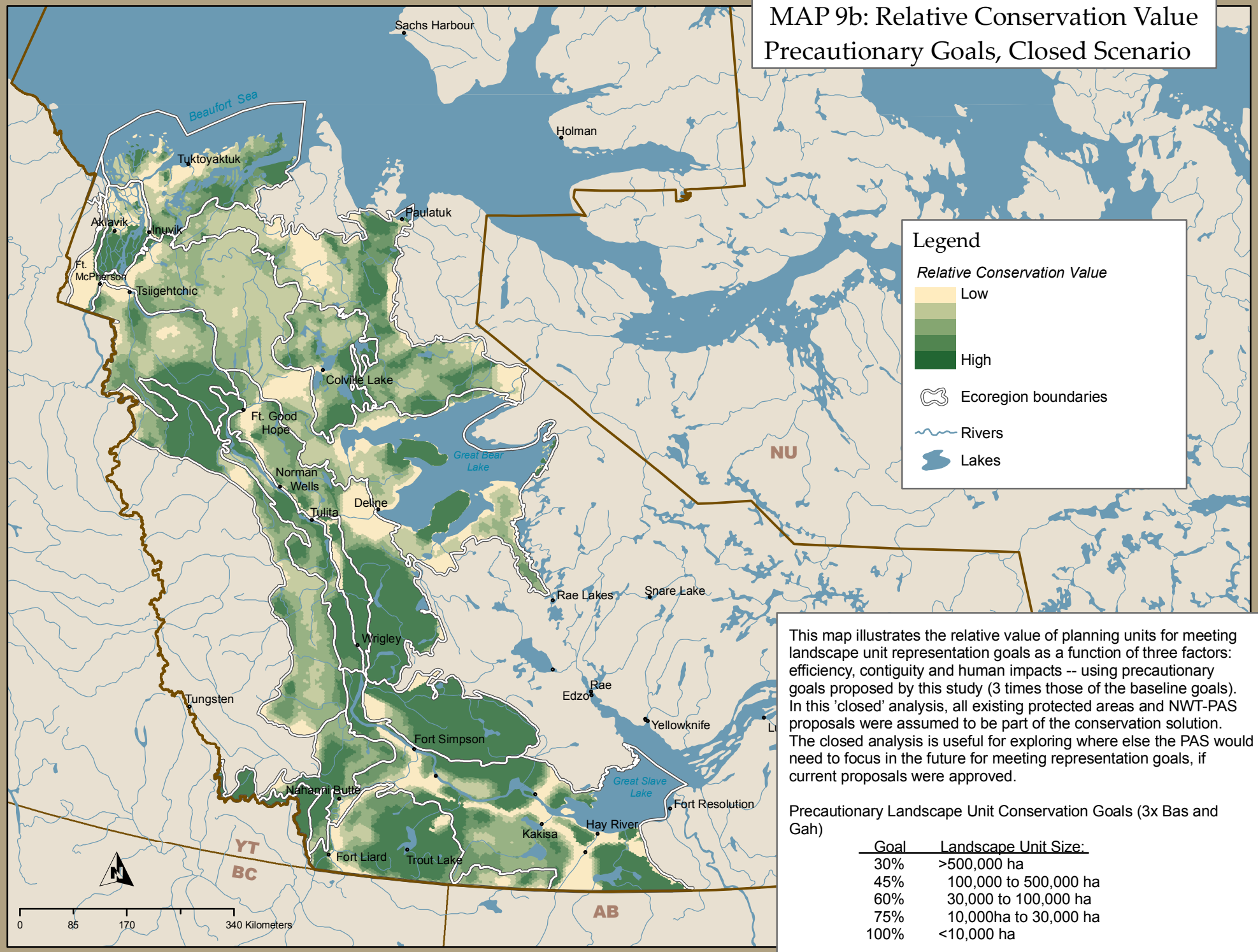
- Low
- High
- Existing protected areas and NWT-PAS proposals
- Ecoregion boundaries
- Rivers
- Lakes

This map illustrates the relative value of planning units for meeting landscape unit representation goals as a function of three factors: efficiency, contiguity and human impacts -- using proposed goals established by the Government of the NWT for the PAS.
In this 'closed' analysis, all existing protected areas and NWT-PAS proposals were assumed to be part of the conservation solution. Note that such analyses are wholly dependent on the conservation goals and results would change dramatically with inputs of additional data (e.g. species data, habitat models etc.) and is not meant to be prescriptive. Nevertheless, the closed analysis is useful for exploring methods that would illustrate how the PAS could identify additional areas to meet representation goals, if current proposals were approved.

Proposed Landscape Unit Conservation Goals (from Bas and Gah, NWT)

Goal	Landscape Unit Size:
10%	>500,000 ha
15%	100,000 to 500,000 ha
20%	30,000 to 100,000 ha
25%	10,000ha to 30,000 ha
100%	<10,000 ha

MAP 9b: Relative Conservation Value Precautionary Goals, Closed Scenario

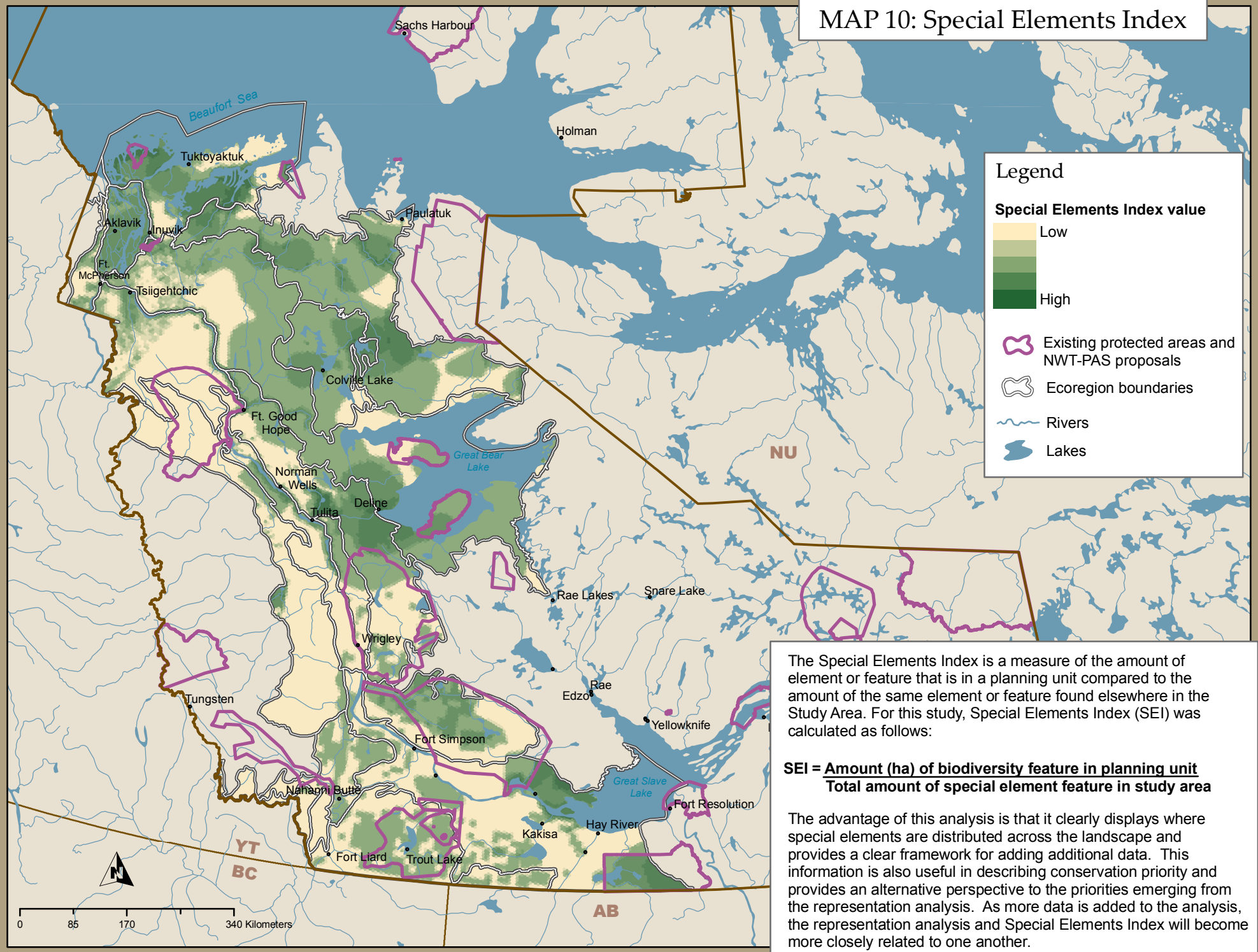


This map illustrates the relative value of planning units for meeting landscape unit representation goals as a function of three factors: efficiency, contiguity and human impacts -- using precautionary goals proposed by this study (3 times those of the baseline goals). In this 'closed' analysis, all existing protected areas and NWT-PAS proposals were assumed to be part of the conservation solution. The closed analysis is useful for exploring where else the PAS would need to focus in the future for meeting representation goals, if current proposals were approved.

Precautionary Landscape Unit Conservation Goals (3x Bas and Gah)

Goal	Landscape Unit Size:
30%	>500,000 ha
45%	100,000 to 500,000 ha
60%	30,000 to 100,000 ha
75%	10,000ha to 30,000 ha
100%	<10,000 ha

MAP 10: Special Elements Index

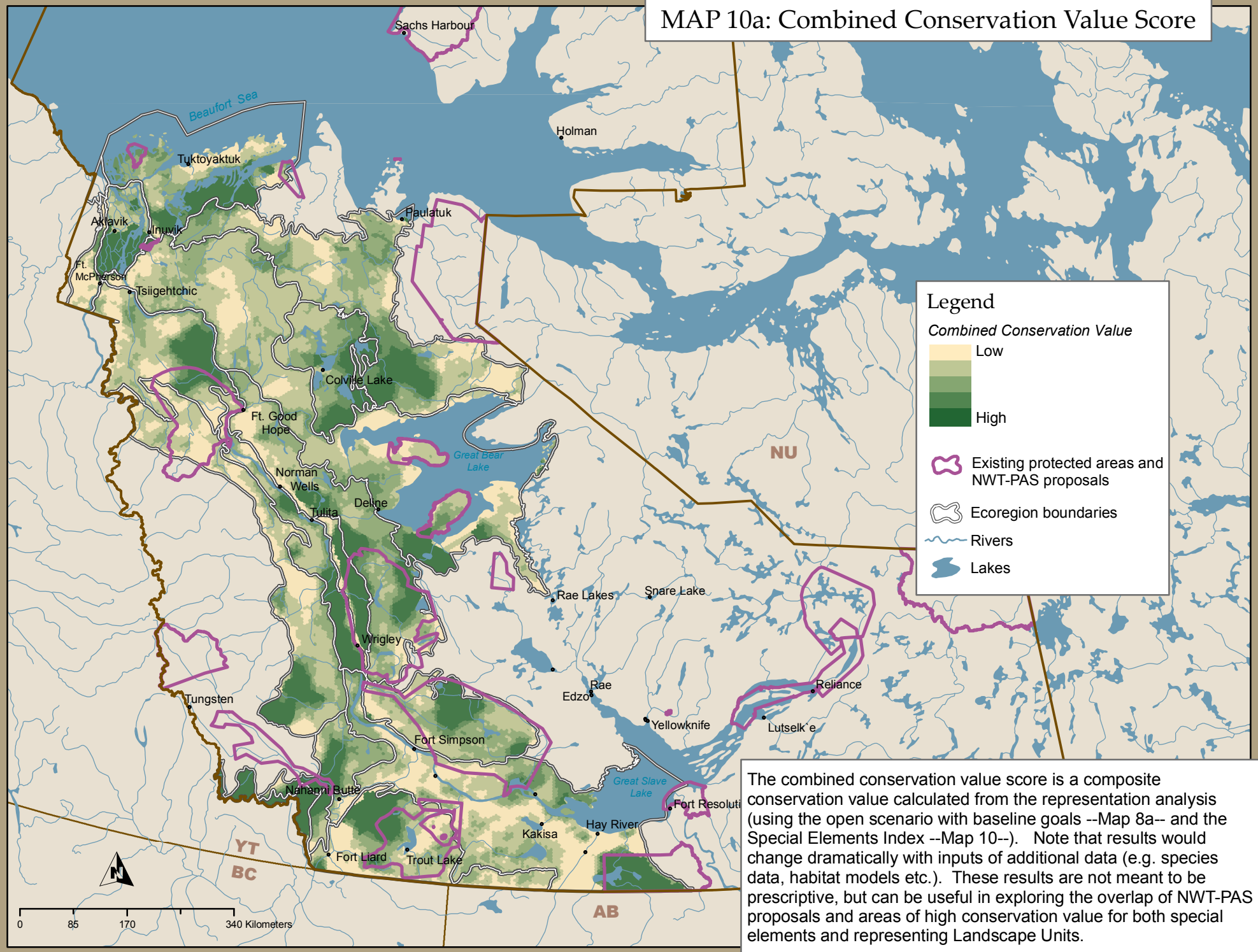


The Special Elements Index is a measure of the amount of element or feature that is in a planning unit compared to the amount of the same element or feature found elsewhere in the Study Area. For this study, Special Elements Index (SEI) was calculated as follows:

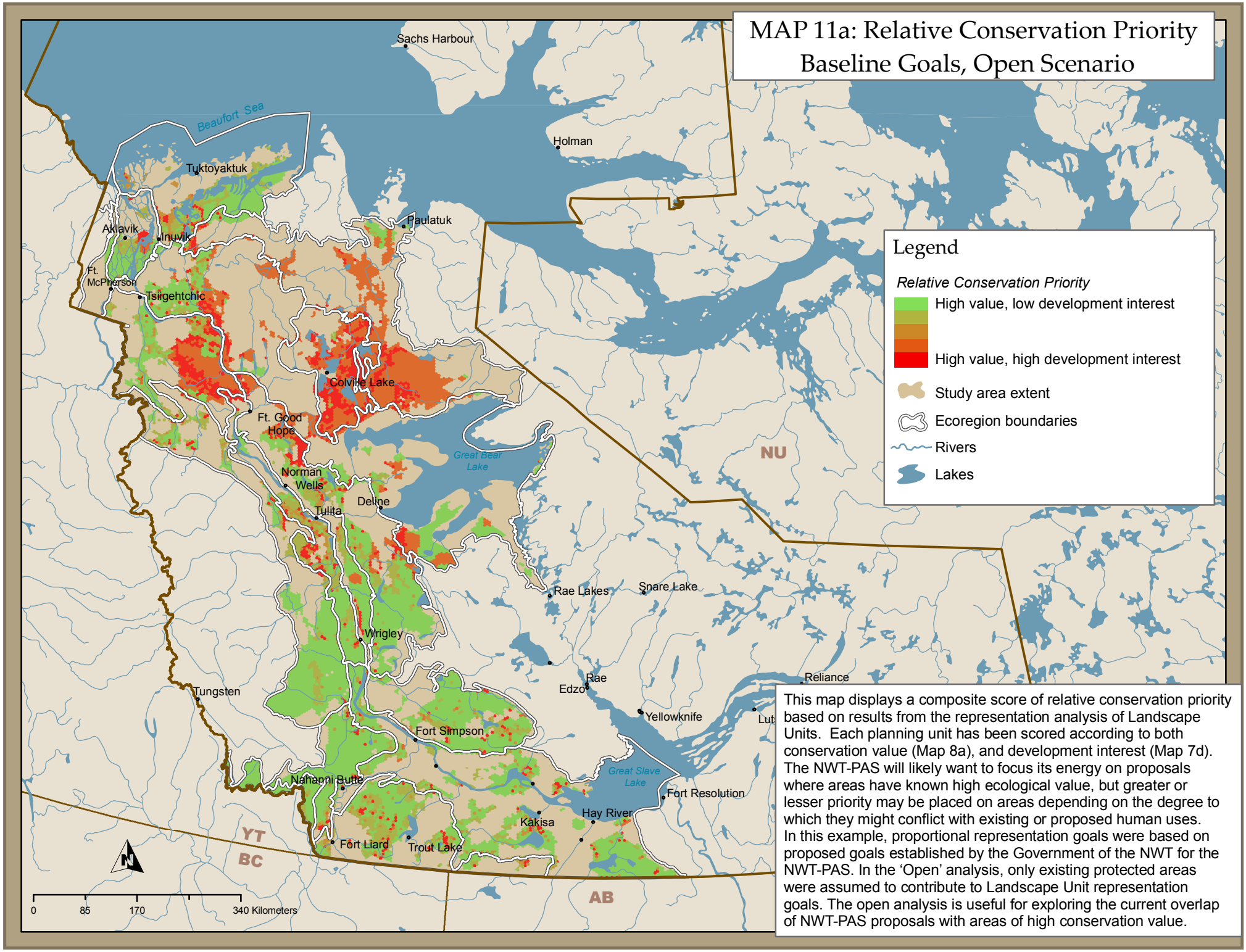
$$\text{SEI} = \frac{\text{Amount (ha) of biodiversity feature in planning unit}}{\text{Total amount of special element feature in study area}}$$

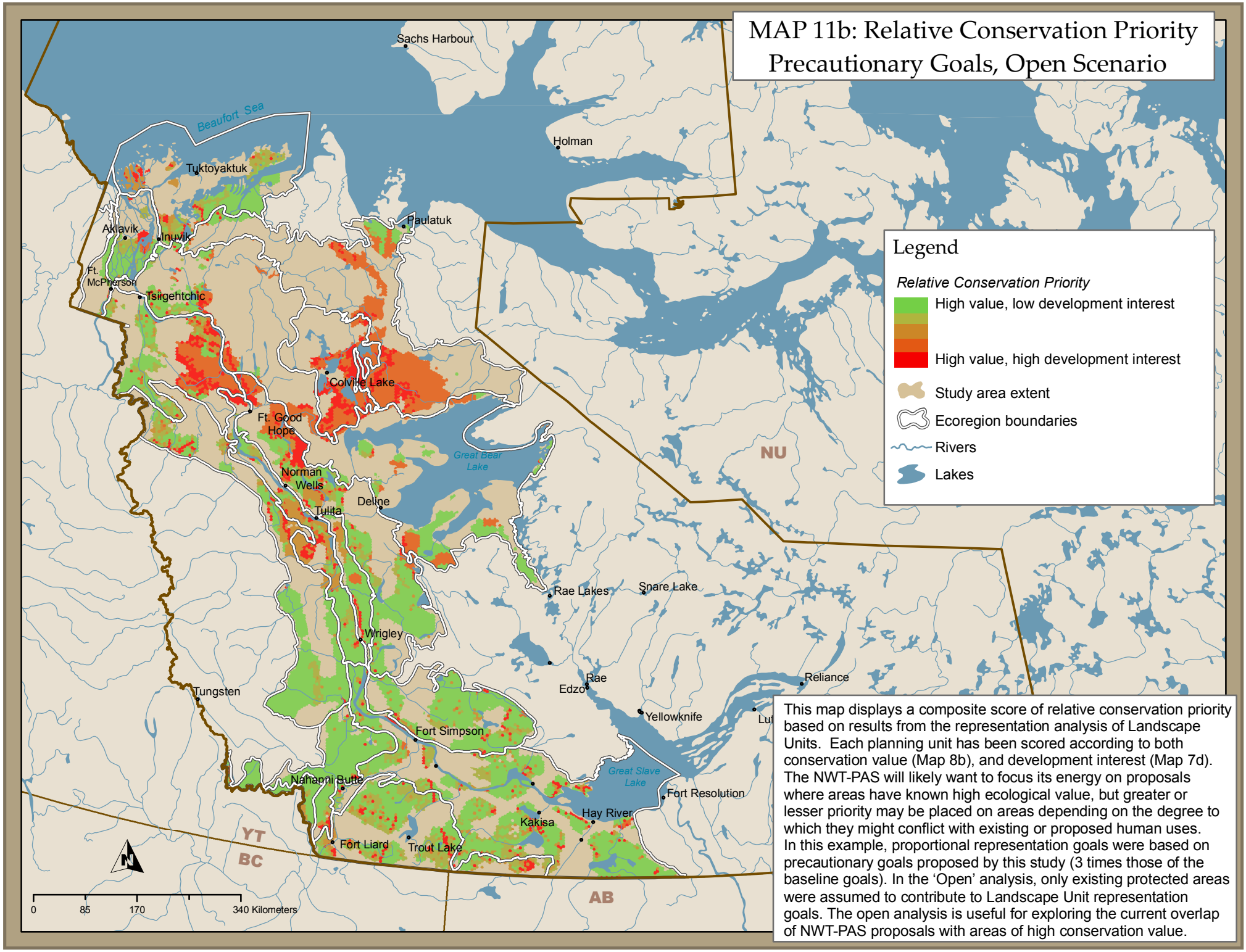
The advantage of this analysis is that it clearly displays where special elements are distributed across the landscape and provides a clear framework for adding additional data. This information is also useful in describing conservation priority and provides an alternative perspective to the priorities emerging from the representation analysis. As more data is added to the analysis, the representation analysis and Special Elements Index will become more closely related to one another.

MAP 10a: Combined Conservation Value Score



The combined conservation value score is a composite conservation value calculated from the representation analysis (using the open scenario with baseline goals --Map 8a-- and the Special Elements Index --Map 10--). Note that results would change dramatically with inputs of additional data (e.g. species data, habitat models etc.). These results are not meant to be prescriptive, but can be useful in exploring the overlap of NWT-PAS proposals and areas of high conservation value for both special elements and representing Landscape Units.


MAP 11a: Relative Conservation Priority
Baseline Goals, Open Scenario
Legend
Relative Conservation Priority
High value, low development interest
High value, high development interest
Study area extent
Ecoregion boundaries
Rivers
Lakes
This map displays a composite score of relative conservation priority based on results from the representation analysis of Landscape Units. Each planning unit has been scored according to both conservation value (Map 8a), and development interest (Map 7d). The NWT-PAS will likely want to focus its energy on proposals where areas have known high ecological value, but greater or lesser priority may be placed on areas depending on the degree to which they might conflict with existing or proposed human uses. In this example, proportional representation goals were based on proposed goals established by the Government of the NWT for the NWT-PAS. In the 'Open' analysis, only existing protected areas were assumed to contribute to Landscape Unit representation goals. The open analysis is useful for exploring the current overlap of NWT-PAS proposals with areas of high conservation value.
Sachs Harbour
Beaufort Sea
Holman
Tuktoyaktuk
Paulatuk
Aklavik
Inuvik
Ft. McPherson
Tsiigehtchic
Colville Lake
Ft. Good Hope
Great Bear Lake
NU
Norman Wells
Deline
Tulita
Rae Lakes
Snare Lake
Wrigley
Tungsten
Rae
Edzo
Reliance
Yellowknife
Fort Simpson
Great Slave Lake
Nahanni Butte
Fort Resolution
Hay River
Kakisa
YT
BC
Fort Liard
Trout Lake
AB
N
0
85
170
340 Kilometers


MAP 11b: Relative Conservation Priority
Precautionary Goals, Open Scenario
Legend
Relative Conservation Priority
High value, low development interest
High value, high development interest
Study area extent
Ecoregion boundaries
Rivers
Lakes
This map displays a composite score of relative conservation priority based on results from the representation analysis of Landscape Units. Each planning unit has been scored according to both conservation value (Map 8b), and development interest (Map 7d). The NWT-PAS will likely want to focus its energy on proposals where areas have known high ecological value, but greater or lesser priority may be placed on areas depending on the degree to which they might conflict with existing or proposed human uses. In this example, proportional representation goals were based on precautionary goals proposed by this study (3 times those of the baseline goals). In the 'Open' analysis, only existing protected areas were assumed to contribute to Landscape Unit representation goals. The open analysis is useful for exploring the current overlap of NWT-PAS proposals with areas of high conservation value.
Sachs Harbour
Beaufort Sea
Holman
Tuktoyaktuk
Paulatuk
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Inuvik
Ft. McPherson
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Fort Simpson
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Nahanni Butte
Fort Resolution
Hay River
Kakisa
YT
BC
Fort Liard
Trout Lake
AB
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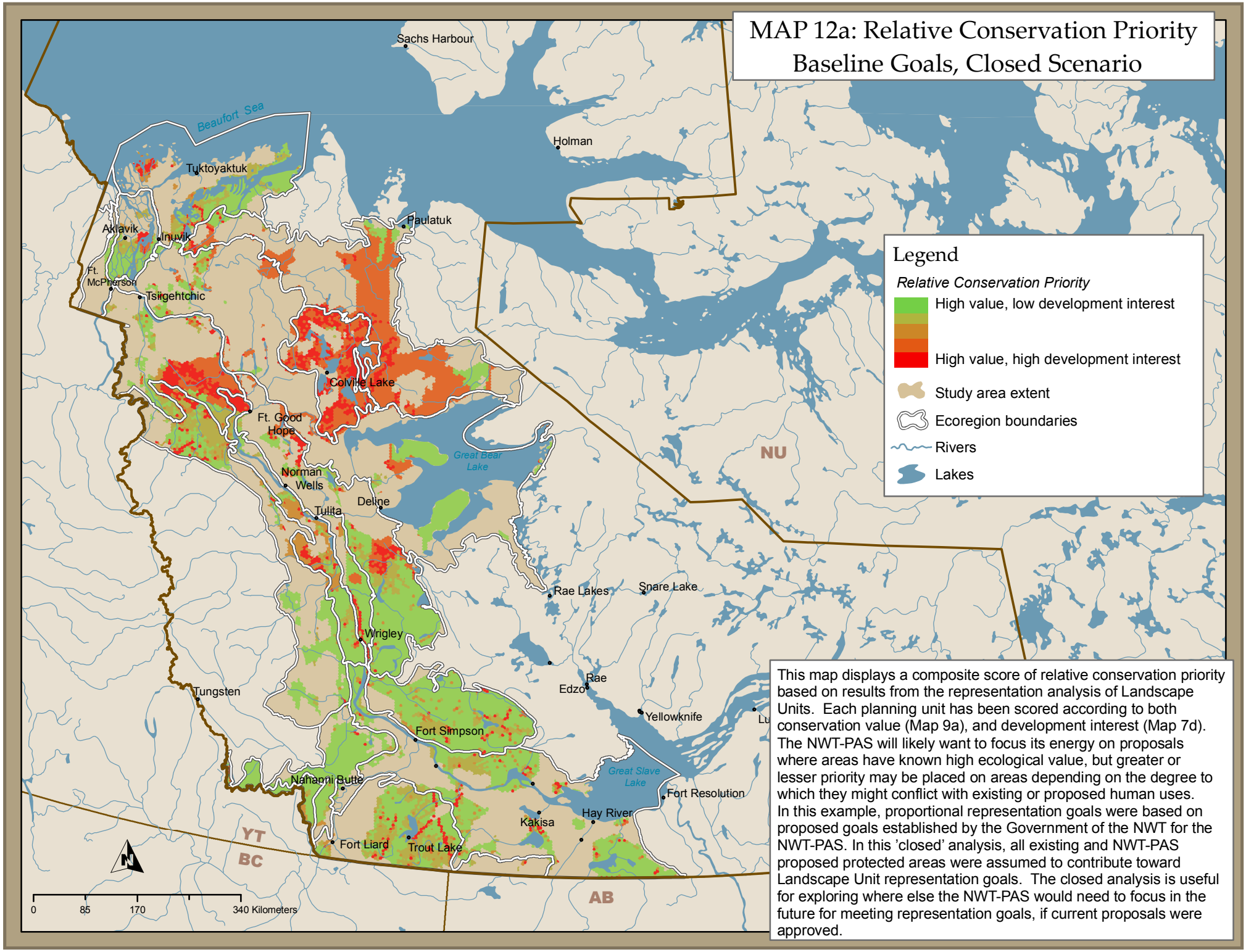
85
170
340 Kilometers


MAP 12a: Relative Conservation Priority
Baseline Goals, Closed Scenario
Legend
Relative Conservation Priority
High value, low development interest
High value, high development interest
Study area extent
Ecoregion boundaries
Rivers
Lakes
This map displays a composite score of relative conservation priority based on results from the representation analysis of Landscape Units. Each planning unit has been scored according to both conservation value (Map 9a), and development interest (Map 7d). The NWT-PAS will likely want to focus its energy on proposals where areas have known high ecological value, but greater or lesser priority may be placed on areas depending on the degree to which they might conflict with existing or proposed human uses. In this example, proportional representation goals were based on proposed goals established by the Government of the NWT for the NWT-PAS. In this 'closed' analysis, all existing and NWT-PAS proposed protected areas were assumed to contribute toward Landscape Unit representation goals. The closed analysis is useful for exploring where else the NWT-PAS would need to focus in the future for meeting representation goals, if current proposals were approved.
Sachs Harbour
Beaufort Sea
Holman
Tuktoyaktuk
Paulatuk
Aklavik
Inuvik
Ft. McPherson
Tsiigehtchic
Colville Lake
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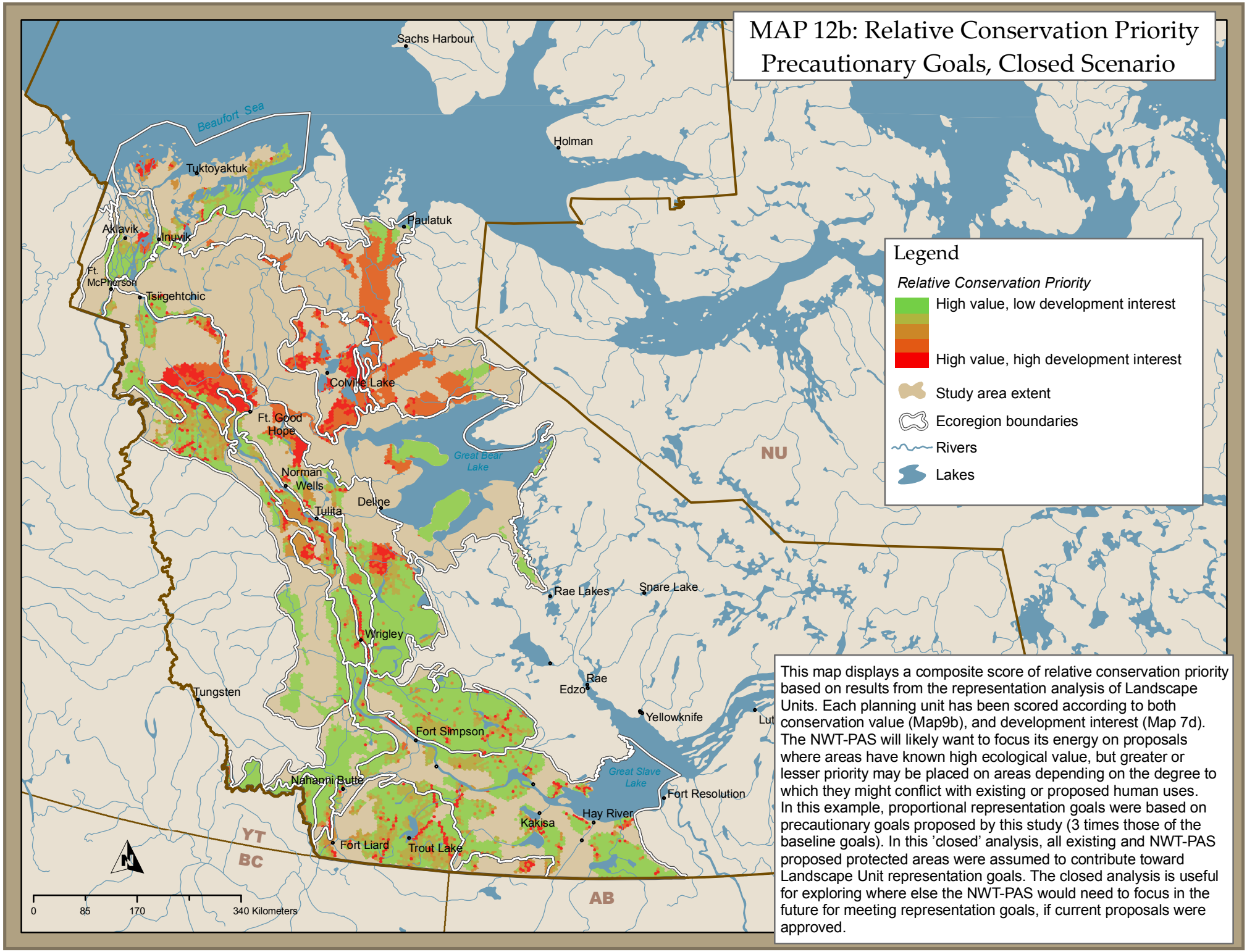
Fort Simpson
Great Slave Lake
Nahanni Butte
Fort Resolution
Hay River
Kakisa
YT
BC
Fort Liard
Trout Lake
AB
N
0
85
170
340 Kilometers


MAP 12b: Relative Conservation Priority
Precautionary Goals, Closed Scenario
Legend
Relative Conservation Priority
High value, low development interest
High value, high development interest
Study area extent
Ecoregion boundaries
Rivers
Lakes
This map displays a composite score of relative conservation priority based on results from the representation analysis of Landscape Units. Each planning unit has been scored according to both conservation value (Map9b), and development interest (Map 7d). The NWT-PAS will likely want to focus its energy on proposals where areas have known high ecological value, but greater or lesser priority may be placed on areas depending on the degree to which they might conflict with existing or proposed human uses. In this example, proportional representation goals were based on precautionary goals proposed by this study (3 times those of the baseline goals). In this 'closed' analysis, all existing and NWT-PAS proposed protected areas were assumed to contribute toward Landscape Unit representation goals. The closed analysis is useful for exploring where else the NWT-PAS would need to focus in the future for meeting representation goals, if current proposals were approved.
Sachs Harbour
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Tsiigehtchic
Colville Lake
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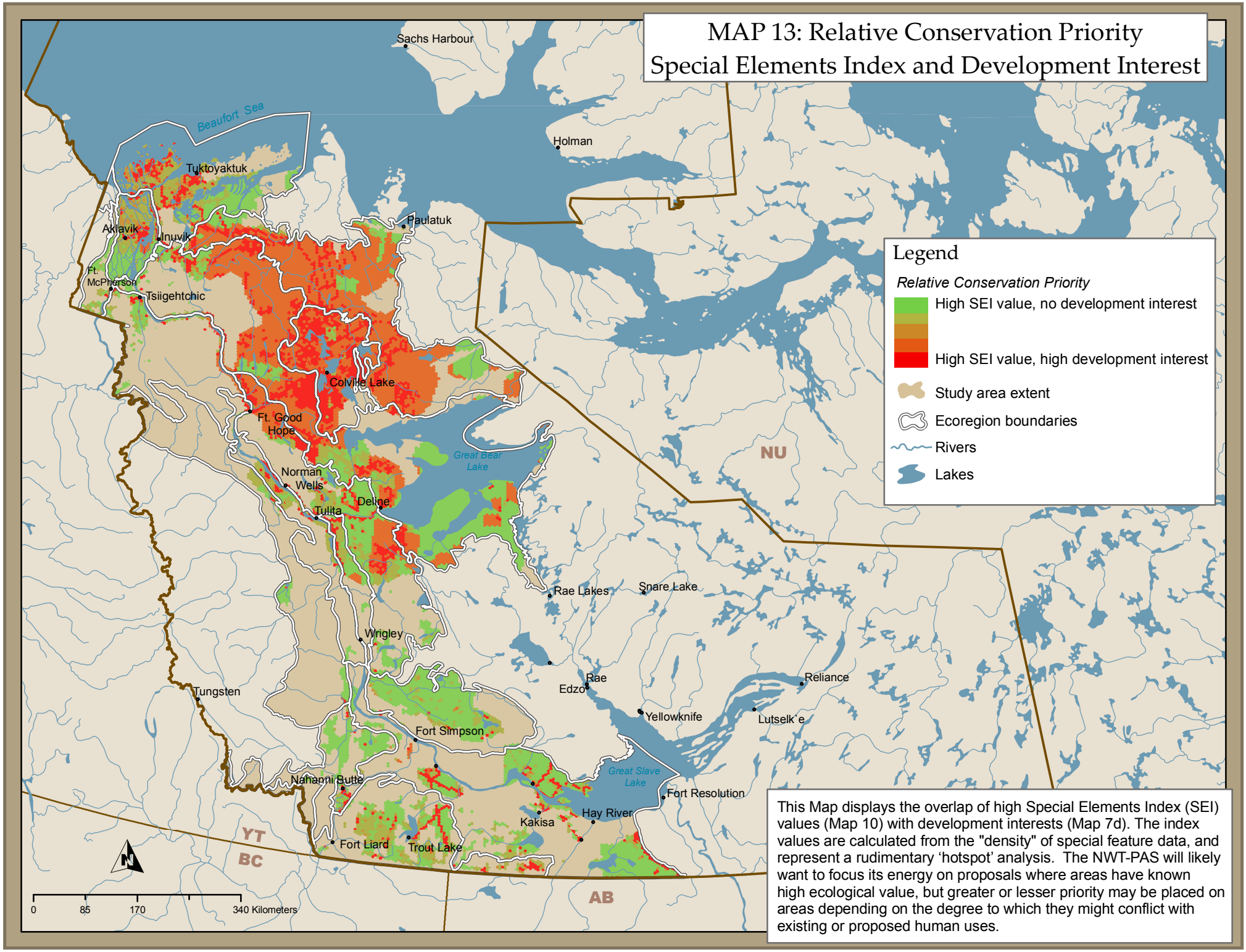
Rae
Tungsten
Yellowknife
Fort Simpson
Great Slave Lake
Nahanni Butte
Fort Resolution
Hay River
Kakisa
YT
BC
Fort Liard
Trout Lake
AB
N
0
85
170
340 Kilometers


MAP 13: Relative Conservation Priority
Special Elements Index and Development Interest
Legend
Relative Conservation Priority
High SEI value, no development interest
High SEI value, high development interest
Study area extent
Ecoregion boundaries
Rivers
Lakes
Sachs Harbour
Beaufort Sea
Holman
Tuktoyaktuk
Paulatuk
Aklavik
Inuvik
Ft. McPherson
Tsiigehtchic
Colville Lake
Ft. Good Hope
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Lutselk`e
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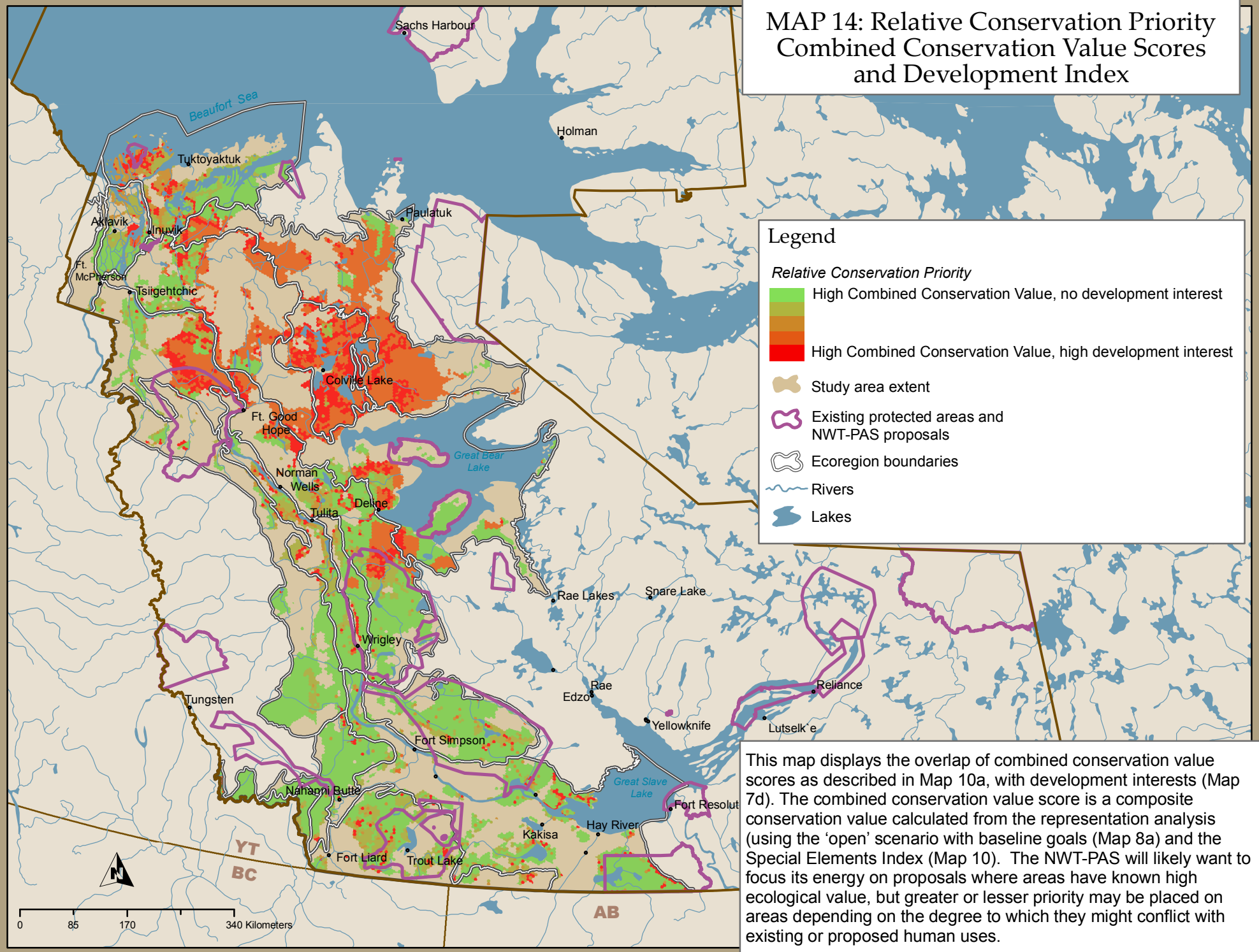
Great Slave Lake
Nahanni Butte
Fort Resolution
Hay River
Kakisa
Fort Liard
Trout Lake
YT
BC
AB
N
0
85
170
340 Kilometers
This Map displays the overlap of high Special Elements Index (SEI) values (Map 10) with development interests (Map 7d). The index values are calculated from the "density" of special feature data, and represent a rudimentary 'hotspot' analysis. The NWT-PAS will likely want to focus its energy on proposals where areas have known high ecological value, but greater or lesser priority may be placed on areas depending on the degree to which they might conflict with existing or proposed human uses.

MAP 14: Relative Conservation Priority Combined Conservation Value Scores and Development Index



Legend

Relative Conservation Priority

- High Combined Conservation Value, no development interest
- High Combined Conservation Value, high development interest
- Study area extent
- Existing protected areas and NWT-PAS proposals
- Ecoregion boundaries
- Rivers
- Lakes

This map displays the overlap of combined conservation value scores as described in Map 10a, with development interests (Map 7d). The combined conservation value score is a composite conservation value calculated from the representation analysis (using the 'open' scenario with baseline goals (Map 8a) and the Special Elements Index (Map 10). The NWT-PAS will likely want to focus its energy on proposals where areas have known high ecological value, but greater or lesser priority may be placed on areas depending on the degree to which they might conflict with existing or proposed human uses.

List if Maps

Map1. Study Area, Existing Protected Areas, and NWT-PAS Initiatives
Map 2. Priority Ecoregions of the Mackenzie Valley 5-Year Action Plan
Map 3. Landscape Units Within the Study Area
Map 4a. Special Features and Elements: Northern Land Use Information Series, Critical Habitats
Map 4b. Special Features and Elements: Areas of Ecological Interest
Map 4c. Special Features and Elements: Raptor Nest, Rae Plant Locations and Important Bird Areas
Map 4d. Special Features and Elements: High Value Caribou Habitat
Map 4e. All Special Features and Elements
Map 5. Human Uses Data:
Map 6. Human Use Footprint
Map 7a. Mining Interest
Map 7b. Oil and Gas Interest
Map 7c. Road Length by Analysis Unit
Map 7d. Development Interest
Map 8a. Relative Conservation Value: Baseline Goals, Open Scenario
Map 8b. Relative Conservation Value: Precautionary Goals, Open Scenario
Map 9a. Relative Conservation Value: Baseline Goals, Closed Scenario
Map 9a. Relative Conservation Value: Precautionary Goals, Closed Scenario
Map 10. Special Elements Index
Map 10a. Combined Conservation Value Score
Map 11a. Relative Conservation Priorities: Baseline Goals, Open Scenario
Map 11b. Relative Conservation Priority: Precautionary Goals, Open Scenario
Map 12a. Relative Conservation Priority: Baseline Goals, Closed Scenario
Map 12b. Relative Conservation Priority: Precautionary Goals, Closed Scenario
Map 13. Relative Conservation Priority: Special Elements Index and Development Interest
Map 14. Relative Conservation Priority: Combined Conservation Value Scores and Development Interest

LIST of APPENDICES - Volume III

A. Rationales and approaches to Regional-scale Conservation Planning

B. Profiles of Ecoregions in the Study Area

C. Data Used in the Study

D. Landscape Units Classification

E. Expanded methods for Development Interest Index

F. Ecoregion Distribution of Landscape Units by and Protection Type

G. Landscape Unit Representation by Individual Legislated Protected/NWT-Pas Proposal Area.

H. Representation of special elements by Individual Legislated Protected/NWT-Pas Proposal Area.

I. Conservation Goals Background

J. Comparison of Conservation Tiers from Landscape Unit Representation Analysis

PRELIMINARY ANALYSIS OF REPRESENTATIVE CORE AREAS

for the

NORTHWEST TERRITORIES PROTECTED AREAS STRATEGY

Volume III

Appendices

May 1, 2005

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Chuck Rumsey, Round River Canada
Richard Jeo, Round River Canada

Table of Contents

A. Rationales and approaches to Regional-scale Conservation Planning 1
Purpose and Goals 1
Uncertainty, Stochasticity and the Precautionary Principle 2
Elements of Conservation Area Design 2
Special Elements 2
Representation 3
Focal Species 3
Connectivity 4
New Directions in Boreal Planning 4
B. Profiles of Ecoregions in the Study Area 8
Tuktoyaktuk Coastal Plain 8
Dease Arm Plain 8
Mackenzie Delta 9
Peel River Plateau 9
Great Bear Lake Plain 10
Fort Mcpherson Plain 10
Colville Hills 11
Norman Range 11
Mackenzie River Plain 12
Franklin Mountains 12
Sibbeston Lake Plain 13
Horn Plateau 13
Hay River Lowland 14
Northern Alberta Uplands 14
Hyland Highland 15
C. Data Used in the Study 16
D. Landscape Units Classification 25
Determining landscape units 25
Applying landscape unit representation 26
1. Proportional representation 27
2. Replication and reserve integrity 27
3. Reserve Size 28
4. Reserve boundary criteria 29
E. Expanded Methods for Development Interest Index 32
Development Interest Index: Quantifying Third Party development interests 32
Methods 32
F. Ecoregional Distribution of Landscape Units by Protection Type 34
G. Landscape Unit Representation by Individual Legislated Protected/NWT-Pas Proposal Area. 51

H. Representation of special elements by Individual Legislated Protected/NWT-Pas Proposal Area. 62
I. Conservation Goals Background 64
Minimum Conservation Area Size 64
Other Benchmarks and Goals 64
References....65
J. Comparison of Conservation Tiers from Landscape Unit Representation Analysis....66
Tier 1 results: open vs. locked 66
Tier 2 and 3 results: open vs. locked scenarios....67

A. Rationales and approaches to Regional-scale Conservation Planning

Purpose and Goals

The goals established by the NWT-PAS clearly reflect a growing understanding around the need to think about, and manage for, the maintenance of functioning ecosystem processes and populations across appropriately large regions (Hawkins & Selman 2002; Howard et al. 2000; Jepson et al. 2002; Pfab 2002; Soulé & Terborgh 1999; Wisdom et al. 2002). Planning for the maintenance of landscape functions and species across broad regions is particularly important in regions such as the Canadian North, where ecosystem richness and productivity are maintained through large-scale disturbance regimes (Bunnell 1995; Segerstrom 1997) and other natural processes (Pringle 2001). Additionally, in systems with relatively low productivity (e.g., boreal forests), some species, particularly large mammal species (e.g., grizzly bear, caribou, and wolf), have evolved life-history strategies that require extensive landscapes to meet seasonal and annual life requisites for food and breeding. Additionally, maintaining ecologically effective populations of these species also may be key to the maintenance of community dynamics and complexity over the long term (Berger et al. 2001; Soulé et al. 2003).

While the need for biodiversity conservation and planning has long been recognized, few areas are actually managed primarily for this purpose. World wide, only about 3% of the terrestrial land base has been designated for biodiversity management (McNeely 1994). Moreover, the location, size and juxtaposition of these existing biodiversity reserves are often based on political factors rather than consideration of the needs for conservation. For example, most protected areas in Canada and the United States are located in alpine or sub-alpine zones and are usually too small and isolated to maintain viable populations of certain species, particularly wide-ranging animals such as carnivores (Newmark 1995).

Worldwide, conservation scientists have become increasingly engaged in assisting conservation organizations and governments striving to meet their regional conservation missions. Measuring success at maintaining long term ecological functions and biodiversity in any region has proven difficult and elusive. Therefore, to provide more tangible measures of success scientists have proposed sets of conservation and management goals. Noss (1992) and Noss and Cooperrider (1994) stated four goals of regional conservation to be satisfied to achieve the overarching mission of maintaining biodiversity and ecological integrity, into perpetuity. These goals are:

- Represent, in a system of protected areas, all native ecosystem types and seral stages across their natural range of variation.
- Maintain viable populations of all native species in natural patterns of abundance and distribution.
- Maintain ecological and evolutionary processes, such as disturbance regimes, hydrological processes, nutrient cycles, and biotic interactions.
- Design and manage the system to be resilient to short-term and long-term environmental change and to maintain the evolutionary potential of lineages.

These four goals are often cited and have become central to most regional conservation strategies and conservation area designs endorsed and/or developed by government agencies and conservation organizations.

Uncertainty, Stochasticity and the Precautionary Principle

Conservation biologists and natural resources managers must allow for uncertainty inherent in limited data. Additionally, since natural systems are inherently stochastic and unpredictable, considering and incorporating natural stochasticity must be an integral part of developing a conservation area design. The "precautionary principle" forwards that the uncertainty in managing natural systems should be explicitly acknowledged and managers should make every effort to err on the side of caution (deFur & Kaszuba 2002; Raffensperger & deFur 1999; Van Den Belt & Gremmen 2002). Given the finality of extinction, conservation planning should incorporate wide margins of safety against the potential loss of organisms, populations or ecological processes. In particular, biodiversity conservation plans must carefully consider the consequences of further human impact and loss of natural habitat, even when no obvious role or effect on the ecosystem has been empirically described. In other words, the absence of ecological data does not equate with the absence of ecological importance. As has already been acknowledged, significant data gaps exist for informing the NWT-PAS, and accordingly, precautionary representation goals for the current coarse filter are recommended. These are discussed in more detail below. We also stress that all lands and waters of the NWT should be managed to some degree for the conservation of biodiversity, regardless of their designation in this study.

Elements of Conservation Area Design

A number of increasingly sophisticated techniques are being applied to regional conservation area designs. Many represent technological or theoretical advancements in our attempts to model and predict the fundamental dynamics and diversity of the landscapes; most attempt to optimize the amount of information gleaned from sparse data, and rely on computer-intensive and GIS-based approaches. Regardless of the techniques, many recent landscape conservation planning efforts rely upon three types of information to provide the foundation of the design: focal species analyses, coarse-filter ecosystem representation analyses and fine-filter targets (special elements), as described by Noss et al. (1999). The combination of these analyses provides complementary information sources that should increase the robustness of the design as compared to the use of a single information source. A critical addition to this suite is the explicit consideration of connectivity across landscapes, for the maintenance of demographic and genetic exchange between populations, as well as the maintenance of ecosystem and landscape processes (Dobson 1999; Hoctor et al. 2000; Taylor et al. 1993). Other analyses may further our ability to capture important dynamic processes, including spatial population viability analyses (advancing focal species analyses), and ecological process modeling (e.g., fire modeling).

Special Elements

The special elements approach typically results in the mapping of hotspots and other biologically or ecologically important areas that are recommended for protection above other areas. Hotspots usually are based on concentrations of species (usually rare or endemic taxa) and can be recognized on a variety of spatial scales, from local to global (e.g., see Myers et al. 2000). Identified hotspots of species richness or endemism, and any other priorities based on

special elements, are only as reliable as the underlying data. In most cases, including the majority of the NWT and the rest of Canada, biological surveys are spotty at best. Areas that show up as "cold spots" could either be areas where species richness or endemism is truly low or they could simply be areas that were never surveyed.

The fine-filter approach works well for plants and small-bodied animals, especially in regions where biodiversity databases (e.g., Conservation Data Centres) are reasonably complete. It is not as well suited for large-bodied or wide-ranging animals, such as grizzly bears, salmon or northern goshawks, whose needs cannot be effectively captured by occurrence data. In all cases, the fine filter is dependent on reasonably comprehensive, or at least well-distributed, biological surveys to be most useful. But, despite the fact that surveys are not comprehensive for most of Canada, to neglect areas known to be rich in special element occurrences or other ecological values simply because survey data across the region in question are incomplete would be foolhardy. A precautionary approach would protect known hotspots. Hence, the fine filter remains valuable (indeed necessary, if not sufficient) even in relatively poorly surveyed regions.

Representation

Given that species distributions are determined largely by environmental factors, such as climate and substrate, and that vegetation and other species assemblages respond to gradients of these factors across the landscape, protecting examples of all types of vegetation or physical environmental classes ought to capture the vast majority of species without having to consider those taxa individually (Noss and Cooperrider 1994). It has been estimated that 85-90% of all species can be protected by the coarse filter (Noss 1987). Testing this optimistic assumption empirically is difficult, as doing so would require a reasonably complete inventory of all taxa, including cryptic organisms such as bacteria and small invertebrates, sampled over a broad area. In regions with relatively low endemism, such as most of Canada, the coarse filter is predicted to perform better than in regions with high endemism, where species populations are highly localized (Noss and Cooperrider 1994).

Representation assessments typically rely on vegetation (often based on remote sensing, as in the U.S. Gap Analysis Program; Scott et al. 1993), surrogate taxa (e.g., vertebrate species richness, also used in the U.S. Gap Analysis Program), abiotic environmental classes (e.g., landforms, habitat classes defined by soils or geology), or some combination of biological and physical factors (e.g., ecological land units) as proposed coarse filters. Increasing evidence suggests that a combination of biological and abiotic data, as in ecological land units, provides a more secure basis for representation than either class alone (Kirkpatrick and Brown 1994; Kintsch and Urban 2002; Noss et al. 2002a; Groves 2003; Lombard et al. 2003).

Focal Species

Although conservation planning for all biodiversity is desirable, it would be impossible (and possibly counterproductive) to determine and manage for the ecological needs of every species in a region (Franklin 1993; Poiani et al. 2000). As an alternative, researchers have suggested the identification of a suite of focal species to guide conservation planning (Lambeck 1997; Miller et al. 1998). Focal species are selected such that their protection, as a group, would concurrently protect all or at least most remaining native species. Planning for the maintenance or restoration of healthy populations of multiple focal species can provide a manageable set of objectives for identifying and prioritizing areas, and for determining the necessary size, location and

configuration of conservation areas. Focal species monitoring can also be a useful tool in judging the effectiveness of the conservation plan once implemented.

Using a diverse suite of focal species should provide umbrella protection for a broader array of biodiversity than the selection of a single focal species or guild. For example, Kerr (1997) points out that using only carnivores for conservation area selection fails to protect a number of invertebrates. Similarly, an analysis of the umbrella function of grizzly bears in Idaho found that protection of grizzly bears in Idaho would protect 71% of other mammalian species, 67 % percent of birds, and 61 % of amphibians, but only 27 % of native reptiles (Noss 1996). It is now generally accepted that a suite of focal species should be selected, and these species-specific analyses be combined with other approaches, such as coarse-filter representation analyses and special elements filters (Margules et al. 2002; Noss et al. 1999; Poiani et al. 2000; Reyers et al. 2002).

Given the central role of focal species planning to current landscape planning efforts, much thought has gone into providing guidance to focal species selection. Below, some key characteristics that are broadly used in focal species selection are discussed.

Keystone Species are those that play a disproportionately large role (relative to numerical abundance or biomass) in ecosystem function (Collen & Gibson 2001; Miller et al. 1999; Mills et al. 1993; Power et al. 1996). The influences of keystone species can occur through a variety of interactions and processes including competition, mutualism, dispersal, pollination, disease and by modifying habitats and abiotic factors. The loss of keystone species can trigger changes in relative abundance and distribution (including local extinction) of many other species present in an ecosystem (Berger et al. 2001; Rosell & Parker 1996; Soulé et al. 2003; Terborgh et al. 1999).

Umbrella species are those that require significant conservation protection, such that successful maintenance of umbrella species requirements will ensure the conservation of many other native species. Umbrella species typically have large area requirements and cover large areas in their daily or seasonal movements, and/or require a diversity of habitats to meet their life requisites (Caro 2003; Carroll et al. 2001; Lambeck 1997; Noss et al. 1996). In general, an umbrella species approach is suited to answering the questions of how much land is necessary in a conservation area network and how that land should be configured.

Connectivity

Explicit consideration of connectivity is required when considering large study areas that will likely support multiple core conservation areas. Maintenance of ecological linkages is critical to the long term viability of all species, as well as key ecological processes. The value of connectivity is reviewed in several publications (e.g., Andreassen et al. 1995; Beier & Noss 1998; Collinge 1996). Regional connectivity can be represented through predictions of potential generalized wildlife movements across the study area. These predictions should capture wildlife movements that tend to be determined by energetic considerations related to topography modified by security concerns; they will not capture the movements of species such as sheep or goats which use topography for security.

New Directions in Boreal Planning

With the advent of a partnership between the Canadian Boreal Initiative and the Canadian BEACONs Project, advances for conservation planning in Canada's Boreal region are being realized. Efforts by BEACONs include confirming appropriate levels of protection required to

maintain the ecological integrity of the boreal region. Research also focuses on proactive conservation planning, maintenance of ecological integrity, and demonstration of ecological sustainability. Part of the BEACONs approach is directed at identifying anchor sites for a regional protected areas network through the identification of criteria for benchmark areas. These benchmarks can provide important reference areas against which resource development activities can be evaluated. As reference areas, benchmark areas should be large enough to maintain ecological processes, such as natural disturbance regimes and predator-prey dynamics.

The BEACONs Project makes the important case that for the Canadian Boreal, uncertainty around management decisions, as well as ecosystem processes and condition, demand a science-based approach that integrates the disciplines of resource management and conservation planning. BEACONs has proposed several avenues for this integration, including the application of a reverse-matrix model. This model focuses on the matrix as the supportive environment in which limited development occurs and activities compatible with ecological sustainability are identified through an adaptive management framework.

The Northwest Territories could provide an important opportunity for testing and implementing the reverse matrix approach. In particular, the goals of the NWT-PAS should fit well with its conceptual foundation, as it likely has broad applicability in the design of ecological networks that facilitate biodiversity conservation and sustainable use. Given the short time frames of this study, a thorough exploration of how these concepts and principles might be applied was not possible. However, a number of key elements of the BEACONs model are incorporated into the approach discussed in this study, including the identification of minimum size area requirements for core or anchor sites. Further, as part of this study, we have been asked to help convene a visioning workshop, and to build a workplan for a second phase of analysis, both of which would specifically address application of the reverse-matrix model.

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B. Profiles of Ecoregions in the Study Area

Ecoregional Profiles

These descriptions are taken directly from the Government of Canada's "Narrative Descriptions of Terrestrial Ecozones and Ecoregions of Canada", which can be located at,

http://www.ec.gc.ca/soer-ree/English/Framework/Nardesc/default.cfm

Tuktoyaktuk Coastal Plain

This ecoregion covers the outer Mackenzie River delta and Tuktoyaktuk Peninsula bordering the Beaufort Sea. Much of the ecoregion is covered by small lakes. The mean annual temperature is approximately -11.5°C with a summer mean of 4.5°C and a winter mean of -26.5°C. The mean annual precipitation ranges 125-200 mm with higher values for more southerly locations. This ecoregion is classified as having a low arctic ecoclimate. It is characterized by a continuous cover of shrubby tundra vegetation, consisting of dwarf birch, willow, northern Labrador tea, Dryas spp., and sedge tussocks. Tall dwarf birch, willow, and alder occur on warm sites; wet sites are dominated by sphagnum moss and sedge. Much of the ecoregion is composed of distinctive delta landforms at the mouth of the Mackenzie River. These include wetlands, active alluvial channels, and estuarine deposits. Characteristic wetlands which cover 25-50% of the area are lowland polygon fens, both the low- and high-centre varieties. On the peninsula, innumerable lakes and pingos, some very large, form unique and outstanding features of the landscape. The region is underlain by continuous permafrost with high ice content in the form of ice wedges and pingos. Organic and Turbic Cryosols developed on level to rolling organic, morainal, alluvial, fluvioglacial, and marine deposits are the dominant soils of the ecoregion. Regosolic Static Cryosols are the dominant soils in the active delta portion of the ecoregion. Characteristic wildlife includes caribou, muskox, snowshoe and arctic hare, red fox, wolf, and arctic ground squirrel. A variety of birds are present, including raptors, songbirds, ptarmigan, snowy owl, waterfowl, and shorebirds. In the marine environment, species present include walrus, seal, beluga whale, and polar bear. Land uses include subsistence trapping, hunting and fishing, and tourism-related recreation. Considerable hydrocarbon exploration has occurred in this ecoregion, which acted as the staging point and main base for the Beaufort Sea exploration program. The main settlement is Tuktoyaktuk and the population of the ecoregion is approximately 1000

Dease Arm Plain

This expansive ecoregion covers the upland from just east of the Mackenzie Delta to Dease Arm of Great Bear Lake. The mean annual temperature is approximately -11°C with a summer mean of 5°C and a winter mean of -26°C. The mean annual precipitation ranges 200-300 mm. This ecoregion is classified as having a high subarctic ecoclimate. Tall shrub tundra, usually consisting of dwarf birch and willow, is the most common vegetative cover. The southern boundary of the ecoregion encompasses the area of tundra and subarctic forest transition, where open, very stunted stands of black spruce and tamarack with secondary quantities of white spruce and ground cover of dwarf birch, willow, ericaceous shrubs, cottongrass, lichen, and moss, are predominant. This ecoregion's rolling surface, which is generally below about 300

m asl elevation, is covered by glacial drift and outwash. A number of hills reach about 460 m asl. A wide range of Cryosolic soils, as well as Eutric and Dystric Brunisolic soils, have formed on hummocky to undulating, loamy glacial till. Organic landforms are usually high-centred lowland polygons. Permafrost is continuous throughout the ecoregion with high ice content and abundant ice wedges in the northern half, and low to medium ice content in the southernmost quarter along Great Bear Lake. Characteristic mammals include caribou, moose, black and grizzly bear, lynx, red and arctic fox, and snowshoe hare. Representative birds include sparrow, songbirds, spruce grouse, osprey, and waterfowl. Land use is limited to trapping, hunting, and fishing. Mineral exploration activities are common. Paulatuk is the main settlement and the population of the ecoregion is approximately 300.

Mackenzie Delta

This ecoregion is composed of the southern two-thirds of the distinctive Mackenzie River delta. The ecoregion is marked by very cold winters and cool summers. The mean annual temperature is approximately -9.5°C. The mean summer temperature is 8.5°C and the mean winter temperature is -26.5°C. Mean annual precipitation ranges from 200 mm to less than 275 mm. The ecoregion is classified as having a high subarctic ecoclimate. The predominant vegetation consists of open, very stunted stands of black spruce and tamarack with secondary quantities of white spruce, and a ground cover of dwarf birch, willow, ericaceous shrubs, cottongrass, lichen, and moss. Poorly drained sites usually support tussocks of sedge, cottongrass, and sphagnum moss. Low shrub tundra, usually dwarf birch and willow, is also common. The delta is a complex area of peat-covered deltas and fluvial marine deposits. The present delta is remarkable for its multitude of lakes and channels. Wetlands extend over 50% of the ecoregion, and are characteristically polygonal peat plateau bogs with ribbed fens. Regosolic Static and Gleysolic Static Cryosols with Organic Cryosols developed on level fluvioglacial, organic, and marine deposits are the dominant soils. Extensive discontinuous permafrost with low to medium ice content is prevalent throughout the ecoregion, and is characterized by sparse ice wedges. Characteristic wildlife includes muskrat, beaver, mink, and waterfowl. Land uses are limited to trapping, hunting, recreation, and tourism. Major communities include Aklavik and Inuvik. The population of the ecoregion is approximately 4000.

Peel River Plateau

This ecoregion spans the Yukon and Northwest Territories border between the Peel and Arctic Red rivers along the foothills of the Mackenzie and Richardson mountains. The ecoregion is marked by long, very cold winters and short cool summers. The mean annual temperature is approximately -6°C. The mean annual summer temperature is 10°C and the mean winter temperature is -22.5°C. Mean annual precipitation ranges 200-275 mm. The ecoregion is classified as having a high subarctic ecoclimate. The predominant vegetation consists of open, very stunted stands of black spruce and tamarack with secondary quantities of white spruce, and a ground cover of dwarf birch, willow, ericaceous shrubs, cottongrass, lichen, and moss. Poorly drained sites usually support tussocks of sedge, cottongrass, and sphagnum moss. Low shrub tundra, consisting of dwarf birch and willow, is also common. The surface of this ecoregion is characterized by truncated and upturned edges of Palaeozoic and Mesozoic strata, forming terraces, and rounded plateaus. Some portions of the ecoregion in the southwest are unglaciated, but most of its surface is covered by thin, discontinuous, hummocky to dissected glacial drift and organic deposits. Wetlands are present on over 25% of the ecoregion, characterized by peat plateau bogs, and ribbed and horizontal fens. Permafrost is continuous,

and characterized by sparse ice wedges and massive ground ice bodies, with high to medium ice content in the northern part of the ecoregion above Mountain River, and extensive discontinuous permafrost with medium to low ice content below the river. Turbic and Organic Cryosols with some Eutric Brunisols and Static Cryosols are the dominant soils in the ecoregion. Characteristic wildlife includes caribou, moose, grizzly and black bear, wolf, red fox, snowshoe hare, and beaver. Common birds include raven, osprey, spruce grouse, and waterfowl. Land use activities include trapping, hunting, and fishing, with some recreation and tourism. There are no permanent communities in this ecoregion.

Great Bear Lake Plain

This ecoregion extends southward from the Mackenzie River delta to Great Bear Lake, including some of the terrain surrounding the southern shore of the lake. It is marked by short, cool summers and long, very cold winters. The mean annual temperature is approximately -9°C. The mean summer temperature is 8°C and the mean winter temperature is -25.5°C. Mean annual precipitation ranges 200-300 mm. The ecoregion is classified as having a high subarctic ecoclimate. The latitudinal limits of tree growth are reached along its northern boundary. The predominant vegetation consists of open, very stunted stands of black spruce and tamarack with secondary quantities of white spruce and a ground cover of dwarf birch, willow, ericaceous shrubs, cottongrass, lichen, and moss. Poorly drained sites usually support tussocks of sedge, cottongrass, and sphagnum moss. Low shrub tundra, consisting of dwarf birch and willow, is also common. Composed of flat-lying Cretaceous shale and Devonian limestone strata, the surface of this ecoregion is generally below 310 m asl. As elevations gradually increase southward, entrenched river channels lie some 60-150 m below the surrounding surface. The ecoregion is generally covered by undulating glacial drift and outwash deposits. Turbic Cryosols with Static and Organic Cryosols developed on organic deposits with deep permafrost are the dominant soils. Unfrozen Organic and Brunisolic soils also occur. Permafrost is extensive and discontinuous with low to medium ground ice content, and is characterized by sparse ice wedges. Wildlife includes caribou, moose, black bear, wolf, red fox, snowshoe hare, and beaver. Common birds include spruce grouse, raven, osprey, and waterfowl. Land use activities include trapping, hunting, fishing, recreation, and tourism. There are no permanent communities in this ecoregion.

Fort Mcpherson Plain

This ecoregion spans the Yukon and Northwest Territories' borders and extends from Fort McPherson to the Mackenzie and Ramparts rivers. The climate is marked by short cool summers and long very cold winters. The mean annual temperature is approximately -8°C. The mean summer temperature is 9.5°C and the mean winter temperature is -25°C. Mean annual precipitation ranges between 250 mm in the eastern portion of the ecoregion to 350 mm in the west. The ecoregion is classified as having a high subarctic ecoclimate. The predominant vegetation consists of open, very stunted stands of black spruce and tamarack with secondary quantities of white spruce, and a ground cover of dwarf birch, willow, ericaceous shrubs, cottongrass, lichen, and moss. Poorly drained sites usually support tussocks of sedge, cottongrass, and sphagnum moss. Low shrub tundra, consisting of dwarf birch and willow, is also common. This ecoregion is underlain by Cretaceous shale, and incorporates a broad, shallow basin in its southwestern section at about 120 m asl. Some parts of the ecoregion have numerous lakes, and others are without. In the northeast, isolated hills rise to about 460 m asl, where it consists of Palaeozoic carbonate rocks. Both the Arctic Red and the Ontaratue rivers

follow deeply incised valleys through this ecoregion to the Mackenzie River. Permafrost is continuous with medium to high ice content, and is characterized by sparse ice wedges. Turbic and Organic Cryosols with some Static Cryosols developed on level to undulating morainal and organic deposits are the dominant soils. Unfrozen Dystric and Eutric Brunisolic soils also occur. Wetlands cover over 25% of the area in the north of the ecoregion, over 50% of the area in the south. Characteristic wildlife includes caribou, moose, black bear, wolf, red fox, snowshoe hare, beaver, spruce grouse, raven, osprey, and waterfowl. Land use activities are limited to trapping, hunting, fishing, recreation, and tourism. Major communities include Fort McPherson and Arctic Red River. The population of the ecoregion is approximately 900.

Colville Hills

This ecoregion lies north of the Smith Arm of Great Bear Lake and encompasses Aubry and Colville lakes, and lacs des Bois and Maunoir. It is marked by short, cool summers and long, very cold winters. The mean annual temperature is approximately -10°C. The mean summer temperature is 6.5°C and the mean winter temperature is -25.5°C. Mean annual precipitation ranges 200-300 mm. The ecoregion is classified as having a high subarctic ecoclimate. The predominant vegetation consists of open, very stunted stands of black spruce and tamarack with secondary quantities of white spruce, and a ground cover of dwarf birch, willow, ericaceous shrubs, cottongrass, lichen, and moss. Poorly drained sites usually support tussocks of sedge, cottongrass, and sphagnum moss. Low shrub tundra, consisting of dwarf birch and willow, is also common. This ecoregion embraces several ridges of Palaeozoic carbonate strata that stand above the surrounding plains. The hills and ridges enclose basins which contain several large lakes in a netlike pattern with meshes of 15 km or more across. The lowlands lie at about 245-300 m asl, whereas sinuous ridges reach elevations of 670 m asl. This hummocky to undulating plain is also characterized by extensive polygonal peat plateaus. Organic and Turbic Cryosols and Dystric Brunisols are the dominant soils in the ecoregion. Permafrost is continuous with low to medium ice content. It is characterized by sparse ice wedges in the southern half of the ecoregion, and by abundant ice wedges, massive ground ice and pingo ice in the north. Characteristic wildlife includes caribou, moose, grizzly and black bear, wolf, red fox, snowshoe hare, beaver, muskrat, spruce grouse, raven, osprey, and waterfowl. Land uses include trapping, hunting, fishing, recreation, and tourism. The principal community is Colville Lake, and the population of the ecoregion is approximately 70.

Norman Range

This ecoregion extends from Fort Good Hope on the east side of the Mackenzie River to Willowlake River south of Great Bear Lake. It is marked by cool summers and long, very cold winters. The mean annual temperature is approximately -6.5°C. The mean summer temperature is 10.5°C and the mean winter temperature is -23.5°C. The mean annual precipitation ranges from 225 mm in the eastern portion of the ecoregion to less than 400 mm in the west. The ecoregion is classified as having a low subarctic ecoclimate. Vegetation is dominated by open stands of black spruce with an understory of dwarf birch, Labrador tea, lichen, and moss. Drier and warmer sites tend to have more white spruce, paper birch, and some aspen. Wet sites are usually covered with bog-fen vegetation such as dwarf black spruce, Labrador tea, ericaceous shrubs, and mosses. The Norman Range forms a series of north-south-trending, linear, relatively low ridges, largely of resistant Palaeozoic carbonates, and reaching elevations of about 1040 m asl. Great Bear Plain, composed of Cretaceous strata, has a rolling surface generally below 500 m asl. The surface of the ecoregion is covered with steeply sloping to

undulating glacial drift, colluvium, and organic deposits in the form of polygonal peat plateaus. Turbic and Organic Cryosols, as well as Eutric Brunisols, are the dominant soils. Permafrost is extensive and discontinuous with low to medium ice content, and is characterized by sparse ice wedges. In the area northeast of Fort Good Hope, ice wedges and pingo ice are more abundant. Characteristic wildlife includes caribou, moose, grizzly and black bear, wolf, coyote, beaver, snowshoe hare, muskrat, and red fox. Common birds include spruce grouse, raven, and osprey. Land uses include hunting, trapping, recreation, and tourism. The principal communities are Fort Good Hope and Deline. The population of the ecoregion is approximately 1200.

Mackenzie River Plain

This ecoregion extends from north of Fort Good Hope on the west side of the Mackenzie River to Wrigley. It is a narrow northern extension of the boreal forest along the east side of the Mackenzie River. The ecoregion is marked by cool summers and very cold winters. The mean annual temperature is approximately -6.5°C. The mean summer temperature is 11.5°C and the mean winter temperature is -24.5°C. The mean annual precipitation ranges 300-400 mm. The ecoregion is classified as having a subhumid high boreal ecoclimate. The ecoregion is a broad, rolling, drift-covered plain lying between Mackenzie and Franklin mountains, into which the Mackenzie River is entrenched for part of its course. Native vegetation consists predominantly of medium to tall, closed stands of black spruce and jack pine with an understory of feathermoss, bog cranberry, blueberry, Labrador tea, and lichens. White spruce, balsam fir, and trembling aspen occur in the warmer, more moist sites in the southern section of the region. Drier sites have more open stands of black spruce and jack pine. Low, closed and open stands of black spruce, ericaceous shrubs, and sphagnum mosses dominate poorly drained, peat-filled depressions. Wetlands cover 25-50% of the ecoregion, and are characteristically peat plateau bogs, and ribbed and horizontal fens. Permafrost is extensive and discontinuous with medium ice content, and is characterized by sparse ice wedges. Dominant soils in the ecoregion are Organic and Turbic Cryosols and Eutric and Dystric Brunisols with some Regosols that have developed on terraced to rolling morainal, alluvial, lacustrine, and organic deposits. Characteristic wildlife includes moose, black bear, beaver, fox, wolf, hare, raven, grouse, and waterfowl. Limited forestry, oil production near Norman Wells, hunting, and trapping are the principal land use activities. The main communities include Norman Wells and Fort Norman. The population of the ecoregion is approximately 1200.

Franklin Mountains

This ecoregion occupies the Franklin Mountains from Norman Wells to Wrigley along the east side of the Mackenzie River in the District of Mackenzie. It is marked by cool summers and very cold winters. The mean annual temperature is approximately -5.5°C. The mean summer temperature is 10°C and the mean winter temperature is -25°C. Mean annual precipitation ranges 200-300 mm. The ecoregion is classified as having a low subarctic ecoclimate. The predominant vegetation consists of open stands of black spruce with an understory of dwarf birch, Labrador tea, lichen, and moss. Drier and warmer sites tend to have more white spruce, paper birch, and some aspen. Wet sites are usually covered with bog-fen vegetation such as dwarf black spruce, Labrador tea, ericaceous shrubs, and mosses. The Franklin Mountains form a series of linear, relatively low ranges and ridges, largely composed of resistant carbonates, that reach elevations of about 1525 m asl. This ecoregion's surface is covered with steeply sloping glacial drift, colluvium, and organic deposits in the form of polygonal peat plateaus. Turbic Cryosols, Eutric Brunisols, and Organic Cryosols are the dominant soils. Permafrost is

extensive and discontinuous with low to moderate ice content, and is characterized by sparse ice wedges. Characteristic wildlife includes caribou, moose, grizzly and black bear, wolf, coyote, beaver, snowshoe hare, muskrat, red fox, spruce grouse, raven, and osprey. Hunting, trapping, outdoor recreation, and tourism are the main land use activities.

Sibbeston Lake Plain

This ecoregion lies in the southwest corner of the Northwest Territories. It is bisected by the southern extension of the Franklin Mountains west of the Mackenzie River, and forms a series of linear, relatively low ranges and ridges (about 1650 m) consisting largely of resistant carbonates. The southern extension of the Mackenzie Plain, a broad, rolling, drift- and tree-covered plain lies to the west of the Franklin Mountains, and part of the Great Slave Plain lies to the east. The Great Slave Plain has generally little relief, and the surface below 300 m is characterized by low scarps of resistant carbonates and small shallow lakes. The narrow western extension of the ecoregion is composed of part of the Liard Plateau between the South Nahanni and Liard rivers. It is characterized by tree and alpine tundra covered hills (less than 1500 m), which are underlain mainly by Cretaceous shale and sandstone. The mean annual temperature is approximately -5°C. The mean winter temperature is -1°C and the mean summer temperature is 10°C. The mean annual precipitation ranges from 200 mm in the east to 350 mm in the west. This ecoregion is classified as having a low subarctic ecoclimate. It is dominated by open stands of black and white spruce, paper birch, and some aspen. There is an altitudinal transition from forest to alpine tundra, which occurs between 1050-1150 m. Wetlands cover approximately 50% of the ecoregion. Wet sites are usually covered with bog-fen vegetation such as dwarf black spruce, Labrador tea, ericaceous shrubs, and mosses. The ecoregion's surface materials consist of steeply sloping glacial drift, colluvium, and organic deposits in the form of peat plateaus, palsas, and fens. Dystric and Eutric Brunisols and Turbic Cryosols are the dominant soils. Permafrost is extensive and discontinuous with moderate to low ice content, and is characterized by sparse ice wedges. Characteristic wildlife includes caribou, moose, grizzly and black bear, wolf, coyote, beaver, snowshoe hare, muskrat, red fox, spruce grouse, raven, and osprey. Land uses include hunting, trapping, recreation, and tourism.

Horn Plateau

This ecoregion extends from the Horn River west along the Willowlake River to the Mackenzie River. To the northeast and south, the plateau (300-900 m asl) rises abruptly above the flat-lying terrain of the surrounding Great Slave Lake Plain and the Hay River Lowland ecoregions (generally less than 300 m asl). The plateau slopes more gently to the west. The ecoregion is marked by cool summers and very cold winters. The mean annual temperature is approximately -5.5°C. The mean summer temperature is 12°C and the mean winter temperature is -21°C. Mean annual precipitation ranges from 250 mm in the east to 400 mm in the west. The ecoregion is classified as having a high boreal ecoclimate. Native vegetation consists predominantly of low to medium, closed stands of black spruce and jack pine with an understory of feathermoss, bog cranberry, blueberry, Labrador tea, and lichens. White spruce, balsam fir, and trembling aspen occur in the warmer, moister sites in the southern section of the region. Black spruce is the climatic climax species. Drier, colder sites have more open stands of black spruce and jack pine. Low, closed and open stands of black spruce, Labrador tea, blueberry, bog rosemary, and sphagnum mosses dominate poorly drained, peat-filled depressions. Wetlands cover approximately 50% of the ecoregion and are characterized by peat plateau bogs, palsas and fens. There is extensive discontinuous permafrost with low to

moderate ice content, characterized by sparse ice wedges. The ecoregion is underlain by Cretaceous shale and Devonian limestone bedrock, and is characterized by a smooth, level to undulating surface covered with loamy glacial till and organic deposits. Organic and Turbic Cryosols with some Eutric Brunisols are the dominant soils. Characteristic wildlife includes moose, black bear, fox, wolf, hare, raven, grouse, and waterfowl. Land use activities include forestry, and the hunting and trapping of wildlife.

Hay River Lowland

This ecoregion is the broad, level lowland plain that is drained by the Fort Nelson and Liard rivers in northeastern British Columbia, and the Hay River in northwestern Alberta, which all ultimately flow into the Mackenzie River in the Northwest Territories. The ecoregion is marked by short, warm summers and long, cold winters. The mean annual temperature is approximately -2.5°C. The mean summer temperature is 13°C and the mean winter temperature is -19°C. The mean annual precipitation ranges 350-450 mm. This ecoregion is classified as having a subhumid mid-boreal ecoclimate. It is characterized by closed mixed stands of trembling aspen, balsam poplar, white spruce, balsam fir, and black spruce on drier sites. Poorly drained fens and bogs, about 30% of the ecoregion, are covered with tamarack and black spruce. The ecoregion is composed of low-relief, flat-lying Palaeozoic strata near Great Slave Lake, and Cretaceous shale in its western section. Surface deposits are predominantly peat-covered clayey lacustrine and glacial till on nearly level to gently rolling topography. Gleysolic and Organic soils with some Organic Cryosols are dominant in the lowlands. Luvisols are the dominant upland soils. Sporadic discontinuous permafrost with low ice content is confined to organic deposits, and is characterized by sparse ice wedges. Characteristic wildlife includes moose, black bear, wolf, beaver, and snowshoe hare. Woodland caribou are found in some areas. The most species-rich habitats are the mixed woods and shrublands associated with the fens, bogs, ponds, streams, and lakes. Some pulpwood and local sawlog forestry, oil and gas extraction and exploration, water-oriented recreation, and wildlife trapping and hunting are the dominant uses of land in this region. The major communities include Hay River, Fort Simpson, and Fort Providence. The population of the ecoregion is approximately 13 200.

Northern Alberta Uplands

This ecoregion includes the flat-topped Caribou Mountains in northern Alberta (67) and the Cameron Hills uplands that span the border with British Columbia and the Northwest Territories (65). Composed of Cretaceous shales, the uplands rise some 400-500 m above the surrounding lowlands with steep scarps on their eastern sides. The ecoregion is marked by cool summers and very cold winters. The mean annual temperature ranges from -2°C to -2.5°C. The mean summer temperature ranges from 13°C to 14°C, and the mean winter temperature from -18°C to -20°C. The mean annual precipitation ranges 350-500 mm. The ecoregion is classified as having a subhumid high boreal ecoclimate. Between 50-70% of the ecoregion is covered by wetlands. Undulating to rolling morainal surfaces are covered with organic deposits supporting open stands of stunted black spruce and some birch and shrubs. Sporadic discontinuous permafrost with low ice content is common in these Organic Cryosolic soils. Upland slopes free of organic blankets are mainly loamy glacial till supporting a white spruce, balsam fir, and aspen mixedwood forest. Exposed mineral soils are mainly Gray Luvisols with some Brunisols. Characteristic wildlife includes woodland caribou, moose, black bear, wolf, beaver, snowshoe hare, red squirrel, raven, and waterfowl. One of the largest concentrations of nesting bald eagles occurs in the Cameron Hills around Bistcho Lake. Land use is mainly limited to hunting and

trapping, and oil and gas exploration. The main communities include Fort Liard and Trout Lake. The population of the ecoregion is approximately 600.

Hyland Highland

This ecoregion in southeastern Yukon spans the boundary with British Columbia north of the Liard River. The mean annual temperature for the area is approximately -2°C with a summer mean of 10°C and a winter mean of -18°C. Precipitation varies 500-600 mm being greatest at higher elevations in the northern portion of the ecoregion. Open stands of black and white spruce with an understory of dwarf birch, Labrador tea, lichen, and moss predominate the boreal forest. Drier and warmer sites tend to have more white spruce with lodgepole pine, paper birch, and some aspen. The ecoregion supports forests with considerable productivity. Wet sites are usually covered with bog or fen vegetation such as dwarf black spruce, larch, Labrador tea, ericaceous shrubs, sedges and mosses. The ecoregion takes in parts of the Liard Plateau physiographic unit that is underlain mainly by Cretaceous shale. Many summits and hills are flat, but extensive remnants of former erosion surfaces are evident. Elevations are usually less than 1400 m asl, but some local ranges contain summits over 1800 m asl. The valleys are wide. Permafrost is sporadic, being confined to lower, north-facing slopes and some organic deposits primarily in the northwestern part of the ecoregion. Brunisolic Gray Luvisols are common on medium-textured deposits. Eutric Brunisols are common on coarse materials. Dystric Brunisols occur in alpine and subalpine areas. This ecoregion provides habitat for a wide range of wildlife species, including moose, red fox, beaver, snowshoe hare, arctic ground squirrel, wolf, lynx, weasel, snowy owl, and various raptors. Land uses include some forest harvesting, mineral exploration, big game hunting and guiding, subsistence hunting and trapping, and minor amounts of recreation and tourism. There are no major settlements in the ecoregion. The population of the ecoregion is approximately 100.

C. Data Used in the Study

(this information is supplied to DIAND in digital format as an excel file along with the data themselves in DVD format)

	Data Layer	Data layer description	Scale	Date Acquired	Data Provider and Contact Information	Citation	Original Data Type	Original Projection	Original Geographic Extent	Acquired by:	Use constraint
All data provided by NWT-PAS, GNWT											
Base Data	*Administrative boundaries*	NWT boundary	1:1,000,000	Feb/March 2005	Cathie Harper, GIS Specialist, NWT Center for Geomatics, Government of the NWT. E-mail: Cathie_Harper@gov.nt.ca	NWT boundaries: NWT Center for Geomatics, Government of the NWT	Shapefile (polygon)	Geographic	NWT	Email from NWT-PAS	
		Province boundaries	1:10,000,000	Feb/March 2005	Norm Mair, GIS Technician, NWT Center for Geomatics, Government of the NWT. E-mail: Norm_Mair@gov.nt.ca	Provincial boundaries: NWT Center for Geomatics, Government of the NWT	Shapefile (polygon)	Geographic	Canada	Email from NWT-PAS	
	National Road Network, Canada, Level 1	National road network lines, publication date Nov. 2003	1:50,000	Feb/March 2005	http://www.geobase.ca/geobase/en/data/nrnc1.html	National Road Network, Canada, Level 1, Government of Canada, Natural Resources Canada, Earth Sciences Sector, Geomatics Canada, Centre for Topographic Information, Sherbrooke, Quebec, Canada, 2003	Shapefile (lines)	Geographic	NWT	Download from website	see http://www.geobase.ca/geobase/en/metadata.jsp?id=12367
	Communities			Feb/March 2005	Norm Mair, GIS Technician, NWT Center for Geomatics, Government of the NWT. E-mail: Norm_Mair@gov.nt.ca	NWT Communities: NWT Center for Geomatics, Government of the NWT	Shapefile (points)	Geographic	NWT	Email from NWT-PAS	
	Hydrography	Rivers and lakes,	1:1,000,000	Feb/March 2005	http://geogratis.cgdi.gc.ca/download/frameworkdata/hydrology/	National Scale Frameworks Hydrology: Government of Canada, Natural Resources Canada,	Shapefiles, lines and polygons)	Geographic	NWT, NU, YK	Download from GNWT ftp site	

						Canada Centre for Remote Sensing, The Atlas of Canada, 2003				
Mineral Activities	*Mineral claims, mineral leases, prospecting permits*	Boundaries of mineral claims, mineral leases, prospecting permits in the NWT and associated dbf files	Unknown	Feb/March 2005	Shawn Larocque (larocques@inac-ainc.gc.ca) or Evangelos Kirizopoulos (kirizopoulose@inac-ainc.gc.ca), GIS Specialists, Information Management Group (IMAG), Department of Indian and Northern Affairs Canada (INAC), Government of Canada	Mineral claims, mienral leases, prospecting permits: Mining Recorder's Office, Resources & Petroleum Directorate, Indian and Northern Affairs Canada (INAC), Government of Canada, February 2005	Shapefile (polygon)	Geographic	NWT	Download from GNWT ftp site
	Mineral showing in the NWT	Text tables defining lat/long locations of mineral showings and degree of development of a showing from initial discovery to a mine. For more details on the database see http://www.nwtgeoscience.ca/normin/help_readme.htm	N/A	Feb/March 2005	http://www.nwtgeoscience.ca/normin/	NORMIN.DB The Northern Minerals Database 2005/Feb. http://www.nwtgeoscience.ca/normin. NWT Geoscience Office, Yellowknife, Northwest Territories.	TXT table	Geographic	NWT	Download from website
Surface Land Use Permits and Surface Dispositions	*Surface Land Use Permits and Surface Dispositions*	surface dispositions, surface land use permits, point locations	N/A	March 2005	Shawn Larocque (larocques@inac-ainc.gc.ca) or Evangelos Kirizopoulos (kirizopoulose@inac-ainc.gc.ca), GIS Specialists, Information Management Group (IMAG), Department of Indian and Northern Affairs Canada (INAC), Government of Canada	Surface dispositions and surface land use permits: Lands Administration division, Indian and Northern Affairs Canada (INAC), Government of Canada, February 2006	Shapefile (points)	Geographic	NWT	Email from NWT-PAS
Oil and Gas Activities	*Oil and gas dispositions*	Boundaries for existing exploration licences, significant discovery licences, production licences, former	Unknown	Feb/March 2005	http://www.ainc-inac.gc.ca/oil/act/lan/index_e.html	Oil and Gas Rights: Northern Oil and Gas, Indian and Northern Affairs, Canada, January 2005	Shapefile (polygon)	Geographic	NWT	Download from website

		permits or leases and the Norman Wells Proven Area									
	Seismic lines	Historic seismic lines, line features, current to 1991	Unknown	Feb/March 2005	WWF NWT Digital Atlas, Main disk, 2002	Frontier Seismic Line Location Data - National Energy Board, Government of Canada, 1999	Shapefile (lines)	Geographic	NWT	Copied from WWF NWT Digital Atlas CD-ROM	
	Oil and Gas Well Sites	Historic oil and gas well sites, point locations, current to 1991	N/A	Feb/March 2005	WWF NWT Digital Atlas, Main disk, 2002	Frontier Well Data for North of 60 - National Energy Board, Government of Canada,	Shapefile (points)	Geographic	NWT	Copied from WWF NWT Digital Atlas CD-ROM	
	Oil & gas bids	2005 call for bids for petroleum exploration rights. This file only includes call for bids for the Central Mackenzie Valley as no nominations were received for elsewhere in the NWT. For more information please visit http://www.ainc-inac.gc.ca/oil/whn/index_e.html	Unknown	April-05	Mythily Thadchanamoorthy, Northern Oil and Gas, Indian and Northern Affairs, Canada. E-mail thadchanamoorthym@ainc-inac.gc.ca	Call for bids for petroleum exploration rights: Northern Oil and Gas, Indian and Northern Affairs, Canada, 2005	Shapefile (polygon)	Geographic	Central Mackenzie Valley (no nominations were made for elsewhere in the NWT in 2005)	Email from NWT-PAS	
	Existing pipeline routes	Existing Norman Wells oil pipeline	1:50,000,	Feb/March 2005	WWF NWT Digital Atlas, Main disk, 2002	Enbridge pileline route: Deh Cho First Nations, Executive Director, Deh Cho first Nations.	Shapefile (lines)	Geographic	NWT	Copied from WWF NWT Digital Atlas CD-ROM	
		Other pipeline routes	various	Feb/March 2005	WWF NWT Digital Atlas, Main disk, 2002	WWF Canada, digitized from various publicly available maps.	Shapefile (lines)	Geographic	NWT	Copied from WWF NWT Digital Atlas CD-ROM	
	Proposed Mackenzie Valley Gas Pipeline	Proposed Mackenzie Valley gas pipeline route	1:50,000	Feb/March 2005	Wasi Raza, GIS Specialist, Colt Geomatic Solutions Limited (Colt GSL), Calgary, Alberta. E-mail: raza.wasi@colteng.com on behalf of Imperial Oil Resources Ventures Ltd (IORVL)	Mackenzie Gas Project Pipeline Route Revision 3: Colt Geomatic Solutions Limited (Colt GSL) and Imperial Oil Resources Ventures Ltd (IORVL)., December 2003.	Shapefile (lines)	Geographic	NWT	Download from GNWT ftp site	Data for internal GNWT use only. Cannot be distributed without prior permission by Imperial Oil Resources Venture Ltd.

	Proposed Mackenzie Valley Gas Pipeline infrastructure	Various point files	N/A	Feb/March 2005	Wasi Raza, GIS Specialist, Colt Geomatic Solutions Limited (Colt GSL), Calgary, Alberta. E-mail: raza.wasi@colteng.com on behalf of Imperial Oil Resources Ventures Ltd (IORVL)	Mackenzie Gas Project Pipeline Route Revision 3: Colt Geomatic Solutions Limited (Colt GSL) and Imperial Oil Resources Ventures Ltd (IORVL)., December 2003.	Shapefile (points)	Geographic	NWT	Download from GNWT ftp site	Data for internal GNWT use only. Cannot be distributed without prior permission by Imperial Oil Resources Venture Ltd.
Protected Areas, National Park Proposals, NWT-PAS Proposals	*Existing Legislate Protected Areas*	Boundaries of National Parks, Migratory Bird Sanctuaries, Thelon Wildlife Sanctuary, Territorial Parks that meet habitat protection requirements.	Various, ranging from 1:250K to 1:1M	Feb/March 2005	http://www.gov.nt.ca/RWED/pas/index.htm	Existing Legislated Protected Areas, NWT Geomatics Center, Government of the NWT, 1997	Shapefile (polygon)	Geographic	NWT	Download from NWT-PAS website	
	NWT-Protected Areas Strategy (PAS) proposals	Boundaries of Areas of Interest	Various, some unknown	Feb/March 2005	Evelyn Gah, GIS Analyst Protected Areas Strategy, Department of Environment and Natural Resources, Government of the NWT. E-mail: Evelyn_Gah@gov.nt.ca	Areas of Interest, Northwest Territories Protected Areas Strategy (NWT-PAS), Dept. of Environment and Natural Resources (ENR), Government of the NWT, 2005	Shapefile (polygon)	Geographic	NWT	Download from GNWT ftp site	Digital boundaries of Areas of Interest cannot be distributed until a public notice has been made that the area has advanced to a Candidate Protected Area
		Boundaries of Candidate Protected Areas	Various, some unknown	Feb/March 2005	http://www.enr.gov.nt.ca/pas/index.htm	Candidate Protected Areas, Northwest Territories Protected Areas Strategy (NWT-PAS), Dept. of Environment and Natural Resources (ENR), Government of the NWT, 2005	Shapefile (polygon)	Geographic	NWT	Download from NWT-PAS website	
		Boundaries of Candidate Protected Areas with Interim Protection	Various, some unknown	Feb/March 2005	http://www.enr.gov.nt.ca/pas/index.htm	Candidate Protected Areas with Interim Protection, Northwest Territories Protected Areas Strategy (NWT-PAS), Dept. of Environment and Natural Resources (ENR), Government of the NWT, 2000	Shapefile (polygon)	Geographic	NWT	Download from NWT-PAS website	

Previously Identified Areas	*International Biological Programme (IBP) Sites*	Boundaries of IBP sites	1:250,000	Feb/March 2005	Norm Mair, GIS Technician, NWT Center for Geomatics, Government of the NWT. E-mail: Norm_Mair@gov.nt.ca	International Biological Programme (IBP) Sites: NWT Center for Geomatics, Government of the NWT, 1999. Data digitized from 1:250,000 scale Northern Land Use Information Series maps, Department of the Environment and the Department of Indian Affairs and Northern Development (DIAND),1972 - 1983, and additional information based on D.K.B. Beckel (ed.). 1975. IBP Ecological Sites in Subarctic Canada: Areas recommended as Ecological Sites in Region 10, Yukon and Northwest Territories Boreal Forest to the Treeline. Lethbridge, University of Lethbridge Production Services.	Shapefile (polygon)	Geographic	NWT	Download from GNWT ftp site
	Key Migratory Bird Terrestrial Habitat Sites	Boundaries of key migratory bird terrestrial habitat sites	Unknown	Feb/March 2005	Freya Nales, GIS Specialist, World Wildlife Fund (WWF) Canada, Yellowknife NT. E-mail: fnales@wwfcanada.org	Key migratory bird terrestrial habitat sites: World Wildlife Fund (WWF) Canada, 2004. Data digitized based on report: Key Migratory Bird Terrestrial Habitat Sites, Canadian Wildlife Service (CWS), Ottawa, 1991. ISBN 0-662-18988-4	Shapefile (polygon)	Geographic	NWT	Download from GNWT ftp site
	Wildlife Areas of Special Interest	Boundaries of wildlife areas of specieal interes	Unknown	Feb/March 2005	Freya Nales, GIS Specialist, World Wildlife Fund (WWF) Canada, Yellowknife NT. E-mail: fnales@wwfcanada.org	Wildlife Areas of Special Interest to the Dept. of Renewable Resources, Government of the NWT: World Wildlife Fund (WWF) Canada, 2004. Data digitized based on report and maps in: R.S. Ferguson. 1987. Wildlife Areas of Special Interest to the Department of	Shapefile (polygon)	Geographic	NWT	Download from GNWT ftp site

						Renewable Resources. Yellowknife, Department of Renewable Resources, Government of the Northwest Territories.				
	Mackenzie Basin Committee - Sensitive Areas	Boundaries of Mackenzie Basin Committee - Sensitive Areas	Unknown	Feb/March 2005	Freya Nales, GIS Specialist, World Wildlife Fund (WWF) Canada, Yellowknife NT. E-mail: fnales@wwfcanada.org	Mackenzie Basin Committee - Sensitive Areas: World Wildlife Fund (WWF) Canada, 2004. Data digitaized/information obtained from: Mackenzie River Basin Committee. 1981. Sensitive Areas: Literature Review WATDOC References. Mackenzie River Basin Study Report Supplement 1. Unpublished.	Shapefile (polygon)	Geographic	NWT	Download from GNWT ftp site
	Critical Habitat	Boundaries of Critical Habitat for various wildlife species	Unknown	Feb/March 2005	Freya Nales, GIS Specialist, World Wildlife Fund (WWF) Canada, Yellowknife NT. E-mail: fnales@wwfcanada.org	Critical habitat: World Wildlife Fund (WWF) Canada, 2004. Data digitaized/information obtained from 1:250,000 scale Northern Land Use Information Series maps, Department of the Environment and the Department of Indian Affairs and Northern Development (DIAND), 1972 - 1983.	Shapefile (polygon)	Geographic	NWT	Download from GNWT ftp site
Ecoregions	*Terrestrial Ecoregions of the NWT*	Boundaries of NWT ecoregions	1:1,000,000	Feb/March 2005	http://sis.agr.gc.ca/cansis/nsdb/ecostrat/gis_data.html	National Soils Database, 1:1 M, Agriculture and Agri-Food Canada, Research Branch, Government of Canada, 1996	Shapefile (polygon)	Geographic	NWT	Download from GNWT ftp site
Landscape Units	*NWT Landscape units*	Boundaries of NWT landscape units which are based on the Soil Landscape (SLC) Polygons of the Naational Soils Database	1:1,000,000	Feb/March 2005	Evelyn Gah, GIS Analyst Protected Areas Strategy, Department of Environment and Natural Resources, Government of the NWT. E-mail: Evelyn_Gah@gov.nt.ca	Landscape Units: NWT Protected Areas Strategy, Department of Environment and Natural Resources, Government of the NWT, 1999. Data is based on Soil Landscapes of Canada, Ver. 2.2 and Soil	Shapefile (polygon)	Geographic	NWT	Download from GNWT ftp site

						Organic Carbon Digital Database of Canada, National Soils Database, 1:1 M, Agriculture and Agri-Food Canada, Research Branch, Government of Canada, 1996				
Tourism	*Regulated outfitter areas in the NWT*	Outfitter area boundaries, polygons	Unknown	Feb/March 2005	Cathie Harper, GIS Specialist, NWT Center for Geomatics, Government of the NWT. E-mail: Cathie_Harper@gov.nt.ca	Regulated outfitter areas in the NWT: Compliance Division, Department of Environment and Natural Resources, Government of the NWT	Shapefile (polygons)	Geographic	NWT	Email from NWT-PAS
	Tourism outfitter lodges and camps	Outfitter lodges & camps, lat/long point locations	N/A	Feb/March 2005	Norm Mair, GIS Technician, NWT Center for Geomatics, Government of the NWT. E-mail: Norm_Mair@gov.nt.ca	Toruism outfitters, lodges and camps: Tourism and Parks Division, Department of Industry, Tourism and Investment, Government of the NWT, 2005	Shapefile (points)	Geographic	NWT	Email from NWT-PAS
Caribou Habitat Data	*High value late winter habitat data for boreal woodland caribou in the Deh Cho region*	High value late winter boreal caribou habitat in the Deh Cho Region, Northwest Territories. Study area is divided into 10 x 10 km grid. For more details on how data was generated, please see: http://www.nwtwildlife.rwed.gov.nt.ca/Publications/ManuscriptReports/NumberedReports.htm	10x10 km grid	April 2005	Adrian D'Hont, Wildlife Biologist/Wildlife Techician, Wildlife Division, Department of Environment and Natual Resources, Government of the NWT. E-mail: Adrian_D'Hont@gov.nt.ca	Gunn, A., J. Antoine, J. Boulanger, J. Bartlett, B. Croft, and A. D'Hont. 2004. Boreal Caribou Habitat and Land Use Planning in the Deh Cho Region, Northwest Territories. Manuscript Report No. 153. Department of Resources, Wildlife and Economic Development, Government of the Northwest Territories, Yellowknife, NT.	Shapefile (polygons)	Geographic	Deh Cho Region, NWT	Email from NWT-PAS
	Probability of occurrence of boreal woodland caribou in the Lower	Areas of low, moderate, and high relative probability of occurrence for boreal woodland	1 x 1 km grid	April 2005	Wendy Wright, Geospatial Analyst, Wildlife Division, Department of Environment and Natural Resources,	J. A. Nagy, D. Auriat, W. Wright, T. Slack, I. Ellsworth, and M. Kienzler. 2005. Ecology of Boreal Woodland Caribou in the Lower	Shapefile (polygons)	Geographic	Lower Mackenzie Valley / Peel Plateau,	Email from NWT-PAS

	Mackenzie River/Peel Plateau Area	caribou in the Lower Mackenzie River/Peel Plateau area of the NWT. Study area is divided into 1x1 km grid. For details on this work, please see http://www.nwtwildlife.com/Publications/otherresearch.htm.			Government of the NWT, Inuvik Region. E-mail: Wendy_Wright@gov.nt.ca	Mackenzie Valley, NT: work completed in the Inuvik Region April 2003 to November 2004			NWT	
	Seasonal distribution of Bluenos East, Bluenose West and Cape Bathurst barren ground caribou herds	Individual polygon shape files for each Bluenose East, Bluenose West and Capebathurst barren ground caribou herds showing combined seasonal utilization distribution for the period of summer to spring/spring migration. Data is for adult female caribou tracked with satellite collars during period of March 1996 to May 2004	Unknown	April 2005	Wendy Wright, Geospatial Analyst, Wildlife Division, Department of Environment and Natural Resources, Government of the NWT, Inuvik Region. E-mail: Wendy_Wright@gov.nt.ca	J.A. Nagy, W.H. Wright, T.M. Slack, and A.M. Veitch. 2004. Seasonal Ranges of the Cape Bathurst, Bluenose-West, and Cape Bathurst Barren-ground Caribou Herds, Department of Resources, Wildlife, and Economic Development, Government of the Northwest Territories, Inuvik and Sahtu Regions	Shapefile (polygons)	Geographic	Mainland Inuvialuit Region and western portion of Sahtu Region, NWT	Email from NWT-PAS
Dall's Sheep	*Dall's sheep and mineral licks*	lat/long locations of mineral licks	N/A	April 2005	James Auld, GIS Specialist, Sahtu GIS Project, Department of Environment and Natural Resources, Government of the NWT, Sahtu Region. E-mail: James_Auld@gov.nt.ca	© World Wildlife Fund Canada, 2005	Shapefile (points)	Geographic	Mackenzie Mountains, NWT	Email from NWT-PAS
Rare Plants	*Rare Plants database*	Point locations of rare vascular plants	N/A	April 2005	Dr. Suzanne Carrière, Ecosystem Management Biologist, Wildlife Division, Department of	Government of the NWT and Canadian Museum of Nature . 2005. Draft general status ranks for	Shapefile (points)	Geographic	Scattered information for NWT	Email from NWT-PAS

					Environment and Natural Resources (ENR), Government of the Northwest Territories. E-mail: Suzanne_Carriere@gov.nt.ca	vascular plants in the NWT - CAN specimen locations: subset of species that may be at risk. Data from NWT Species Monitoring Infobase, version 2005 (Government of the NWT, Yellowknife, NT), and CAN database (Canadian Museum of Nature,Ottawa)				
Raptor Data	*Raptor nest sites*	Point locations of known raptor nest sites, buffered by 3km with the center scrambled	N/A	April 2005	Dr. Suzanne Carrière, Ecosystem Management Biologist, Wildlife Division, Department of Environment and Natural Resources (ENR), Government of the Northwest Territories. E-mail: Suzanne_Carriere@gov.nt.ca	Department of Environment and Natural Resources, Government of the NWT	Shapefile (polygons)	Geographic	Scattered information for NWT	Email from NWT-PAS
Important Bird Areas		Generalized boudnaries of important bird areas in Canada			Andrew Couturier, GIS Analyst, Bird Studies Canada, Port Rowan, Ontario. E-mail: acouturier@bsc-eoc.org	Important Bird Areas of Canada Database: Bird Studies Canada and The Canadian Nature Federation. 2004. Important Bird Areas of Canada Database. Port Rowan, Ontario: Bird Studies Canada	Shapefile (polygons)	Geographic	Canada	Email from NWT-PAS

D. Landscape Units Classification

LANDSCAPE UNIT REPRESENTATION – SELECTION AND DESIGN FOR PROTECTED AREAS IN THE NORTHWEST TERRITORIES

Bas Oosenbrug and Evelyn Gah
NWT Department of Resources, Wildlife and Economic Development

One of the goals of the Northwest Territories Protected Areas Strategy (PAS) is to protect areas representative of the biological diversity, or biodiversity of each ecoregion of the Northwest Territories. Implicit in this goal is that a system of protected areas representing the biodiversity of the NWT will initially be based on biophysical land units defined within the framework of a Canada-wide ecological land classification[1]. Such an approach has been advocated by most ecologists and geographers because detailed information on species and communities is often lacking, and elements of the landscape - landforms, soils, water and climate, create the dimensions of habitat which can be used to approximate biodiversity.

Northwest Territories views representation of landscape units[2] as an underlying principle of the selection process for **core reserves** in each of its ecoregions. By representing portions of all landscape units in a protected areas network, a significant portion of the biological elements of each ecoregion can be protected. Landscape unit representation is considered a regional or "coarse-filter" approach and is intended to identify potential locations of core protected areas. Final area selection however will most likely rely on landscape unit representation, plus other biological features including rare species and communities. As relatively little land is required to achieve representation objectives, these will not assure population viability of species with large area requirements, such as grizzly bears and caribou. Landscape unit representation should thus be used as an initial identification framework to which other ecological data will be added to guide the process of selecting and designing protected areas.[3]

Determining landscape units

Northwest Territories has adopted the National Ecological Framework for Canada and the 1:1 million Soil Carbon Digital Database, a discrete layer of soil polygons within the Canadian Soil Information System (CanSIS), as the basis for determining landscape units. Soil polygons in the CanSIS database can contain up to nine (9) different components, which are described in the database but not mapped. Components differ in one or more of their characteristics, or attributes. One or more components and their attributes can be used to describe different soil polygons.

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[1] See *A National Ecological Framework for Canada* (1996)
[2] Determined from component coverage/attributes (CanSIS 1:1 million Soil Carbon Database 1998)
[3] Also described on CD-ROM, *Using GIS to select protected areas in the NWT – an example from the Slave Geological Province (1999)*
Some jurisdictions, e.g. Manitoba, Saskatchewan use only the single largest soil polygon component and relevant attributes to describe each polygon. In many cases this means that the characteristics of a component comprising less than 30% of a polygon may actually describe that polygon. The approach

used by World Wildlife Fund Canada (WWF), as part of its Endangered Spaces Campaign, requires that one or more components comprise at least 75% of the soil polygon in order to describe the polygon.

Northwest Territories uses 65% component coverage and four (4) attributes - **parent material**, **soil development**, **texture**, and **topography** (slope and local surface form combined) to describe soil polygons as unique landscape units believed to be best-correlated with biodiversity. Northwest Territories has followed WWF's approach to group texture classes, and on the advice of CanSIS staff has combined classes for slope and local surface form.

Examples of soil polygon descriptions that use one, two or three components and which comprise 65% or more of a soil polygon are described below; every soil polygon description is linked to an identical corresponding landscape unit.

Attributes with one (1) component comprising at least 65% of a soil polygon:

A/R/f/w A = alluvial, R = regasolic, f = fine texture, w = weakly broken

Attributes with two (2) components comprising at least 65% of a soil polygon:

M.L/5.F/m.f/w.vw M.L = morainal and lacustrine, 5.F = brunosolic turbic cryosolic and grey luvisolic, m.f = medium or fine texture, w.vw = weakly or very weakly broken

Attributes with three (3) components comprising at least 65% of a soil polygon:

A.M.B/M.F.Y/m.f.-/w.w.vw A.M.B = alluvial, morainal and bog, M.F.Y = eutric brunisolic, grey luvisolic and mesisol, m.f.- = medium or fine, or no texture (for organic soils), w.w.vw. = weakly or very weakly broken

Applying landscape unit representation

Conservation of biodiversity, via a representative network of protected areas requires the solution of two problems, namely:

1) ensuring (by means of the reserve, or protected area selection process) that the region's full range of biodiversity is represented in areas slated for protection, and
2) designing the protected areas network in such a way that each of its component reserves is capable of maintaining population, community, and ecosystem processes over ecological and evolutionary time.

An important adjunct is the consideration of reserves to:

1) most efficiently conserve biological diversity, and
2) serve as ecological benchmarks against which the effects of human disturbance and management practices on lands outside these areas can be gauged.

The following requirements for landscape unit representation and reserve design within Northwest Territories ecoregions will ensure that areas of the right size and in the right location help conserve the

biodiversity of ecoregions in an efficient and comprehensive manner. Northwest Territories is using these requirements to assess whether landscape unit representation and design of existing protected areas is adequate, and also to identify other potential reserves.

1. Proportional representation

Representation should consider differences in prominent versus less prominent landscape units (as described by their spatial extent) such that smaller, less prominent landscape units are represented proportionately more than larger landscape units. The idea here is to protect more of a landscape unit if it is less common, and thus more likely to be easily destroyed by human disturbance. Below is a 4-step protocol for achieving proportional representation of landscape units based on landscape unit size categories[4], as they are preferably represented in one or more large reserves, or secondarily by a number of smaller sites within the ecoregion.

Within each ecoregion:

- Landscape units comprising a total area of >500,000 ha must be represented by at least 10% of that area.
- Landscape units comprising a total area of 100,000 to 500,000 ha must be represented by at least 15% of that area.
- Landscape units comprising a total area of 30,000 to 100,000 ha must be represented by at least 20% of that area.
- Landscape units comprising a total area of <30,000 ha must be represented by at least 25% of that area.

[4] Size categories were determined from the 42 NWT ecoregions, using approximately equal landscape unit frequency-of-occurrence for upper and lower size categories of landscape units, and also for the two mid-range size categories.

2. Replication and reserve integrity

Since landscape units vary in size and frequency, and occur as a mosaic in ecoregions, representation should consider the **location and diversity** of landscape units. The following requirements are intended to i) accommodate geographic variation of landscape units within ecoregions, ii) diminish the impact of potential catastrophic loss of individual sites, and iii) maintain population stability. Furthermore, these requirements are also intended to minimize negative edge effects and habitat isolation of small landscape units required for ecoregion representation.

- Landscape units must be represented in replicated protected areas in geographically diverse locations of the ecoregion. Priority for representation will be landscape units occurring uniquely or infrequently in the ecoregion.

- Small landscape units, e.g.<10,000 ha, must be captured in their entirety within larger protected areas representing the ecoregion.

3. Reserve Size

Ecological literature indicates that unlike scattered smaller protected areas, **large reserves** allow genes, species, populations, communities and ecosystems to persist over time. Additionally, large reserves can better sustain natural disturbances, and more likely protect species and habitats from exotic invasions, fragmentation and negative edge effects. For sub-arctic boreal forest regions, large reserves of **400,000 ha or more** may be required to encompass the variety of habitat changes associated with long-term fire frequency. Furthermore maintaining viable population sizes for large carnivores and migratory ungulates such as caribou requires large reserves to include those species' normal pattern of distribution.

- At least one reserve of 400,000+ ha is required in each ecoregion; such an area will be identified to include a wide variety of landscape units. Where establishing these large sites is not possible, two or more reserves of 200,000+ ha is a less preferred but acceptable option.

The objective of this requirement is to locate and design at least one large, or several reasonably large reserves in each ecoregion in order to capture representative portions of a wide variety of landscape units in one area. In addition, such a "large-area" approach will also identify reserves that have a high probability to:

- Include a wide variety of wildlife habitats
- Incorporate characteristic stages of habitat succession
- Accommodate normal disturbance influences
- Maintain ecological processes over reasonably long periods of time
- Sustain land and water systems that can withstand outside environmental changes
- Preserve areas for sensitive species with large home-range requirements

In cases where establishing one or more large core reserves to achieve these objectives is not possible, landscape units can be represented by a number of smaller reserves throughout the ecoregion. The habitat requirements of many (but not all) species may be met by such a system of smaller and preferably linked protected areas.

4. Reserve boundary criteria

A GIS-based selection model similar to that described for Saskatchewan has been used to identify portions of Northwest Territories ecoregions that most efficiently capture the unrepresented diversity of landscape units. Within 400,000 ha quadrats, or windows, the model combines values for rarity (proportional representation), current area protected, and number and area of unrepresented landscape units, into window scores that are mapped to display the optimal locations of large core reserves. This procedure locates the general area, or centroid of potential large reserves using landscape unit analysis, however ideally most reserves will incorporate other land, species and habitat considerations, and be part of a protected areas network that also deals with connectivity and buffer zones.

- Reserve boundaries identified initially through landscape unit representation will be refined using available additional ecological information, which may include one or more of the following:

  - Watersheds, headwaters, wetlands and estuaries
  - Concentrated occurrence of rare species, or rare or unusual plant or animal communities
  - Areas of unusually high productivity or species diversity
  - Delineated home ranges of focal species
  - Locations of animal concentration areas or important phases of their life cycle
  - Diverse topographical and land cover features and their associated plant and animal communities

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E. Expanded Methods for Development Interest Index

Development Interest Index: Quantifying Third Party development interests

Methods

Data for each general 3rd party interest category were grouped (see table 5.2 for categories and data used). Standard z-scores (n - mean(N) / standard deviation(N), where n is a planning unit summary measure and N is overall population distribution) of physical measurements (e.g. number of points, km of line features) were calculated to produce sub-index values of similar scale. A composite development interest index was calculated as the natural log of the mean sub-index for each category +1 scaled to be between 0 and 100. These transformations reduced variance in the data and resulted in a more uniform distribution of values that reflected relative intensity of 3rd party interests.

Table 5.2 Summary of data and attributes used for Development Interest Index

Category	Attribute	Type	Measure	Sub-index
Mining				
	Mine_drilled	Point	# per pu	z-transformed (subtract mean, divide by std)
	Mine_abandoned	Point	# per pu	z-transformed
	Mine_renewed	Point	# per pu	z-transformed
	Claim	Boolean	mining claim (y or n)	z-transformed
Oil and Gas				
	Pipeline - proposed	Line	km per pu	z-transformed
	Pipeline	Polygon	ha per pu	z-transformed
	Pipeline – proposed facilities (point)	Point	# per pu	z-transformed
	Seismic Line	Line	km per pu	z-transformed
	Oil and Gas claim	Boolean	Oil and Gas clim	z-transformed
Category	**Attribute**	**Type**	**Measure**	**Sub-index**
Road				
	All-season	Line	km per pu	z-transformed
	Winter	Line	km per pu	z-transformed
Towns				
	Presence	Buffered point	ha within 1km	z-transformed
Human Presence				
	Lodges and Camps	Buffered point	ha within 250m	z-transformed
	Trails	Line	km trails	z-transformed
Development Interest Index				
				mean for each category
				log transformation
				scale between 0 - 100

Summary Index

A single development interest index , for each analysis unit, was derived by calculating the sum of the mean values for each category, then log transforming that number and converting to a score between zero and one-hundred. This index provides a measure of the number of development interests – a rough measure of development likelihood or threat by planning unit. Separate indices can also be calculated for each category (Mining, Oil and Gas, Roads and Human Habitation).

F. Ecoregional Distribution of Landscape Units by Protection Type

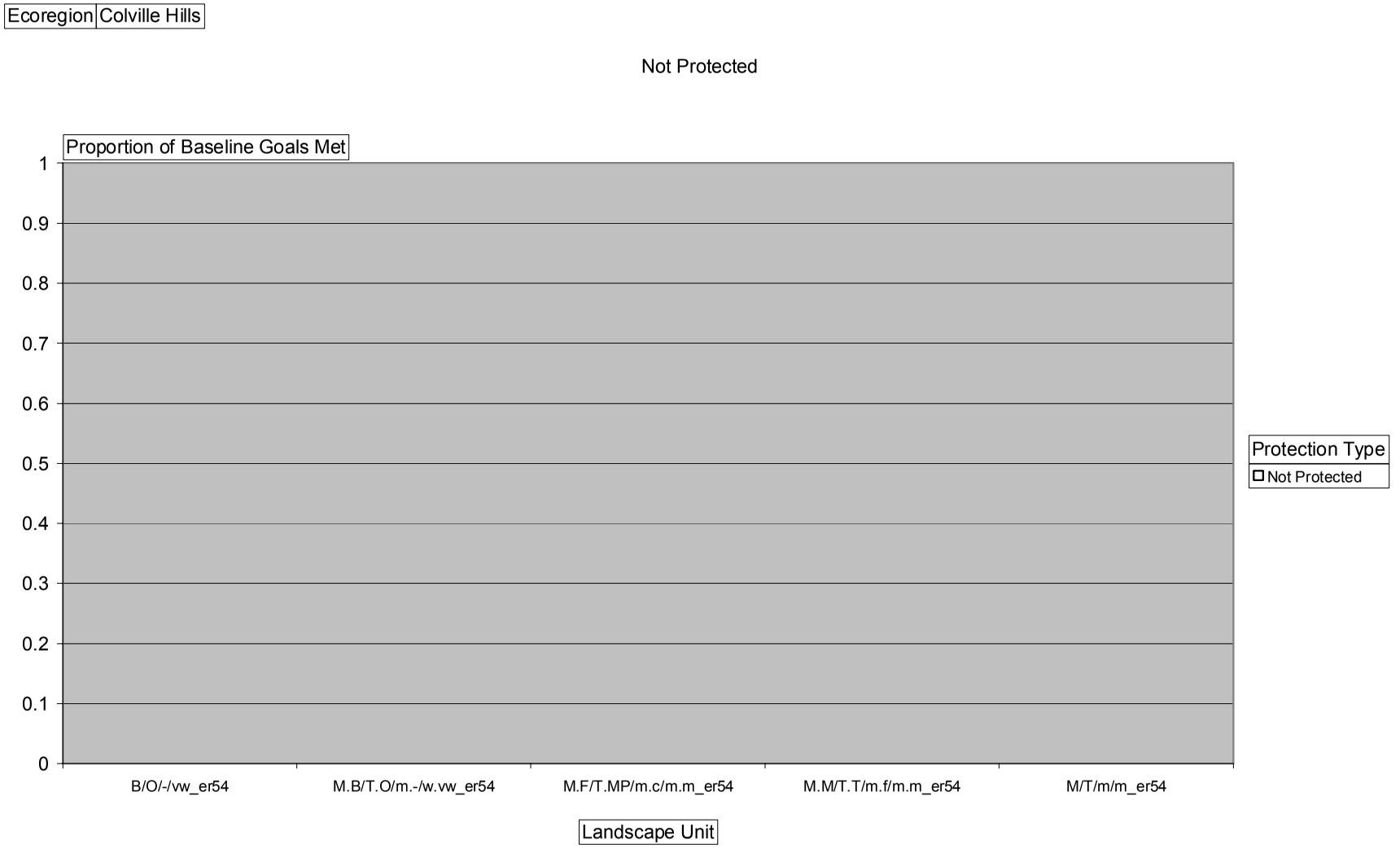
APPENDIX E

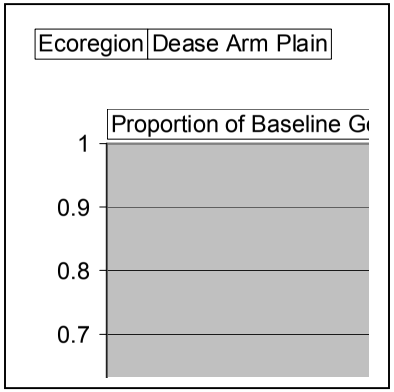
REPRESENTATION OF LANDSCAPE UNITS IN EXISTING LEGISLATED PROTECTED AREAS AND NWT-PAS PROPOSALS

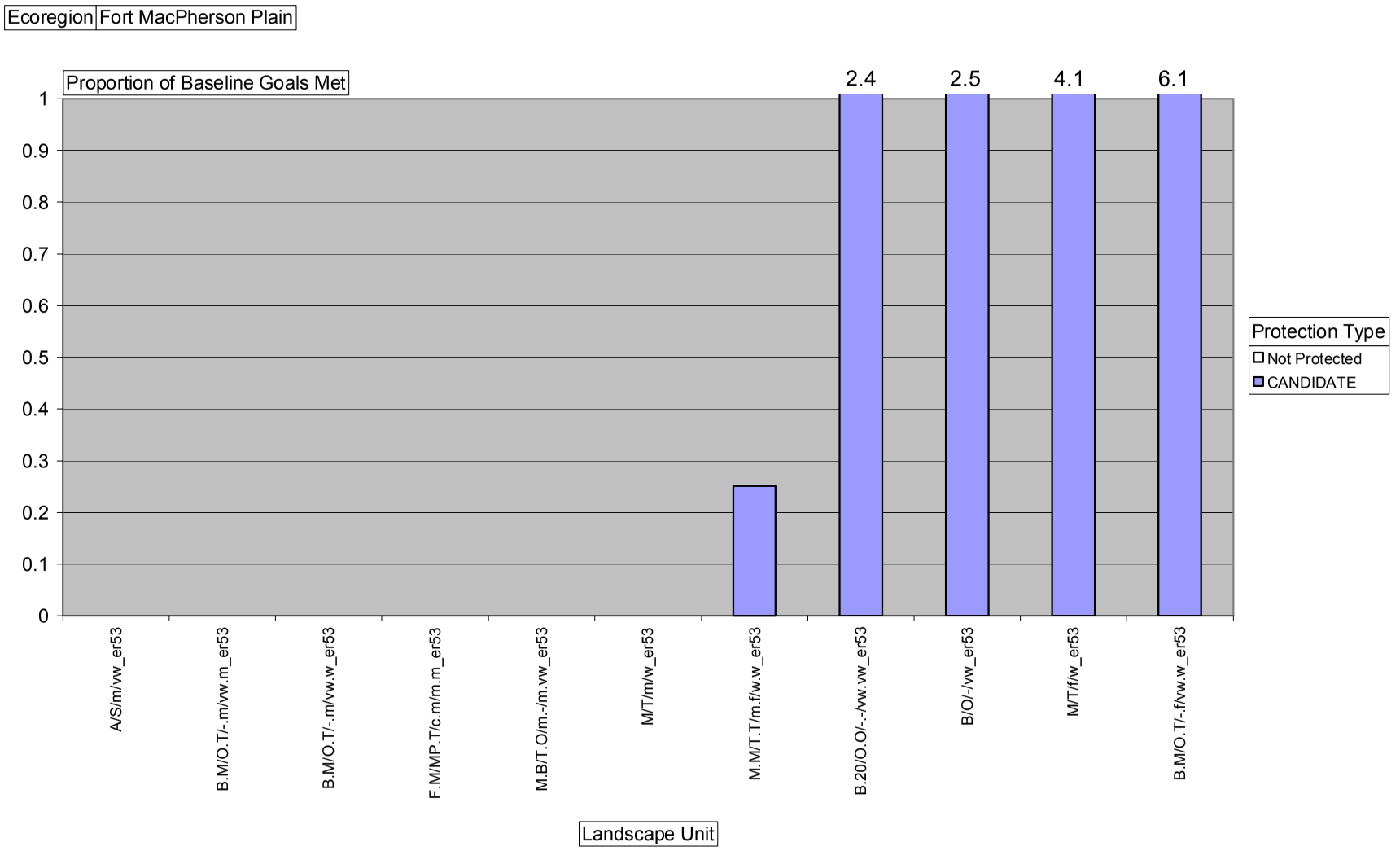
The following charts describe Landscape Unit representation by existing legislated protected areas and NWT-PAS proposals, by ecoregion. Results are based on the proportion of baseline goals met as described by the following:

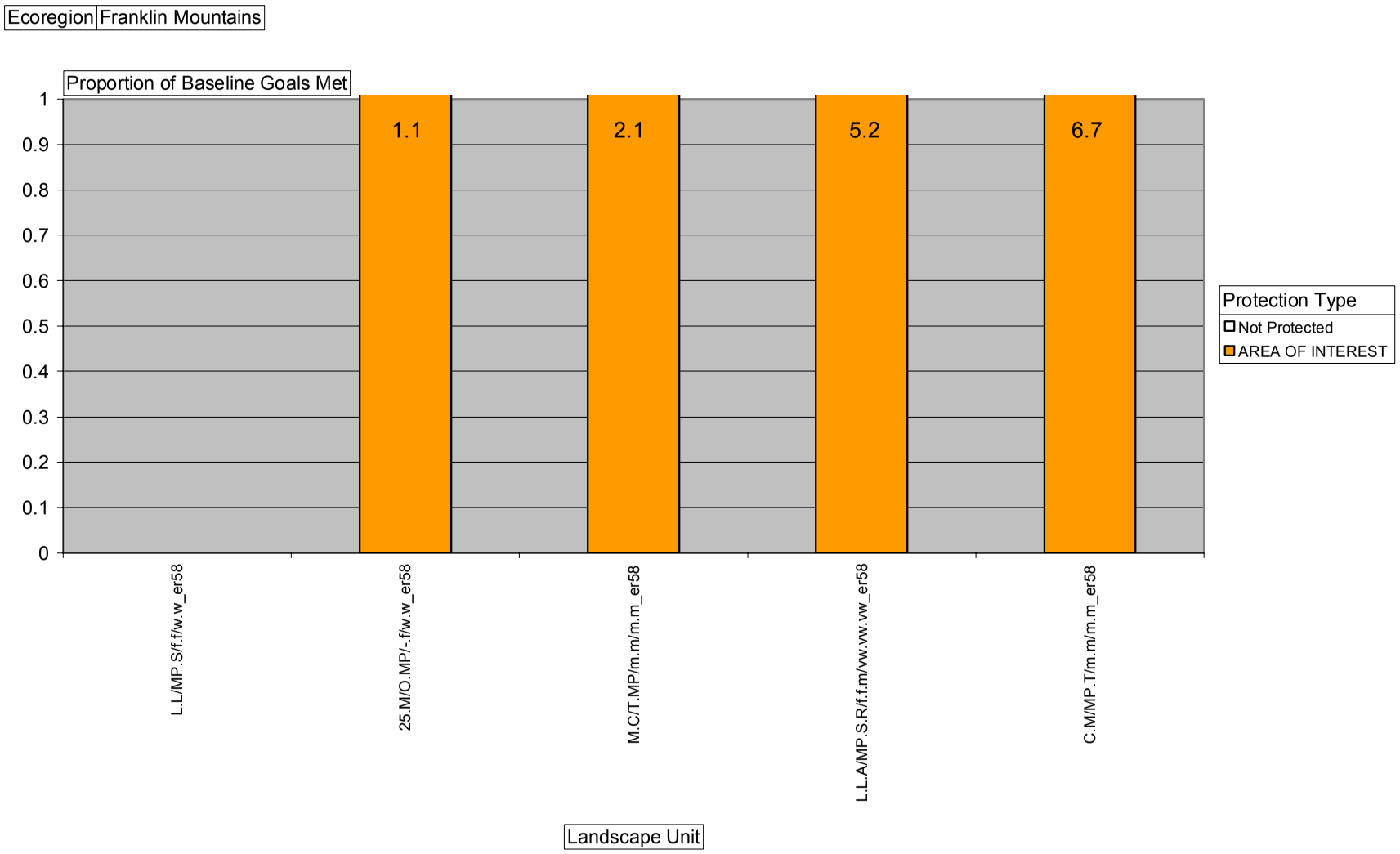
Goal	Landscape Unit Size:
10%	>500,000 ha
15%	100,000 to 500,000 ha
20%	30,000 to 100,000 ha
25%	10,000ha to 30,000 ha
100%	<10,000 ha

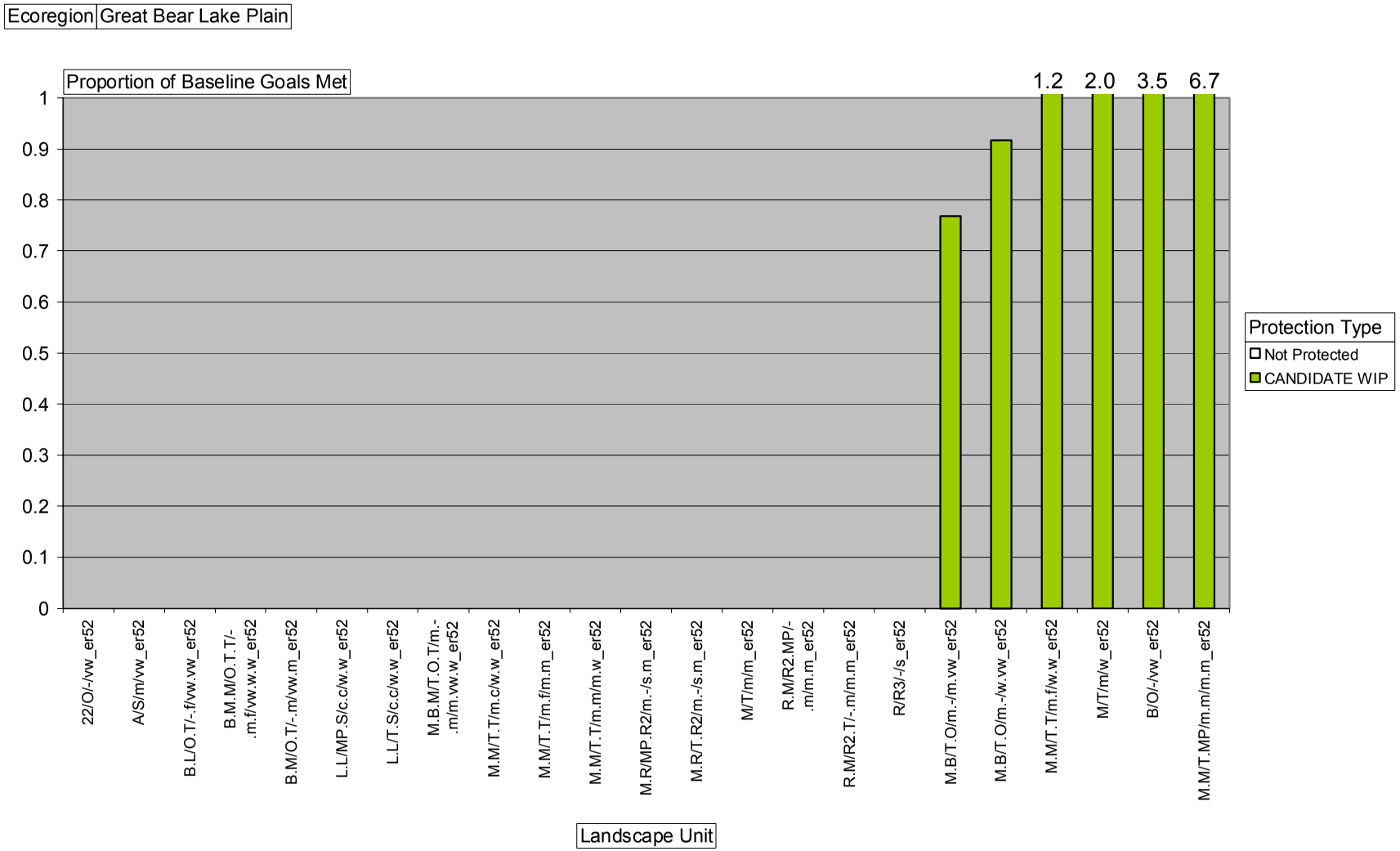
For each ecoregion, all the Landscape Unit types that are found in the ecoregion are described along the x-axis. The proportion of the goal met is described along the y-axis e.g. if 100% of a stated representation goal is met for a Landscape Unit type, the proportion of goal met would equal 1. Many Landscape Units are not represented at all by existing or proposed protected areas, while others are substantially over-represented (i.e. proportion of goal met >1). In the charts below, for Landscape Units with a proportional representation greater than 1, the factor of overrepresentation is expressed as a number at the top of the bar.

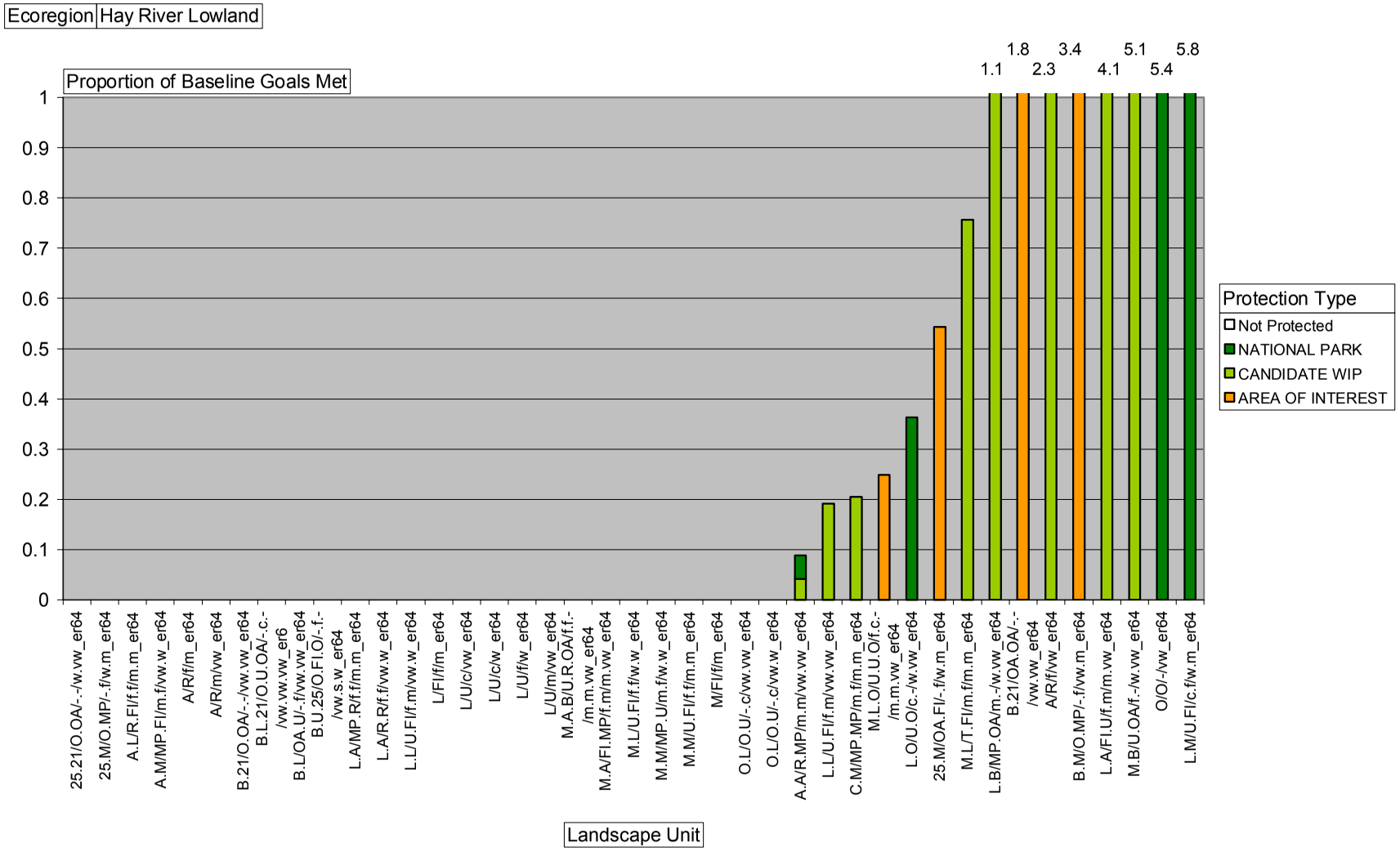

Ecoregion Colville Hills
Not Protected
Proportion of Baseline Goals Met
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
B/O/-/vw_er54
M.B/T.O/m.-/w.vw_er54
M.F/T.MP/m.c/m.m_er54
M.M/T.T/m.f/m.m_er54
M/T/m/m_er54
Landscape Unit
Protection Type
Not Protected

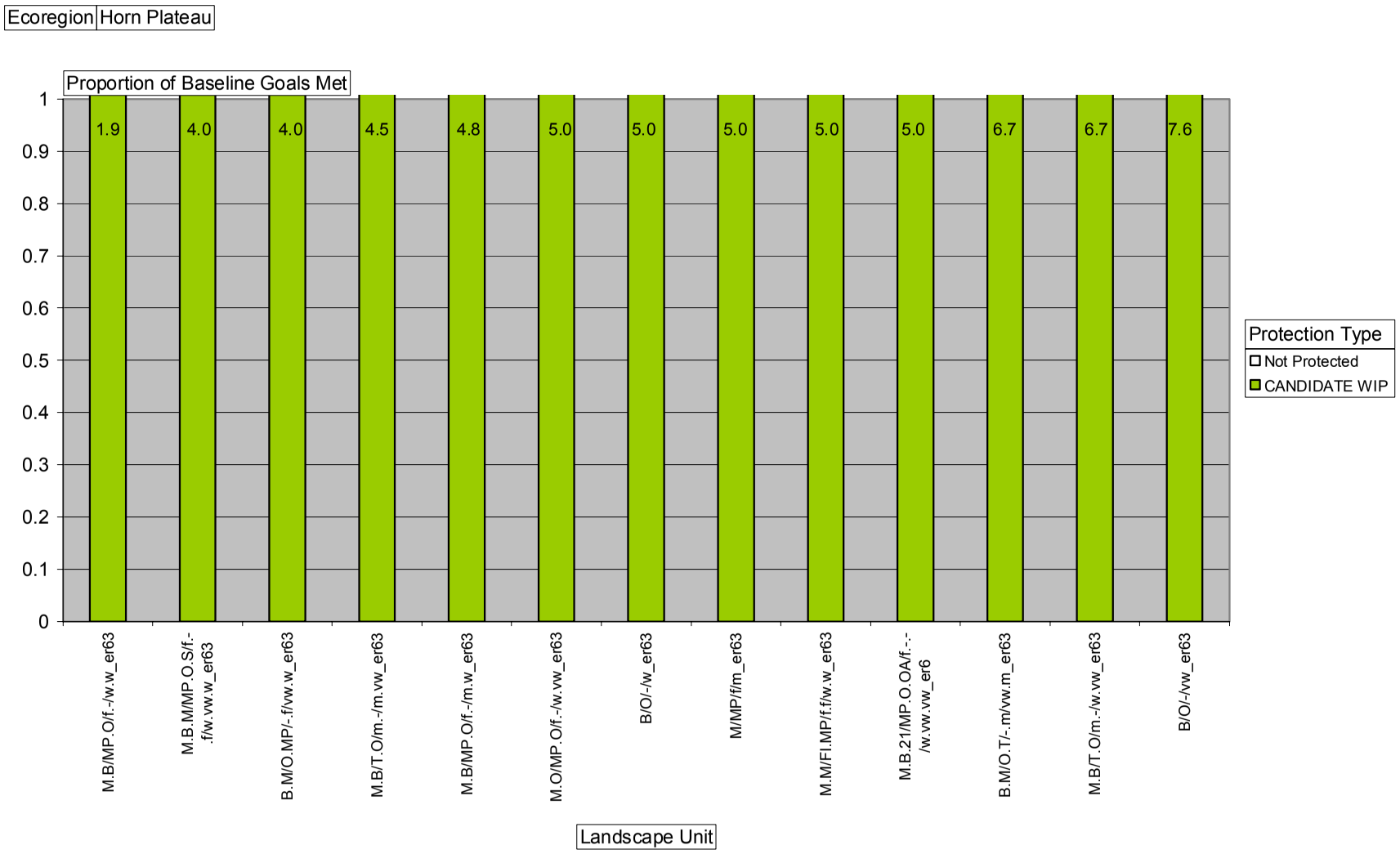

Ecoregion
Dease Arm Plain
Proportion of Baseline G
1
0.9
0.8
0.7

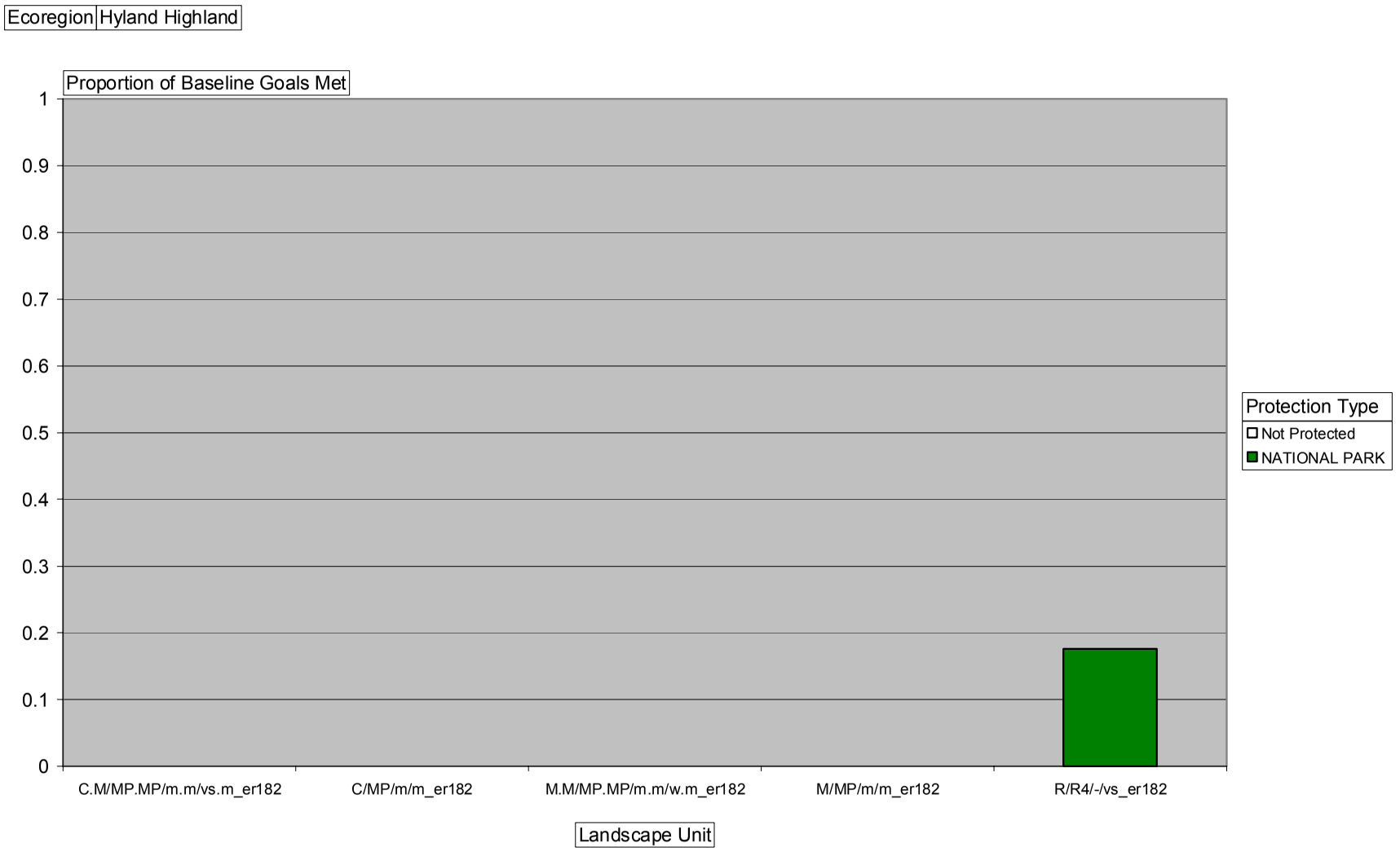

Ecoregion
Fort MacPherson Plain
Proportion of Baseline Goals Met
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2.4
2.5
4.1
6.1
A/S/m/vw_er53
B.M/O.T/-.m/vw.m_er53
B.M/O.T/-.m/vw.w_er53
F.M/MP.T/c.m/m.m_er53
M.B/T.O/m.-/m.vw_er53
M/T/m/w_er53
M.M/T.T/m.f/w.w_er53
B.20/O.O/-.-/vw.vw_er53
B/O/-/vw_er53
M/T/f/w_er53
B.M/O.T/-.f/vw.w_er53
Landscape Unit
Protection Type
Not Protected
CANDIDATE

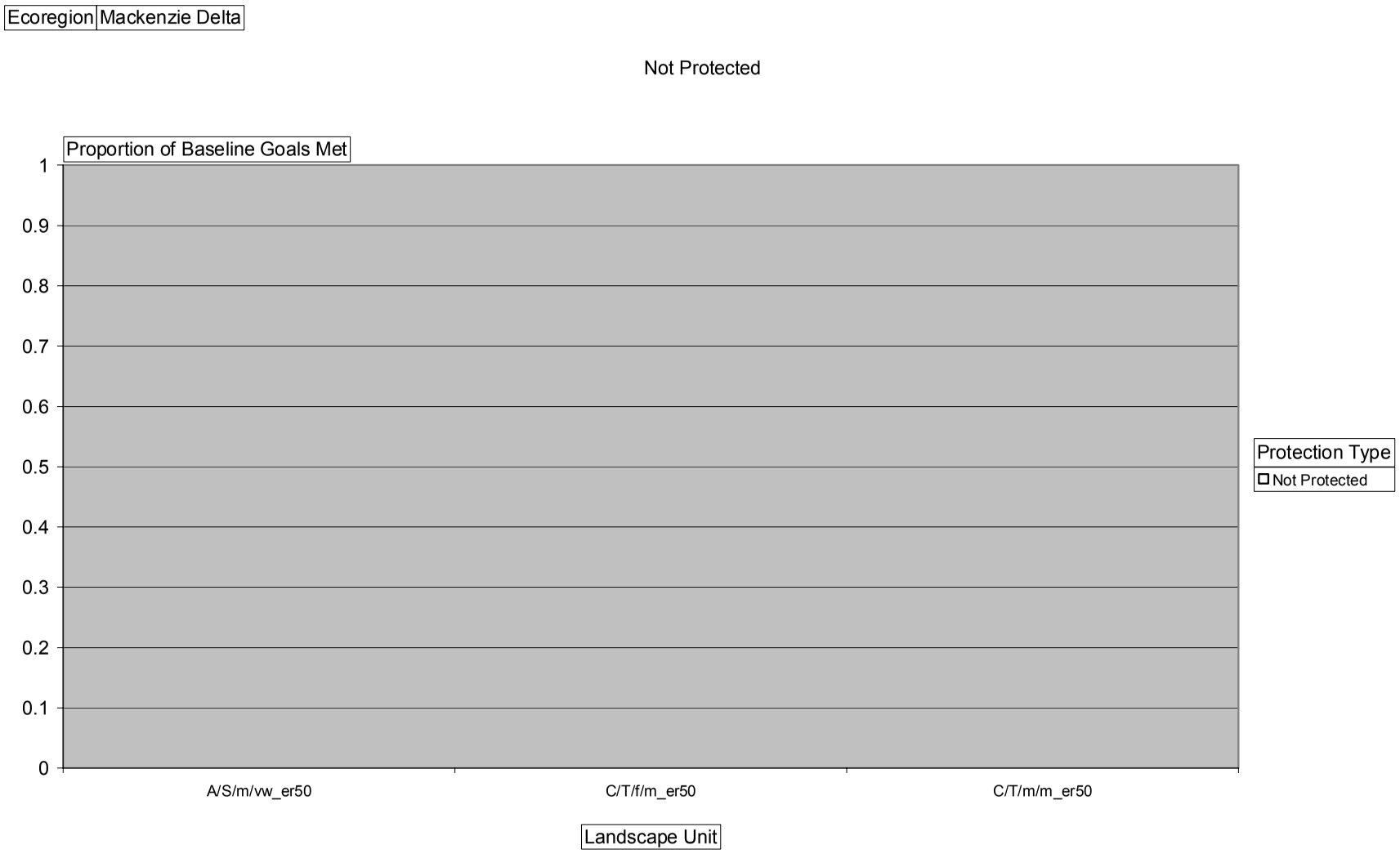

Ecoregion Franklin Mountains
Proportion of Baseline Goals Met
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1.1
2.1
5.2
6.7
Protection Type
Not Protected
AREA OF INTEREST
L.L/MP.S/f.f/w.w_er58
25.M/O.MP/-.f/w.w_er58
M.C/T.MP/m.m/m.m_er58
L.L.A/MP.S.R/f.f.m/vw.vw.vw_er58
C.M/MP.T/m.m/m.m_er58
Landscape Unit

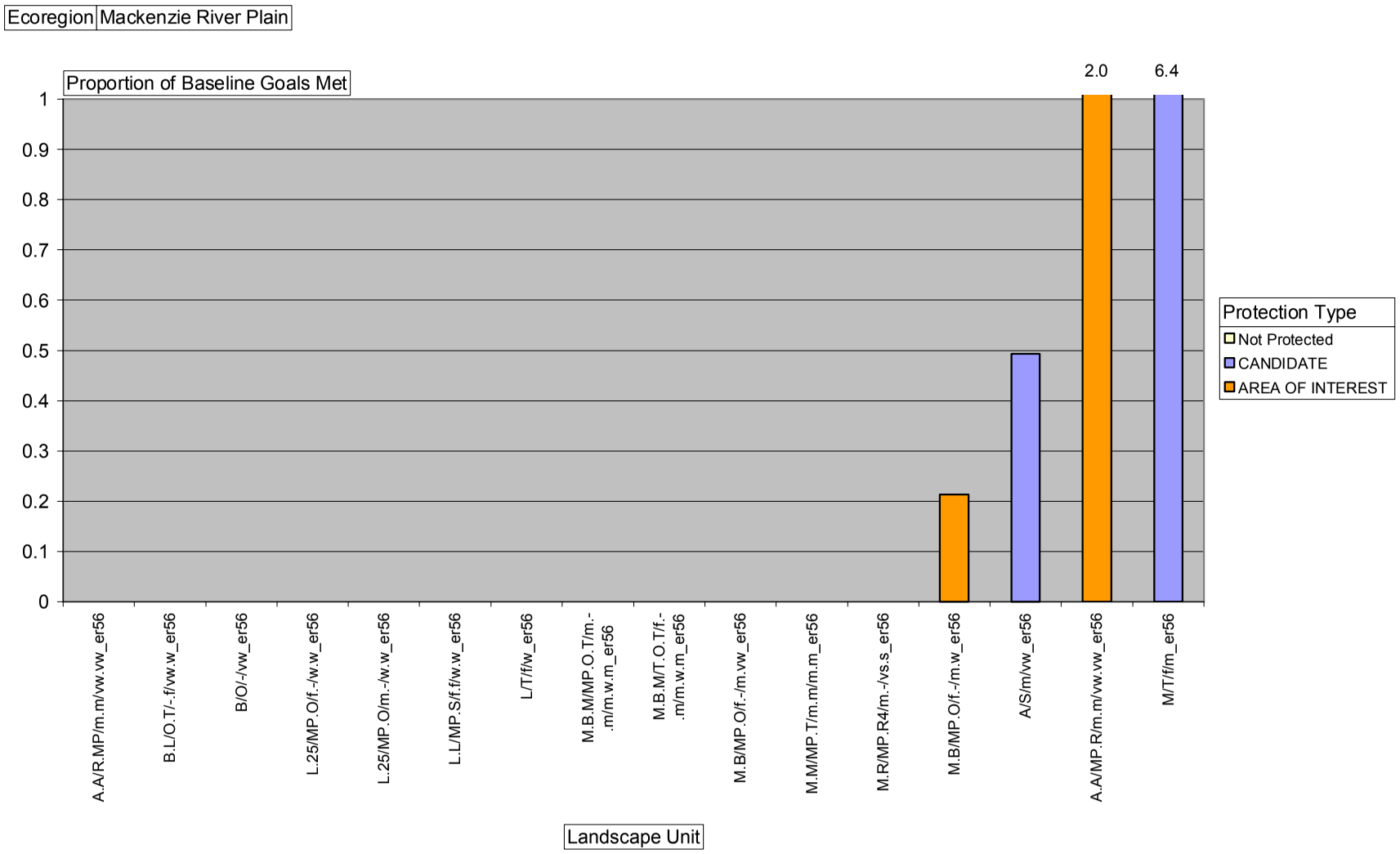

Ecoregion Great Bear Lake Plain
Proportion of Baseline Goals Met
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1.2
2.0
3.5
6.7
22/O/-/vw_er52
A/S/m/vw_er52
B.L/O.T/-.f/vw.vw_er52
B.M.M/O.T.T/-.m.f/vw.w.w_er52
B.M/O.T/-.m/vw.m_er52
L.L/MP.S/c.c/w.w_er52
L.L/T.S/c.c/w.w_er52
M.B.M/T.O.T/m.-.m/m.vw.w_er52
M.M/T.T/m.c/w.w_er52
M.M/T.T/m.f/m.m_er52
M.M/T.T/m.m/m.w_er52
M.R/MP.R2/m.-/s.m_er52
M.R/T.R2/m.-/s.m_er52
M/T/m/m_er52
R.M/R2.MP/-.m/m.m_er52
R.M/R2.T/-.m/m.m_er52
R/R3/-/s_er52
M.B/T.O/m.-/m.vw_er52
M.B/T.O/m.-/w.vw_er52
M.M/T.T/m.f/w.w_er52
M/T/m/w_er52
B/O/-/vw_er52
M.M/T.MP/m.m/m.m_er52
Landscape Unit
Protection Type
Not Protected
CANDIDATE WIP

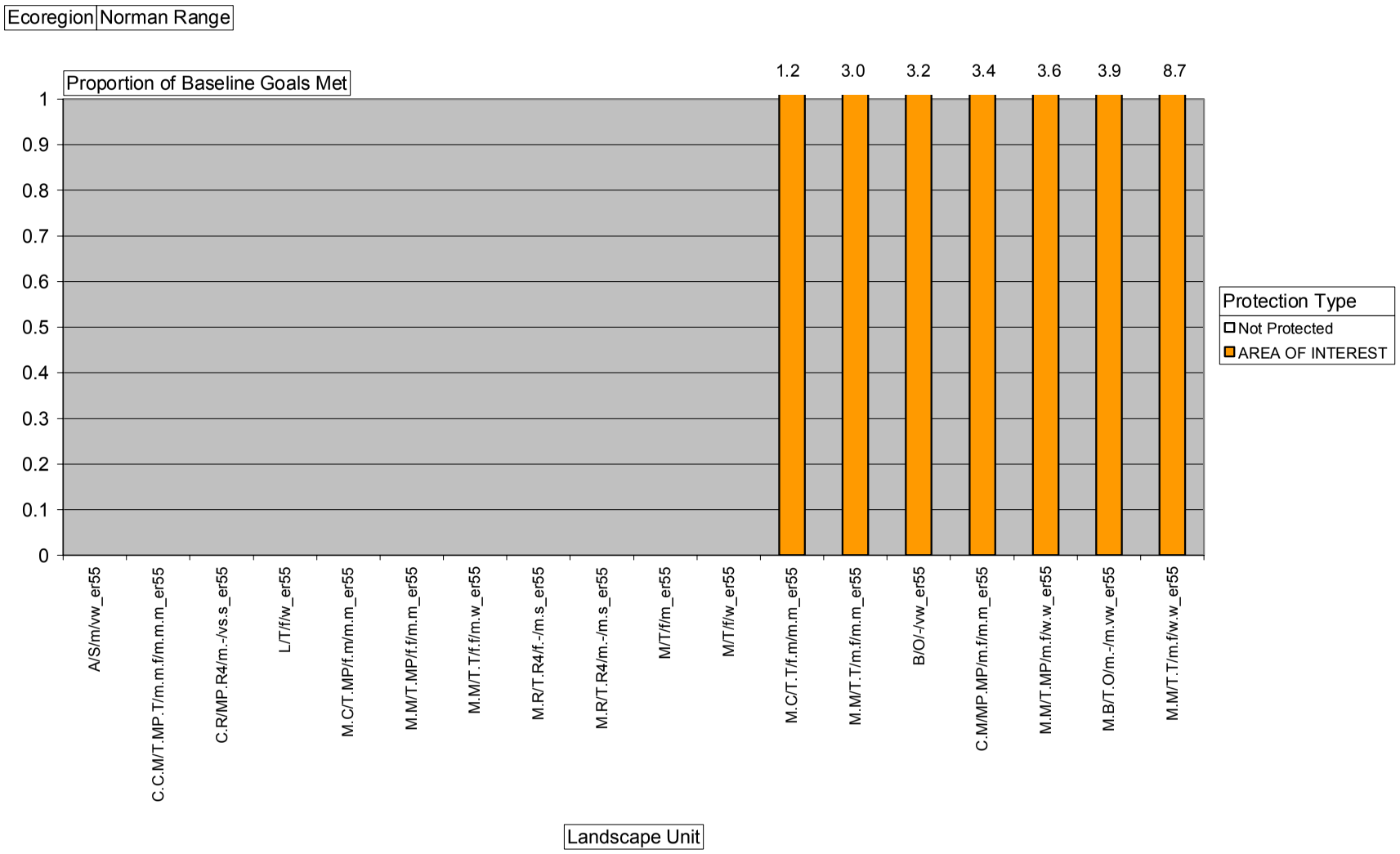

Ecoregion Hay River Lowland
Proportion of Baseline Goals Met
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1.1
1.8
2.3
3.4
4.1
5.1
5.4
5.8
Protection Type
Not Protected
NATIONAL PARK
CANDIDATE WIP
AREA OF INTEREST
25.21/O.OA/-.-/w.vw_er64
25.M/O.MP/-.f/w.m_er64
A.L/R.Fl/f.f/m.m_er64
A.M/MP.Fl/m.f/vw.w_er64
A/R/f/m_er64
A/R/m/vw_er64
B.21/O.OA/-.-/vw.vw_er64
B.L.21/O.U.OA/-.c.-/vw.vw.vw_er6
B.L/OA.U/-.f/vw.vw_er64
B.U.25/O.Fl.O/-.f.-/vw.s.w_er64
L.A/MP.R/f.f/m.m_er64
L.A/R.R/f.f/vw.w_er64
L.L/U.Fl/f.m/vw.w_er64
L/Fl/f/m_er64
L/U/c/vw_er64
L/U/c/w_er64
L/U/f/w_er64
L/U/m/vw_er64
M.A.B/U.R.OA/f.f.-/m.m.vw_er64
M.A/Fl.MP/f.m/m.vw_er64
M.L/U.Fl/f.f/w.w_er64
M.M/MP.U/m.f/w.w_er64
M.M/U.Fl/f.f/m.m_er64
M/Fl/f/m_er64
O.L/O.U/-.c/vw.vw_er64
O.L/O.U/-.c/vw.w_er64
A.A/R.MP/m.m/vw.vw_er64
L.L/U.Fl/f.m/vw.vw_er64
C.M/MP.MP/m.f/m.m_er64
M.L.O/U.U.O/f.c.-/m.m.vw_er64
L.O/U.O/c.-/w.vw_er64
25.M/OA.Fl/-.f/w.m_er64
M.L/T.Fl/m.f/m.m_er64
L.B/MP.OA/m.-/w.vw_er64
B.21/OA.OA/-.-/vw.vw_er64
A/R/f/vw_er64
B.M/O.MP/-.f/vw.m_er64
L.A/Fl.U/f.m/m.vw_er64
M.B/U.OA/f.-/w.vw_er64
O/O/-/vw_er64
L.M/U.Fl/c.f/w.m_er64
Landscape Unit

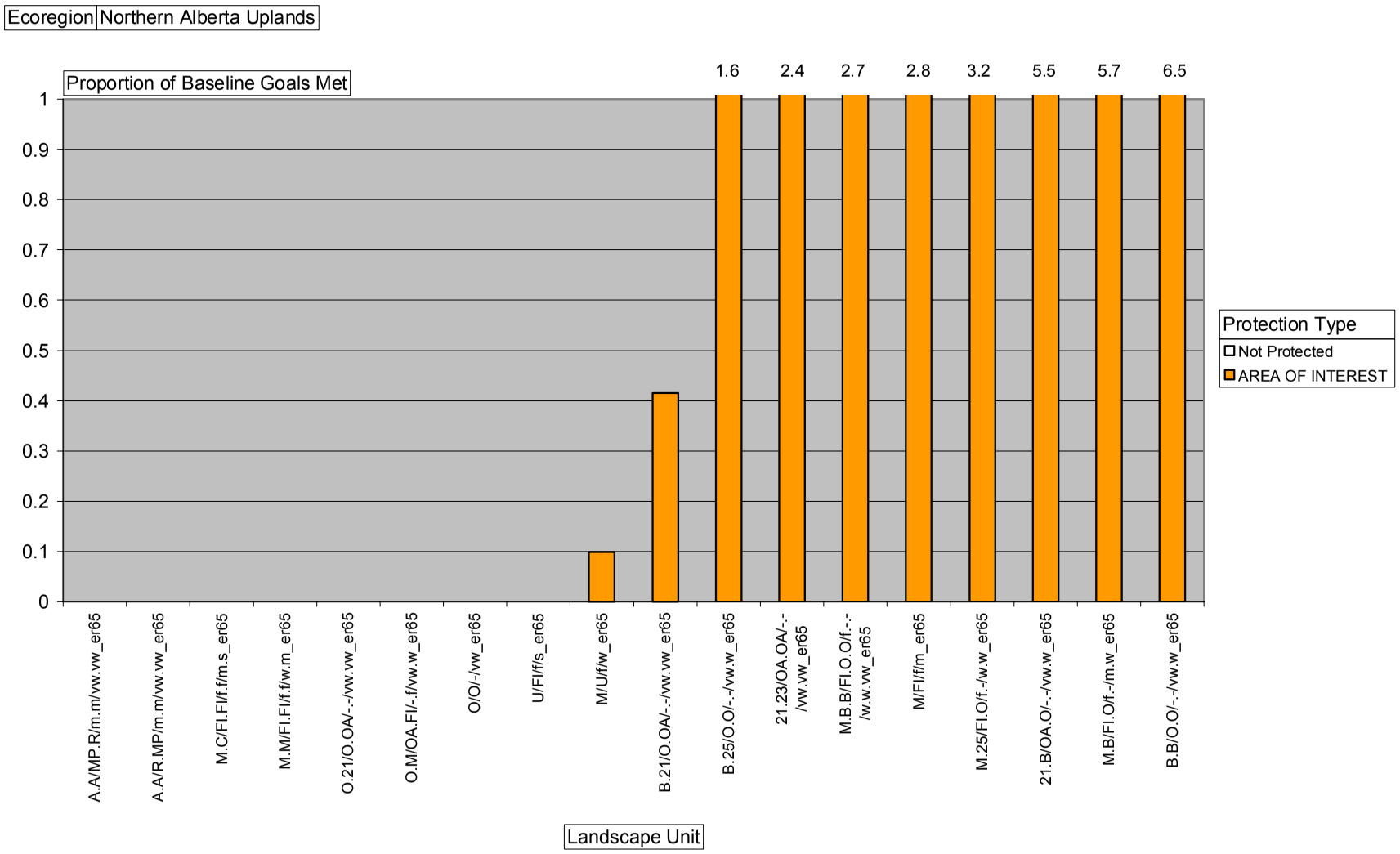

Ecoregion Horn Plateau
Proportion of Baseline Goals Met
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1.9
4.0
4.0
4.5
4.8
5.0
5.0
5.0
5.0
5.0
6.7
6.7
7.6
M.B/MP.O/f.-/w.w_er63
M.B.M/MP.O.S/f.-.f/w.vw.w_er63
B.M/O.MP/-.f/vw.w_er63
M.B/T.O/m.-/m.vw_er63
M.B/MP.O/f.-/m.w_er63
M.O/MP.O/f.-/w.vw_er63
B/O/-/w_er63
M/MP/f/m_er63
M.M/Fl.MP/f.f/w.w_er63
M.B.21/MP.O.OA/f.-.-/w.vw.vw_er6
B.M/O.T/-.m/vw.m_er63
M.B/T.O/m.-/w.vw_er63
B/O/-/vw_er63
Landscape Unit
Protection Type
Not Protected
CANDIDATE WIP

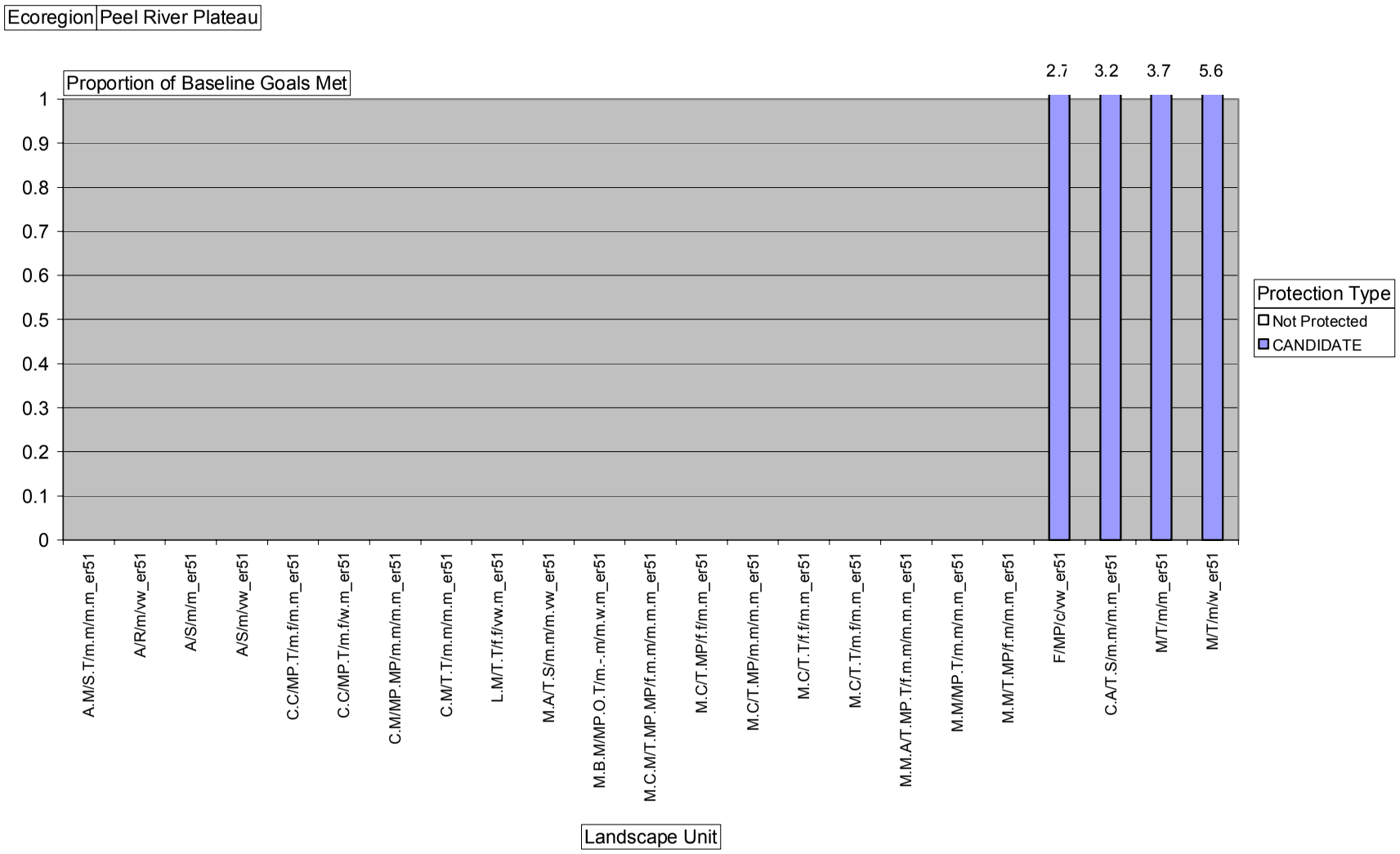

Ecoregion
Hyland Highland
Proportion of Baseline Goals Met
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
C.M/MP.MP/m.m/vs.m_er182
C/MP/m/m_er182
M.M/MP.MP/m.m/w.m_er182
M/MP/m/m_er182
R/R4/-/vs_er182
Landscape Unit
Protection Type
Not Protected
NATIONAL PARK

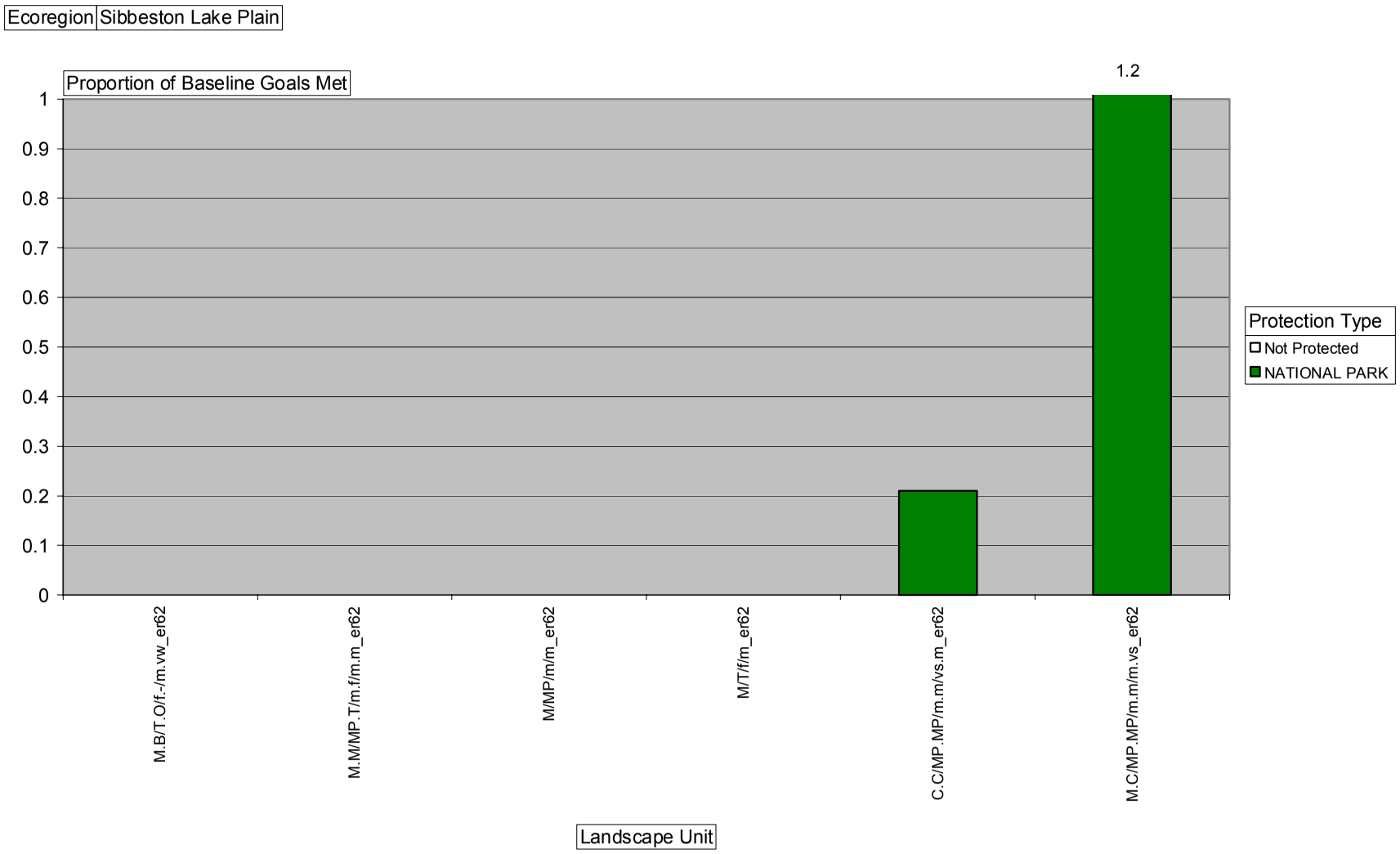

Ecoregion
Mackenzie Delta
Not Protected
Proportion of Baseline Goals Met
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
A/S/m/vw_er50
C/T/f/m_er50
C/T/m/m_er50
Landscape Unit
Protection Type
Not Protected

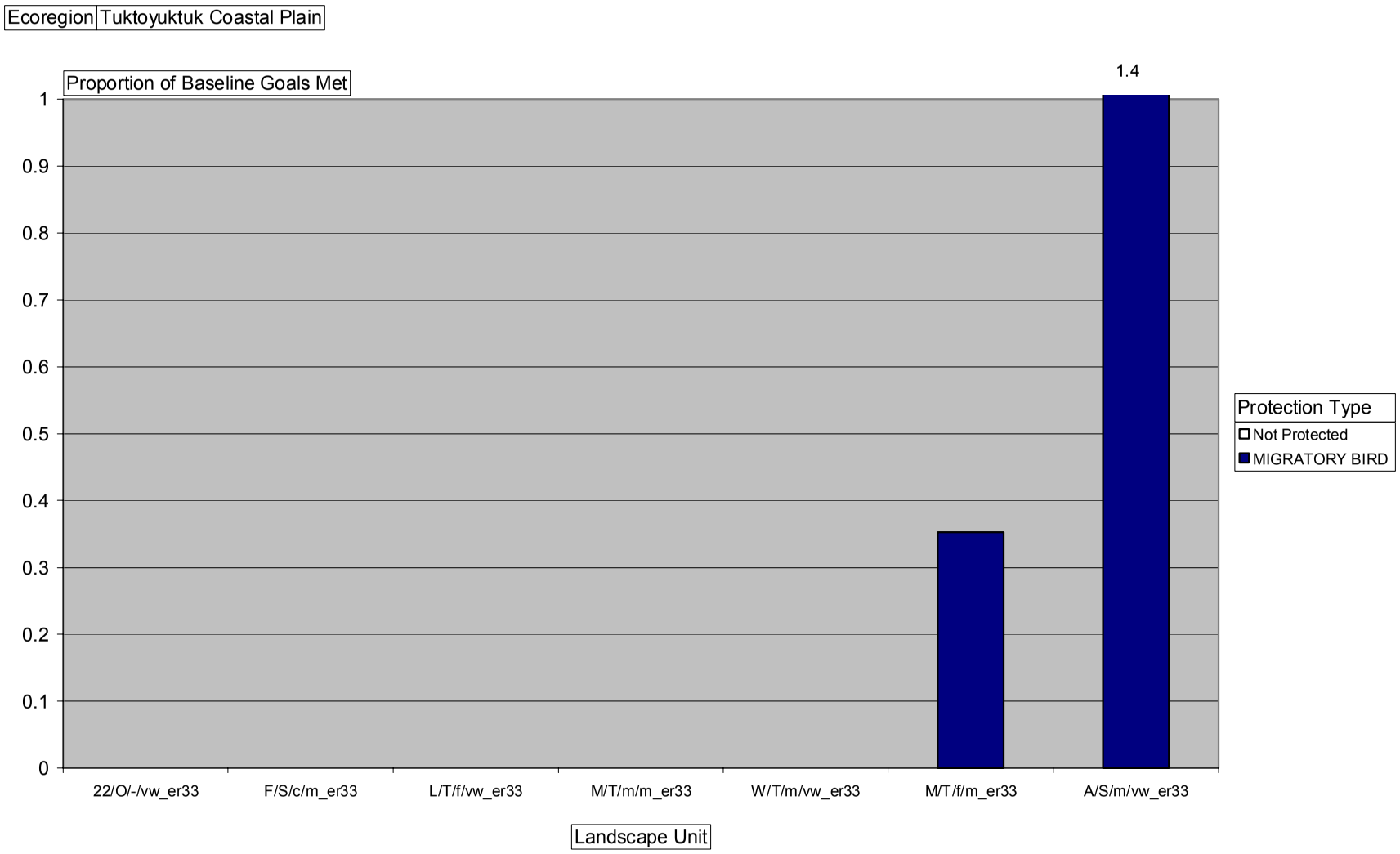

Ecoregion Mackenzie River Plain
Proportion of Baseline Goals Met
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2.0
6.4
Protection Type
Not Protected
CANDIDATE
AREA OF INTEREST
A.A/R.MP/m.m/vw.vw_er56
B.L/O.T/-.f/vw.w_er56
B/O/-/vw_er56
L.25/MP.O/f.-/w.w_er56
L.25/MP.O/m.-/w.w_er56
L.L/MP.S/f.f/w.w_er56
L/T/f/w_er56
M.B.M/MP.O.T/m.-.m/m.w.m_er56
M.B.M/T.O.T/f.-.m/m.w.m_er56
M.B/MP.O/f.-/m.vw_er56
M.M/MP.T/m.m/m.m_er56
M.R/MP.R4/m.-/vs.s_er56
M.B/MP.O/f.-/m.w_er56
A/S/m/vw_er56
A.A/MP.R/m.m/vw.vw_er56
M/T/f/m_er56
Landscape Unit


Ecoregion
Norman Range
Proportion of Baseline Goals Met
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1.2
3.0
3.2
3.4
3.6
3.9
8.7
A/S/m/vw_er55
C.C.M/T.MP.T/m.m.f/m.m.m_er55
C.R/MP.R4/m.-/vs.s_er55
L/T/f/w_er55
M.C/T.MP/f.m/m.m_er55
M.M/T.MP/f.f/m.m_er55
M.M/T.T/f.f/m.w_er55
M.R/T.R4/f.-/m.s_er55
M.R/T.R4/m.-/m.s_er55
M/T/f/m_er55
M/T/f/w_er55
M.C/T.T/f.m/m.m_er55
M.M/T.T/m.f/m.m_er55
B/O/-/vw_er55
C.M/MP.MP/m.f/m.m_er55
M.M/T.MP/m.f/w.w_er55
M.B/T.O/m.-/m.vw_er55
M.M/T.T/m.f/w.w_er55
Landscape Unit
Protection Type
Not Protected
AREA OF INTEREST


Ecoregion
Northern Alberta Uplands
Proportion of Baseline Goals Met
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1.6
2.4
2.7
2.8
3.2
5.5
5.7
6.5
A.A/MP.R/m.m/vw.vw_er65
A.A/R.MP/m.m/vw.vw_er65
M.C/FI.FI/f.f/m.s_er65
M.M/FI.FI/f.f/w.m_er65
O.21/O.OA/-.-/vw.vw_er65
O.M/OA.FI/-.f/vw.w_er65
O/O/-/vw_er65
U/FI/f/s_er65
M/U/f/w_er65
B.21/O.OA/-.-/vw.vw_er65
B.25/O.O/-.-/vw.w_er65
21.23/OA.OA/-.-/vw.vw_er65
M.B.B/FI.O.O/f.-.-/w.w.vw_er65
M/FI/f/m_er65
M.25/FI.O/f.-/w.w_er65
21.B/OA.O/-.-/vw.w_er65
M.B/FI.O/f.-/m.w_er65
B.B/O.O/-.-/vw.w_er65
Landscape Unit
Protection Type
Not Protected
AREA OF INTEREST


Ecoregion
Peel River Plateau
Proportion of Baseline Goals Met
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2.7
3.2
3.7
5.6
Protection Type
Not Protected
CANDIDATE
A.M/S.T/m.m/m.m_er51
A/R/m/vw_er51
A/S/m/m_er51
A/S/m/vw_er51
C.C/MP.T/m.f/m.m_er51
C.C/MP.T/m.f/w.m_er51
C.M/MP.MP/m.m/m.m_er51
C.M/T.T/m.m/m.m_er51
L.M/T.T/f.f/vw.m_er51
M.A/T.S/m.m/m.vw_er51
M.B.M/MP.O.T/m.-.m/m.w.m_er51
M.C.M/T.MP.MP/f.m.m/m.m.m_er51
M.C/T.MP/f.f/m.m_er51
M.C/T.MP/m.m/m.m_er51
M.C/T.T/f.f/m.m_er51
M.C/T.T/m.f/m.m_er51
M.M.A/T.MP.T/f.m.m/m.m.m_er51
M.M/MP.T/m.m/m.m_er51
M.M/T.MP/f.m/m.m_er51
F/MP/c/vw_er51
C.A/T.S/m.m/m.m_er51
M/T/m/m_er51
M/T/m/w_er51
Landscape Unit


Ecoregion
Sibbeston Lake Plain
Proportion of Baseline Goals Met
1.2
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
M.B/T.O/f.-/m.vw_er62
M.M/MP.T/m.f/m.m_er62
M/MP/m/m_er62
M/T/f/m_er62
C.C/MP.MP/m.m/vs.m_er62
M.C/MP.MP/m.m/m.vs_er62
Landscape Unit
Protection Type
Not Protected
NATIONAL PARK


Ecoregion
Tuktoyuktuk Coastal Plain
Proportion of Baseline Goals Met
1.4
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
22/O/-/vw_er33
F/S/c/m_er33
L/T/f/vw_er33
M/T/m/m_er33
W/T/m/vw_er33
M/T/f/m_er33
A/S/m/vw_er33
Landscape Unit
Protection Type
Not Protected
MIGRATORY BIRD

G. Landscape Unit Representation by Individual Legislated Protected/NWT-Pas Proposal Area.

Table G.1 Percentage gap to meet baseline representation goals for Landscape Units, assuming all existing legislated protected areas and NWT-PAS proposals were protected.

Landscape Unit Name (combined w ecoregion)	Goal (%)	Total Ha of Landscape Unit	Ha required to meet baseline goal	Ecoregion	% Gap to meet Goal (negative numbers indicate over-representation)
21.23/OA.OA/-.-/vw.vw_er65	25%	25262.249	6315.5622	Northern Alberta Uplands	-142.92%
21.B/OA.O/-.-/vw.w_er65	15%	212128.846	31819.3269	Northern Alberta Uplands	-445.64%
22/O/-/vw_er33	15%	229299.973	34394.9959	Tuktoyuktuk Coastal Plain	100.00%
22/O/-/vw_er52	25%	17253.406	4313.3515	Great Bear Lake Plain	100.00%
25.21/O.OA/-.-/w.vw_er64	20%	98386.06	19677.212	Hay River Lowland	100.00%
25.M/O.MP/-.f/w.m_er64	20%	75639.523	15127.9046	Hay River Lowland	100.00%
25.M/O.MP/-.f/w.w_er58	15%	107455.996	16118.3994	Franklin Mountains	-8.19%
25.M/OA.FI/-.f/w.m_er64	15%	239544.018	35931.6027	Hay River Lowland	45.66%
A.A/MP.R/m.m/vw.vw_er56	25%	27230.045	6807.5112	Mackenzie River Plain	-95.50%
A.A/MP.R/m.m/vw.vw_er65	20%	33091.199	6618.2398	Northern Alberta Uplands	100.00%
A.A/R.MP/m.m/vw.vw_er56	25%	17142.108	4285.527	Mackenzie River Plain	100.00%
A.A/R.MP/m.m/vw.vw_er64	15%	199498.88	29924.832	Hay River Lowland	91.11%
A.A/R.MP/m.m/vw.vw_er65	100%	2160.114	2160.114	Northern Alberta Uplands	100.00%
A.L/R.FI/f.f/m.m_er64	25%	24995.31	6248.8275	Hay River Lowland	100.00%
A.M/MP.FI/m.f/vw.w_er64	25%	11066.394	2766.5985	Hay River Lowland	100.00%
A.M/S.T/m.m/m.m_er51	25%	25953.91	6488.4775	Peel River Plateau	100.00%
A/R/f/m_er64	100%	4027.926	4027.926	Hay River Lowland	100.00%
A/R/f/vw_er64	20%	45170.561	9034.1122	Hay River Lowland	-132.41%
A/R/m/vw_er51	25%	20797.158	5199.2895	Peel River Plateau	100.00%
A/R/m/vw_er64	100%	7947.601	7947.601	Hay River Lowland	100.00%
A/S/m/m_er51	20%	37396.777	7479.3554	Peel River Plateau	100.00%
A/S/m/vw_er33	15%	239363.249	35904.4874	Tuktoyuktuk Coastal Plain	-40.31%
A/S/m/vw_er35	100%	6426.243	6426.243	Dease Arm Plain	100.00%
A/S/m/vw_er50	10%	800002.19	80000.219	Mackenzie Delta	100.00%
A/S/m/vw_er51	100%	1274.195	1274.195	Peel River Plateau	100.00%
A/S/m/vw_er52	20%	53065.424	10613.0848	Great Bear Lake Plain	100.00%
A/S/m/vw_er53	20%	75352.254	15070.4508	Fort MacPherson Plain	100.00%
A/S/m/vw_er55	20%	36005.067	7201.0134	Norman Range	100.00%
A/S/m/vw_er56	20%	43982.589	8796.5178	Mackenzie River Plain	50.65%
B.20/O.O/-.-/vw.vw_er53	15%	274486.25	41172.9375	Fort MacPherson Plain	-136.87%
B.21/O.OA/-.-/vw.vw_er64	15%	438712.38	65806.857	Hay River Lowland	100.00%
B.21/O.OA/-.-/vw.vw_er65	20%	39937.521	7987.5042	Northern Alberta Uplands	58.47%
B.21/OA.OA/-.-/vw.vw_er64	20%	80225.355	16045.071	Hay River Lowland	-78.58%
B.25/O.O/-.-/vw.w_er65	15%	322231.114	48334.6671	Northern Alberta Uplands	-63.26%
B.B/O.O/-.-/vw.w_er65	15%	201098.049	30164.7073	Northern Alberta Uplands	-553.30%
B.L.21/O.U.OA/-.c.-/vw.vw.vw_er64	15%	203789.057	30568.3585	Hay River Lowland	100.00%

B.L/O.T/-.f/vw.vw_er52	15%	117898.812	17684.8218	Great Bear Lake Plain	100.00%
B.L/O.T/-.f/vw.w_er56	20%	87348.944	17469.7888	Mackenzie River Plain	100.00%
B.L/OA.U/-.f/vw.vw_er64	15%	161510.907	24226.6361	Hay River Lowland	100.00%
B.M.M/O.T.T/-.m.f/vw.w.w_er52	10%	606548.379	60654.8379	Great Bear Lake Plain	100.00%
B.M/O.MP/-.f/vw.m_er64	15%	183054.383	27458.1574	Hay River Lowland	-240.79%
B.M/O.MP/-.f/vw.w_er63	25%	12894.862	3223.7155	Horn Plateau	-300.00%
B.M/O.T/-.f/vw.w_er53	15%	334741.853	50211.2779	Fort MacPherson Plain	-510.86%
B.M/O.T/-.m/vw.m_er52	15%	119110.078	17866.5117	Great Bear Lake Plain	100.00%
B.M/O.T/-.m/vw.m_er53	20%	95483.242	19096.6484	Fort MacPherson Plain	100.00%
B.M/O.T/-.m/vw.m_er63	15%	338273.992	50741.0988	Horn Plateau	-566.67%
B.M/O.T/-.m/vw.w_er53	15%	124142.786	18621.4179	Fort MacPherson Plain	100.00%
B.U.25/O.FI.O/-.f.-/vw.s.w_er64	15%	209004.467	31350.6701	Hay River Lowland	100.00%
B/O/-/vw_er52	15%	137145.923	20571.8885	Great Bear Lake Plain	-252.55%
B/O/-/vw_er53	15%	130089.723	19513.4584	Fort MacPherson Plain	-155.02%
B/O/-/vw_er54	15%	156163.226	23424.4839	Colville Hills	100.00%
B/O/-/vw_er55	10%	1285346.033	128534.6033	Norman Range	-223.84%
B/O/-/vw_er56	20%	46452.885	9290.577	Mackenzie River Plain	100.00%
B/O/-/vw_er63	10%	654084.51	65408.451	Horn Plateau	-664.52%
B/O/-/w_er63	20%	67393.622	13478.7244	Horn Plateau	-400.00%
C.A/T.S/m.m/m.m_er51	20%	80243.24	16048.648	Peel River Plateau	-220.11%
C.C.M/T.MP.T/m.m.f/m.m.m_er55	20%	41102.437	8220.4874	Norman Range	100.00%
C.C/MP.MP/m.m/vs.m_er62	20%	90701.314	18140.2628	Sibbeston Lake Plain	78.97%
C.C/MP.T/m.f/m.m_er51	20%	53023.875	10604.775	Peel River Plateau	100.00%
C.C/MP.T/m.f/w.m_er51	15%	199820.718	29973.1077	Peel River Plateau	100.00%
C.M/MP.MP/m.f/m.m_er55	20%	91137.683	18227.5366	Norman Range	-241.87%
C.M/MP.MP/m.f/m.m_er64	100%	7393.805	7393.805	Hay River Lowland	79.55%
C.M/MP.MP/m.m/m.m_er51	10%	539088.515	53908.8515	Peel River Plateau	100.00%
C.M/MP.MP/m.m/vs.m_er182	20%	53899.282	10779.8564	Hyland Highland	100.00%
C.M/MP.T/m.m/m.m_er58	15%	277631.311	41644.6966	Franklin Mountains	-566.67%
C.M/T.T/m.m/m.m_er51	15%	118809.445	17821.4168	Peel River Plateau	100.00%
C.R/MP.R4/m.-/vs.s_er55	25%	20796.381	5199.0953	Norman Range	100.00%
C/MP/m/m_er182	25%	19702.246	4925.5615	Hyland Highland	100.00%
C/T/f/m_er50	100%	2466.47	2466.47	Mackenzie Delta	100.00%
C/T/m/m_er50	100%	4882.918	4882.918	Mackenzie Delta	100.00%
F.M/MP.T/c.m/m.m_er53	20%	62912.574	12582.5148	Fort MacPherson Plain	100.00%
F/MP/c/m_er35	20%	90818.474	18163.6948	Dease Arm Plain	100.00%
F/MP/c/vw_er51	20%	42849.121	8569.8242	Peel River Plateau	-166.71%
F/S/c/m_er33	15%	354799.924	53219.9886	Tuktoyuktuk Coastal Plain	100.00%
F/S/c/m_er35	20%	45337.546	9067.5092	Dease Arm Plain	100.00%
L.25/MP.O/f.-/w.w_er56	25%	13975.13	3493.7825	Mackenzie River Plain	100.00%
L.25/MP.O/m.-/w.w_er56	25%	10893.363	2723.3407	Mackenzie River Plain	100.00%
L.A/FI.U/f.m/m.vw_er64	20%	48776.295	9755.259	Hay River Lowland	-306.90%
L.A/MP.R/f.f/m.m_er64	25%	13009.859	3252.4648	Hay River Lowland	100.00%
L.A/R.R/f.f/vw.w_er64	20%	92839.591	18567.9182	Hay River Lowland	100.00%
L.B/MP.OA/m.-/w.vw_er64	15%	144338.899	21650.8348	Hay River Lowland	-12.87%
L.L.A/MP.S.R/f.f.m/vw.vw.vw_er58	15%	126842.13	19026.3195	Franklin Mountains	-423.40%
L.L/MP.S/c.c/w.w_er52	15%	157469.917	23620.4875	Great Bear Lake Plain	100.00%
L.L/MP.S/f.f/w.w_er56	20%	30249.591	6049.9182	Mackenzie River Plain	100.00%
L.L/MP.S/f.f/w.w_er58	20%	93993.961	18798.7922	Franklin Mountains	100.00%
L.L/T.S/c.c/w.w_er52	100%	9565.151	9565.151	Great Bear Lake Plain	100.00%
L.L/U.FI/f.m/vw.vw_er64	20%	58129.598	11625.9196	Hay River Lowland	80.87%
L.L/U.FI/f.m/vw.w_er64	25%	20940.535	5235.1338	Hay River Lowland	100.00%
L.M/T.T/f.f/vw.m_er51	20%	82535.425	16507.085	Peel River Plateau	100.00%
L.M/U.FI/c.f/w.m_er64	15%	117967.196	17695.0794	Hay River Lowland	-475.36%

L.O/U.O/c.-/w.vw_er64	15%	156609.911	23491.4866	Hay River Lowland	63.67%
L/FI/f/m_er64	15%	170594.107	25589.116	Hay River Lowland	100.00%
L/T/f/vw_er33	100%	8274.819	8274.819	Tuktoyuktuk Coastal Plain	100.00%
L/T/f/w_er55	100%	9228.653	9228.653	Norman Range	100.00%
L/T/f/w_er56	20%	90304.662	18060.9324	Mackenzie River Plain	100.00%
L/U/c/vw_er64	15%	377768.625	56665.2937	Hay River Lowland	100.00%
L/U/c/w_er64	20%	83031.877	16606.3754	Hay River Lowland	100.00%
L/U/f/w_er64	25%	15096.235	3774.0588	Hay River Lowland	100.00%
L/U/m/vw_er64	25%	17249.915	4312.4788	Hay River Lowland	100.00%
M.25/FI.O/f.-/w.w_er65	15%	382623.558	57393.5337	Northern Alberta Uplands	-217.44%
M.A.B/U.R.OA/f.f.-/m.m.vw_er64	25%	22399.357	5599.8393	Hay River Lowland	100.00%
M.A/FI.MP/f.m/m.vw_er64	20%	78805.724	15761.1448	Hay River Lowland	100.00%
M.A/T.S/m.m/m.vw_er51	20%	97647.613	19529.5226	Peel River Plateau	100.00%
M.B.21/MP.O.OA/f.-.-/w.vw.vw_er63	15%	122460.27	18369.0405	Horn Plateau	-566.67%
M.B.B/FI.O.O/f.-.-/w.w.vw_er65	15%	364413.544	54662.0316	Northern Alberta Uplands	-172.40%
M.B.M/MP.O.S/f.-.f/w.vw.w_er63	25%	22786.635	5696.6587	Horn Plateau	-300.00%
M.B.M/MP.O.T/m.-.m/m.w.m_er51	15%	165090.114	24763.5171	Peel River Plateau	100.00%
M.B.M/MP.O.T/m.-.m/m.w.m_er56	15%	221457.991	33218.6986	Mackenzie River Plain	100.00%
M.B.M/T.O.T/f.-.m/m.w.m_er56	15%	185433.753	27815.063	Mackenzie River Plain	100.00%
M.B.M/T.O.T/m.-.m/m.vw.w_er52	20%	35290.161	7058.0322	Great Bear Lake Plain	100.00%
M.B/FI.O/f.-/m.w_er65	15%	171042.417	25656.3625	Northern Alberta Uplands	-470.40%
M.B/MP.O/f.-/m.vw_er56	15%	182992.52	27448.878	Mackenzie River Plain	100.00%
M.B/MP.O/f.-/m.w_er56	15%	250093.676	37514.0514	Mackenzie River Plain	78.60%
M.B/MP.O/f.-/m.w_er63	15%	313166.536	46974.9804	Horn Plateau	-376.16%
M.B/MP.O/f.-/w.w_er63	15%	330083.268	49512.4902	Horn Plateau	-98.02%
M.B/T.O/f.-/m.vw_er62	20%	60296.538	12059.3076	Sibbeston Lake Plain	100.00%
M.B/T.O/m.-/m.vw_er35	15%	316461.947	47469.292	Dease Arm Plain	100.00%
M.B/T.O/m.-/m.vw_er52	15%	487704.447	73155.667	Great Bear Lake Plain	23.18%
M.B/T.O/m.-/m.vw_er53	10%	561852.451	56185.2451	Fort MacPherson Plain	100.00%
M.B/T.O/m.-/m.vw_er55	15%	167849.442	25177.4163	Norman Range	-292.26%
M.B/T.O/m.-/m.vw_er63	20%	62473.538	12494.7076	Horn Plateau	-351.60%
M.B/T.O/m.-/w.vw_er52	10%	831104.185	83110.4185	Great Bear Lake Plain	8.31%
M.B/T.O/m.-/w.vw_er54	10%	511902.676	51190.2676	Colville Hills	100.00%
M.B/T.O/m.-/w.vw_er63	15%	338286.813	50743.022	Horn Plateau	-566.67%
M.B/U.OA/f.-/w.vw_er64	10%	676423.339	67642.3339	Hay River Lowland	-414.70%
M.C.M/T.MP.MP/f.m.m/m.m.m_er51	15%	455544.047	68331.6071	Peel River Plateau	100.00%
M.C/FI.FI/f.f/m.s_er65	20%	65550.14	13110.028	Northern Alberta Uplands	100.00%
M.C/MP.MP/m.m/m.vs_er62	10%	693391.028	69339.1028	Sibbeston Lake Plain	-24.65%
M.C/T.MP/f.f/m.m_er51	20%	62573.965	12514.793	Peel River Plateau	100.00%
M.C/T.MP/f.m/m.m_er55	15%	114299.444	17144.9166	Norman Range	100.00%
M.C/T.MP/m.m/m.m_er51	20%	97103.553	19420.7106	Peel River Plateau	100.00%
M.C/T.MP/m.m/m.m_er58	20%	46143.038	9228.6076	Franklin Mountains	-113.03%
M.C/T.T/f.f/m.m_er51	20%	43668.109	8733.6218	Peel River Plateau	100.00%
M.C/T.T/f.m/m.m_er55	20%	76722.383	15344.4766	Norman Range	-21.28%
M.C/T.T/m.f/m.m_er51	25%	22904.469	5726.1173	Peel River Plateau	100.00%
M.F/T.MP/m.c/m.m_er35	10%	1479273.549	147927.3549	Dease Arm Plain	100.00%
M.F/T.MP/m.c/m.m_er54	10%	843597.297	84359.7297	Colville Hills	100.00%
M.F/T.S/f.c/m.m_er35	20%	73799.745	14759.949	Dease Arm Plain	100.00%
M.L.O/U.U.O/f.c.-/m.m.vw_er64	15%	415809.014	62371.3521	Hay River Lowland	75.08%
M.L/T.FI/m.f/m.m_er64	15%	141448.01	21217.2015	Hay River Lowland	24.32%
M.L/U.FI/f.f/w.w_er64	15%	177399.26	26609.889	Hay River Lowland	100.00%

M.M.22/T.T.O/m.m.-/m.w.vw_er35	15%	167871.532	25180.7298	Dease Arm Plain	100.00%
M.M.A/T.MP.T/f.m.m/m.m.m_er51	15%	190132.638	28519.8957	Peel River Plateau	100.00%
M.M/FI.FI/f.f/w.m_er65	15%	103689.288	15553.3932	Northern Alberta Uplands	100.00%
M.M/FI.MP/f.f/w.w_er63	20%	74960.212	14992.0424	Horn Plateau	-400.00%
M.M/MP.MP/m.m/w.m_er182	15%	139573.555	20936.0332	Hyland Highland	100.00%
M.M/MP.T/m.f/m.m_er62	15%	149846.607	22476.991	Sibbeston Lake Plain	100.00%
M.M/MP.T/m.m/m.m_er51	15%	182594.762	27389.2143	Peel River Plateau	100.00%
M.M/MP.T/m.m/m.m_er56	20%	99996.134	19999.2268	Mackenzie River Plain	100.00%
M.M/MP.U/m.f/w.w_er64	20%	43798.107	8759.6214	Hay River Lowland	100.00%
M.M/T.MP/f.f/m.m_er55	15%	302743.453	45411.5179	Norman Range	100.00%
M.M/T.MP/f.m/m.m_er51	10%	534861.88	53486.188	Peel River Plateau	100.00%
M.M/T.MP/m.f/w.w_er55	20%	94178.515	18835.703	Norman Range	-257.55%
M.M/T.MP/m.m/m.m_er52	15%	114105.445	17115.8168	Great Bear Lake Plain	-566.67%
M.M/T.T/f.f/m.w_er55	15%	207287.655	31093.1482	Norman Range	100.00%
M.M/T.T/m.c/w.w_er52	15%	193045.587	28956.838	Great Bear Lake Plain	100.00%
M.M/T.T/m.f/m.m_er52	10%	894730.795	89473.0795	Great Bear Lake Plain	100.00%
M.M/T.T/m.f/m.m_er54	15%	155718.955	23357.8432	Colville Hills	100.00%
M.M/T.T/m.f/m.m_er55	15%	118514.506	17777.1759	Norman Range	-196.27%
M.M/T.T/m.f/w.w_er52	10%	1210266.01	121026.601	Great Bear Lake Plain	-19.50%
M.M/T.T/m.f/w.w_er53	10%	585149.156	58514.9156	Fort MacPherson Plain	74.87%
M.M/T.T/m.f/w.w_er55	10%	911133.595	91113.3595	Norman Range	-770.81%
M.M/T.T/m.m/m.w_er52	10%	1663072.335	166307.2335	Great Bear Lake Plain	100.00%
M.M/U.FI/f.f/m.m_er64	20%	89629.482	17925.8964	Hay River Lowland	100.00%
M.O/MP.O/f.-/w.vw_er63	20%	57004.334	11400.8668	Horn Plateau	-396.01%
M.R/MP.R2/m.-/s.m_er52	100%	296.021	296.021	Great Bear Lake Plain	100.00%
M.R/MP.R4/m.-/vs.s_er56	20%	46356.384	9271.2768	Mackenzie River Plain	100.00%
M.R/T.R2/m.-/s.m_er52	20%	48924.814	9784.9628	Great Bear Lake Plain	100.00%
M.R/T.R4/f.-/m.s_er55	25%	16451.238	4112.8095	Norman Range	100.00%
M.R/T.R4/m.-/m.s_er55	100%	6854.251	6854.251	Norman Range	100.00%
M/FI/f/m_er64	20%	43581.005	8716.201	Hay River Lowland	100.00%
M/FI/f/m_er65	15%	245763.085	36864.4627	Northern Alberta Uplands	-177.39%
M/MP/f/m_er63	20%	62593.523	12518.7046	Horn Plateau	-400.00%
M/MP/m/m_er182	25%	26110.88	6527.72	Hyland Highland	100.00%
M/MP/m/m_er62	15%	167985.875	25197.8812	Sibbeston Lake Plain	100.00%
M/T/f/m_er33	10%	1152708.453	115270.8453	Tuktoyuktuk Coastal Plain	64.68%
M/T/f/m_er35	15%	439307.112	65896.0668	Dease Arm Plain	100.00%
M/T/f/m_er55	15%	472607.777	70891.1665	Norman Range	100.00%
M/T/f/m_er56	15%	143850.56	21577.584	Mackenzie River Plain	-542.95%
M/T/f/m_er62	15%	196323.215	29448.4822	Sibbeston Lake Plain	100.00%
M/T/f/s_er35	20%	97432.834	19486.5668	Dease Arm Plain	100.00%
M/T/f/w_er35	10%	577092.397	57709.2397	Dease Arm Plain	35.32%
M/T/f/w_er53	15%	208501.218	31275.1827	Fort MacPherson Plain	-311.80%
M/T/f/w_er55	20%	63332.066	12666.4132	Norman Range	100.00%
M/T/m/m_er33	20%	48717.248	9743.4496	Tuktoyuktuk Coastal Plain	100.00%
M/T/m/m_er35	10%	1195893.777	119589.3777	Dease Arm Plain	100.00%
M/T/m/m_er51	10%	956498.701	95649.8701	Peel River Plateau	-270.13%
M/T/m/m_er52	10%	719635.259	71963.5259	Great Bear Lake Plain	100.00%
M/T/m/m_er54	20%	76503.821	15300.7642	Colville Hills	100.00%
M/T/m/w_er35	10%	1082567.579	108256.7579	Dease Arm Plain	100.00%
M/T/m/w_er51	10%	508073.873	50807.3873	Peel River Plateau	-463.03%
M/T/m/w_er52	15%	372589.098	55888.3647	Great Bear Lake Plain	-95.28%
M/T/m/w_er53	15%	189934.874	28490.2311	Fort MacPherson Plain	100.00%

M/U/f/w_er65	15%	486094.987	72914.248	Northern Alberta Uplands	90.17%
O.21/O.OA/-.-/vw.vw_er65	15%	108195.799	16229.3698	Northern Alberta Uplands	100.00%
O.L/O.U/-.c/vw.vw_er64	20%	53912.291	10782.4582	Hay River Lowland	100.00%
O.L/O.U/-.c/vw.w_er64	20%	43010.562	8602.1124	Hay River Lowland	100.00%
O.M/OA.FI/-.f/vw.w_er65	100%	7061.828	7061.828	Northern Alberta Uplands	100.00%
O/O/-/vw_er64	10%	811400.782	81140.0782	Hay River Lowland	-440.38%
O/O/-/vw_er65	20%	43333.75	8666.75	Northern Alberta Uplands	100.00%
R.M/R2.MP/-.m/m.m_er52	25%	10404.716	2601.179	Great Bear Lake Plain	100.00%
R.M/R2.T/-.m/m.m_er52	100%	7360.297	7360.297	Great Bear Lake Plain	100.00%
R/R3/-/s_er52	25%	19277.341	4819.3353	Great Bear Lake Plain	100.00%
R/R4/-/vs_er182	15%	221268.815	33190.3222	Hyland Highland	82.39%
U/FI/f/s_er65	15%	114326.726	17149.0089	Northern Alberta Uplands	100.00%
W/T/m/vw_er33	20%	43319.093	8663.8186	Tuktoyuktuk Coastal Plain	100.00%

Table G.2 Contribution of each protected area towards baseline Landscape Unit representation goals, expressed as a proportion of contribution (i.e. 100% of goal met equals a proportion of 1). Areas that have greater amount of Landscape Unit protected than called for by goals have values greater than 1.

Proportion of baseline goal met by existing legislated protected areas and NWT-PAS proposals.

Landscape Unit Name (combined w ecoregion)	Anderson River Delta	EdƟhzhǫe	Ehdacho	Kendall Island	Nahanni	Pehdzeh Ki Deh	Sahoyue	Sambaa K'e Area 1	Sambaa K'e Area 2	Slave River Delta	Tsodehnɛline Tuyɓt'ah	Tuktut Nogait	Wood Buffalo
21.23/OA.OA/-.-/vw.vw_er65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.43	0.00	0.00	0.00	0.00	0.00
21.B/OA.O/-.-/vw.w_er65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.46	0.00	0.00	0.00	0.00	0.00
22/O/-/vw_er33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22/O/-/vw_er52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25.21/O.OA/-.-/w.vw_er64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25.M/O.MP/-.f/w.m_er64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25.M/O.MP/-.f/w.w_er58	0.00	0.00	0.00	0.00	0.00	1.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25.M/OA.FI/-.f/w.m_er64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.54	0.00	0.00	0.00	0.00
A.A/MP.R/m.m/vw.vw_er56	0.00	0.00	0.00	0.00	0.00	1.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A.A/MP.R/m.m/vw.vw_er65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A.A/R.MP/m.m/vw.vw_er56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A.A/R.MP/m.m/vw.vw_er64	0.00	0.04	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A.A/R.MP/m.m/vw.vw_er65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A.L/R.FI/f.f/m.m_er64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A.M/MP.FI/m.f/vw.w_er64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A.M/S.T/m.m/m.m_er51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A/R/f/m_er64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A/R/f/vw_er64	0.00	2.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A/R/m/vw_er51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A/R/m/vw_er64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A/S/m/m_er51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A/S/m/vw_er33	0.09	0.00	0.00	1.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A/S/m/vw_er35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A/S/m/vw_er50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

A/S/m/vw_er51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A/S/m/vw_er52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A/S/m/vw_er53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A/S/m/vw_er55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A/S/m/vw_er56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.00	0.00
B.20/O.O/-.-/vw.vw_er53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.37	0.00	0.00
B.21/O.OA/-.-/vw.vw_er64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B.21/O.OA/-.-/vw.vw_er65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.00
B.21/OA.OA/-.-/vw.vw_er64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.79	0.00	0.00	0.00	0.00
B.25/O.O/-.-/vw.w_er65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.87	0.76	0.00	0.00	0.00	0.00
B.B/O.O/-.-/vw.w_er65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.53	0.00	0.00	0.00	0.00	0.00
B.L.21/O.U.OA/-.c.-/vw.vw.vw_er64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B.L/O.T/-.f/vw.vw_er52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B.L/O.T/-.f/vw.w_er56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B.L/OA.U/-.f/vw.vw_er64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B.M.M/O.T.T/-.m.f/vw.w.w_er52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B.M/O.MP/-.f/vw.m_er64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	3.26	0.00	0.00	0.00	0.00
B.M/O.MP/-.f/vw.w_er63	0.00	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B.M/O.T/-.f/vw.w_er53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.11	0.00	0.00
B.M/O.T/-.m/vw.m_er52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B.M/O.T/-.m/vw.m_er53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B.M/O.T/-.m/vw.m_er63	0.00	6.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B.M/O.T/-.m/vw.w_er53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B.U.25/O.FI.O/-.f.-/vw.s.w_er64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B/O/-/vw_er52	0.00	0.00	3.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B/O/-/vw_er53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.55	0.00	0.00
B/O/-/vw_er54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B/O/-/vw_er55	0.00	0.00	0.00	0.00	0.00	3.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B/O/-/vw_er56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B/O/-/vw_er63	0.00	7.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B/O/-/w_er63	0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C.A/T.S/m.m/m.m_er51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.20	0.00	0.00
C.C.M/T.MP.T/m.m.f/m.m.m_er55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C.C/MP.MP/m.m/vs.m_er62	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C.C/MP.T/m.f/m.m_er51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C.C/MP.T/m.f/w.m_er51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C.M/MP.MP/m.f/m.m_er55	0.00	0.00	0.00	0.00	0.00	3.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C.M/MP.MP/m.f/m.m_er64	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C.M/MP.MP/m.m/m.m_er51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C.M/MP.MP/m.m/vs.m_er182	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

C.M/MP.T/m.m/m.m_er58	0.00	0.00	0.00	0.00	0.00	6.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C.M/T.T/m.m/m.m_er51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C.R/MP.R4/m.-/vs.s_er55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C/MP/m/m_er182	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C/T/f/m_er50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C/T/m/m_er50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F.M/MP.T/c.m/m.m_er53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F/MP/c/m_er35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F/MP/c/vw_er51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.67	0.00	0.00
F/S/c/m_er33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F/S/c/m_er35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
L.25/MP.O/f.-/w.w_er56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
L.25/MP.O/m.-/w.w_er56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
L.A/Fl.U/f.m/m.vw_er64	0.00	4.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
L.A/MP.R/f.f/m.m_er64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
L.A/R.R/f.f/vw.w_er64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
L.B/MP.OA/m.-/w.vw_er64	0.00	1.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
L.L.A/MP.S.R/f.f.m/vw.vw.vw_er58	0.00	0.00	0.00	0.00	0.00	5.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
L.L/MP.S/c.c/w.w_er52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
L.L/MP.S/f.f/w.w_er56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
L.L/MP.S/f.f/w.w_er58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
L.L/T.S/c.c/w.w_er52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
L.L/U.Fl/f.m/vw.vw_er64	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
L.L/U.Fl/f.m/vw.w_er64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
L.M/T.T/f.f/vw.m_er51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
L.M/U.Fl/c.f/w.m_er64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.75
L.O/U.O/c.-/w.vw_er64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36
L/Fl/f/m_er64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
L/T/f/vw_er33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
L/T/f/w_er55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
L/T/f/w_er56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
L/U/c/vw_er64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
L/U/c/w_er64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
L/U/f/w_er64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
L/U/m/vw_er64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.25/Fl.O/f.-/w.w_er65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.98	0.20	0.00	0.00	0.00	0.00
M.A.B/U.R.OA/f.f.-/m.m.vw_er64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.A/Fl.MP/f.m/m.vw_er64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.A/T.S/m.m/m.vw_er51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.B.21/MP.O.OA/f.-.-/w.vw.vw_er63	0.00	6.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

M.B.B/FI.O.O/f.-.-/w.w.vw_er65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.72	0.00	0.00	0.00	0.00	0.00
M.B.M/MP.O.S/f.-.f/w.vw.w_er63	0.00	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.B.M/MP.O.T/m.-.m/m.w.m_er51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.B.M/MP.O.T/m.-.m/m.w.m_er56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.B.M/T.O.T/f.-.m/m.w.m_er56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.B.M/T.O.T/m.-.m/m.vw.w_er52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.B/FI.O/f.-/m.w_er65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.70	0.00	0.00	0.00	0.00	0.00
M.B/MP.O/f.-/m.vw_er56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.B/MP.O/f.-/m.w_er56	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.B/MP.O/f.-/m.w_er63	0.00	4.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.B/MP.O/f.-/w.w_er63	0.00	1.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.B/T.O/f.-/m.vw_er62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.B/T.O/m.-/m.vw_er35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.B/T.O/m.-/m.vw_er52	0.00	0.00	0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.B/T.O/m.-/m.vw_er53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.B/T.O/m.-/m.vw_er55	0.00	0.00	0.00	0.00	0.00	3.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.B/T.O/m.-/m.vw_er63	0.00	4.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.B/T.O/m.-/w.vw_er52	0.00	0.00	0.00	0.00	0.00	0.00	0.92	0.00	0.00	0.00	0.00	0.00	0.00
M.B/T.O/m.-/w.vw_er54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.B/T.O/m.-/w.vw_er63	0.00	6.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.B/U.OA/f.-/w.vw_er64	0.00	5.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.C.M/T.MP.MP/f.m.m/m.m.m_er51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.C/FI.FI/f.f/m.s_er65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.C/MP.MP/m.m/m.vs_er62	0.00	0.00	0.00	0.00	1.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.C/T.MP/f.f/m.m_er51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.C/T.MP/f.m/m.m_er55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.C/T.MP/m.m/m.m_er51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.C/T.MP/m.m/m.m_er58	0.00	0.00	0.00	0.00	0.00	2.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.C/T.T/f.f/m.m_er51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.C/T.T/f.m/m.m_er55	0.00	0.00	0.00	0.00	0.00	1.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.C/T.T/m.f/m.m_er51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.F/T.MP/m.c/m.m_er35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.F/T.MP/m.c/m.m_er54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.F/T.S/f.c/m.m_er35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.L.O/U.U.O/f.c.-/m.m.vw_er64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00
M.L/T.FI/m.f/m.m_er64	0.00	0.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.L/U.FI/f.f/w.w_er64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.M.22/T.T.O/m.m.-/m.w.vw_er35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.M.A/T.MP.T/f.m.m/m.m.m_er51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.M/FI.FI/f.f/w.m_er65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

M.M/FI.MP/f.f/w.w_er63	0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.M/MP.MP/m.m/w.m_er182	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.M/MP.T/m.f/m.m_er62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.M/MP.T/m.m/m.m_er51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.M/MP.T/m.m/m.m_er56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.M/MP.U/m.f/w.w_er64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.M/T.MP/f.f/m.m_er55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.M/T.MP/f.m/m.m_er51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.M/T.MP/m.f/w.w_er55	0.00	0.00	0.00	0.00	0.00	3.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.M/T.MP/m.m/m.m_er52	0.00	0.00	0.00	0.00	0.00	0.00	6.67	0.00	0.00	0.00	0.00	0.00	0.00
M.M/T.T/f.f/m.w_er55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.M/T.T/m.c/w.w_er52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.M/T.T/m.f/m.m_er52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.M/T.T/m.f/m.m_er54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.M/T.T/m.f/m.m_er55	0.00	0.00	0.00	0.00	0.00	2.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.M/T.T/m.f/w.w_er52	0.00	0.00	1.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.M/T.T/m.f/w.w_er53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00
M.M/T.T/m.f/w.w_er55	0.00	0.00	0.00	0.00	0.00	8.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.M/T.T/m.m/m.w_er52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.M/U.FI/f.f/m.m_er64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.O/MP.O/f.-/w.vw_er63	0.00	4.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.R/MP.R2/m.-/s.m_er52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.R/MP.R4/m.-/vs.s_er56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.R/T.R2/m.-/s.m_er52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.R/T.R4/f.-/m.s_er55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M.R/T.R4/m.-/m.s_er55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M/FI/f/m_er64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M/FI/f/m_er65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.77	0.00	0.00	0.00	0.00	0.00
M/MP/f/m_er63	0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M/MP/m/m_er182	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M/MP/m/m_er62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M/T/f/m_er33	0.33	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M/T/f/m_er35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M/T/f/m_er55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M/T/f/m_er56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.43	0.00	0.00
M/T/f/m_er62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M/T/f/s_er35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M/T/f/w_er35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.65	0.00
M/T/f/w_er53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.12	0.00	0.00
M/T/f/w_er55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

M/T/m/m_er33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M/T/m/m_er35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M/T/m/m_er51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.70	0.00	0.00
M/T/m/m_er52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M/T/m/m_er54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M/T/m/w_er35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M/T/m/w_er51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.63	0.00	0.00
M/T/m/w_er52	0.00	0.00	0.00	0.00	0.00	0.00	1.95	0.00	0.00	0.00	0.00	0.00	0.00
M/T/m/w_er53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M/U/f/w_er65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00
O.21/O.OA/-.-/vw.vw_er65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
O.L/O.U/-.c/vw.vw_er64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
O.L/O.U/-.c/vw.w_er64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
O.M/OA.Fl/-.f/vw.w_er65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
O/O/-/vw_er64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.40
O/O/-/vw_er65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
R.M/R2.MP/-.m/m.m_er52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
R.M/R2.T/-.m/m.m_er52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
R/R3/-/s_er52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
R/R4/-/vs_er182	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U/Fl/f/s_er65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
W/T/m/vw_er33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

H. Representation of special elements by Individual Legislated Protected/NWT-Pas Proposal Area.

Table H.1 Assessment of Special elements representation in existing legislated protected areas and NWT-PAS proposals

Area Name	Area(ha)	# LU	LU Goal Index	Normalized LU Representation Index (efficiency index)	Normalized Special Element Index	Normalized Bird Index	Normalized Caribou Index	Normalized Mammal (other) index	Normalized Rare Plant index
Anderson River Delta	55,956	3	0.412	0.21	2.80	9.35	0.00	0.00	0.00
EdΘhzhφe	2,503,418	22	18.194	1.43	1.07	0.52	0.34	0.28	0.00
Ehdacho	338,178	4	2.768	0.58	0.67	0.00	1.11	0.00	0.00
Kendall Island	84,761	3	1.026	0.60	4.07	14.87	0.00	0.00	26.85
Nahanni	97,509	4	1.434	0.52	0.43	1.29	0.16	1.39	23.34
Pehdzeh Ki Deh	2,053,135	15	12.214	0.84	0.54	0.04	0.87	0.00	0.00
Sahoyue	349,042	4	2.917	1.01	1.75	0.00	2.97	0.00	0.00
Sambaa K'e Area 1	1,070,998	11	8.527	1.14	0.95	0.10	1.58	0.00	0.00
Sambaa K'e Area 2	201,607	6	3.755	1.40	0.49	0.08	0.23	0.00	0.00
Slave River Delta	31,464	0	0.000	0.00	0.50	2.49	0.00	0.00	0.00
Tsodehnɛline Tuyßt'ah	1,464,753	12	9.745	0.95	0.05	0.21	0.01	0.00	0.00
Tuktut Nogait	37,324	1	0.647	0.44	1.12	0.00	0.00	17.24	0.00
Wood Buffalo	605,217	4	2.363	0.61	2.49	12.79	0.00	0.00	0.00

LU

Number of landscape units represented in the protected/proposed area.

LU Goal Index

This index provides a measure of relative contribution of each protected area towards meeting overall representation goals. This was calculated as the sum of the proportional contribution of towards baseline goals for each landscape unit found in the protected area. For example, if a protected area had 3 landscape units, each measuring 50% of overall goals, the LU Goal Index would be calculated as 3 * 0.5 or 1.5. Overrepresentation is not credited however, and in these calculations no contribution towards representation of any Landscape unit goal can be greater than 100%.

Normalized LU Representation Goal Index

This index provides another measure of relative contribution of each protected area towards meeting representation goals. This index is normalized for area and provides a measure of how much each protected area contributes towards landscape unit representation as a function of area. Higher numbers suggest greater efficiency, where relatively greater contributions are found per unit of area. This was calculated as follows:

A = sum of LU target area in protected area / overall sum of LU target area

B = protected area size (ha) / study area size (ha)

Normalized LU representation index = A / B

Normalized Special Elements Index

This index was calculated in the same manner as the Normalized LU Representation Goal Index, except special elements found in protected areas were substituted for Landscape Unit targets. This index provides a measure of representation, per unit of area, for each special element. Separate Bird, Caribou, Mammal (other than caribou) and Rare plant indices are also calculated.

I. Conservation Goals Background

Goals represent the end toward which conservation efforts are directed for targeted species, communities, and ecosystems and as such, are fundamental to systematic conservation planning (Margules and Pressey 2000). Goals provide the quantitative basis for identifying and prioritizing areas that contribute to a network of conservation areas. Moreover, tracking progress toward goals provides an evaluation of the performance of a conservation program, from the scale of individual projects up to province/territory or nation-wide. Tackling the question of "how much is enough?" is one of the most difficult - and most important - scientific questions in conservation planning. Further, current theoretical tools may lack the robustness required to make satisfactory assumptions (Noss 1996, Sanjayan and Soule 1997), thus requiring an empirical approach, target-by-target, and a commitment to monitoring and continual re-evaluation over the long-term.

Minimum Conservation Area Size

The size of individual conservation areas is an important consideration for the NWT-PAS. In particular, and as discussed below, a reserve system made up of fewer, but larger protected areas is more likely to allow genes, species, populations, communities and ecosystems to persist over time when compared to a system of scattered, smaller reserves. Additionally, large reserves can better sustain natural disturbance regimes, and are more likely protect species and habitats from exotic invasions, fragmentation and negative edge effects.

The required size of individual conservation areas can be considered relative to the natural disturbance regime. Pickett and Thompson (1978) defined a "minimum dynamic area" as the smallest area that contains patches unaffected by the largest expected disturbances. This large size is required to allow recolonization from undisturbed patches within the reserve. Further, it has been shown in several recent studies on protected areas in North America, Canada, and East Africa, that single protected areas or parks become island-like within a landscape inhospitable to biodiversity and natural processes. Parks and protected areas that are effectively isolated inevitably lose key species, particularly wide-ranging mammalian species. In 14 western North American park assemblages, only the very largest park *complexes* did not lose any mammals (Newmark 1995) and a similar pattern was observed in East African parks (Newmark 1996). The parks or park complexes that escaped the loss of mammal species over time were exceptionally large, over 1000 km^2 and usually around 10,000 km^2. The smaller the park, the greater the losses. For mammals in the Alleghenian-Illinoian mammal province of eastern North America, the estimated minimum area requirement is 5037 km^2 (Gurd et al. 2001). Canadian parks smaller than this have lost species (Glenn and Nudds 1989, Gurd and Nudds 1999).

Other Benchmarks and Goals

Conservation goals are not always assigned directly conservation target by conservation target, but rather are simply expressed in terms of total percent area of the Study Area required to maintain the long-term viability for the region's biodiversity. In some cases these figures are based on estimates by experts of the area necessary to maintain viable populations, ecosystem services, or the persistence of biodiversity generally; in other cases they are based on the empirical results of studies employing site-selection algorithms and/or population viability

analyses. Generally, most experts have reported that some degree of protection for at least 40-60% of the terrestrial lands and fresh waters would be required to sufficiently protect biodiversity, assuming that the very "best" and representative areas are selected. When existing protected areas – which generally were not selected on the basis of biological criteria -- are included in designs, the results are less efficient, and more land (e.g., 70% of the Greater Yellowstone Ecosystem, where 27% of the landscape is already protected; Noss et al. 2002) is needed to meet similar conservation goals. Using spatially-explicit population models linked to site selection procedures, Carroll and colleagues (2003) determined that at least 37% of their US-Canadian Rocky Mountain study area would need to be protected to meet population viability criteria for large carnivores (grizzly bear and wolf). Their modeling procedures preferentially selected the most productive (e.g., source) habitats, based on estimated fecundity, mortality and connectivity parameters.

Drawing from the above mentioned research and several other ongoing studies, the Boreal Forest Conservation Framework (www.borealcanada.ca) presents a proactive conservation vision for the Boreal region that emphasizes both protection and sustainable development. The Framework calls for at least 50 percent of Canada's boreal region to be protected and additionally recommends that sustainable management be implemented on the remaining landscapes.

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J. Comparison of Conservation Tiers from Landscape Unit Representation Analysis

Open and Locked scenarios resulted in varying amounts of areas being identified, as well as cumulative costs. All conservation goals were fulfilled for all Marxan runs. Not surprisingly, open scenarios resulted in more efficient solutions and there appears to be a clear trade-off between efficiency and utilization of proposed protected areas in the locked scenarios (table J.1).

TableJ.1 Ecoregional comparison of the spatial efficiency between Open and Locked Scenarios in meeting Tier 1 goals for large contiguous areas.

Ecoregion	ER area	Best Run (ha) Open Scenario	Best Run (ha) Locked Scenario	Area Efficiency
Colville Hills	2,019,716	400,195	400,371	-0.04%
Dease Arm Plain	5,710,689	401,176	400,750	0.11%
Fort MacPherson Plain	2,738,260	400,393	597,509	-49.23%
Franklin Mountains	652,069	400,215	416,238	-4.00%
Great Bear Lake Plain	10,755,680	400,312	601,407	-50.23%
Hay River Lowland	7,580,340	547,291	1,209,025	-120.91%
Horn Plateau	2,492,726	401,226	2,035,160	-407.24%
Hyland Highland	460,556	400,050	400,291	-0.06%
Mackenzie Delta	916,598	400,196	400,126	0.02%
Mackenzie River Plain	1,640,914	400,438	400,281	0.04%
Norman Range	4,207,919	400,028	1,620,121	-305.00%
Northern Alberta Uplands	3,002,415	400,094	1,145,440	-186.29%
Peel River Plateau	4,547,886	400,095	714,325	-78.54%
Sibbeston Lake Plain	1,371,324	400,230	400,505	-0.07%
Tuktoyuktuk Coastal Plain	4,218,720	400,643	400,038	0.15%

Tier 1 results: open vs. locked

Further examination of experiment results yields additional insights. Not surprisingly, there are uneven distributions of values between ecoregions. In some cases, differences between locked and unlocked scenarios can be dramatic (e.g. for the Horn Plateau, the locked scenario results are 400% larger in area than those for the open scenario). These results suggest that each ecoregion should be evaluated separately as well as part of the whole in subsequent analyses. Similarly, major differences in overall conservation cost are observed between locked and unlocked scenarios (table J.2). In all cases, open scenarios are able to efficiently meet goals while avoiding the majority of human impacts. This illustrates the importance of developing an accurate human impact (cost) model – based on key ecological factors for each conservation element being targeted (e.g. each Landscape Unit) – that can estimate actual condition, as site selection software can clearly be parameterized to avoid areas of higher impacts. Note that some human activities may not have a negative impact on particular conservation targets and expert judgments may be needed to develop a more effective cost model.

Table J.2 Ecoregional comparison of human use cost between Open and Locked Scenarios in meeting Tier 1 goals for large contiguous areas.

Ecoregion	Mean Cost Entire Ecoregion	Mean cost Open Scenario	Mean cost Locked Scenario	Cost Efficiency open vs. locked
Colville Hills	4.79	1.09	1.09	0.69%
Dease Arm Plain	1.90	1.03	1.01	1.84%
Fort MacPherson Plain	6.46	1.09	1.96	-79.77%
Franklin Mountains	71.44	1.13	52.17	-4537.33%
Great Bear Lake Plain	4.93	1.00	1.01	-0.61%
Hay River Lowland	30.02	1.05	8.04	-668.31%
Horn Plateau	5.57	1.02	2.05	-101.65%
Hyland Highland	1.10	1.01	1.01	-0.12%
Mackenzie Delta	33.57	1.31	1.30	1.01%
Mackenzie River Plain	13.69	1.04	13.84	-1232.29%
Norman Range	13.13	1.05	1.19	-14.16%
Northern Alberta Uplands	17.01	1.22	12.08	-888.12%
Peel River Plateau	4.12	1.06	2.20	-108.24%
Sibbeston Lake Plain	1.18	1.00	1.00	0.00%
Tuktoyuktuk Coastal Plain	8.67	1.35	2.02	-49.82%

Tier 2 and 3 results: open vs. locked scenarios

Tiers 2 and 3 results were similar to tier 1 but more dramatic across the board. Locked solutions resulted in markedly less efficient and more costly solutions, but results varied widely across different ecoregions (tablesJ.3, J.4, J.5, J.6). We also note that these solutions are largely based on input targets as well as the cost constraints. Adding additional species and special element targets may serve to improve overall efficiency as site selection is more accurately directed towards critical and diverse areas.

TableJ.3 Ecoregional comparison of the spatial efficiency between Open and Locked Scenarios in meeting Tier 2, baseline goals for Landscape Unit representation.

Ecoregion	ER area	Best Run (ha) Open Scenario	Best Run (ha) Locked Scenario	Area Efficiency
Colville Hills	2,019,716	1,028,013	1,139,711	-10.87%
Dease Arm Plain	5,710,689	1,679,194	2,330,604	-38.79%
Fort MacPherson Plain	2,738,260	1,096,211	1,725,444	-57.40%
Franklin Mountains	652,069	440,337	516,481	-17.29%
Great Bear Lake Plain	10,755,680	1,608,179	3,383,424	-110.39%
Hay River Lowland	7,580,340	1,768,836	3,398,127	-92.11%
Horn Plateau	2,492,726	918,028	1,343,230	-46.32%
Hyland Highland	460,556	410,617	423,231	-3.07%
Mackenzie Delta	916,598	493,655	509,405	-3.19%
Mackenzie River Plain	1,640,914	872,880	1,116,585	-27.92%
Norman Range	4,207,919	1,156,561	2,117,388	-83.08%

Northern Alberta Uplands	3,002,415	896,678	1,593,887	-77.75%
Peel River Plateau	4,547,886	1,522,478	2,158,858	-41.80%
Sibbeston Lake Plain	1,371,324	871,697	977,629	-12.15%
Tuktoyuktuk Coastal Plain	4,218,720	1,006,941	1,157,259	-14.93%

Table J.4Ecoregional comparison of human use cost accumulation between Open and Locked Scenarios in meeting Tier 2, baseline goals for Landscape Unit representation.

Ecoregion	Mean Cost Entire Ecoregion	Mean cost Open Scenario	Mean cost Locked Scenario	Cost Efficiency open vs. locked
Colville Hills	4.79	1.46	1.41	3.64%
Dease Arm Plain	1.90	1.18	1.20	-1.84%
Fort MacPherson Plain	6.46	1.45	1.50	-3.55%
Franklin Mountains	71.44	1.15	6.02	-424.76%
Great Bear Lake Plain	4.93	1.19	1.21	-1.58%
Hay River Lowland	30.02	2.62	2.73	-4.10%
Horn Plateau	5.57	1.12	1.08	3.68%
Hyland Highland	1.10	1.02	1.04	-1.53%
Mackenzie Delta	33.57	2.50	2.45	2.31%
Mackenzie River Plain	13.69	1.49	1.64	-10.26%
Norman Range	13.13	2.57	3.14	-21.88%
Northern Alberta Uplands	17.01	1.63	2.20	-34.93%
Peel River Plateau	4.12	1.21	1.35	-11.52%
Sibbeston Lake Plain	1.18	1.07	1.19	-11.91%
Tuktoyuktuk Coastal Plain	8.67	1.58	1.86	-18.24%

Table J.5 Ecoregional comparison of the spatial efficiency between Open and Locked Scenarios in meeting Tier 3, precautionary goals for Landscape Unit representation.

Ecoregion	ER area	Best Run (ha) Open Scenario	Best Run (ha) Locked Scenario	Area Efficiency
Colville Hills	2,019,716	1,139,711	1,339,823	-17.56%
Dease Arm Plain	5,710,689	2,330,604	2,647,864	-13.61%
Fort MacPherson Plain	2,738,260	1,725,444	1,545,058	10.45%
Franklin Mountains	652,069	516,481	521,213	-0.92%
Great Bear Lake Plain	10,755,680	3,383,424	2,875,977	15.00%
Hay River Lowland	7,580,340	3,398,127	3,643,133	-7.21%
Horn Plateau	2,492,726	1,343,230	2,231,232	-66.11%
Hyland Highland	460,556	423,231	415,632	1.80%
Mackenzie Delta	916,598	509,405	493,930	3.04%
Mackenzie River Plain	1,640,914	1,116,585	1,208,363	-8.22%
Norman Range	4,207,919	2,117,388	2,695,059	-27.28%
Northern Alberta Uplands	3,002,415	1,593,887	2,144,838	-34.57%
Peel River Plateau	4,547,886	2,158,858	2,403,990	-11.35%
Sibbeston Lake Plain	1,371,324	977,629	887,779	9.19%
Tuktoyuktuk Coastal Plain	4,218,720	1,157,259	1,156,981	0.02%

Table J.6 Ecoregional comparison of human use cost accumulation between Open and Locked Scenarios in meeting Tier 3, precautionary goals for Landscape Unit representation.

Ecoregion	Mean Cost Entire Ecoregion	Mean cost Open Scenario	Mean cost Locked Scenario	Cost Efficiency open vs. locked
Colville Hills	4.79	1.41	1.48	-5.09%
Dease Arm Plain	1.90	1.20	1.15	4.42%
Fort MacPherson Plain	6.46	1.50	1.50	-0.13%
Franklin Mountains	71.44	6.02	42.47	-605.83%
Great Bear Lake Plain	4.93	1.21	1.16	4.31%
Hay River Lowland	30.02	2.73	4.14	-51.72%
Horn Plateau	5.57	1.08	1.97	-82.46%
Hyland Highland	1.10	1.04	1.04	-0.40%
Mackenzie Delta	33.57	2.45	2.45	-0.32%
Mackenzie River Plain	13.69	1.64	5.42	-231.07%
Norman Range	13.13	3.14	2.64	15.92%
Northern Alberta Uplands	17.01	2.20	7.52	-240.99%
Peel River Plateau	4.12	1.35	1.72	-27.44%
Sibbeston Lake Plain	1.18	1.19	1.14	4.44%
Tuktoyuktuk Coastal Plain	8.67	1.86	2.18	-16.95%