



# **Ecological classification system for the ecosystem status and trends report**

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# PREFACE

The Canadian Council of Resource Ministers developed a Biodiversity Outcomes Framework<sup>1</sup> in 2006 to focus conservation and restoration actions under the *Canadian Biodiversity Strategy*.<sup>2</sup> *Canadian Biodiversity: Ecosystem Status and Trends 2010*<sup>3</sup> was a first report under this framework. It assesses progress towards the framework's goal of "Healthy and Diverse Ecosystems" and the two desired conservation outcomes: i) productive, resilient, diverse ecosystems with the capacity to recover and adapt; and ii) damaged ecosystems restored.

The 22 recurring key findings that are presented in *Canadian Biodiversity: Ecosystem Status and Trends 2010* emerged from synthesis and analysis of technical reports prepared as part of this project. Over 500 experts participated in the writing and review of these foundation documents. This report, *Ecological classification system for the ecosystem status and trends report*, is one of three background papers prepared to assist the Ecosystem Status and Trends Reporting (ESTR) Steering Committee in guiding this project. It describes how and why the ecozone+ framework was chosen.

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<sup>1</sup> Environment Canada. 2006. Biodiversity outcomes framework for Canada. Canadian Councils of Resource Ministers. Ottawa, ON. 8 p. <http://www.biodivcanada.ca/default.asp?lang=En&n=F14D37B9-1>

<sup>2</sup> Federal-Provincial-Territorial Biodiversity Working Group. 1995. Canadian biodiversity strategy: Canada's response to the Convention on Biological Diversity. Environment Canada, Biodiversity Convention Office. Ottawa, ON. 86 p. <http://www.biodivcanada.ca/default.asp?lang=En&n=560ED58E-1>

<sup>3</sup> Federal, Provincial and Territorial Governments of Canada. 2010. Canadian biodiversity: ecosystem status and trends 2010. Canadian Councils of Resource Ministers. Ottawa, ON. vi + 142 p. <http://www.biodivcanada.ca/default.asp?lang=En&n=83A35E06-1>

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# INTRODUCTION

When embarking on Canada's first ecosystem assessment, the Ecosystem Status and Trends Reporting (ESTR) Steering Committee recognized that an ecological classification framework was required. They envisioned one framework that covered terrestrial, freshwater, and marine ecosystems. They developed some principles and criteria, conducted a series of interviews with experts and users of ecological frameworks from across Canada, and selected four options for further consideration prior to making a decision. This report documents the process and rationale for the framework selected.

## Importance of ecological classification

Biodiversity data collection, analysis, interpretation, and reporting are time and scale-dependent activities. Reporting data at a national and regional scale provide a broad overview of landscape characteristics and temporal trends that are useful on a regional to global scale for ecosystem health assessments but can be too coarse for operational planning purposes. Having too coarse a scale, such as national reporting, can mask regional trends, amalgamate contradictory trends, and convey misinformation. Subregional to local data are useful for delineating regional to local landscape characteristics and temporal trends and are useful for both strategic and operational ecosystem management. Having too fine a scale can compromise assessments by resulting in too many data gaps caused by discontinuous data thereby precluding integrated assessments.

Ecological classification is an explicit, consistent method of mapping terrestrial and marine ecosystems at regional to local scales. Mapped ecological units are usually defined by a combination of regional to subregional climatic, physiographic, aquatic/marine, and biotic characteristics that are delineated at various scales as entities that are more "homogeneous" within their boundaries than across boundaries. These units can provide a common framework for local to national assessments of ecological indicators and for integrated assessments that include information from areas of similar ecosystem drivers, composition, structure, and processes. They facilitate the amalgamation of datasets and the extrapolations of trends to contiguous regions. Because trends in ecosystem goods and services are part of the biodiversity assessments for ESTR, the ecological units should show some homogeneity in how humans not only affect but benefit from biodiversity within each ecological unit.

## What are the major approaches to mapping ecosystems?

Several approaches to ecological classification are used by scientists, resource managers, and ecosystem policy experts depending upon information requirements. Consultations with experts and users identified the following as approaches to be considered for ESTR:

1. Realms/physiognomic units – discontinuous areas based on vegetation life form, structure, and composition (for example tundra, tall grasslands, wetlands, coniferous forests). The Canadian National Vegetation Classification intends to harmonize the nomenclature and hierarchy of disparate provincial vegetation classification systems. This system will not be completed within the timeline for completion of the ESTR.
2. Bioclimatic and biogeoclimatic zones – either discontinuous or contiguous areas of overarching climate drivers, soil, and geology, which interact to yield “potential” vegetation zones.
3. Watersheds – contiguous units based on either major river drainage basins or ocean basins. Sub-basins are often delineated by distributions of fish and amphibian species.
4. Ecoregionalization – contiguous units that are nested at various scales and for which the boundaries are defined by biotic and abiotic characteristics. Sometimes these boundaries are sharp and clearly visible (such as the boundary between alpine and subalpine biomes in the mountains) and sometimes they are broad and less distinct (such as the boundary between parkland and boreal ecosystems or between marine ecosystems). At the national level, terrestrial ecoregionalization was generally described by Wiken (1986) and refined in 1995 to become the *National Ecological Framework for Canada* (Ecological Stratification Working Group, 1995) which delineates Ecozones, Ecoregions, Ecodistricts, and Soil Landscapes of Canada. These delineations were informed in part by pre-existing provincial classifications (for example Alberta, British Columbia, Ontario) and in part by broad reconnaissance surveys based on topography, hydrology, and available satellite imagery (for example Yukon, Northwest Territories, Nunavut). The *National Ecological Framework for Canada* has been adopted by many jurisdictions. An updated national framework based on a synthesis of existing systems is planned for the future.

Consultations with federal and provincial scientists and policy experts revealed strong support for some form of ecoregionalization, although there was not a clear majority among interviewees in support of any particular approach. Selection of a framework for ESTR required a decision about what level of subdivision is optimal for assessing status and trends of ecosystems nationally. This demonstrates the difficulty of ESTR and other multi-jurisdictional reports to reach consensus on the most suitable delineation of ecosystems.

# PRINCIPLES OF ECOLOGICAL UNITS FOR ESTR

Instead of deciding *a priori* on a suitable framework, the ESTR Steering Committee first drafted a report outline that included a number of principles for ecological reporting units that were considered necessary to meet the needs of the report. These were:

## ***Contiguous and integrating***

Ecological units should be “place-based” and continuous, integrating many of the site-level ecosystems traditionally associated with vegetation composition and structure (such as grasslands and wetlands). The latter “physiognomic units” reflect a more intuitive concept of ecosystems; however, continuous ecological units facilitate integrated land-use management and the “ecosystem approach” because they capture a host of ecosystem components, such as soil, climate, wildlife, water, geology, human influences, and importantly, their interactions, which span across many vegetation structural classes.

## ***Thematically consistent***

Ecosystem boundaries should be consistent for all indicators throughout the report. This approach contrasts with other reports, which, for example, use administrative units for socio-economic data, bioclimatic units for climate change indicators, and so on. In these cases, the different boundaries do not nest within one another, which make an integrated assessment of any one location difficult.

## ***Spatially exclusive***

Every point on the Canadian map will be included in only one assessment. This principle led to the decision by the ESTR Steering Committee to conduct integrated assessments of both terrestrial and freshwater realms in an area, but not work at the scale of entire watersheds. There are merits to assessing the health of a freshwater system by integrating the many influences and processes in its entire catchment; however, many of Canada’s larger watersheds include parts of different terrestrial ecosystems. Moreover, it would be impossible to assess many aspects of terrestrial biodiversity without considering freshwater availability and related ecological processes. Thus, assessing freshwater separately from the terrestrial realm would produce multiple assessments with overlapping ecological units that could lead to redundancies, possible confusion, and contradictions with regard to the state of the ecosystems.

Consequently, a decision was made that assessments of lake and riverine systems should consider information on processes and activities throughout entire catchments, but the trends would be integrated within the assessment of the ecological reporting units. Nevertheless, two extensive lake systems, the Great Lakes and Lake Winnipeg, would be assessed as distinct ecological units separate from the adjacent terrestrial landscapes because of their long history of monitoring programs and unique trends. Information contributing to the status assessment of these lakes would consider processes occurring within their entire watersheds, but the

assessment would be for the lakes themselves and not for their drainage basins. All other lakes would be included within the appropriate terrestrial ecological unit.

### ***Flexible application at different scales***

Not all indicators are meaningful across all scales at which ecological units can be mapped. For subregional and local resource management purposes, data is typically collected over relatively small geographic areas and often only once for a specific focus and using a variety of measurement types and scales (such as rangeland assessments or freshwater biological integrity indices). It may not be appropriate to interpolate, extrapolate, or determine statistical trends from local biodiversity studies across the much larger ecoregional unit within which the study area is located (for example to draw conclusions that rangeland composition and productivity trends in the moist, cool northwestern part of the prairies are adequately represented by rangeland studies of the dry southern grasslands).

Similarly, some trends could be different or even opposite in different parts of the ecological unit. Taking the average of differing trends can lead to misinformation. In these cases, subunits could be highlighted and treated separately from the surrounding ecological unit for that particular indicator. Authors of the assessment of each ecological unit should determine which subdivisions are appropriate. These subunits could be contiguous subzones (for example ecoregions), watersheds, or physiognomic units.

The principles of integration, consistency, exclusivity, and spatial flexibility apply to both terrestrial (including freshwater) and marine ecosystems, however their application varies. Where the basic medium upon which terrestrial ecosystems are founded is stability in space and time, in marine systems the water bodies are fluid and mobile. Meaningful ecoregionalization frameworks for marine systems must consider fundamental processes influenced by such attributes as bathymetry, latitude (solar radiation), and global currents, and are presented separately from the ecoregionalisation frameworks for terrestrial systems.

## **TERRESTRIAL/FRESHWATER ECOLOGICAL FRAMEWORKS**

The above principles outline basic attributes that an ecosystem classification framework for ESTR should possess. The ESTR Steering Committee then identified four ecological frameworks for further consideration:

- The National Ecological Framework for Canada, level 1 (Ecozones) (1995)
- North American Bird Conservation Initiative Bird Conservation Regions (BCRs) (2005a)
- Commission on Environmental Cooperation Ecoregions, level 2 (CEC) (1997a)
- World Wildlife Fund Conservation Planning Regions (CPRs) (2003)

A summary of the purpose, process, and status of each of these four frameworks is presented in Table 1.



Table 1. Details of the ecological frameworks considered by the ESTR Steering Committee.

	<b>Ecozones</b> Ecological Stratification Working Group (1995)	<b>Bird Conservation Regions (BCRs)</b> NABCI (2005b)	<b>CEC Ecological Regions</b> CEC (1997b)	<b>Conservation Planning Regions (CPRs)</b> WWFC (2003)
<b># of Units</b>	15	12	22	25
<b>Purpose</b>	Meet the needs of the first State of the Environment Report for Canada; facilitate ecosystem approach to sustainable resource management and planning.	Coordinating regional conservation bird initiatives, promote new regional initiatives, and identify overlapping conservation priorities.	Assist governments and the public assess ecosystem status and trends; facilitate the ecosystem approach in landuse and conservation planning.	To evaluate practical, regionally based conservation actions for the Nature Audit.
<b>Process</b>	Delineations based on interactions between geologic, landform, soil, vegetative, climatic, wildlife, water and human factors. Dominance of each factor varies for different units.	Aggregations of CEC level II, III, and IV ecoregions to reflect land bird species distribution and life history requirements.	Transition zones of attributes of soil, landform, climate, water bodies, and human influences, through satellite imagery and natural resource maps. Dominance of each factor varies by unit.	Modified other ecological frameworks to create conservation planning regions. More attention given to ensure that each CPR encompasses areas of similar human development, interest and activity.
<b>Status</b>	Revisions of the framework were in the planning stage at the time of writing.	Completed. Re-evaluated in 3 years.	Completed. Updates are expected	Completed

## Example applications of frameworks under consideration

### **Ecozones**

- The Canadian Council of Forest Ministers *Criteria and Indicators of Sustainable Forest Management in Canada* publicly reports data from the Canadian Forest Inventory grid by forest ecozones (Canadian Council of Forest Ministers, 2006).
- Under the *Canadian Environmental Assessment Act*, all federal environmental assessments are recorded by Ecozones.
- The Canadian Council on Ecological Areas uses the framework to report on protection of areas representative of Canada's ecological biodiversity (Ecoregions) (CARTS, 2009).
- Several provincial/territorial jurisdictions follow the Ecozone Framework for their natural regions and ecoregions.

- As part of the federal State of the Environment Report series, there was an ecological assessment of Boreal Shield Ecozone (Urquizo et al., 2000).
- NatureWatch commissioned an *Assessment of species diversity of the Montane Cordillera Ecozone* (Smith and Scudder (eds.), 1998), as did Scudder and Smith for the Mixedwood Plains Ecozone (Smith (ed.), 1996).

### **BCRs**

- The NABCI bird species "conservation priority" scores are calculated based on the relative concentration of a bird species' breeding range in a given BCR, relative to the species' overall breeding distribution. Each BCR has a unique list of "priority" species.

### **CEC Ecological Regions**

- CEC level 2 ecoregions were used to identify 14 regions of highest concern for the 2003 *Strategic Plan for North American cooperation in the conservation of biodiversity* (CEC, 2003).
- The CEC framework is referenced in *North America's environment: a thirty-year state of the environment and policy retrospective* by the World Resources Institute, the International Institute for Sustainable Development, and the CEC (PNUE, 2002).

### **CPRs**

- The CPRs are used to rank threats and evaluate conservation priorities in the World Wildlife Fund Nature Audit (WWFC, 2003).

## **Major differences among terrestrial frameworks**

### **Ecozones**

Ecozones as defined by the National Ecological Framework are highly consistent with the BCRs and CEC framework. The ecozone classification is the only one that does not include a southern arid British Columbia interior unit or a mixed-wood shield unit (which is considered part of the Boreal Shield Ecozone).

### **BCRs**

BCRs have the lowest number of units. The Southern Arctic, Northern Arctic, and Arctic Cordillera Ecozones are one Arctic Region in the BCR framework. The Taiga Shield and Hudson Plains Ecozones are united as one region, as are the Boreal Plains and Taiga Plains. The framework recognizes an arid British Columbia interior unit and a mixed-wood shield unit.

### **CEC**

Except for the Yukon, northern CEC delineations are the same as ecozones. However, in the south, the CEC recognizes an arid British Columbia interior unit and a mixed-wood shield unit. It also differentiates a semi-arid prairie, a temperate prairie, and a small patch of western Cordillera for the Cypress Hills.

## **CPRs**

The World Wildlife Fund CPRs have the lowest consistency with the other frameworks. There are 25 units, many of which resemble other framework units but appear to follow land cover classes. The Boreal Shield is divided into three regions: Central Canadian; Upper Great Lakes and Laurentians; and the Quebec-Newfoundland Boreal, the latter of which has patches extending into Cape Breton and the Gaspé Peninsula. The Taiga Shield is divided into an eastern and western region. There is no simple equivalent to the Prairie Ecozone, but this boundary is instead straddled by a discontinuous Aspen Parkland. As compared with ecozones, the boundaries between the Boreal and Taiga Plains is much further north, while the boundaries of the Taiga Cordillera and Boreal Cordillera are further south. The Montane Cordillera is further divided into its three smaller units.

## **Selection of a terrestrial/freshwater framework**

The ESTR Steering Committee used the following criteria to evaluate the four frameworks. It was recognized that a combination of boundaries may best suit the needs of ESTR.

- Ecologically meaningful -- whether boundaries are consistent with species distributions, climatic gradients, and major human influences.
- Meaningful heterogeneity -- whether divisions between adjacent units reflect meaningful differences in trends and status (for example, are there sufficient differences in the trends and status of the eastern and western Taiga Shield to warrant their separation as is done in the CPRs).
- Consistent scale -- whether boundaries demarcate biogeoclimatic gradients and human density patterns of a similar scale.
- Conformity with data -- in some cases, ecological monitoring programs conform to certain boundaries better than others. For some ecological units, there is not a lot of data available to support them as separate units. For example, BCRs have one Arctic unit, whereas ecozones separate this region into three units. Despite the ecological merits of separating these units, are there enough data to speak meaningfully about them separately?
- Manageable quantity of units -- the ESTR Steering Committee initially agreed that more than 20 units would be unmanageable within the timeline for ESTR. This criterion implies that if there were not significant advantages of one framework over another using the other four criteria, the one with fewer units would be preferred.

None of the terrestrial frameworks met the needs of ESTR perfectly. In general, certain elements of the CPRs and CEC ecoregions were attractive, but their high number of units was prohibitive -- with 25 and 22 respectively. The BCRs were considered to be too coarse for northern regions, linking Boreal and Taiga Shield and Boreal and Taiga Plains. The ecozones seemed to have conflicting scales of biodiversity, especially, being the only framework with one Boreal Shield and one Montane Cordillera within whose gradients in biodiversity were at least as varied as the differences across the Northern Arctic, Southern Arctic, and Arctic Cordillera.

## ***Region-specific considerations***

Six major regional issues were raised during the ESTR framework discussions:

1. Responsible jurisdictions agreed that having three Arctic regions was not backed by supporting data, species distributions, species trends, or the scale of biodiversity among other units. The BCR united Arctic region was favoured.
2. All frameworks recognized an arid British Columbia interior, except the ecozones. Given its importance to species at risk, its agricultural predominance, and its unique climate and ecosystem structure, recognizing this unit was favoured.
3. Most frameworks recognized the same boundary between the softwood boreal forest and the mixed-wood boreal shield, except the Ecozones. However, the ecology, species and stressors were considered too minor to warrant the duplication of effort, and these boundaries are not favoured by provincial biodiversity strategies. The CPRs provided a further division between a Quebec-Newfoundland boreal, which was favoured, based on the different marine influences, climate change direction, and length of post-contact settlement compared with the central-western boreal forest. However, these gradients are strongest between the mainland and the island of Newfoundland, while the ecological monitoring programs and resource inventories in Quebec do not conform to the CPR boundary that follows a Hudson Bay-Gulf of St. Lawrence drainage basin divide. Thus, recognizing the island of Newfoundland as a separate unit was favoured.
4. Both the CEC and the CPRs arid/temperate prairie and parkland subdivisions were considered based on different climatic attributes, residual tall and short grasslands, and provincial monitoring programs that recognize these boundaries. However, to reduce complexity, it was decided that a single prairies unit should be used and that heterogeneity within it could be highlighted by describing subunit trends.
5. Consideration was given to having a western and eastern Taiga Shield, as is used in the CPRs, due to the differences in climate drivers and Atlantic marine influences. Nevertheless, it was thought that poor data availability would hinder the ability to discern meaningful differences in separate assessments. Therefore, a united Taiga Shield was accepted, while recognizing that a partition may occur in the future should further investigation reveal significant differences.
6. Some jurisdictions have updated the ecozone boundaries.
  - a. The Government of Northwest Territories has extended the boundary of the Taiga Plains northward based on new tree line mapping. Other changes based on geomorphology, climate, vegetation patterns, and other environmental factors were applied to the 1995 national ecozone boundaries for both the Taiga Plains and the Taiga Shield Ecozones. These changes are included in the ESTR ecological classification and are described in:
    - i. Ecological Regions of the Northwest Territories – Taiga Plains (Ecosystem Classification Group, 2007 rev. 2009)
    - ii. Ecological Regions of the Northwest Territories – Taiga Shield (Ecosystem Classification Group, 2008)

- b. The Government of Ontario made revisions to ecozone boundaries in order to use consistent drivers to determine the boundaries at different scales. The main driver used to determine boundaries at the ecozone scale is bedrock, at the ecoregion scale is climate, and at the ecodistrict scale is physiographic or surficial geology. This decision resulted in small changes to the boundary between the Hudson Plains and Boreal Shield Ecozones within Ontario.

### ***Ecozone revisions***

Based on the considerations outlined above, it was decided that the ecozone framework was the most flexible of the four systems under consideration, with inclusion of some attributes of the other three systems. The Arctic Cordillera, Southern Arctic, and Northern Arctic were merged into one Arctic unit, the BCRs Western Interior Basin was added, Newfoundland became its own unit, and the Great Lakes and Lake Winnipeg each became their own freshwater units<sup>4</sup>. The resulting framework of 15 terrestrial and 2 large lake units was given the working title of the *Ecozone<sup>plus</sup> Framework* to avoid confusion with the more familiar “ecozones” of the original framework (Ecozone<sup>plus</sup> was later changed to Ecozone<sup>+</sup>). The units are:

1. Arctic
2. Atlantic Maritime
3. Mixedwood Plains
4. Boreal Shield
5. Newfoundland Boreal
6. Boreal Plains
7. Boreal Cordillera
8. Hudson Plains
9. Taiga Shield
10. Taiga Plains
11. Taiga Cordillera
12. Prairies
13. Western Interior
14. Pacific Maritime
15. Montane Cordillera
16. Great Lakes
17. Lake Winnipeg

A comparison between the Terrestrial Ecozones of Canada described in the *National Ecological Framework for Canada* and the ecozones<sup>+</sup> is shown in Figure 1.

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<sup>4</sup> It was later decided to include Lake Winnipeg in the Boreal Plains ecozone<sup>+</sup>

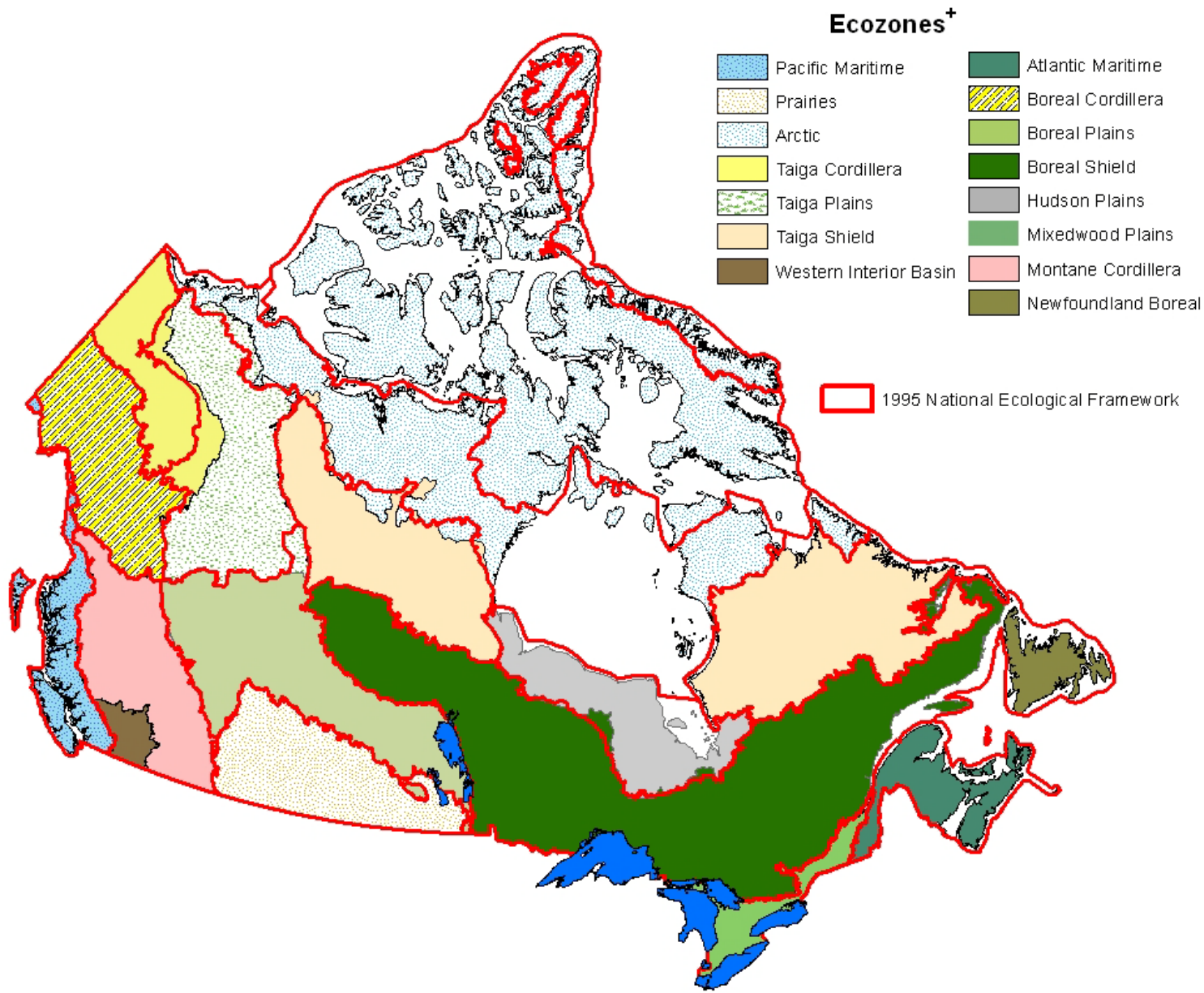


Figure 1. Map showing the boundaries of the new ESTR terrestrial ecozone<sup>+</sup> classification framework compared with the ecozones of the National Ecological Classification (1995).

## MARINE FRAMEWORKS

Few ecoregionalization classifications have been proposed for Canadian marine waters. In the late 1990s, the federal Department of Fisheries and Oceans developed a system of ecoregionalization based primarily on physical oceanography, bathymetry, and lower trophic levels. This classification system has not proved useful for Department of Fisheries and Oceans work on Large Ocean Management Areas because many important species have life histories using several ecoregions and the ecoregions have little correspondence to the provision of ecosystem goods and services. About the same time, World Wildlife Fund Canada developed an ecoregionalization system for use in identifying candidate locations for marine protected areas, but these divisions are finer and too numerous to be tractable for indicator-based assessments.

Work under *Canada's Ocean Action Plan* (Government of Canada, 2005) has provided a better understanding of the scale of ecological units for which meaningful assessments can be done -- particularly for assessments which are to be integrated across physical and biological processes and consider the provision of ecosystem goods and services. The lessons learned from this work were applied to describe the following nine marine ecological units for ESTR:

1. Estuary and Gulf of St. Lawrence
2. Gulf of Maine and Scotian Shelf
3. Newfoundland and Labrador Shelves
4. Hudson Bay, James Bay and Foxe Basin
5. Canadian Arctic Archipelago
6. Beaufort Sea
7. North Coast and Hecate Strait
8. West Coast Vancouver Island
9. Strait of Georgia

Legally Canada's marine jurisdiction extends out to 200 miles from the coast. Aside from the nose and tail of the Grand Bank however, the seafloor falls from the coastal shelves to the deep ocean basins well within the 200 mile boundary. There are few or no monitoring programs beyond the continental shelf in Canada's three oceans, and very few human activities that use ecosystem goods and services from the Canadian deep seas. For these reasons, the assessments for ESTR would be restricted to the coastal and shelf marine areas, although deep-sea portions could be added at some future time.

## ECOLOGICAL FRAMEWORK FOR ESTR – ECOZONES<sup>+</sup>

The ecological classification framework to be used in ESTR is shown in Figure 2.



Figure 2. Ecological classification framework for the Ecosystem Status and Trends Report for Canada.



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