Chapter 3: Current Forest Conditions

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3. CURRENT FOREST CONDITIONS

Chapter 3 of the Forest Management Plan describes the Current Forest Conditions within of Forest Management Licence #3. It is a description of the existing ecological-biophysical, socio-economic, and land use settings.

The current forest conditions are important. This chapter describes the baseline conditions at the beginning of the Forest Management Plan (the year 2020), before any forest management activities, such as harvesting and reforestation, have been proposed. Therefore, the baseline or current forest conditions will be compared to proposed forest management activities for the next 20 years (i.e. 2020 to 2040). For example, the forested area by cover type (hardwood, hardwood-mixedwood, softwood-mixedwood, and softwood) at the beginning of the plan can be compared to future projections of cover type, to see if changes occur due to forest management activities.

Furthermore, the current forest conditions also provide an opportunity for Information Sharing and Engagement, before any forest management decisions have been made. Maps, tables, and other information summaries can be brought to communities as a good start for discussion of what is important to the community. If information is provided to the planning team, a community's objectives can be incorporated into the plan and can help guide the forest management decisions for the next 20 years.

Ecological-Biophysical Conditions

Forest Management Licence #3 spans two Ecoregions, the majority being the Boreal Plain ecozone, but also contains the Prairie ecozone in the southern portion of FML #3. The Duck Mountain Provincial Forest is an 'island' forest, surrounded by farmland.

The current ecological-biophysical condition describes ecosystems and ecosystem components such as climate, geology, soils, vegetation, wildlife, species at risk, water, wetlands, carbon, *etc*. The current forest conditions are an important baseline that summarizes characteristics of the ecosystems before any proposed forest management activities are applied at either at the landscape or stand level.

Located within the Boreal Plains Ecoregion, in the west central Parklands portion of the province, Forest Management Licence 3 is bounded to the south by Riding Mountain National Park, to the west by the Saskatchewan/Manitoba provincial border, to the north by the Porcupine Mountain Provincial Forest, and to the east by Lake Winnipegosis and Lake Manitoba (Figure 3.1). The area is well-accessed with the existing road network, including Provincial highways #5, #10, and #83. A significant amount of the transportation infrastructure is located in agricultural areas as grid roads.

Socio-Economic Conditions

The social and economic environment is described in the middle of this chapter. Statistics Canada data from 2006, 2011, and 2016 census periods are used to describe the Parklands Economic Region, including current population, employment, and income. An economic profile of the Town of Swan River is also described.

The economic contribution of the Swan Valley siding mill is described. Recreational, cultural, and historic values that contribute to socio-economic conditions are also described. Communities' economic development policies are summarized.

Land Use Conditions

Land use is described in the third portion of this chapter. There is a wide diversity of overlapping land uses in Forest Management Licence #3. Traditional land uses include trapping, hunting, and fishing. Currently, there are both commercial guiding by licenced outfitters, licenced hunting, and fishing. The Duck Mountain have Registered Trap Lines, and there is open trapping in the rest of FML #3.

Tourism is significant, with trails being the common feature needed by various groups such as snowmobilers, All-Terrain Vehicle riders, mountain bikers, hikers, and cross-country ski enthusiasts. These trails are in both the Duck Mountain Provincial Forest and the Duck Mountain Provincial Park. Local (non-commercial) use of timber and non-timber products is also described.

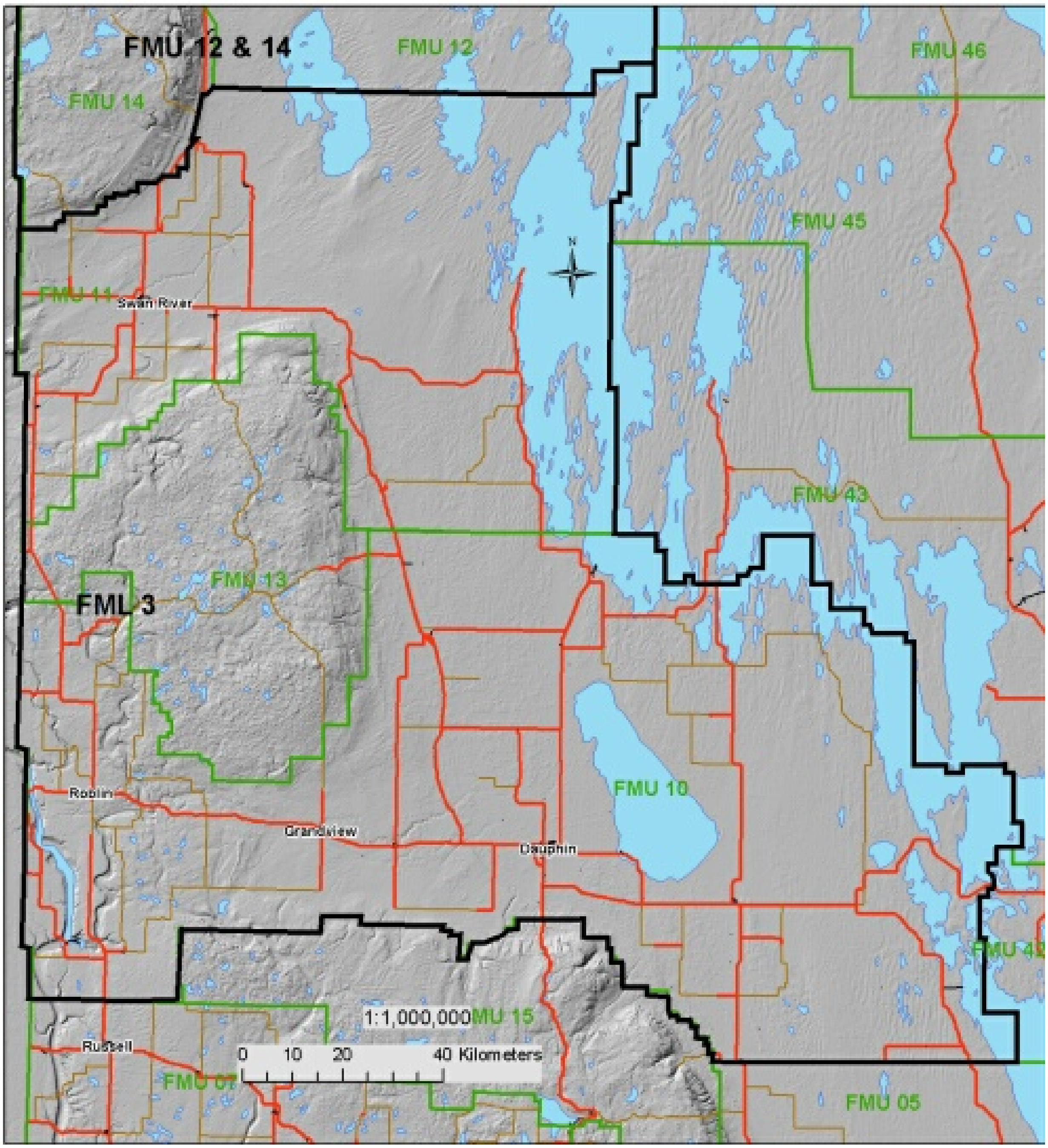

Figure 3.1 The geographic area of Forest Management Licence #3.

3.1. ECOLOGICAL-BIOPHYSICAL ENVIRONMENT

The current ecological and biophysical environment of Forest Management Licence #3 is described in this section of Chapter 3. A physical description of the FML #3 area is required in the Forest Management Plan (Manitoba Conservation 2007a), and is required to include a description on climate, soils, geology, terrestrial and aquatic flora and fauna, water resources, physical infrastructure and protected areas.

Forest Management Licence #3 (FML #3) lies mostly within the Boreal Plain ecozone that is part of the Boreal Forest. A small portion of FML #3 contains Prairie ecozone in the Roblin and Dauphin areas.

An ecosystem-based approach is used to describe climate, surficial geology, soils, ecological land classification, wetlands (bogs, fens, swamps, marshes, and open water), and water (rivers, streams, and waterbodies). Vegetation (trees, shrubs, herbs, forbs *etc.*) are described at both the landscape and the ecosite-levels.

Common wildlife species are listed by lifeform (mammals, birds, fish, amphibians, reptiles, insects, and invertebrates) but details are focused on the socially important moose, elk, and marten. Endangered or threatened wildlife species are also listed and detailed. Song birds represent the full range of biodiversity (age, cover type, interspersion) in FML #3. Sufficient data exists from the LP Bird Project to link 17 song birds to probability of occupancy by habitat.

3.1.1. General Climate Conditions

The climate of the Parklands region is continental with large seasonal temperature variations. Winters are cold and long, with hot and short summers. A moderate amount of precipitation falls in the area, with the most precipitation in summer. Winter has the least precipitation, due to the cold air being unable to hold much moisture.

Weather data for Swan River, Manitoba (station ID 10188) was downloaded from Environment Canada website (accessed Jan. 25, 2018). A 12-year period of 2006 to 2017 calendar years were selected and summarized for temperature and precipitation:
http://climate.weather.gc.ca/climate_data/daily_data_e.html?StationID=10188

An overall climate summary (Table 3.1) of the recent past (1976 to 2005) for the Duck Mountain area was downloaded from the University of Winnipeg's Prairie Climate Centre's Climate Atlas interactive tool:
https://climateatlas.ca/

Table 3.1 Overall climate summary 1976 to 2005 (source: Climate Atlas Report).

Variable	Period	1976-2005 Mean
Precipitation (mm)	Annual	472
Precipitation (mm)	Spring	95
Precipitation (mm)	Summer	207
Precipitation (mm)	Fall	104
Precipitation (mm)	Winter	64
Mean Temperature (°C)	Annual	1.1
Mean Temperature (°C)	Spring	1.1
Mean Temperature (°C)	Summer	16.5
Mean Temperature (°C)	Fall	2.8
Mean Temperature (°C)	Winter	-16.4
Tropical Nights	Annual	0
Very hot days (+30°C)	Annual	6
Very cold days (-30°C)	Annual	17
Date of Last Spring Frost	Annual	May 27
Date of First Fall Frost	Annual	Sep. 15
Frost-Free Season (days)	Annual	111

3.1.1.1 Temperature

The air temperature in FML #3 is highly variable (Table 3.2). A 12-year average (2006 to present) of the daily mean temperature is 1.8 degrees Celsius. The hottest and coldest recorded temperatures have been +35.4 and -40.8 degrees Celsius, respectively. The range of temperature across an entire year has been as much as 75 degrees Celsius.

Table 3.2 Temperature summary in Swan River for the years 2006 to 2017 (Environment Canada).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly Average
Average Temperature (°C) by month													
Daily Average (°C)	-15.0	-15.5	-8.0	2.6	10.0	15.6	18.5	17.3	12.4	4.5	-5.9	-15.0	**1.8**
Standard Deviation (+/-)	3.1	3.4	4.1	2.6	1.4	0.9	1.2	1.0	1.5	1.7	4.0	4.5	**2.4**
Daily Maximum (°C)	-4.5	-5.0	3.1	14.2	20.7	24.9	26.8	26.5	23.9	13.1	5.9	-3.8	**12.2**
Daily Minimum (°C)	-24.8	-26.6	-19.6	-8.3	0.0	7.4	9.4	9.1	3.7	-3.4	-15.4	-25.7	**-7.9**
Extreme Maximum (°C)	6.0	6.0	14.3	26.0	35.4	32.5	33.7	33.9	35.1	27.9	19.6	8.2	n/a
Extreme Minimum (°C)	-37.4	-40.8	-36.2	-23.1	-11.6	-3.0	3.6	1.5	-4.0	-11.5	-33.1	-38.2	n/a

The Climate Atlas of Canada interactive tool utilizes two climate change scenarios, and can display temperature metrics (mean, maximum, minimum temperature) and display them on a map for three time periods:

1. the recent past (1976 to 2005);
2. estimates for the future (2021-2050); and
3. estimates for further future (2051-2080).

The Climate Atlas of Canada also has hot and cold weather metrics. Hot weather metrics include:

- Tropical Night - occurs when the lowest temperature of the day does not go below 20 °C.
- Warmest Maximum Temperature - The highest temperature of the year.
- Summer Days - A Summer Day is a day when the temperature rises to at least 25 °C.
- Cooling Degree Days (CDD) are equal to the number of degrees Celsius a given day's mean temperature is above 18 °C. For example, if the daily mean temperature is 21 °C, the CDD value for that day is equal to 3 °C. If the daily mean temperature is below 18 °C, the CDD value for that day is set to zero.

Cold weather metrics include:

- Freeze-Thaw Cycles - This is a simple count of days when the air temperature fluctuates between freezing and non-freezing temperatures. Under these conditions, it is likely that some water at the surface was both liquid and ice at some point during the 24-hour period.
- Frost Days – coldest temp of the day is 0 or colder. Frost might form at ground level or on cold structures.
- Icing days – Air temp does not go above 0°C
- Coldest minimum temperature - coldest temperature of the year
- Heating Degree Days - Heating Degree Days (HDD) are equal to the number of degrees Celsius a given day's mean temperature is below 18 °C. For example, if the daily mean temperature is 12 °C, the HDD value for that day is equal to 6 °C. If the daily mean temperature is above 18 °C, the HDD value for that day is set to zero.
- Freezing Degree Days - Freezing degree days (FDD) begin to accumulate when the daily mean temperature drops below freezing: if a day's mean temperature is -21 °C, for example, it increases the annual FDD value by 21. Days when the mean temperature is 0 °C or warmer do not contribute to the annual sum.

3.1.1.2 Frost-Free Period

The frost-free period is the portion of the year when the temperature stays continuously above freezing or 0° C. The frost-free period is the potential growing season, during which there are no freezing temperatures to kill or damage plants. The last spring frost in FML #3 is usually the last week of May, but varies from mid-May to early June. The frost-free period averages 116 days (Table 3.3), and in the 2006 to 2018 period has varied from 104 days to as many as 135 frost-free days.

Table 3.3 Frost-free period in Swan River for the years 2006 to 2019 (Environment Canada).

	Frost Free Days	Last Spring Frost		First Fall Frost	
2006	108	May	22	Sept	7
2007	107	May	27	Sept	11
2008	121	May	22	Sept	20
2009	123	June	7	Oct	7
2010	131	May	10	Sept	17
2011	109	May	27	Sept	12
2012	112	May	27	Sept	15
2013	104	June	3	Sept	15
2014	111	May	22	Sept	9
2015	119	June	1	Sept	27
2016	135	May	15	Sept	26
2017	121	May	20	Sept	17
2018	108	May	20	Sept	5
2019	122	May	26	Sept	27
Average	**116 days frost free**				

3.1.1.3 Precipitation

Yearly precipitation in FML #3 varies by year and also seasonally by month (Table 3.4). Extreme precipitation events by month are also shown. Unfortunately, some snow fall data are missing from the weather records, but snow depth was recorded. Warmer air temperatures all for greater rainfall in the summer months.

Table 3.4 Precipitation summary in Swan River for the years 2006 to 2017.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Average Monthly Precipitation													
Total Precipitation (mm)	16.1	9.5	17.8	19.1	50.3	77.1	82.2	59.2	37.9	41.7	16.4	12.2	**36.6**
Extreme Monthly Total Precipitation (mm)	24.5	17.2	42.0	54.5	134.2	151.7	184.7	137.7	73.4	99.0	31.5	18.0	
Avg. Monthly Snow Depth (cm)	16.9	22.5	21.9	10.5	0.9	0.1				1.6	5.6	10.5	**10.0**
Extreme Snow Depth (cm)	49	53	65	49	8	4			1	7	32	31	

The Climate Atlas of Canada has annual and seasonal precipitation, in addition to heavy precipitation metrics:

- Heavy Precipitation Days (10 mm) - A Heavy Precipitation Day (HPD) is a day on which at least a total of 10 mm (or 20 mm) of rain or frozen precipitation falls. Frozen precipitation is measured according to its liquid equivalent: 10 cm of snow is usually about 10 mm of precipitation.
- Heavy Precipitation Days (20 mm) - A Heavy Precipitation Day (HPD) is a day on which at least a total of 10 mm (or 20 mm) of rain or frozen precipitation falls. Frozen precipitation is measured according to its liquid equivalent: 10 cm of snow is usually about 10 mm of precipitation.

3.1.1.4 Climate Moisture Index (CMI)

Climate Moisture Index (CMI) is a simple, climate-driven index of water balance (Hogg *et. al.* 2013), that is very important to plant growth. CMI is the difference between precipitation and potential evapotranspiration over an entire growing season. Long-term positive CMI values denote moist climates capable of supporting closed-canopy forests. Negative CMI values indicate drier climates with a moisture deficit, where forest cover is typically patchy (Parklands) or absent (prairie) (Hogg and Bernier, 2005).

Climate Moisture Index varies from year to year, depending on that years' annual precipitation compared to the temperature and wind (evapotranspiration). The 2015 and 2016 growing years for FML #3 are compared in Figure 3.2 showing the spatial variation of drier and wetter areas within FML #3.

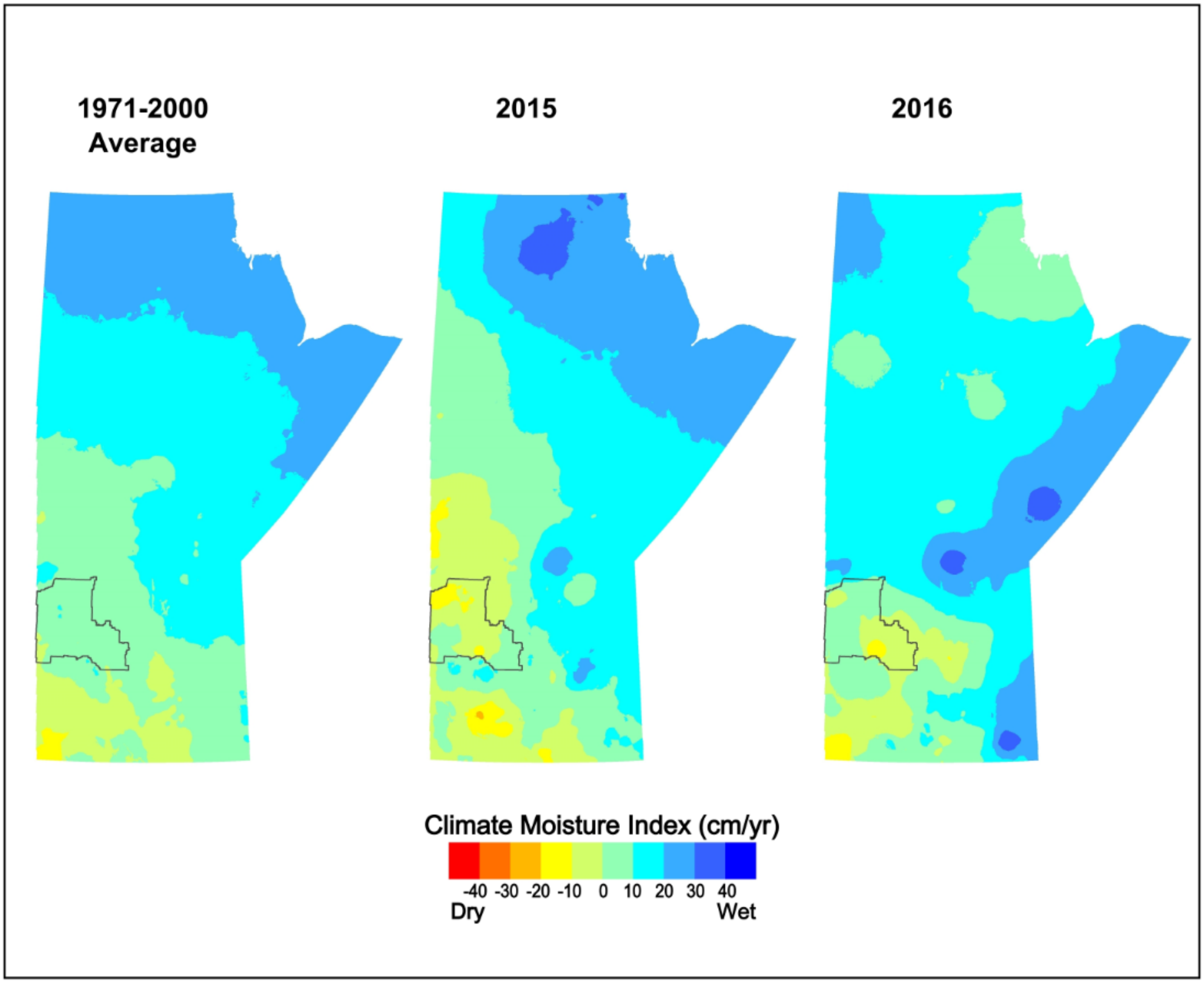

Figure 3.2 Climate moisture index compared for 2015 to 2016, as well as the 1971-2000 average (Natural Resources Canada).

3.1.2. Air and Atmosphere

The composition of the earth's atmosphere is mostly (78%) nitrogen, 21% oxygen, 1% argon, 0.4% carbon dioxide or 400 parts per million (CO_2), and trace elements, including neon, helium, methane, water vapour, krypton, hydrogen, xenon, and ozone. The composition by percentage is represented in Figure 3.3. Note that argon is a chemically inert gas, and not significant to ecosystems, and is therefore not discussed further.

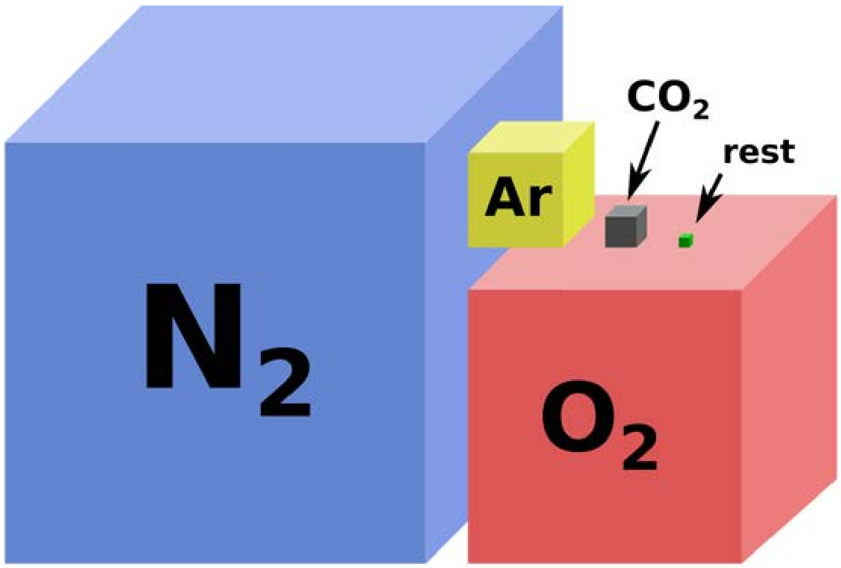

Figure 3.3 Composition of the earth's atmosphere

3.1.2.1 Nitrogen

Nitrogen is the most prevalent gas in the earth's atmosphere. Previously science has indicated that 100% of the nitrogen on Earth available to plants comes from the atmosphere. However, a recent study from the University of California, Davis, indicates that up to 26% comes from Earth's bedrock, with the remaining fraction from the atmosphere (Houlton *et al.* 2018). Nitrogen weathering, physical or chemical, is a globally significant source of nutrition for soils and ecosystems worldwide. Nitrogen may allow forests and grasslands to sequester more CO_2 emissions than previously thought.

The nitrogen cycle (Figure 3.4) describes movement of the element from the air into the biosphere and organic compounds, and then back into the atmosphere. The nitrogen cycle is a biogeochemical cycle in which by that nitrogen is converted into multiple chemical forms as it circulates throughout the atmosphere, and terrestrial and marine ecosystems. The conversion of nitrogen is carried out through both biological and physical processes. Important processes in the nitrogen cycle include fixation, ammonification, nitrification, and denitrification. Atmospheric nitrogen (N_2) has limited availability for biological use and leads to a scarcity of usable nitrogen in many types of ecosystems.

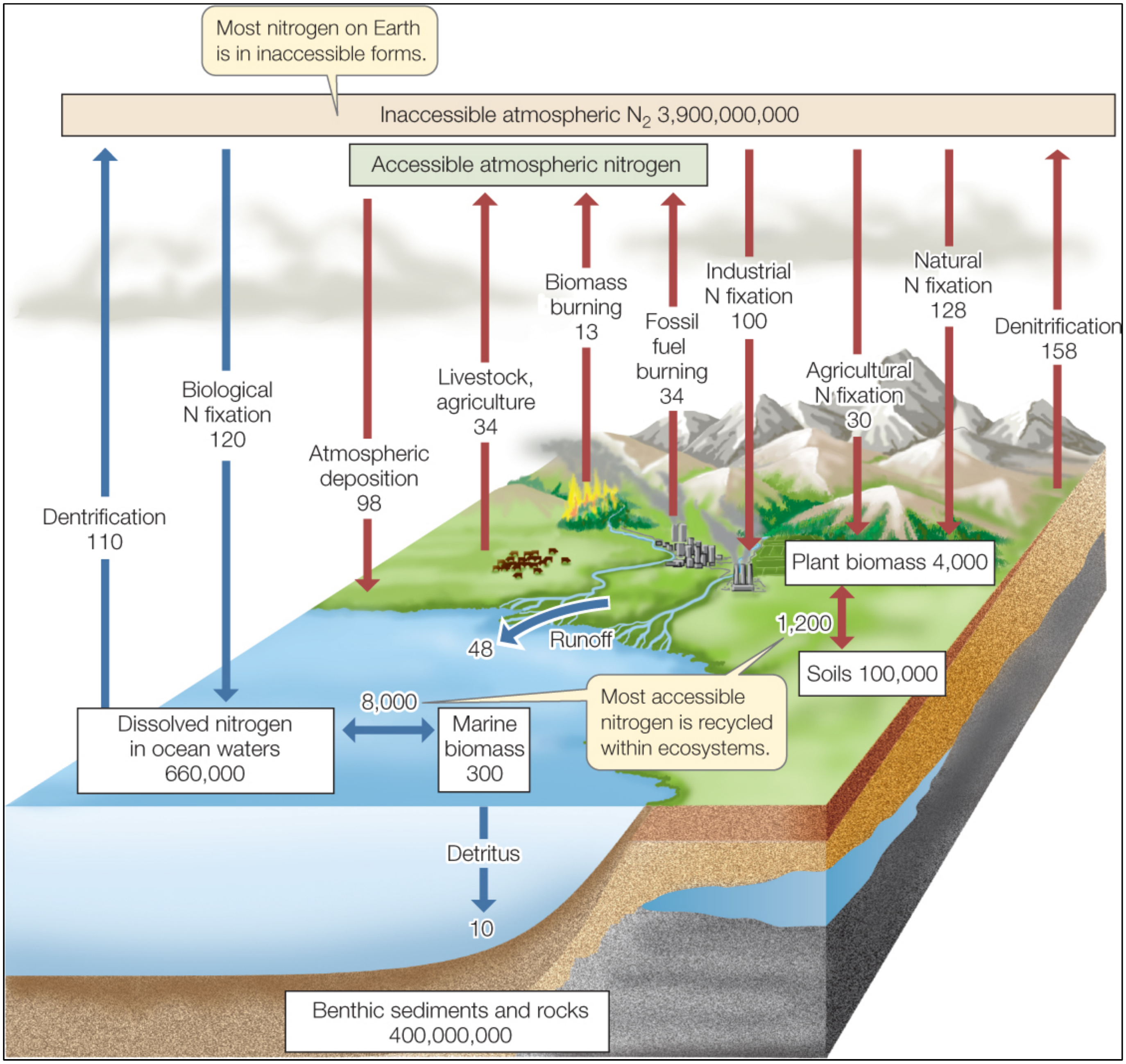

Figure 3.4 Nitrogen pools and fluxes (www.macmillanlearning.com).

Source:
http://www.macmillanhighered.com/BrainHoney/Resource/6716/digital_first_content/trunk/test/hillis2e/asset/img_ch45/c45_fig07.html

The nitrogen cycle is of particular interest since nitrogen availability can affect the rate of key ecosystem processes, including primary production and decomposition. Productivity affects all aspects of ecosystems, including the soils, herbs, shrubs, trees, and the insects, birds, mammals and other animals that utilize ecosystems as part of their life cycle.

3.1.2.2 Global Oxygen Budget

Oxygen is the second most common gas in the atmosphere, and is essential for life (*e.g.* respiration, decomposition, oxidization, and stratospheric ozone). The photosynthesis process converts carbon dioxide (CO_2) from the atmosphere into sugars, which are used for energy. Oxygen (O_2) is emitted, and carbon (C) is sequestered in plant tissues. Oxygen is consumed by living organisms are also used for combustion.

Most of the Earth's oxygen (99.5%) is in mineral oxides in the crust or lithosphere (Figure 3.5). A small fraction (0.5%) resides in the atmosphere and an even smaller fraction (0.01%) resides in the biosphere. The biosphere is crucial to understanding the atmospheric oxygen budget, as it controls short-term exchanges between sediments and the atmosphere.

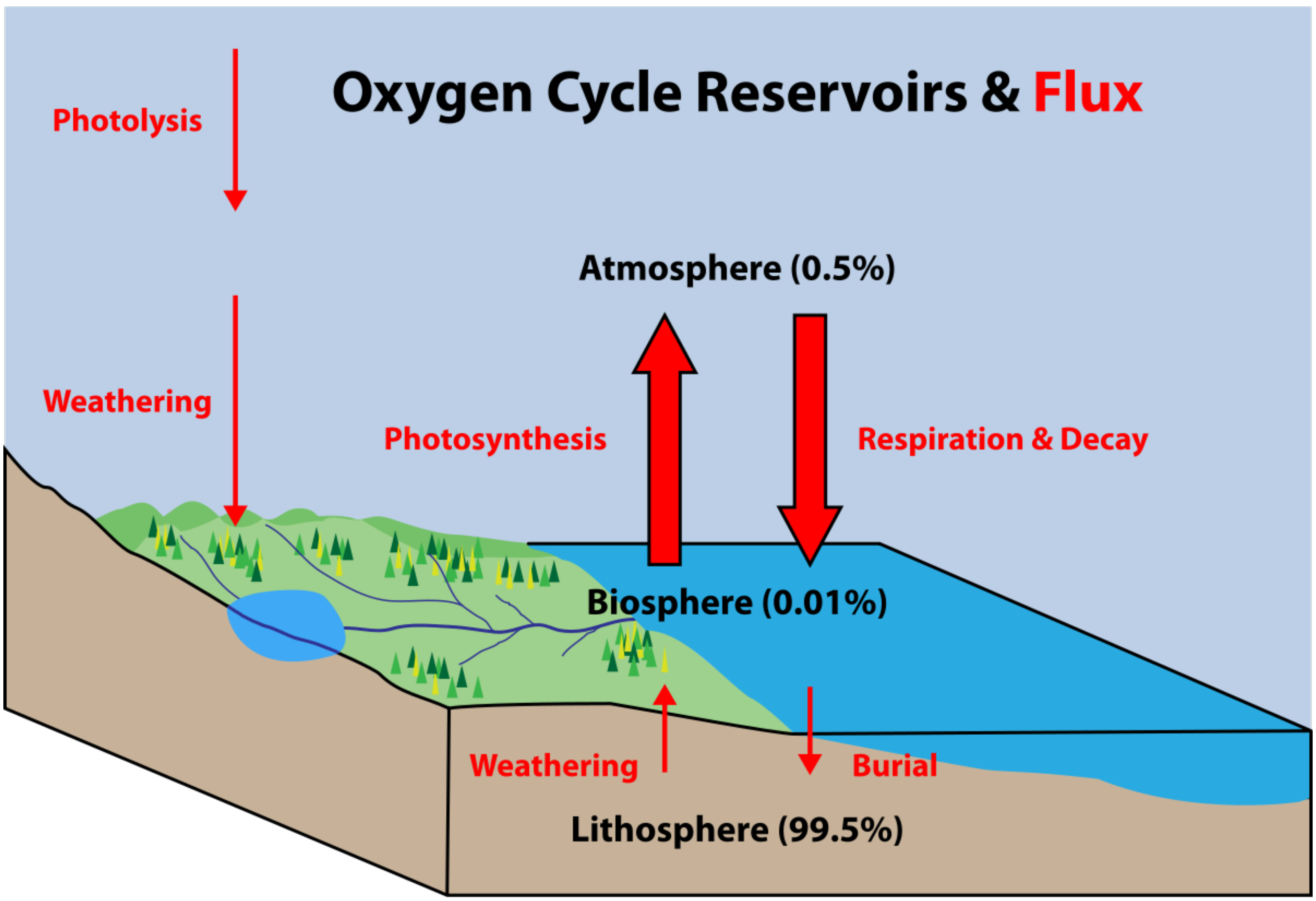

Figure 3.5 Oxygen cycle reservoirs and flux (exchanges)

source: https://en.wikipedia.org/wiki/Oxygen_cycle

3.1.2.3 Global Carbon Dioxide Budget

Carbon dioxide (CO_2) is one form of carbon in the atmosphere. Estimated CO_2 exchanges are depicted by red arrows. Estimated CO_2 pools are shown in blue text (Figure 3.6).

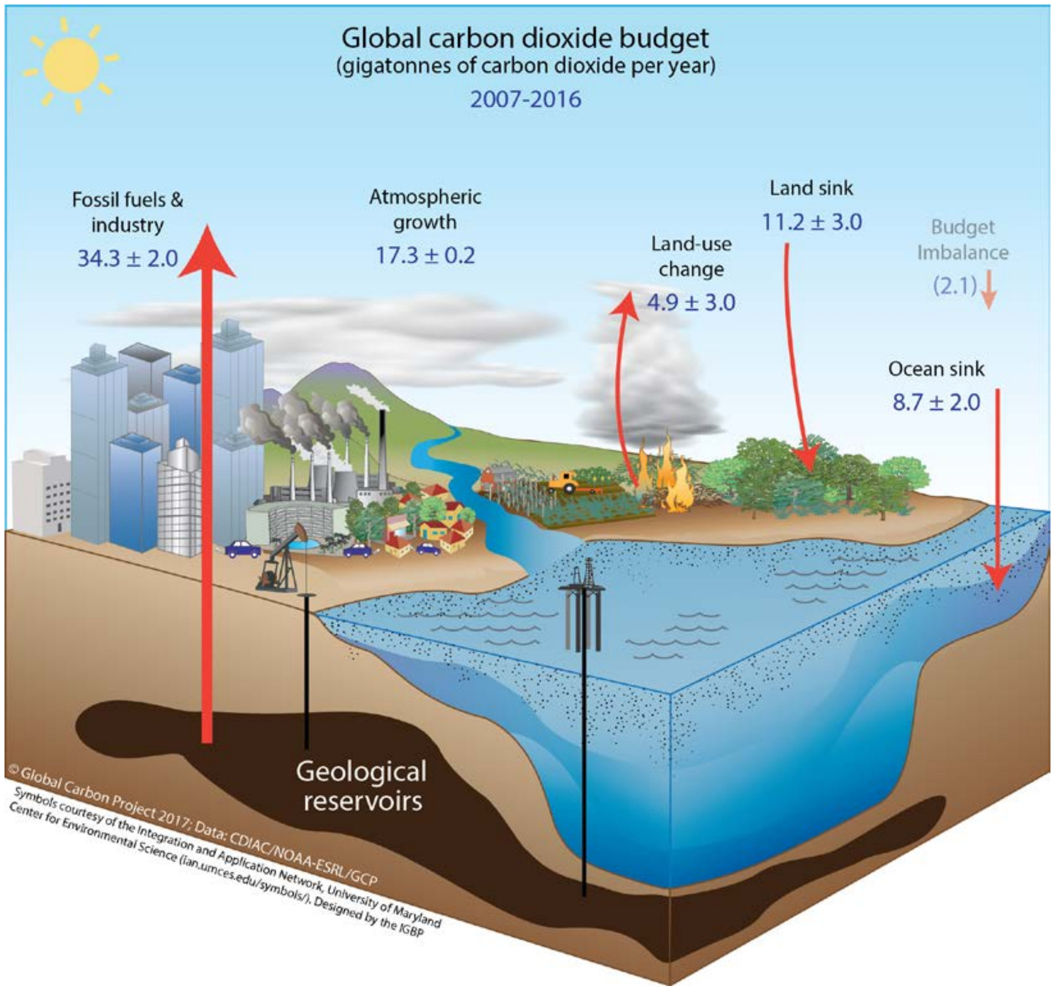

Figure 3.6 Global carbon dioxide cycle averaged globally for the decade 2007–2016 (Global Carbon Project 2017).

The flux, or change, in CO_2 levels from 1990 to 2016 are depicted in Figure 3.7 (Global Carbon project). CO_2 from fossil fuels is absorbed by the ocean, land (vegetation and soil), as well as the atmosphere.

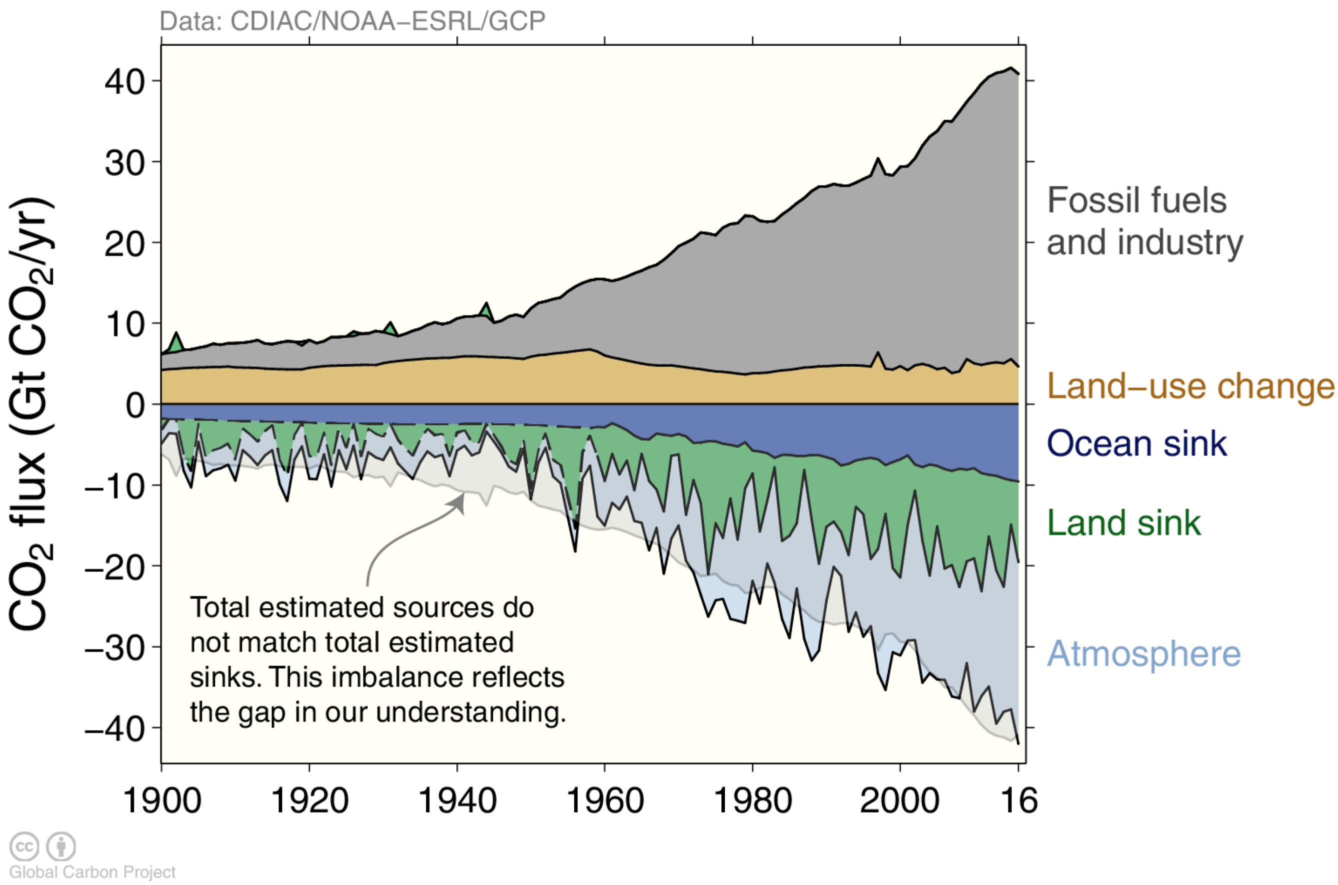

Figure 3.7 Global carbon dioxide fluxes (changes) from 1900 to 2016 (source: Global Carbon project 2017).

3.1.2.4 *Carbon*

Carbon is important because it occurs in various forms in the atmosphere, vegetation, soils, ocean, and in the sediment and rocks. Our carbon focus tends to be on the atmosphere and above-ground vegetation, but the greatest carbon reservoir is by far the sediments and rocks. The largest carbon exchange is estimated to be the transfer of carbon from the atmosphere to the earth's vegetation (Figure 3.8)

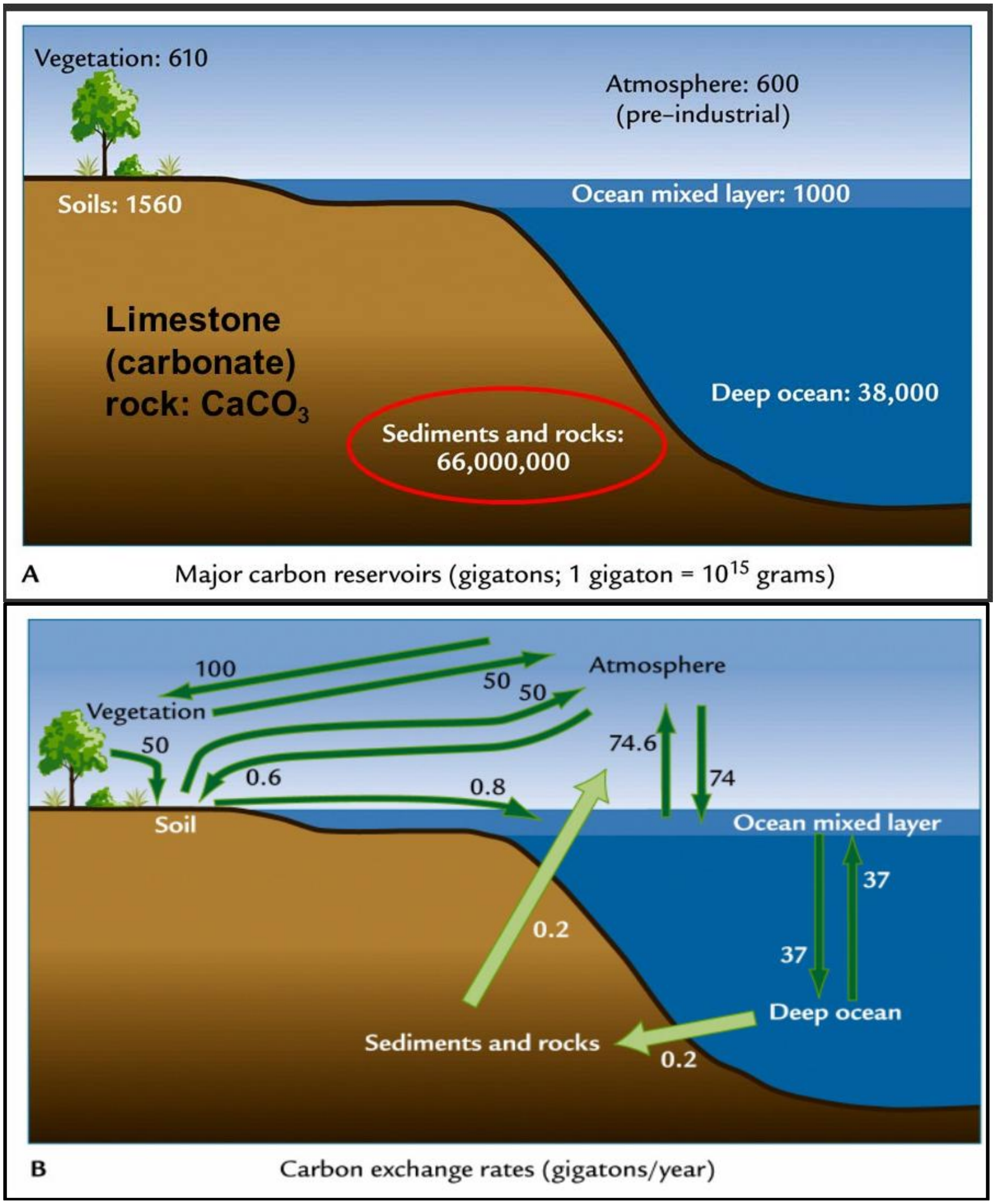

Figure 3.8 Carbon reservoirs and carbon exchange rates (source: atmosedu.com).

3.1.2.5 Air Quality Health Index

The federal and provincial governments quantify an Air Quality Health Index (AQHI) and alerts people to health risks posed by air pollution. The AQHI uses a scale of 1 to 10. The higher the number, the greater the health risk associated with local air quality. In Manitoba, AQHI is monitored in both Winnipeg and Brandon. Health messages for each of the AQHI Health Risk Categories for 'at risk' individuals and the general public are shown in Table 3.5.

Air Quality Health Index measures common air pollutants that are known to harm human health. These pollutants include Ground-level Ozone (O_3), Particulate Matter ($PM_{2.5}$), and Nitrogen Dioxide (NO_2). The AQHI does not measure the health effects of odour, pollen, dust, heat or humidity. Other air pollutants, such as sulphur dioxide and carbon monoxide, are not included in the index because their health effects are largely predicted by measures of ground-level ozone, nitrogen dioxide, and particulate matter.

Table 3.5 Air Quality Health Index Categories and Health Messages (Environment Canada).

Health Risk	Air Quality Health Index	At Risk Population* Health Messages	General Population Health Messages
Low	1 - 3	**Enjoy** your usual outdoor activities.	**Ideal** air quality for outdoor activities.
Moderate	4 - 6	**Consider reducing** or rescheduling strenuous activities outdoors if you are experiencing symptoms.	**No need to modify** your usual outdoor activities unless you experience symptoms such as coughing and throat irritation.
High	7 - 10	**Reduce** or reschedule strenuous activities outdoors. Children and the elderly should also take it easy.	**Consider reducing** or rescheduling strenuous activities outdoors if you experience symptoms such as coughing and throat irritation.
Very High	Above 10	**Avoid** strenuous activities outdoors. Children and the elderly should also avoid outdoor physical exertion.	**Reduce** or reschedule strenuous activities outdoors, especially if you experience symptoms such as coughing and throat irritation.

*persons with breathing or heart difficulties

Weather conditions can affect the Air Quality Health Index. Wind speed plays a role in diluting pollutants. Generally, strong winds disperse pollutants. However, light winds can result in stagnant conditions that allow pollutants to build up over an area, increasing the AQHI. An inversion or stagnant layer of air at ground level may trap pollutants near the ground and will not be dispersed until the wind speed increases. Clear, cloudless skies allow more sunlight to penetrate the Earth's surface that may result in higher levels of ground-level ozone, increasing the AQHI.

Forest fire smoke can spread and travel over a wide area. Smoke from grass fires, stubble burning, or building fires may also increase levels of particulate matter, but do not carry as far as forest fire smoke. Both kinds of fires increase pollutants that are measured on the Air Quality Health Index and will reduce air quality.

3.1.3. Surficial Geology

This section provides a synthesis of the surficial geology, topography, and landforms for the area within Forest Management Licence #3.

The FML #3 area is bisected by the Manitoba escarpment and dominated by the Duck Mountain. Historically, the area has contained a mixture of open prairie grasslands and forests dominated by hardwoods, mixedwoods, and softwoods. During the last century, much of the grassland was converted to agricultural use by cultivation, or as pasture.

3.1.3.1 Surficial Geology

FML #3 consists of eastward-facing bedrock escarpments, culminating in cuestas that form the Manitoba Escarpment. Above the Manitoba Escarpment in the Duck Mountain, the landscape is dominated by hummocky moraine or dead-ice topography, streamlined topography and glacial spillways (Figure 3.9). Many areas are covered by thick sequences of glacial till representing numerous glacial episodes. The most recent glacial advances were from the northwest. Glacial till tends to be clay rich.

Till deposits are commonly clay-textured soils with mixed (limestone and granitic) coarse fragments in the Duck Mountain. Tills south and east of the Duck Mountain tend to be silty, with limestone coarse fragments.

Glaciolacustrine deposits include Lake Agassiz beach ridges along the east toe slope of the Duck Mountain and were formed by waves at the margin of glacial Lake Agassiz. Provincial highway #10 closely follows these glaciolacustrine features. Offshore glaciolacustrine sediments, typically clay, were formed from clay suspended in glacial lake water. This process formed layers of clay.

Organic deposits occur as peat in moisture-receiving depressional areas. The type of mineral soil deposit below the peat varies.

Glaciofluvial sediment deposits were formed by sediment-laden meltwater flowing into glacial Lake Agassiz, forming outwash fans of sediment and consist of sand, gravel, or thin layers of silt or clay. Proximal glaciofluvial sediments consist of sand and gravel in esker ridges or kames, and are much less common than glaciofluvial sediments.

Colluvium is composed of landslide debris and deposits associated with the steep slopes along the escarpment. The Shell Valley Spillway also has minor amounts of colluvium.

Alluvial deposits are floodplains and reworked channel and streambank material, which are found along most river systems.

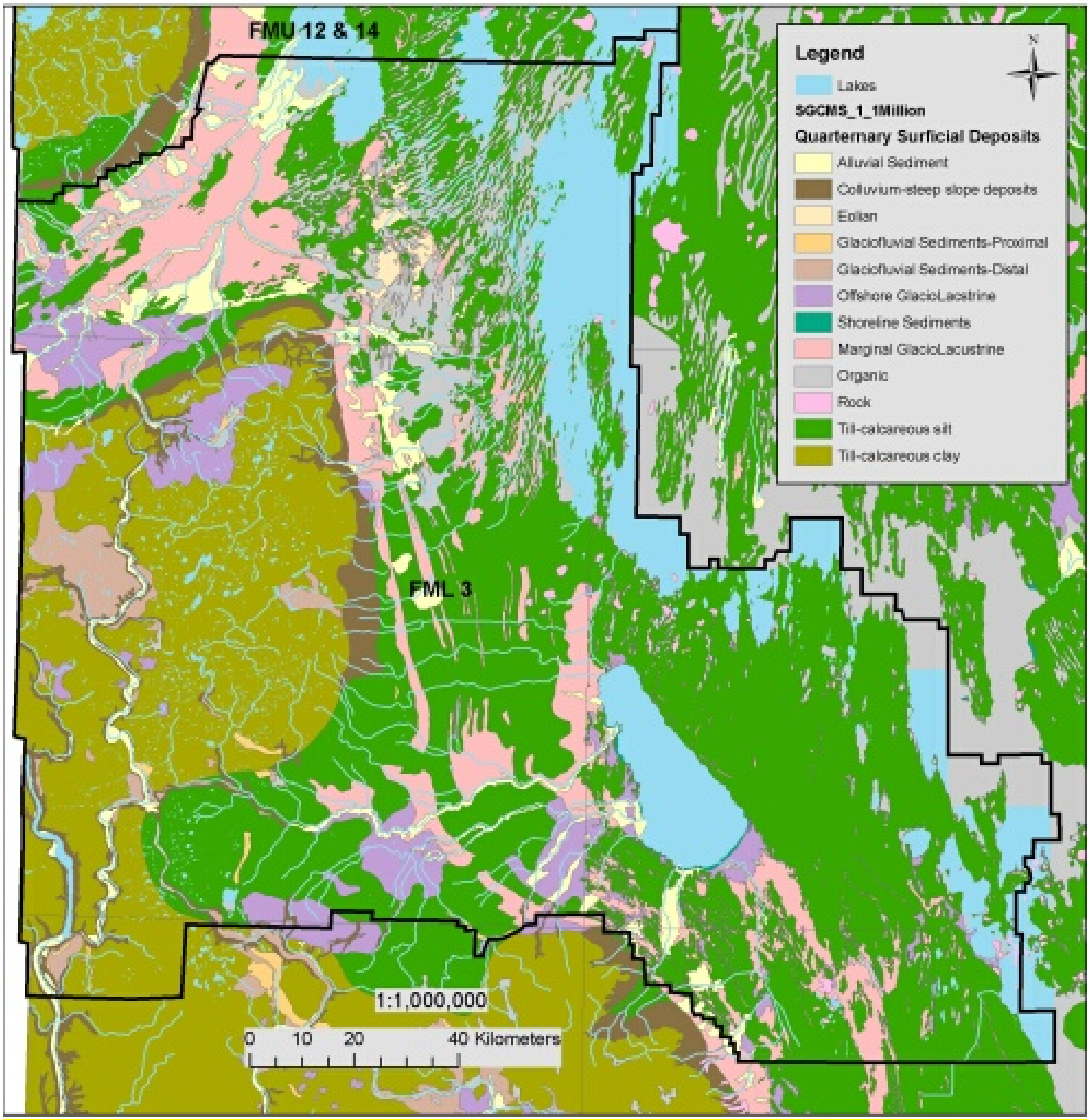

Figure 3.9 Surficial Geology in FML #3 (Matile and Keller, 2004).

3.1.3.2 Enduring Features Description

Enduring features are a collection of landscape types characterized by a unique combination of soils and surficial geology (landforms). Enduring features are very stable over long periods of time and are likely to be occupied by characteristic plant and animal communities. Application of this coarse filter approach to the selection of areas requires that the characteristics used in defining enduring features be indicative of the composition and diversity of biological communities across landscapes.

Significant enduring features in FML #3 include:

- Manitoba escarpment
- Shell River glacial spillway
- Baldy Mountain – highest elevation in Manitoba

All organisms share a connection to the landscapes in which they are found. Unlike plants and animals, soils and landforms are more stable and endure over geologic time. When an ecological process such as fire passes through an area, the area's biodiversity is temporarily changed. However, there is potential for the area to return to its previous state because the soils and landforms remain. As a result, it is much easier to define these somewhat more permanent enduring features than to identify the complex biodiversity occupying a given site over time as natural ecological processes such as succession occur.

"Representation" is the term used to describe the proportion of each enduring feature that is protected within an ecoregion and the confidence that ecological integrity is likely to be maintained over time. Representation is assessed as adequate, moderate, partial, or not captured.

The Protected Areas Initiative routinely conducted a gap analysis to evaluate representation with regards to protected areas planning on a regional basis. The representation map of Manitoba's enduring features gives an indication of where Manitoba's enduring features are adequately, moderately, partially, and not represented.

Although there is still work to be done before the network of protected areas within Manitoba is complete, the Protected Areas Initiative has made significant progress towards the goal of representing the biodiversity across Manitoba.

Note that the Duck Mountain Provincial Forest and Duck Mountain Provincial Park receive Parks Branch highest rating 'Adequately Captured', similar to Riding Mountain National Park. The portion of FML #3 outside the Duck Mountain is ranked as 'Partially Captured', 'Not Captured', and 'Moderately Captured'.

3.1.3.3 Landforms

Landforms are physical features largely defined by their surface form. Landforms within FML #3 were influenced by the glaciation and deposition of materials as the glaciers receded. The Duck Mountain consists mostly of hummocky moraine, with clay loam as the dominant soil texture. Occasionally, lacustrine silt and clay were deposited on top of the clay loam moraine. Outwash deposits consisting mainly of bedded silt, sand and gravel are also present. Small to medium-sized inclusions of fens and marshes occur across the Duck Mountain, wherever low spots occur and water flow is impeded.

Landform Mapping

Detailed soil and landform mapping for the Duck Mountain was completed at a scale of 1:60,000 during the creation of the Forest Lands Inventory (2002). Due to the complexity of some areas, some landform polygons contain two or three surface expressions (dominant, codominant1, and codominant2). Please note that FMUs 10 and 11 have not yet been landform mapped to this standard. The surface expression was mapped (Figure 3.10) and categorized in general terms (*e.g*. floodplains, hummocky, valleys, organic, *etc*.).

The western side of the Duck Mountain has a lot of undulating and hummocky terrain. The Shell River spillway is characterized by depositional floodplains near the river, and inclined plains along the banks. The top of the Duck Mountain is hummocky and undulating with occasional organic areas. The east edge of the Duck Mountain, which is part of the Manitoba Escarpment, has two kinds of valleys running east: i) V-shaped erosional valleys; and, ii) wide valleys. These valleys dissect the inclined plains of the escarpment, which generally run in a south-south-east direction.

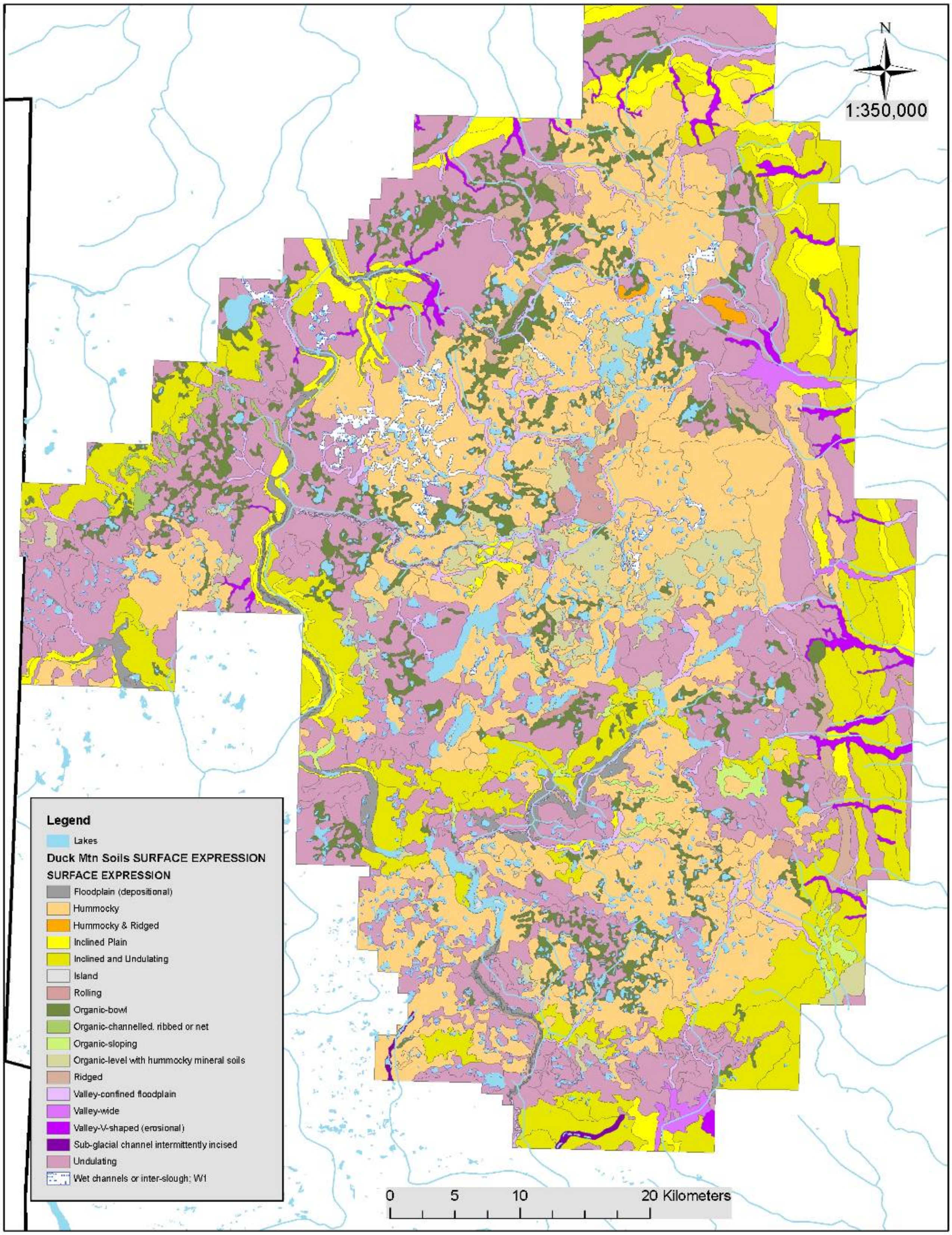

Figure 3.10 Surface expression of the Duck Mountain (The Forestry Corp 2004).

3.1.3.4 Elevation

The highest point in FML #3 and all of Manitoba is Baldy Mountain (Figure 3.11), located within the Duck Mountain Provincial Park at 831 m above sea level. The lowest point is 275 m above sea level in the extreme eastern part of the Duck Mountain area called the Westlake plain. The Assiniboine River plain runs along the Saskatchewan border with steep east facing slopes that form a part of the Manitoba Escarpment. This formation is responsible for the steep drop from 670 m to 425 m over 7 to 10 km to the Westlake plain. Part of the northwesterly slope near the Swan River plain is also an abrupt drop, falling from 610 to 275 m in about 6 km (Klassen, 1979).

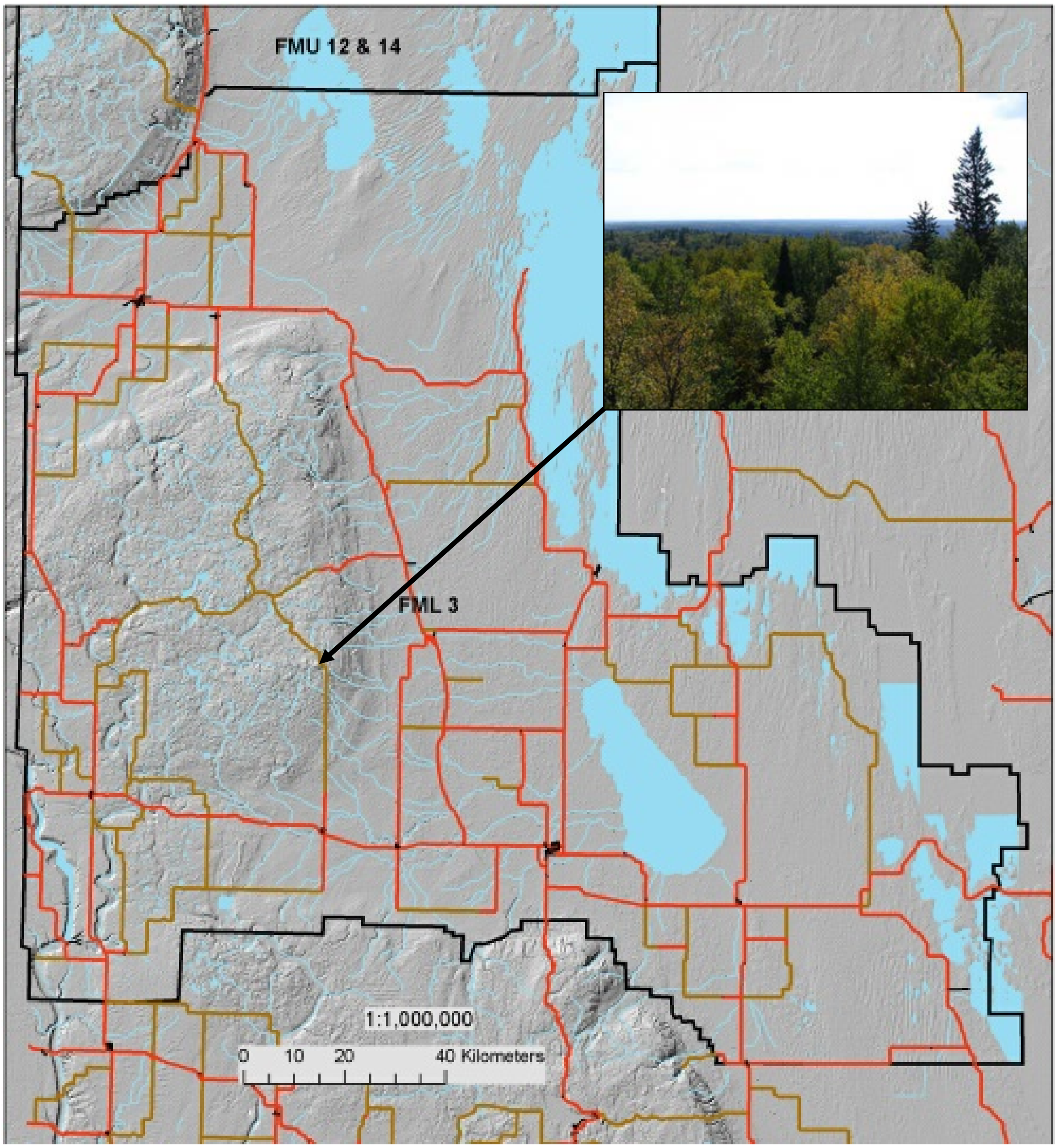

Figure 3.11 Map of elevations in FML #3, inset picture from Baldy Mountain lookout tower.

3.1.3.5 Topography

Swan River Plain (north)
This plain has the nearly flat or gently irregular till. Almost everywhere the surface is slightly eroded by glacial lakes and streams. Several patches of outwash occur to the north and northeast. These patches are, in part, pitted and consist of coarse fragments, gravel, and sand, or else the surface is gently rolling with finer deposits.

Lacustrine silt and sand give a nearly flat or gently rolling surface to portions of the northeastern part of the Swan River plain. The straight part of Swan Valley terminates at the western apex of a gently rolling sand plain between Swan Valley and Benito. An end moraine ridge, one to three km wide and 8 to 15 m high, trends east for about 26 km. This moraine marks the transition from the till of the Arran Formation on the Swan River plain to the till of the Zelena Formation on the Duck Mountain upland, and to the till of the Lennard Formation on the Assiniboine River plain.

Spillways, meltwater channels, and partly buried valleys occur in abundance within the Swan River plain.

Duck Mountain Upland (central)
The Duck Mountain Upland consists mostly of hummocky moraine. The eastern boundary with the Westlake plain is a steep drop from about 670 to 425 m above sea level over 7 to 10 km. Part of the northwesterly slope near the Swan River plain also drops abruptly, falling from 605 to 425 m in about 6 km. Elsewhere the slopes are more gradual, and the boundaries with the Assiniboine plain, Riding Mountain upland, and Valley River plain lie between 460 and 580 m (Klassen, 1979).

Lacustrine deposits consisting mainly of thinly bedded or varied silt and clay and outwash deposits of bedded silt, sand, and gravel are present. The surface of both lacustrine and outwash deposits resembles hummocky moraine. Till knolls, ridges and depressions form a belt from 1 to 2.5 km wide and up to 8 m high that extends nearly continuously for about 56 km to the Grifton township.

The heavy tree cover over essentially all of the Duck Mountain upland make the identification of glacial features, such as eskers, kames, and moraine plateaus, difficult and uncertain. Some prominent meltwater channels and buried valleys cross parts of this upland. The presence of ice contact deposits within some valleys indicate that they predate the last glacier advance, but on the other hand, similar sized valleys have no ice contact deposits and pronounced V-shaped slumping occurs on the sides, suggesting they were formed in late glacial time. Large lakes occupying the uplands were formed by glacial drainage.

Valley River Plain (south)
The Valley River plain is a triangular area of gently rolling or nearly flat till and lake plain between the Riding Mountain upland and Duck Mountain upland. About half of this till plain was eroded by water. These were inundated by short-lived glacial lakes that left the plain slightly eroded or veneered with silty clay typically less than 0.3 m thick.

Lacustrine plain areas vary considerably in size and have a sporadic distribution. They generally consist of silt and clay that cover the minor irregularities of the underlying till plain to give a nearly flat surface. A boulder pavement occurs locally in the western part of the plain. The drift is generally thin, and bedrock outcrops are common on the southern part of the plain.

Tills of the Zelena and Arran formations occur on the plain as well as undivided drift of possibly the Tee Lakes or Minnedosa formations. The Zelena Formation generally is present where the till succession is more than 8 m thick. It commonly lies over shale bedrock and under till of the Arran Formation. In the southwestern part of the plain where the drift is thin, a boulder pavement with west trending furrows marks the contact between the tills of these formations.

Assiniboine River Plain (west and southwest)
The Assiniboine River Plain covers more than 14,000 km^2 adjacent to much of the Qu'Appelle and Assiniboine valleys in Manitoba and Saskatchewan. Tills of the Largs, Tee Lakes, Shell, Minnedosa and Lennard formations underlie the Plain. The Largs Formation seems to be restricted mostly to buried valleys where it is more than 30 m thick. The surface till is from the Lennard Formation, although in places west it is thin and patchy.

Bedrock plains occur in several belts and localized areas. Ice flow features, including drumlins, drumloids and flutings, form both prominent hills and subdued features on the Plain. Gently irregular till plains marked by ridges and knolls generally less than 3 m high cover half the Plain. Pockets of silt and sand commonly occur within the till where it is exposed by dugouts and road cuts (Klassen, 1979).

Corrugated moraine covers portions to the west. The outwash forms a smooth plain, except for some sand dunes. The dunes were built by the northwesterly winds that are still the prevailing winds today. Some dunes may have been built in late Wisconsin period by winds blowing from the glacier situated to the northwest, but the majority of dunes are postglacial in age. Their forms show the controlling influence of recent vegetation.

To the south of Shellmouth small ridges formed by retreating glaciers, or kames, occur along the margin of a narrow pitted belt of outwash. Here the outwash is gravely.

A flat lacustrine plain occurs east of Big Boggy Creek. The deposits consist of veneers of massive clay that probably was deposited in a small, pre-glacial lake along the northeastern margin of the Assiniboine ice lobe. Esker ridges are scattered here and there either singly or as complexes, but most are near or within outwash plains. Highway cuts in the esker ridge exposes typical ice-contact deposits of silt, sand, gravel, and till (Klassen, 1979). Kames occur in isolated hills or in chains of hills and knolls beside or within meltwater channels. They are mostly gravel, sand, and wedges of till. Scattered boulders are also present but are more common near the surface (Klassen, 1979).

Buried valleys are fairly common but are either completely masked and traceable only by subsurface mapping of the bedrock topography, or are only partly buried and readily traced on air photos. These valleys have floors of hummocky moraine. Most are less than 1 km wide. Where several valleys meet they may be twice as wide. The fill in the valleys consists of sand, gravel and till, with till over the gravel or else grading laterally into it.

Many road ditches in the bedrock plains and till plains expose a nearly horizontal boulder pavement. In places, the boulders are in till of the Lennard Formation, but generally they are in the underlying till sand, gravel, or shale. The boulder pavement formed may well have formed in conditions unique to the east-central Saskatchewan and southwestern Manitoba regions where they are most extensive. The boulders in a boulder pavement from southwestern Manitoba may have been deposited under the ice during ice stagnation and produced the pavement when the ice was rejuvenated.

Westlake Plain (east)

The plain is nearly flat or gently irregular. In most places it reflects the topography of the underlying Mesozoic sandstones and shales. The plain slopes gradually eastward along the boundary with the Valley River Plain and Duck Mountain Upland. Flights of distinct abandoned beaches trend south along the western boundary of the plain, and more subdued ones mark much of the cultivated southern part. Peatlands and mixed forest mask small glacial features in the northern half.

Tills of the Zelena and Arran formations are present. However, where the drift is thin, only Arran Formation till occurs and lies directly over bedrock.

An extensive lake plain is present in the eastern part of the plain, and smaller ones are found elsewhere on the plain. Lacustrine plains occur below the main beach complexes and apparently most of these sediments were derived from the deglaciated region into the west by stream erosion rather than from meltwater off the continental glacier to the northeast. The complex is mostly sand and fine gravel generally 1.5 to 3 m thick beneath the ridge crests and a veneer of sand, silt and clay over till or bedrock between the ridges.

3.1.4. Soils

Soils in the Forest Management Licence #3 area vary greatly, and have been heavily influenced by post-glaciation processes, as described in the above surficial geology section. Soils are the 'hub' of ecosystems. Soil characteristics have a significant and permanent influence on ecosystems, and have been found to be ecologically significant in every ecological classification system across Canada. Soils are important part of Ecosystem-Based Management and forest management in general. For example, it is important to know where the wet soils are, and schedule winter only harvest on wet soils. Conversely, summer harvest needs dry or mesic soils. Soils support forests, wetlands, prairies, and grassland biodiversity.

Soil plays a vital role in boreal forest ecosystems, and are essential for life, because soils provide a medium for plant growth, are habitat for many insects and other organisms, act as a filtration system for surface water, store carbon, and contribute to the maintenance of atmospheric gases. Soils are home to micro-organisms that fix nitrogen, decompose organic matter, and to animals such as insects and microbes.

Soil is important in providing an adequate water supply and maintaining its quality. Soil and the vegetation it supports catch and distribute rainwater and play a key role in the water cycle and supply. Soil distribution can impact rivers, lakes, and streams by changing their shape, size, capacity, and direction. Soil filters rainwater and regulates the discharge of excess rainwater, reducing flooding. Soil filters water, making aquifers or underground water one of the purest sources of water.

Soils help regulate atmospheric carbon dioxide (CO_2) by acting as a carbon store. Decomposition of trees and their leaves store carbon in the soil, although the majority of carbon returns to the atmosphere. During humification, soil organisms form complex and stable organic matter. Some organic matter breakdown does not occur completely, especially in soils like peat, because peat has a high acidity and water content, restricting respiration. Soils contain more carbon than the above-ground vegetation. Organic matter accumulates in the soil, forming the LFH layer and a black Ah horizon, high in carbon content. Nitrogen, phosphorus, potassium, and many other nutrients necessary for plant growth, are transformed and cycled in the soil.

3.1.4.1 Soil Mapping

Soil mapping is a very important step in ecosystem-based management. Soils help define the ecosystem strata for the Forest Management Plan. There is a need to know *what* the soil characteristics are, and also *where* the different soil types are located. In Forest Management Licence #3, soils have been mapped and described at different scales, using different methods, and are based on different soil characteristics (Table 3.6).

Table 3.6 Soil mapping efforts in FML #3 and surrounding area.

	Forest Lands Inventory	Manitoba Agriculture	Manitoba Geological Society	CanSIS (Canadian Soils Survey Information System)
scale(s)	1:60,000 and 1:15,000	Reconnaissance Survey 1:125,000; Detailed surveys 1:20,000	1:250,000 1:1 million	1:3.5 million and 1:1.5 million
focus	mapping landforms and forest soils	Soil survey with agricultural interpretations	surficial geology	Canada-wide mapping of soils polygons, aggregated upward to form EcoRegions and EcoZones
web address	none	http://www.gov.mb.ca/agriculture/crops/cropproduction/gaa01d08.html	http://www.gov.mb.ca/stem/mrd/geo/gis/surfgeomap.html	http://sis.agr.gc.ca/cansis/
Mapping method	top-down using photos, combined with ground-up from field sampling)	ground-up (field survey and photos)	top-down	top-down

*3.1.4.1.1 **Soil mapping in the Forest Lands Inventory***

Landscape and soil mapping for the Duck Mountain and Porcupine Mountain Provincial Forests was completed at a scale of 1:60,000 during the creation of the Forest Lands Inventory (2002). Soil orders were mapped (Figure 3.12), utilizing both aerial photography and ground observations. The majority of the Duck Mountain are Luvisols, followed by Gleysols and Organic soils. Part of the east escarpment are Brunisolic soils.

Soil texture class was assigned to each of the soil polygons (Figure 3.13). Soil texture is ecologically important in defining ecosystems, and is the X-axis on the edatopic grid of every ecological classification system across Canada. The Duck Mountain contain mostly fine-textured or clay soils. Some of the clay soils are layered over coarse-textured soils. The eastern portion of Duck Mountain is characterized by medium-textured and layered soils where coarse-textured soils are the upper-most layer. Organic soils are found throughout the Duck Mountain, in low-lying areas, and are typically moisture-receiving bottoms of short hills in the hummocky terrain.

Soil moisture regime classes are mapped (Figure 3.14). Soil moisture regime is ecologically important when defining ecosystems, and is the Y-axis on the edatopic grid of every ecological classification system across Canada.

*3.1.4.1.2 **Agricultural Soil Maps***

In the agricultural area of FML #3, soils were mapped using a bottom-up approach. Eight to 16 soil pits per quarter-section were dug and described. The information was aggregated upwards and used to generate soils maps. These maps are now available digitally.

*3.1.4.1.3 **Manitoba Geological Society***

The Manitoba Geological Society produced surficial geology maps at a scale of 1:250,000. Top-down mapping utilized field observations and aerial photography.

*3.1.4.1.4 **Canadian Soils Survey Information System***

The Canadian Soils Survey Information System (CanSIS) soils polygons form the Ecoregions described in the Ecological Land Classification System section.

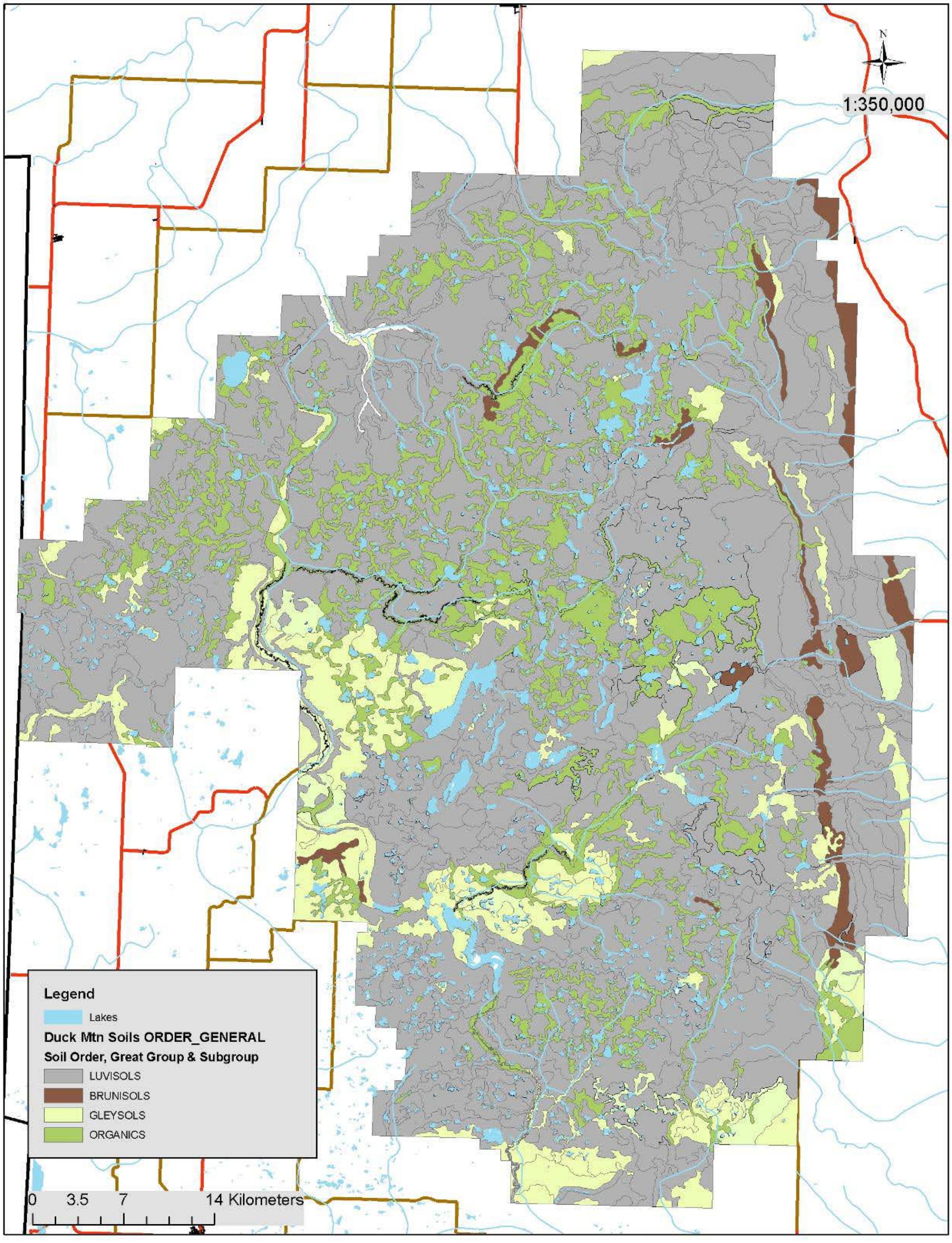

Figure 3.12 Soil orders in the Duck Mountain.

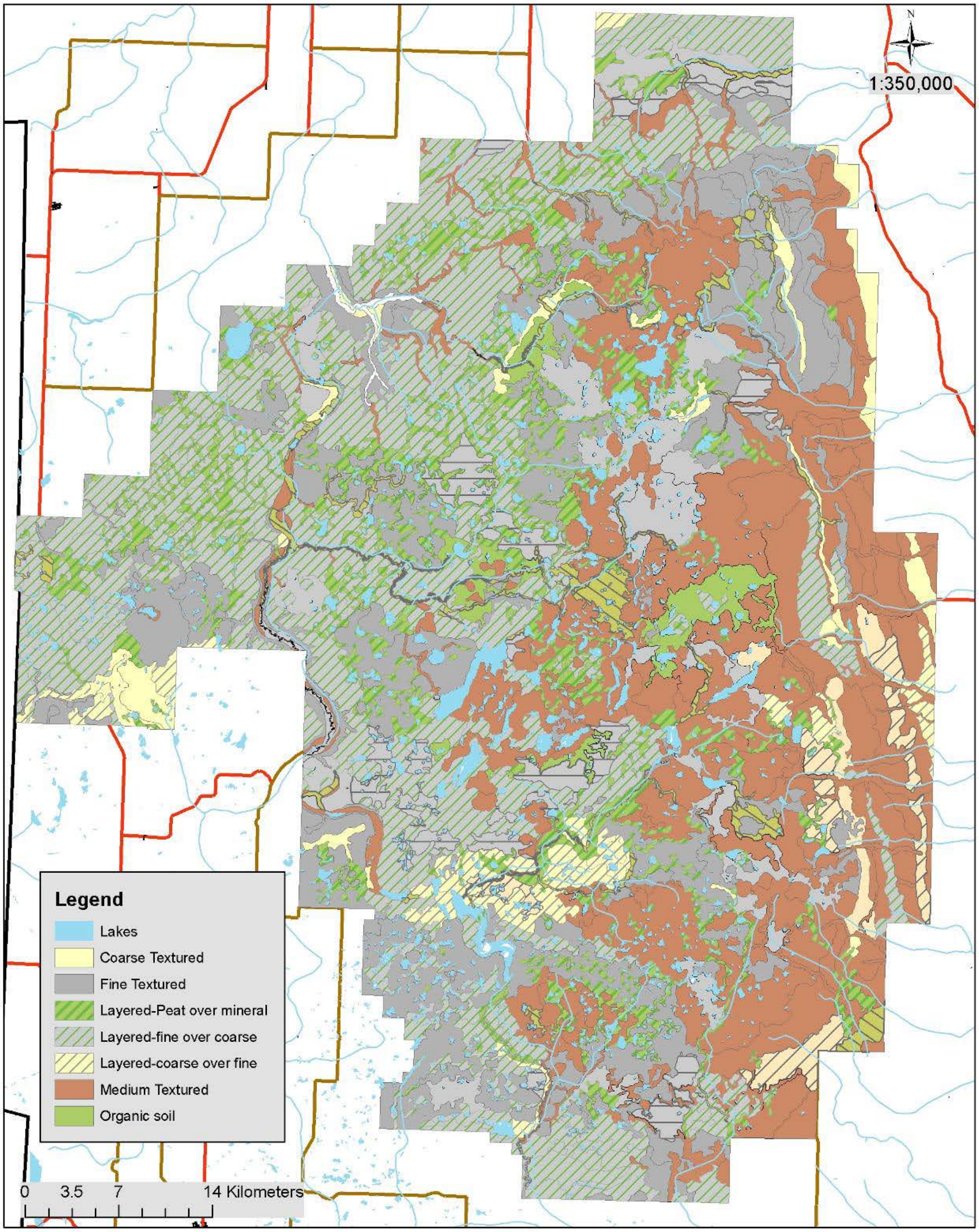

Figure 3.13 Soil texture classes in the Duck Mountain.

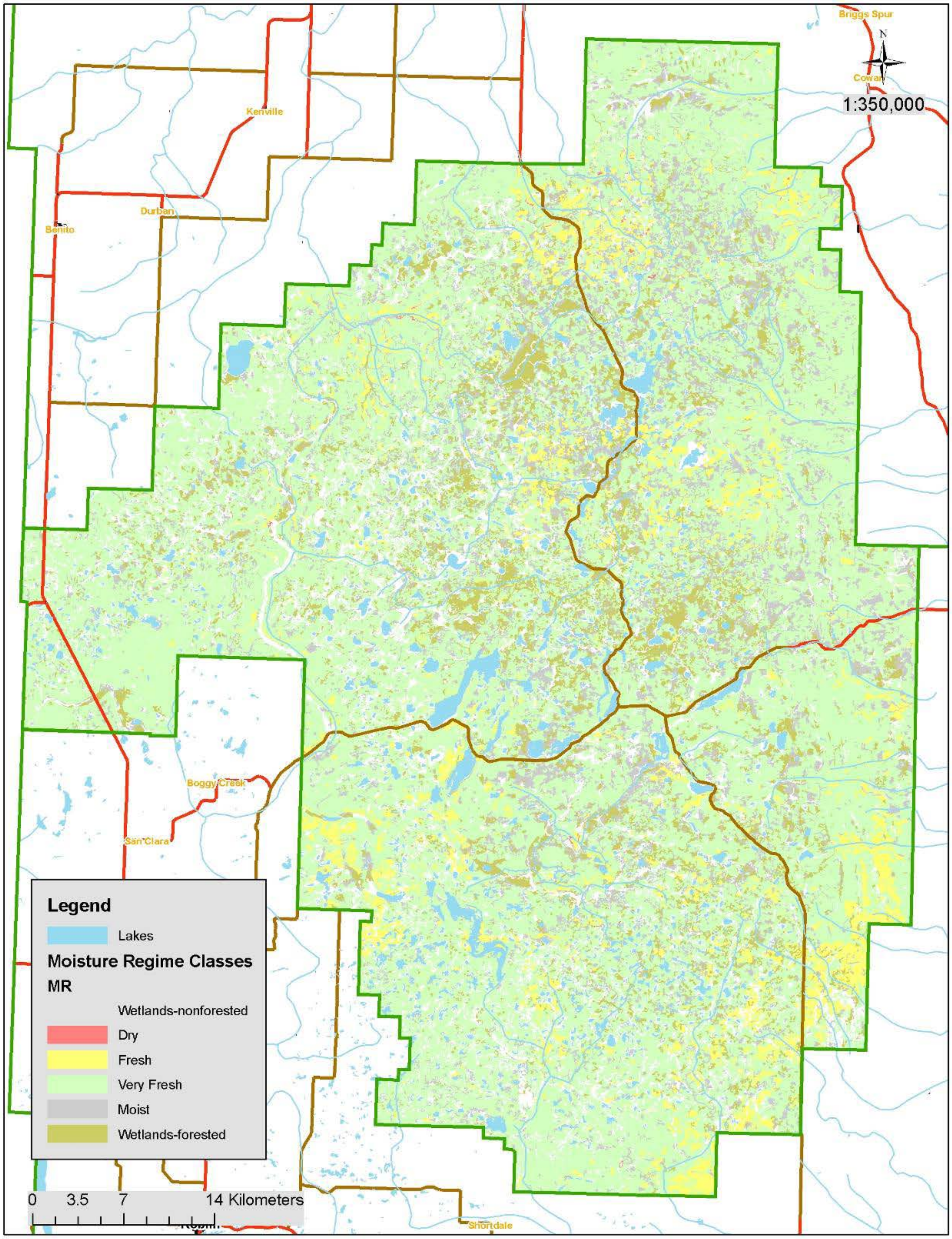

Figure 3.14 Soil moisture regime classes in the Duck Mountain.

3.1.4.2 Soil Conservation

Soil stability is typically a reference of the potential for soil to erode by either wind or water. Stability is influenced by soil type, slope, aspect, amount of rainfall, season, runoff, and ground cover. Conserving soil in the forest is achieved by minimizing erosion through reducing disturbance to the vegetation and litter or duff layer, and maintaining the soil profile. Wind and water are the main eroding forces that need to be considered when implementing forest operations with respect to conserving soils.

Wind erosion potential

There is a negligible potential for wind erosion in the Duck Mountain, because forest vegetation (*i.e*. trees, shrubs, forbs, mosses, and their roots) prevents the soil from being exposed to the wind. Cultivated farm land has a much higher wind erosion potential. Harvest blocks are not left bare of vegetation, they retain shrubs, forbs, and mosses in addition to the regenerating the trees. This prevents any long-term potential for wind erosion.

Manitoba Land Resource Unit produced a map (scale 1:1,000,000) that indicates that there is negligible potential for wind erosion in the Duck Mountain. To ensure that the risk of wind erosion remains low, the following Best Management Practices are implemented on the forest:

- Retain surface organic matter and vegetation (Arnup, 2000);
- Promptly regenerate trees; and,
- Decommission in-block roads by ‘rolling back’ the organic matter, tree stumps, and slash.

Water erosion potential

The risk of water erosion is a consideration for management of areas where topography is complex, slopes are steep, and soils are silty to sandy. Areas of high water erosion risk are associated with steep slopes, including V-shaped valleys and gullies on the edges of the uplands. These higher risk areas will require very special care and attention if harvested.

Water erosion risk on roads and water crossings is minimized in the forest by re-establishing a vegetative cover of grass, willows, shrubs, or trees. In addition, non-vegetative Best Management Practices of preventing erosion on roads and water crossings include:

- 'Armouring' water crossings with rip rap (stones);
- Use of a silt fence;
- Runoff ditches to divert water off slopes and into standing timber;
- Use of ‘pipe bundles’ to protect the stream bed when crossing a stream to install a bridge;
- Use of erosion control blankets and straw / gently sloping cut banks; and
- Installing of wing walls on portable bridges for fill containment.

Best Management Practices are followed to reduce water erosion risk on cutovers, including:

- Avoiding long steep slopes, greater than 40%;
- Harvesting on moist or wet soils in the winter only (frozen ground);
- Shutting down summer and fall operations after a heavy rainfall, reducing rutting and compaction;
- Skidding trees downhill or going around small hills to prevent soil exposure on a slope (Sutherland, 2003; Sutherland, 2005);
- Skidding on many trails instead of concentrating skidder traffic on only one trail;
- Minimizing road development within a cutblock;
- Spreading slash and debris along roads;
- Maintaining tree and shrub vegetation along wetlands, water courses, and swales inside cutblocks; and,
- Training operators and contractors to be aware of and follow all the above Best Management Practices (Sutherland, 2005).

3.1.4.3 Carbon in the Soil

The current forest condition of carbon stocks for upland ecosystems was calculated by applying Johnston's (2005) upland carbon yield curves to the land base. It is estimated that there are approximately 52.5 million tonnes of upland carbon in the Duck Mountain Provincial Forest Table 3.7. There is a very significant amount of carbon in the upland soils (72%), compared to the amount of carbon in trees (28%).

Table 3.7 Upland and wetland carbon estimates for the Duck Mountain Provincial Forest.

Ecosystem Portion	Tonnes Carbon	Proportion of Total Carbon (%)
***UPLANDS** (80% of land base)		
Soil C	37,781,300	72%
Tree stem Biomass C	11,136,823	21%
Tree roots, stump, top, branches Biomass C	3,570,245	7%
Upland subtotal	**52,488,368**	**100%**
****WETLANDS** (20% of land base)		
Soil C	39,604,185	88%
Vegetation –above ground C	5,187,810	12%
Wetland subtotal	**44,791,995**	**100%**
TOTAL	**97,280,363**	

*314,093 ha within FMU 13 - utilizing the Forest Lands Inventory

**79,417 ha within FMU 13 -utilizing the Enhanced Wetland Classification by Ducks Unlimited

Carbon calculations for organic soils in wetlands were quantified from the carbon in wetlands project. Although there is less wetlands area in FML #3 that uplands, wetlands account for approximately 70% of the carbon in the Duck Mountain (Figure 3.15).

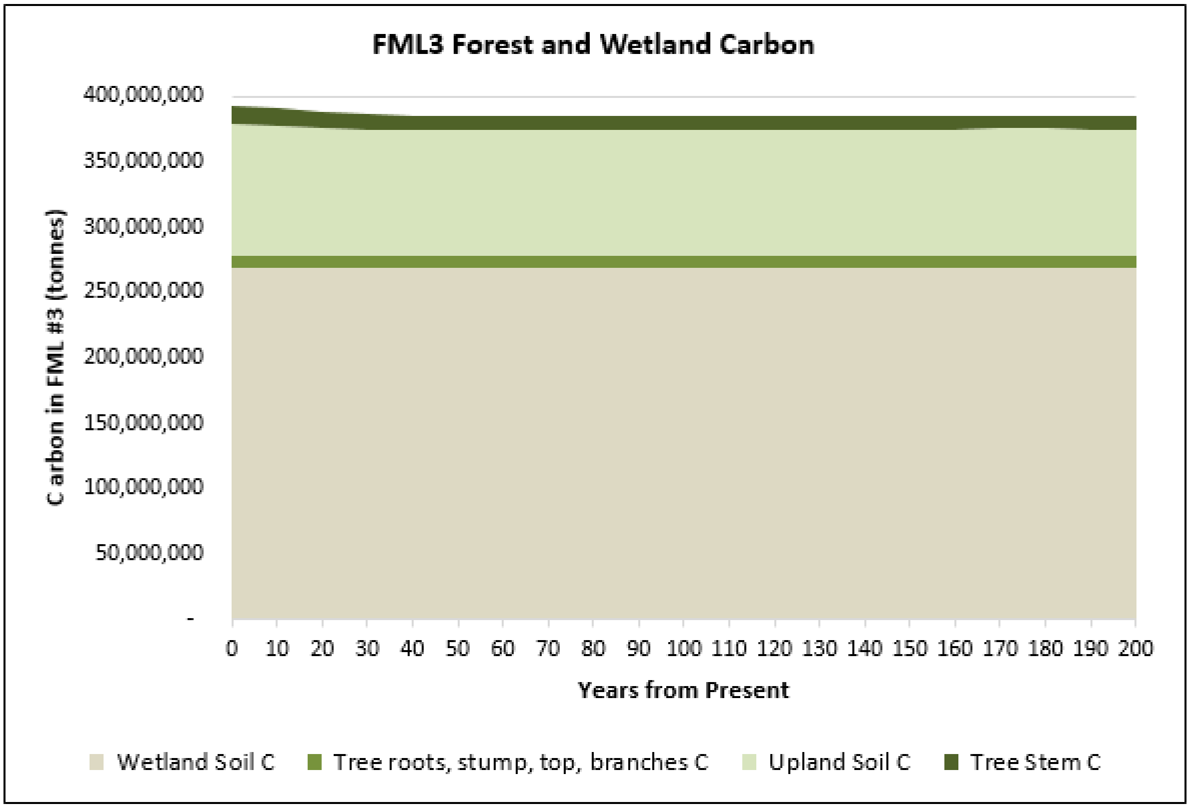

Figure 3.15 Combined upland and wetland carbon stocks in FML #3.

The majority of wetland carbon is in the peat (organic soil). Average peat depths by major wetland type were 2.5 m, 2.4 m, and 0.9 m for bogs, fens, and swamps, respectively. Note that grasslands, shallow open water, and agricultural land were not sampled, nor estimated for carbon content. A carbon density map for FML 3# is shown in Figure 3.16.

It is relevant to note that when softwood and hardwood harvesting occurs, only the stem biomass portion of upland forest is removed from the site. Both softwood lumber and hardwood siding are used to build homes. The average carbon sequestration period for these homes is 100 years. Overall, forest harvesting for durable wood products such as construction materials, removes or sequesters atmospheric carbon because the subsequent regenerating forest will absorb large amounts of carbon.

Living forests and their soils contain a significant portion of the earth's carbon reservoir (Moore 1977). Watson *et al.* (1990) estimate that forest biomass contains about two-thirds as much carbon as the atmosphere, and detritus and soil organic carbon pools contain about twice as much carbon as the atmosphere. Hence, forest management and harvesting activities must consider the effects on atmospheric carbon dioxide concentrations.

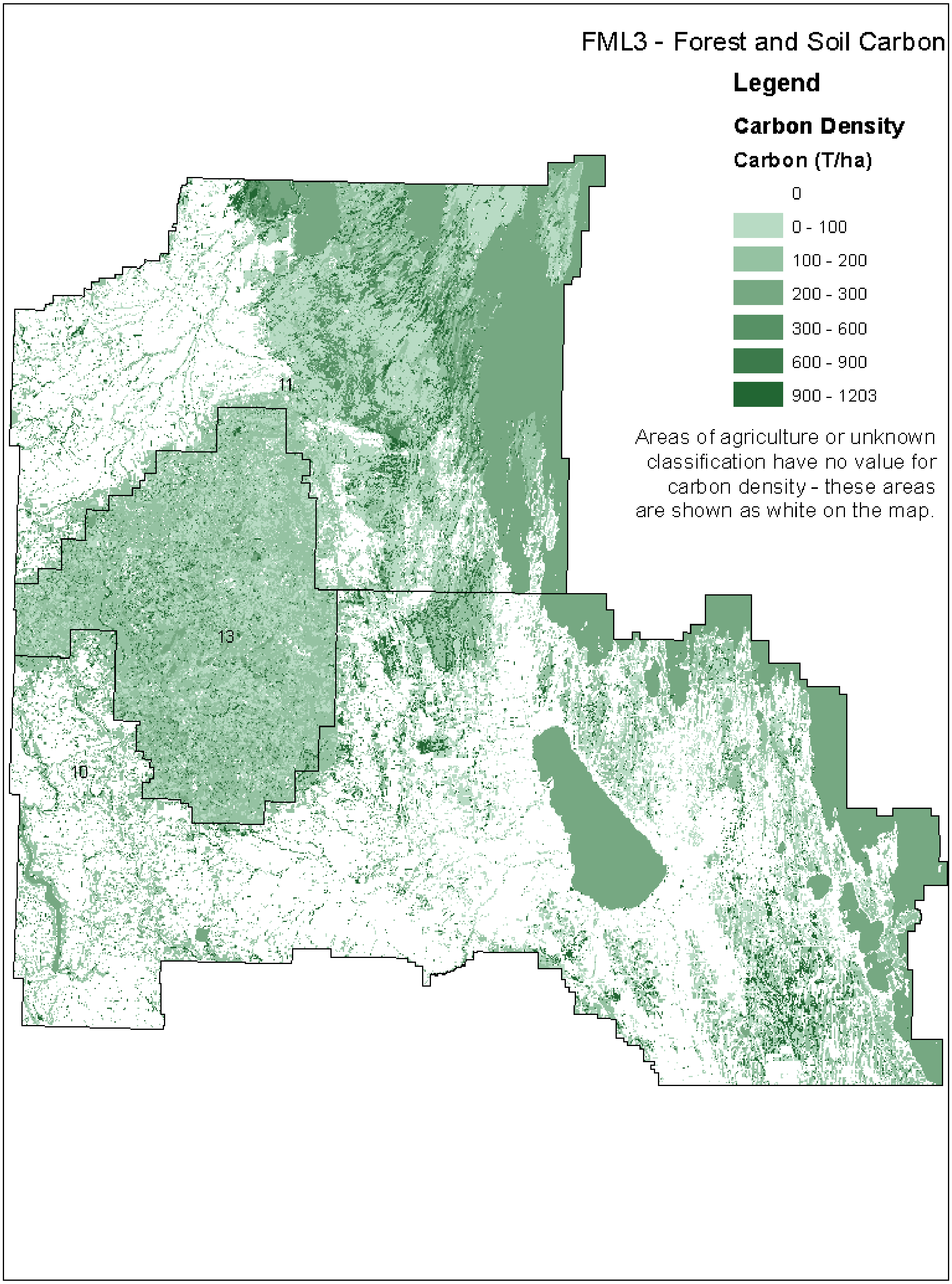

Figure 3.16 Carbon density map of upland and wetland ecosystems across FML #3.

Moore (1977) notes that the removal of old forests and their replacement with young, actively growing forests results in a net loss of atmospheric carbon. Most natural forests, he notes, are at or near their climax or equilibrium, that represents "a no-growth situation…its carbon uptake will be equalled by its carbon loss." Kurz *et al*. (1992), however, state that the old growth forest continues to transfer carbon to the soil through deposits of litter and coarse woody debris.

Moore (1977) concludes: "If one were to consider forest clearance purely from the point of view of global carbon balance…it represents the creation rather than the destruction of a carbon sink in that it revitalizes successional processes."

The Canadian Federal Standing Committee on Environment (SCE) (1990) noted that young forests absorb more atmospheric carbon than older, mature stands. Plantation forests in the southern US or Pacific Northwest absorb more than 5.4 tonnes of C/ha annually (Standing Committee on Environment 1990). Woodwell (1989) notes that a vigorous program of reforestation removes up to nine tonnes a hectare of atmospheric carbon annually.

Although the SCE noted the ecological significance of maintaining old growth forests, they recommended, as a strategy to combat global warming, the maximization of carbon absorption "through programs designed to develop and maintain vigorously growing forest stands. This can be done by ensuring prompt regeneration of harvested areas, either through planting or by natural means, and reducing the extensive losses of stands to wildfire, insects, and disease."

Activities associated with the forest sector, particularly for construction materials, like result in a net accumulation of carbon. This is particularly significant when compared to natural disturbances. A study by Kurz *et al.* (1992) shows that wildfire adds the most carbon to the atmosphere. Thus, suppressing fires, using mature and overmature trees for construction products and regenerating highly productive hardwood and mixedwood stands in FML #3 should result in a net accumulation of carbon from the atmosphere.