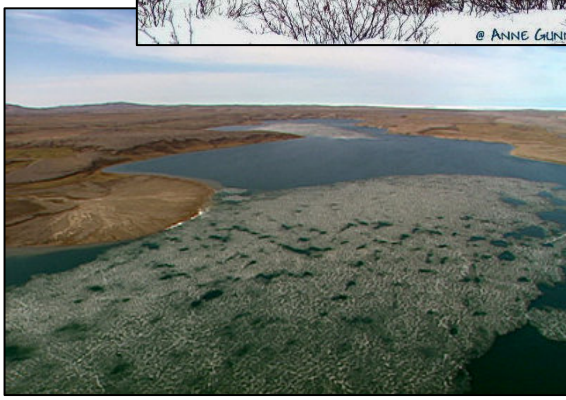

Field Testing the Draft Canadian Biodiversity Index:

A Report on Applying Real Ecosystem Data to the CBI

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International Institute for Sustainable Development
Institut international du développement durable

A Report Prepared for Environment Canada

Field Testing the
Draft Canadian Biodiversity Index:

A REPORT ON APPLYING REAL ECOSYSTEM DATA TO THE CBI

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Risa Smith[3], and Henry Venema[1]

A report prepared for:

Environment Canada
Federal/Provincial/Territorial Biodiversity Working Group
Monitoring and Reporting Sub-Group

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COVER PHOTOS:
Banks Island, NWT - http://www.canadianparks.com/northwest/aulavnp/page3.htm
Caribou - Photo by Anne Gunn
Muskox - http://www.canadianparks.com/northwest/aulavnp/page2.htm#
Mountains, BC - unknown
Killer Whale - http://www.speciesatrisk.gc.ca/search/speciesDetails_e.cfm?SpeciesID=699#photo
Forster's Tern - http://www.enature.com/fieldguide/showSpecies_LI.asp?imageID=17625
Netley-Libau Marsh, Manitoba - Photo by Gordon Goldsborough, University of Manitoba, 2003

Executive Summary

The loss of biodiversity is recognized as one of the most serious global environmental issues. The Canadian Biodiversity Index (CBI) was developed from a need for a consistent mechanism to assess and convey biodiversity issues and management across Canada. The CBI is a tool for capturing and conveying credible information on the status and trends in biodiversity in a consistent manner and presents it in a composite index. The primary goal of this phase of proof of concept testing (POCT) was to test and evaluate the framework and Testing Manual of the CBI against real ecosystem data. This report addresses key questions and issues resolved during testing, and provides recommendations to the CBI framework and methodology.

One of the main issues and challenges encountered during POCT was data suitable for biodiversity monitoring. This included actual public availability and existence of indicator data, as well as the quality of existing data. This will continue to be a major challenge with any future use of the CBI. Data availability and quality will be an unavoidable problem with any type of biodiversity monitoring, and should be expected for most ecounits undergoing CBI calculations. Utilization of a simple yet effective data gap analysis chart during POCT revealed quite early in indicator selection the data gaps and issues within an ecounit. This simple charting of existing data has potential use for any work requiring temporal data management. Simply charting indicator data availability by year not only gave an immediate visual of an ecounit's data availability issues, but also revealed the striking difference in data management between ecounits and the apparent value of a central data management or monitoring organization..

POCT did demonstrate that there is significant potential for the CBI as a nationally utilized index of biodiversity and monitoring. True strengths of the CBI include: the flexible nature of the CBI 20-point range normalized scale, which allows indicators measuring very different things in different ways to be compared, as well as the uncomplicated nature of the CBI methodology for indicator scoring, calculation, and presentation. Summarized biodiversity performance scores, as calculated by the CBI, give an immediate and comprehensive visual of an ecounit's state of biodiversity, while highlighting indicators of greatest management concern within that ecounit.

Ultimately, the CBI could serve as a valuable framework for organizing and designing future monitoring programs; essentially helping to identify key indicators for biodiversity monitoring. The CBI framework could aid in modifying already existing monitoring programs to ensure proper data is being collected in a way to be used for future trend comparisons and measures of biodiversity change. This is not meant to suggest the CBI would dictate what organizations monitor, nor that they have to spend more time and resources monitoring new indicators. Rather, the CBI could be used quite readily with whatever data jurisdictions are already collecting.

Several recommendations emerged from testing, and are intended to help further testing and implementation of the index by a wider range of participants and in a wider range of ecounits across the country. Some recommendations were dealt with and implemented immediately during testing since they affected the process and outcome of this current phase of POCT. Several comments were also raised, which are included for future consideration. Ultimately, future testing and implementation will need to expose the CBI to a broader expert community in order to gather additional feedback on the index and gather strategies for its wider application.

Acknowledgements

Dale Wrubleski at Ducks Unlimited Canada; Suzanne Carriere at Resources, Wildlife and Economic Development, Government of the NWT; and James Quayle at the Ministry of Water, Land and Air Protection, Government of British Columbia provided direction in choosing the two ecounits used in this study and in locating data for the purpose of proof of concept testing of the Canadian Biodiversity Index (CBI). Funding and technical support was provided by Environment Canada and the International Institute for Sustainable Development (IISD).

Glossary and Abbreviations

CBI	Canadian Biodiversity Index
DFS	Desired Future State
Ecounit	A geographically definable, ecologically meaningful unit of land or water which will be assessed for the CBI.
Indicator	Environmental indicators are physical, chemical, biological or socio-economic measures that best represent the key elements of a complex ecosystem or environmental issue. An indicator is embedded in a well developed interpretive framework and has meaning well beyond the measure it represents
IISD	International Institute for Sustainable Development
POCT	Proof of Concept Testing

Table of Contents

List of Figures

List of Tables

List of Appendices

1. Introduction

1.1. Biodiversity and the Canadian Biodiversity Index (CBI)

Biodiversity is critical to human society, wildlife, and our physical and natural environment. The Government of Canada (1995) defines biodiversity as the variety of species and ecosystems on Earth and the ecological processes of which they are a part of. Despite the importance of biodiversity, ecosystems are degraded and species and genetic diversity are being reduced at an alarming rate. This is primarily due to the impact of a growing human population and its efforts to satisfy its needs and desires (Government of Canada 1995). The loss of biodiversity is recognized as one of the most serious global environmental issues of our time.

In 1992, the United Nations Convention on Biological Diversity (CBD) was negotiated in response to the world-wide loss of biodiversity, with the objective to conserve and promote the sustainable use of biological resources. By December of that year Canada became the first industrialized country to ratify the Convention. The Canadian Biodiversity Strategy's goals are as follows (Government of Canada 1995):

- conserve biodiversity and use biological resources in a sustainable manner
- improve our understanding of ecosystems and increase our resource management capability
- promote an understanding of the need to conserve biodiversity and use biological resources in a sustainable manner
- maintain or develop incentives and legislation that support the conservation of biodiversity and the sustainable use of biological resources
- work with other countries to conserve biodiversity, use biological resources in a sustainable manner and share equitably the benefits that arise from the utilization of genetic resources

One of the most important aspects of the Canadian Biodiversity Strategy is that it requires jurisdictions within Canada to report on the status of biodiversity. Given that there is still no consistent mechanism to assess and convey the overall state of biodiversity and the success of biodiversity management across Canada, the Federal-Provincial-Territorial Biodiversity Working Group began development of a Canadian Biodiversity Index (CBI; Smith et. al. 2003). The CBI is envisioned as a tool for capturing and conveying credible information on changing status and trends in biodiversity in a consistent, accessible, and regular manner. It is intended to integrate local and regional assessments to form a broad, national-scale picture on the status of biodiversity and how it is changing over time.

One of the needs and challenges with the CBI is to capture biodiversity trends in a composite index that consists of a small number of sub-indices and indicators that can be applied on different data levels and scales. The CBI differs from other measures of biodiversity in that it tries to collectively capture diversity at the species, habitat, and ecosystem levels. Indices can often intensify information oversimplification, subjectivity and masking of important relationships in underlying data because they attempt to convert data in different forms to simple scales (Brown and Dick 2001). Indicators need to be identified that minimize these problems. Ultimately the goal of the CBI is for it to be applicable to different regions in Canada with very different ecosystem and biodiversity issues and conditions, therefore the index will need to be flexible and accommodate different sets of ecounit specific indicators and data.

Over the past two years, substantial work has been done in support of CBI development. A draft conceptual framework was completed and approved by the Wildlife Ministers in September 2003 (Smith et al. 2003). The Federal-Provincial-Territorial Biodiversity Working Group was directed to begin proof of concept testing and report back to Ministers by September 2005. The testing process began in 2003, with development of a Manual for Testing (Murray et al. 2004) and a Training Manual (Pintér and Murray 2004) to ensure a consistent approach is used. In September 2004 the Canadian Forest Service carried out preliminary testing of the CBI against National Forest Inventory data.

Development of the CBI started with the design of a draft conceptual framework in a process that involved consultation with a large number of organizations and experts across the country. The conceptual framework provides an overall, high level perspective on the structure of the index and defines the CBI's main themes and types of issues and indicators included within each category (Smith et al. 2003). The current working framework for the CBI illustrated in Figure 1 is not meant to be final, and is expected to be further modified as necessary based on results of further proof of concept testing.

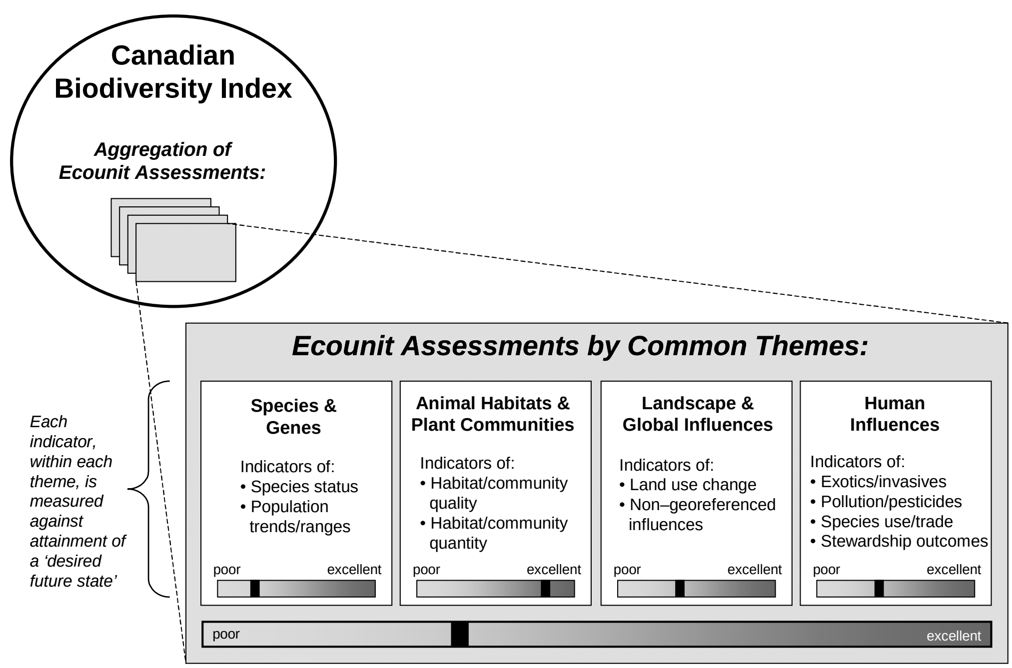


Figure 1. Current Canadian Biodiversity Index (CBI) framework (*from Smith et al. 2003*)

The draft framework comprises six main elements (Smith et al. 2003), further defined by Murray et al. (2004):

1. ***Themes***: The CBI is organized into selected high-level biodiversity topics we believe we have enough knowledge and capacity to measure. The framework currently has four themes, as shown on Figure 1.
2. ***Indicators***: A suite of indicators of biodiversity will be measured under each theme. Indicator examples have been suggested and discussed during framework development, but ecounit-specific indicators will be selected as part of the proof-of-concept-testing (POCT) process.
3. ***Analysis***: Actual trends associated with the indicators will be analysed against some desired future state, scored according to their attainment of this desired future state, and weighted as appropriate given a range of relevant factors.
4. ***Aggregation within ecounits***: The analysis for each indicator will be 'rolled up" within themes to provide an overall result for that theme and across themes to provide an overall result for that ecounit.
5. ***Aggregation across ecounits***: The results for themes and ecounits will be "rolled up" across geographic areas, to provide the index for the country, as well as for the provinces and territories.
6. ***Reporting***: The result will be conveyed in a manner that is simple to understand by a non-technical audience, but that also shows the underlying assumptions and calculations from the analysis and aggregation for audience members who wish to probe for the details.

1.2. Proof of Concept Testing of the CBI Framework and Methodology

The purpose of this first phase in proof of concept testing (POCT) is to test the framework and algorithms of the CBI against real data in a variety of different ecosystems to ensure the fully-developed CBI is a useful and meaningful measure of biodiversity. This phase of POCT was not meant as an objective test of the scientific merit of the concept, since this would require independent validation against another benchmark, rather this exercise was intended to gauge the relative ease with which the CBI concepts can be applied in a practical context. Additionally, this phase of POCT evaluated the Testing Manual (Murray et al. 2004) that was developed, which provides detailed instructions and guidance to testers of the CBI.

This report addresses key questions and issues resolved during testing, and provides recommendations on revisions to the *Draft CBI Framework* based on experiences from using real data, as well as highlighting questions remaining unresolved (in whole or in part). Since this was also the first testing of real data against the CBI framework following the methodology and guidance outlined in the *Testing Manual* (Murray et al., 2004) recommendations are given concerning its approach and future implementation. Recommendations as a result of POCT are intended to help further testing of the index by a wider range of participants and in a wider range of ecounits across the country.

2. General Approach

2.1. Guiding Principles for CBI Development and Testing

Early in the CBI development process a set of guiding principles were established (Smith et al. 2003). We followed these principles during testing, and used them as benchmarks against which we tested the overall POCT experience.

The CBI principles

Principle 1. The CBI should be usable by different jurisdictions and at different scales.
Principle 2. The CBI should be designed in a manner that facilitates aggregation and comparison of results.
Principle 3. The CBI must be scientifically defensible.
Principle 4. The CBI results should be easy to understand by a non-scientific audience.
Principle 5. The CBI must be transparent.
Principle 6. The CBI will focus on outcomes.
Principle 7. The CBI will measure indicators against a "desired future state".
Principle 8. The CBI will allow for reporting on trends.
Principle 9. The CBI must be practical and cost-effective.

2.2. Building on Earlier Work on the CBI

Considerable work has been done in support of CBI development and initial POCT. Following development of the initial framework for the CBI in 2003 (Smith et al. 2003), ESSA Technologies Ltd. and IISD were contracted to start preparations for POCT. Pilot testing against data sets from different scales, different types of ecosystems, and data held by different organizations was necessary to adjust the design and calculation methods that would make the index more robust and prepare the CBI for use by a broader community.

Preparatory work on POCT lead to a more precise definition of the CBI themes and their relationships, the development of detailed algorithms for the calculation of the index and its components and creation of graphic displays for communicating CBI results. A *Testing Manual* for initial POCT was subsequently produced to guide development of the details of the CBI and ensure a consistent approach is used by all interested organizations (Murray et al. 2004). While the framework and *Testing Manual* provide the overall structure of the CBI, POCT was needed to continue addressing through experimentation with real data questions related to key design issues. In March 2004 a one-day workshop was held in Vancouver to discuss the emerging methodology for calculating the CBI with potential CBI testers. The BC Ministry of Sustainable Resource Management was involved in initial testing, which occurred in parallel with framework development. However, earlier efforts stopped short of initiating detailed POCT with a wider range of stakeholders. A number of other participants at the Vancouver workshop also expressed initial interest in POCT. As part of preparations for testing, Environment Canada established an inventory of biodiversity indicators from different sources across the country. By using this database it was envisioned that testers would not only have better access to biodiversity data, but also produce a CBI with increased comparability across Canada (Murray et al. 2004.

3. Methods for CBI Calculation - Testing Manual Methodology and Amendments from POCT

3.1. The CBI Calculation Steps

The *Testing Manual* by Murray et al. (2004) provides detailed instructions and guidance for proof of concept testing. We followed the developed framework of the CBI and the eight steps outlined in the *Testing Manual* (Figure 2) and "tested" the framework against real data provided by three different organizations. Amendments and additional information regarding the methodology are described in the following section (3.2. Testing Manual Methodology and Amendments from POCT).

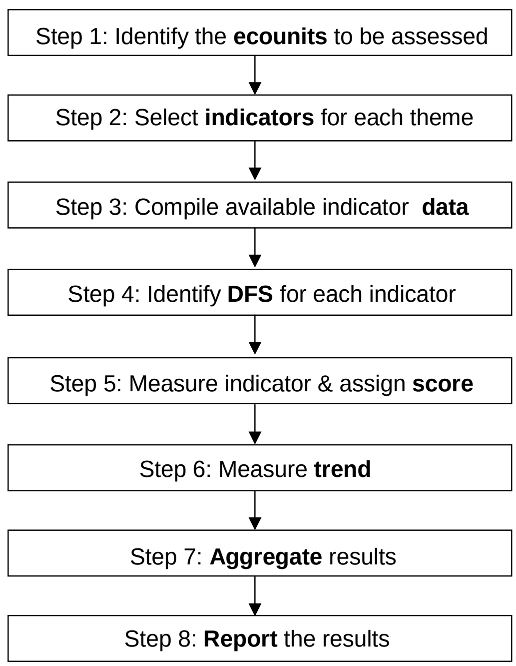


Figure 2. The eight steps for calculating the CBI for initial Proof of Concept Testing.

3.2. Testing Manual Methodology and Amendments from POCT

Step 1 – Identification of the Ecounits to be Assessed

In contrast with earlier plans when the CBI was to be calculated by organizations volunteering for POCT, all calculations and decisions for this current phase of testing were performed by the POCT team. Since many of the CBI calculation steps presume thorough familiarity with the ecounit for which the CBI is being calculated (i.e. selection of ecounit specific indicators under each CBI theme, identification of desired future state (DFS) values for respective indicators, and ultimately obtaining an ecounit CBI score), some consultation was needed with organizations that were familiar with the respective ecounits.

Three organizations that had suitable biodiversity data holdings and had expressed previous interest in POCT were identified. Selection was based on:

- Long-term strategic interest in the CBI;
- Ecological and geographic diversity of ecounits within the organization
- Type of organization (public and private);
- Ability and willingness to provide quick access to relevant biodiversity data;
- Willingness to assist with indicator selection for the CBI;
- Interest in providing feedback on the lessons learnt from CBI POCT.

Based on consultation with external organizations, two ecounits were identified within the context of which the CBI was tested. Following initial POCT guidelines (Murray et al. 2004), ecounits were large enough to be able to measure indicators and identify a desired future state for each indicator within each theme measured. The two selected ecounits were ultimately determined based on whether they had enough relevant data available.

Step 2 – Selection of indicators for each theme

Indicators were selected, where possible, that currently exist in monitoring programs within the ecounits. Others were adapted from biodiversity indicator lists such as those provided with the *Testing Manual* and *CBI Framework*. The first step in indicator selection was identifying key biodiversity issues within the four CBI themes that are identified in Figure 1. Although the majority of the data collection started once the list of indicators had been finalized, data availability and quality were among the key criteria considered in indicator selection. The final pool of indicators chosen for testing was based somewhat on the set of indicator selection criteria as listed in Appendix 1 of the *Testing Manual*, as well as ultimately whether there was enough data available and the speed at which data could be made available for testing.

Since participating organizations had in most cases a better understanding and knowledge of the ecounits selected for CBI testing, where possible relevant indicators and data sets selected within each of the CBI themes (Figure 1) were chosen after some consultation. Indicators were selected by the testing team from an initial pool of indicators identified by the participating organizations as relevant and more representative of biodiversity of their respective ecounit. An attempt was made to select indicators within a theme that together represented the status of biodiversity within that theme (eg. choosing indicators for both mammals and bird species), and collectively represented the status of biodiversity in the ecounit across themes. In many cases, however, reliable indicator data simply wasn't available and as a result, some indicators were better than others. Emphasis was given to indicators part of ongoing monitoring programs to allow trends to be measured. Effort was also made not to select indicators with naturally high variability, which would make scaling and DFS determination even more problematic.

Early on in indicator selection it became apparent that there were serious challenges working with "*Theme 3 -Landscape and Global Factors*" in its current form. Trying to develop landscape level indicators that included the ecounit became more of a challenge and led towards a fair amount of subjectivity and questions on what and how to measure. It was agreed to change Theme 3 to focus on "External Influences". Issues and recommendations regarding this change are discussed further in following sections.

Step 3 – Compilation of Available Indicator Data

Once ecounits were identified and indicators for each theme selected, datasets or links to datasets available on the internet via reports or tables were obtained from organizations who hold the data. During the process of data acquisition and defining of desired future state (DFS) levels, a confidentiality agreement for using data from the three organizations was developed to address concerns regarding: release of proprietary data, data that was not publicly released, premature publication of indicators that have not undergone technical review, and identification of 'desired future states' that have not yet been vetted through a proper consultation process. In particular, since the purpose of this phase in testing is not to report on the state of any particular ecounit, but rather to use real ecosystem data to test viability of the proposed CBI methodology, data was considered confidential where required and not released outside of the testing team or circulated in any way or manner without prior consent of the organizations who owned the data.

Step 4 – Identification of Desired Future States (DFS)

Desired future state values, or DFS, were selected in relation to assigning the CBI score scales as described in Figure 4 below. DFS values can either represent values at the top of the scale where more is better, at the bottom of the scale where less is better, or in many cases the middle of the scale where too much becomes a nuisance and too little is a concern (Figure 4a-4c).

We attempted to define DFS values for each individual indicator for each ecounit based on some existing desired goal or level. In most cases DFS values were not readily available (i.e. already articulated). For data provided by Ducks Unlimited Canada and the Government of the NWT, indicator DFS values were identified for the ecounit by the POCT team based on knowledge from these organizations and based on some already established desired level or benchmark determined from publicly released data. In all cases, the source of the DFS value (and how it was obtained by the testing team) was carefully referenced.

Box 1: Identification of Desired Future States (DFS)

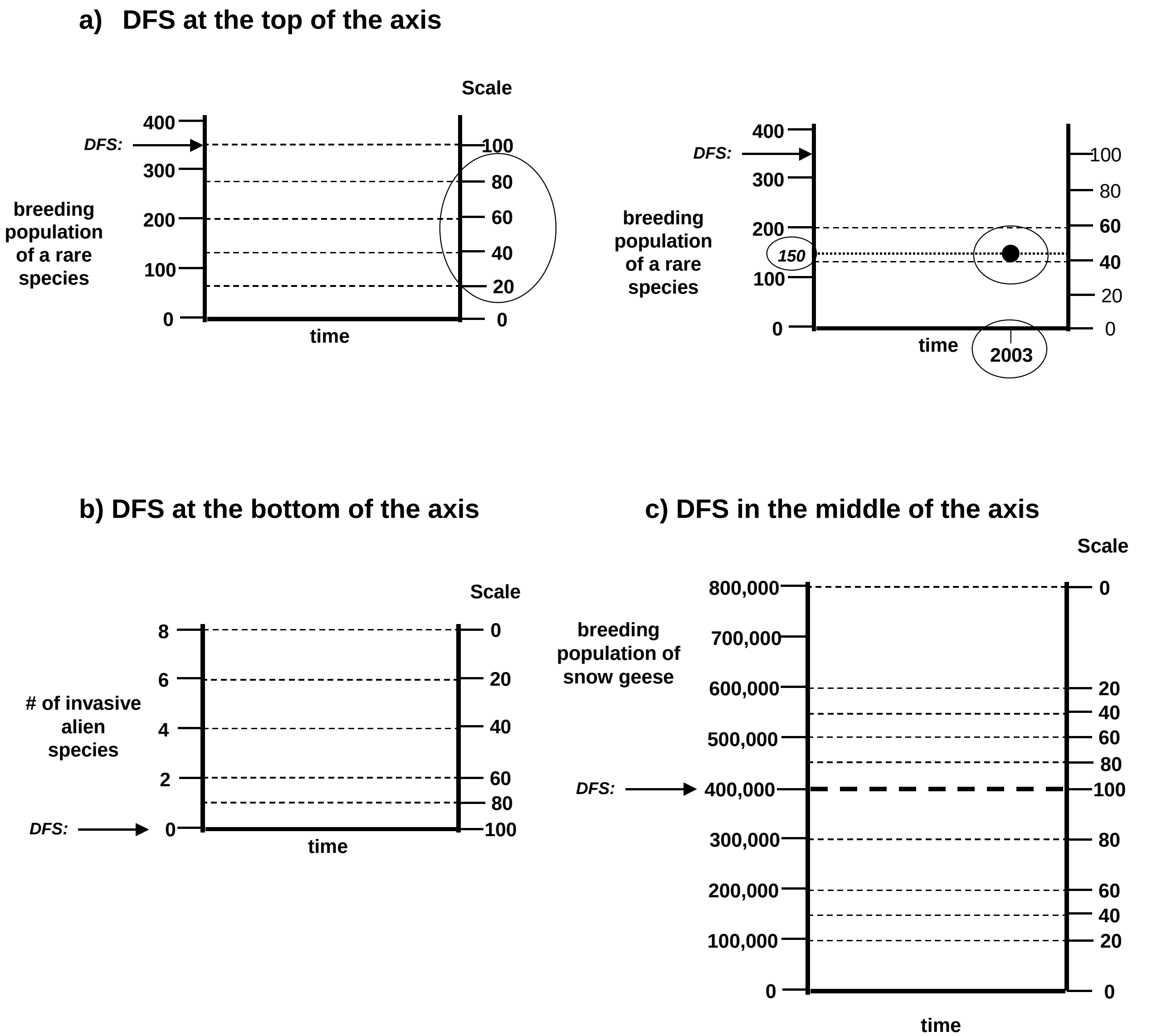


Figure 4. Examples above show how to determine scores for an indicator where the DFS is a) at the top of the y-axis ("more is better"); b) an example scale for indicators where the DFS is at the bottom on the y-axis ("less is better"); or c) in the middle of the y-axis ("too much" makes it a nuisance species, and "too little" may endanger it) are shown below. The same instructions apply.

Source: CBI *Testing Manual* (Murray et al. 2004).

Steps 5 – Measuring Indicators and Assigning Scores

We followed the guidance provided in the CBI *Testing Manual* (Murray et al. 2004) to calculate a CBI score for each indicator selected within each of the two ecounits (Further detailed in section 4. *Following the Testing Manual – Step-by-Step*). All indicators were "normalized" to a common scale from 0-100, based on attainment of their DFS. This allowed indicators measuring different things and expressed in different units of measure to be compared. The scale was set for each indicator in each ecounit, and the scale divided into 5 subcategories that were used to distinguish and compare performance among the indicators (Figure 4). Current data were plotted on these normalized graphs. For methodology refer to the Testing Manual (Murray et al. 2004).

Steps 6 – Measuring Indicator Trends

Current data were plotted on the normalized graphs and repeated for each data point from previous years for the given indicator to reveal historical trends where possible.

Steps 7 – Aggregating Results

An aggregate CBI score was calculated for each theme, and an overall aggregate score calculated for the entire ecounit, following the guidance provided in the Testing Manual (Box 2 below). Additionally, for the purposes of testing an alternate scoring method, theme scores and final ecounit scores were also calculated and presented in this report following an alternative methodology as revealed from testing. This is further detailed in following sections and outlined in the final recommendations.

Steps 8 – Reporting

Key Questions outlined in the Testing Manual were addressed throughout following sections as calculation steps were completed, as per the Testing Manual's guidance. Any issues encountered and resolved during testing were discussed. Recommendations for final reporting and graphically displaying CBI calculations and final theme and ecounit score results are discussed in Key Questions and in greater detail in later sections.

Insights concerning the actual approach and steps laid out in the manual, as well as the CBI Framework itself (Smith et al. 2004) and its future implementation, were addressed. Recommendations in this report are intended to help further the testing, development, and implementation of the CBI, as well as promote testing of the index by a wider range of participants and in a wider range of ecounits.

Box 2: Scoring Methods from the *Testing manual*

Indicator scores within a theme:
The bar chart below shows one example from the *Testing Manual* of how individual indicator scores could be displayed within a theme. Each bar represents one indicator, and the height and colour of the bar illustrates the score for that indicator. The overall result for that theme would be the lowest-scoring indicator, shown in bold on the y-axis. Showing the scores for all indicators provides a bigger picture for that theme.

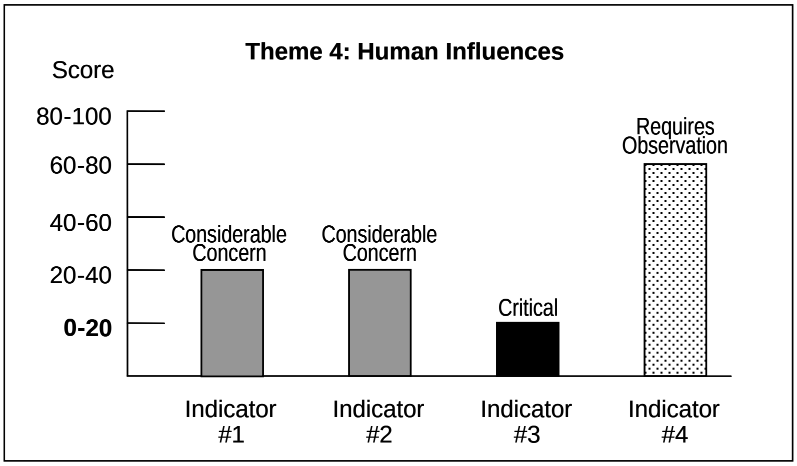


Figure 3. Example chart of indicator Scores within a theme.

Theme scores within an ecounit:
The diamond-shaped diagram in Figure 5 is one example of how the theme scores could be displayed. The numbers report the score for each theme as determined in Step 7. The colours and shapes provide a quick visual illustration of the results. However, this method does not convey any potential “good news” within lower-scoring themes, as the theme scores are based on the worst-scoring indicator. For example, the Species and Genes theme might have included an indicator that scored very high on the scale, which is not apparent from this diagram.

An alternative graphic for displaying theme scores is a bar graph where the height and colour of the bar illustrates the score for the theme (similar to the bar chart for showing indicator scores within a theme on the previous page). In contrast to the diamond-shaped graphic, this bar chart also shows the range of indicator scores within each theme. For example, while 20-40 was the score of the lowest-scoring indicator in the Species and Genes theme, other indicators in that theme scored 40-60, and 60-80. What this graphic does not show is the total number of indicators in each theme (i.e. if there were two indicators that scored 40-60 in the Species and Genes theme, they would be represented by the same shaded dot).

Source: CBI *Testing Manual* (Murray et al. 2004).

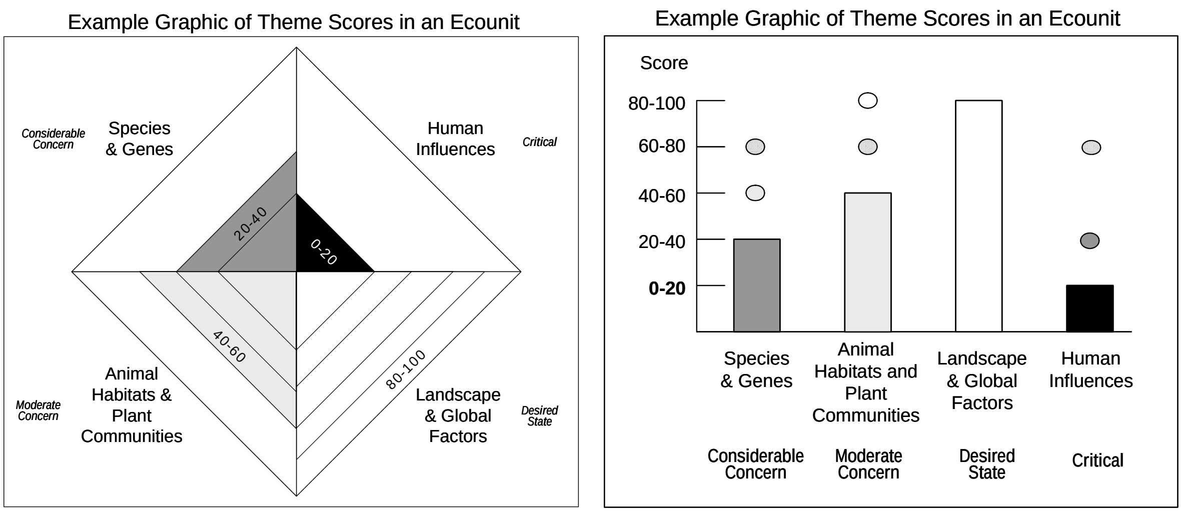


Figure 5. Examples of theme scores within an ecounit

Scores across ecounits:
The instructions in the manual do not currently include displaying results across ecounits, as each tester is expected to only conduct testing within one ecounit. Once testers have completed these instructions, the intent is to convene a workshop with the testers to discuss the results. This workshop will also provide an opportunity to explore methods for aggregating the results across ecounits.

Figure 6 shows one way that ecounit results could be displayed, in a manner that also conveys some underlying information. The small theme arrows point to the theme scores in that ecounit, and the colour of the theme arrows reflects the score for that theme. For example, Ecounit 3 shows the same data as for the previous graphic, but through this display method the reader can easily discern that within this ecounit the score for theme 3 is quite high (indicating potential successes), and the score for themes 1 and 2 signal cause for concern (and require appropriate management action).

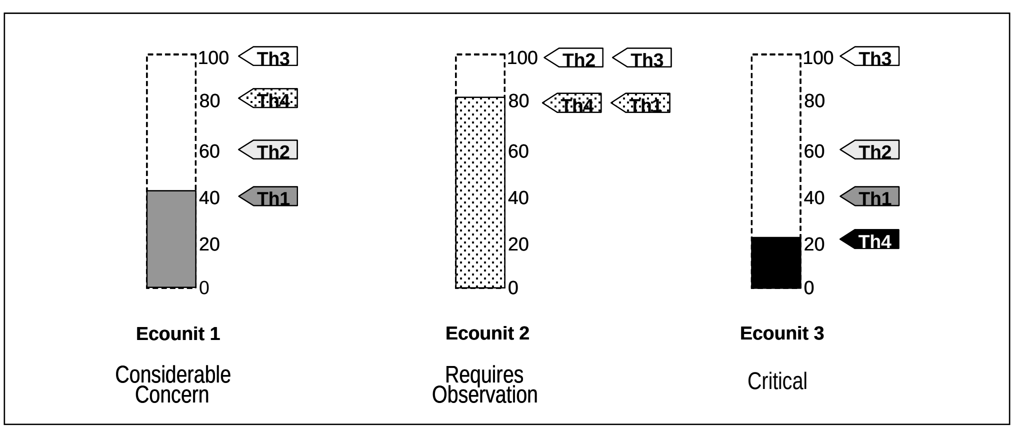


Figure 6. Example of biodiversity scores across ecounits.

4. Results - Following the Testing Manual – Step-by-Step and addressing Key Questions

Step 1: Identify the ecounits to be assessed

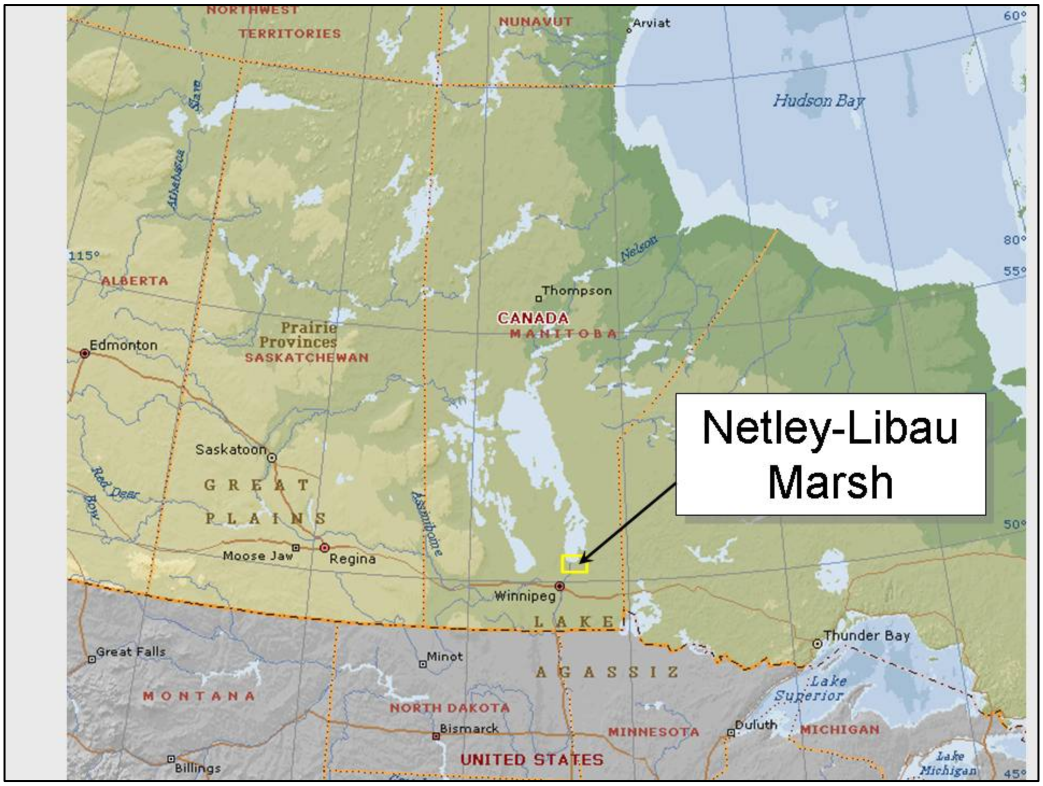
➔ *Choose the ecounits where you would like to test the CBI. (Figure 7)*

Netley-Libau Marsh, Manitoba: (Figure 8) A large freshwater coastal marsh (25000 ha in size) situated at the southern extent of Lake Winnipeg, Manitoba, where the Red River drains into the lake. It is considered a sensitive ecosystem.

Banks Island, NWT: (Figure 9) Banks Island, also known as Banksland, is the westernmost island of the Canadian Arctic Archipelago with an area of almost 70,000 km^2. This fifth largest island in Canada is an arctic tundra island habitat home to threatened and protected species of Peary Caribou, as well as Muskox.

➔ *Obtain or produce a spatial map of the chosen ecounits.*

Figure 7. Map of Canada showing locations of the 2 ecounits.



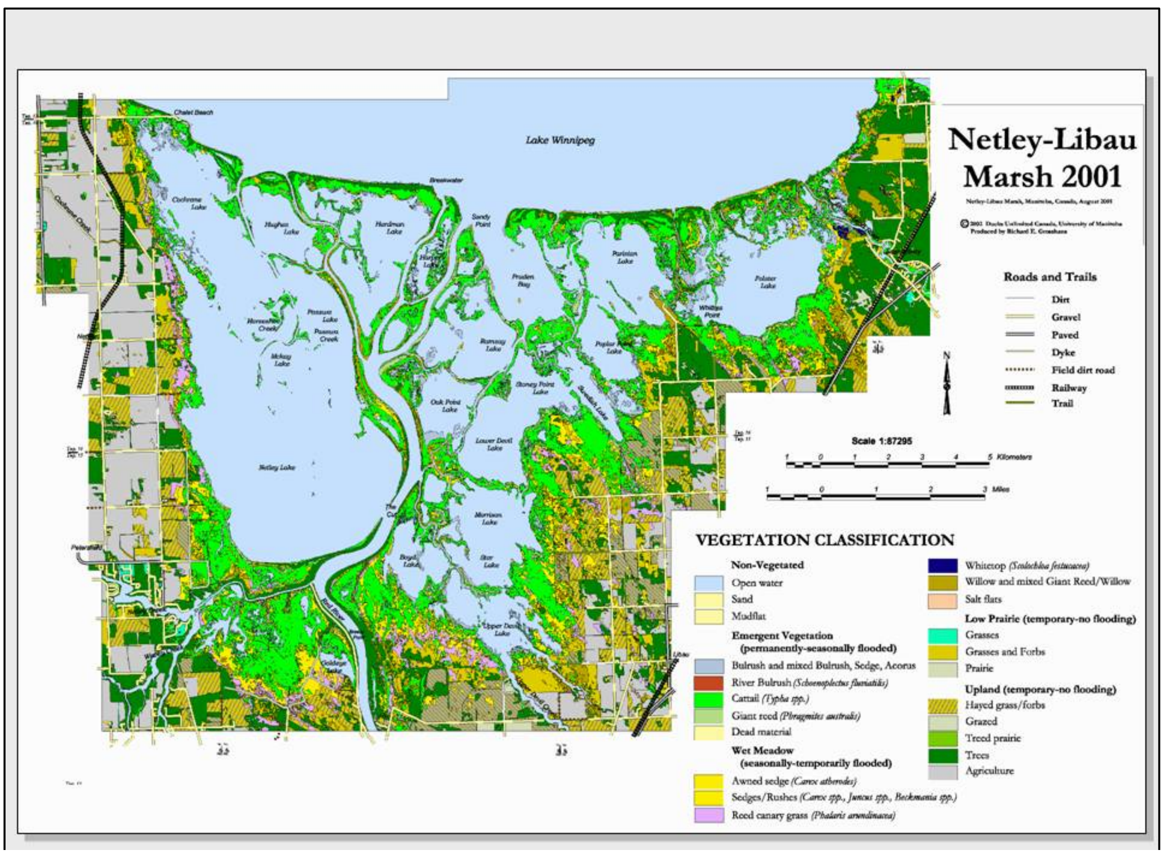


Figure 8. Location of Netley-Libau Marsh ecounit in Manitoba and the 2001 vegetation map by Grosshans et al. (2004) showing marsh boundaries

Figure 9. Banks Island, NWT showing ecounit boundaries, Aulavik National Park boundaries (Parks Canada), and a Landsat based vegetation map of a portion of the west coast region.

Step 1 - Key Questions

1. How difficult was it to identify an ecounit?

NWT and Ducks Unlimited Canada were organizations willing to be involved with this phase in the CBI testing. Some consultation narrowed each geographic area down to a couple potential sites that were either: part of a monitoring program, reporting, or designated as a significant area. The final ecounit for testing from each area was chosen based on significance and diversity in ecosystem type, and availability of appropriate data for testing.

2. Did any unexpected issues arise during this step? If so, please describe.

None. We briefly considered the following 3 other sites:

i. Delta Marsh in Manitoba due to the large amount of data that is available, but decided to proceed with Netley-Libau Marsh because of its significance to the current issues with Lake Winnipeg, the Red River and water quality within these watersheds.

ii. Mackenzie Great Bear river sub-basin in NWT, but decided to choose Banks Island because it was an arctic habitat ecounit, which is quite different than the other 2 chosen ecounits. Banks Island also has considerable monitoring data available and is part of ongoing monitoring.

Step 1 - Optional Questions

3. Is the ecounit you selected part of an ecological classification system already in use in your jurisdiction?

Yes, both ecounits are part of some kind of monitoring program. Boundaries of the two ecounits are from ecological classification systems or from management.

a. If so, what classification system is the ecounit part of?

Netley-Libau Marsh habitat classification by Grosshans (2001) for Ducks Unlimited Canada. The boundaries were established from earlier work by the Province of Manitoba. Classification is not part of a broader system but for habitat loss and mapping conducted by Ducks Unlimited Canada in 2001..

b. Is the system widely used by your jurisdictions? For what purposes?

Netley-Libau Marsh vegetation classification was developed for vegetation studies in Manitoba marshes conducted by Ducks Unlimited Canada and MB Conservation by Grosshans et al. (2004), based on previous work by Verbiwski (1984).

Banks Island: c.26,000 sq mi (67,340 sq km), NW Northwest Territories, Canada, in the Arctic Ocean, in the Arctic Archipelago. It is the westernmost of the group and is separated from the mainland by Amundsen Gulf. Banks Island, which has many lakes, is a hilly plateau rising to c.2,000 ft (610 m) in the south. Once inhabited by Inuit, it is now uninhabited except for occasional trappers. British explorer Sir Robert McClure discovered that it was an island in 1851. Canadian explorer Vilhjalmur Stefansson spent much time (1914-17) there and explored the interior.

(*Source*: Encyclopedia.com: http://www.encyclopedia.com/html/B/BanksI1sl.asp)

c. Is it widely used by other jurisdictions in Canada? Which jurisdictions? For what purposes?

Netley-Libau Marsh boundaries are defined and used by MB Conservation Wildlife Branch, Ducks Unlimited Canada, Delta Marsh Field Station (University of Manitoba), local groups such as the Netley Waterfowl Foundation and Selkirk Bird Watchers, and research groups from the University of Manitoba and International Institute for Sustainable Development (IISD).

Banks Island is an island area identified by the Governments of Canada and North West Territories, which has several protected areas and a National Park..

Step 2: Select Indicators for each theme

➔ ***Identify a minimum of 3 indicators for each of the 4 themes in your chosen ecounit.***

The Canadian Biodiversity Index (CBI) Themes

Theme 1: Species and Genes
The intent of this theme is to address genetic diversity and species diversity, as defined in the Canadian Biodiversity Strategy, within the ecounit being assessed.

Theme 2: Animal Habitats and Plant Communities
The intent of this theme is to broaden the scale beyond species to address the diversity of the biophysical environments they inhabit within the ecounit. This theme comprises "ecosystem diversity" as defined in the Canadian Biodiversity Strategy, at a scale that can be measured within the ecounit. This is analogous to what some readers may envision as "habitat diversity", although the name of the theme has been crafted to accommodate the different ways in which people interpret the word "habitat".

Theme 3: External Influences (previously "Landscape and Global Factors")
The intent of this theme is to expand the "ecosystem diversity" scale beyond theme 2 to address issues at the landscape scale or higher. This will involve consideration of diversity beyond the boundaries of the ecounit, but in a way that relates to the ecounit. (For example, if one if your indicators for theme 1 relates to a species at risk, you might want to consider the proportion of the population of that species occurring in the ecounit. While the population may be stable in that ecounit, the species might be in decline elsewhere.)

Theme 4: Human Influences
While themes 1, 2 and 3 are currently envisioned as measuring biodiversity condition, the Human Influences theme is envisioned as measuring pressures on biodiversity (positive and negative).

Ecounit 1 – Netley-Libau Marsh, Manitoba (figure 8)

Netley-Libau Marsh - Theme 1: Species and Genes.

1. **Trends in the abundance of the waterfowl species Blue-Winged Teal**
   There are extensive waterfowl surveys covering a fairly long period of time dating back to the 1940's and including almost every decade up to the 1980's. Recent data is more limited, but was collected by the Selkirk Bird Watcher annual surveys (2000-2003) and recent aerial surveys (C. Lindgren pers. Comm.). Blue-winged teal are identified as one of the most numerous and extensive waterfowl users of the marsh and a good indicator of marsh health.

2. **Trends in the abundance of Forster's Tern**
   There is fairly good survey with gaps in the time line, but this species nests in the marsh and represents 1% of the global population. Will depend on survey data, but this species is a good indicator of marsh health.

3. **Trends in the abundance of the fish species Brown bullheads**
   There is some fish survey data, mostly from 1980's and 1990's. A fish species addresses a whole different ecosystem dynamic rather than including muskrats as a mammal species for example. Bullheads are the only fish species that stays within the marsh (all others use the marsh at various times of the year), so presence would depend on the timing of fish surveys. Unfortunately data did not become available in time for testing.

Netley-Libau Marsh - Theme 2: Animal Habitats and Plant Communities.

1. **Trends in the distribution and areal extent of habit - change in marsh open water habitat**
   There is extensive spatial data covering a fairly good period of time, dating back to the 1940's and including almost every decade. Recent data is more limited, but is extremely detailed (1979 and 2001 studies). There is some very good detailed vegetation data, but the question was asked whether future monitoring will be as detailed, or more general. Open water or general marsh area changes are much easier to track by satellite data and more likely to be included in future monitoring of the marsh. Aerial photography and vegetation mapping is laborious and expensive.

2. **Loss of bulrush and mixed bulrush/sedge habitats**
   There is fairly good data on this as well, both spatial and non-spatial dating back to a long period of time. These communities are considered critical habitat for waterfowl, both breeding and staging, and for fish spawning habitat, as well as important food and lodging.

3. **Change in cattail habitats**
   There is fairly good data on this as well, both spatial and non-spatial dating back to a long period of time. Cattail is considered an invasive species, and it can invade other communities creating dense homogenous communities less desirable to waterfowl and other wildlife. A good indicator of changes due to nutrient enrichment as well as stable water level conditions.

Netley-Libau Marsh - Theme 3: External Influences.

1. **Nutrient input from the Red River into Netley-Libau Marsh**
   Nutrient input is a surrogate for water quality of the surrounding watershed, and has a direct influence on the biodiversity of the marsh. Nutrient inputs affect habitat, habitat conditions, wildlife populations, invertebrates, cause algae growth, etc. An external influence on the Netley-Libau Marsh ecounit.

2. **Landuse changes around the marsh – increase in agricultural pressure**
   Agricultural intensification data has been tracked over time. Landuse change around the marsh also has a direct impact on the marsh ecounit. By tracking changes in the surrounding indicator, this can help us protect biodiversity within the ecounit. This data did not become available for testing.

3. **Climate change – Temperature trends**
   Climate data has been collected by Environment Canada locally. Average local increases due to climate change could be calculated. Local precipitation and weather trends have a direct influence on the marsh ecounit. Availability of water upstream affects the marsh downstream. Severe drought conditions as well as flood conditions impact the marsh, both positively and negatively.

Netley-Libau Marsh - Theme 4: Human Influences.

1. **Measure of physical restructuring of the marsh - # of separate water bodies**
   In this case the loss of shoreline and physical restructuring of the marsh is due to human influence and physical alterations to the marsh. For example the Neltey Cut within the Red River bank was created and as a result has altered the flow of the river and caused extensive loss of island and channel habitats. As well, regulation of the lake is thought to have led to loss of shoreline and marsh habitat.

2. **Landuse changes within the marsh – increase in agricultural pressure**
   Agricultural intensification has been tracked over time both spatially and nonspatially. Landuse change around the periphery of the marsh within the ecounit has a direct impact on the marsh biodiversity. Agriculture will include both haying, cropland, and cattle grazing due to long term data sets.

3. **Percent of the marsh that is protected**
   How much of important ecosystems are protected? Shows whether protected areas are actually protecting naturally functioning ecosystems. A portion of Netley-Libau Marsh is a game bird refuge, established in 1966. Since then, the marsh has been designated an IBA and a Manitoba Heritage Marsh.

Ecounit 2 – Banks Island, North West Territories (NWT) (figure 9)

Banks Island, NWT - Theme 1: Species and Genes

1. **Population trends for Peary Caribou**
   How have the populations changed over time? Status of key species used as indicators of health and quality of habitat and the ecounit. The Peary Caribou are an endangered species and Banks Island is a critical calving area.

2. **Trends in the abundance of Muskox**
   Muskox were very endangered at one point in time, but have rapidly recovered on Banks Island to the point that they have become the largest muskox herd in the world. One of the concerns is they are beginning to compete for habitat and food resources with the endangered Peary Caribou herds on the island, and the population is now becoming overpopulated.

3. **Trends in the abundance of Snow Geese**
   The largest nesting population of snow geese in the western Arctic breeds at the Egg River colony on Banks Island. The Western Arctic Population of Lesser Snow Geese (*Anser caerulescens caerulescens*) consists of four major colonies, and 98% are in the Banks Island colony. These birds also make up an important part in local diets and are harvested by communities in the Inuvialuit Settlement Region.

Banks Island, NWT - Theme 2: Animal Habitats and Plant Communities

1. **Ratio of native to non-native plant species**
   368 species of vascular plants occur in the Arctic Archipelago of which 9 are exotics (ratio 100/2.4)

2. **Changes in plant productivity and growth (NDVI)**
   The timing of green-up is important for identifying and describing the effects of climate change on regional scales and more specifically the effects of warmer temperatures on the arctic environment. Reflectance data from AVHRR satellite imagery can be used to calculate the Normalized Difference Vegetation Index (NDVI); an index that is considered a good measure of relative biomass and plant productivity. Over the last decade there has been an increasing trend in NDVI, which translates to increased plant productivity. This trend coincides with increases in air temperature during the winter and spring seasons in the region. Climate change models predict increases in productivity due to simple warming permitting more growth as well as elevated CO2 in the atmosphere stimulating plant growth. Increasing NDVI can be linked to increased global temperatures as a result of climate change. There is significantly more vegetation productivity now than 11 years ago.

3. **Proportion of rare plants to all native plants**
   General status of rare plants. Banks Island was not part of the last glaciation, so very rare plants still exist on the island. Unfortunately this data did not become available for CBI testing, but will be available in the near future.

Banks Island, NWT - Theme 3: External Influences

1. **Climate change - Temperature trends**
   Climate data has been collected by Environment Canada locally. Average local increases due to climate change could be calculated. Local precipitation and weather trends have a direct influence on all ecounits. Increases in temperatures, availability of water, severe drought conditions, as well as severe flood conditions impact all ecosystems, both positively and negatively. This data did not become available in time for testing

2. **Levels of disease or pollutant contamination – Mercury levels in liver of Beluga Whales**
   Northern Contaminant program, part of Indian and Northern Affairs, is dedicated to the monitoring of contaminants in the north. Evidence shows mercury has increased in Canadian Arctic animals from pre-industrial times to present. It has been suggested that increased temperatures in the Mackenzie River region have liberated mercury and may explain the increases in mercury concentrations observed in the Beaufort Sea Beluga Whale population.

3. **Human presence and use around the island**
   Increased pressure from human use and presence around the island affects the wildlife inhabiting the island and marine mammals around the island coast. Increased presence from surveying, mining, oil and gas industry, research studies and monitoring. Indian and Northern Affairs monitors all activity. Data did not become available for testing.

Banks Island, NWT - Theme 4 – Human Influences

1. **Hunting harvest rates- number of animals shot each year**
   Hunting is a viable and sustainable resource important for local communities. Quota of Peary Caribou allowed to be shot each year, must be monitored until population goal is reached.

2. **Human presence and use on the island**
   Increased pressure from human use and presence on the island affects the wildlife inhabiting the island, and the marine mammals around the island coast. Increased presence from surveying, mining, oil and gas industry, research studies and monitoring, and visitors to Aulavik National Park.

3. **Percentage of ecounit habitat area that is protected**
   Shows whether protected areas are actually protecting naturally functioning ecosystems. Aulavik National Park on Banks Island is protected habitat. The Banks Island Migratory Bird Sanctuary, a designation that applies to the Castel Bay and the lower region of the Thomsen River Valley protects sedge meadow habitat. Important caribou calving and polar bear denning areas however are not protected, but boundaries have been recommended.

STEP 2 - KEY QUESTIONS

1. Did you have difficulty identifying at least 3 indicators for all 4 themes?

Yes. For the most part indicators were easy enough to identify (exception being for theme 3, which is discussed below), however, difficulties arose when deciding which indicators to use based on available data. Some indicators or datasets include very detailed and sometimes very current data, but it is from a very limited and short period in time. For example, the bird surveys in Netley-Libau Marsh from the Selkirk Bird Watchers are an excellent and very current datasource, but unfortunately there is very limited historical data on songbirds and non-game species in general. In some cases it is merely side observations or casual notes. Only a few species were recorded in historical surveys. So while there is an extremely detailed current survey of bird species, there is very little historical data to compare it with at the present time. Nevertheless, future surveys will be able to compare to these surveys.

Another point that was discussed for theme 1 was, should we use a species that inhabits the ecounit throughout the year, or could we track a species that uses it only for a certain time of the year? Would this be a better indicator to monitor? It was tentatively agreed that it is better to track a species that inhabits the ecounit since timing of surveys really determines if a species is recorded or not. Uncertainty arises when using historical species survey datasets.

a. Which theme(s) did you have difficulty with?

By far the most difficulty was with theme 3 – *Landscape and Global factors*. In its present form, it was difficult to develop landscape level indicators that included the ecounit itself as well as “landscape” level influences. There was uncertainty as to what to measure, and often how to measure it reliably. The problems and challenges of theme 3 in its current form included:

Theme 3 problems of scale:

For large ecounits, “landscape” factors could be measured inside the ecounit itself, making it difficult to decide which indicators fit into themes 1 and 2 versus theme 3 (problem 1). For smaller ecounits, landscape factors were more clearly operating outside the ecounit, simply because of its smaller size. This made it hard to be consistent in how theme 3 was used across ecounits of very different sizes (problem 2). If theme 3 was viewed as “factors external to the ecounit”, it was difficult to find useful/meaningful indicators of such factors for very large ecounits (problem 3).

For example, would we measure the percentage of Netley-Libau Marsh as a percent of wetland habitat across the prairies? The relative percentage of this area within the ecounit would increase with the continued loss of wetland habitat across the prairies. What would this actually mean for biodiversity in the ecounit, and what would the DFS be? A loss of a given habitat within the ecounit itself would cause a decrease in the overall percentage or ratio of that habitat on the landscape, which would accordingly score “bad” on the CBI. However, restoration of the same type of habitat outside the ecounit, which is “good”, would cause a decrease in the ratio of total habitat within the ecounit causing the score to decrease as well. Each of these scenarios have different implications for the overall state of biodiversity at each scale (ecounit, versus provincial for example) and different implications for where management efforts to conserve or restore biodiversity should be focused. Another option considered was the % of area protected in the ecounit versus in all of the province or territory for example or even across Canada; and another was the degree of fragmentation within the ecounit compared to outside the ecounit. The problem again is it is difficult to know whether an increase in this indicator should score high or low in the CBI, since an increase could be a result of a loss within the landscape.

The same type of issue arises when comparing indicators of theme 1 or 2 with the same indicators outside the ecounit (provincially or across Canada for instance). For example if we used bird species that nest in Netley-Libau Marsh, or large mammals breeding on Banks Island, they represent a percentage of the entire world population. But once again, a decrease in their global percentage could be due to a decrease in their population locally or an increase in global population, so confusion comes again when deciding DFS and trends to measure.

Essentially, since these types of indicators are fractions, an increase can be for one or both of the following reasons: a) the numerator gets bigger, which is good for some indicators (e.g. more parks designated in the ecounit) b) the denominator gets smaller, which is bad (e.g. some parks dismantled outside the ecounit). The opposite is true for a decrease in the indicator: this can occur because the numerator gets smaller (bad) or because the numerator gets bigger (good).

Contextual problems:

If the quality or quantity of an indicator within an ecounit is being compared with that outside the ecounit, it is difficult to determine what type of change should score higher in the CBI.

Recommendations for Changing Theme 3:

During the course of proof of concept testing, it was determined that theme 3 should be changed to: "**External Influences",** as opposed to **"Landscape and Global Factors".** The rationale is to consider landscape and global pressures around the ecounit. Not factors within the ecounit, but to reflect external influences outside within the surrounding landscape that have a direct affect on the ecounit. A given indicator within the ecounit might not necessarily be showing an affect yet, but by monitoring or measuring outside external influences this could give us an early warning signal for affects to the ecounit.

Changing theme 3 to reflect "External Influences" removes much of the uncertainty as it was in its current form. Nevertheless, the challenge of identifying external influences to an ecounit will be a scale dependent issue: how to delimit the extent of the area causing external pressures within the ecounit.

b. ***Did you use indicators from the menu? (see Guidance section below)***

Yes. The lists provided gave some good examples of biodiversity indicators that could be used or modified for the selected two ecounits.

2. ***Do we have the right themes?***

If the question means: do these themes really capture the elements of biodiversity that need to be included to meet the overall objective of the index?
Then Yes, so far at this step the four themes seem to capture biodiversity in a way that appears to be confidently expressed in the context of the overall index. Although this question can't be fully answered until after indicators have been measured and scored.

This question could also be interpreted at this step as: Were the themes easy to use?
In this case, then Yes, exception being theme 3. As already discussed, this theme needed to be modified to clarify and reflect external influences outside of the ecounit. This removed much of the "grey areas" with theme 3 in its current form.

3. ***Were there important indicators that you could not fit into any theme?***
   a. ***If so, what were they?***

In some cases the issue was trying to determine which theme they fit into, because a few seemed to fit into more than 1 theme.

Invasive species- Theme 2 or theme 4? Not all due to human influence – most likely fits into theme 2 with regards to changes in habitat. Unless it is a direct human influence.

Shoreline loss – Theme 2 or theme 4? Is it because of human influence, or is it habitat change? In this case the loss of shoreline and physical restructuring of the marsh is due to human influence and physical alterations to the marsh (i.e. the Neltey Cut within the Red River bank was created). The same quandary applied to habitat fragmentation and loss of connectivity.

Nutrients and contamination – Theme 3 or theme 4? Is it an external influence, or due to human influence? Most likely both, but which would be more relevant and a more direct measure of influence. Over time, which theme would this indicator track?

4. ***Did any unexpected issues arise during this step? If so, please describe.***

When dealing with theme 1, we discussed the issue of needing to be aware of global or local effects and changes. If a species population or presence changes for example, is it due to something that is occurring within the ecounit, or is it because of something that is occurring outside the ecounit? Does it make any difference, or is it important simply that there *is* a change? Actual monitoring of biodiversity within an ecounit, or even further testing, could need to include monitoring or measuring of an outside population of the same species, (i.e. control population) outside the ecounit. If they both drop or increase in number, this change in the ecounit trend might not be because of anything happening with the ecounit itself. At this phase in testing this was not considered, but could be for future monitoring and use of the index. Nevertheless, since the goal of the CBI in one sense is monitoring and not explaining, simultaneous monitoring inside and outside the ecounit to understand if changes are due to local or general effects may not really be an issue since the priority is monitoring changes within the ecounit. Causal analysis and determining source of change would be revealed from the simultaneous and subsequent interpretation of the CBI at multiple scales and from similar ecounits at the same scale.

Another issue that arose at this step, which pertains to any future involvement with participating organizations, was data confidentiality. Ultimately, at this phase in POCT the primary objective was to use real ecosystem data to test the CBI framework and *Testing Manual*, rather than the final ecounit data. One consideration was if the identity of the ecounits needed to be protected while still using actual ecounit data, it could have been presented in an anonymous way. If necessary, generic names could be used for reporting in a public dispersed document or publication. For example identifying Ecounit A, Ecounit B, Species A, Habitat B, etc. An internal report could be available to the project team with the actual data, unless the data is already publicly available as is the case with most of the Netley-Libau Marsh and Banks Island datasets. This reporting method could be considered for future CBI testing and third party organization involvement. Nevertheless, the suggestion of a report or document containing no data and only presenting testing results and methods at this phase of proof of concept testing was considered far less valuable, so confidentiality issues were dealt with as required.

It was determined that:

1. A letter of confidentiality would be required from Environment Canada that sensitive data would not be circulated beyond the testing team.
2. A statement to the effect that “if data is circulated beyond the testing team, it will not be circulated in any way or manner without the participating organizations written consent”
3. That two documents could be released if needed – an internal document/report containing ecounit specific data, and a second document/report for public circulation containing the real data but with no attribution or references to specific ecounits.

Step 3: Compile available indicator data

➔ ***Acquire all of the available data for each indicator selected in Step 2.***

See Appendix I

➔ ***Graph the data, with time on the x-axis.***

See Appendix II

➔ ***Carefully consider these graphs, and decide whether you have indeed chosen useful indicators. If necessary, modify your indicator selection, and acquire and graph the data for any new indicators.***

In some cases graphing of data was not necessary to choose indicators, since selection of indicators with appropriate data was minimal, and the amount of data available for a given indicator was often minimal as well.

With regards to holes in the data, what we are experiencing is more or less what was expected from the onset. One of the questions that arose during testing was whether it was possible to use data gap filling using statistical techniques, even if very simple ones. For example, producing regression lines based on the data we have and working with the point on the line applicable to a given year, even if it is based on extrapolation, not actual measurement.

➔ ***Document the following metadata for each of the chosen indicators:***

- ***Units of measurement*** *(e.g. hectares, kilometres, or % of known species)*
- ***Method of calculation****, if the indicator is generated from more than one data set*
- ***Title:*** *the name by which the data set(s) used to generate the indicator is known*
- ***Originator:*** *the name of an organization or individual that developed the data set(s)*
- ***Online linkage:*** *the name of an online computer resource that contains the data set(s)*
- ***Publication date:*** *date the data set(s) is published or otherwise available for release*
- ***Description*** *of the data set(s), including intended use and limitations*
- ***Beginning date*** *and* ***end date*** *for the data set(s)*
- ***Status:*** *the state of and maintenance information for the data set(s), including the frequency with which changes and additions are made*
- ***Spatial domain:*** *the geographic areal domain of the data set*
- ***Bounding coordinates:*** *the limits of coverage of the data set(s) in latitude and longitude, in the order western-most, eastern-most, northern-most, and southern-most*

Step 3 Results: Compile available indicator data

For all documented indicator metadata see Appendix I

Step 3 - Key Questions

1. ***Sometimes when we populate an indicator with real data, it does not present as clear a trend as expected.***
   a. ***Did this happen to you? If so, for which indicator(s)?***

      Yes. Once the data was gathered and graphed according to time, issues arose with the data. Some of the data was not as good as originally anticipated because it did not span a long enough period of time, or was collected in ways that made it difficult to draw conclusions and calculate long term trends.

   b. ***Did you repeat Step 2 and change your indicator selection? If so, how?***

      Yes, in a sense. A pool of indicators was initially compiled and from these 3 indicators were selected for each theme determined by which ones had reasonable or enough data. An excel file was created to chart data gaps and data availability and while final indicators were selected. In some cases, scrounging 3 indicators together for a given theme was a challenge, particularly theme 3 and theme 4. Themes 1 and 2 typically had the most data available for an ecounit simply because they deal with animal populations and habitats; indicators agencies and individuals typically monitor and track over time.

2. ***Did any unexpected issues arise during this step? If so, please describe.***

   Yes. Discovering some indicators had poorer than expected datasets, both in quantity and quality. Either data collected for only a short period of time, missing data, or time periods collected or measured in very different ways or at different scales that was difficult for long term comparisons. As well, trying to determine what exactly was to be measured was often a challenge, as was determining exactly what to chart over time.

   In many cases, ALL ecounits will have the same challenges with regards to availability of data, and quality of data. Historically data was just not collected in the kind of manner or format that is useful for documenting changes or plotting meaningful trends.

Step 4: Identify a Desired Future State (DFS) for each indicator

For each indicator selected in Step 2:

➔ ***Investigate whether a suitable DFS has already been identified that applies in the ecounit you are using for POCT. If a suitable DFS already exists, document:***
   - ***What it is, Where it comes from, and***
   - ***The time horizon (e.g. whether is it a medium-term or long term target).***

➔ ***If a DFS is not already identified, determine one. Document:***
   - ***What it is,***
   - ***The process used to determine it (including who participated), and***
   - ***The time horizon (e.g. whether is it a medium-term or long term target).***

The DFS is critical for calculating the CBI, as scoring will be based on measuring the current status of each indicator against its DFS. To proceed any further in CBI calculation, a DFS must be identified for each indicator, in each ecounit.

The DFS must be articulated in the same units of measure as the indicator. If the DFS is a rate of change, the indicator should also be converted to a rate of change such that the indicator and its DFS can both be identified along the same y axis of a time-trend graph.

The DFS should not be a short-term target that might be revised on a frequent basis. It should have a lifespan of at least 10 years.

Step 4 Results: Identificatin of Desired Future States (DFS)

For all documented indicator DFS selection for charting see Appendix II

Ecounit 1 – Netley-Libau Marsh, Manitoba (figure 8)

Netley-Libau Marsh - Theme 1: Species and Genes.

Theme 1 Indicator	DFS
1. Trends in the abundance of the waterfowl species Blue-Winged Teal	1,700 birds during fall flight – average of local 1970's levels*
2. Trends in the abundance of Forster's Tern	217 nests – IBA Globally significant population criteria is 1% of global population**
3. Bullheads? Muskrats?	***

***1. Trends in the abundance of the waterfowl species Blue-Winged Teal**

From the 1970's NAWMP baseline reference for duck population

Duck population objectives, from North American Waterfowl Management Plan:
"The abundance of ducks in North America from 1970 to 1979 is the baseline reference for duck population objectives under the North American Waterfowl Management Plan (NAWMP). The 1986 Plan contended that duck numbers during the decade of the 1970s, with the exception of a few species, generally met the needs of all users. This number of ducks and the amount of habitat required to support them throughout their annual cycle determined the major objectives of the Plan. Thus, information from the 1970s supported the overall objectives of 62 million breeding ducks and a fall flight of 100 million birds under average environmental conditions—that is, average weather conditions in the Mid-continent Region." [1]

Example indicator	Example DFS
Continental breeding population	Achieve a continental breeding population of 62 million ducks (mid-continent population of 39 million) during years with average environmental conditions, which would support a fall flight of 100 million ducks

****2. Trends in the abundance of Forster's Tern**

Forsters Terns nesting in Netley-Libau marsh represented 1.5% of the global population (325 nests) in 1979. The IBA criteria for Globally Significant is 1%, which would be approx. 217 nests.[2]

Netley-Libau Marsh IBA Criteria: Globally Significant: Congregatory Species, Waterfowl Concentrations, Migratory Landbird Concentrations, Nationally Significant: Congregatory Species

In general, a 'significant number' is considered to be 1% or more of the relevant population, although in a few cases less than this was accepted. Regular occurrence at a site was

[1] U.S. Fish and Wildlife Service, SEMARNAP Mexico, and Canadian Wildlife Service. 1998. *North American Waterfowl Management Plan, 1998 Update – Expanding the Vision.* http://www.nawmp.ca/pdf/update-e.pdf

[2] From the Important Bird Areas Website (IBA)
Criteria for IBAs: http://www.bsc-eoc.org/iba/ibacriteria.jsp
IBA info specific to Netley-Libau Marsh :http://www.bsc-eoc.org/iba/site.jsp?siteID=MB009&seedet=Y

generally defined as the yearly presence of a species, if known. If information on the species abundance was known for several years the data from the most recent five years was used in many but not all cases.

*****3. Trends in the abundance of the fish species Brown bullheads**

There is some fish survey data, mostly from 1980's and 1990's. A fish species addresses a whole different ecosystem dynamic. Bullheads are the only species that stays within the marsh, all others use the marsh at various times of the year.

Netley-Libau Marsh - Theme 2: Animal Habitats and Plant Communities.

Theme 2 Indicator	DFS
1. Trends in distribution and extent of habitat –change in marsh open water habitat.	Restore marsh habitat to 1979 levels – decrease Open Water areas to 9000 ha*
2. Loss of bulrush and mixed bulrush/sedge habitats	Restore mixed bulrush communities to 1979 levels – 4100 ha**
3. Change in cattail habitats	Avoid monodominant expansion of cattail – < 5000 ha***

***1. Trends in distribution and extent of habit – change in marsh open water habitat**

Percent area of open water and marsh habitats in 1979 has been considered an ideal ratio of habitat for many species in Netley-Libau marsh, and was recommended as the target level for any kind of revitalization or habitat work in the marsh during the 1980's Netley-Libau marsh assessment study. The most desirable stage for many species is what is called the hemi-marsh. During this stage, the wetland has a 50:50 mix of open water and aquatic plants such as bulrush, sedges, and cattails. The ratio of open water to emergent marsh habitat in Netley-Libau Marsh in 1979 was near this hemi-marsh target of 50:50 (8800 ha : 9800 ha).

****2. Loss of bulrush and mixed bulrush/sedge habitats**

Bulrush communities are considered critical habitat for waterfowl, both breeding and staging, as well critical fish spawning habitat, muskrat food sources and lodge building material, and home to numerous other song bird and non-game species. Also an important component in nutrient cycling, marsh biodiversity, protection of submersed plant and invertebrate communities, decreasing wave action and turbidity. The 1979 percent cover of mixed bulrush communities have been recommended as the target level for the marsh.

*****3. Change in cattail habitats**

Cattail is considered an invasive species, and can invade other communities creating dense homogenous communities less desirable to waterfowl and other wildlife. A good indicator of changes due to nutrient enrichment as well as stable waterlevel conditions. Cattail has not increased substantially in area in Netley-Libau Marsh compared to other marshes in Manitoba, but with nutrient problems in the Red River and Lake Winnipeg system, this could change. Avoiding further cattail expansion is desirable. The 1979 percent cover of cattail habitats can be considered as an acceptable % cover of cattail within the marsh.

Netley-Libau Marsh - Theme 3: Landscape and Global Factors.

Theme 3 Indicator	DFS
1. Nutrient input from the Red River into Netley-Libau Marsh	Decrease N and P inputs to 1970's levels – 13% or more reduction in current P loading (2600 T/year)*
2. Climate changes – local precipitation trends	Limit to 1.5 degree increase in temperature **
3. Landuse changes around the marsh – increase in agricultural pressure	***

***1. Nutrient input from the Red River into Netley-Libau Marsh**

Nutrient input is a surrogate for water quality of the surrounding watershed, and has a direct influence on the biodiversity of the marsh.

Manitoba Water Stewardship's Lake Winnipeg Action Plan and Nutrient Management Strategy identify commitment to reduce nutrients in the lake to pre-1970's levels by reducing N and P inputs by 13% or more or current levels,
http://www.gov.mb.ca/waterstewardship/water_quality/lake_winnipeg/action_plan.html

The Lake Winnipeg Action Plan can be found here:
http://3438bd.mercuryspace.com/web/downloads/LWSB_ActionPlan.pdf
Action under the six-point plan includes:

> Establishment of a Lake Winnipeg Stewardship Board to help Manitobans identify further actions necessary to reduce nitrogen and phosphorous to pre-1970 levels in the lake by 13 per cent or more, subject to further findings of the Nutrient Management Strategy;

****2. Climate changes – local precipitation trends**

Climate change report indicates changes in the various regions.

Temperature and precipitation trends are tracked over time. Show an average increase over time. The DFS is based on the global objective to limit to 1.5 degree increase at most.

*****3. Landuse changes around the marsh – increase in agricultural pressure**

Agricultural intensification data has been tracked over time. Landuse change around the marsh also has a direct impact on the marsh ecounit. By tracking changes in the surrounding indicator, this can help us protect biodiversity within the ecounit.

Netley-Libau Marsh - Theme 4: Human Influences.

Theme 4 Indicator	DFS
1. Measure of physical restructuring of the marsh – # of separate water bodies	Restore shoreline and channels – average 34 separate water bodies to protect habitat from wave erosion*
2. Landuse changes within the marsh – increase in agricultural pressure	Minimize agriculture around marsh periphery to less than 10% of the ecounit.**
3. Percent of the marsh that is protected	Protect the entirety of the marsh as a heritage marsh***

***1. Measure of physical restructuring of the marsh – # of separate water bodies**

In this case the loss of shoreline and physical restructuring of the marsh is due to human influence and physical alterations to the marsh. The number of relatively separate water bodies has changed dramatically over the last 60 years. Seperation of large bodies of water helps protect habitat from wind and wave erosion. An average of the # of distinct water bodies since 1936 was identified as the DFS.

****2. Landuse changes within the marsh – increase in agricultural pressure**

Agriculture around the periphery of the marsh, which includes haying, cropland, and cattle grazing, has a direct impact on the marsh biodiversity. It is difficult to determine a desired level of agriculture since the amount of land hayed each year, and even grazed, depends significantly on that years weather conditions. The current amount of land under agriculture or less is considered an acceptable level.

*****3. Percent of the marsh that is protected**

In 1966 a 2650 acre portion of Netley-Libau Marsh was established as a game bird refuge. In October 2000 the marsh was designated as an IBA (Important Bird Area) and has since been names a candidate Manitoba Heritage Marsh. This protects the entirety of the marsh as an important natural marsh ecosystem.

Ecounit 3 – Banks Island, NWT (figure 9)

Banks Island, NWT - Theme 1 – Species and Genes

Theme 1 Indicator	DFS
1. Population trends for Peary Caribou	Population size goal as outlined by the National Recovery Strategy and Sachs Harbour Community Conservation Plan – 5500 animals*
2. Trends in the abundance of Muskox	Population size goal as outlined by the National Recovery Strategy and Sachs Harbour Community Conservation Plan – 30,000 animals**
3. Trends in the abundance of Snow Geese	Western Arctic Population size goal as outlined by the by the National Recovery Strategy and Sachs Harbour Community Conservation Plan – 200,000 birds***

***1. Population trends for Peary Caribou**

http://www.nwtwildlife.rwed.gov.nt.ca/rwed_infobase/asp/full.asp?SpecID=2
http://www.taiga.net/projectcaribou/pdf/casestudies/peary_study.PDF

A National Recovery Strategy for Peary caribou and arctic-island caribou is in the final stages of development, which includes population objectives for the caribou (the size the population needs to be before its status can change from endangered to threatened).The strategy is part of a program called RENEW (Recovery of Nationally Endangered Wildlife).

In 1972 Peary Caribou numbers were up around 12,000, but have declined dramatically to a current level of 480 animals. Critically at risk.

http://www.nwtwildlife.rwed.gov.nt.ca/Publications/speciesatriskweb/pearycaribou.htm#Population%20Size%20and%20Trends

****2. Trends in the abundance of Muskox**

Muskox were endangered at the turn of the century, but have rapidly recovered to the point where the Banks Island herd has become the largest muskox herd in the world. The local populations believe the growing muskox population is threatening the Peary Caribou, and so management plans have been recommended to selectively harvest muskox while maintaining numbers near Sachs Harbour for tourism, subsistence hunting, and trophy hunting. A desired population goal recommended by the Sachs Harbour Community Plan and the National Recovery Strategy is 30,000 animals.

*****3. Trends in the abundance of Snow Geese**

The largest nesting population of the Western Arctic Population of Lesser Snow Geese (*Anser caerulescens caerulescens*), consisting of 98% of the western arctic population, breeds at the Egg River colony on Banks Island. The lesser snow goose population has tripled over the past 20 years and continues to grow at a rate of five percent a year. It now stands at over 4.5 million breeding birds. The expanding populations threaten to damage and destroy the fragile sub-Arctic and Arctic coastal marsh ecosystem where they nest in the summer. It cannot sustain this many geese. The Western Arctic goal is to cut this population in half to 200,000. This is consistent with the Arctic Goose Joint Ventures goals to reduce the snow goose population from 4.5 million to 1.5 million.
http://www.pnr-rpn.ec.gc.ca/nature/migratorybirds/dc00s04.en.html

Banks Island, NWT - Theme 2: Animal Habitats and Plant Communities

Theme 2 Indicator	DFS
1. Ratio of native to non-native plant species	Exotics compose not more than 10% of plant population – DFS = 0%*
2. Trend in plant productivity and growth (NDVI)	No increase above the 10 year mean NDVI. DFS = 0.058 NDVI**
3. Proportion of rare plants to all native plants	***

***1. Ratio of native to non-native plant species**

368 species of vascular plants occur in the Arctic Archipelago of which 9 are exotics (ratio 100/2.4)

****2. Changes in plant productivity and growth (NDVI)**

The Normalized Difference Vegetation Index (NDVI) is considered a good measure of relative biomass and plant productivity. Over the last decade there has been an increasing trend in NDVI (i.e. plant productivity), which coincides with increases in air temperature during the winter and spring seasons in the region. This increase in temperatures and resulting increase in plant productivity has been linked to global temperatures effects as a result of climate change. There is significantly more vegetation productivity now than there was 11 years ago. Tracking NDVI monitors global effects of climate change on the Canadian arctic. The DFS has been recommended as no increase above the 10 year mean NDVI of 0.058.

*****3. Proportion of rare plants to all native plants**

General status of rare plants. Banks Island was not part of the last glaciation, so there are some very rare plants still existing on the island. Unfortunately this data did not become available for CBI testing, but will be available in the near future.

Banks Island, NWT - Theme 3: External Influences

Theme 3 Indicator	DFS
1. Climate change - Precipitation trends	Limit to 1.5 degree increase in temperature *
2. Levels of disease or pollutant contamination – Mercury levels in liver of Beluga Whales	DFS recommended as 0 ppm. Lowering mercury levels to the 20 year average of 12 ppm (calculated from all sampled arctic populations) will score the indicator in the 60-80 range, which is considered stable.**
3. Human presence and use around the island	Levels unchanged or decreasing ***

***1. Climate change - Precipitation trends**

Extensive precipitation data has been collected by Environment Canada locally. Average local increases due to climate change have also been calculated. Available from the climate change reports. Local precipitation and weather trends have a direct influence on all ecounits. Increases in temperatures, availability of water, severe drought conditions, as well as severe flood conditions impact all ecosystems, both positively and negatively.

****2. Levels of disease or pollutant contamination – Mercury levels in liver of Beluga Whales**

There is historical evidence that mercury has increased in Canadian Arctic animals from pre-industrial times to the present. Mercury concentrations observed in the Beaufort Sea Beluga Whale population have increased significantly. Health Canada has established a guideline level of 0.5 parts per million (ppm) for mercury in commercial fish, and an allowance of 0.5 to 1.5 ppm for certain species. Since any presence is bad, DFS is for 0 ppm, but lowering mercury levels to the 20-year average of 12 ppm, calculated from all arctic populations sampled since 1981, will score within the 60-80 range, which is considered stable. Levels should atleast remain unchanged and decreasing.

*****3. Human presence and use around the island**

Increased pressure from human use and presence around the island affects the wildlife inhabiting the island, and the marine mammals around the island coast. Current use could be considered the DFS since current surveying and use has been approved. To protect critical wildlife species, the less human presence the better.

Banks Island, NWT - Theme 4: Human Influences

Theme 4 Indicator	DFS
1. Hunting harvest rates- what number of animals are shot each year	36 male-only caribou tags are available each year*

2. Human presence and use on the island	Levels unchanged or decreasing – highest number of long term visitors to Aulavik National Park was 50 in one year **
3. Percentage of ecounit habitat area that is protected	Protection of all traditional habitat range of Peary Caribou – 1972 levels**

***1. Hunting harvest rates- what number of animals are shot each year**

Hunting is a viable and sustainable resource important for local communities. A hunting quota system has been in place on Banks Island since 1991. Thirty-six tags, one male only per household, are available each year to hunters of Sachs Harbour, and will be in place until the population reaches the target goal (theme 1).
http://www.taiga.net/projectcaribou/pdf/casestudies/peary_study.PDF
http://www.jointsecretariat.ca/WMACNWT/pdf/Sachs%20CCP%20-%20Final.pdf

****2. Human presence and use on the island**

Increased pressure from human use and presence on the island affects the wildlife inhabiting the island marine mammals around the island coast. No net increase could be considered the DFS since current surveying and use has been approved. To protect critical wildlife species less human presence the better. The highest number of long-term human visits to Aulavik National Park in one year was 50 visitors.

*****3. Percentage of ecounit habitat area that is protected**

Shows whether protected areas are actually protecting naturally functioning ecosystems. Aulavik National Park on Banks Island is protected habitat. The Banks Island Migratory Bird Sanctuary, a designation that applies to the Castel Bay and the lower region of the Thomsen River Valley protects sedge meadow habitat. However, important caribou calving and polar bear denning areas are not protected, although boundaries have been recommended. The recommended areas in the north west and eastern regions of the island would protect an additional 25,000 sq. km. This would represent approx. 80% of the island. The DFS is set at protecting 100% of critical caribou and polar bear habitat.

STEP 4 - KEY QUESTIONS

1. *How difficult was this step?*

Selecting the Desired Future States (DFS) was one of the more challenging steps in CBI calculation. Once indicators were chosen and data was revealed, coming up with a suitable DFS was often not as straight forward as initially perceived. For example, on examination of "agricultural encroachment on Netley-Libau Marsh", the DFS would be "no further increase in agricultural area". However, the current level of habitat does not warrant a score of 100 on the CBI scale. This suggests the DFS should be some level of decrease in agricultural area surrounding the marsh with some degree of restoration of lost habitat. Realistically, this might be considered a difficult and unrealistic goal to achieve. The challenge is that DFS levels need to be based on some selected area extent or potential desired amount that may realistically be attained. This will be a continuing challenge in CBI scoring, where no further loss is ideal, and the difficulty will be in determining what a possible future state should realistically be. Some sort of baseline might need to be established for future CBI testing. In Alberta for example, they are choosing the current state as the baseline and measuring against that – but with this type of approach you still don't know where you want to go in the end.

Another challenge that arose was when national DFS levels were already established for the indicator (i.e. climate change level indicators), but were not suitable or could not be measured within the context of the ecounit scale. In these cases an ecounit level DFS had to be determined based on national levels, which led to some subjectivity during selection.

2. *Are you happy with the results of this step?*

For the most part, yes. However, without more indepth knowledge or data in some cases it was difficult to describe an ideal and suitable DFS, and in some cases the DFS level seemed too arbitrary or random.

3. *Did any unexpected issues arise during this step? If so, please describe.*

One issue that was discussed was the following scenario: What if an ecounit scores 100, or close to the 80-100 range where the indicator is considered at the desired future state, is this ecounit now no longer a management concern? What needs to be kept in mind is that the selected indicators for CBI calculation do not cover every area of concern within the ecounit, and do not completely represent biodiversity within the ecounit as a whole. As well, selected DFS values for indicators may not completely or accurately reflect biodiversity within the ecounit. This emphasises the need to hold stakeholder meetings and consultation with area experts for selection of indicators and determining DFS levels, in conjunction with some level of continued and future monitoring. All stakeholders must be consulted as to what constitutes an indicator, theme, and ecounit score of 80-100, and whether the calculated index scores reflect some guarantee of biodiversity within the ecounit or not.

Step 5: Measure indicator and assign a score

For each indicator selected in Step 2:

➔ ***Draw an x-y graph, where the x-axis represents time and the y-axis represents the units of measurement of that indicator.***
- ***Mark the DFS on the y-axis.*** *(Box 1)*

  At the DFS the indicator is expected to be sustainable (given best available knowledge), is consistent with the future vision for biodiversity in that ecounit (or a larger area encompassing that ecounit), and is not of management concern (from a biodiversity perspective).

➔ ***Draw another vertical axis, on the right side of the graph – which will represent the scale to be used for scoring. Now set the scale:***
- ***Draw a horizontal line from the DFS across the graph to the scale axis, and assign it "100" on the scale.***
- ***Decide what indicator measurement should correspond to "0" on the scale, and mark this on the graph.*** *(Box 1)*

  0 on the scale corresponds with the worst possible outcome for that indicator.

➔ ***Finish setting the scale by marking 20, 40, 60 and 80 on the scale axis*** *(Box 1).*

➔ ***Add the most-recent year's data to the graph, and observe where it appears in relation to the scale.*** *(Box 1)*

  The band it lies within is the score for that indicator.

Step 5 Results: Measure indicators and assign a score

For all ecounit indicator measures and scoring See Appendix II

Step 5 - Key Questions

1. ***How easy was it to identify the measure of the indicator on the y-axis that corresponds to 0 on the scale? How confident are you regarding this designation?***

   Setting the indicator unit that corresponded to 0 on the normalized CBI scale did not present significant problems. Zero of something was often considered a worst-case-scenario, therefore 0 on the indicator unit scale typically corresponded to 0 on the normalized CBI scale for all indicators where less was considered worse. In the case of indicators where the desired future state (DFS) was for less of an indicator, (i.e. more of an invasive species was worse therefore less was better), then selecting the indicator measure that corresponded to 0 on the CBI scale was a little bit more of a challenge. In many cases this corresponded to a particular management goal or was based on knowledge of the biological systems. Many indicators exhibited the DFS in the middle of the y-axis, where "too much" makes it a nuisance and "too little" cause it to be endangered. In this case the 0's on the scale were selected following both procedures above (less of something is a concern but too many is a nuisance, desired level would be somewhere in the middle).

2. ***How easy was it to assign 20, 40, 60 and 80 on the scale? Did you employ "rules" or other tools or procedures that might apply more generally (e.g. to other indicators in other ecounits)? How confident are you regarding these designations?***

   Out of all the CBI Steps, this was by far the most challenging step of the CBI calculation. Assigning the positions of 20, 40, 60, and 80 on the normalized scale is definitely one of the most important steps in CBI calculation, but at the same time one of the most subjective. Some degree of subjectivity arises from the flexibility to adjust the normalized scale up or down on the indicator unit scale, and ultimately can be set to any desired range based on the knowledge of whoever is calculating the CBI. Setting the 0 and 100 scores is less problematic, but placement of the remaining four scores (20, 40, 60, 80) was more critical and required much more deliberation.

   No set "rules" were necessarily used to assign the scale categories, only that the ranges were adjusted based on knowledge of the historical trends and biodiversity issues related to the ecounit. Historical indicator data and trends were used to set the normalized scale ranges. Consequently, this requires a significant amount of knowledge of the ecounit in question and its historical trends and issues, as well as an understanding of ecological systems, wildlife and population dynamics, and habitat management in general. Stakeholder meetings and consultation with managers and researchers familiar with the ecounits or with specific areas within the ecounit is definitely recommended prior to and during this step for any future testing or implementation of the CBI.

   We were fairly confident of the CBI score designations for most indicators for the purposes of POCT based on the knowledge and data that we as the project team obtained for the two ecounits tested. DFS levels and indicator scores, from our perspective, appear to present a realistic representation of biodiversity trends and issues that we determined were important and relevant to the ecounits, and represent the ecounit issues and final score overall as we perceive it to be. Consultation with participating organizations and hosting stakeholder workshops would be necessary, and required, following any ecounit scoring, with regards to any future decisions or outcomes based on CBI testing and scoring results.

3. ***Did any unexpected issues arise during this step? If so, please describe.***

One issue that arose was utilizing the set CBI score ranges of: 0-20, 20-40, 40-60, 60-80, and 80-100. When comparing indicators within a theme to assign theme scores, indicators that fell within the same range could not be distinguished. For example if indicators 1 and 2 of theme 2 both score in the 40-60 range, we cannot distinguish which one may be in a worse state of biodiversity. Summarizing an indicator score into one of the five ranges or categories of concern did not allow for more detailed comparisons between indicators on the normalized CBI scale. Perhaps more relevant, is that there was no indication of whether the indicator scored towards the bottom or top of the CBI scale range category. An indicator at the bottom of the 40-60 range for example, could be in a much more critical state than an indicator that scores at the top of the 40-60 range. By placing them within the 20-point concern ranges, this slight difference can be observed. Additionally, charting and presenting an indicator's CBI score as a range does not allow for relatively minor future changes in the indicator to occur. An indicator that scores at the top of the 40-60 range could be getting worse for a fairly long period of time, but its downward trend would not be presented on the CBI scale until it fell within the 20-40 range. Steps for managing this indicator could have been taken earlier if the CBI score was calculated on a slightly finer scale during monitoring and presentation to decision makers.

Although the intent of the CBI was to avoid emphasis on actual numbers or scores to minimize the arbitrariness of trying to assign a numerical score for a given indicator, much less a theme or an ecounit, rounding to some extent for proof of concept testing did aid in making comparisons between indicators and ultimately for determining final scores. A slightly finer scale within the 20-point score ranges rounded to the nearest "5"aided in assigning scores and allowed for comparisons and some distinction between indicator and theme scores, particularly within a given 20-point score range. Rounding to the nearest 5 or 10 CBI score for example could more effectively place indicator scores within the five larger general ranges for comparisons. The five CBI score ranges or concern categories in their current form give a good indication as to the current state or level of concern of indicators (Murray et al. 2004). But rather than rounding CBI scores to the nearest category, scores could also be rounded to the nearest 5 or 10 CBI score for placement somewhere within these ranges on the CBI normalized scale. This is discussed in more detail in Section 4, and has been listed in the recommendations for future consideration.

Step 6: Measure trend

For each indicator in your Ecounit:

➔ ***Repeat Step 5 for data from previous years, if past data are available. For example, if you have data for this indicator for 1986, 1991 and 2002, then calculate the score for each of these years against the DFS identified in Step 4. Back-cast the score for as far back as data availability will allow.***

➔ ***Analyse and articulate the trend of the score that emerges through back-casting. Use whatever means you think most appropriate (e.g. qualitative description, or statistical analysis).***

See Appendix II

STEP 6 - KEY QUESTIONS

1. Did you have any difficulties in back-casting?

Graphing historical indicator data worked well since the CBI scale and DFS chart were already established from Step 5, and from plotting current levels of indicators. Plotting historical CBI scores over time and calculating average trend lines presented a very immediate and comprehensive picture of historical trends.

2. Do you think back-casting with the current DFS is a valid exercise?

Definitely yes, it is more valuable to have historic indicator trends presented if available rather than simply reporting current levels. Presenting current indicator levels, or in most cases the last reported or monitored level, does not indicate whether current conditions are the norm or just a short term fluctuation due to some other factor – i.e. weather, growing conditions, harsh winter conditions, pulse in nutrient release, low food availability, migration, or time of sampling and surveying. Presenting historic conditions and levels reveals whether: a current state is an anomaly, a particular indicator is of a management concern, and if there is a concern for overall ecounit biodiversity.

Presenting historical trend data alongside the CBI scoring data gives a fairly clear representation of what an indicator's CBI score actually represents. For example, a decreasing trend in a CBI score over time for a wildlife population could simply be associated with a decrease in the number of that species population, such as in the Banks Island caribou herd (Figure 11). However, a decreasing CBI score could also be associated with an increase in the population of a nuisance wildlife species, such as Banks Island snow geese where more is "bad" (Figure 11). In the case of Banks Island muskox, both scenarios occurred at some point in time. A low CBI score occurs as a result of a population decrease in the early 1970's, and as the population recovered the CBI score reached the current DFS level, and scores 100 on the CBI normalized scale. However, the muskox population continued to grow past its DFS, causing a decreasing CBI score trend once again to a level where the population *Requires Observation* (CBI of 60-80) (Figure 11). Evidently, further growth without management of the Banks Island muskox could negatively affect the endangered Peary caribou herd and overall biodiversity on the island. The cause of changing CBI scores is quickly revealed when a graph of historical indicator data is presented along with the CBI data, providing a valuable and immediate visual.

One of the goals of the CBI is transparency behind the scoring and interpretation, so historical data should be included in some form with any ecounit being scored. How the overall data is presented and summarized, however, still needs further consideration and some standardized method would benefit future testing and any implementation of the CBI.

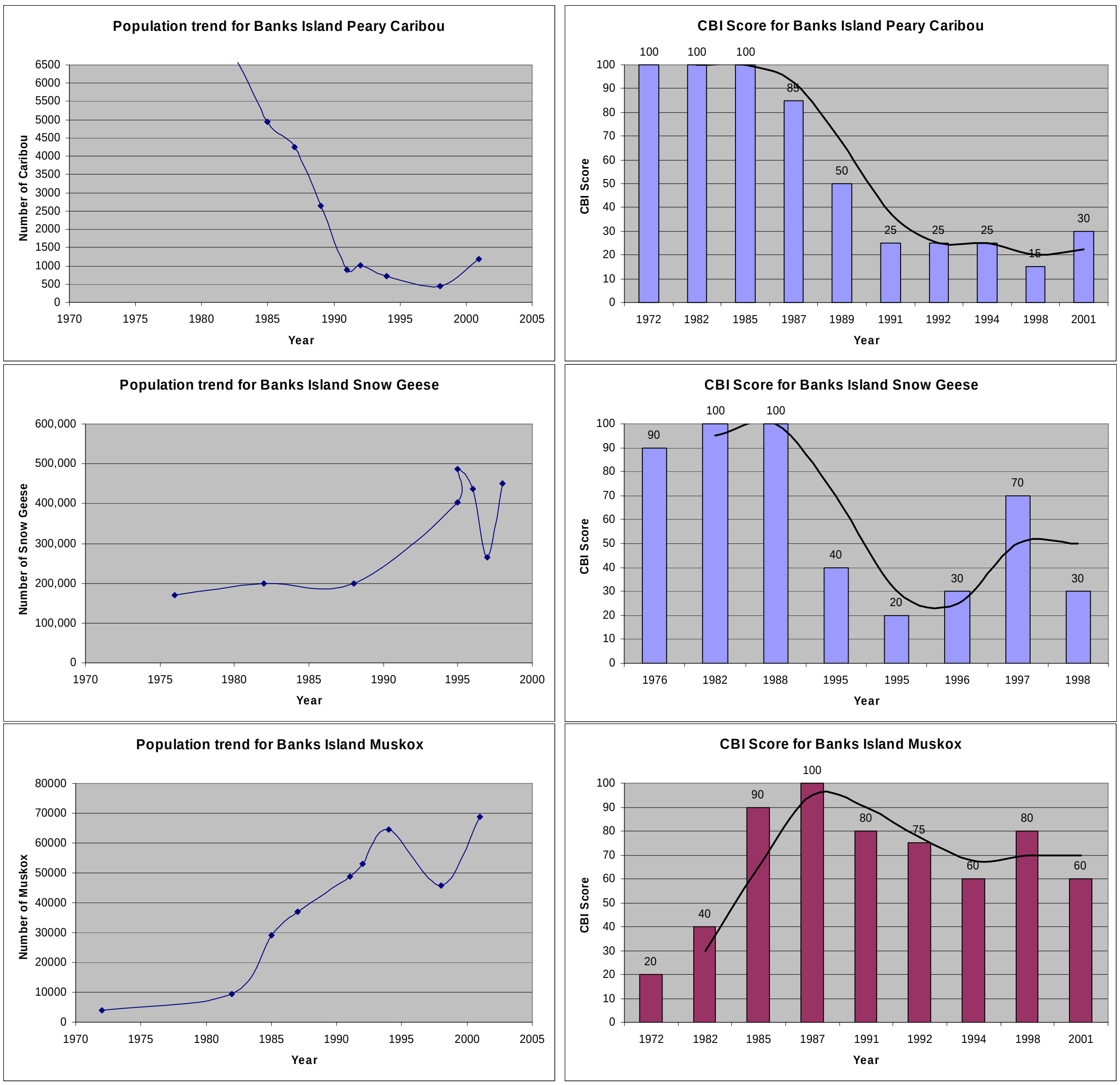


Figure 11. Historical population trend data and historical indicator CBI Score trends for the Banks Island, NWT ecounit. Demonstrates how high and low CBI Scores can result from various long-term population trends.

3. ***What method(s) did you use to articulate the trend? Can you suggest a standard methodology that is valid and credible and will work across all indicators?***

The CBI scores for each year were calculated by plotting indicator historical data on the graphs previously developed for DFS selection and current state scoring. Historical data was plotted on the unit scale (left hand scale) and the corresponding score on the CBI normalized scale was recorded (right hand scale). For the purposes of POCT this score was rounded to the nearest 5 CBI score for placement within the 20-point score ranges. A bar graph of CBI scores over time was plotted for each indicator (where available) to reveal historical CBI trends. An historical CBI trend line was plotted by calculating a simple "moving-average" trend line. Applying only a "linear" trend line did not realistically represent the fluctuating nature of biological data nor the imprecise nature of how the CBI score is calculated.

This method was applied to all indicators and worked fairly well. Calculated CBI trend lines appeared to be fairly good representations of historical trends for an indicator, particularly for the purposes of biodiversity monitoring within the scope of the CBI. Plotting historical CBI scores as a category range did not fully reveal historic trends compared to calculating CBI scores to the nearest "5" for example, which further revealed historic trends.

4. ***Did any unexpected issues arise during this step? If so, please describe.***

This stage further revealed indicators that did not completely represent biodiversity within the given ecounit. Indicators were replaced with other suitable indicators where needed. For example, plotting *Population Trends for Bears* in the Banks Island, NWT ecounit revealed there was not as much historical data available compared to *Population Trends for Snow Geese*, which is also considered an immediate concern for this ecounit's biodiversity. Snow geese were chosen as a better representation of biodiversity changes within the Banks Island, NWT ecounit because of their impact on vegetation communities and destruction of tundra habitat. Similarly in Netley-Libau Marsh, MB *Physical Restructuring of the Marsh - # of separate water bodies,* was originally *Physical Restructuring of the Marsh – loss of shoreline.* However, as the marsh shoreline data was plotted and CBI trend calculated, it did not accurately represent the significant loss of island habitats and channels previously present in the marsh. The overall length of shoreline has been interpreted in different ways and the calculated totals from various sources did not change even though separating uplands and channels have been lost from the marsh. Decreasing number of separate water bodies in the marsh has also been used as an historical reference of the decline of the marsh, representing loss of separating upland areas and channel banks. This was chosen as a better biodiversity indicator for the marsh.

The only issue at this stage was how to graphically present historic data trends with CBI score trends in the most comprehensive form.

Step 7: Aggregate results

Obtaining a theme Score

➔ ***Document the lowest score among the indicators in theme 1. This will be the score for theme 1. Repeat for themes 2, 3 and 4.***

> According to the instructions in Step 2, indicators within a theme should together be representative of the status of biodiversity in that theme, and across themes should collectively represent the status of biodiversity in the ecounit. Achieving the DFS for all of the chosen indicators is necessary to achieve the future vision for biodiversity in that ecounit (or a larger area encompassing that ecounit). Therefore, the biodiversity vision cannot be achieved unless all of the indicators are in (or very close to) their desired future state (i.e. have a score of 80-100). Even one indicator having a score of less than 80-100 means that the biodiversity vision is not achieved in that ecounit. This approach highlights the weakest link, and the theme in which it occurs.
>
> *Source: CBI Testing Manual – Murray et al. (2004)*

Obtaining an Ecounit Score

➔ ***Document the lowest of the theme scores. This will be the score for that ecounit.***

STEP 7 - KEY QUESTIONS

1. ***How do you feel about this weakest-link (lowest-scoring) indicator approach for identifying theme scores, and the ecounit score?***

   The lowest-scoring indicator approach for representing the theme score works fairly well, because it brings attention to themes that require observation or are in need of management. It also provides an early warning signal during future monitoring if a biodiversity concern occurs within a given theme. Nevertheless, final CBI reporting and presentation should include all indicator scores within each theme and not just the lowest-scoring indicators. Presenting only lowest-scoring themes does not reveal whether there are other indicators in the theme which are of concern or nearing concern, nor does it tell us if others are doing well and are improving over time.

   With regards to using the lowest-scoring approach for the overall ecounit score – where ultimately the lowest scoring indicator drives the entire ecounit score – this method does not appear to completely represent biodiversity issues of the ecounit as a whole. This type of ecounit scoring simply highlights the one "bad" indicator to represent the entire ecounit. It definitely indicates whether an ecounit is in need of attention and is of a management concern, however, one concern is that because of the state of our ecosystems in general, most ecounits would most likely have an indicator that would score poorly on the CBI scale, and therefore drive the overall ecounit score down. Most ecounits would probably end up with a score of 20-40 if not in the 0-20 range. Following this "lowest-scoring" approach both of the ecounits we tested for POCT scored in the 0-20 range, and ultimately were all driven by one indicator in each ecounit that fell within the "Critical" range. In the end, this does not differentiate ecounits of greater management concern.

During POCT, we also tested an alternative method to calculate ecounit scores by calculating an average of all four theme scores. In this case, the lowest-scoring indicator from each theme represents the ecounit score as a whole, rather than just the one lowest-scoring indicator within the ecounit representing the ecounit. A bar chart visually represented all indicator scores on one graph, with the average CBI score for the ecounit given below (Figures 13 and 14). This approach better differentiated ecounit scores and could be summarized to reveal overall biodiversity scores for the four themes on one "report card".

Weighting of individual indicator and theme scores has been considered and suggested for CBI calculations. Although at this stage of POCT all indicators were weighted equally, weighting of indicators should be considered for future testing or during CBI implementation. This method of averaging theme scores for the ecounit did provide a simple form of "weighting" that equally weighted all themes to represent the ecounit score, and was simply and readily calculated. Calculating an average of theme scores to represent the ecounit is included in the recommendations.

2. ***Did any unexpected issues arise during this step? If so, please describe.***

Deciding how to graphically display the results of CBI scoring, and how to calculate a realistic CBI value that represents the entire ecounit as a whole. Discussed in more detail above and in the following section.

Step 8: Report the results

- ***Graphically display the indicator scores in each theme.***
  - ***Show trends in indicator scores if you had historic data and were able to back-cast.***

- ***Graphically display the theme scores in your ecounit.***

- ***Compile relevant documentation from all previous steps, including information specifically requested in the instruction for prior steps.***
  - ***This should include:***
    - ***a map of the ecounit from Step 1,***
    - ***Indicator metadata from Step 2,***
    - ***Indicator data and time-series graphs of each indicator from Step 3,***
    - ***the DFS for each indicator (and sources or methodology) from Step 4,***
    - ***the scale and scores for each indicator from Step 5, and***
    - ***a description of the trend for each indicator from Step 6.***

Step 8 Results: Reporting the results

See Figure 12 for ecounit indicator and theme scores, and Figures 13 and 14 for overall summarized ecounit scores presented in a report card type format.

STEP 8 - KEY QUESTIONS

1. ***What do you think is the most effective way to present the indicator scores within a theme, and the theme scores within an ecounit, in a synthesized manner that is easy to understand but does not mask important underlying messages?***

   This was addressed earlier in questions from Steps 6 and 7.

2. ***Did any unexpected issues arise during this step? If so, please describe.***

   Once again, an issue was simply in selecting charts, graphs, and tables to include with reporting, and how to properly and most comprehensively present historic data trends with historic CBI score trends. One of the challenges that needs further consideration is how to graphically display CBI scoring results that communicates the issues and data in a quick and easy to interpret format; particularly when presenting to managers, decision makers, and government. This should follow some standardization for future use of the CBI.

NETLEY-LIBAU MARSH Ecounit - Indicator CBI Scores

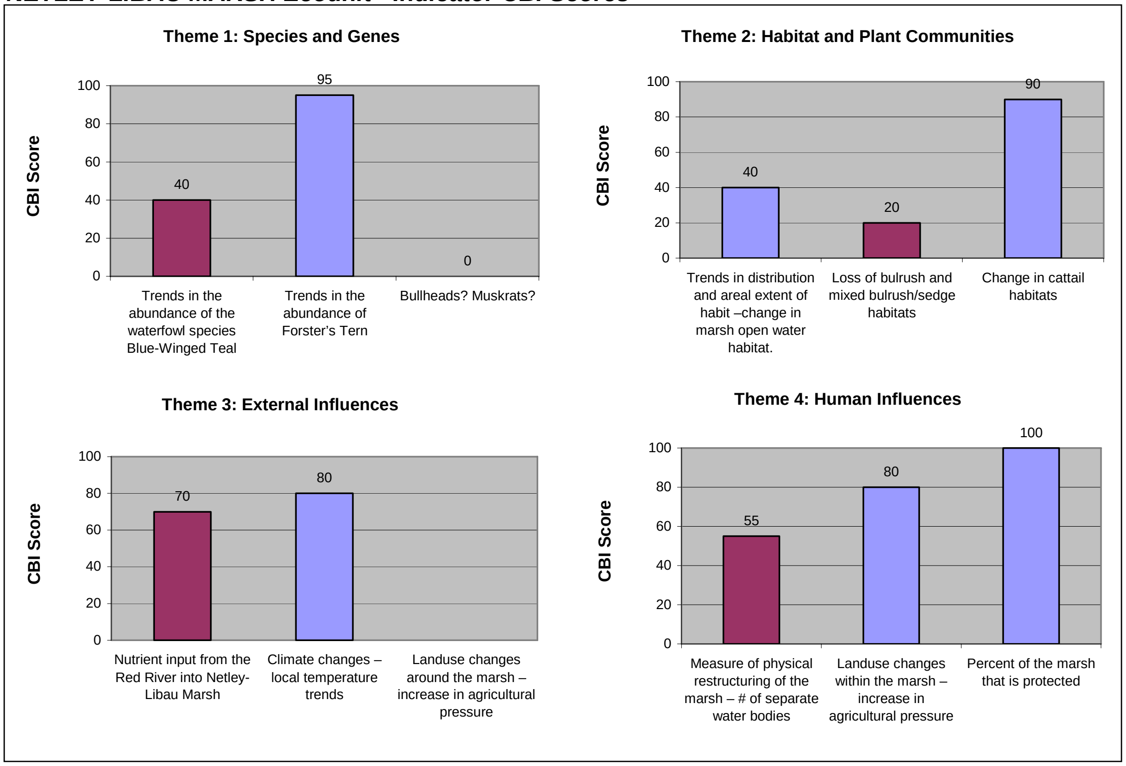


Figure 12a. Indicator and theme scoring for the Netley-Libau Marsh, Manitoba ecounit.

B ANKS ISLAND Ecounit - Indicator CBI Scores

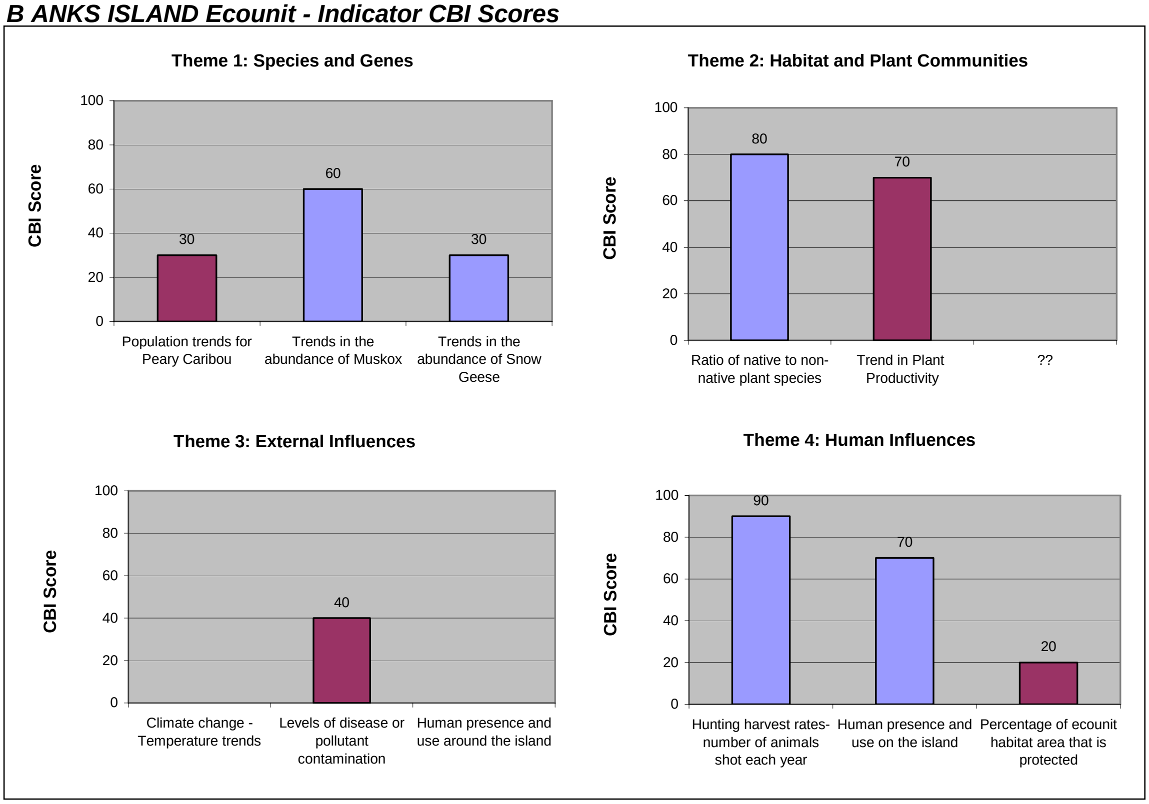
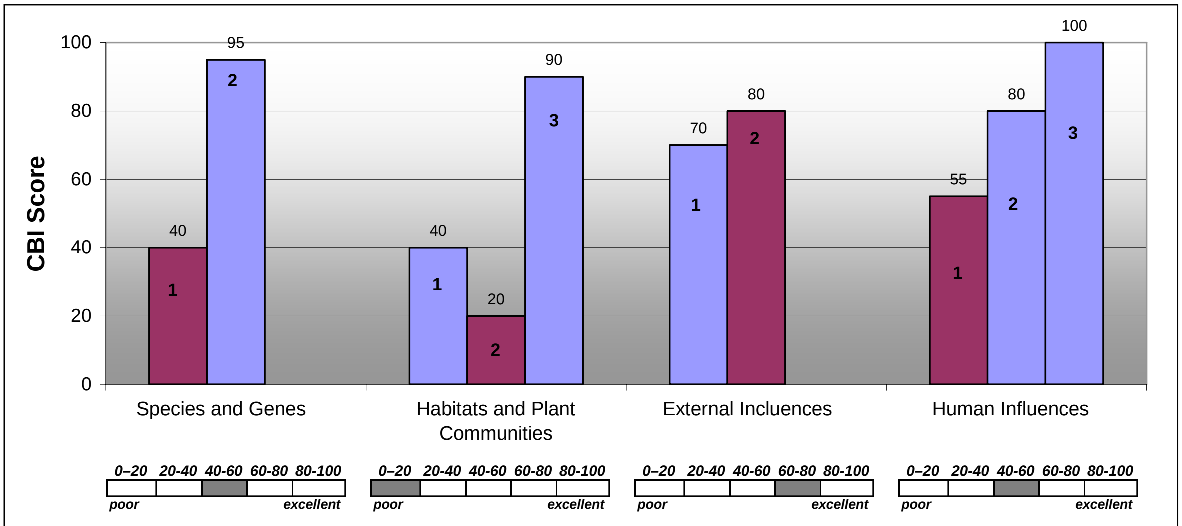


Figure 12b. Indicator and theme scoring for the Banks Island, NWT ecounit.

NETLEY-LIBAU MARSH Ecounit Assessment



Primary Indicators of Concern:

Population trend of Blue-Winged Teal
Loss of Bulrush and mixed sedge habitat
Physical restructuring of the marsh - number of seperate water bodies

***Aggregated Ecounit Scores*:**

Lowest-Scoring Theme Approach:

0 – 20	*20-40*	*40-60*	*60-80*	*80-100*

Considerable to Critical Concern

Average Theme Score Approach:

0 – 20	*20-40*	*40-60*	*60-80*	*80-100*

Moderate Concern

NETLEY-LIBAU MARSH ECOUNIT - GRAPHING AND SCORING

Theme 1: Species and Genes
Theme 2: Animal Habitats and Plant Communities
Theme 3: External Influences
Theme 4: Human Influences

Ind	Theme 1	Theme 2	Theme 3	Theme 4
1	40	40	70	55
2	95	20	80	80
3		90		100

AVERAGE	LOWEST SCORES
Theme 1	40
Theme 2	20
Theme 3	70
Theme 4	55
	46.25

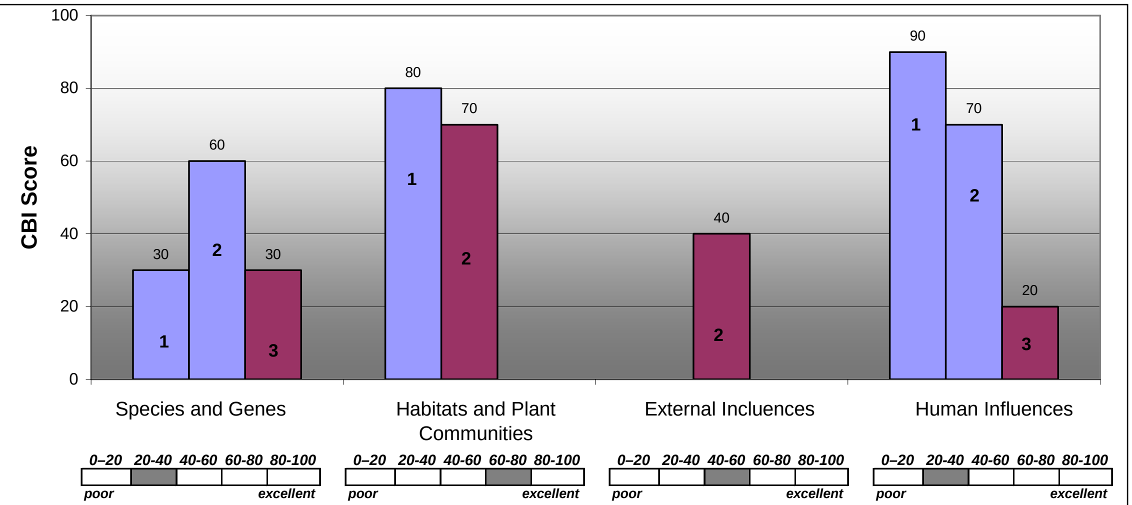
Ecounit Score:

Lowest-scoring theme approach:	20
Average theme score approach:	50

* In the Lowest-Scoring Theme, or Weakest-Link, scoring method, the lowest-scoring inidcator in each theme drives the theme score, and lowest-scoring indicator overall drives the ecounit score.
** In the Average Lowest-Scoring Theme Score method, the lowest-scoring indicator in each of the four themes drives the theme score, and the average of the theme scores drives the overall ecounit score.

Figure 13. Ecounit scoring report card for the Netley-Libau Marsh, Manitoba ecounit (*based on indicator selection and DFS selection by the POCT team*).

Banks Island Ecounit Assessment



Primary Indicators of Concern:
Percent of total wilderness area that is protected
Change in Status of Red-Listed Species

Aggregated Ecounit Scores *:*

Lowest-Scoring Theme Approach **:**

0 – 20	20-40	40-60	60-80	80-100
	■			

Considerable to Critical Concern

Average Theme Score Approach **:**

0 – 20	20-40	40-60	60-80	80-100
		■		

Moderate to Considerable Concern

BANKS ISLAND ECOUNIT GRAPHING AND SCORING

Theme 1: Species and Genes
Theme 2: Animal Habitats and Plant Communities
Theme 3: External Influences
Theme 4: Human Influences

Ind	Theme 1	Theme 2	Theme 3	Theme 4
1	30	80		90
2	60	70	40	70
3	30			20

AVERAGE LOWEST SCORES	
Theme 1	30
Theme 2	70
Theme 3	40
Theme 4	20
	40

Ecounit Score:

Lowest-scoring theme approach:	20
Average theme score approach:	40

* In the Lowest-Scoring Theme, or Weakest-Link, scoring method, the lowest-scoring inidcator in each theme drives the theme score, and lowest-scoring indicator overall drives the ecounit score.
** In the Average Lowest-Scoring Theme Score method, the lowest-scoring indicator in each of the four themes drives the theme score, and the average of the theme scores drives the overall ecounit score.

Figure 14. Ecounit scoring report card for the Banks Island, NWT ecounit (*based on indicator selection and DFS selection by the POCT team*).

General questions from the Testing Manual

1. What do you think about the results? Are they credible based on what you know about the ecounit? Is there sufficient indicator diversity?

Yes, for the data and indicators that were available for POCT, indicator CBI scores appear to represent current biodiversity concerns within the two ecounits, and to a degree realistically portray long-term biodiversity trends. Calculated CBI scoring identified and highlighted the indicators that we presumed to be of most serious management concern within each ecounit theme. The overall CBI scores for the ecounits, however, did not completely represent biodiversity for the ecounit as a whole when calculated in its present form outlined in the *Testing Manual*. Because of the manner in which it is calculated – i.e. the lowest-scoring theme and ultimately the lowest-scoring indicator drives the overall ecounit CBI score – it only highlighted the one "bad" indicator in the ecounit, as discussed in Step 7 – Key Questions. In many ecounits this might result in a perpetually low CBI score and overshadow any improvement that may occur. An alternative calculation method was also tested – where an ecounit CBI score is calculated from an average of the four theme scores within the ecounit – and has been included in the recommendations for future consideration. Averaging theme scores across the ecounit could provide a better representation of overall biodiversity concerns within the ecounit and provide some differentiation between other ecounits that may be of relatively greater or less concern.

2. Were these instructions adequate and clear? What other instructions or guidance would have been helpful in accomplishing any of the above steps?

Yes, for the most part the instructions, guidance and questions in the testing manual for Steps 1-8 worked very well. Additional instructions for guidance could help, but simple clarification of certain points and steps are all that would be needed.

3. How much time (both person-days, and elapsed time) did this initial POCT take? (Can you break this down by step?)

Step 1 selection of ecounits took about 1 week until the final two ecounits were selected for testing. This was done with some consultation with organizations to determine which ecounits had data available for CBI testing. "Best" data being determined by: how readily data was available, whether it included historic data, if it was a part of on-going monitoring, and ultimately how fast we could obtain indicator information and data.

Steps 2 – 4 are difficult to breakdown or separate since most of this occurred simultaneously for both ecounits. After a few weeks of researching the sites, selecting indicators, and some preliminary DFS evaluation, data collection began. This resulted in several indicators changing at this point due to data gaps being revealed or discovering the data was just not available. Both ecounits were dealt with simultaneously, so person-days are difficult to determine. After 2 months of elapsed time, all ecounits had been selected, all indicators were selected, most of the DFS values and most of the data were selected.

Steps 5-7 began at the 1.5 month stage. Measuring and scoring of indicators was completed for 1 ecounit at a time starting with Netley-Libau Marsh, since this ecounit was more familiar to the primary researcher of the testing team. Measuring and scoring took up to approximately 5 days for each ecounit.

This stage of testing also revealed further gaps in data, and more specifically data that just wasn't as good or useful as it initially suggested when indicators and DFS values were being selected. This required more time spent choosing new indicators and collection of more indicator data.

4. What insights and guidance can you suggest for subsequent iterations of POCT?

One lesson learned was not to spend too much time initially deliberating over data availability, which indicators will be *the* final selected for testing and/or calculating the CBI, and agonizing over realistic DFS levels. It was more useful to collect all available data, create a pool of indicators, and evaluate potential DFS values before attempting to select final indicators. A helpful initial step during testing was creating a data gap chart to plot time periods for all available data for the ecounit. This provided a visual time chart of all available data (example in Appendix I). Plotting historic data trends also aided in selecting indicators to represent biodiversity, as did selecting initial DFS values, or conceptual levels for indicators. This quickly revealed whether there were realistic attainable goals, and if indicators could accurately represent biodiversity of an ecounit. Steps 5-7, measuring and scoring, also worked very well to further reveal indicators that were better than others, and in final selection of a realistic DFS level by comparison to where it fell on the CBI scale. Ultimately, selecting more indicators for measuring and scoring than were actually required allowed selection of those that together better represented biodiversity within the ecounit.

5. What insights and guidance can you suggest for the CBI framework, based on your experience through initial POCT?

This is discussed in greater detail in the following section.

6. Based on your experience in Step 4, can you suggest a methodology for determining a DFS that might be applicable more broadly for use in other ecounits elsewhere?

It is hard to generalize a method for selecting DFS. Selecting a realistic and relevant DFS requires knowledge of the ecounit and historical changes of the given indicator, and each one requires researching historical trends and existing knowledge, as well as consultation with area experts. Indicators that span ecounits, such as climate change goals, could have the same DFS value, but they still need to be locally specific. Methods from the literature should be explored for future POCT and CBI implementation.

7. Was data availability or quality a problem?

Yes, definitely. Aside from delays in finding and receiving available data, the single most biggest problem was actual availability and existence of indicator data, as well as the quality of data; data that was collected in such a way that in some cases it was difficult for determining historic trends or use for management or policy recommendations. Data availability and quality will continue to be an unavoidable problem with any type of biodiversity monitoring, and will be the norm for most ecounits undergoing CBI calculations.

5. Applying Real Ecosystem Data to the CBI – Findings from Proof of Concept Testing (POCT)

5.1. Addressing the Inherent Uncertainties in the CBI

Proof of concept testing (POCT) involved facing and addressing a series of inherent uncertainties associated with the CBI. These uncertainties arise partly from the complexity of biodiversity itself and the complexity of its interaction with both other environmental factors and the human subsystem. There are additional uncertainties, however, associated with the complexity of the CBI's design and scoring which needed to be considered when undertaking testing of the CBI.

First, there is no real comparable index of biodiversity calculated for the selected ecounits, so there is no baseline against which the CBI score could be compared. Nevertheless, where the CBI is calculated over a lengthy period of time a baseline biodiversity trend did emerge. Comparison of the calculated CBI scores over time to historic indicator data and management goals did allow for interpretation of the CBI as to how effectively it represents biodiversity changes within an ecounit.

The second inherent uncertainty in CBI calculation is setting the normalized scale of 0-100, which allows indicators measuring different things to be compared. Setting the normalized scale for each indicator was the most challenging and subjective step of the CBI calculation process, adding uncertainty to the CBI. Nevertheless, with proper knowledge, consultation with area experts, and care in constructing indicator CBI scales and in selecting realistic DFS values, this uncertainty can be minimized. The CBI accomplished what it was designed to do; it captured and conveyed credible information on the status and trends in biodiversity in a realistic manner and presented it in an easily understandable composite index – the underlying goal of the CBI. Strengths of the CBI normalized scale, which sets the CBI apart from other biodiversity measures, are discussed further in following sections.

5.2. Working with Participating Organizations

Even though organizations agreed to participate in POCT, there were considerable differences in terms of availability and access to data. Relying on others to help select ecounits and indicators, and in providing data or links and contacts to data sources for CBI testing in a timely manner did and will result in delays. Considerable delays were the norm and should be expected and scheduled with any future testing or implementation of the CBI. People are away from the office or busy with work priorities, and weeks can pass waiting for contacts and datasets only to find out in some cases that the indicator data is not useful for CBI testing, not complete, or just not available. The availability of 2-2.5 months for POCT was a significant challenge particularly for data collection and identification of DFS values. In cases where DFS values were not obvious and immediately available, project staff needed to make a best guess in the interest of time to make the calculation of the index possible, with the understanding that these DFS values might not agree with levels envisioned by stakeholders and other organizations from the respective ecounits.

5.3. Indicators and Data Challenges

One question that arose during testing was how much standardization of targets and indicators is desirable and possible, and what the consequences are of different ecounits using very different indicators and desirable future state (DFS) values. Some degree of standardization for the CBI is possible across ecounits in a general sense, which is the rationale for using the four standard biodiversity themes. Biodiversity indicators typically monitor animal and plant populations, human influences, toxins, protected areas, landuse changes, etc., therefore many of the chosen indicators for the two ecounits tested did monitor similar indicators in general. Indicators for CBI calculation need to be regionally specific, scientifically sound, understandable, identify temporal and spatial change, feasible to develop and implement, policy relevant, and where possible, compatible with national efforts. Ultimately indicators should be specific to a given ecounit and its biodiversity issues but also relatable to a much larger scale across ecounit and ecosystems. Where possible, indicators for this phase of testing were selected from already established indicator lists and modified to fit indicators within the individual ecounits. This ensured some degree of standardization while simultaneously tailoring the indicator for the ecounit. DFS values, however, depended on indicator scale and ultimately reflected biodiversity concerns directly related to the ecounit.

In some cases, standardized indicators could effectively be used across ecounits, such as ecounits monitoring similar habitats (i.e. wetlands, boreal forests, tall grass prairie), the same wildlife populations (i.e. whitetail deer, bald eagles, salmon), external influences (i.e. nutrient enrichment from populated areas, climate change impacts to temperature), or human influences (agricultural encroachment, development). Some degree of use of standard biodiversity indicators that are monitored in a variety of ecounits for CBI in addition to being ecounit specific would be ideal. This could be a consideration when developing new monitoring programs and enhancing existing ones, particularly when utilizing indicators measuring currently collected data i.e. satellite imagery or climate data. Ecounits with existing monitoring programs, however, would be less able to incorporate additional indicators if further data collection and resources were required.

One of the biggest challenges in the CBI calculation was availability and quality of data. Some indicators or datasets included very detailed and in some cases very current monitoring data, but it is from a very limited and short period in time, as was the case for the Netley-Libau Marsh ecounit, where there was no other data to compare it too. In some of these cases target levels or DFS values have been calculated even though historic data is not available, and so a CBI score could still be calculated. Regardless, any current survey and monitoring data from any indicator in any ecounit will be extremely valuable for future monitoring and comparisons, even if developing current historic trends is difficult. Consequently, CBI scores in many cases will not only be influenced by indicator trends but also simply by availability of data. Discovering gaps in the datasets during POCT is more or less what was expected before testing began. An insight from POCT is that statistical techniques could be used for data gap filling, such as simple regressions based on existing data, where any point in time representing a given year could be calculated on the regression line. By calculating a "moving average" type of trend line, a CBI score can be calculated for any point in time with confidence that it portrays a realistic average score for comparison to other monitoring data during that time period.

5.4. Selecting a Realistic DFS and CBI Scoring

Another challenge encountered in CBI calculation was determining realistic indicator DFS levels that adequately measured and represented biodiversity within an ecounit. Can we select a DFS value that is impossible to obtain? Selecting a conservative DFS level, which in many cases would be a more realistic management goal from the view of policy makers and managers, often did not reveal if an indicator was of management concern. For example, selecting "*Preservation of the remaining area of an endangered habita*t" as a DFS level would score 100 on the CBI scale, even though the current area extent of habitat is not acceptable from an environmental perspective. What needs to be considered is whether we look back to the historical extent of this habitat and set our DFS at some historical level when the habitat was sustainable or acceptable, or select some current level as a DFS. Some compromise between these two extremes should most likely be considered.

The consequence of selecting a DFS that is too high could result in an indicator perpetually scoring low on the CBI and consistently driving the overall ecounit score. This would clearly indicate the critical nature and need for management or protection of this indicator, but in order to guarantee some level of future interest and management within an ecounit, DFS levels should be set to a more realistic goal. Setting DFS goals to high would lose the usefulness of the CBI.

Another issue encountered during POCT was whether indicators and DFS values can change over time. Proof of concept testing suggests that this would have to occur. With the dynamic nature of human and environment interactions, new issues and management concerns are bound to occur over time. An ecounit's indicator monitoring program needs to be flexible enough to allow additional CBI indicators to be included in monitoring, as well as changing current DFS levels as new information emerges.

5.5. CBI Scoring and the Normalized 0-100 CBI Scale

A fundamental step of CBI calculation is applying the normalized CBI scale (0-100) to indicator unit scales in Step 5: *Measure indicator and assign a score*. The normalized scale is what allows indicators measuring different things and expressed in different units of measure to be compared (Murray et al. 2004). Normalizing all indicators to a common scale allows for direct comparisons between indicators within a theme and across themes regardless of: what the indicators represent, the measurement units, and any scale dependant issues. The normalized CBI scale also enables comparisons across ecounits between indicators and biodiversity trends on a much larger scale. Consequently, there is some inherent subjectivity to the CBI normalized scale. This arises from the flexible nature of the 20-point categories or scale ranges that do not have to be the same fixed width in size, and essentially can be repositioned to any range against the indicator unit scale based on the tester's knowledge. This requires some degree of knowledge of biological systems and ecosystems, wildlife dynamics, habitat management, impacts of human influence, as well as intimate knowledge of the ecounit and indicator historical trends. Consulting with stakeholders and researchers with knowledge of the historical issues related to an ecounit is essential.

Despite inherent uncertainties, the flexible nature of the CBI score ranges is a true strength of the CBI, and sets it apart from other indices and measures of biodiversity. Using fixed ranges for the normalized scale could remove much of the uncertainty involved in setting the CBI scale to the indicator unit scale, but this would be no different than other indicator scales that simply measure distances or percentages away from the "goal" or "objective level". Adaptable CBI ranges accommodates the flexible and nonlinear nature of biological data. An indicator could be considered a biodiversity concern within a much wider range before reaching a level where it is no longer threatened, or in the case of the CBI satisfies the DFS. Area of habitat or population numbers of an animal species, for example could remain in the 0-20 or 20-40 CBI range for a much wider corresponding range on the indicator unit scale. Once a certain threshold level of area extent or population number is reached, it is at a state that simply requires observation for the success of biodiversity. The reverse is true; the 80-100 success or safe range could exist for a fairly wide range on the indicator unit scale until reaching a threshold critical state where it is threatened, endangering the success for ecounit biodiversity (Figure 15).

Because the normalized scale can be adjusted along the indicator unit scale to whatever range is needed, simply shifting a CBI scale range against its indicator unit scale can affect the score for the entire ecounit. This sensitive nature of the CBI ranges or categories was revealed during POCT. If an indicator scored near the bottom or top of one of the five CBI categories, a simple minor adjustment in either direction while selecting ranges and DFS levels could propel the indicator score from one range into another. This could ultimately drive the entire ecounit score up or down. Utilizing 20-point CBI score ranges (0-20, 20-40, 40-60, 60-80, 80-100) also masks some of the finer changes that occur over time. A gradual trend, good or bad, may go undetected until the indicator score drops into the next lower or raises into the next higher category. An indicator that scores near the top of the 40-60 range, for example, could be getting worse for a significant period of time, but the downward trend would not be presented on the CBI scale until it fell within the next category (20-40). Steps for managing this indicator while monitoring with the CBI could have been taken earlier if scores were calculated on a slightly finer scale.

Figure 15 gives an example following the downward population trend of species X. Presenting the CBI score as one of five 20-point scale categories does not reveal a significant downward concern until sometime around 2003. If the CBI scores were tracked at a slightly finer scale, rounded to the nearest "5" for example, this downward trend would have been noticed by atleast 1995 and steps could have been taken for improvement.

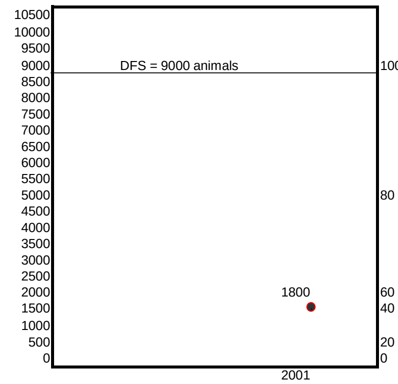
Summarizing an indicator score into one of the five categories also in some cases did not allow for comparisons between indicator scores. There was no representation of where within the category range it lies (i.e. whether it was at the bottom or top of the category range) therefore two indicators could score the same although they are in very different states of concern. An indicator near the bottom of the 40-60 range, for example, could be of greater concern than an indicator near the top of this range, although both score 40-60. As previously discussed in Key Questions for Step 5 a finer CBI score calculation was tested to place indicator scores within the five CBI ranges to aid in comparisons between indicators, themes, and ecounits.

Because of the level of subjectivity in setting the CBI scale, one must keep in mind that it is difficult to reliably assign an arbitrary difference between a CBI score of 57 and 62 for example. Nevertheless, one of these scores falls within the 40-60 range and the other into 60-80, so there is a significant difference between the two scores. For the purposes of POCT a finer scale was needed to compare indicators, select lowest-scoring indicators to represent each theme, and ultimately to assign an overall score for the ecounit without compromising the validity of the CBI normalized scale. Indicator scores were rounded to the nearest "5", which effectively placed indicator scores within the larger 20-point ranges. This helped identify and compare indicator states according to the CBI, and still accounted for the subjective nature of assigning CBI scores.

For the purposes of POCT, CBI scoring for each ecounit was compared following both the 20-point category method outlined in the *Testing Manual*, as well as following the method developed during POCT; calculating indicator scores to the nearest "5" and placing them within the 20-point CBI "concern" ranges (Figures 13 and 14).

There are definitely concerns and criticisms involved with placing too much emphasis on calculated CBI score values as opposed to summarized CBI category ranges as originally intended for the CBI. Consequently rounding to any extent, such as to the nearest "5" or "10", needs further consideration. This has been listed as one of the recommendations for future consideration.

Population trends for Species X				
Year	#	CBI Score range	CBI Score (CBI score range)	CBI Score (Nearest 5 CBI Score)
1970	12000	80-100	100	100
1975	10000	80-100	100	100
1980	9000	80-100	100	100
1985	8000	80-100	100	95
1990	5500	80-100	100	85
1995	4500	60-80	80	75
1997	2500	60-80	80	65
1999	2100	60-80	80	60
2001	2000	60-80	80	60
2003	1800	40-60	60	50
2005	1500	40-60	60	40



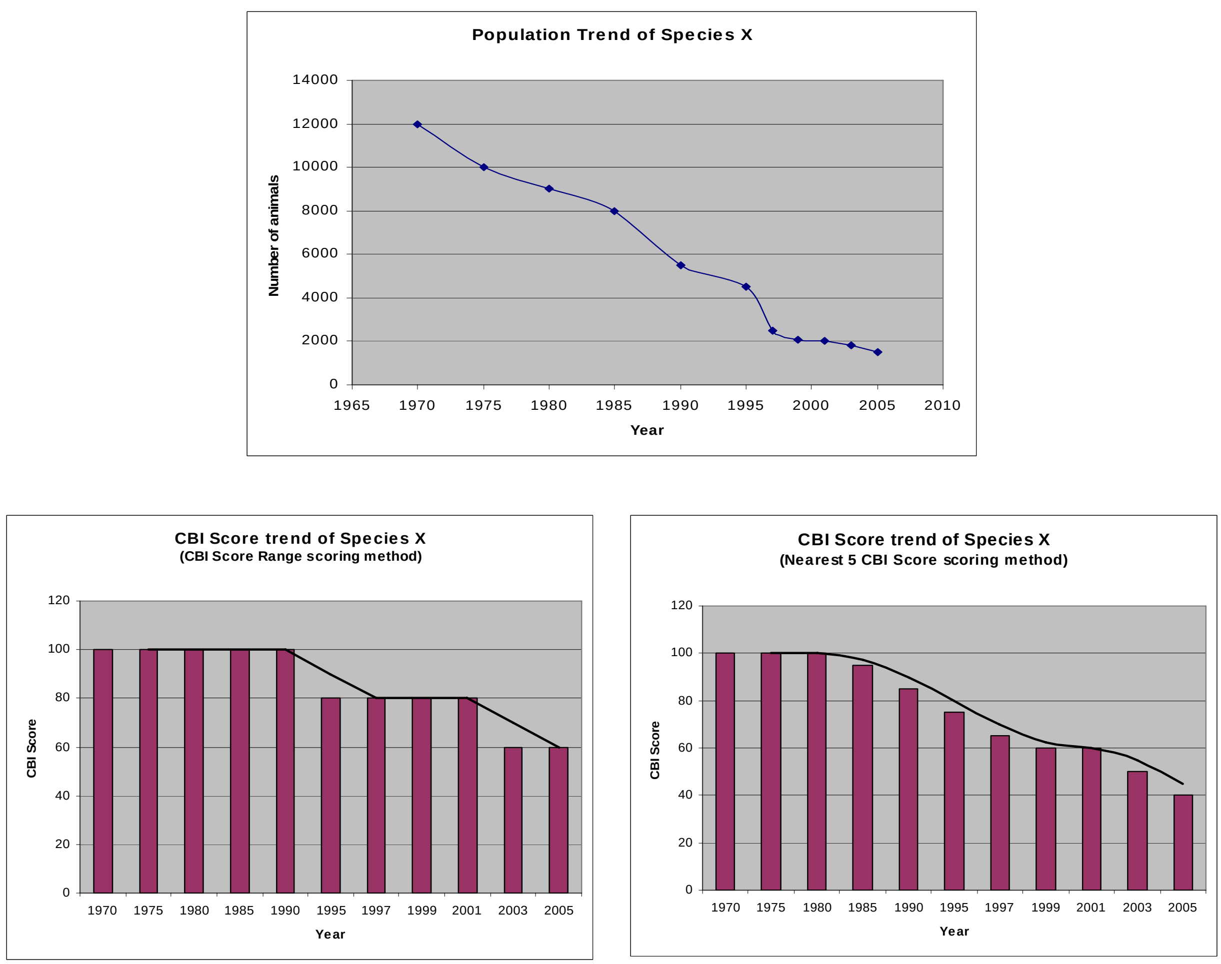


Figure 15. Historical population trend data and historical indicator CBI Score trends for Species X. Demonstrates calculation and presentation of CBI scoring methods.

5.6. CBI Ecounit Scoring

As discussed earlier in Key Questions from the Testing Manual, using a lowest-scoring approach to represent the overall ecounit score did not completely represent biodiversity issues as a whole. The lowest-scoring approach only highlighted the one "bad" indicator to represent the entire ecounit. As previously discussed, it definitely highlights a given ecounit as a management concern, but not to what overall extent. A concern from POCT was that because of the state of our ecosystems in general, most ecounits would most likely have a poorly-scoring indicator following the CBI that would drive the overall score of the ecounit down. By following the lowest-scoring approach all two of the ecounits from POCT would score in the 0-20 range and all would be driven by the one indicator in each ecounit that is in need of immediate management attention and fell within the Critical range (Figures 13 and 14). We also tested an alternate method to calculate ecounit scores as an average of all theme scores, as previously discussed in Key Questions. This is included in the recommendations from POCT.

5.7. Conclusions from CBI POCT

POCT demonstrated there is significant potential for the CBI as a nationally utilized index of biodiversity and monitoring. True strengths of the CBI include the flexible nature of the CBI 20-point range normalized scale, which allows indicators measuring very different things in different ways to be compared, as well as the uncomplicated nature of the CBI methodology for indicator scoring and calculation. The flexible nature of the normalized scale for indicator measurement is a robust attribute of the CBI. Additionally, presentation of biodiversity performance scores as calculated by the CBI gives an immediate and comprehensive visual of an ecounit's state of biodiversity, while highlighting indicators and themes of greatest management concern within that ecounit.

POCT also resulted in utilization of a simple yet effective chart for data gap analysis that could be useful for any work requiring temporal data management (Appendix I). Simply charting indicator data availability by year gave an immediate visual of an ecounit's data availability issues, and more particularly revealed the striking difference in data management between ecounits (example in). The "scattergun" pattern of data availability of the Netley-Libau Marsh ecounit – an ecounit in a populated and easily accessible are of Southern Manitoba – compared to the systematic monitoring of Banks Island – a remote arctic island in the NWT – shows the apparent value of a central data management or monitoring organization – i.e. Parks Canada in the case of Banks Island. The CBI methodology revealed a realistic need for a centralized system of data management and monitoring.

Data quality and availability will continue to be one of the challenges with any future use of the CBI. Aside from delays in finding and receiving available data, the single biggest problem was actual availability and existence of indicator data, as well as the quality of existing data. Data availability and quality will be an unavoidable problem with any type of biodiversity monitoring, and will be the norm for most ecounits undergoing CBI calculations.

What was revealed during POCT is that one of the strengths of the CBI, and other indices of biodiversity in general, is that it could serve as a valuable framework for organizing and designing future monitoring programs; essentially identifying key indicators for biodiversity

monitoring. The CBI framework could modify already existing monitoring programs to ensure proper data is being collected and in such a way that it can be used for future trend comparisons and measures of biodiversity change. This is not to suggest that the CBI will dictate what organizations will monitor, nor that they have to spend more time and resources monitoring new indicators of biodiversity. Rather, the CBI can be used quite readily with whatever data jurisdictions are already collecting - i.e. it is flexible enough to mesh with programs already underway. It is a valuable tool to help organizations do what they want to do in their own jurisdiction anyway (i.e. measure the status and trends in overall biodiversity), but to help them monitor in a way that allows for sustainable long-term biodiversity comparisons.
The CBI methodology presents a potential general protocol for biodiversity monitoring and a rationale for a centralized system of data management.

6. Recommendations

The primary goal for this phase of CBI proof of concept testing was to utilize and follow the steps as outlined in the CBI *Testing Manual* by Murray et al. (2004) adhering to the included guidance and addressing Key Questions. Essentially to utilize the CBI framework as is in order to "test" the manual and CBI framework against "real ecosystem data". Key Questions outlined in the manual were addressed as each step in the CBI process was completed, and issues resolved as testing proceeded. Several recommendations to the steps outlined in the manual, as well as to the CBI framework in general, emerged from POCT. These recommendations are intended to help further testing and implementation of the index by a wider range of participants and in a wider range of ecounits across the country. Some recommendations were dealt with and implemented immediately during testing because they affected the process and outcome of the current phase of POCT. These changes have been discussed through key questions and are further outlined below.

6.1. Change theme 3 "Landscape & Global Factors" to "External Influences"

Changing Theme 3 from "*Landscape and Global Factors*" to "*External Influences*" was implemented during POCT. Focusing on *External Influences* removed much of the uncertainty that was inherent under the previous description. Rational for modifying the theme to monitor influences outside the ecounit was to consider landscape and global pressures around the ecounit habitat, and identify indicators outside within the surrounding landscape with a direct influence on the ecounit. Indicators within the ecounit might not necessarily be showing an affect yet, whereas indicators measuring external influences could provide an early warning signal.

Several challenges had to be addressed regarding "external influences", including to what extent outside the ecounit did "external" include, as well as how far outside the ecounit could an external influence have a direct affect on the ecounit. Some sort of guidelines will need to be developed with regards to boundaries for external influences and whether the same external boundary could be drawn for all external indicators. POCT revealed that external influences would most likely be scale dependent and could include local as well as regional influences.

In the Netley-Libau Marsh ecounit for example, water pollution is clearly an issue for the entire Lake Winnipeg basin since nutrient loading comes from the entire watershed area, and could be considered in this context for policy responses and DFS. However, since Netley-Libau Marsh is connected at the south end of the lake and is directly influenced by the Red River entering Lake Winnipeg through the marsh, a useful DFS for the marsh may not coincide for the entire watershed even though they are a connected system. For the current testing it was decided to target the largest influence of direct nutrient loading to the marsh itself, i.e. the Red River which flows directly through the marsh. In this case the external influence boundary was the Red River watershed. If we now consider the indicator of "climate change", the Red River watershed doesn't make sense as a unit of analysis, nor does even Manitoba or Canada for that matter. Climate change is a global issue and even if Canada were to meet its GHG reduction targets, it would matter little if there is no progress on the global scale. Climate change related pressures on Netley-Libau Marsh would change only if there is simultaneous progress on the global level overall. Canada or Manitoba meeting its obligations of course matters, but its impact is negligible and possibly within the margin of error.

Therefore, when considering external influences, we may need to accept that external influences arise from processes that manifest themselves on different scales. This would mean for example, choosing a water quality measure and DFS at a local watershed level such as in the Netley-Libau Marsh econit, and a GHG emission or temperature increase DFS with a global DFS value. The common challenge of identifying any external influences will be how to delimit the extent of area causing external pressures within the ecounit.

6.2. Modify theme 4 to reflect "Internal" Human Influences

A second recommendation identified during Steps 2-3 was to consider rewording the title of theme 4 to reflect internal human influences on the ecounit, since human influence occurs at all scales. *Human Influences within the ecounit*, or *Internal Human influences*, or something in that regards was suggested. This might better reflect that this theme is meant to measure direct human influences *within* the ecounit and not in the landscape surrounding the ecounit. This would also further help distinguish between theme 3 and theme 4 and the concept of "external" vs. "internal" influences. Accordingly, it might make sense to renumber these two themes for consistent spatial hierarchy; species<habitat<internal human<external human.

6.3. Selecting a suite of indicators.

Selecting more indicators than are actually required allows for comparisons between indicators and particularly to select those that better represent biodiversity within the ecounit, as well as to eliminate those later revealed to have data related problems of both quality and quantity.

6.4. CBI score calculated to nearest 5 or 10?

As revealed during POCT and discussed in previous sections in much greater detail, CBI scoring could benefit from a slightly finer calculation for the purposes of placement within the 20-point CBI ranges on the normalized scale. This would allow comparisons and differentiation between indicators, themes, and ecounits, while still utilizing the 20-point CBI categories for overall CBI scoring. For the purposes of POCT indicator, theme, and ecounit scores were calculated to the nearest "5" to aid in placing indicator CBI scores within one of the five 20-point CBI score ranges or "concern" categories on the normalized scale. This very effectively identified whether an indicator fell towards the bottom or top of the range, and how much effort or time was required to move it to the next CBI category.

Recommendation is that a solution be found in regards to the problem associated with differences in sensitivity of the CBI to indicators scoring in the middle of a range versus those that score near the boundary of a range. One suggestion that was tested during POCT was rounding to the nearest "5". This also raised some concerns and criticisms about placing too much emphasis on actual CBI scores. Rounding to the nearest "5" or perhaps "10" could be offered as a suggested solution and is recommended for future consideration.

6.5. Average theme score (lowest-scoring indicator from each theme) to calculate overall ecounit score rather than lowest-scoring theme representing the ecounit.

Calculating an average of the four theme scores (average of the lowest-scoring indicator in each theme) appeared to better represent a score for the entire ecounit**.** Using a lowest-scoring approach to represent the overall ecounit score did not completely represent biodiversity issues as a whole. The lowest-scoring approach only highlighted the one "bad" indicator to represent the entire ecounit. POCT tested an alternate method to calculate ecounit scores by averaging the four theme scores. Essentially, the lowest-scoring indicator from each theme represented the ecounit score rather than just the one lowest-scoring indicator from the lowest-scoring theme. This better differentiated between ecounit scores and presented an overall biodiversity score that represented all four themes. An additional approach could present an average of the highest-scoring indicators in each theme in addition to the average of the lowest-scoring indicators in each theme. This could give a good idea of the "spread" within an ecounit without allowing one indicator to have too much "power". Averaging lowest scores provided a simple pseudo weighting that is simply calculated and incorporates all four themes.

6.6. Indicator Weighting

Weighting of individual indicator and theme scores has been considered and suggested for CBI calculations. For the purposes of POCT it was decided not to weight indicators, but rather to test the robustness of CBI methodology, and consistency with scoring and presentation of ecounit data. Some level of indicator weighting, as envisioned by the CBI, should be considered for future POCT and implementation of the CBI. Using the lowest scoring indicator might not be a reflection of the most serious threat to the ecounits biological integrity, although POCT clearly demonstrated that careful selection of the appropriate set of indicators would partially solve the problems associated with any kind of weighting.

6.7. Presentation of CBI scores – An Ecounit "Report Card"

Methods for presentation and reporting of ecounit scores still needs much consideration. Presentation recommended from this phase of POCT suggests all theme indicators should be presented together with the lowest scoring indicator highlighted in the final ecounit score graph, rather than just presenting the lowest scoring indicator that represents the score for each theme. Additionally, historic indicator trend data presented alongside CBI score trend lines reveals a comprehensive and immediate visual of indicator changes over time and describes the reasons behind CBI score trends.

It is recommended that an effort be put into developing an attractive and comprehensive ecounit CBI "report card" to summarize and present ecounit CBI scores. The summary figures presented in this report (Figs. 13 and 14) simply summarize scoring results for presentation and discussion of CBI testing methodology. A much more visually appealing summary card needs to be developed. Presentation methods from the literature should be explored.

7. Experiences Learned from CBI Testing

Creating a data gap chart - One of the first steps in data collection was developing a data gap chart to determine what data is available for the ecounit (example in Appendix I). Availability meaning both whether it exists and if it's publicly available. This quickly revealed the years for which monitoring data was available and indicated indicators having appropriate and adequate data to realistically represent biodiversity within the ecounit. In many cases the chosen indicators for CBI calculation will be dictated by whatever indicators have any data available for the ecounit.

Stakeholder meetings/consultation - Once data availability is known, an initial suite or pool of indicators selected, and preliminary DFS levels examined, it is highly recommended to hold a stakeholder meeting and consult with area experts. CBI indicators need to realistically represent biodiversity and future management concerns within the ecounit. Indicators need to represent priority species or habitats, and immediate issues affecting biodiversity. Utilizing indicators from an existing monitoring program or selecting those that can be readily integrated into an existing monitoring program is ideal, as it ensures future interest and monitoring will be carried out.

Delays – When dealing with other organizations there will be delays in both indicator selection and data acquisition, and needs to be accounted for during scheduling. Whether there are ownership issues or the primary data contact is away from the office or busy with work priorities, there will be delays obtaining indicator and monitoring data.

Selecting DFS - DFS values often fell within the middle of the indicator range where too much became a nuisance and less was not enough to ensure biodiversity. This was often the case with species populations and area extent of habitats.

Applying the Normalized CBI scale - When applying the normalized CBI scale to indicator unit scales, some knowledge of historic trends, changes, and fluctuations of that indicator, as well as knowledge of ecological systems, is critical.

Comprehensively present trend scores - Indicator historic data trends presented alongside calculated historic CBI scores reveals a comprehensive and immediate picture of indicator change over time, and identifies why CBI scores have changed as they do.

Comprehensively present ecounit CBI scores - All theme indicators should be presented together, with the lowest scoring indicators highlighted on ecounit score graphs, rather than just presenting the lowest-scoring indicator in each theme. Ultimately, the lowest scoring indicator drives the score in each theme, but there is more value in seeing all indicator scores presented together in the final graph or "report card".

8. Comments to Consider from POCT

1. The CBI can in effect become a tool for communicating with ecounit stakeholder groups, such as government, NGOs, and local conservation groups, who conduct monitoring. Testing of the CBI revealed its strength as a communications vehicle that reinforces the importance of standardized protocols for archiving data collected by organizations, including volountary interest groups. The CBI also has potential to evolve as a scientific protocol for archiving and organizing continuously collected remotely sensed data, i.e. hydrologic (quality and quantity), and meteorological data for themes 3 and 4 particularly.
2. Through testing there was difficulty in utilizing climate data, although, it was recognized that climate data and climate change are an influence that affects all ecounits. If climate change is consistently interpreted as the magnitude of an external human influence this could work.
3. One of the most important outcomes of the CBI's application is that it will force managers to think carefully about what they want to measure, and what can be practically measured. The need for stakeholder consultation to identity indicators and define DFS will be an important step in CBI calculations for any ecounit. Consultations and stakeholder involvement should also integrate traditional ecological knowledge (TEK) as part of the DFS-setting process.
4. In essence, the CBI could incorporate a 10th principle: "The CBI should establish a monitoring and reporting protocol for ecounits under consideration".
5. If themes 3 and 4 were to be changed to reflect external and internal human influences, does it makes sense to use indicators here such as species at risk or could this more accurately be represented in theme 1? National/global significance of species at risk, could be presented according to % of population within the ecounit.
6. Figure 11 graphs of Peary Caribou are a good illustration of the concerns regarding rounding and uncertainty that evolved with CBI POCT. Rounding of CBI scores to the nearest 5 or 10 for example will inevitably dampen some of the information from indicator data, however, since the goal of the CBI is to track and highlight biodiversity issues of an ecounit, the significance and effect of rounding indicator data for the purpose of scoring ecounit indicators, comparisons between indicators and themes, and final scoring of the ecounit needs to be considered. Transparency of the CBI and the ability to dig deeper into the existing data is one of the guiding principles of the CBI, therefore the merit of any CBI scoring system and presentation of results needs consideration.
7. Target values (DFS) are typically unavailable for many indicators (protected areas, population sizes, remaining habitat levels). Setting realistic DFS values will be one of the main challenges and limitations of the CBI, along with availability of appropriate data.
8. Within a given ecounit, indicators might need to be selected across habitat types to represent the entire ecounit, which might ultimately result in additional monitoring within

the ecounit for specific indicators (i.e. habitat or species population). Indicators need to be selected that truly represent biodiversity within the ecounit but they must also fully represent the dynamic and changing nature of the ecosystems within the ecounit.

9. How will the CBI for different ecounits be combined to produce a CBI for national reporting? How will CBI change over time if indicators are dropped, added, more ecounits are assessed or stopped being assessed, etc.

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