Section 2: Methods

2.1 Overview

The 2010 Cordillera ecosystem classification was developed through a consultative process that involved representatives from the Government of the Northwest Territories, Environment and Natural Resources (ENR) and the Government of Canada (Agriculture and Agri-Food Canada). Revisions to the current Northwest Territories classification were based on recent concept-development work applied to the Taiga Plains (Ecosystem Classification Group 2007 (revised 2009)) and the Taiga Shield (Ecosystem Classification Group 2008).

The revision process employed a variety of spatial data sources including Landsat imagery, digital elevation models, hydrology, permafrost, bedrock geology, surficial geology, soils and climate that were displayed on a common base within the ESRI ArcGIS 9.1® geographic information system platform. This provided an efficient way to view landscapes from various perspectives. Air and ground verification of the proposed changes was an integral part of the revision process. Section 2 presents in general terms the GIS processes and data employed, the field data collection methods, and the process by which concepts, GIS-based data and field information was integrated to produce the final map and report.

2.2 GIS Processes

2.2.1 Information Assembly

ESRI ArcGIS® 9.2 was the principal GIS software used to manage the spatial datasets. All datasets were transformed to a common projection (Lambert Conformal Conic, NAD 83 Datum) and maintained in an ArcGIS® 9.2 Geodatabase. Other software packages used to create and manipulate spatial data were ArcInfo® 8.3 (Unix), ArcInfo® 9.2 (PC) and ArcView® 3.2. A brief description of spatial themes is provided below.

Soil Landscapes of Canada

The initial ecoregion framework for this project was the Soil Landscapes of Canada spatial database as modified by ENR using the Soil Carbon Digital Database of Canada. This dataset was supplied as a polygon shapefile.

Digital Elevation Model (DEM)

This dataset is derived from Canadian Digital Elevation Data (CDED) files and consists of an ordered array of ground elevations at regularly spaced intervals. The source digital data for CDED at a scale of 1:250,000 are extracted from the hypsographic and hydrographic elements of the digital National Topographic Data Base. This dataset was supplied by ENR as a TIF file with a ground resolution of 125 metres.

Ecoclimatic Regions of Canada

An ArcGIS® coverage was produced from a scanned image of the map accompanying the report *Ecoclimatic Regions of Canada* (Ecoregions Working Group 1989).

Peatlands

The *Peatlands of Canada* spatial and aspatial data were extracted directly from Tarnocai *et al*. (2005).

Satellite Imagery

Digital Landsat 7 ETM imagery was supplied by Environment and Natural Resources (ENR) as 3 band geoTIF orthorectified images in 5-4-3 band combination. The imagery was acquired during the months of June through September from 1999 to 2002. For some areas where ENR images were not available, Landsat 7 Orthorectified Imagery over Canada, Level 1 was downloaded from GeoBase® (http://www.geobase.ca).

2.2.2 Map Production and Database Update

All map products were created with ArcGIS® 9.2, utilizing the extensions 3D Analyst™ and Spatial Analyst™ for 3D surface visualization and analysis. Using these tools and the 125 m raster DEM, several new feature themes were created:

- Contours at 25, 50 and 100 m intervals;
- Hillshade raster themes of various sun angles and directions; and
- Vertical exaggeration of datasets to enhance surface variations in the landscape.

Two map products formed the basis for ecoregion analyses:

1) DEM theme maps consisting of a hillshade raster overlaid with preliminary ecoregion polygons and base features (hydro, transportation); and
2) Landsat 7 maps with preliminary ecoregion polygons and base features (hydro, transportation). Each of these two basic theme maps could then be overlaid with any other theme as required. The general working map scale was 1:500,000. Scales ranging from 1:100,000 to 1:750,000 were used as required.

Spatial and database updates to the modified SLC digital coverage were carried out in ArcGIS® ArcMap™. This environment provided the ability to incorporate various dataset file formats (vector, raster) and allowed for spatial editing based on the underlying themes.

2.3 Field Data Collection

An intensive aerial reconnaissance of the entire Cordillera area was undertaken from July 28 through August 26, 2007, using provisional ecoregion lines prepared from existing information as a sampling framework. Representatives of ENR (Bob Decker) and Timberline Natural Resource Group (Dave Downing) participated. Flight lines were planned in advance to cover the area efficiently given aircraft and fuel

limitations. The aerial survey spanned a total of 26 days, of which 25 days were suitable for flying. A Eurocopter EC120 rotary-wing aircraft was used for flights in late July to early August, and a Eurocopter AS350 B2 A-star rotary-wing aircraft was used in mid- to late August. Aerial traverses totalled over 18,000 km. A Hewlett-Packard® notepad computer with ArcPad® software was used for navigation. With this system, the planned flight lines, Landsat imagery and provisional ecoregion lines could be simultaneously viewed, and a Garmin GPSMap76CSx® global positioning system (GPS) unit with an external antenna provided real-time location information.

Information collected during aerial traverses included:

- Digital images, captured with a Nikon D2Xs® 12 megapixel single-lens reflex camera and an 18-200 mm zoom lens with vibration reduction;
- Geographic locations (waypoints), collected at the same time as digital images using a Garmin GPSMap 76CSx® GPS unit; and
- Comments referenced to waypoint and digital photo numbers that included photo direction and free-form remarks about landform, vegetation, permafrost, wildlife, and other features.

Approximately 17,500 geo-referenced digital images were collected, each with accompanying comments. On average, a geo-referenced image and an associated comment were recorded every two to three km, or about every 30 seconds.[9] Figure 33 shows the flight lines flown during the aerial reconnaissance in July and August 2007; the Level III ecoregion theme is shown to illustrate transect coverage across each of these ecoregions[10]. Most images are oblique aerial views; however, there are also approximately 2,000 ground-level images.

Over 50 ground stops were made, and plots were established at 31 of these. Plot information collected included basic site, soil and vegetation information characteristics, along with representative geo-referenced digital images.

2.4 Post-field Data Review and Mapping

2.4.1 General Procedures

Digital images were organized by flight line and date to facilitate their use. All of the digital information themes outlined in Section 2.2 and Section 2.4.2 (below) were brought together on an ArcGIS 9.2® platform and manipulated to produce different views of landscapes that provided insights into processes and patterns. In addition, flight lines were overlaid on the thematic map layers; the digital images and associated comments were then reviewed to augment the vegetation, permafrost and landform patterns detectable through existing coverages and models. Ecoregion boundaries were finalized and ecoregion descriptions were completed in line with the conceptual framework agreed upon by members of the Ecosystem Classification Group. On-screen line adjustments were made using software editing tools.

2.4.2 Information Sources Used to Describe Ecoregions

A number of standard information sources were consulted during preparation of the ecoregion descriptions and are briefly discussed below.

Geology and Geomorphology

Two Geologic Survey of Canada (GSC) maps provided a good general overview of surficial geology (*Surficial Materials of Canada* (Fulton 1995)) and bedrock geology (*Geological Map of Canada* (Wheeler *et al.* 1997)). More detailed 1:250,000 scale bedrock and surficial geology maps were obtained from the GSC website[11] and provided further detail on the bedrock and surficial geology of individual ecoregions; refer to Table 3 below. Extensive reference was made to the glacial history maps and accompanying report produced by Duk-Rodkin *et al.* (2004). A report by Parks Canada (1984) provides a comprehensive natural resource description for that area of the Cordillera within Nahanni National Park.

Soils

The Canadian System of Soil Classification (Soil Classification Working Group 1998) is the authority for soil nomenclature. Soil Landscape of Canada (SLC) polygon delineations and field observations were used to assess soil types and distributions within ecoregions.

Water

Published National Topographic Map Series maps (1:250,000) are the source of river and lake names reported in ecoregion descriptions.

Vegetation

Extensive and detailed plot sampling was not undertaken during the 2007 Cordillera field program because of time constraints. Most vegetation descriptions are therefore very general, and have been derived from information collected over a sparsely distributed plot network and digital photographs collected along aerial transects. Gimbarzevsky *et al*. (1979) prepared lists of the dominant flora and vegetation for the Nahanni National Park Reserve area.

Common and scientific vascular plant names used throughout this report generally follow *NWT Species 2006 – 2010* (Working Group on General Status of NWT Species 2006). A list of common and scientific plant names is provided in Appendix 1.

[9] The geo-referenced digital image location indicates the point at which the image was collected, not the image centre, as most of the images were oblique views and not directly below the aircraft.

[10] Level III ecoregion concepts are described in Sections 1.4 and 3.4.

[11] Geological Survey of Canada Map Image Rendering Database for Geoscience: gdr.nrcan.gc.ca/**mirage**/index_e.php

Table 3. Summary of surficial and bedrock geology information sources used in the classification of the Cordillera, Northwest Territories.

Map Area	Level II or III Ecoregion	Level IV Ecoregion or general comment	Filename as provided on Geologic Survey of Canada website
Surficial Geology			
Canada	Cordillera	Surficial Materials of Canada	gscmap-a_1880a_b_1995_mn01.pdf
Canada	Cordillera	Glacial history - early stages	gscof_1574_e_2003_mn01.pdf, gscof_1574_e_2003_mn2.pdf
Canada	Cordillera	Glacial history - paleogeography	gscmap-a_1703A_e_1987_mn1.pdf, gscmap-a_1703A_e_1987_mn2.pdf, gscmap-a_1703A_e_1987_mn3.pdf
Mackenzie Valley	Cordillera	Environmental review of climate change in Mackenzie Valley; climate, geology, landslides, permafrost addressed.	The physical environment of the Mackenzie Valley, Northwest Territories
Yukon	Cordillera	Glacial history of Yukon and extreme western Northwest Territories	gscof_3694_e_1999_mn1_dukrodkin_glaciers_yukon.pdf
106C Nadaleen River	Taiga Cordillera	Northern Backbone Ranges HS*as*	gscof_207_e_1974_mn01.pdf
106G Upper Ramparts River	Taiga Cordillera	Arctic Red Upland LS*b*, Canyon Ranges LS*sa*, Shattered Range HS*as*, Northern Backbone Ranges HS*as*	gscmap-a_1783a_e_1993_mn01.sid
106H Sans Sault Rapids	Taiga Cordillera	Arctic Red Upland LS*b*, Carcajou Plain LS*b*, Canyon Ranges LS*sa*, Shattered Range HS*as*	gscmap-a_1784a_e_1993_mn01.pdf
106M Fort McPherson	Tundra Cordillera	Fort McPherson- Bell River. West half includes the British-Richardson Foothills	gscmap-a_1745a_e_1992_mn01.sid
96D	Taiga Cordillera	Canyon Ranges HS*as*, Canyon Ranges LS*sa*, Carcajou Plain LS*b*, Mackenzie Foothills LS*bs*	gscmap-a_1988a_e_2002_mn01.sid
105H (NE)	Boreal Cordillera	Logan Mountains MB*as*, Ragged Range MB*as*, Ragged Range Valley MB*bs*	gscmap-a_1677a_e_1990_mn01.pdf
105I Little Nahanni River	Boreal Cordillera/ Taiga Cordillera	Itsi Mountains MB*as*, Natla Plateau MB*as*, Sapper Ranges MB*as*, Mt. Pike MB*as*	gscof_886_e_1982_mn01.pdf
Bedrock geology			
All of Cordillera	Cordillera	All Level IV ecoregions	gscmap-a_1712a_b_1991_mn01.pdf
117A Blow River	Tundra Cordillera	Richardson Plateau HS*as*, Richardson Mountains HS*a*	gscmap-a_1516a_e_1981_mn01.pdf
107B Aklavik Range	Tundra Cordillera	Richardson Plateau HS*as*, Richardson Mountains HS*a*	gscof_4827_e_2005_mn01.pdf
106F Snake River	Taiga Cordillera	Arctic Red Upland LS*b*, Canyon Ranges LS*sa*	gscmap-a_1529a_e_1982_mn01.pdf
106G Upper Ramparts River	Taiga Cordillera	Arctic Red Upland LS*b*, Canyon Ranges LS*sa*, Shattered Range HS*as*, Northern Backbone Ranges HS*as*	gscmap-a_1452a_e_1979_mn01.pdf
106H Sans Sault Rapids	Taiga Cordillera	Arctic Red Upland LS*b*, Carcajou Plain LS*b*, Canyon Ranges LS*sa*, Shattered Range HS*as*	gscmap-a_1453a_e_1979_mn01.pdf
106M Fort McPherson	Tundra Cordillera	Richardson Plateau HS*as*, Richardson Mountains HS*a*	gscmap-a_1520a_e_1981_mn01.pdf
106A, 106B, 105O, 105P, 95M, 106F, 106G, 106H	Taiga Cordillera	North half of main Cordillera massif	gscof_710_e_1980_mn01.pdf
96B/4 Twin Peaks	Taiga Cordillera	Franklin Mountains LS*sa*	gscof_5335_e_2007_mn01.pdf
96D Carcajou Canyon	Taiga Cordillera	Canyon Ranges HS*as*, Canyon Ranges LS*sa*, Carcajou Plain LS*b*, Mackenzie Foothills LS*bs*	gscmap-a_1390a_e_1974_mn01.pdf
95B	Boreal Cordillera	Liard Range MB*bs*	gscmap-a_1379a_e_1976_mn01.pdf
95C Labiche River	Boreal Cordillera	Liard Plateau HB*bs*, Hyland Plateau HB*bs*, Tlogotsho Range HB*ab*	gscmap-a_1380a_e_1976_mn01.pdf
95C/10 Tika Creek.	Boreal Cordillera	Liard Range MB*bs*	gscof_1660_e_2003_mn01.pdf
95C/NW La Biche	Boreal Cordillera	Liard Plateau HB*bs*, Hyland Plateau HB*bs*	gscof_5018_e_2005_mn01.pdf
95E Flat River	Boreal Cordillera	Ragged Range MB*as*, Hyland Plateau HB*bs*	gscmap-a_1313a_e_1973_mn01.pdf
95F Virginia Falls	Boreal Cordillera	Ragged Range MB*as*, Sunblood Range HB*as*, Liard Plateau HB*bs*, Tundra Ridge Hb*as*, Tlogotsho Range HB*ab*	gscmap-a_1378a_e_1977_mn01.pdf
95G Sibbeston Lake.	Boreal Cordillera	Nahanni-Tetcela Valley HB*b*, Nahanni Range HB*sb*	gscmap-a_1377a_e_1977_mn01.pdf
95J Camsell Bend	Boreal Cordillera	Mackenzie Foothills HB*bs*, Mackenzie Valley HB*b*	gscmap-a_1375a_e_1977_mn01.pdf
95K Root River	Taiga Cordillera, Boreal Cordillera	Thundercloud Range LS*as*, Painted Mountains LS*sa*, Mackenzie Foothills HB*bs*	gscmap-a_1376a_e_1977_mn01.pdf
95L Glacier Lake	Taiga Cordillera, Boreal Cordillera	Ragged Range Mb*as*, Ragged Range Valley MB*bs*, Southern Backbone Ranges LS*as*	gscmap-a_1314a_e_1973_mn01.pdf
95M Wrigley Lake	Taiga Cordillera	Southern Backbone Ranges LS*as*, Raven-Redstone Valley LS*bs*, Painted Mountains LS*sa*	gscmap-a_1315a_e_1973_mn01.pdf
95N Dahadinni River	Taiga Cordillera	Raven-Redstone Valley LS*bs*, Painted Mountains LS*sa*, Mackenzie Foothills LS*bs*	gscmap-a_1374a_e_1974_mn01.pdf
95O Wrigley	Taiga Cordillera, Boreal Cordillera	Central Mackenzie Valley HB*b*, Franklin Mountains LS*sa*	gscmap-a_1373a_e_1974_mn01.pdf
105I Little Nahanni River	Boreal Cordillera	Itsi Mountains MB*as*, Natla Plateau MB*as*, Sapper Ranges MB*as*, Mt. Pike MB*as*	gscmap-a_1762a_e_1992_mn01.pdf
105P Sekwi Mountain	Boreal Cordillera, Taiga Cordillera	Itsi Mountains MB*as*, Natla Plateau MB*as*, Sayunei-Sekwi Ranges LS*as*, Sapper Ranges MB*as*	gscmap-a_1333a_e_1972_mn01.pdf

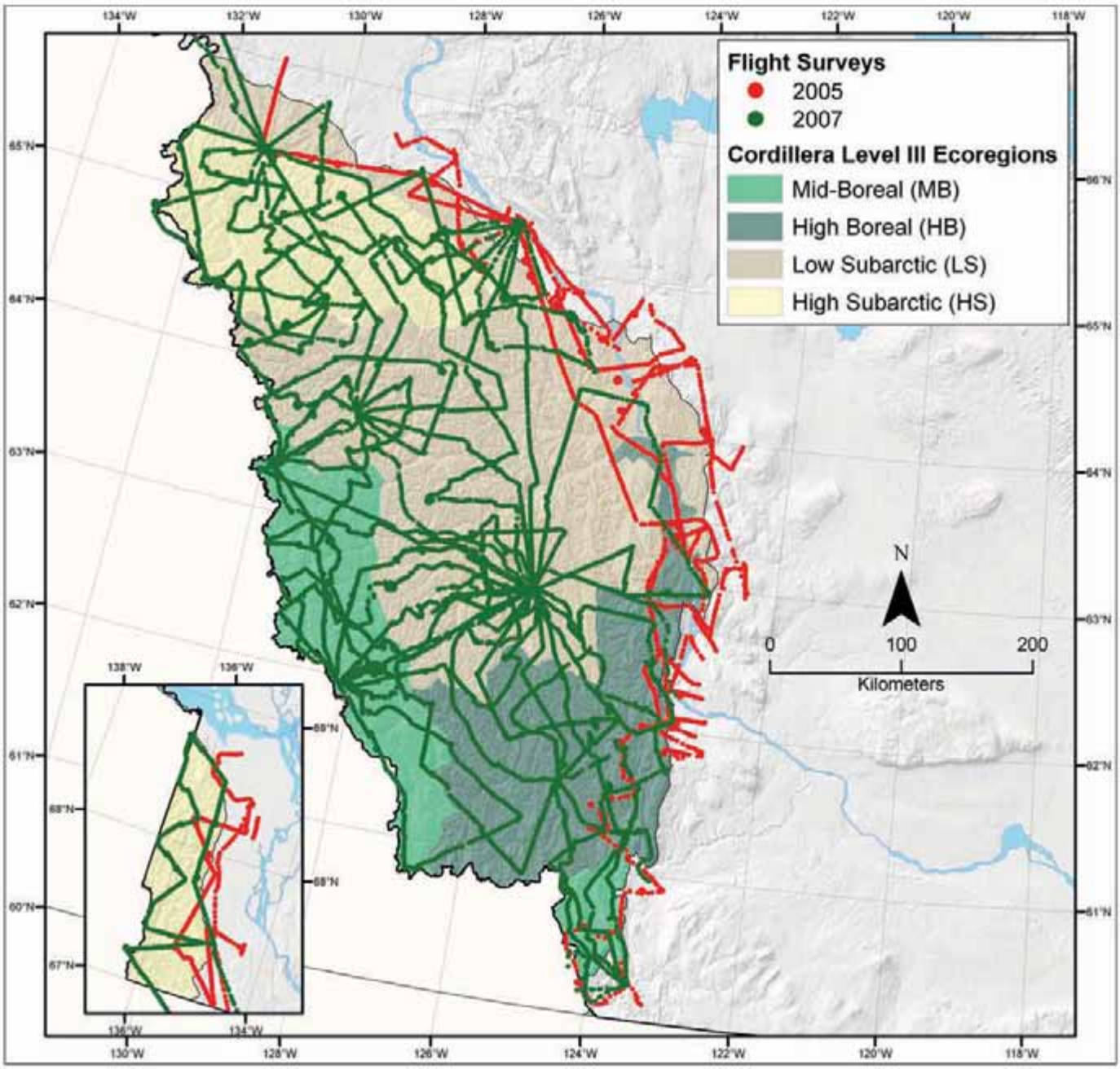

Figure 33. Transects flown during July and August 2007 are shown in green. Transects with useful coverage from the 2005 Taiga Plains survey (Ecosystem Classification Group 2007 (revised 2009)) are shown in red. Each transect line is a series of dots; each dot indicates an individual digital photo location. A detailed map of the Cordillera is provided in Appendix 3 and Level III ecoregions are described in Sections 3.4 through 3.8. The inset map shows the northern Tundra Cordillera Ecoregion adjacent to the Mackenzie Delta.