Ontario Snowmobile Tourism: Responses to Climate Variability and Change

by

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Author's Declaration

I hereby declare that I am the sole author of this thesis.

This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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Abstract

A suitable climate, varied scenic terrain, and proximity of communities along Ontario's system of 39,742 km of snowmobile trails have provided for domestic and international snowmobile tourism. Outdoor winter tourism in many parts of the world has been identified to be at risk to changes in global climate. The Intergovernmental Panel on Climate Change in its Fourth Assessment Report (AR4) reported a global increase of temperature of 0.74 degrees Celsius for the period 1906 to 2005 and estimates that by the end of the 21st century the global mean temperature will increase between 1.8 degrees Celsius to 4.0 degrees Celsius. Temperature increases of only a few degrees may contribute to variances in snow-based tourism reliant on the reliability of natural snow cover.

This study examines the spatial and temporal impacts of climate change scenarios upon snowmobile season length and operations within the snowmobile industry in the Province of Ontario Canada to six climate change scenarios for the 21st century. Snowmobile trail operations in Ontario are reliant upon a minimum natural snow cover of 15 cm for smooth terrain trails and 30 cm to 60 cm for rough terrain trails, temperatures less than 0 degrees Celsius and, human and financial capital. Three or more consecutive snowmobile seasons with $\leq$ 28 days have been identified as having serious implications for human and financial capital necessary to develop and maintain the snowmobile trail system. As early as the 2020s, north eastern snowmobile districts are projected to be least vulnerable to changes in climate with the longest snowmobile seasons > 28 days, while south central snowmobile districts are projected to be the most vulnerable to changes in climate with the shortest snowmobile seasons of < 28 days. Snowmobile trail managers identified possible strategies to adapt to a changing climate (2020s to 2080s) including: pre-season preparation of the terrain including early season packing of snow cover, re-location of the most vulnerable snowmobile trails, and strengthening inter-district alliances.

Acknowledgements

Firstly, I wish to thank my supervisor, Dr. Daniel Scott (Canada Research Chair in Climate Change and Tourism) for his guidance and support through this process. I wish also to thank my committee Dr. Barbara Carmichael (Wilfrid Laurier University) and Dr. Judith Cukier (University of Waterloo) for their valuable comments.

Secondly, I wish to thank the research participants who generously offered their expertise and insights into snowmobile tourism in Ontario.

Dedication

This thesis is dedicated to the volunteer members of snowmobile clubs in the Province of Ontario, without their generous offering of their time and expertise; snowmobile tourism would not be possible.

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Acronyms

AGCI	Aspen Global Change Institute
CCCSN	Canadian Climate Change Scenarios Network
CCME	Canadian Council of Ministers of the Environment
CCSO/CCOM	Canadian Council of Snowmobile Organizations
CTC	Canadian Tourism Commission
GCM	Global Climate Model
GDP	Gross Domestic Product
GHG	Greenhouse Gas
HFWR	Haliburton Forest & Wildlife Reserve
IASA	International Association of Snowmobile Administrators
INM	Institute of Numerical Mathematics
IPCC	Intergovernmental Panel on Climate Change
LARS-WG	Long Ashton Research Station – Weather Generator
MIROC	Model for Interdisciplinary Research on Climate
MNR	Ministry of Natural Resources
MPPACC	Model of Private Proactive Adaptation to Climate Change
MSC	Meteorological Service of Canada
OFATV	Ontario Federation of All Terrain Vehicles
OFSC	Ontario Federation of Snowmobile Clubs
OMT	Ontario Ministry of Tourism
PKFC	Pannell Kerr Forster Consulting
S.T.O.P.	Snowmobile Trail Officer Patrol
SWOT	Strengths Weaknesses Opportunities Threats
TGCIA	Task Group on Scenarios for Climate Impact Assessment
TOP	Trans Ontario Provincial
UNWTO	United Nations World Tourism Organization

Chapter 1

Introduction

Snowmobiling in the Province of Ontario, as a winter outdoor adventure activity, generally occurs from December to March. Annual economic benefits of snowmobiling in Ontario are estimated at CAN $1.2 billion and generate CAN $112 million in provincial tax revenue (OFSC, 2008a). A suitable climate including adequate snow cover, freezing temperatures, varied scenic terrain, and proximity of communities along Ontario's system of snowmobile trails provide for domestic and international snowmobile tourism. However, changes in climate from both natural and anthropogenic causes are influencing the spatial and temporal distribution of the Ontario snow-pack and consequently snowmobiling (McBoyle, Scott, & Jones, 2007; Scott, Jones, Lemieux, McBoyle, Mills, Svenson, & Wall, 2002).

The Ontario Federation of Snowmobile Clubs (OFSC) consists of 234 volunteer member snowmobile clubs in 17 snowmobile districts, and manages the delivery of the snowmobile trail product upon which snowmobile tourism is predicated. These volunteers are unique, in that not only do they provide for the supply of the snowmobile trail product, but many are also active snowmobile participants. Prior to 1992 snowmobile clubs primarily developed local systems of snowmobile trails for the enjoyment of club members. Since 1992 the focus has been on snowmobile tourism trails with the development of Trans-Ontario-Provincial (TOP) snowmobile trails by the OFSC. These TOP trails link many snow-belt communities, border crossings and tourism regions and local and regional snowmobile trails. Climate variability and change are just one of many challenges, presently and in the future, facing Ontario snowmobile tourism; others include access to private and public lands, costs of participation (e.g. rising costs of fuel and snowmobile insurance), volunteer attraction and retention, environmental stewardship, and risk management.

The Intergovernmental Panel on Climate Change (IPCC) (IPCC, 2007a) reports a global increase in temperature of 0.74^0C for the period 1906 to 2005. The trend in Canada for the period 1948 (since nationwide records were kept) to 2007 was an increase in temperature of 1.4^0C (Statistics Canada, 2008). During the 1972 to 2003 period the extent of snow cover in the Northern Hemisphere has declined by 10% and in the Arctic region the duration of snow cover has declined by 20 days since the 1950s (Brown, 2000). Temperatures that remain above 0^0C during the Ontario snowmobile season limit snowfall and depth of ground frost that may result in shorter snowmobile season lengths. The reliability of snowfalls has also been an important concern for snowmobile participants during the holiday periods of Christmas/New Years and March school break.

1.1 Goals and Objectives

Climate change is a long-term phenomenon that may provide challenges and relative advantages for snowmobile tourism in Ontario. Recent studies conducted pertaining to snowmobile tourism in the Province of Ontario include (McBoyle et al., 2007; Scott et al., 2002). Each study explored the potential loss of snow cover and reduced snowmobile season lengths, related to projected changes in climate. Scott et al. (2002) considered seven sites within the Lakelands Tourism Region and McBoyle et al. (2007) four sites within Ontario and 2 sites in Saskatchewan and Manitoba, 3 sites in Quebec, and 1 site in Nova Scotia and Newfoundland. This study enhances the previous two studies by: (1) using climate thresholds for snowmobile trail operations identified by senior Ontario snowmobile trail managers/operators to model snowmobile seasons, (2) examining all seventeen of the OFSC snowmobile districts to identify where spatial and when temporal changes of the Ontario snow-pack may occur and how the snowmobile industry may evolve, and (3) identifying the potential response options of snowmobile trail managers/operators to projected changes in the length of the snowmobile season.

The goal of this study is to explore the potential vulnerability of snowmobile tourism in each of the 17 OFSC snowmobile districts to changes in climate. To achieve this goal, three objectives have guided the research:

(1) to discover the sensitivity of snowmobile trail operations and adaptations to past climate variability,

(2) using a modelling approach examine the influence of climate change upon snowmobile season length in each OFSC snowmobile district during the future periods 2010 to 2039, 2040 to 2069, and 2070 to 2099, and

(3) to discover the possible adaptations that senior Ontario snowmobile trail managers/operators may consider in the future to climate change.

1.2 Structure of Thesis

This introduction chapter is the first of six chapters. Chapter two establishes the context of this study reviewing the literature pertaining to tourism, climate change and human responses to risks of climate change. Chapter three describes a three-phased, mixed-methods approach for data collection for this study. Chapter four presents the analysis of the collected data for each of the methods (qualitative and quantitative). Data from interviews is presented along with the results from climate change scenarios. Chapter five presents a discussion of the results and implications for snowmobile tourism. Finally, Chapter six provides conclusions and recommendations.

Chapter 2

Review of the Literature

2.1 Introduction

The review of the literature considers three topics that have informed the study. The first topic situates the study within tourism, nature-based tourism, and snowmobile tourism. The second topic, climate change is considered in a tourism context. The final topic, human responses to climate change explores factors influencing human actions to changes in climate.

2.2 Tourism

Worldwide, international tourism was estimated in 2007 to account for 903 million arrivals (+6.6% from 2006) and US $856 billion (CAN $920 billion) (+5.6% from 2006) in receipts (UNWTO, 2008). An estimated 51% of these arrivals were for the purpose of leisure recreation and holidays, 15% for business travel, 27% for other purposes (e.g. visiting friends and relatives, religious reasons/pilgrimages, health treatment, etc.) and 7% were unspecified (UNWTO, 2008). Canada is a popular tourist destination ranking 12th overall with 17.9 million international tourist arrivals and ranks 13th overall with US $15.5 billion (CAN $16.6 billion) in international receipts (UNWTO, 2008).

Tourism in 2007 was important to the Canadian economy, reaching CAN $28.6 billion in Gross Domestic Product (GDP) (+5.9% from 2006) or ~2% of total GDP and creating 653,400 full and part time jobs (+2.8% from 2006) (CTC, 2008). Total tourism receipts amounted to CAN $70.8 billion (+6.1% from 2006 Canada's international travel deficit was estimated at CAN $10 billion. The deficit has increased in all years since 2002, from a low of CAN $1.7 billion (CTC, 2008).

Ontario received approximately 8.6 million (42%) of international arrivals to Canada (-3.6% from 2006) (CTC, 2008). Tourism receipts in Ontario were CAN $22.1 billion generating $2.6 billion in provincial tax revenues and providing 200,900 full and part-time jobs (OMT, 2007). The outlook for international arrivals to Ontario in 2012 is projected with 15.7 million and 101.8 million domestic arrivals (OMT, 2008). Ontario's Resource-based Tourism Region is comprised of the following Canada Census Divisions/OFSC Districts: Victoria (District 2), Peterborough (District 3), Northumberland (District 3), Halliburton (District 6), Muskoka (District 7), Parry Sound (District 10), Nipissing (District 11), Manitoulin (District 12), Sudbury (District 12), Sudbury Region (District 12), Algoma (District 13), Timiskaming (District 14), Cochrane (District 15), Thunder Bay (District 16), Rainy River (District 17), and Kenora (District 17) (Research Resolutions Consulting, 2003a). In 2001 this region attracted 5.9 million visitors engaging in activities including: alpine and Nordic skiing, boating, camping, fishing, hunting, snowmobiling, and wildlife viewing predominately on Crown lands (Research Resolutions Consulting, 2003a). Spending within this region CAN $1.1 billion, contributed to CAN $143 million in provincial tax revenues, CAN $629.2 million in GDP, and 24,923 full and part-time jobs (Research Resolutions Consulting, 2003a).

2.2.1 Nature-Based Tourism

The natural environment has long been a strong attraction for tourism activities and is the primary attraction for Canadian and American visitors to the Province of Ontario (OMT, 2006). Nature-based tourism has been segmented into four niche markets based upon travel motivations and includes: (1) ecotourism, (2) wilderness travel, (3) adventure travel, and (4) car camping (Eagles, 2003). Ecotourism involves travel in natural environments for the purpose of discovery and education. Wilderness travel involves primitive forms of travel through natural environments where human disturbance has been minimal (Eagles, 2003). Adventure travel has become popular for tourists desiring to explore personal challenges in the natural environment. Sung, Morrison, and O'Leary (1996, p. 66) offer a definition; "a trip or travel with the specific purpose of activity participation to explore new experiences, often involving personal risk or controlled danger associated with personal challenges, in a natural or exotic outdoor location." The balance between perceived risk and perceived competence is essential for an optimal adventure experience (Cater, 2006; Morgan, Moore, & Mansell, 2005; Sung, et al., 1996). Fear due to its level of uncertainty, has also been considered a strong attractor in adventure tourism (Cater, 2006).

Environment Canada (1999) released the report, *The Importance of Nature to Canadians*, revealing that 10.3 million Canadians participated 166 million days and 3.9 million Ontarians participated 58.5 million days in outdoor activities in natural areas during 1996 (Table 2.1). Nature-related expenditures were estimated by Canadians at $7,246.7 million and by Ontarians $2,851 million (Environment Canada, 2000). For Canadians, relaxing in an outdoor setting (32.4%), sightseeing in a natural area (31.1%), and picnicking (26.0%) were the top three activities. Ontarians enjoyed relaxing in an outdoor setting (32.7%) sightseeing in a natural area (29.6%), and a swimming/beach activity (26.1%) (Environment Canada, 2000). Snowmobiling accounted for 2.5% of Canadian participants and 2.4% of Ontario participants in 1996. Southwick Associates (2006) estimated that in the United States 15.6 million participants in snow-based activities (excluding snowmobiling) contributed US $66.3 billion to the economy and generated US $8.8 billion in federal and state taxes.

Table 2.1: Importance of Nature to Canadians

Region	Total Participation of Outdoor Activities in Natural Areas (millions) (EC, 1999)	Total Days (millions) (EC, 1999)	Total Trips (millions) (EC, 1999)	Total Expenditures ($ millions) (EC, 2000)
Canada	10.300	166.000	137.100	7,246.70
Ontario	3.878	58.525	46.910	2,851.00

Source: Environment Canada (1999), (2000)

2.2.2 Snowmobile Tourism

An estimated 3.1 million Canadian adults in 2000 were considered to be winter outdoor activity participants (Research Resolutions, 2003b). Day use snowmobiling on organized snowmobile trails represented 32% of participants and overnight touring 13% of participants (Research Resolutions, 2003b). Demographically males accounted for 56% and females 44% and 66% of participants were between 18-44 years of age. An average income of CAN $55,800 was reported with 70% having some post secondary or completed secondary education levels (Research Resolutions, 2003b).

In Canada in 2009 743 non-profit volunteer snowmobile clubs operated 127,662 km of recreational snowmobile trails (Table 2.2) (Canadian Council of Snowmobile Organizations (CCSO/CCOM), 2009a). Overnight snowmobile tourism in Canada generally occurs from December to March and was estimated in 1999 at 845,000 domestic, 75,000 US, and 34,000 international participants, generating direct expenditures of $122 million and $256 million in total economic activity (Pannell Kerr Forster Consulting (PKFC), 2001). An overnight snowmobile tourist is “any person-trip taken to or within Canada, either inter-provincially or intra-provincially, with at least one overnight stay and where either snowmobiling is the main purpose of the trip or one of a number of activities participated in during the trip" (PKFC, 2001, p. 28).

Table 2.2: Snowmobiling in Canada 2009

Province / Territory	Snowmobile Clubs	Kilometres of Trails
Newfoundland	17	4,000
Prince Edward Island	3	1,100
Nova Scotia	20	3,500
New Brunswick	51	7,100
Quebec	208	32,720
Ontario	234	39,742
Manitoba	48	12,000
Saskatchewan	67	10,000
Alberta	32	5,000
British Columbia	60	12,000
Yukon	3	500
Nunavut	N/A	N/A
Totals	**743**	**127,662**

Source: CCSO/CCOM (2009a)

PKFC (2001) determined that snowmobile tour operators providing all-inclusive snowmobile tours, including an experienced guide, snowmobile, insurance, clothing, accommodations, and meals in Canada for both the experienced (60%) and novice (40%) participants, averaged 210 clients per operator per season, and ranged from 4.5 to 5.5 days. PKFC (2001) estimated the all-inclusive snowmobile tour market to be made up of international participants (47%), US participants (38%) and, Canadian participants (15%).

Approximately 48% of all snowmobile trails in Canada in 1999 were classified as primary, meaning that trails are a minimum of 12 feet wide, groomed at least 2 times per week, fully signed and 52% as secondary, meaning trails not meeting the criteria of the primary trails (PKFC, 2001). Sixty percent of snowmobile trails in Ontario are used for tourism purposes, while local use is 40% (PKFC, 2001).

PKFC (2001) identified thirteen essential criteria necessary for snowmobiling to be tourism export ready (Table 2.3). The trail product and trail amenities categories are the responsibility of each provincial/territorial snowmobile association and the destination product/experience readiness the responsibility of the tourism/hospitality sector. Snowmobile trails that are well groomed and maintained, interconnected with varying loop distances, with high levels of safety and informational signage, established for longevity, and a level of standardization enhance the overall tourism experience.

Table 2.3: Snowmobiling Tourism Export Ready Requirements

Trail Product
1. Well groomed trails
2. Signage regarding safety, routing, and location of service
3. Interconnectivity
4. Permanence
5. Standardization of tourism trails
Trail Amenities
6. Staging areas
7. Warm up safety shelters
8. Snowmobile patrol safety/ rescue systems
Destination Product/Experience Readiness
9. Tourism & hospitality services
10. Proximity and access to markets
11. All inclusive snowmobile services
12. Safety procedures/training
13."Snowmoble friendly" community attitude

Source: PKFC (2001)

The grooming of snowmobile trails is essential in providing a trail surface that any level of snowmobiler can ride comfortably and safely. Grooming is conducted in four stages (International Association of Snowmobile Administrators (IASA), 2005):

(1) the removal of moguls formed in the trail surface perpendicular to snowmobile traffic and natural processes (e.g. warm ground and creeks beneath the snow surface and the effects of sun and shade),

(2) processing of the snow; mixing, de-aerating, and the introduction of moisture,

(3) compaction of the snow further de-aerating and increasing snow density, and

(4) trail set-up; the undisturbed time required for the trail to re-freeze establishing a durable surface.

In the construction of snow roads and runways a robust surface can be achieved with processing techniques that create small snow grains with varying diameters (Lang, Blaisdell, D'Urso, Reinemer, & Lesher, 1997). Surfaces that would support land vehicles and aircraft with tire pressures of 1380 kPa would be ideal. Lang et al. (1997) concluded that ambient air temperatures and temperature gradients within the snow-pack had the greatest influence upon the daily strength of the processed surface. Increases in ambient air temperatures decreased temperature gradients within the snow-pack and subsequently increased the strength. Conversely as ambient temperatures decreased strength decreased. Snowmobile trails are prepared similarly, to withstand deterioration by snowmobile traffic.

An analysis of the Strengths, Weaknesses, Opportunities, and Threats (SWOT) of the delivery of snowmobile tourism in Canada; based upon the expectations/needs of the tourist market, was conducted by PKFC (2001). Strengths were considered to be internal advantages (organizational and available physical resources), weaknesses were identified in all three categories of export - readiness, opportunities were considered to be external indicators of potential growth, and threats were considered external challenges. The study overlooked the influence of climate variability and change upon snowmobile tourism in Canada.

Strengths (as identified by PKFC, 2001)

Throughout Canada strengths included: (1) a strong national organization (CCSO/CCOM) establishing a working relationship between provinces and territories, (2) a strong volunteer commitment for the snowmobile product delivery, (3) an effective user pay system able to generate much of the needed operational revenues, (4) available open spaces, and (5) an overall longer snowmobile season compared to that of the United States.

In Ontario the strengths include: (1) a committed volunteer force with extensive snowmobile trail operations and management experience, (2) a well established user pay system, (3) an extensive, interconnected and well developed snowmobile trail system, (4) a high level of snowmobile advocacy, (5) quality and quantity of snow, (6) scenic wilderness, and (7) friendliness of hospitality.

Weaknesses (as identified by PKFC, 2001)

Nationally, snowmobile organizations are reliant upon user pay fees and fundraising as the reinvestment of revenues generated by snowmobiling has been minimal. The generation of additional revenues diverts the volunteers from their primary objective of trail development and maintenance. The burnout of volunteers due to excessive workloads is a concern of the snowmobile organizations.

The user-pay system in Ontario alone does not provide adequate financial resources for trail development and maintenance. Ontario's dependence of volunteers in some areas for snowmobile trail operations has resulted in trail product inconsistencies. The remoteness of some of Ontario's snowmobile trails may limit the tourism potential for the majority of snowmobilers. In some areas there is a lack of quality accommodations that are snowmobile trail accessible.

Opportunities (as identified by PKFC, 2001)

The declining snowmobile tourism opportunities in the United States, limiting or restricting of motorized recreational vehicles into backcountry or wilderness areas due to capacity issues and strong environmental advocacy provides Canada with a competitive advantage for the development of a snowmobile trail system with sound environmental concerns.

Additionally opportunities are emerging for snowmobile tourism as Canada's profile internationally as a winter tourism destination increases.

Opportunities in Ontario include: (1) a sharing of infrastructure costs with other trail user groups lessening the burden of trail development and maintenance by snowmobile clubs/associations, and (2) an increased interest in adventure-based tourism by international visitors and the proximity of a large US snowmobile market are opportunities for expansion of snowmobile tourism.

Threats (as identified by PKFC, 2001)

Increasing demand for the use of recreational vehicles, including snowmobiles, all-terrain vehicles and personal watercraft has escalated real or perceived environmental threats, which consequently may lead to policies and legislation restricting their use, and declining snowmobile tourism. The annual availability and affordability of insurance for both the snowmobiler and the commercial tour operators is a concern. Overall consumer confidence, influenced by economic factors, costs of travel and terrorism were identified as other pertinent threats.

Increasing administrative workloads in addition to snowmobile trail operations in Ontario are contributing to volunteer burnout. The competition for trail use by other user groups, particularly all-terrain vehicles, may result in the loss of trail routes on private lands due to trail damage. The increasing cost of participation, including insurance, equipment/clothing, snowmobile trail permit fees, fuel costs, food, and accommodations are of particular concern for snowmobile tourism.

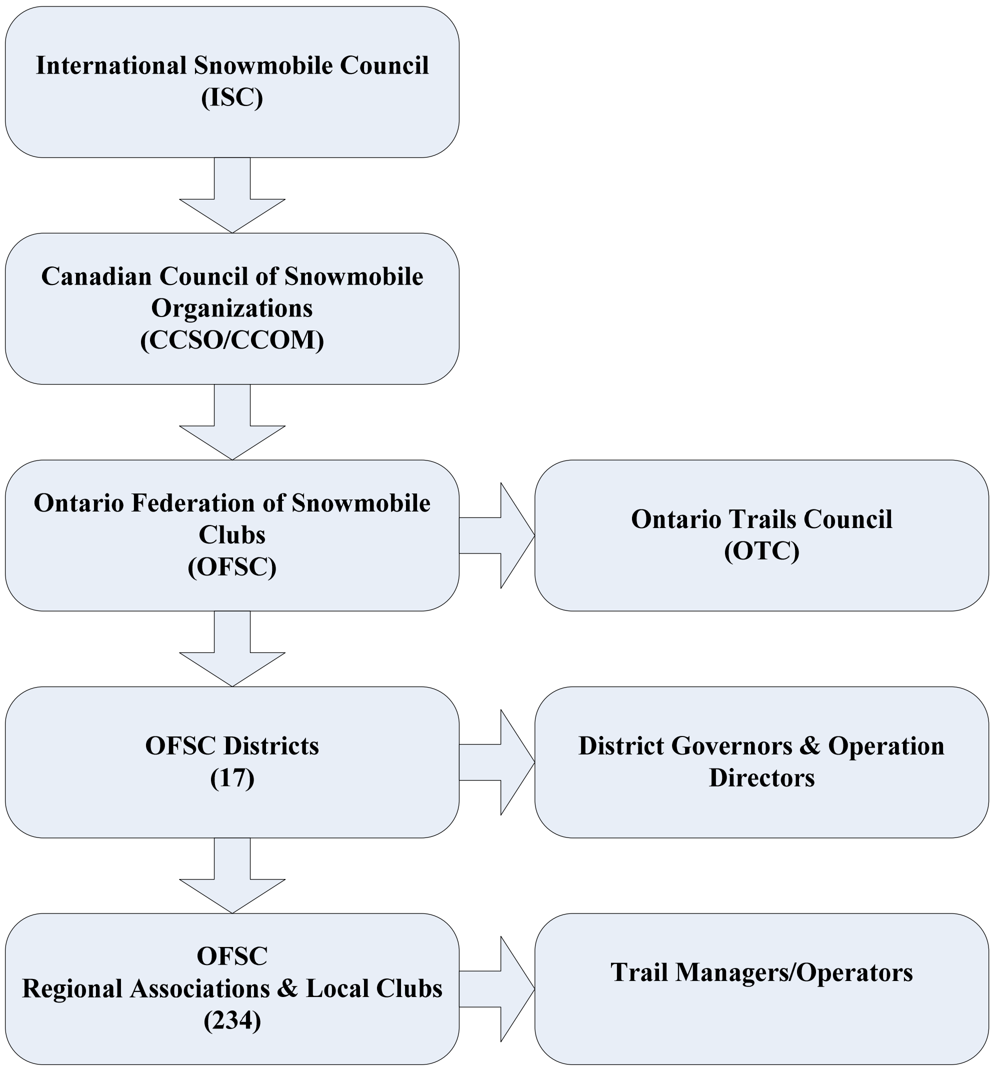
Snowmobile sales in Canada have declined from 602,697 units (mean annual 60,270 units) for the period 1990 to 1999 to 483,252 units (mean annual 48,325 units) for the period 2000 to 2009 (CCSO/CCOM, 2009b). The average cost of a snowmobile for the 1990 to 1999 period was US $4,925 and for the 2000 to 2009 period US $7,420 (CCSO/CCOM, 2009b). Total sales were US $2.9 billion for 1990 to 1999 period and US $3.6 billion for the 2000 to 2009 period (CCSO/CCOM, 2009b).

Internationally, snowmobile tourists to Ontario predominately originate in the United Kingdom, Germany and France. Ontario receives the greatest number of American snowmobile tourists from the border states of Michigan, Minnesota and New York. Direct expenditures for overnight trips of domestic, US, and international snowmobile tourists to Ontario in 1999 were estimated at CAN $32.1 million with 75% of expenditures for transportation, accommodation and food and beverage (PKFC, 2001). Total economic activity from snowmobiling in Ontario in 1999 was estimated at CAN $68.3 million, CAN $29.9 million in GDP, CAN $15.3 million in tax revenues, and 851 full-year employments (PKFC, 2001).

Member snowmobile clubs/associations of the OFSC operate 39,742 km of snowmobile trails in Ontario, nearly one third of the national total (OFSC, 2008a). The OFSC (2007) classifies trails as: (1) trunk trails; the primary routes for trans-provincial touring, (2) feeder trails; feeding traffic to and from trunk trails, (3) connector trails, connect two trunk trails, and (4) club trails; localized trails providing links to communities and tourism infrastructure. Ontario's 17,899 km (45%) of primary trails, Trans-Ontario-Provincial (TOP), includes trunk, feeder and connector trails (OFSC, 2008a).

The OFSC (2008b) is "dedicated to providing strong leadership and support to member clubs and volunteers, to establishing and maintaining quality snowmobile trails which are used in a safe and environmentally responsible manner, and to further the enjoyment of organized snowmobiling" The 234 local snowmobile clubs and regional associations form 17 Districts each electing a Governor and Operations Director (Figure 2.1). The Board of Governors undertakes strategic planning, oversees provincial operations, and approves an annual budget; while Operation's Directors manage trail related issues and District operational concerns.

Figure 2.1: OFSC Organizational Chart



During the 2007/2008 Ontario snowmobile season revenues from the sale of 90,085 seasonal and visitor snowmobile trail permits generated an estimated CAN $16.4 million (OFSC, 2008a). Seasonal trail permit fees were CAN $180 when purchased on or before December 1st and CAN $230 after December 1st. A 3-day visitor permit was CAN $90 and a 7-day visitor permit was CAN $120. The operating budget of the OFSC was CAN $9.1 million with CAN $3.3 million directed to the Trail Fund and CAN $80,605 directed to an Environment Fund. The balance of CAN $7.3 million remains with the local snowmobile clubs for trail operational expenses. Snowmobile clubs may make an application to the Trail Fund for assistance for equipment purchases and trail development projects. Approximately 75% of the Environment Funds are directed towards social marketing and 25% are directed towards grants to member snowmobile clubs to assist in local projects protecting environmental values like grass seeding, tree planting, and ice storm 1998 recovery. From 1992 to 2009 the Ontario Provincial Government has contributed an estimated CAN $35 million for snowmobile trail development projects (Respondent 1).

2.3 Climate Change

The IPCC (2007b) defines climate change as "a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use."

The earth's climate system is a dynamic system consisting of five elements: (1) the atmosphere, (2) the hydrosphere; oceans, lakes, rivers, and aquifers, (3) the cryosphere; sea ice, ice sheets, snow fields, permafrost and glaciers, (4) land surface and biosphere, and (5) the sun (IPCC, 2001a). Energy emitted from the sun in the form of short-wave radiation is the primary driving force of the system. A climate in equilibrium prevails when a balance occurs between incoming solar radiation and outgoing radiation from the climate system, therefore an average of $235 Wm^{-2}$ must be radiated back to space (IPCC, 2001a). Naturally occurring atmospheric greenhouse gases (GHG) including: water vapour (H_2O), carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and ozone (O_3) absorb infrared radiation emitted by the earth's surface and emit infrared radiation in all directions including downward trapping heat between the earth's surface and the atmosphere (IPCC, 2001a). The release of anthropogenic GHG, since the Industrial Revolution in the mid-18th century, largely through the burning of fossil fuels, deforestation and wetland drainage, has resulted in increased concentrations of atmospheric GHG, which have trapped more heat energy in the lower atmosphere altering precipitation and temperature patterns (IPCC, 2001a). Carbon dioxide (CO_2), for example, has increased from 280 ppm in the pre-industrial period to 379 ppm in 2005 (IPCC, 2007a).

An average global temperature increase of 4^0C to 6^0C has been the difference between glacial and interglacial conditions prevailing on the earth's surface over the last 2.5 million years (Lemmen, Warren, Lacroix, & Bush, 2008). The IPCC (2007a) has reported a global increase in temperature for the period 1906 to 2005 of 0.74^0C, and over the last 50 years a 0.65^0C (a rate of 0.13^0C per decade) increase was observed. In Canada, an average increase in temperature of 1.3^0C for the period 1948 to 2006, nearly twice the global average for the same time period, has been observed (Lemmen, et al., 2008). During 1948 to 2003, winter temperatures have increased > 3^0C in north western Canada (Lemmen, et al., 2008).

Ontario's annual average temperatures have increased from 0^0C to 1.4^0C between 1948 and 2006 with seasonal temperature increases having been greatest during the spring months (Lemmen, et al., 2008). Between 1950 and 2003 the greatest incidence of warm days and warm nights has been observed to occur in northern regions of Ontario (Lemmen, et al., 2008). In London, Ontario the frost free season has been observed to have increased > 18 days since the 1940s (Canadian Council of Ministers of the Environment (CCME), 2003). Warmer temperatures are benefitting the agricultural sector enabling a longer growing season and summer outdoor recreation activities. Shorter winter seasons are contributing to challenges for northern regions and forestry and transportation companies needing to move goods and products over frozen ground and waterways.

In the Northern Hemisphere snow cover has decreased by approximately 10% since 1966 (IPCC, 2001b). Total annual snowfalls in Canada during 1950 to 2003 have declined in southern regions and increased in northern and north eastern regions (Lemmen, et al., 2008). In Canada's Arctic the duration of snow cover has declined, on average, by approximately 20 days since 1950 (Lemmen, et al., 2008). Snowfalls in Ontario have increased in the fall in northern regions, declined in the winter and spring in central regions and in southern regions increased in the west and decreased in the east (Lemmen, et al., 2008). Days with freezing rain events between 1953 and 2001, on averaged, occurred between 2 and 10 times with Ottawa, North Bay, and Sudbury the highest annual averages and Thunder Bay, Kenora, and Sioux Lookout the lowest (Lemmen, et al., 2008).

The 1998 ice storm deposited up to 100 mm of freezing rain between January 6th and 10th upon central and eastern Canada affecting 5,404,285 people (Statistics Canada, 1998). The greatest damage in Ontario occurred along the St. Lawrence River between Kingston and Cornwall. Most economic sectors in rural communities were hardest hit including: agriculture, manufacturing, transportation and tourism, primarily as a result of the loss of electricity due to damaged transmission towers and utility poles. The damage and loss to forests was the primary issue for the temporary closure of snowmobile trails in areas affected by the ice storm. Snowmobile tourism was disrupted until the snowmobile trails were cleared of debris and re-opened. An ice storms impact on forests is dependent upon the ice load, storm duration, strong winds, and stand and individual tree characteristics (Van Dyke, 1999). The vulnerability of a tree species is dependent upon the crown surface area and the position within the canopy (Van Dyke, 1999).

Freeze-thaw events, when $T_{min} < 0^0C$ and $T_{max} > 0^0C$ occur in a single day, in Trenton Ontario has been observed to increase from 80 days in the 1940s to 95 days in the 1990s (CCME, 2003). These events contribute to water accumulating in low areas of snowmobile trails and in combination with rainfall may washout sections of snowmobile trails making them impassable. In icy conditions snowmobile trail maintenance is impaired particularly in hilly terrain, grooming equipment requires maintenance, and snowmobilers are more susceptible to personal injury and damage to equipment.

The annual duration of lake and river ice has declined by about two weeks in the mid and high latitudes (IPCC, 2001b). The trend in most Canadian regions during the period 1947 to 1966 was for lake and river ice to freeze-up and break-up earlier in the year (Zhang, Harvey, Hogg, & Yuzyk, 2001). Earlier freeze-ups were related to decreasing October, November, and December mean temperatures; while earlier break-ups were related to changes in spring temperatures. Lake Simcoe in the south central region of Ontario has been observed to freeze-up approximately 13 days later and break-up 4 days earlier than 140 years ago (CCME, 2003).

2.3.1 Climate Change in a Tourism Context

Changes in climate may have positive and negative effects on global tourism. A range of potential impacts and implications for the tourism sector are illustrated in Table 2.4. Most important to this study are the potential implications of changes to temperature and precipitation/snow cover that may affect recreational activities in the winter season.

Table 2.4: Major Climate Change Impacts and Implications for Tourism Destinations

Impact	Implications for Tourism
Warmer temperatures	Altered seasonality, heat stress for tourists, cooling costs, changes in plant-wildlife-insect populations and distribution, infectious disease ranges
Decreasing snow cover and shrinking glaciers	Lack of snow in winter sport destinations, increased snow-making costs, shorter winter sports seasons, aesthetics of landscape reduced
Increasing frequency and intensity of extreme storms	Risk for tourism facilities, increased insurance costs/loss of insurability, business interruption costs
Reduced precipitation and increased evaporation in some regions	Water shortages, competition over water between tourism and other sectors, desertification, increased wildfires threatening infrastructure and affecting demand
Increased frequency of heavy precipitation in some regions	Flooding damage to historic architectural and cultural assets, damage to tourism infrastructure, altered seasonality
Sea level rise	Coastal erosion, loss of beach area, higher costs to protect and maintain waterfronts
Sea surface temperatures rise	Increased coral bleaching and marine resource and aesthetics degradation in dive and snorkel destinations
Changes in terrestrial and marine biodiversity	Loss of natural attractions and species from destinations, higher risk of diseases in tropical-subtropical countries
More frequent and larger forest fires	Loss of natural attractions; increase of flooding risk; damage to tourism infrastructure
Soil changes (e.g., moisture levels, erosion and acidity)	Loss of archaeological assets and other natural resources, with impacts on destination attractions

Source: UNWTO-UNEP-WMO (2008)

The geography of tourism and climatology are considered as two branches of geography, having traditionally studied the relationships between climate and tourism (Gómez-Martin, 2005). The first branch considers the location of tourism centres, tourism experiences, and for planning purposes the tourism potential of atmospheric conditions in an area (Gómez-Martin, 2005). The second branch studies temporal and spatial variations of climate to assess environmental conditions for the planning of tourism areas (Gómez-Martin, 2005). Climate may be considered a resource or a risk when integrated with a good or service and is different from other natural resources in the following ways: (1) climate is a free resource, (2) climate cannot be transported or stored, (3) distribution varies in time and space, and (4) climate is considered a special natural resource in that it is renewable and non-degradable (Gómez-Martin, 2005).

Climate and weather affects tourism planning by: (1) the environmental context in which tourism may be undertaken, (2) influences seasonality of demand, (3) influences tourism activities, (4) climate as an attraction, (5) extreme climatic events are not compatible with tourism activities, (6) influences tourist complexes and infrastructure, (7) affects the orderly working of transportation networks, (8) tourist enjoyment, (9) tourist's perceptions of comfort and health, and (10) level of satisfaction of the holiday (Gómez-Martin, 2005).

de Freitas (2003) considers climate as a resource exploited by tourism, an economic asset for tourism. Participation in recreational activities may occur when climate is perceived to be suitable and conversely decreases as discomfort or dissatisfaction increases (de Freitas, 2003).

A classification of tourism climate is offered in which three facets: (1) thermal (e.g. temperature, humidity), (2) physical (e.g. precipitation, wind), and (3) aesthetic (e.g. sunshine, visibility) are related to human attitudinal and behavioural responses (de Freitas, 2003).

Climate is a dominate attribute affecting the perceived attractiveness of resource based tourism destinations. Wall and Badke (1994) in a survey of national meteorological and tourism agencies found that 81% of respondents considered weather and climate to be major determinants of tourism and recreation and > 75% considered that climate change may be a significant issue within their countries. Kozak (2002) examined the motivations of British and German tourists travelling for summer vacations in Mallorca and Turkey and found that to *enjoy good weather* was the most important factor for the choice of destinations.

Hu and Ritchie (1993) examined the relative importance of touristic attributes contributing to the attractiveness of international destinations in the context of recreational and educational vacation experiences. Climate was perceived to be of greater importance (rated higher and ranked higher) for those desiring a recreational vacation experience and less important for those desiring an educational vacation experience. Other attributes that influenced the relative attractiveness of a recreational vacation experience included: availability/quality of accommodations, sports and recreational opportunities, scenery, food, and entertainment.

An examination of the perceived preferable optimum climate variables (temperature, rain, sky conditions, and wind) was conducted in 2005/2006 of Canadian, New Zealand, and Swedish university students for three different environments (coastal beach, urban, and summer mountain) (Scott, Gössling, & de Freitas, 2008). The findings revealed that: (1) perceptions of optimal climate conditions varied in each of the tourism environments, (2) the relative importance of climatic variables varied in each of the tourism environments, and (3) preferences and the relative importance for climatic variables in each tourism environment varied amongst students from each country.

Agnew and Viner (2001) speculated on the potential consequences of climate change upon ten international tourist destinations reflecting variances in climate, environment and socio-economic conditions. Changes in climate may directly and indirectly affect tourism; directly during the decision-making process of when and where to travel due in part to weather and climate at the destination and the home location, and indirectly by affecting the local environmental conditions (e.g. snow cover, air quality, health threats) (Agnew & Viner, 2001). The vulnerability of resorts and regions were influenced by: (1) level and extent of the climate impact, (2) importance of tourism to the local economy, and (3) adaptive capacity (Agnew & Viner, 2001).

Climate is a primary influencing factor of the physical resources upon which nature-based tourism is dependent. Recent nature-based tourism studies in Canada’s National Parks have contributed to an understanding of projected climate change on ecosystems and visitor behaviour (Jones & Scott, 2006; Scott, Jones, & Konopek, 2007; Scott & Suffling, 2000). Canada's most popular parks are located in the western mountain regions. Projected warmer spring and fall temperatures may accelerate the rate of retreat of low elevation glaciers as a result of an increased melting season (Scott & Suffling, 2000). Changes in the extent of these glaciers may directly affect glacial-fed rivers and lakes and aquifers, vegetative colonization, and tourism operations dependent upon an accessible resource. Projected increases in temperatures, 1^0C to 6^0C may affect an upward shift of vegetative zones by 500m to 600m contributing to the loss of some alpine species due to competition of sub-alpine species (Scott & Suffling, 2000). The frequency of wildfires is projected to increase due to drier summer conditions affecting vegetative species distributions. During winter with projected increased snowfalls wildlife may migrate in search of accessible food. Alpine skiing may enjoy improved quality snow conditions at higher elevations; however increased temperatures may contribute to shorter season lengths and increased avalanche hazard (Scott & Suffling, 2000).

Scott, et al. (2007) examined the direct and indirect influences of climate change during three time periods (2020s, 2050s, 2080s) upon visitation in Waterton Lakes National Park. Increases in visitation related to direct affects of climate change were projected during all time periods; 6% to 10% (2020s), 10% to 36% (2050s), and 11% to 60% (2080s). Indirect affects of climate-induced environmental change revealed a nominal influence upon visitation; > 90% of respondents would not alter visitation plans during the 2020s and 2050s. In the 2080s, however; approximately 56% of respondents revealed that they would no longer visit the park or visit less frequently.

Jones and Scott (2006) considered changes of climate during the 2020s, 2050s, and 2080s and demographics during the 2020s upon the visitation levels of 15 high visitation Canadian National Parks. The study revealed increases in visitation levels due to climate change of 5.5% to 8.2% (2020s), 8.6% to 28.7% (2050s), and 10.2% to 41.0% (2080s). During the 2020s, demographic change accounted for an increase of 13.8% in visitation and the combined affect of climate change and demographic change revealed visitation increases of 19.9% to 22.9%.

2.3.2 Winter Tourism Seasonality

Seasonality has been considered a temporal imbalance in the demand for tourism that generally has negative implications for the tourist industry (e.g. access capital, employment, and return-on-investment) (Butler, 1994). Tourism in urban areas may be less affected by seasonality than rural areas as facilities and attractions (e.g. museums, theatre, and sport events) are protected from the weather and are also visited by residents and business persons in addition to tourists (Wall & Mathieson, 2006). Five causes of seasonality have been identified: (1) natural (variations in climate and true seasons), (2) institutional (religious and public holidays), (3) social (for the elite class it was necessary to participate in certain activities in certain locations), (4) sporting seasons (e.g. golf, ski, surfing), and (5) tradition (vacations at the same time each year) (Butler, 1994). Snowmobile tourism is most affected by natural, institutional, and sporting seasons.

Climate is considered as a *push* factor and *pull* factor, often the primary resource for some destinations on which tourism is based (Scott, McBoyle, & Swartzentruber, 2004). Weather and climate influence nature-based tourism worldwide, directly by limiting season lengths, the quality of the experience, and influencing participation and indirectly by affecting the dependent environmental resources (e.g. snow cover and ice thickness) (Scott, et al., 2004).

Seasonality induced by climate change, will have challenges for supply-side management including return – on – investment, employment, the ability to train and retain full-time employees, and pressures of overuse in the natural environment (Fernández-Morales, 2003).

Outdoor winter activities are sensitive to changes in climate, and in particular warmer temperatures (McBoyle, et al., 2007; Scott et al., 2008; Scott, Jones, & Khaled, 2005; Scott, et al., 2002). Assessments of winter tourism influenced by climate change have primarily focused on alpine skiing, projecting negative consequences including; reduced season lengths, upward elevation shifts of the snowline in mountain areas, and inter-annual variability in snowfalls [Australia (Bicknell & McManus, 2006; Hennessy et al., 2003); Austria (Abegg et al., 2007; Breiling & Charamza, 1999); Canada (Scott et al., 2002; 2003; 2006; 2007; Scott & McBoyle, 2007); France (Abegg et al., 2007); Germany (Abegg et al., 2007); Italy (Abegg et al., 2007); Japan (Fukushima, et al., 2002); Sweden (Moen & Fredman, 2007); Switzerland (Elsasser & Bürki, 2002; Elsasser & Messerli, 2001; Koenig & Abegg, 1997); United States (Casola et al., 2005; Dawson & Scott, 2007; Scott et al., 2008)].

The impacts on ski tourism in Switzerland of three consecutive snow-deficient seasons between 1987/1988 to 1989/1990 varied among regions, altitudes, and sectors (e.g. ski lift operations and accommodations) (Koenig & Abegg, 1997). Resorts with glaciers at altitudes > 3,000 masl benefited from decreased demand at lower altitude resorts, attributable to an earlier start to the ski season and consistent snow conditions during the season (Koenig & Abegg, 1997). Shorter winter season lengths in the Swiss Alps have been affected by an earlier spring melt rather than later first snowfalls (Laternser & Schneebeli, 2003). It was suggested that the snowline in mountainous regions will increase by approximately 150 m for every 1^{0}C increase in temperature (Beniston, 2003; Koenig & Abegg, 1997). The likelihood of sufficient snow cover at lower altitudes during critical holiday periods may diminish with warmer winters (Beniston, 2003). The potential retreat of glaciers in the European Alps may also negatively affect the "mountain aesthetics" for summer tourism (Abegg, Agrawala, Crick, & de Montfalcon, 2007).

Snow-based tourism is dependent on natural features (terrain, altitude, etc.) and climatic conditions (temperature, precipitation, etc.) (Moen & Fredman, 2007). The reliability of snow cover is considered to be one crucial factor for snow-based tourism activities, including skiing, snowboarding, Nordic skiing and snowmobiling; another is the localized weather conditions particularly on weekends and holidays when demand for activities is strongest (Elsasser & Bürki, 2002).

The natural reliability of snow cover (i.e. without snowmaking) in the European Alps (Austria, France, Germany, Italy and Switzerland) was recently examined by Abegg, et al. (2007). Under present climatic conditions 609 (91%) of 666 of ski resorts examined may be considered snow reliable. Three scenarios were projected for snow reliability: (1) a $+1^{0}$C, 500 (75%) of ski resorts may be snow reliable, (2) a $+2^{0}$C, 404 (61%) may be snow reliable, and (3) a $+4^{0}$C, 202 (30%) may be snow reliable. Under a $+1^{0}$C scenario Germany is the most vulnerable with only 40% of ski resorts projected to be snow reliable, while Switzerland is the least vulnerable with 90% of ski resorts projected to be snow reliable.

Alpine ski resorts in Switzerland, without snowmaking, are considered snow reliable when a 30 cm to 50 cm of natural snow cover prevails for a minimum of 100 days, in 7 out of 10 winters (Elsasser & Bürki, 2002). A projected increase in the snow line from the current 1,200 masl to 1,800 masl may find a decrease in snow reliable resorts from 85% to 44%. Koenig and

Abegg (1997) projected 63% of Switzerland's alpine ski resorts would be snow reliable, without snowmaking, with a 2^0C increase in temperature. Elsewhere in Europe, in Sweden, Moen and Fredman (2007) examining the alpine ski sector projected a decline in skier days, without snowmaking, between 64 (40%) and 96 (59%) for the period 2070 to 2100. In Japan, Fukushima, Kureha, Ozaki, Fujimori, and Harasawa (2002) projected a 30% decline in skiers, without snowmaking, at seven alpine ski resorts with a 3^0C temperature increase. Snow-based tourism activities may focus at areas that are distinctly snow reliable, thus increasing relative advantages between areas.

In the United States, Casola (2005) in the northwest and Scott, Dawson, and Jones (2008) in the northeast projected trends of declining season lengths for ski resorts. Casola (2005) examined the effects of increasing temperature on three ski resorts, without snowmaking, in the Cascade Mountains in Washington State. As early as the 2020s, a projected 2^0C temperature increase may reduce the season length of two resorts with elevations < 1238 masl by 14% to 28%. Days during the season with rain are projected to occur 50% of the time. The length of the ski season of one resort at an elevation of 1372 masl is not projected to be significantly affected by temperature increases. It is projected to receive an increase of approximately 15% of days with rain. Resorts at higher elevations may be more susceptible to variability in precipitation than regional warming.

Scott et al. (2008) examined 41 resorts in 14 areas in the states of Connecticut, Maine, Massachusetts, New Hampshire, New York, Pennsylvania, and Vermont. Climate change scenarios project trends of declining season lengths, without snowmaking, for the study areas, -6% to -23% in the 2020s, -8% to -38% in the 2050s, and -8% to -59% in the 2080s. It was concluded that within this region it will be individual ski resorts and communities reliant on ski tourism that will be most vulnerable to changes in climate rather than the entire ski industry. This is because these individual resorts have varying technological (e.g. snowmaking capacity) and business (e.g. governance models and access to capital) capacities.

2.3.3 Climate Change and Snowmobiling

Snowmobile tourism in Ontario at present relies entirely on natural features and suitable climatic conditions, including freezing temperatures and natural snowfalls. Changes in climate are influencing the spatial and temporal distribution of the Ontario snow-pack and consequently snowmobile tourism. The length of the snowmobile season is important to the sustainability of the activity, quality of experience, and the provincial economy.

Scott et al. (2002) examined the vulnerability of winter tourism to climate change within the Lakelands Tourism Region of Ontario. This region is located in south Central Ontario in the District of Muskoka and the counties of Bruce, Grey, Simcoe, and Haliburton. Snowmobiling is important to this region; an estimated $5.5 million was generated from the sale of snowmobile trail permits during the 1998/1999 snowmobile season (Scott et al., 2002).

Mean snowmobile season length is projected to decline in the 2010 to 2039 period with the CGCM1 scenario -49% and with the HadCM3 scenario -29%. In the 2040 to 2069 period mean snowmobile season length is projected to decline with the CGCM1 scenario -69% and with the HadCM3 scenario -44%. Mean snowmobile season length is projected to decline in the 2070 to 2099 period with the CGCM1 scenario -80% and with the HadCM3 scenario -70% (Scott et al., 2002). Economic losses for snowmobiling in the Lakelands Tourism Region were projected for the 2010 to 2039 period to range from $93.2 million to $157.5 million.

McBoyle et al. (2007) examined snowmobiling in non-mountainous regions of Canada. Thirteen study sites, in four geographic regions (Prairies, Ontario, Quebec, and East Coast), were selected. In consultation with snowmobile industry stakeholders, McBoyle et al. (2007) determined that snow cover thresholds of 15 cm for smooth terrain snowmobile trails and 30 cm for rough terrain snowmobile trails were required to open the trail systems. The Prairies and East Coast have the shortest observed average season length, 49 days and 30 days respectively. Ontario and Quebec have the longest observed average season length, 78 days and 69 days respectively. Projected season length in the 2010 to 2039 and 2040 to 2069 periods is anticipated to decline across all regions with each climate change scenario.

In the 2010 to 2039 period mean snowmobile season length is projected to decline with the NCARPCM B21 scenario -69% in the Prairies, -19% in Ontario, -29% in Quebec, and -49% in the East Coast and with the CCSRNIES A11 scenario in the Prairies -80%, Ontario -56%, Quebec -53%, and East Coast -45%. Mean snowmobile season length in the 2040 to 2069 period, is projected to decline with the NCARPCM A11 scenario -69% in the Prairies, -40% in Ontario, -37% in Quebec, and -79% in the East Coast and with the CCSRNIES A11 scenario in the Prairies -98%, Ontario -95%, Quebec -95%, and East Coast -93% (McBoyle et al., 2007).

Projections of shorter season length may result in fewer snowmobilers participating, fewer volunteers for snowmobile trail operations, and declining trail permit revenues (McBoyle, et al., 2007). Economic losses for Ontario and Quebec in the 2010 to 2039 period may reach $US 252 million and $US 377 million under the NCARPCM B21 scenario and $US 486 million and $US 689 million under the CCSRNIES A11 scenario.

In the Northeast of the United States, Scott et al. (2008) examined the vulnerability of snowmobiling at 15 study areas located throughout Maine, Massachusetts, New Hampshire, New York, Pennsylvania, and Vermont. In the 1961-1990 baseline period, modeled snowmobile season length, with a 15 cm snow cover threshold, ranged from 4 to 106 days (mean of 59 days) among the 15 study areas. Season length > 70 days were reported in seven generally more northerly and higher elevation study areas during this same period.

Climate change scenarios project a trend towards shorter season length in all study areas through each time period (2010-2039, 2040-2069, and 2070-2099). In the 2010 to 2039 period a > 50% decline in season length is projected to occur in 4 of 15 study areas under the B1 emissions scenario and 6 of 15 study areas under the A1Fi emission scenario. Under the B1 emissions scenario in the 2040 to 2069 period 7 of 15 study areas are projected to lose > 50% of season length and 11 of 15 in the A1Fi emissions scenario. In the 2070 to 2099 period a > 50% decline in season length is projected to occur in 8 of 15 study areas under the B1 emissions scenario and 14 of 15 study areas under the A1Fi emissions scenario (Scott et al., 2008).

With projected marginal season length for local snowmobiling in 9 of 15 study areas as early as the 2040 to 2069 period, snowmobilers may consider travelling further to reach areas with sufficient snowmobile season length or substitute another form of recreation for snowmobiling that is not reliant upon snow cover (Scott et al., 2008). Areas with sufficient season length may consider marketing these areas to attract snowmobilers from snow deficient areas to increase the tourism benefits. The influence of distance costs and destination loyalty or environmental concerns with a greater concentration of snowmobile activity on the remaining areas is not yet known (Scott et al., 2008).

2.4 Human Responses to Climate Change

Two types of human responses to the risks associated with climate change upon natural and anthropogenic systems include mitigation and adaptation. The characteristics of mitigation and adaptation are illustrated in Table 2.5. Localized sector benefits are often attained by adaptation with fewer time lags than mitigation, which operates at a global scale.

Table 2.5: Characteristics of Mitigation and Adaptation

Characteristic	Mitigation of Climate Change	Adaptation to Climate Change
Benefited Systems	All Systems	Selected Systems
Scale of Effect	Global	Local to Regional
Lifetime	Centuries	Years to Centuries
Effectiveness	Certain	Generally Less Certain
Ancillary Benefits	Sometimes	Mostly
Monitoring	Relatively Easy	More Difficult

Source: Füssel & Klein, (2006)

The IPCC (2007c) considers mitigation as the implementation of policies for the reduction of GHG emissions and the enhancement of natural sinks. A country's ability, referring to skills, competencies, fitness and proficiencies, to reduce GHG emissions and enhance natural sinks is referred to as mitigative capacity. Tourists can mitigate their carbon footprint while travelling by selecting energy efficient modes of transportation, selecting environmentally certified accommodations, and avoiding energy intense activities (Simpson, Gössling, Scott, Hall, & Gladin, 2008).

Adaptation to climate change is considered as an adjustment to actual or anticipated climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2007d). Adaptive responses may be anticipatory or reactive and may seek to minimize present impacts, reduce sensitivity and exposure, and increase resiliency (Table 2.6) (Lemmen et al., 2008). These responses may be planned or autonomous. Adaptive capacity inequities have been noted between different regions of the world (IPCC, 2007d) and in Canada between urban and rural communities (Lemmen, et al., 2008).

Table 2.6: Different Types of Adaptation

<table>
<tr><th>Based On</th><th colspan="6">Type of Adaptation</th></tr>
<tr><td>Intent
In Relation to Climatic Stimulus</td><td colspan="3">Autonomous
(e.g. unmanaged natural systems)</td><td colspan="3">Planned
(e.g. public agencies)</td></tr>
<tr><td>Action</td><td colspan="2">Reactive
(Post)
(From Observed Modification)</td><td colspan="2">Concurrent
(During)</td><td colspan="2">Anticipatory
(Ante)
(Prior Modification)</td></tr>
<tr><td>Temporal Scope</td><td colspan="3">Short Term
(Adjustments, Instantaneous, Autonomous)</td><td colspan="3">Long Term
(Adaptation, Cumulative, Policy)</td></tr>
<tr><td>Spatial Scope</td><td colspan="3">Localized</td><td colspan="3">Widespread</td></tr>
</table>

Source: Lemmen et al. (2008, p. 428) (modified from Smit et al., 1999)

Adaptation to present climate variability and long-term climate change occurs among individuals, groups, organizations and governments. Potential risks of climate change to developing countries and society are ranked higher than risks to individuals (Lorenzoni & Pidgeon, 2006). Effective climate change adaptation strategies are dependent upon the public acceptability amongst institutional, economic and social constraints (Adger, 2003; Smithers & Smit, 1997). Lemmen and Warren (2004) identified a range of adaptive strategies to minimize vulnerability to climate change (Table 2.7).

Table 2.7: Adaptive Strategies

Category	Explanation	Example
Bear the Costs	Do nothing to reduce vulnerability and absorb losses	Allow households lawns and gardens to wither
Prevent the loss	Adopt measures to reduce vulnerability	Protect coastal communities with seawalls or groins
Spread or share the loss	Spread burden of losses across different systems or populations	Crop insurance
Change the activity	Stop activities that are not sustainable under the new climate, and substitute with other activities	Make ski resort a four-season facility to attract tourists year round
Change the location	Move the activity or system	Move ice fishing operations farther north
Enhance adaptive capacity	Enhance the resiliency of the system to improve its ability to deal with stress	Reduce non-climatic stresses, such as pollution

Source: Lemmen & Warren (2004, p. 10) (adapted from Burton, et al., 1968)

2.4.1 Risk

Jones (2001) considers climate change an environmental risk as the environment is directly exposed to the risks of climate change and human activities may be threatened by environmental changes resulting from changes in climate. Critical biophysical (e.g. days of snow cover for recreation, winter temperatures, and species extinction) and behavioural thresholds of climate change are used to assess the severity of perceived impacts.

Top-down and bottom-up approaches have been used to provide assessments of climate change (van Aalst, Cannon, & Burton, 2008). Top–down approaches measure physical vulnerability at global and local scales of natural and human systems; while bottom-up approaches consider social vulnerability to climate variability and climate change among individuals and groups (Dessai, Adger, Hulme, Turnpenny, Köhler, & Warren, 2004). Bottom-up approaches to adaptive strategies may shift the perception of climate change from a global to local issue (Adger, 2003).

2.4.2 Trust

Trust is a dynamic process, an essential social bond gained between persons sharing a common belief of a particular situation. This is of importance to the development and continuation of relationships between snowmobile clubs and stakeholders (e.g. pubic and private landowners). It may often develop over a long period of time and instances. Slovic (1993) offered the *asymmetry principle* as an explanation of certain human psychological mechanisms reflecting that trust may be easily destroyed and more difficult to create for the following reasons: (1) negative events are more visible and carry greater weight than positive events, (2) sources of bad news are viewed as more credible than sources of good news, and (3) mistrust once begun perpetuates mistrust by inhibiting personal contacts and experiences needed to overcome mistrust and by reinforcing prior beliefs.

In the public participation process, three dimensions of trust exist: (1) trust of scientific experts and expertise (expert trust), (2) trust of government decision makers (decision maker trust), and (3) trust of other stakeholders (social trust) (Anex & Focht, 2002). Participation of stakeholders is dependent by the level of trustworthiness of the other participants. A high level of trust increases the willingness of participants to defer decisions to other participants and a low level of trustworthiness increases the willingness to participate. Expert trust is influenced by perceptions of: (1) relevant facts, (2) competence, (3) lack of bias, and (4) responsiveness to participants concerns and analysis frames. Decision maker trust is influenced by perceptions of fiduciary responsibility and social trust by the willingness to cooperate.

2.4.3 Perceptions

O'Connor, Bord, and Fisher (1999) conceptualize risk perception as the perceived likelihood of negative consequences to oneself and society. Perceptions of risks are linked to the risk target (e.g. personal, family or society) and whether the risk is new or old, of dread consequences, and the number of people exposed (Sjoberg, 2000). Real risk, in which people may have some direct or indirect experience, is a primary determinant of perceived risk (Sjoberg, 2000). Perceptions of climatic risks flow through two primary communication channels, the news media and informal personal networks (e.g. friends, co-workers, and social groups) (Kasperson, Renn, Slovic, Brown, Emel, Goble, Kasperson, & Ratick, 1988). Scientific assessments of potential risks may interact with psychological, social, and cultural processes that may amplify or attenuate perceptions and subsequent behavioural responses (Kasperson et al., 1988). These responses may be further amplified resulting in ripple effects leading to secondary and tertiary impacts.

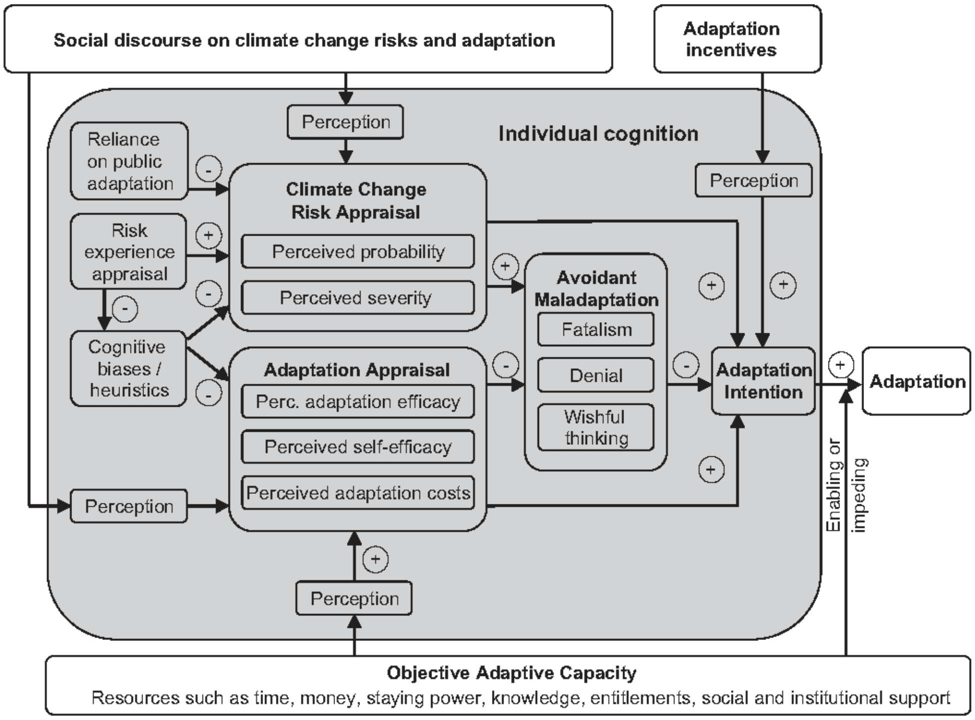
Snowmobile trail managers may perceive that their snowmobile districts are less vulnerable than other snowmobile districts to changes in climate, and take more reactive action. Weinstein (1980) in a study of the bias of university students to 18 positive and 24 negative events found that students tended to believe that they were more likely to experience positive events and less likely to experience negative events. Five event considerations were identified that influenced the amount of optimistic bias of these students: (1) a level desirability, (2) perceived probability, (3) personal experience, (4) perceived controllability, and (5) stereotype salience (Weinstein, 1980). When people perceive an event overly optimistically an appropriate level of caution may be ignored.

Lay people and experts may perceive risks to ecosystems differently. Risks to ecosystems induced by climate change (e.g. decreased or increased rainfall, extreme temperatures, increase in severity of winter storms, etc.) are perceived by lay people, more so than experts, as having greater impact, are more controllable or avoidable, less acceptable, and more understandable

(Lazo, Kinnell, & Fisher, 2000). The loss of outdoor recreation, and travel and tourism are perceived by both groups as the most acceptable among 25 risks to ecosystems. The overall rank of outdoor recreation by laypeople was 25 of 25 and tourism and travel 22 of 25. Experts overall ranking of outdoor recreation was 23 of 25 and tourism and travel 20 of 25. There is a need for both groups to effectively communicate these differences to each other in order for adaptation strategies to be developed.

The decision-making process undertaken may influence responses to climate change. Grothmann and Patt (2005) developed the socio-cognitive Model of Private Proactive Adaptation to Climate Change (MPPACC) (Figure 2.2), based upon Protection Motivation Theory, which describes the psychological process of adaptation in response to climate change risk appraisal and adaptation appraisal. MPPACC has been applied to natural hazards research, drought and flooding. Risk appraisal has two sub-components; perceived probability and perceived severity. Adaptation appraisal occurs only when a minimum threat threshold is exceeded and is comprised of three sub-components; perceived adaptation efficacy, self-efficacy, and adaptation costs. The next phase in the process is a decision of intent to adopt an adaptation response or to have a maladaptive response to the threat. Objective adaptation influences the adaptation intention and perceived adaptation appraisal. Reliance on the public sector for assistance may result in less precautionary action taken.

Figure 2.2: Model of Private Proactive Adaptation to Climate Change



Source: Grothmann & Patt (2005, p. 204)

2.4.4 Adaptation in Winter Tourism

Alpine ski resorts have developed technological (e.g. snowmaking, slope development and operational practices, and cloud seeding) and business practices (e.g. ski conglomerates, revenue diversification, marketing, and indoor facilities) in response to declining, limited and less reliable natural snowfalls (Scott & McBoyle, 2007). A range of adaptive strategies used by alpine ski resorts include:

Technological

(1) concentrated operations at higher altitudes, glacier fields, where snow is most reliable, and development of new skiable terrain (Bürki, Elsasser, & Abegg, 2003; Elsasser & Messerli, 2001; Koenig & Abegg, 1997; Scott & McBoyle, 2007),

(2) enhanced snowmaking capabilities and coverage (Appendix 1) (Bürki, Elsasser, & Abegg, 2003; Koenig & Abegg, 1997; Moen & Fredman, 2007; Scott, McBoyle, & Mills, 2003; Scott, McBolyle, Minogue, & Mills, 2006),

(3) stockpiling water in reservoirs during spring and summer for use in snowmaking during the winter (Scott & McBoyle, 2007),

(4) stockpile snow early in season for use later in the season (Aspen Global Change Institute (AGCI), 2006),

(5) strategic planting or retention of tree cover to capture and shade snow minimizing snowmelt and snowmaking (Scott & McBoyle, 2007),

(6) slope contouring to enable grooming in lower snow cover and lower costs associated with snowmaking (Scott & McBoyle, 2007),

(7) adjust grooming techniques (AGCI, 2006),

(8) avalanche control strategies (AGCI, 2006),

(9) expand skier downloading capability (AGCI, 2006),

(10) opening later in season if necessary (AGCI, 2006), and

(11) cloud seeding to increase snowfalls and storage of spring melt (Scott & McBoyle, 2007).

Business Practices

(1) diversified operations (e.g. music and cultural festivals, activities for non-skiers, four-season resorts) (Koenig & Abegg, 1997; Scott & McBoyle, 2007),

(2) business partnership development (e.g. fusion of companies and interconnecting of resorts, (e.g. Trois Vallées in the Alps) (Koenig & Abegg, 1997; Scott & McBoyle, 2007; Tuppen, 2000),

(3) marketing incentives to encourage the booking of vacations due to less desirable ski conditions (Scott & McBoyle, 2007), and

(4) the promotion of indoor ski facilities in near proximity to large skier markets to facilitate an early season interest in skiing and to develop the long-term skier market (Scott & McBoyle, 2007).

Weather derivatives and weather insurance may be adaptive strategies to be considered by the outdoor recreation sector to minimize weather related risks. Each strategy relies on a range of climatic variables (e.g. temperature, precipitation) occurring over varying periods of time (e.g. week, month). Weather derivatives are flexible to meet the diverse needs of many different sectors (Zeng, 2000). Businesses for example, in the energy, agriculture, and transportation sectors purchase derivatives to stabilize annual earnings from the negative affects of weather (Conley, 1999). Snowmobile manufactures have used weather derivatives as a marketing strategy to increase snowmobile sales in areas negatively affected by limited snowfalls. In the 1998/1999 snowmobile season Bombardier Recreational Products offered purchasers in the central United States a $1,000 rebate if the snowfall in their area was less than 50% of a 3-year average for their area (Conley, 1999). With the purchase of weather insurance a weather related financial loss must have occurred to receive a payment.

2.5 Summary

In summarizing the review of the literature, snow-based tourism is most sensitive to changes in climate, in particular warmer temperatures and precipitation falling as snow. Studies of climate change and snowmobile tourism have focused on the potential limitations of snow cover and speculate response strategies for supply-side organizations.

Knowledge gaps that remain, and that this study has been designed to address include: (1) the limited spatial coverage of projected climate change for snowmobile tourism in the Province of Ontario, (2) factors that may influence snowmobile tourism supply-side responses to climate change have not been explored, and (3) the range of projected responses by supply-side organizations to climate change.

Chapter 3

Methodology

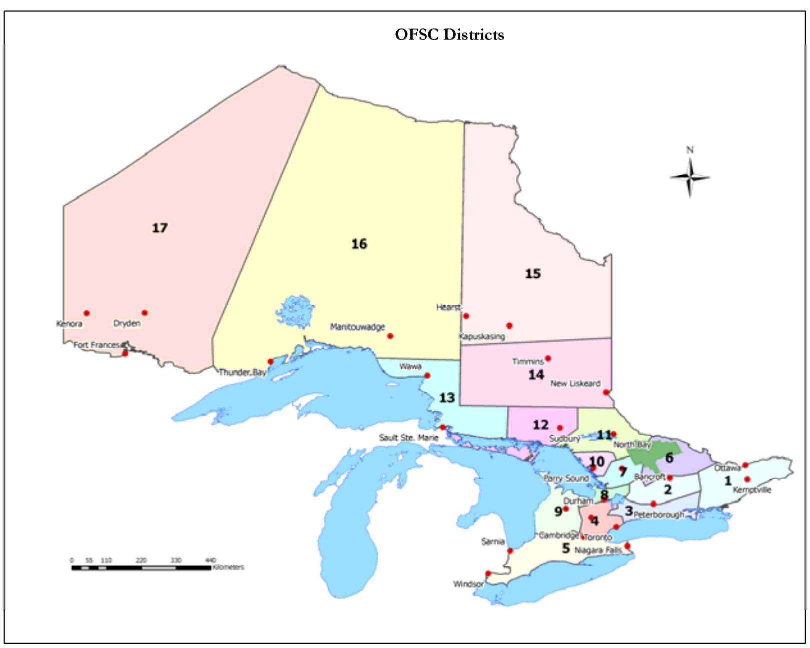
3.1 Introduction

This chapter discusses the development and implementation of the research. The selection of a mixed-methods approach is explained and the two methods, qualitative and quantitative are further described.

3.2 Study Area

The Ontario Federation of Snowmobile Clubs (OFSC) seventeen snowmobile districts (Figure 3.1), maintains a snowmobile trail system of 39,742 km in the province of Ontario (OFSC, 2008a), and was selected for this study. Trans-Ontario-Provincial (TOP) trails comprise approximately 45% (17,899 km) of the total trail kilometres and are the primary snowmobile touring routes (OFSC, 2008a). Snowmobile trails located on private lands account for 65% (25,700 km) of trail length and on public lands 35% (14,042 km) (OFSC, 2008a). An estimated 64% of snowmobilers reside in Southern Ontario (OFSC, 2008a).

Figure 3.1: OFSC District Map



Source: OFSC (2009a)

3.3 Data Collection Methods

A three-phased, mixed-methods approach was developed and implemented for this study. Mixed methods provides for sequential data collection using both qualitative and quantitative methods so as to most effectively understand the research question through data triangulation (Creswell, 2003). Denzin and Lincoln (2000, p.3) describe qualitative research as involving "the studied use and collection of a variety of empirical materials – [including] case studies; personal experiences; … life story;… artifacts;… - that describe routine and problematic moments and meanings in individuals' lives." Qualitative research is essentially interpretive, studying panoramic views using multiple methods that are informative and humanistic (Creswell, 2003).

Quantitative research uses strategies of inquiry like surveys with closed-ended questions, generalizing from the sample to a population and experiments collecting data on predetermined instruments which may be analysed using statistical processes (Creswell, 2003).

3.3.1 Defining Snowmobile Season Length

An essential element in this study was the determination of suitable climatic indicators used to define the length and quality of snowmobile seasons. Research participants identified three thresholds of snow cover, 15 cm, 30 cm, and 60 cm necessary to commence snowmobile trail grooming operations over smooth to rough terrain. These snow cover thresholds were used to parameterize the snow model used in Phase 2 of the study. Also identified to conduct effective grooming operations, were optimal temperatures, -25^{0}C to -35^{0}C and rainfall of < 20 mm to 30 mm over a period of 3 days.

3.3.2 Ethical Considerations

A *Research Ethics Application* for this study was approved by the University of Waterloo's Office of Research Ethics on September 17, 2008. A copy of the Phase I Participant Information Letter (Appendix 2), Phase 1 Consent Form for Participants (Appendix 3) and Phase

III Information Letter (Appendix 4) and Phase 3 Consent Form for Participants (Appendix 5) are provided.

3.3.3 Phase 1: Interviews

Research participants manage snowmobile trail systems in southern snowmobile districts (4, 6, & 7) and northern snowmobile districts (11, 12, & 16) (Figure 3.1) within diverse terrains (e.g. agricultural, forested, and rocky). Each participant has had a long (an average of 30 years) and varied involvement with snowmobile trail operations and experience with variable climate in Ontario.

Key informant interviews were conducted over a period of 29 days in January and February 2009 with durations of 2:10 to 3:06 (Table 3.1) with five willing research participants. It was intended to obtain a larger sample size, however interviews were concluded once the information gained from the respondents become repetitive. Participants were forwarded an identical set of 14 written questions (Appendix 6) prior to conducting semi-structured, audio-recorded, telephone interviews. One participant chose to submit written responses to these questions instead of participating in an interview. These interviews were conducted to discover the experiences of senior Ontario snowmobile trail managers/operators to past changes in climate variability, environmental stewardship, snow cover thresholds for grooming operations, ideal and worst snowmobile seasons, roles in snowmobile tourism, and future challenges of snowmobiling in Ontario.

Table 3.1: Duration of Phase 1 Interviews

Respondent	OFSC District	Interview Phase 1	
		Date	Duration
1	11	January 27, 2009	2:41:38
2	16	February 12, 2009	2:10:20
3	12	February 2, 2009	3:06:17
4	7	January 15, 2009	2:24:21
5	6	N/A	0:00:00
6	4	February 1, 2009	Written Response

3.3.4 Phase 2: Climate Change and Snow Operations Modelling

A historical climate data set was constructed for the baseline period 1961 to 1990 for each of the 17 selected climate stations (Table 3.2), one climate station for each OFSC district (Figure 3.1). Climate stations were selected based on the proximity to major snowmobile touring routes within each snowmobile district and the existence of a high quality climate record with no prolonged periods of missing data (McBoyle, et al., 2007). Climate records for precipitation and temperature used in this study were obtained from the Meteorological Service of Canada (MSC), Environment Canada.

Table 3.2: Selected Climate Stations

OFSC District	OFSC Station	Climate Station	Station Number	Latitude	Longitude	Elevation (m)	Record
D1	Kemptville	Kemptville	6104025	45^0 0' N	75^0 38' W	99	1928-1997
D2	Bancroft	Bancroft	6160465	45^0 3' N	77^0 51' W	327	1882-1985
D3	Keene	Peterborough	6166416	44^0 17' N	78^0 19' W	194	1886-1970
D4	Orangeville	Orangeville	6155790	43^0 55' N	80^0 5' W	412	1961-2006
D5	Cambridge	Cambridge/Galt MOE	6141095	43^0 20' N	80^0 17' W	268	1879-1994
D6	Haliburton	Haliburton A	6163156	45^0 0' N	78^0 35' W	320	1883-1992
D7	Huntsville	Hunstsville WPCP	6113663	$45^0$21' N	79^0 10' W	321	1960-2003
D8	Midhurst	Midhurst	6115099	44^0 27' N	79^0 46' W	226	1947-1996
D9	Durham	Durham	6112171	44^0 11' N	80^0 49' W	384	1882-2003
D10	Parry Sound	Parry Sound	6116254	45^0 20' N	80^0 0' W	194	1874-1976
D11	North Bay	North Bay A	6085700	46^0 22' N	79^0 25' W	370	1939-2007
D12	Sudbury	Sudbury A	6068150	46^0 38' N	80^0 48' W	348	1954-2007
D13	Sault Ste Marie	Sault Ste Marie 2	6057590	46^0 32' N	84^0 20' W	212	1957-2002
D14	Timmins	Timmins A	6078285	48^0 34' N	81^0 23' W	295	1955-2007
D15	Kapuskasing	Kapuskasing A	6073975	49^0 25' N	82^0 28' W	227	1937-2007
D16	Thunder Bay	Thunder Bay A	6048261	48^0 22' N	89^0 20' W	199	1941-2004
D17	Dryden	Dryden	6032117	49^0 47' N	92^0 50' W	372	1914-1997

Source: (MSC, 2008; OFSC, 2009b)

The two climate change scenarios used in this study, the Institute of Numerical Mathematics (INMCM3.0 B1) and the Model for Interdisciplinary Research on Climate (MIROC3.2 HIRES A1B) were obtained from the Canadian Climate Change Scenarios Network (CCCSN). Three future time periods were examined; 2010 to 2039 (2020s), 2040 to 2069 (2050s), and 2070 to 2099 (2080s). Each of these scenarios has been constructed using methodologies accepted by the Task Group on Scenarios for Climate Impact Assessment (TGCIA) of the Intergovernmental Panel on Climate Change (IPCC). Global climate models are complex mathematical models of the earth's climate systems that assist in understanding past climate and projecting future climate (IPCC, 2007a). Changes in near-surface climates will have the greatest influence on the Ontario snow-pack (Wilks, 1999) and consequently snowmobile tourism.

Statistical downscaling of monthly climate data, using the Long Ashton Research Station Weather Generator (LARS-WG) was selected for this study as it: (1) has been applied to assessments in Canada of winter recreation (e.g. McBoyle et al., 2007; Scott et al., 2002) and nature base-tourism (e.g. Jones & Scott, 2006) and many others, (2) has been determined to simulate precipitation in the study area better than other weather generators (Qian, Gameda, Hayhoe, DeJong, & Bootsma, 2004), and (3) it is economical and readily available to use.

Stochastic weather generators are mathematical models that are capable of generating simulated, site-specific, multi-year climate change scenarios at a daily time scale, based on the observed record (Semenov, Brooks, Barrow, & Richardson, 1998). In a weather generator precipitation is considered the salient climate variable as it deals with the incidence of a wet day and the total precipitation on a wet day (Qian et al., 2004). Other variables (e.g. temperature and solar radiation) may be dependent upon a wet or dry day. The LARS-WG use of empirical distributions of climate variables makes it ideal for applications in diverse climates (Qian et al., 2004).

Jones, Scott, Barrow, and Wun (2003) provides a procedure for generating simulated weather using LARS-WG involving the following stages: (1) obtaining daily observed weather variables (temperature and precipitation) data for each of the seventeen selected climate stations (Table 3.2) for the baseline period 1961 to 1990, (2) formatting the data for use by the LARS-WG, (3) the LARS-WG was then parameterized with the data from each of the selected climate stations, (4) a Q-Test was then performed comparing the statistical distributions of the weather variables of LARS-WG to observed, (5) monthly mean temperature and precipitation change values from the INMCM3.0 and MIROC3.2 HIRES global climate models were then used to develop climate change scenarios for each of the three time periods (2010 to 2039, 2040 to 2069, and 2070 to 2099), and (6) the parameterized climate station files were then run with the six climate change scenarios using the same random number seed. Once completed, the daily temperature and precipitation data set for each climate station included 1961 to 1990 baseline (simulated) and projected 2010 to 2039, 2040 to 2069, and 2070 to 2099.

Daily temperature and precipitation data for each of the selected climate stations were used as inputs into a snow model. Scott et al. (2002) and McBoyle et al. (2007) used this snow model in assessments of snowmobile season lengths in Ontario. The model projected season length based on calculations of three parameters: (1) the amount of precipitation (rainfall and snowfall), (2) snow accumulation, and (3) snowmelt (McBoyle et al., 2007).

3.3.5 Phase 3: Interviews

Audio-recorded telephone interviews were conducted with three research participants (2 of 5 phase 1 and 1 phase 3) over a period of 10 days in April 2009 with durations of 1:29 to

2:48 (Table 3.3). Each research participant was provided in advance of the interview for their snowmobile district reporting location with the following: (1) seven interview questions (Appendix 7), (2) projections in tabular and chart form of annual snowmobile season length for snow cover thresholds of 15 cm, 30 cm, and 60 cm in the baseline period and three future time periods for each GCM, (3) annual peak snow cover and the timing of peak snow cover for the baseline period and three future time periods for each GCM, and (4) projections of monthly (November to April) snow cover distributions in chart form for snow cover thresholds of 15 cm, 30 cm, and 60 cm in the baseline period and three future time periods for each GCM. The focus of these interviews was the possible responses of each research participant to future projections of snowmobile season length, reliability of snowmobile seasons, and the influence of season length on snowmobile tourism in Ontario.

Table 3.3: Duration of Phase 3 Interviews

Respondent	OFSC District	Interview Phase 3	
		Date	Duration
1	11	April 24, 2009	2:48:28
2	16	N/A	0:00:00
3	12	April 15, 2009	2:29:40
4	7	N/A	0:00:00
5	6	April 22,2009	1:29:34
6	4	N/A	0:00:00

3.4 Data Analysis

Several procedures were used to analyze the collected data. Creswell (2003, p.190) considers data analysis as a process involving "preparing the data for analysis, conducting different analysis, moving deeper and deeper into understanding the data, representing the data, and making an interpretation of the larger meaning of the data." Qualitative data from the participant interviews was analyzed for content, keywords and emerging themes. Charmaz (2006) contends that coding shapes an analytic frame and links data collection to an emergent theory. Quantitative climatic data was used to compare observed climatic records to future climate change scenarios.

3.5 Limitations

The elicited text obtained from the one participant, Respondent 6, while providing the opportunity and time for reflecting on past experiences, may be limited in the following ways: (1) questions once posed may not to be modified, (2) there is no immediate opportunity to follow-up, encourage or re-direct a response, and (3) participants may have varying levels of literacy for writing full accounts of their experiences (Charmaz, 2006).

The use of a follow-up interview would have strengthened the study by minimizing these limitations and permitting the researcher to explore participant experiences in greater depth. However, there were no observable differences between participants with the range and quality of written versus telephone responses. Creswell (2003) cautions the researcher that participant interviews may occur in a designated place, rather than the natural setting in which the experiences occurred. All participants were confident in the researchers understanding of volunteer organizations and snowmobile tourism enabling deeper meanings of issues of concern to be revealed.

Observed climate records (1961 to 1990) from each MSC climate station are considered to be a “best fit” with a central OFSC trail status reporting location and may not represent the average or range of climate of each OFSC district. Climate stations with incomplete data were supplemented with the nearest adjacent climate station. Snowfall measurements are generally collected at MSC climate stations in open locations and thus may underestimate (enhanced or reduced) snowfalls in forested or higher altitude terrains within each OFSC district (Scott et al., 2002).

Snowmobile trails located in open terrain and MSC climate stations are most vulnerable to the loss of snow cover earlier during the snowmobile season than more protected terrains due to exposure to sunlight, precipitation as rainfall, and wind. The snow model is valid only for each selected MSC climate station and nearby areas exhibiting similar climatic conditions, extrapolation to other areas may be limited as differing microclimates exist over the system of snowmobile trails in each OFSC district (McBoyle, 2007).

3.6 Summary

To address the study objectives of (1) discovering the sensitivity of snowmobile trail operations and adaptations to past climate variability, (2) examining the influence of climate change upon snowmobile season length in each OFSC snowmobile district during the future periods 2010 to 2039, 2040 to 2069, and 2070 to 2099 using a modelling approach, and (3) discovering the possible adaptations that senior Ontario snowmobile trail managers/operators may consider in the future to climate change a sequential three-phased mixed methods approach was selected. Qualitative methods were used in Phase 1 and Phase 3 of the study discovering human responses of climate change. Quantitative methods were used in Phase 2 of the study to develop and compare climate change scenarios.

Chapter 4

Results

4.1 Introduction

This research examines the potential influence of climate change on the length of the Ontario snowmobile season and the potential responses of supply-side snowmobile trail managers/operators. The results of the two method phases (quantitative and qualitative) are provided. Snow cover thresholds identified through interviews with senior trail managers/operators were used to parameterize a snow model projecting season length through three future time periods. This chapter is organized into four sections: (1) respondent profiles, (2) factors that influence season length, (3) projections of season length, and (4) potential responses to climate change.

4.2 Characteristics of Respondents

Respondents have an average of 30 years of comprehensive volunteer snowmobile trail development experience, beginning with their local snowmobile club. All have served in executive positions with their local snowmobile clubs and four have served on provincial trail and safety committees. Respondents have found their involvement in organized snowmobiling to be personally challenging and rewarding. Snowmobiling is considered by all respondents to be a great part of their lifestyle. As each of the respondent's level of involvement in snowmobile trail development has increased, personal time for recreational snowmobiling have declined and are often limited to day trips of 200 km to 300 km in their local or adjacent area and on occasion long distance trips in Ontario (Respondents 1 & 2), Canada (Respondent 6), and the United States (Respondent 6).

4.2.1 Conscience of Nature

Natural areas have been identified as special places for each of the respondents. The attachment to these areas may be connected to participating at a younger age in family activities within these types of areas. "I have an avid snowmobiler since 1970 and became involved with the OFSC in 1988, being an outdoors person and used to the forest I was chosen to lead the local club in developing their trail system…" (Respondent1). For personal snowmobiling respondents have embraced the OFSC *Leave Tracks not Trash* environmental message. Respondent 2 has replaced a two-stroke snowmobile for a four-stroke snowmobile for the benefits of decreased emissions and noise.

Respondents recognize the importance and value of undertaking snowmobile trail operations on public lands within the provincial/federal legislation and policy frameworks during water crossing planning and construction (Respondents 3, 4, & 5) . Sensitive wildlife habitat and wetland areas are avoided in snowmobile trail route selection; existing corridors (e.g. forestry roads, abandoned railway corridors, utility corridors, and municipal road allowances) are used where possible minimizing additional environmental impacts.

Large wildlife species like; deer, moose, elk, and wolf have been observed on and adjacent to snowmobile trails and the presence of industrial snowmobile trail grooming equipment and snowmobiles has not negatively affected these species (Respondents 1 & 3). White-tailed deer have been observed to become familiar with snowmobile traffic (Dorrance, Savage, & Huff, 1975). Persons afoot, due to a longer period of engagement, disturbed mule deer more than snowmobiles (Freddy, Bronaugh, & Fowler, 1986).

Moose are expected, under a warmer climate and less preferred habitat, to retreat further northwards towards the boreal forest and deer are expected to enter the southern range vacated by the moose (Thompson, Flannigan, Wotton, & Suffling, 1998). The shift of these wildlife ranges may contribute to a change in the attractiveness of these snowmobile districts for snowmobile tourists (Agnew & Viner, 2001). Wild turkeys have recently been observed in some snowmobile trail systems as well (Respondent 1). The most challenging wildlife species for the operation of snowmobile trails is the beaver (Respondent 3). Often portions of snowmobile trails require reconstruction as they may become flooded or washed out when beaver dams fail. Wildlife viewing has added to the scenic values of a snowmobile tourism experience (Respondent 1).

The Ontario Federation of All Terrain Vehicles (OFATV) promotes safe and responsible riding on trails through its *Trail Etiquette & Environmental Guidelines* (OFATV, 2006) and *Winter Riding Policy* (OFATV, 2001). Despite the efforts of the OFATV independent recreational motorized users (e.g. ATV, 4x4, and off road motorcycles) of public lands are a concern for snowmobile clubs, often contributing to soil erosion by creating ruts on slopes and within wet areas. Respondents 4 and 5 share the frustration of themselves being caring and responsible for the environment and having to allocate valuable time and money in repairing these effected areas.

Snowmobile trails on private property, particularly agricultural lands, require pre-season consultation with the landowners to determine the least impacting route, recognizing the location of winter crops (Respondents 1 & 6). Snowmobile trail operations can not begin until fall crops have been harvested and also need to conclude in time for spring planting operations (Respondents 1 & 6). Respondent 6 stated “In the Club’s environmental stewardship role, they attempt to responsibly manage the establishment of the snowmobile trail in a way that helps protect the winter cops, land and waterways during the winter trail season.” The responsible management of these trails on private lands strengthens relationships with landowners Respondent 6 summarizes “Without this long-term objective, aimed at the care and management of our Landowners’ property, trail sustainability is in jeopardy.”

4.2.2 Roles in Snowmobile Tourism

Snowmobile club volunteers are critical to the development and delivery of snowmobile trails necessary for snowmobile tourism. Respondent 3 stated, “The sharing of one’s time is the greatest resource that a volunteer can give us… it is the greatest resource that we have to take use of, take pride of, and respect.” The volunteer base is variable throughout the province (Respondent 1). Declining employment in the resource-based economies in Northern Ontario are negatively influencing snowmobile club membership and consequently the available volunteer base (Respondent 1).

Volunteers are more likely to contribute their time during a good snowmobile season than in a poor season (Respondent 3). During the fall hunting season volunteers are often unable to initiate per-season snowmobile trail maintenance activities due in part to conflicting land use and safety issues (Respondent 1). A change in elected municipal, provincial, and federal officials often requires volunteer time to establish positive relationships concerning the benefits of snowmobiling and the needs of the snowmobile club (Respondent 1).

Snowmobile clubs adopting a business approach to trail operations also consider the return-on-investment value of volunteer activities (e.g. attendance at trade shows and participation in familiarization tours) outside of the core trail activities (Respondent 4). Some clubs consider these activities beneficial to partnership relations (Respondents 1, 2, & 5); while others view these activities as detracting from the primary role of trail development and generating little monetary value (Respondents 3 & 4). The OFSC's *Volunteer in Action Committee* assists member snowmobile clubs in the management of their volunteer resources.

Snowmobile trails are established with the permission of private and public landowners. Snowmobile clubs offer few incentives or direct compensation to private landowners for the use of their lands. Seasonal property easements have been negotiated in some locations to maintain a snowmobile trail route over a longer period of time (Respondent 1). A change in ownership of private lands or priorities for public lands (e.g. forestry operations) may require re-routing of seasonal snowmobile trails (Respondents 2 & 3). The access of snowmobiles on private lands when trails are posted as *Closed* and ATVs at any time of the year, without landowner permission, has jeopardize landowner relations (Respondent 6). OFSC Trail Patrol officers regularly patrol the snowmobile trails during the season enforcing the Ontario Trespass to Property and Occupier's Liability Acts (Respondent 3).

4.3 Snowmobile Season Length Influencing Factors

4.3.1 Climate Variability

In an ideal snowmobile season once temperatures reach $< 0^0$ C from generally mid-November frost is able to penetrate the ground enabling the development and maintenance of a snow base (Respondent 1). These temperatures also promote the freezing of low lying water, necessary to open the complete snowmobile trail system. A gradual accumulation of snow cover in early December permits final trail preparation activities and trail grooming can commence prior to the Christmas/New Years holiday period for the enjoyment of snowmobile tourists and local snowmobilers. Each January temperatures $> 0^0$ C followed by rainfall is anticipated. Less than 3 days of rainfall are beneficial, saturating the snow cover, re-freezing and establishing a natural snow base (Respondents 3 & 5). Continued temperatures < 0^0 C and snowfalls until mid-April are considered ideal.

In a less than ideal snowmobile season temperatures > 0^0 C accompanied with rainfalls in November and December does not permit the penetration of ground frost, water accumulates in low lying areas, and erosion can occur on slopes (Respondent 3). Heavy snowfalls in October and November result in falling trees and branches, the ground is insulated from frost, and trail preparation activities are slowed (Respondents 4 & 5). Strong winds have contributed to blow downs requiring removal prior to opening of the trails (Respondents 1, 2, & 5). Snow cover less than thresholds required for trail grooming in December and January extends the opening of the snowmobile trail system. More than one period of temperatures > 0^0 C and rainfall of 20 mm to 30 mm for 3 days or more during the snowmobile season has resulted in the deterioration of the existing snow base (Respondents 3 & 5). A delay in the return to freezing temperatures and new snowfalls has limited the re-establishment of a snow base and snowmobile trails have remained closed (Respondent 3). Temperatures > 0^0 C, increased hours of sunlight and rainfall during the month of March have eliminated the remaining snow cover and first closed snowmobile trails in non-forested areas for the season (Respondents 1, 5, & 6).

The occurrence of freezing rain, more prevalent in southern snowmobile districts, is considered the most damaging to the snowmobile trail system in the short and long term (Respondents 1, 4, & 5) . Often there is insufficient warning of a freezing rain event to groom the entire snowmobile trail system. A snowmobile trail re-frozen flat followed by new snowfalls contributes to long-term snow base development. Branches are often heavily ice laden resulting in bent and fallen branches on the snowmobile trails. This effected vegetation must be removed prior to re-opening the snowmobile trail system. Volunteer time and financial resources are heavily taxed during this often lengthy process.

Temperatures < -25^0 C for extended periods of time contribute to increase ground frost penetration resulting in a delay in the spring planting on agricultural lands, and also an increased potential of grooming equipment break downs and operator safety (Respondents 2 & 4).

Snowmobile trail managers/operators have experienced as many as three consecutive snowmobile seasons in the past 10 years with ≤ 28 of snowmobile trail grooming (Respondents 1, 3, & 5). In year one an operational budget surplus may occur due in part to less snowmobile trail grooming hours and equipment maintenance expenses. In years two and three snowmobile trail permit revenues have declined upwards of 30% as snowmobilers respond to declining snowmobile season length (Respondent 3). Snowmobile trail permits have also been purchased by snowmobilers later in the snowmobile season; thus contributing to cash flow shortages at the critical pre-season period. Pre-season expenses have included fuel and equipment maintenance, safety and informational signs, culverts, and trail maintenance (e.g. brushing and bulldozing) (Respondents 1, 2, 3, 4, & 6). Non-essential operating expenses have been deferred, operational budgets have been adjusted and financial reserves have be used, where available, to offset these revenue shortfalls. Year four is the most challenging, when trail permit revenues continue to remain low and expenses rise due to increased snowmobile trail grooming hours. Snowmobile seasons with greater than 98 days have place additional pressure upon limited financial resources for operational and equipment maintenance expenses (Respondent 3).

4.3.2 Effective Snowmobile Trail Maintenance Operations

To achieve the best possible snowmobile trail product, trail grooming occurs at night when temperatures < -10^0 C prevail and snowmobile trail traffic is minimal (Respondent 1).

Night grooming also increases the safety of groomer operators and snowmobilers due to the visibility of oncoming vehicle lights and beacons (Respondent 2). Temperatures between -25^0 C and -35^0 C are reported by respondents as being optimal (Table 4.1). Daytime grooming is only desirable early in the snowmobile season to establish the trail, after heavy snowfalls, when snowmobile traffic is minimal, and when temperatures < -35^{0}C prevail (Respondent 3). The snowmobile trail requires an undisturbed time to re-freeze to establish a durable surface. A light fluffy new snowfall is considered to be optimal for processing by a multi-bladed drag (Respondent 1). The snow is rolled from side-to-side within the drag, de-aerated, and moisture is introduced due to friction and is finally compressed. Following heavy snowfalls the snowmobile trail can be packed with only the grooming vehicle's tracks or with an attached compactor bar. The use of compactor bars in the early season has also been effective to assist ground frost penetration (Respondent 1).

Table 4.1: Optimal Snowmobile Trail Grooming Temperatures

Respondent	OFSC District	Grooming Temperatures
1	11	-15^{0}C to -25^{0}C
2	16	-25^{0}C to -35^{0}C
3	12	-25^{0}C to -35^{0}C
4	7	-10^{0}C to -15^{0}C
5	6	-20^{0}C to -30^{0}C
6	4	< -10^{0}C

4.4 Season Length Projections

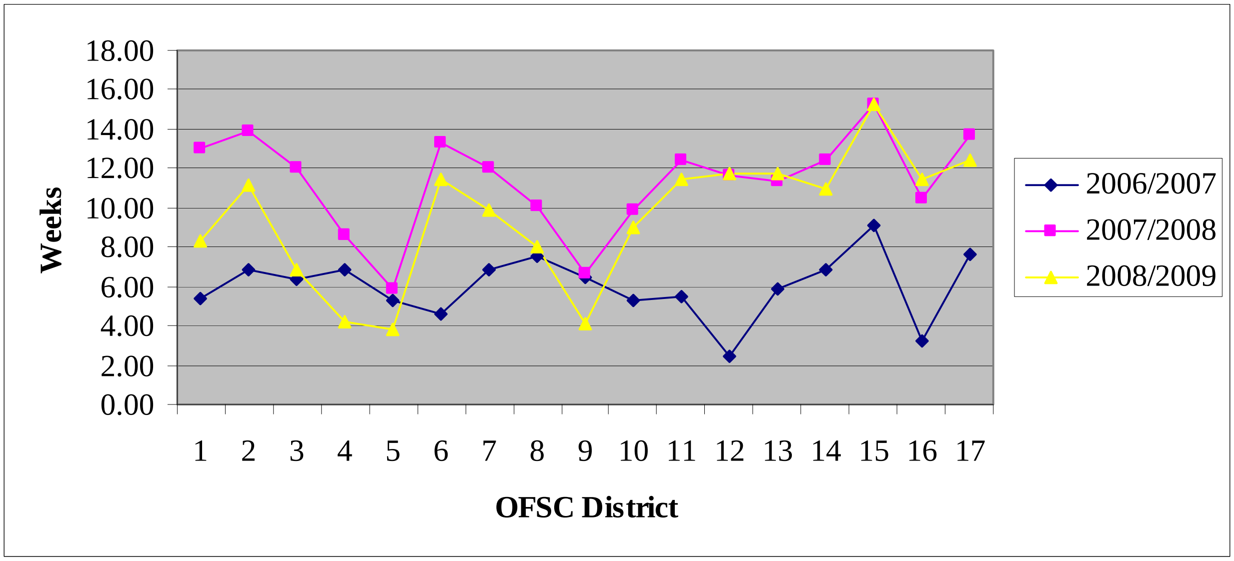
The OFSC (2008c) each week throughout the snowmobile season posts on its website, the status of each districts' snowmobile trails as: *closed* (trails are not open and unsafe for snowmobiling), *limited* (some trails are passable for marginal snowmobiling; some trails may be closed, so extra caution is advised), *open* (trails are open to snowmobiles with valid permits to enter at their own risk), and *data not available* (data has not been received). A number of key variables are considered by OFSC districts when reporting including: accumulated snow base, new snowfall, temperature, wind, terrain, and snowmobile traffic as influencing the status of the snowmobile trails (OFSC, 2008c). Snowmobile trails reported as limited and open, during the three snowmobile seasons, 2006/2007 to 2008/2009, ranged from an average of 5.01 weeks in District 5 to an average of 13.21 weeks in District 15 (Table 4.2, Figure 4.1).

Table 4.2: Trail Status Reports 3-Year Mean (2006/2007 to 2008/2009)

OFSC District	Mean Weeks				
	Season Length	Closed	Limited	Open	DNA
D1	12.67	3.72	4.06	4.87	0.02
D2	14.00	3.37	6.91	3.72	0.00
D3	13.33	4.59	4.40	4.01	0.33
D4	10.67	4.11	4.18	2.37	0.00
D5	9.33	4.32	3.00	2.01	0.00
D6	14.00	3.82	5.46	4.33	0.38
D7	12.33	2.75	3.64	5.94	0.00
D8	12.33	3.79	3.75	4.79	0.00
D9	11.00	5.29	3.74	1.97	0.00
D10	11.33	3.30	2.13	5.90	0.03
D11	12.67	2.90	3.37	6.40	0.36
D12	12.67	4.08	2.75	5.83	0.00
D13	15.00	5.30	2.88	6.79	0.03
D14	13.00	2.94	3.21	6.85	0.00
D15	15.33	2.13	1.75	11.46	0.00
D16	14.67	6.24	4.26	4.11	0.06
D17	15.00	3.71	5.76	5.50	0.03
Mean	**12.90**	**3.90**	**3.84**	**5.11**	**0.07**
SD	**1.68**	**1.04**	**1.30**	**2.26**	**0.14**

Source: (OFSC, 2009b)

Figure 4.1: Mean Weeks Reported with Limited and Open Trails



Source: (OFSC, 2009b)

In 2006/2007 the length of limited and open snowmobile trails ranged from an average of 2.4 weeks in District 12 to an average of 9.13 weeks in District 15. The 2007/2008 was the longest of the three seasons with the range of limited and open trails in District 5 reported as an average of 5.88 weeks and District 15 reported as an average of 15.25 weeks. Limited and open trails ranged in 2008/2009 from an average of 3.84 weeks in District 5 to an average of 15.25 weeks in District 15.

A critical climate threshold is the number of days during the period November 1st to April 30th when the minimum temperature is < 0^0 C (Table 4.3). Temperatures less than this threshold promote an accumulation of snow cover, the freezing of surface water and water bodies, and the penetration of ground frost, all necessary for snow base development. In the 1961-1990 baseline period District 15 experienced the most days (172.90 days / 95.52%) and District 5 the least days (142.86 days / 78.93%) a 30.04 day difference. The provincial mean for this period was 155.46 days (85.89%).

Table 4.3: Projected Mean Days with Minimum Temperatures < 0^0 C (November 1st to April 30th)

OFSC District	1961-1990	2010-2039		2040-2069		2070-2099	
		INMCM3.0	MIROC3.2	INMCM3.0	MIROC3.2	INMCM3.0	MIROC3.2
D1	150.17	-1.72	-4.03	-2.00	-5.03	-2.14	-5.97
D2	156.14	-2.17	-4.34	-2.55	-5.45	-2.45	-6.21
D3	143.55	-1.79	-2.21	-2.21	-2.21	-2.21	-2.21
D4	147.21	-4.03	-4.03	-4.03	-4.03	-4.03	-4.03
D5	142.86	-4.41	-9.93	-5.03	-11.69	-5.21	-13.72
D6	154.07	-2.52	-4.86	-2.66	-5.79	-2.59	-7.10
D7	150.00	-1.55	-4.17	-2.00	-5.14	-2.03	-6.17
D8	144.21	-1.86	-6.24	-2.07	-7.55	-2.14	-8.48
D9	146.55	-1.10	-7.10	-2.07	-8.52	-0.76	-9.41
D10	148.83	-1.52	-4.45	-1.66	-5.59	-1.00	-6.41
D11	162.03	-1.03	-1.38	-1.00	-1.45	-0.90	-1.93
D12	163.52	-1.03	-1.86	-1.00	-2.17	-0.76	-2.55
D13	154.00	-5.00	-4.93	-2.21	-6.03	-1.45	-9.07
D14	171.34	-0.69	-0.72	-0.59	-0.76	-0.76	-0.83
D15	172.90	0.03	-0.07	0.03	-0.10	0.03	-0.38
D16	167.59	-0.93	-1.21	-0.90	-1.83	-1.03	-2.24
D17	167.83	-1.52	-1.31	-1.28	-1.45	-1.28	-1.66
Mean	**155.46**	**-1.93**	**-3.70**	**-1.95**	**-4.40**	**-1.81**	**-5.20**
SD	**10.14**	**1.36**	**2.58**	**1.23**	**3.10**	**1.30**	**3.67**

District 15 is projected to have the greatest days with temperatures < 0^0 C in the INMCM3.0 B1 scenario for the 2020s to 2080s at 172.93 (95.54%) and in the MIROC3.2 A1B scenario decline from 172.83 days (95.48%) in the 2020s to 172.52 days (95.31%) in the 2080s. District 5 is projected to have the least days with temperatures < 0^0 C in the 2020s to the 2080s INMCM3.0 B1 scenario from 138.45 days (76.49%) to 137.65 days (76.05%) and in the MIROC3.2 A1B scenario from 132.93 days (73.44%) in the 2020s to 129.14 days (71.35%) in the 2080s. The mean value for the INMCM3.0 B1 scenario ranges from 153.51 days (84.81%) to 153.65 days (84.89%) and in the MIROC3.2 A1B scenario ranges from 150.26 days (83.02%) to 151.76 days (83.85%).

Another variable beneficial for planning snowmobile trail grooming operations is the mean peak snow cover (Table 4.4). Projections of mean peak snow cover will enable snowmobile trail mangers to determine which snowmobile trails requiring the greatest snow cover to open for the snowmobile season (Respondents 1 & 3). During the 1961 to 1990 baseline period mean peak snow cover ranged from 66.65 cm in District 10 to 23.28 cm in District 4. The provincial mean for this time period was 42.45 cm.

Table 4.4: Projected Change in Mean Peak Snow Cover (cm)

OFSC District	1961-1990	2010-2039		2040-2069		2070-2099	
		INMCM3.0	MIROC3.2	INMCM3.0	MIROC3.2	INMCM3.0	MIROC3.2
D1	35.18	7.10	-21.59	3.96	-6.86	3.43	-9.17
D2	35.01	10.35	-5.88	7.29	-9.08	6.84	-10.72
D3	24.62	7.73	-2.87	5.15	-4.57	4.63	-6.49
D4	23.28	-2.35	-1.53	-4.02	-3.23	-3.99	-5.16
D5	29.34	-8.76	-8.97	-9.59	-11.08	-9.47	-13.02
D6	45.00	6.16	-8.07	3.56	-11.74	3.66	-14.04
D7	47.64	5.25	-11.21	2.20	-15.25	1.67	-19.71
D8	30.63	7.10	-3.98	4.56	-7.03	4.13	-9.42
D9	44.46	-6.00	-16.98	-7.49	-19.44	-1.55	-22.72
D10	66.65	-4.34	-19.25	-5.61	-25.83	1.12	-30.69
D11	54.42	19.38	4.01	16.43	-0.84	16.07	-5.31
D12	50.45	12.14	9.02	12.00	8.45	15.65	4.02
D13	56.67	-6.84	-20.15	-7.58	-24.53	-1.71	-27.02
D14	61.77	21.58	21.59	20.08	20.71	22.43	15.29
D15	60.99	25.41	26.17	24.43	26.47	27.33	21.67
D16	27.71	14.88	10.96	12.61	7.51	13.77	5.60
D17	27.87	17.87	12.77	17.15	11.10	18.00	9.08
Mean	**42.45**	**7.45**	**-2.11**	**5.60**	**-3.84**	**7.18**	**-6.93**
SD	**14.33**	**10.45**	**14.40**	**10.37**	**14.75**	**10.05**	**14.46**

The greatest increase in mean peak snow cover during the 2020s to 2080s is projected to occur in District 15 in the INMCM3.0 B1 scenario (25.41 cm to 27.33 cm) and in the MIROC3.2 A1B scenario (21.67 cm to 26.47 cm). The greatest decline in mean peak snow cover is projected to occur during the 2020s to 2080s in District 5 in the INMCM3.0 B1 scenario (-8.76 cm to -9.59 cm). In the MIROC3.2 A1B scenario the greatest decline is projected in District 1 is projected in the 2020s (-21.59 cm) and District 10 in the 2050s (-25.83 cm) and in the 2080s (-30.69 cm). The mean value in the INMCM3.0 B1 scenario ranges from (48.05 cm to 49.90 cm) and in the MIROC3.2 A1B scenario from (35.52 cm to 40.34 cm).

Senior snowmobile trail managers/operators identified three critical thresholds of snow cover (15 cm, 30 cm, and 60 cm) to commence snowmobile trail grooming operations over varying terrain (Table 4.5). A snow cover threshold of 5 cm identified by Scott et al. (2002) was lower than those identified by the trail managers/operators. The snow cover threshold of 15 cm is confirmed in studies by McBoyle et al. (2007) in Canada and Scott et al. (2008) in North-Eastern US, as the minimum snow cover to open snowmobile trails on smooth terrain. McBoyle et al. (2007) also identified the requirement of 30 cm of snow cover to open rough terrain snowmobile trails. The 60 cm snow cover threshold was not discussed in the literature. Snowmobile trail types requiring a minimum snow cover of 15 cm may include; abandoned railway corridors, agricultural lands, and graded forest access roads. Snow cover of 30 cm may be required in forested and rocky terrain and 60 cm in extreme localized rough terrain. These snow cover thresholds were used to calculate projected average snowmobile season lengths in the periods 1961-1990 (baseline), 2010-2039 (Table 4.6), 2040-2069 (Table 4.8), and 2070-2099 (Table 4.10). District season lengths are provided in Appendices 8 to 25.

Table 4.5: Snow Cover Thresholds

Respondent	OFSC District	Smooth Trails	Rough Trails
1	11	10cm to 15cm	No Response
2	16	20cm to 30cm	90cm
3	12	15cm to 30cm	50cm to 60cm
4	7	15cm	60cm
5	6	20cm	30cm
6	4	15cm to 20cm	60cm to 90cm

Snowmobile trail managers prepare annual operational budgets assuming an average of 70 days of trail grooming operations. Trail grooming of ≤ 28 days are considered by respondents as a poor season which has negatively effected volunteer attraction and retention and the following seasons trail permit revenues (Respondents 1, 3, & 5). Managers consider trail and grooming expenses and revenues from trail permits, fundraising, sponsorship, marketing, and grants. Projections of season lengths > 28 days are summarized for the 2010 to 2039 (Table 4.7), 2040 to 2069 (Table 4.9), and 2070 to 2099 (Table 4.11) time periods.

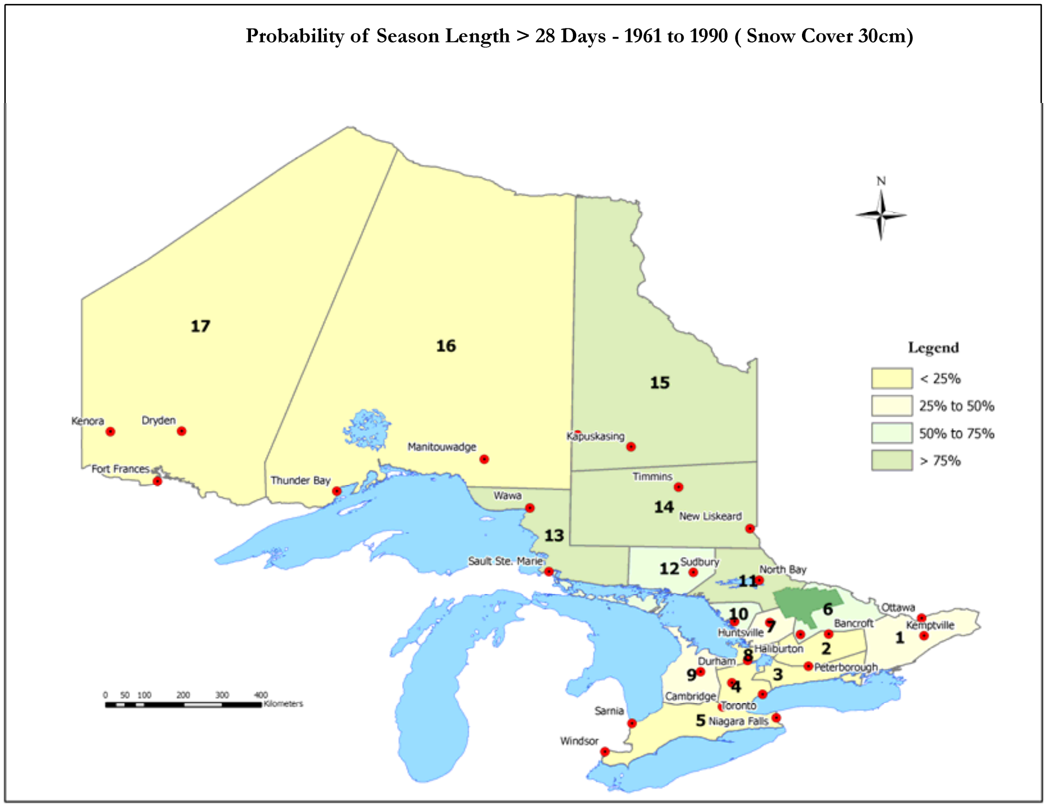
4.4.1 The 1961 - 1990 Baseline Period (Figure 4.2)

Five districts (3, 4, 5, 16, & 17) experienced a mean peak snow cover of ≥ 15 cm and two districts (14 & 15) experienced a mean peak snow cover of ≥ 60 cm. The provincial mean was 42.45 cm.

At a snow cover threshold of 15 cm, District 15 had the greatest average season length (109.10 days) and District 4 the least (20.41 days). The provincial mean value was 57.16 days. Fourteen districts (1, 2, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, & 17) had average season lengths > 28 days.

District 15 had the greatest average season length at a snow cover threshold of 30 cm (73.45 days) and Districts 3 and 4 the least (2.03 days). The provincial mean value was 28.61 days. Seven districts (7, 10, 11, 12, 13, 14, & 15) had average season lengths > 28 days. At a snow cover threshold of 60 cm, District 14 had the greatest average season length (11.59 days) and Districts 3, 4, 5, 16, and 17, the least (0 days). The provincial mean value was 4.16 days. There were no districts with season lengths > 28 days.

Figure 4.2: Probability of Season Length > 28 Days - 1961 to 1990 - INMCM3.0 B1 (Snow Cover 30 cm)



4.4.2 The 2010 - 2039 Period (Tables 4.6 & 4.7, Figure 4.3)

At a snow cover threshold of 15 cm in the INMCM3.0 B1 and MIROC3.2 A1B scenarios District 17 is projected to have the greatest increase in average season length (10.34 days & 2.48 days) and District 13 the greatest decline (-25.86 days) in the INMCM3.0 B1 scenario and in the MIROC3.2 A1B scenario (-46.55 days). The provincial mean values are 45.34 days and 35.68 days respectively. Twelve districts (1, 2, 6, 7, 10, 11, 12, 13, 14, 15, 16, & 17) in the INMCM3.0 B1 scenario and eight districts (10, 11, 12, 13, 14, 15, 16, &17) in the MIROC3.2 A1B scenario are projected to have average season lengths > 28 days.

At a snow cover threshold of 30 cm District 17 is projected in the INMCM3.0 B1 and MIROC3.2 A1B scenarios to have the greatest increase in average season length (31.93 days & 19.17 days) and District 13 the greatest decline (-21.10 days & -38.00 days). The provincial mean values are 29.45 days and 20.41 days. Six districts (10, 11, 12, 14, 15, & 17) in the INMCM3.0 B1 scenario and four districts (11, 12, 14, & 15) in the MIROC3.2 A1B scenario are projected to have average season lengths > 28 days.

At a snow cover threshold of 60 cm District 15 in the INMCM3.0 B1 and MIROC3.2 A1B scenarios is projected to have the greatest increase in average season length (31.72 days & 30.69 days). District 10 is projected to have the greatest decline in average season length in the INMCM3.0 B1 and MIROC3.2 A1B scenarios (-7.62 days & -13.97 days). The provincial mean values are 9.58 days and 6.87 days. Two districts (14 & 15) are projected in the INMCM3.0 B1 and MIROC3.2 A1B scenarios to have average season lengths > 28 days.

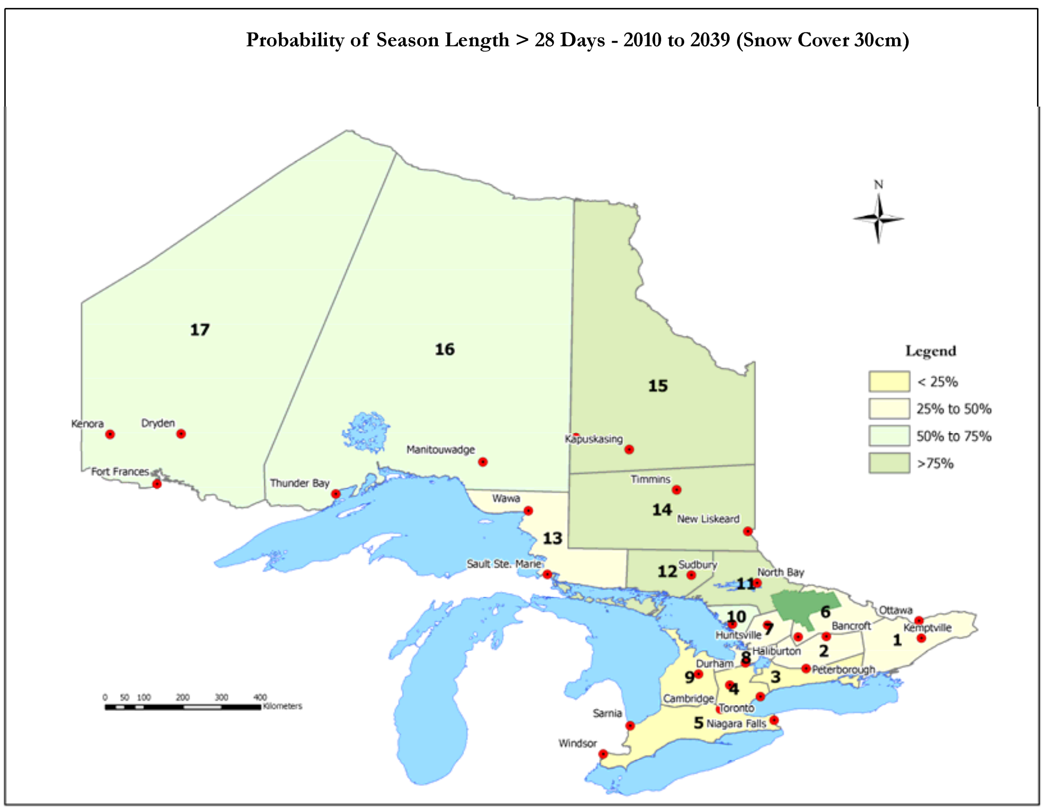
Table 4.6: Mean Projected Change in Snowmobile Season Length - 2010 to 2039 (Days)

OFSC District	15cm Snow Cover			30cm Snow Cover			60cm Snow Cover		
	1961-1990	INMCM3.0	MIROC3.2	1961-1990	INMCM3.0	MIROC3.2	1961-1990	INMCM3.0	MIROC3.2
D1	43.03	-12.10	-21.48	18.38	-0.62	-10.31	0.28	2.83	-0.03
D2	50.79	-14.83	-33.69	15.59	4.69	-9.66	0.21	4.10	-0.07
D3	27.10	-7.14	-18.24	2.03	6.38	-0.31	0.00	0.52	0.17
D4	20.41	-13.14	-15.10	2.03	-1.45	-1.72	0.00	0.00	0.00
D5	27.31	-21.31	-22.17	9.00	-7.38	-7.52	0.00	0.00	0.00
D6	53.48	-15.76	-26.41	28.00	-2.45	-15.34	4.34	3.24	-1.31
D7	52.38	13.41	-24.59	28.38	-4.76	-16.86	4.14	2.65	-3.38
D8	32.83	-7.24	-20.76	11.41	2.31	-8.62	0.31	0.66	-0.31
D9	51.83	-25.59	-42.21	26.79	-15.72	-24.17	1.03	-1.03	-1.03
D10	64.14	-21.03	-34.76	45.83	-15.41	-29.59	19.07	-7.62	-13.97
D11	85.34	-15.83	-25.59	53.07	-0.21	-14.48	8.93	16.97	3.97
D12	75.41	-10.24	-14.83	42.86	3.14	-2.83	2.17	11.62	12.14
D13	75.38	-25.86	-46.55	46.34	-21.10	-38.00	7.52	-3.76	-6.62
D14	97.55	-7.31	-9.93	62.93	8.72	5.38	11.59	24.55	22.76
D15	109.10	-6.86	-7.86	73.45	6.90	5.17	11.10	31.72	30.69
D16	47.17	6.38	-3.41	10.48	19.34	10.24	0.00	2.24	1.41
D17	58.38	10.34	2.48	9.83	31.93	19.17	0.00	3.48	1.69
Mean	**57.16**	**-10.24**	**-21.48**	**28.61**	**0.84**	**-8.20**	**4.16**	**5.42**	**2.71**
SD	**24.98**	**11.49**	**13.11**	**21.87**	**12.75**	**14.49**	**5.62**	**10.20**	**10.48**

Table 4.7: Percentage of Season Length > 28 Days - 2010 to 2039

OFSC District	Snow Cover (15cm)			Snow Cover (30cm)			Snow Cover (60cm)		
	1961-1990	INMCM3.0	MIROC3.2	1961-1990	INMCM3.0	MIROC3.2	1961-1990	INMCM3.0	MIROC3.2
1	65.52%	48.28%	41.38%	34.48%	31.03%	13.79%	0.00%	3.45%	0.00%
2	79.31%	65.52%	24.14%	24.14%	34.48%	6.90%	0.00%	6.90%	0.00%
3	58.62%	31.03%	6.90%	3.45%	13.79%	3.45%	0.00%	0.00%	0.00%
4	34.48%	6.90%	3.45%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
5	51.72%	3.45%	6.90%	17.24%	3.45%	3.45%	0.00%	0.00%	0.00%
6	79.31%	62.07%	48.28%	51.72%	48.28%	20.69%	3.45%	13.79%	3.45%
7	79.31%	75.86%	41.38%	48.28%	31.03%	20.69%	3.45%	10.34%	0.00%
8	51.72%	34.48%	17.24%	13.79%	27.59%	3.45%	0.00%	0.00%	0.00%
9	82.76%	37.93%	6.90%	44.83%	17.24%	0.00%	0.00%	0.00%	0.00%
10	89.66%	82.76%	51.72%	72.41%	58.62%	20.69%	37.93%	20.69%	13.79%
11	96.55%	96.55%	86.21%	75.86%	79.31%	65.52%	10.34%	48.28%	20.69%
12	100.00%	100.00%	96.55%	65.52%	86.21%	72.41%	3.45%	27.59%	27.59%
13	100.00%	86.21%	44.83%	75.86%	44.83%	17.24%	10.34%	10.34%	0.00%
14	100.00%	96.55%	96.55%	89.66%	96.55%	96.55%	24.14%	65.52%	62.07%
15	100.00%	100.00%	100.00%	96.55%	100.00%	100.00%	6.90%	65.52%	65.52%
16	62.07%	86.21%	72.41%	17.24%	51.72%	34.48%	0.00%	3.45%	3.45%
17	75.86%	89.66%	82.76%	13.79%	65.52%	44.83%	0.00%	6.90%	3.45%
Mean	**76.88%**	**64.91%**	**48.68%**	**43.81%**	**46.45%**	**30.83%**	**5.88%**	**16.63%**	**11.76%**
SD	**20.13%**	**32.26%**	**34.78%**	**31.17%**	**31.11%**	**33.31%**	**10.40%**	**22.26%**	**21.22%**

Figure 4.3: Probability of Season Length > 28 Days - 2010 to 2039 - INMCM3.0 B1 (Snow Cover 30 cm)



4.4.3 The 2040 - 2069 Period (Tables 4.8 & 4.9, Figure 4.4)

At a snow cover threshold of 15 cm in the INMCM3.0 B1 scenario District 17 is projected to have the greatest increase in average season length (8.76 days). District 9 is projected to have the greatest decline in the INMCM3.0 B1 (-17.76 days) and District 13 in the MIROC3.2 A1B (-52.86 days). The provincial mean values are 43.58 days and 31.82 days. Twelve districts (1, 2, 6, 7, 10, 11, 12, 13, 14, 15, 16, & 17) in the INMCM3.0 B1 scenario and six districts (11, 12, 14, 15, 16, & 17) in the MIROC3.2 A1B scenario are projected to have average season lengths > 28 days.

At a 30 cm snow cover threshold District 17 in the INMCM3.0 B1 and MIROC3.2 A1B scenarios is projected to have the greatest increase in average season length (29.59 days & 16.00 days). The greatest decline in the INMCM3.0 B1 and MIROC3.2 A1B scenarios is projected for District 13 (-21.90 days & -41.14 days). The provincial mean values are 27.70 days and 17.98 days. Six districts (10, 11, 12, 14, 15, & 17) in the INMCM3.0 B1 and four districts (11, 12, 14, & 15) in the MIROC3.2 A1B scenarios are projected to have average season lengths > 28 days.

At a snow cover threshold of 60 cm District 15 in the INMCM3.0 B1 and MIROC3.2 A1B scenarios is projected to have the greatest increase in average season length (29.79 days & 30.69 days). District 13 is projected to have the greatest decline in average season length (-4.28 days) in the INMCM3.0 B1 scenario and District 10 in the MIROC3.2 A1B scenario (-15.86 days). The provincial mean values are 8.71 days and 6.39 days. Districts 14 and 15 are projected to have average season lengths > 28 days in the INMCM3.0 B1 and MIROC3.2 A1B scenarios.

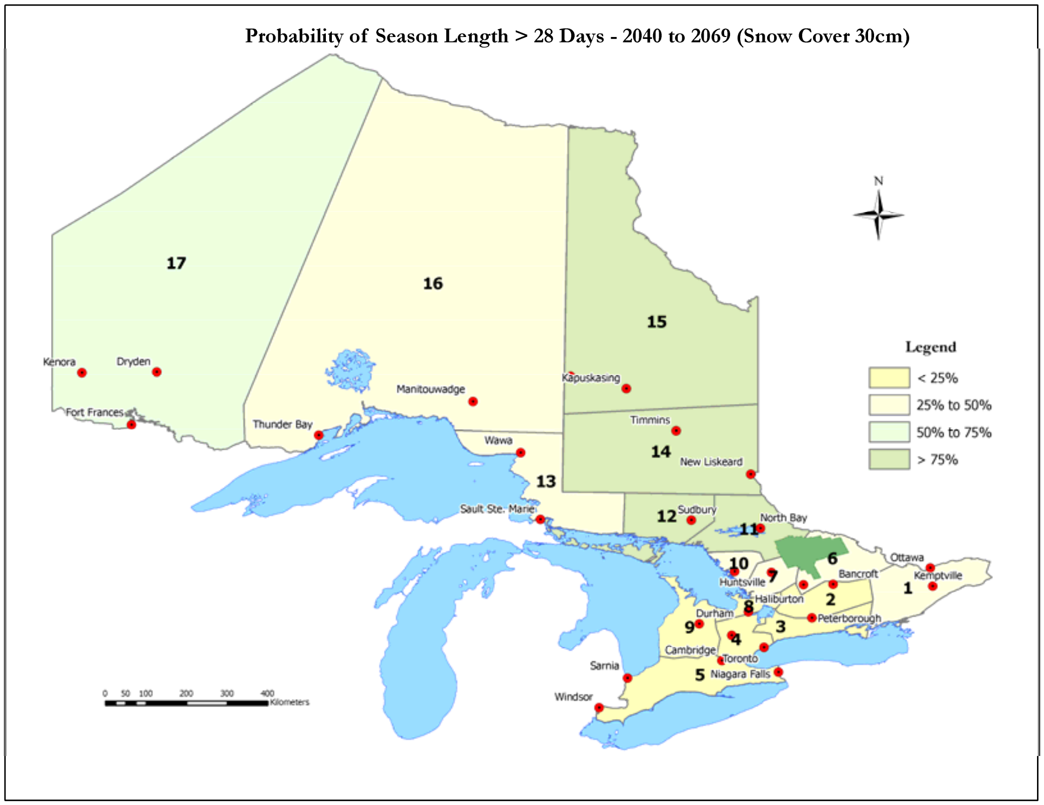
Table 4.8: Mean Projected Change in Snowmobile Season Length - 2040 to 2069 (Days)

OFSC District	15cm Snow Cover			30cm Snow Cover			60cm Snow Cover		
	1961-1990	INMCM3.0	MIROC3.2	1961-1990	INMCM3.0	MIROC3.2	1961-1990	INMCM3.0	MIROC3.2
D1	43.03	-13.90	-25.34	18.38	-3.93	-14.62	0.28	1.72	-0.14
D2	50.79	-17.93	-37.59	15.59	1.00	-11.00	0.21	2.34	-0.21
D3	27.10	-9.21	-21.00	2.03	4.69	-0.69	0.00	0.52	0.00
D4	20.41	-15.59	-17.48	2.03	-1.69	-2.00	0.00	0.00	0.00
D5	27.31	-22.00	-23.66	9.00	-7.55	-7.79	0.00	0.00	0.00
D6	53.48	-17.52	-30.21	28.00	-4.83	-18.28	4.34	1.59	-2.34
D7	52.38	-15.45	-29.35	28.38	-5.76	-21.86	4.14	1.10	-4.14
D8	32.83	-9.14	-25.45	11.41	0.03	-9.76	0.31	-0.10	-0.31
D9	51.83	-27.76	-44.14	26.79	-17.48	-25.28	1.03	-0.86	-1.03
D10	64.14	-22.90	-40.93	45.83	-16.72	-35.72	19.07	-8.59	-15.86
D11	85.34	-18.24	-30.14	53.07	-2.59	-18.28	8.93	13.34	2.24
D12	75.41	-11.24	-16.93	42.86	2.28	-5.34	2.17	12.17	12.14
D13	75.38	-27.41	-52.86	46.34	-21.90	-41.14	7.52	-4.28	-7.38
D14	97.55	-8.17	-11.79	62.93	7.52	2.97	11.59	22.86	21.21
D15	109.10	-7.41	-10.41	73.45	5.76	3.69	11.10	29.79	30.69
D16	47.17	4.28	-10.24	10.48	16.14	8.34	0.00	2.03	1.45
D17	58.38	8.76	-3.21	9.83	29.59	16.00	0.00	3.66	1.55
Mean	**57.16**	**-13.58**	**-25.34**	**28.61**	**-0.91**	**-10.63**	**4.16**	**4.55**	**2.23**
SD	**24.98**	**9.82**	**13.33**	**21.87**	**12.36**	**15.21**	**5.62**	**9.71**	**10.59**

Table 4.9: Percentage of Season Length > 28 Days - 2040 to 2069

OFSC District	15cm Snow Cover			30cm Snow Cover			60cm Snow Cover		
	1961-1990	INMCM3.0	MIROC3.2	1961-1990	INMCM3.0	MIROC3.2	1961-1990	INMCM3.0	MIROC3.2
D1	65.52%	48.28%	24.14%	34.48%	27.59%	6.90%	0.00%	3.45%	0.00%
D2	79.31%	58.62%	13.79%	24.14%	24.14%	6.90%	0.00%	3.45%	0.00%
D3	58.62%	24.14%	3.45%	3.45%	10.34%	0.00%	0.00%	0.00%	0.00%
D4	34.48%	3.45%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
D5	51.72%	3.45%	6.90%	17.24%	3.45%	3.45%	0.00%	0.00%	0.00%
D6	79.31%	65.52%	37.93%	51.72%	48.28%	17.24%	3.45%	10.34%	6.90%
D7	79.31%	72.41%	37.93%	48.28%	34.48%	10.34%	3.45%	6.90%	0.00%
D8	51.72%	34.48%	3.45%	13.79%	17.24%	0.00%	0.00%	0.00%	0.00%
D9	82.76%	31.03%	3.45%	44.83%	10.34%	0.00%	0.00%	0.00%	0.00%
D10	89.66%	79.31%	34.48%	72.41%	44.83%	17.24%	37.93%	20.69%	6.90%
D11	96.55%	93.10%	86.21%	75.86%	79.31%	51.72%	10.34%	41.38%	20.69%
D12	100.00%	100.00%	96.55%	65.52%	82.76%	65.52%	3.45%	27.59%	34.48%
D13	100.00%	86.21%	31.03%	75.86%	44.83%	6.90%	10.34%	6.90%	0.00%
D14	100.00%	96.55%	96.55%	89.66%	96.55%	96.55%	24.14%	62.07%	62.07%
D15	100.00%	100.00%	100.00%	96.55%	100.00%	100.00%	6.90%	68.97%	65.52%
D16	62.07%	86.21%	58.62%	17.24%	44.83%	34.48%	0.00%	3.45%	3.45%
D17	75.86%	86.21%	79.31%	13.79%	68.97%	41.38%	0.00%	6.90%	3.45%
Mean	**76.88%**	**62.88%**	**41.99%**	**43.81%**	**43.41%**	**26.98%**	**5.88%**	**15.42%**	**11.97%**
SD	**20.13%**	**33.00%**	**36.84%**	**31.17%**	**32.21%**	**33.24%**	**10.40%**	**22.02%**	**21.57%**

Figure 4.4: Probability of Season Length > 28 Days - 2040 to 2069 - INMCM3.0 B1 (Snow Cover 30 cm)



4.4.4 The 2070 - 2099 Period (Tables 4.10 & 4.11, Figure 4.5)

At a snow cover threshold of 15 cm District 17 is projected to have the greatest increase in average season length (9.79 days) in the INMCM3.0 B1 scenario. District 5 is projected to have the greatest decline in average season length in the INMCM3.0 B1 scenario (-22.52 days) and District 13 in the MIROC3.2 A1B scenario (-56.03 days). The provincial mean values are 44.77 days and 28.70 days. Twelve districts (2, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, & 17) in the INMCM3.0 B1 scenario and six districts (11, 12, 14, 15, 16, & 17) in the MIROC3.2 A1B scenario are projected to have average season lengths > 28 days.

At a snow cover threshold of 30 cm District 17 is projected to have the greatest increase in average season length in the INMCM3.0 B1 scenario (30.76 days) and in the MIROC3.2 A1B scenario (12.66 days). District 13 is projected to have the greatest decline in average season length in the INMCM3.0 B1 scenario (-13.59 days) and in the MIROC3.2 A1B (-40.76 days). The provincial mean average season lengths are 29.11 days and 15.78 days. Eight districts (10, 11, 12, 13, 14, 15, 16, & 17) in the INMCM3.0 B1 and three districts (12, 14, & 15) in the MIROC3.2 A1B scenarios are projected to have average season lengths > 28 days.

At a snow cover threshold of 60 cm District 15 in the INMCM3.0 B1 and MIROC3.2 A1B scenarios is projected to have the greatest increase in average season length (34.31 days & 24.59 days) The greatest decline in average season length is projected to occur in the INMCM3.0 B1 and MIROC3.2 A1B scenarios in District 10 (-3.69 days & -16.83 days). The provincial mean values are 9.87 days and 5.22 days. Two districts (14 & 15) in the INMCM3.0 B1 scenario and one district (15) in the MIROC3.2 A1B scenario are projected to have average season lengths > 28 days.

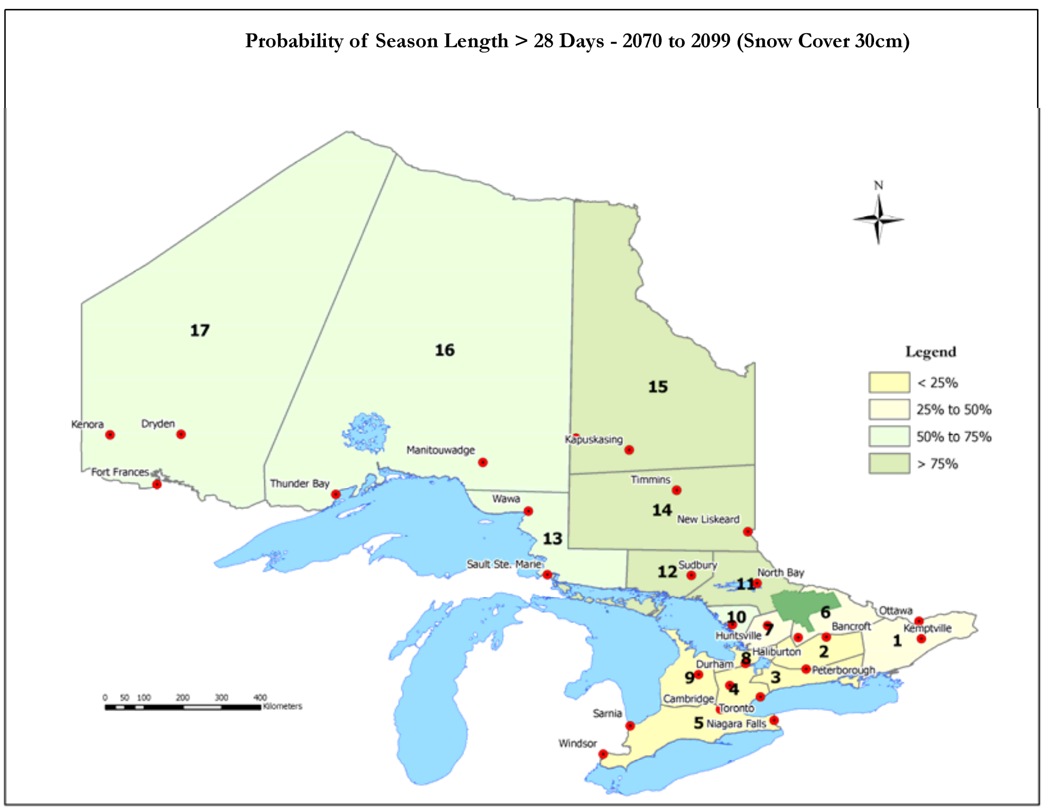
Table 4.10: Mean Projected Change in Snowmobile Season Length - 2070 to 2099 (Days)

OFSC District	15cm Snow Cover			30cm Snow Cover			60cm Snow Cover		
	1961-1990	INMCM3.0	MIROC3.2	1961-1990	INMCM3.0	MIROC3.2	1961-1990	INMCM3.0	MIROC3.2
D1	43.03	-15.69	-29.69	18.38	-4.48	-16.28	0.28	1.79	-0.28
D2	50.79	-17.86	-39.52	15.59	0.24	-12.69	0.21	1.79	-0.21
D3	27.10	-9.93	-21.97	2.03	4.41	-0.97	0.00	0.55	0.00
D4	20.41	-15.34	-18.00	2.03	-1.90	-2.03	0.00	0.00	0.00
D5	27.31	-22.52	-24.48	9.00	-7.55	-8.76	0.00	0.00	0.00
D6	53.48	-17.93	-33.83	28.00	-5.72	-19.14	4.34	2.28	-3.07
D7	52.38	-15.48	-36.00	28.38	-6.31	-25.62	4.14	0.58	-4.14
D8	32.83	-10.14	-27.86	11.41	-0.93	-10.52	0.31	0.31	-0.31
D9	51.83	-21.07	-46.14	26.79	-12.14	-26.17	1.03	0.28	-1.03
D10	64.14	-18.10	-45.79	45.83	-10.59	-38.90	19.07	-3.69	-16.83
D11	85.34	-18.62	-33.59	53.07	-3.48	-25.66	8.93	12.41	-0.17
D12	75.41	-7.62	-21.90	42.86	7.07	-9.97	2.17	14.17	8.38
D13	75.38	-20.83	-56.03	46.34	-13.59	-40.76	7.52	-0.07	-7.45
D14	97.55	-8.31	-14.45	62.93	7.86	-0.17	11.59	25.14	15.66
D15	109.10	-6.45	-12.76	73.45	6.76	1.00	11.10	34.31	24.59
D16	47.17	5.52	-15.00	10.48	17.97	5.90	0.00	2.72	1.34
D17	58.38	9.79	-6.76	9.83	30.76	12.66	0.00	4.59	1.59
Mean	**57.16**	**-12.39**	**-28.46**	**28.61**	**0.49**	**-12.83**	**4.16**	**5.72**	**1.06**
SD	**24.98**	**9.04**	**13.50**	**21.87**	**11.32**	**15.12**	**5.62**	**10.20**	**8.91**

Table 4.11: Percentage of Season Length > 28 Days - 2070 to 2099

OFSC District	15cm Snow Cover			30cm Snow Cover			60cm Snow Cover		
	1961-1990	INMCM3.0	MIROC3.2	1961-1990	INMCM3.0	MIROC3.2	1961-1990	INMCM3.0	MIROC3.2
D1	65.52%	44.83%	13.79%	34.48%	27.59%	3.45%	0.00%	3.45%	0.00%
D2	79.31%	65.52%	10.34%	24.14%	24.14%	3.45%	0.00%	3.45%	0.00%
D3	58.62%	27.59%	6.90%	3.45%	10.34%	0.00%	0.00%	0.00%	0.00%
D4	34.48%	6.90%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
D5	51.72%	3.45%	3.45%	17.24%	3.45%	0.00%	0.00%	0.00%	0.00%
D6	79.31%	62.07%	34.48%	51.72%	44.83%	17.24%	3.45%	10.34%	0.00%
D7	79.31%	65.52%	13.79%	48.28%	34.48%	3.45%	3.45%	3.45%	0.00%
D8	51.72%	34.48%	3.45%	13.79%	17.24%	0.00%	0.00%	0.00%	0.00%
D9	82.76%	48.28%	3.45%	44.83%	20.69%	0.00%	0.00%	0.00%	0.00%
D10	89.66%	82.76%	24.14%	72.41%	68.97%	10.34%	37.93%	31.03%	3.45%
D11	96.55%	93.10%	86.21%	75.86%	79.31%	44.83%	10.34%	37.93%	13.79%
D12	100.00%	100.00%	96.55%	65.52%	93.10%	62.07%	3.45%	31.03%	10.34%
D13	100.00%	96.55%	27.59%	75.86%	58.62%	6.90%	10.34%	10.34%	0.00%
D14	100.00%	96.55%	96.55%	89.66%	96.55%	93.10%	24.14%	65.52%	55.17%
D15	100.00%	100.00%	100.00%	96.55%	100.00%	100.00%	6.90%	75.86%	58.62%
D16	62.07%	86.21%	41.38%	17.24%	51.72%	31.03%	0.00%	6.90%	3.45%
D17	75.86%	93.10%	72.41%	13.79%	68.97%	37.93%	0.00%	6.90%	3.45%
Mean	**76.88%**	**65.11%**	**37.32%**	**43.81%**	**47.06%**	**24.34%**	**5.88%**	**16.84%**	**8.72%**
SD	**20.13%**	**32.57%**	**37.46%**	**31.17%**	**33.21%**	**32.93%**	**10.40%**	**23.64%**	**18.57%**

Figure 4.5: Probability of Season Length > 28 Days - 2070 to 2099 - INMCM3.0 B1 (Snow Cover 30 cm)



4.5 Potential Responses to Perceived Risks of Climate Change

4.5.1 Technological Strategies

The past reliance upon natural snowfalls and temperatures < 0^0 C are anticipated by respondents to continue into all future time periods. The most effective strategy used by snowmobile trail managers to achieve long season lengths has been the preparation of the terrain (e.g. grading, vegetation management, and water crossings) prior to first snowfalls (Respondents 4, 5, & 6). Snowmobile trail managers, early in the snowmobile season, may continue these activities when grooming operations may be delayed due to limited snow cover and temperatures > 0^0 C.

Early in the snowmobile season trail managers have used different grooming equipment to prepare the snowmobile trails (Respondents 3 & 4). Lighter (psi) grooming equipment is preferred to open snowmobile trails with marshes and swamps. These areas are slow to freeze and often delay the opening of the snowmobile trail system. Respondent 4 stated "The BR made it over this marsh twice. We put the tractor in and it dropped through the ice… so obviously the requirements to pull that kind of weight are far greater than a BR as it would be for a Lamtrac or a Snow Cat or whatever… we don't take our drags out; we have a compactor bar on the back of the BR and so what we are trying to do is just drive the frost into the ground where we want the trail … then once we are set up then we bring out the big tractor."

As early as the 2020s four snowmobile districts (3, 4, 5, & 9) at a snow cover threshold of 30 cm are projected to have < 25% of snowmobile seasons with > 28 days and another six districts (1, 2, 6, 7, 8, & 13) are projected to have between 25% to 50% of snowmobile seasons with > 28 days. Snowmobile trails managers in these snowmobile districts may consider opening trails in seasons when snow cover and temperatures are projected to be reliable and closing trails when conditions are not reliable. Snowmobile trail operations may be consolidated into less vulnerable snowmobile districts (e.g. 11, 12, 14, & 15) where snow cover and temperatures are most reliable and projected season lengths are the longest. New snowmobile trails, particularly loop trails, may be required in these snowmobile districts as destinations for snowmobiling decline in southern snowmobile districts. Travel from Southern Ontario markets to northern snowmobile districts is within a one days drive (500 km to 1,200 km) (Respondent 5).

Snowmobile trail managers, when snow cover is limited and temperatures are too warm for grooming snowmobile trails, will temporarily close the trails and wait for new snowfalls and colder temperatures to resume grooming operations. During this period of time equipment maintenance may be performed in preparation to a return to full grooming operations (Respondent 4).

Technological advancements in snowmaking and cloud seeding are not expected to be viable options in any snowmobile district with a linear snowmobile trail system (Respondent 3). However, snowmaking may become viable in a snowmobile resort setting like the Haliburton Forest & Wildlife Reserve (HFWR) where an intensive snowmobile trail system of 300 km has been developed in 24,000 ha in Central Ontario. Numerous lakes adjacent to snowmobile trails provide a water supply for a mobile snowmaking system (Haliburton Forest & Wildlife Reserve, 2009).

4.5.2 Business Strategies

Snowmobile clubs may need to undertake short-term and long-term business strategies to sustain snowmobile tourism in response to a changing climate. Stronger inter-district alliances may be necessary to maintain viable snowmobile touring routes. Three snowmobile districts (6, 7, & 11) are presently marketing a four day circle tour of Algonquin Provincial Park

(Respondents 1 & 5). These alliances may also increase the capacity of these areas to manage extreme climatic events (e.g. freezing rain, snowfalls, and wind storms) by utilizing shared physical and human resources.

Alliances with other recreational user groups (e.g. ATV, hiking, etc.) and municipalities may be needed in order to develop and operate new four season trails on abandoned rail bed corridors, where for snowmobiling less snow cover may be required for grooming operations. Presently the Eastern Ontario Trails Alliance manages multi-use trails on abandoned railway corridors used by ATV, snowmobiles, horseback riders, and cyclists. Infrastructure (e.g. bridges) and trail maintenance equipment may be shared minimizing the costs of acquisition and operation to any single group. Respondent 2 highlighted some local concerns, “Some don’t want the rail bed turned into any kind of a trail network because it might bother their camps or this or that… if we have it organized it can be policed. The more people riding it the less likely that someone is stopping and robbing someone’s camp.” Organizing the trail operations may enable benefits for both the user groups and adjacent landowners

Public and private sector alliances are presently assisting in the development and delivery of provincial programs (e.g. environment and safety) administered by the OFSC (Respondent 1). In response to climate change new programs may be required that leverage financial and human capital for the development of adaptation strategies (e.g. education and risk management). Snowmobile clubs need to be involved, at the early stages, into the land use planning process to secure viable snowmobile trail routes, particularly with corridors (e.g. abandoned railway and road allowances), highway and water crossings (Respondent 3). Media relations may be needed to be strengthened to increase the awareness of potential impacts of climate change (e.g. environmental sensitivity and destinations for snowmobile tourism).

4.6 Summary

This chapter examined the influence of projected climate change on the length of the snowmobile season in Ontario and potential supply-side responses. Three snow cover thresholds identified by respondents to begin snowmobile trail grooming operations were used to calibrate a snow model and project season lengths in the 2020s, 2050s, and 2080s. A season length of ≤ 28 days is considered by respondents to be a poor snowmobile season.

In the 2020s, snowmobile season lengths ≤ 28 days with a snow cover threshold of 15 cm (Figure 4.6) are projected to occur in five snowmobile districts (3, 4, 5, 8, & 9) and with a snow cover threshold of 30 cm in 10 snowmobile districts (1, 2, 3, 4, 5, 6, 7, 8, 9, & 13) (Figure 4.7). At a snow cover threshold of 60 cm, only 2 snowmobile districts (14 & 15) are projected to have season lengths > 28 days.

Figure 4.6: Mean Season Length > 28 Days - 2010 to 2039 (Snow Cover 15 cm)

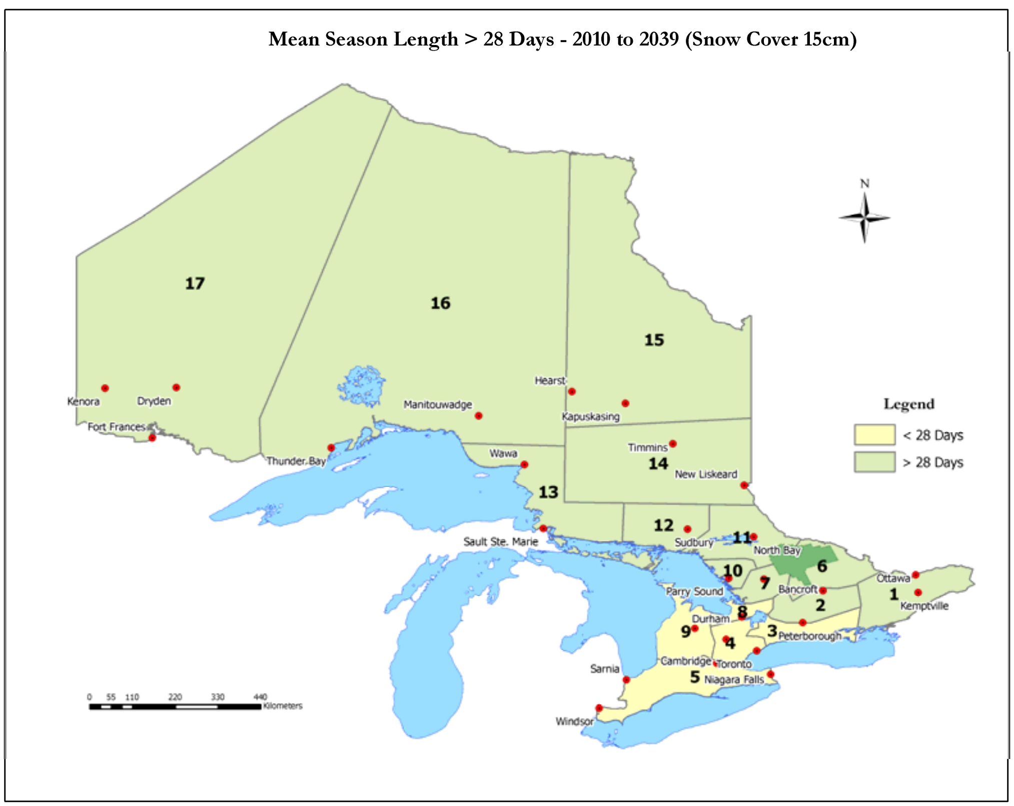
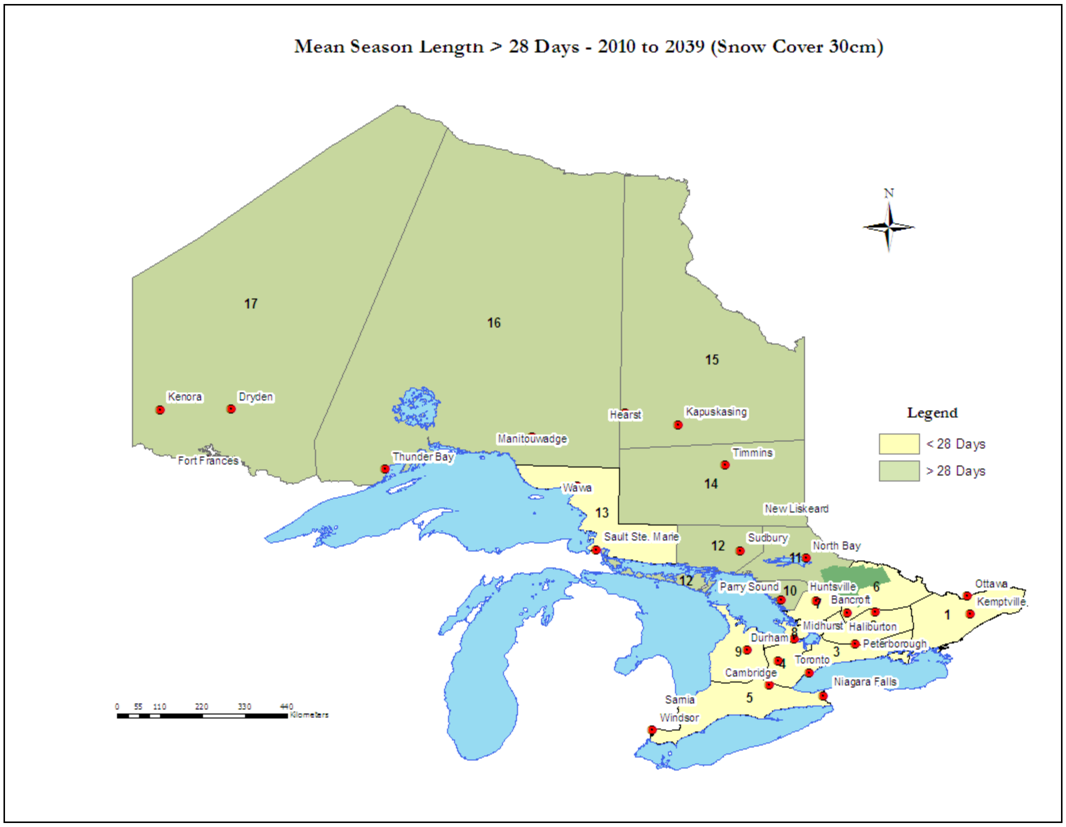


Figure 4.7: Mean Season Length > 28 Days - 2010 to 2039 (Snow Cover 30 cm)



Respondents considered potential technological and business responses to climate change. Potential risks of climate change for snowmobile tourism include: (1) spatial and temporal change in snow cover and season length, (2) declining human and financial capital (see Chapter 5 for a discussion), (3) land use agreements (see Chapter 5 for a discussion), (4) concerns of liability, and (5) institutional arrangements (see Chapter 5 for a discussion).

Chapter 5

Discussion

5.1 Introduction

This chapter synthesises the results of the research and discusses the potential influence of a changing climate upon snowmobile tourism in Ontario. Snowmobile trails in Ontario provide for healthy and active lifestyles and contribute to the strength of local economies through tourism and the social fabric of local communities through volunteerism. Snowmobile trails in Northern Ontario often provides for nature appreciation in remote wilderness areas. The risk of climate change is a major factor influencing snowmobile tourism.

Sustainable snowmobile tourism is a collaborative undertaking of the OFSC, member snowmobile clubs, and the private and public sectors. The OFSC and member snowmobile clubs develop the snowmobile trail infrastructure; including routes, maintenance operations, and way-finding. The private sector contributes capital and in-kind resources for the OFSC programs and snowmobile club operations and may also provide access to private property. Also goods and services (e.g. snowmobiles, tour operators, accommodations, food and beverages) are provided for the snowmobile tourists to enhance their experiences. Through Official Plans and by-laws municipalities establish the frameworks for which enable snowmobile trails to be established and operate within their jurisdictions. The roles of the federal and provincial governments, given substantial periodic investments, have been that of a facilitator and promoter.

5.2 Snowmobile Season Length

Snowmobile tourism in Ontario is affected by the spatial and temporal variability of climate during the winter season. Earlier research undertaken in Ontario by Scott et al. (2002) and McBoyle et al. (2007) considered the direct influence of changes in climate upon the length of snowmobile seasons, and indirect influences upon human and financial capital. Comparisons of changes in snowmobile season length in three future time periods for Scott et al. (2002), in the 2020s, 2050s, and 2080s, McBoyle et al. (2007) in the 2020s and 2050s, and the current study in the 2020s, 2050s, and 2080s are provided in sections 5.2.1, 5.2.2, and 5.2.3. The similarities of each of the three studies includes: (1) seven common snowmobile districts (Districts 1, 6, 7, 8, 9, 12, & 17) of which three (Districts 6, 7, & 12) use identical climate stations, (2) the use of the same climatic variables (minimum temperature, maximum temperature, and precipitation), (3) baseline (1961-1990) and future time periods (2010-2039, 2040-2069, & 2070-2099), and (4) the use of the same snow model to project changes in snowmobile season length. The differences included: (1) snow cover thresholds [Scott et al. (2002) 5 cm, McBoyle et al. (2007) 15 cm, and current study 15 cm, 30 cm, & 60 cm] used to parameterize the snow model, and (2) climate change scenarios [Scott et al. (2002) HadCM3 IS92a and CGCM1 IS92a, McBoyle et al. (2007) NCARPCM B21 and CCSRNIES A11, and current study INMCM3.0 B1 and MIROC3.2 A1B].

5.2.1 The 2010- 2039 Period (Table 5.1)

Snowmobile season length projections in southern snowmobile districts (1, 6, 7, 8, & 9) range from 22 to 75 days (McBoyle et al., 2007; Scott et al., 2002); while in the current study (at a 15 cm snow cover threshold) range from 10 to 39 days. In northern snowmobile districts (12 & 17) snowmobile season length is projected to range from 37 to 75 days (McBoyle et al., 2007); while in the current study (at a 15 cm snow cover threshold) range from 61 to 69 days.

Table 5.1: Season Length Comparisons - 2010 to 2039 (Days)

OFSC District	Scott et al. (2002) Snow Cover (5cm)		McBoyle et al. (2007) Snow Cover (15cm)		Current Study Snow Cover (15cm)		Current Study Snow Cover (30cm)		Current Study Snow Cover (60cm)	
	HadCM3 IS92a	CGCM1 IS92a	NCARPCM B21	CCSRNIES A11	INMCM3.0 B1	MIROC3.2 A1B	INMCM3.0 B1	MIROC3.2 A1B	INMCM3.0 B1	MIROC3.2 A1B
D1			49	26	31	22	18	8	3	0
D2					36	17	20	6	4	0
D3					20	9	8	2	1	0
D4					7	5	1	0	0	0
D5					6	5	2	1	0	0
D6	74	55			38	27	26	13	8	3
D7	75	54			39	28	24	12	7	1
D8	48	42	39	22	26	12	14	3	1	0
D9	69	46			26	10	11	3	0	0
D10					43	29	30	16	11	5
D11					70	60	53	39	26	13
D12			59	37	65	61	46	40	14	14
D13					50	29	25	8	4	1
D14					90	88	72	68	36	34
D15					102	101	80	79	43	42
D16					54	44	30	21	2	1
D17			75	45	69	61	42	29	3	2

5.2.2 The 2040- 2069 Period (Table 5.2)

In southern snowmobile districts (1, 6, 7, 8, & 9) snowmobile season length projections range from 1 to 61 days (McBoyle et al., 2007; Scott et al., 2002); while in the current study (at a 15 cm snow cover threshold) range from 7 to 37 days. Snowmobile season length in northern snowmobile districts (12 & 17) is projected to range from 4 to 68 days (McBoyle et al., 2007); while in the current study (at a 15 cm snow cover threshold) range from 55 to 67 days.

Table 5.2: Season Length Comparisons - 2040 to 2069 (Days)

OFSC District	Scott et al. (2002) Snow Cover (15cm)		McBoyle et al. (2007) Snow Cover (15cm)		Current Study Snow Cover (15cm)		Current Study Snow Cover (30cm)		Current Study Snow Cover (60cm)	
	HadCM3 IS92a	CGCM1 IS92a	NCARPCM B21	CCSRNIES A11	INMCM3.0 B1	MIROC3.2 A1B	INMCM3.0 B1	MIROC3.2 A1B	INMCM3.0 B1	MIROC3.2 A1B
D1			38	1	29	18	14	4	2	0
D2					33	13	17	5	3	0
D3					18	6	7	1	1	0
D4					5	3	0	0	0	0
D5					5	4	1	1	0	0
D6	59	36			36	23	23	10	6	2
D7	61	37			37	23	23	7	5	0
D8	38	21	30	1	24	7	11	2	0	0
D9	56	29			24	8	9	2	0	0
D10					41	23	29	10	10	3
D11					67	55	50	35	22	11
D12			52	4	64	58	45	38	14	14
D13					48	23	24	5	3	0
D14					89	86	70	66	34	33
D15					102	99	79	77	41	42
D16					51	37	27	19	2	1
D17			68	13	67	55	39	26	4	2

5.2.3 The 2070 - 2099 Period (Table 5.3)

Snowmobile season length projections in southern snowmobile districts (6, 7, 8, & 9) range from 12 to 38 days (Scott et al., 2002); while in the current study (at a 15 cm snow cover threshold) range from 5 to 37 days.

Table 5.3: Season Length Comparisons - 2070 to 2099 (Days)

OFSC District	Scott et al. (2002) Snow Cover (5cm)		McBoyle et al. (2007) Snow Cover (15cm)		Current Study Snow Cover (15cm)		Current Study Snow Cover (30cm)		Current Study Snow Cover (60cm)	
	HadCM3 IS92a	CGCM1 IS92a	NCARPCM B21	CCSRNIES A11	INMCM3.0 B1	MIROC3.2 A1B	INMCM3.0 B1	MIROC3.2 A1B	INMCM3.0 B1	MIROC3.2 A1B
D1			N/A	N/A	27	13	14	2	2	0
D2					33	11	16	3	2	0
D3					17	5	6	1	1	0
D4					5	2	0	0	0	0
D5					5	3	1	0	0	0
D6	38	25			36	20	22	9	7	1
D7	34	24			37	16	22	3	5	0
D8	18	12	N/A	N/A	23	5	10	1	1	0
D9	28	20			31	6	15	1	1	0
D10					46	18	35	7	15	2
D11					67	52	50	27	21	9
D12			N/A	N/A	68	54	50	33	16	11
D13					55	19	33	6	7	0
D14					89	83	71	63	37	27
D15					103	96	80	74	45	36
D16					53	32	28	16	3	1
D17			N/A	N/A	68	52	41	22	5	2

5.3 Perceptions of Risk

Snowmobile trail managers perceive the variability of climate to be of greater importance to snowmobile trail development and operations than long-range climate change. Several factors may contribute to this perception. First, time may be discounted in long-range planning horizons (Das & Teng, 2001). Managers are typically using planning horizons of 3 to 5 years for snowmobile trail development (e.g. route planning and infrastructure) and annual horizons for operations (e.g. trail maintenance and signage) unlike 30 year horizons for climate change. Second, respondents were overly optimistic (Weinstein, 1980) as they considered that their snowmobile districts were less vulnerable than other snowmobile districts to changes in climate and their past experiences in responding to similar inter-annual variances in climate would enable them to respond effectively to projections of climate change. Third, there is presently no experience beyond 3 poor (≤ 28 days) consecutive snowmobile seasons of the extent of effects to snowmobile club operations.

In response to projected reduced snowmobile seasons lengths snowmobile trail managers/operators will need to reduce two types of risks identified in the literature, sinking-the-boat (the failure to reach performance targets) and missing-the-boat (the failure to pursue possible opportunities) (Dickson & Giglierano, 1986). Over time sinking-the-boat risks may decline as planning and implementation strategies may reduce the risk of failure, and missing-the-boat risks may initially decline and then rise as the window of opportunity closes. Missing-the-boat risks are often a result of organizations being "short sighted, complacent, conservative, or slow" to recognize potential opportunities and implement effective strategies (Dickson & Giglierano, 1986, p.63).

Snowmobile trail managers will consider the following as sinking-the-boat risks in the failure to supply a sustainable snowmobile tourism product: (1) declines in human capital (e.g. snowmobile club volunteers and remunerated staff) for snowmobile trail operations and administrative activities (Respondents 3, 4, 5, & 6), (2) inadequate financial capital (e.g. trail permit revenues, sponsorship, and grants) (Respondents 1, 2, & 4), (3) increasing liability of snowmobile trail operations in most vulnerable snowmobile districts (Respondents 1, 3, 5, & 6), (4) losses of local and tourism snowmobile trail routes (Respondent 6), and (5) decreased reliability of *open* status of snowmobile trails increasing mistrust by snowmobile tourists (Respondents 1, 3, & 6).

Missing-the-boat risks include: (1) preparation and re-location of snowmobile trails to maximize the use of early season snowfalls (Respondents 1 & 3), (2) reduction of snowmobile trails and infrastructure (e.g. bridges and culverts) in most vulnerable snowmobile districts

(Respondents 1 & 4), (3) expanding the snowmobile trail system including loop trails and access to tourism services in least vulnerable snowmobile districts (Respondent 3), (4) marketing of technologies (e.g. electronic trail navigation devices) (Respondents 3 & 4), (5) market a flexible trail permit program (e.g. pricing and temporal availability) (Respondents 1, 2, 3, & 4), and (6) strengthening of inter-district alliances (Respondents 1 & 5).

5.4 Adaptations to Climate Change

PKFC (2001) identified trail products (e.g. well groomed trails, signage, interconnectivity, permanence, and standardization of tourism trails) and trail amenities (e.g. staging areas and warm up shelters) that may contribute to the enhancement of the snowmobile tourism experience. The vulnerability of snowmobile tourism is related to the level of climate change, adaptive capacity of the snowmobile industry, and political, cultural, economic, institutional, and technological forces (Smit & Wandel, 2006).

Snowmobile season lengths < 28 days have been identified as a threshold of poor seasons (Respondents 1, 3, & 5). The past experience of snowmobile trail managers/operators with the reliability of snow cover and snowmobile season length is a contributing factor in the perceived assessment of probability and severity of projected risks of climate change (Grothmann & Patt, 2005). Respondent 2 stated, "Reliability is a good thing, but as we all know weather isn't very reliable. I mean you never know from one year to the next." Respondent 3 stated further, "Left to the Snow Gods. What can I say? Without the snow we have no trail system." Respondent 1 stated, "The system they try to get it open by Christmas time as much as they can… But lately it is just so unpredictable with the weather… There are some trails that remain open longer than others. They are not a continuous run, but there are sections of trail. The same as there are sections of trail that open earlier." Snowmobile trail managers/operators may consider anticipatory and reactive adaptation responses to projected climate change and reduced snowmobile season lengths (Lemmen et al., 2008).

Several anticipatory responses, those activities initiated prior to observable effects, may be considered. First, a comprehensive adaptation assessment of snowmobile trails, including capacity for grooming operations in lower snow cover, freeze-up of lakes, rivers, marshes, and swamps, and land use planning to develop and implement a long-term strategy to reduce snowmobile trails in most vulnerable snowmobile districts and consolidate and develop new snowmobile trails in least vulnerable snowmobile districts (Respondent 3). Reductions in the snowmobile trail grooming fleet and trail infrastructure (e.g. bridges & signage) may also be necessary in most vulnerable snowmobile districts (Respondent 3). Second, strengthening of inter-district alliances and develop new alliances (Koenig & Abegg, 1997) with other trail user groups for sharing costs and personnel to develop and maintain four season trail systems (Respondents 1 & 5). Third, strengthen the relationships with public agencies for route planning and programs supporting adaptation to climate change (Respondents 1, 2, 3, & 5). Fourth, the advancement of training and development programs for the attraction and retention of snowmobile club volunteers (Respondents 3 & 4). Fifth, the diversification (Koenig & Abegg, 1997) of financial capital may be required as revenues from snowmobile trail permits in most vulnerable snowmobile districts may decline due to reduced snowmobile season length (Respondents 1, 2, 3, & 4).

Several reactive responses may be undertaken following observable effects of changes in climate. First, adjust snowmobile trail grooming patterns and techniques for conditions of low snow cover and delayed freeze up and early break up of lakes and rivers (Respondent 3). Second, use of short-term weather reports to allocate personnel and the grooming fleet (Respondent 3).

Third, recovering the snowmobile trail system following extreme weather events (e.g. freezing rain, heavy snowfalls or rainfalls, and high winds) (Respondent 1, 2, & 4). Fourth, frequent updating of snowmobile trail status reports to inform snowmobilers of those trails that are closed and unavailable for snowmobiling (Respondent 1).

Snowmobile trail managers in least vulnerable snowmobile districts will need to develop operational management plans for increases in snowmobile tourists, should the demand for snowmobiling not decline relative to projected declines in season length in most vulnerable snowmobile districts. Snowmobile trails will become more crowded particularly during weekends and holiday periods, potentially affecting the level of satisfaction of snowmobile tourists. The HFWR (2009) since 2002 has imposed a daily snowmobile permit quota of 100 snowmobiles per day to ensure optimal snowmobile trail conditions. One-way circular loop trails have been identified as a management option to reduce the perception of crowding amongst trail users (Fredman & Hörnsten, 2004). At the Njupeskär waterfall in Sweden 19.9% of hikers hiking in the designated direction of a circular trail perceived some degree of crowding compared to 24.6% of hikers for the reverse direction and 25.6% to 40.2% of hikers on the same trail segment (Fredman & Hörnsten, 2004). Respondent 2 stated "I like the wide-open trails and the less traffic. Muskoka [District 7] was getting a bit much for traffic. Not as much fun."

Conversely, should the demand for snowmobiling decline less than or equal to decreases in season length in most vulnerable snowmobile districts, then least vulnerable snowmobile districts will need to consider a consolidation of existing snowmobile trails and the development of four season trail systems. Declining snowmobile season length may motivate snowmobile tourists to consider alternative activities or vacation types that are central to their lifestyle.

In response to damages to snowmobile trails caused by ATVs, snowmobile trail managers are implementing three strategies. First, snowmobile clubs are entering into agreements with ATV clubs to repair any damage resulting from ATV use prior to the winter snowmobile season (Respondent 1). Second, the development of snowmobile trails along natural frozen waterway corridors. Respondent 3 stated, "MNR likes us using again natural corridors, going across lakes and going across deep swamps because then to build our trails, because that way then during the non-snowmobiling season they don't have to worry about other users accessing it." This strategy may be a maladaptation, with the annual duration of lake and river ice declining (CCME, 2003; Zhang et al., 2001), that will leave snowmobiling more vulnerable to changes in climate. Third, snowmobile trails located on private properties restricts access by other users without landowner permission (Respondents 1 & 3). These strategies are effective in minimizing conflicts arising between motorized user groups sharing the same trails. During the winter season, the *OFATV Winter Riding Policy* states (OFATV, 2001); "No OFATV club will utilize any trails that are groomed in the winter month unless they are expressly designated for the purposes and use of the ATV club. This includes, but is not limited to, those trails maintained by snowmobile and ski clubs."

5.5 Human Capital

Human capital, the dedicated and committed volunteers and staff bringing together a diversity of expertise, of OFSC and its member snowmobile clubs are considered to be the greatest asset. The OFSC's Board of Governors strong leadership, innovation and long-term commitment have provided guidance to the organization since 1966. The capacity to plan and develop the provincial snowmobile trail system for snowmobile tourism and the development of innovated programs (e.g. Snowmobile Trail Officer Patrol (S.T.O.P.)) with key stakeholders are also considered to be strengths of the organization.

Projected declines in snowmobile season lengths, as early as the 2020s in southern snowmobile districts where 64% of snowmobilers reside (OFSC, 2008a), may negatively affect local snowmobile club membership and consequently the volunteer base for administration and snowmobile trail operations. Long periods of freeze-thaw events frustrate volunteers maintaining the snowmobile trail system (Respondents 1 & 3). Volunteers are not easily transferred to areas which may be in need of their expertise.

Short-term commitments are preferred by volunteers (Respondent 3) and many are reluctant to serve in executive positions due to concerns of personal liability and overwhelming paperwork (Respondents 1, 3, 5, & 6). The strength of local economies and personal employment obligations may also influence the ability to volunteer ones time (Respondent 1). Young adults are increasingly difficult to attract as volunteers in snowmobile clubs, despite often their earlier involvement in snowmobiling as younger family members (Respondent 3).

Additional volunteers are required to effectively deliver programs and services, alleviate volunteer burnout, and to infuse fresh ideas (Respondents 4 & 5). Recruitment in small communities may be difficult as many potential volunteers may be engaged in other volunteer activities (e.g. minor hockey or figure skating). Increasingly the use of internal (club membership) and external (community stakeholders) networks may be needed to recruit additional volunteers.

Retaining existing volunteers is important for the continuity of expertise within snowmobile clubs and external relationships with community stakeholders. Respondent 3 stated "We have to be dealing with the present, planning for the future, but knowing where we came from." Volunteers need to experience successful outcomes to remain motivated and to avoid burn out. Respondent 6 stated "Valuable human resources are being lost and are leaving the sport due to demands on their free services for the sake of tourism. Demands on the volunteers through continuous requests/requirements are time consuming and they are asking themselves, why volunteer?" Volunteers at a constant state of readiness during poor snowmobile seasons with ≤ 28 days may be more susceptible for burn out (Respondent 3). The OFSC and snowmobile clubs annually recognize the importance of the contributions of volunteers to Ontario snowmobiling.

Increasingly sufficient remunerated staff or contracted services (e.g. grooming operations) may be required in many snowmobile districts to maintain level of service standards and offset the potential decline in volunteers. Funding for these positions presently comes from snowmobile trail permit revenues. Snowmobile district managers with specialized skills in accounting, fundraising management, and marketing will be required. Excessive workloads placed on too few staff may lead to overwork and turnover resulting in a loss to the snowmobile districts of their developed expertise.

5.6 Financial Capital

The financial capacity, the ability to develop and deploy financial resources, of the OFSC may be negatively impacted by climate change. Early season snowfalls are critical for snowmobile trail permit sales needed for start-up expenses (Respondent 4). Revenues from snowmobile trail permits alone are not presently sufficient to meet the tourism needs of the snowmobile trail system (Respondent 1). Some Northern Ontario snowmobile districts have sales of snowmobile permits as few as 0.5 permits/km compared with the provincial average of 2.2 permits/km (Respondent 2). Respondent 2 stated, "As far as tourist permit sales, not every club gets apiece of that, you might like for example Sault Ste. Marie they sell a shitload of permits to Americans, but then the clubs next-door to them like your Dubreuilvilles and Hornepaynes and stuff they don't see much of that, yet they see almost the same traffic, but they are not seeing the permit dollars…certain clubs are selling most of the permits and that the tourism dollars aren't being spread around properly." Despite the provision of groomed snowmobile trails in North-Western Ontario some snowmobilers choose to snowmobile on Crown lands where snowmobile trail permits are not required (Respondent 2).

Improvements are required in snowmobile trail quality and consistency, infrastructure, and access to tourism services. The OFSC (2008a) estimates that $2,000/km are required to develop new snowmobile trails and $496/km annually are required for operations. The snowmobile trail groomer fleet, valued at $22 million (OFSC 2008a), is aging and is in need of replacement (Respondents 1, 2, & 5). Liability insurance is a multi-million dollar expense each season and without insurance snowmobile trails would not open (Respondent 3).

Respondents 1, 2, 3, 5 and 6 are optimistic that sustainable long-term funding from government sources will be forthcoming to continue development and maintenance of the provincial snowmobile trail system meeting the expectations of snowmobile tourists given the ability of the OFSC to generate annual revenues of their own ($16.4M in trail permits) and provincial taxes from snowmobiler expenditures ($112M) (OFSC, 2008a).

External funding from Federal and Provincial governments since 1992 has been limited to multi-year infrastructure and human resource development projects. Recent provincial funding has enabled clubs to prepare the terrain to accommodate grooming operations with lower snow cover meeting the needs of snowmobilers and tourism service providers (Respondents 1, 2, 4, & 6). Respondent 5 stated, "The funding over the last two years was to help clubs make their trails more early groomer friendly... we took out burms [berms] and filled ditches with culverts, etc… in the past we needed a minimum of 18 inches [45 cm]... now we can get at it with 6 inches [15 cm], packing trails to get ready for the real snow.” Early season snowmobiling is a liability concern for snowmobile trail managers/operators. Respondent 4 stated, “What are the people going to do? Run up and down a 10 km rail line and turn around and come back? No! All we are doing is encouraging people to get there and ride and see how far you can go and then it becomes a liability issue.”

Proposals for funding and subsequent reporting are often an administrative burden for snowmobile clubs and the OFSC (Respondent 6). There exists competition from other trail user groups for limited government and other funds. Of the $25 million available from the Government of Canada’s Economic Action Plan for trail projects in 2009/2010, the OFSC will receive $1.733 million (Supertrax International, 2009). The OFSC has a strong record of directing multi-million dollar funds where best suited to achieve long-term planning targets and exceed the return-on-investment expectations of funding providers.

Changes in climate have directly affected the decision-making process of tourists, where and when to travel (Agnew & Viner, 2001). In the past snowmobile tourists from southern snowmobile districts have followed the snow cover line northwards in search of open trails for snowmobiling (Respondents 1 & 3). It is uncertain given projected declining snowmobile season lengths in southern snowmobile districts what the level of the response of snowmobile tourists may be.

Hamilton, Brown, and Keim (2007) examined the affect of the “backyard hypothesis” on alpine skier demand at two New Hampshire resorts (Cannon and Gunstock) during the 2002/2003 ski season. The two highest visitation days occurring at the Cannon resort corresponded to the two snowiest days in nearby Boston Massachusetts. In the State of Arizona, Bark, Colby and Dominguez (2009) speculated that skier visitation to the remote east-central Sunrise Park Resort may indirectly benefit from snowfalls at the northern Arizona Snowbowl resort. The perception of skiers in the urban centres of Flagstaff, Phoenix, and Tucson, that the ski season is open at Sunrise Park corresponds to the opening of the Arizona Snowbowl resort. Conversely, poor ski seasons at Arizona Snowbowl, may negatively affect visitation to Sunrise Park, even when good local snow cover prevails.

Respondent 3 provided insights into the perception of the snowmobile season by local snowmobilers "If they can't snowmobile from their driveway the season is over … if they can't actually drive from their driveway from in the city they won't go out and according to them the season has never started." Direct access from home to the snowmobile trails is preferred and thus when this is not possible many snowmobilers have chosen not to snowmobile rather than trailer to nearby staging areas (Respondent 2). Snowmobile districts and destination marketing organizations (DMOs) will need to increase their efforts to persuade snowmobile tourists to visit snowmobile districts with open snowmobile trails despite poor snow cover at home or in preferred destinations.

5.7 Land Use

In the 2007/2008 snowmobile season 12,464 private landowners generously offered their permission for 25,700 km (65%) of snowmobile trails to access their properties (OFSC, 2008a). Many landowners are concerned for liability, trespass, and damages to their property resulting from snowmobilers and other users (e.g. ATVs) during the winter (Respondent 6). Agricultural crops in the future may be more sensitive to damage with less prevailing snow cover. Projected declining snowmobile season lengths may increase the frequency of the *closed* status of snowmobile trails and the potential for snowmobilers and other trail users to access private properties when they may be most environmentally vulnerable (Respondent 6). Early season snowfalls exasperate this problem as snowmobilers are anxious to begin snowmobiling. Landowners have chosen to terminate their land use agreements with snowmobile cubs resulting in a potential fragmentation of the snowmobile trail system and the potential loss of snowmobile tourism (Respondent 6). Snowmobile club membership may diminish as a result of limited availability of local snowmobile trails. Increased snowmobile trail patrols and enforcement activities (e.g. safe snowmobiling and trail permits) by snowmobile clubs mitigating trespass and damages to private properties may be required.

5.8 Institutional Arrangements

Institutional arrangements need to be strengthened at the federal, provincial, and municipal levels for land use planning particularly with corridors (e.g. road allowances and abandoned railway), highway and water crossings to maintain the connectivity of the snowmobile trail system (Respondent 1). Respondent 6 stated, “If the government/ministry wishes to promote snowmobile tourism, then within the next few years, they may have to get more involved, i.e. remuneration for manpower to establish, create, and maintain a provincial trail system.” Respondents report regional inequities in the issuance of highway and water crossings permits by provincial agencies (Respondents 2 & 5). Respondent 2 has suggested that in sharing snowmobile trails with forest operations companies that, “I really think that MNR needs to work with Ontario Tourism and come up with a plan of widening these logging roads so that both can be in there at the same time safely. We have to make them a little wider so we can make an area for the groomer to groom… they really need to be widened and we certainly can’t afford to do it ourselves.” A harmonized approach to snowmobile tourism is needed with the myriad of government ministries, legislation, regulation, and policies involved. The greening of legislation is anticipated to increase the costs of development and operation of snowmobile trails.

The affordability to the OFSC of annual snowmobile trail liability insurance is a barrier to the viability of snowmobile tourism. The OFSC in response to perceived risks of liability has developed and integrated risk management and health and safety policies into all operations (Respondents 1, 3, & 4). Public and private landowners are discouraged from permitting access for snowmobile trails on their properties due to perceived liability. Tax credits to private landowners for permitting snowmobile trails on their properties have been identified as possible incentives (Respondents 2 & 6).

5.9 Marketing Snowmobile Tourism

Successful snowmobile tourism marketing strategies will consider the spatial and temporal limitations of season length and the socio-psychological concepts of lifestyle, involvement and place attachment. The availability of a suitable snowpack is a primary requirement for snowmobiling. Early season snowmobiling is preferred by snowmobile tourists rather than late season snowmobiling (Respondents 2, 3, & 5).

The OFSC in the 2007/2008 and 2008/2009 snowmobile seasons has embraced the marketing brand of *Go Snowmobiling*. The goal is to attract new, former and casual snowmobilers to enjoy snowmobiling in Ontario. Three initiatives: (1) *Give it a try tour,* (2) *Take a friend snowmobiling,* and (3) *Go snowmobiling family weekend,* were used to achieve this goal. Snowmobile districts undertake marketing activities (trade shows, trail maps, and web sites) to encourage snowmobiling within their trail systems. Word-of-mouth communications at trade shows with experienced snowmobilers is effective in attracting snowmobile tourists (Respondent 2). Throughout the snowmobile season snowmobile clubs post the status (closed, limited, or open) of their trails on the OFSC website. This information is extensively used by snowmobile tourists in the short-term planning of their vacations.

Snowmobile trail safety is critical for the attraction of snowmobile tourists. Snowmobile clubs undertake safety in all aspects of their operations. Respondents 3 and 4 reported exceeding the minimum OFSC snowmobile trail safety standards for signage in their respective snowmobile districts. Snowmobile club volunteers are provided with training upon the safe operation of equipment and snowmobile trails are designed to minimize natural and man made hazards. Water crossings are monitored regularly for ice quality and thickness that is sufficient to support snowmobile trail groomers and snowmobile traffic (Respondent 3). Additionally way-finding is used extensively to provide route and destination planning. The snowmobile trails are regularly patrolled by Trail Patrol officers promoting the trail permit program and identifying and reporting of trail hazards; while the S.T.O.P. officers enforce the provincial Motorized Snow Vehicle Act (Respondent 3).

Snowmobiling in Ontario is route-based and as such the development of provincial signature snowmobile trail routes (e.g. Round Algonquin Park, Gold Rush Tour, and Superior Snow Challenge Loops) may offer snowmobile tourists new destinations to explore. Additional tourism loop trails may be required in localized snow cover areas. Snowmobile tour operators in Ontario offering all-inclusive snowmobile packages in least vulnerable snowmobile districts have the potential to attract novices and snowmobilers from Ontario's most vulnerable snowmobile districts, the US, and internationally. An integrated marketing approach between the marketing agencies (e.g. CTC, OTMPC, and DMOs) will maximize limited financial resources.

The marketing of snowmobile tourism in future time periods has several challenges. A present time-distance-decay threshold of 12 hours (1,000 km) (Respondent 5) from Southern

Ontario and United States markets will limit the ability of snowmobile tourists to reach more remote locations in Northern Ontario. Travel distances from Ontario/United States border crossings and selected Ontario cities with projected snowmobile season length > 28 days with a snow cover threshold of 30 cm in the 2020s are provided in Table 5.4.

Table 5.4: Travel Distance Matrix

Bancroft (D2)	Barrie (D8)	Cornwall (D1)	Dryden (D17)	Fort Frances (D17)	Haliburton (D6)	Hamilton (D4)	Huntsville (D7)	Kapuskasing (D15)	Kenora (D17)	Kingston (D1)	London (D5)	Niagara Falls (D5)	North Bay (D11)	Ottawa (D1)	Parry Sound (D10)	Peterborough (D3)	Prescott (D1)	Sarnia (D9)	Sault Ste. Marie (D13)	Sudbury (D12)	Thunder Bay (D16)	Timmins (D14)	Toronto (D4)	Windsor (D5)
	202	310	1640	1636	61	305	156	767	1769	190	411	367	280	211	216	114	269	511	661	369	1319	650	242	583
		495	1553	1549	158	140	124	735	1681	326	145	203	248	426	424	129	158	282	345	574	1231	573	100	417
			1859	1855	369	492	434	937	1988	189	598	544	449	99	71	513	333	577	698	869	1538	819	429	770
				174	1580	1693	1503	923	128	1835	1664	1756	1410	1760	1831	1424	1653	1271	1563	979	339	1096	1653	1568
					1576	1689	1499	919	204	1831	1660	1752	1406	1756	1827	1420	1469	1267	1559	975	335	1092	1649	1482
						275	96	707	1708	250	380	337	219	270	155	112	330	480	600	309	1258	589	214	552
							264	875	1821	323	119	84	388	459	421	269	191	422	219	714	1372	713	65	291
								611	1632	346	369	327	123	335	405	79	199	232	470	524	1182	494	224	542
									1051	937	981	938	488	838	673	810	908	1081	572	464	601	173	835	1153
										1963	1792	1884	1539	1889	1553	1781	1959	1692	1108	1399	468	1225	1781	1696
											429	386	450	185	411	190	118	530	855	564	1513	820	260	602
												203	493	565	374	297	527	100	684	527	1342	818	185	172
													450	522	331	253	472	303	776	485	1434	776	127	375
														350	149	322	421	593	420	128	1089	370	348	665
															414	268	87	666	770	478	1439	720	396	738
																229	485	474	445	153	1103	276	142	339
																	179	247	418	237	826	429	80	292
																		390	522	341	937	491	222	434
																			363	389	771	570	177	71
																				181	408	247	418	365
																					589	181	237	434
																						481	826	773
																							418	615
																								222

Legend

- Season Length < 28 Days
- Season Length > 28 Days
- < 500km
- 500km to 1000km
- 1000km to 1500km
- > 1500km

There exists an uncertainty of the effect of the Western Hemisphere Travel Initiative (WHTI) upon US snowmobile tourists in the short-term, the 2020s, and long-term 2050s and 2080s. WHTI requires all travellers to the United States, including US citizens, to present a valid passport or other approved secure document when entering the United States from within the western hemisphere. An estimated 50% of US overnight auto visitors to Canada posses a passport (Conference Board of Canada, 2005). US visitation to Ontario was projected to decline by 4.7 million between 2005 and 2008 due to WHTI (Conference Board of Canada, 2005).

The present global economic decline is affecting all sectors including snowmobile tourism. American visitation has been observed (Respondent 4) to be in a decline in many regions of Ontario throughout the year. In 2007 Ontario received 5.6 million US overnight leisure visits, a -5.8% decline from 2006 (CTC, 2008). Snowmobile tourists from US border states to Ontario's Resource-Based Tourism Region are projected to decline 10% from 2000 visitation of 523,000 by 2025 (Research Resolutions, 2003a). An aging population wanting to participate less in outdoor adventure activities, more in cultural and indoor activities and emigration to warmer southern states are contributing factors (Research Resolutions, 2003a). Snowmobile tourists that once rented seasonal accommodations are now limiting vacations to 2 to 3 weekend trips a season (Respondent 4). There is a need to strengthen the Ontario market and traditional European markets (e.g. United Kingdom, France, and Germany) and explore potential emerging Asia-pacific markets (e.g. Australia, China, Japan, and South Korea) for snowmobile tourism (Respondent 1).

5.10 Contribution of the Research

This research has narrowed the knowledge gaps (limited spatial coverage of climate change for snowmobile tourism and projected responses of supply-side organizations) identified in section 2.5 and has contributed to a further understanding of the potential influence of changes in climate upon snowmobile tourism in the Province of Ontario. Interviews with senior snowmobile trail managers/operators revealed a range of potential technological and business responses. The management of the provincial snowmobile trail system by volunteer snowmobile clubs is reliant upon minimum natural snow cover of 15 cm and freezing temperatures and thus is particularly vulnerable to changes in climate. Man-made snow, often used at alpine ski resorts, is neither presently nor in the future to be a viable option for wide spread use to supplement natural snow cover and increase the length of snowmobile seasons.

5.11 Summary

This chapter has discussed the results of the research and the possible impacts upon the supply-side of snowmobile tourism. Snowmobile trail managers perceive climate variability to be more important than climate change to the development and maintenance of snowmobile trails. These trail managers are cognisant of the limitations of reliance upon natural snowfalls and freezing temperatures upon snowmobile season length. With an average of 30 years of snowmobile trail development experience, managers are optimistic in their ability to meet the challenges of projected climate variability and change upon snowmobile season length and snowmobile tourism.

The recruitment and retention of human capital will continue to be a challenge as early as the 2020s in southern snowmobile districts as local snowmobiling declines due to changes in climate. In northern snowmobile districts, out migration is anticipated due in part to declining employment. Declines in financial capital are anticipated in southern snowmobile districts where 64% of snowmobilers live. New sources of revenue or operating grants will be required to develop and maintain a snowmobile trail system in snowmobile districts that are projected to have reliable seasons for snowmobile tourism.

Chapter 6

Conclusions and Recommendations

6.1 Conclusions

The objectives of this research was an examination of the sensitivity of snowmobile trail operations and adaptations to past climate variability, the influence of climate change upon snowmobile season length in each OFSC snowmobile district during the periods 2010 to 2039, 2040 to 2069, and 2070 to 2099, and possible adaptations that senior Ontario snowmobile trail managers/operators may consider in the future to climate change.

Projected changes in climate will negatively affect snowmobile season lengths and provide challenges and relative advantages for snowmobile tourism in Ontario (Figures 6.1, 6.2, & 6.3). Snowmobile districts at higher elevations and higher latitudes (> 46^0N) are generally less vulnerable to changes in climate. Southern snowmobile districts (3, 4, 5, & 9) are projected to be most vulnerable and northern snowmobile districts (11, 12, 14, & 15) least vulnerable. In the 2020s these southern snowmobile districts are projected with less than 25% of snowmobile season lengths > 28 days. Another six snowmobile districts (1, 2, 6, 7, 8, & 13) are projected to have 25% to 50% of snowmobile seasons with > 28 days. In the 2050s six snowmobile districts (2, 3, 4, 5, 8, & 9) are projected with < 25% of snowmobile seasons > 28 days and another six snowmobile districts (1, 6, 7, 10, 13, & 16) with 25% to 50% of snowmobile seasons lengths > 28 days.

Figure 6.1: Probability of Season Length > 28 Days - 2010 to 2039

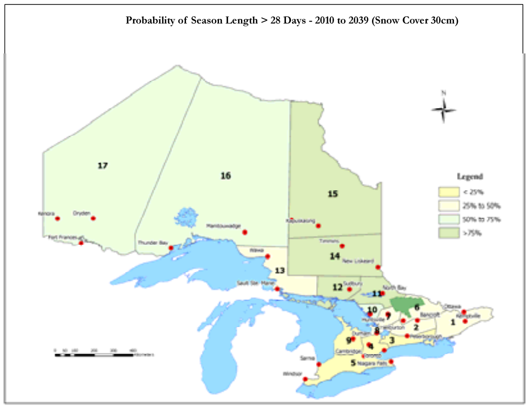


Figure 6.2: Probability of Season Length > 28 Days - 2040 to 2069

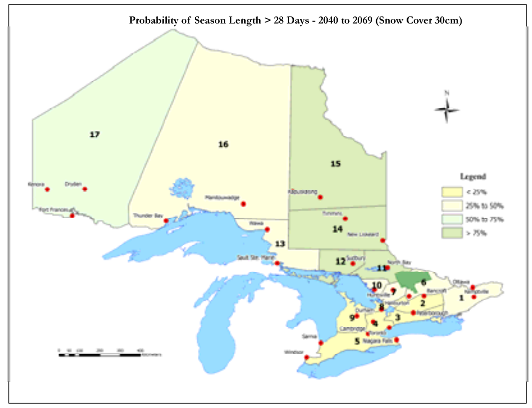
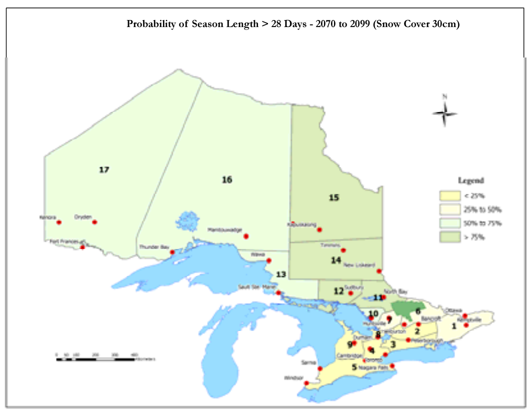


Figure 6.3: Probability of Season Length > 28 Days - 2070 to 2099



Disparities of season length may occur within and between most vulnerable snowmobile districts and result in fragmentation of the provincial snowmobile trail system limiting snowmobile tourism. Local snowmobile club membership has in the past declined by approximately 30% in poor snowmobile seasons (< 28 days) (Respondent 3), and consequently declines in financial and human capital are anticipated in future time periods affecting the capacity of snowmobile clubs to supply maintained snowmobile trails. Respondents 1, 3, and 5 have experienced as many as three consecutive poor snowmobile seasons in the last ten years.

Snowmobile trail managers/operators perceive the variability of climate to be of greater importance to snowmobile trail operations than long-term climate change. Short-term planning horizons of 3 to 5 years have been used in the past to develop and maintain snowmobile trails. Snowmobile trail managers/operators were optimistic that their past experiences with climate variability will enable them to effectively respond to the challenges of projections of reduced snowmobile season lengths.

The most effective adaptation strategies identified by snowmobile trail managers/operators were the pre-season preparation of the terrain to maximize the use of early snowfalls, early season packing of snow cover to assist the penetration of ground frost, re-location of snowmobile trails from areas most vulnerable (e.g. water crossings and open areas) to locations which are snow and temperature reliable, the embracement of new technologies, and the strengthening of inter-district alliances. New programs may be required that leverage financial and human capital for the development of adaptation strategies (e.g. education and risk management) for most vulnerable and least vulnerable snowmobile districts. Government programs in support of snowmobile trail development may also need to be re-evaluated based upon return-on-investment and potential for four season recreational use.

6.2 Recommendations

Recommendations for future consideration include:

(1) projected climate change and influence on snowmobile season length be monitored as new advanced Global Climate Models become available,

(2) increase the awareness of the risks to snowmobile tourism of climate variability and change amongst the OFSC, snowmobile districts, public agencies, and community stakeholders to facilitate the development of effective adaptation strategies,

(3) integrate climate variability and change into the OFSC's strategic trails planning process and risk assessment and management program,

(4) immediately undertake an adaptation assessment of southern snowmobile districts (3, 4, 5, & 9) where the probability of season length greater than 28 days in the 2020s is less than 25%, followed by snowmobile districts (1, 2, 6, 7, 8, & 13) where the probability of season length greater than 28 days is between 25% to 50%,

(5) determine the effects of increased snowmobiling on snowmobile trails in least vulnerable snowmobile districts,

(6) examine the motivational factors of snowmobile tourists including: activity substitution, attachment to destinations, distance-time-costs thresholds, involvement, lifestyle, for snowmobile tourism,

(7) examine risk perceptions and possible responses of snowmobile tourists to climate change,

(8) educate snowmobile tourists of the risks of climate variability and change to environmental sensitivity in most vulnerable snowmobile districts, and

(9) examine how communities in Ontario may respond to reduced snowmobile season lengths.

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Appendices

Appendix 1: Benefits of Snowmaking (Turbocristal, 2008)

Depending on the situation, snowmaking helps you to accomplish the following goals:

1. Ensure snow coverage at the beginning of the season to ensure revenues,
2. Improve snow quality during the season,
3. Maintain snow coverage in sectors that are critical due to their orientation or topography,
4. Ensure skiers return at the beginning and the end of the season,
5. Guaranty the quality of sporting events,
6. Extend the season beyond the limits imposed by natural snow coverage, and
7. Satisfy customers' increasing demand.

Appendix 2: Information Letter for Study Participants (Phase 1) (Date)

Reference: Ontario Snowmobile Tourism: Responses to Climate Variability and Change

I am writing to invite you to participate in a study on Ontario Snowmobile Tourism: Responses to Climate Variability and Change. Changes in climate from both natural and human causes are influencing the Ontario snow-pack (e.g. timing, amount and quality), and consequently snowmobile tourism opportunities. This study is intended to provide insights into past and future responses of snowmobile trail managers/operators to changes in climate. In addition to being published in a thesis form, the outcomes of the research will be aimed at informing a set of practical strategies to meet the challenges of projected climate change. This study is being conducted by Stephen H. Gilmour, Master's Candidate – Tourism Policy & Planning at the University of Waterloo. Dr. Daniel Scott, Canada Research Chair in Global Change and Tourism is supervising the study.

The study asks you to share your past experiences with environmental stewardship, weather and climate as it has affected past snowmobile trail operations, and snowmobile tourism. The interview may take approximately 1 hour of your time to complete. Information provided in the phase one interview will assist in phase 2 to develop climate change scenarios for the periods 2010 to 2039 and 2040 to 2069. Finally, in phase three of the study if you choose to participate you will be asked to project your future responses to these scenarios.

All of the information that you provide will treated with strict confidentiality. No information concerning individuals or organizations will appear in a published thesis, or any document resulting from this study. With your permission, anonymous quotations may be used in the thesis or any publications. Your participation is purely voluntary and you will be free to withdraw at any time or decline to answer any question. There are no known or anticipated risks to participation in the study. To withdraw from the study please contact me directly by telephone or email. The data collected through this study will be kept for a period of four years in a secure location and then confidentially destroyed.

Should you have any questions or concerns about the study or your involvement, please contact Stephen H. Gilmour, Master's Candidate, Tourism Policy & Planning, Faculty of Environment, University of Waterloo, 200 University Avenue West Waterloo, Ontario N2L 3G1 or Associate Professor Daniel Scott (519) 888-4567 (Ext. 35497) dj2scott@uwaterloo.ca. The study has ethics clearance through the University of Waterloo's Office of Research Ethics. Should you have any ethical concerns concerning your participation, please contact Dr. Susan E. Sykes, Director Office of Research Ethics, (519) 888-4567 (Ext. 36005) ssykes@uwaterloo.ca.

Thank you for your contribution to this study.

Sincerely,

Stephen H. Gilmour
Master's Candidate – Tourism Policy & Planning
University of Waterloo
shgilmou@uwaterloo.ca
(519) 888-4567 (Ext. 35928)

Appendix 3: Consent Form for Study Participants (Phase 1)

Study Title:	Ontario Snowmobile Tourism – Responses to Climate Variability and Change
Researchers Name:	Stephen H. Gilmour, Master's Candidate, Tourism Policy and Planning, University of Waterloo
Supervisors Name:	Daniel Scott, Associate Professor, Department of Geography, University of Waterloo

- ✓ I have read the Information Letter, and the nature and purpose of the research study have been explained to me. I understand and agree to take part.
- ✓ I was informed that I may not directly benefit from taking part in the study.
- ✓ I understand that I can withdraw from the study or decline to answer any question at any stage and that this will not affect my status now or in the future.
- ✓ I confirm that I am over 18 years of age.
- ✓ I agree to audio recording the interview.
- ✓ I was informed that the audio recording will be transcribed; both the recording and transcript will be stored securely at the University of Waterloo for four years, then destroyed, and only the research study supervisor and the researcher will have access to them. All records containing personal information will remain confidential and no information that could identify me will be released.
- ✓ Yes ___ / No ___ I agree to the use of anonymous quotations in the thesis or any publications.
- ✓ I was informed that this study has been reviewed by, and received ethics clearance through, the Office of Research Ethics at the University of Waterloo, and I may contact Dr. Susan Sykes at (519) 888-4567 (Ext. 36005) if I have concerns or comments resulting from my participation in this study.

Name of Participant ____

Signed ____

Date ____

I have explained the study to the participant and consider that he/she understands what is involved.

Researcher's Signature and Date ____________________________________

Appendix 4: Information Letter for Study Participants (Phase 3)

(Date)

Reference: Ontario Snowmobile Tourism: Responses to Climate Variability and Change

I am writing to invite you to participate in a study on Ontario Snowmobile Tourism: Responses to Climate Variability and Change. Changes in climate from both natural and human causes are influencing the Ontario snow-pack (e.g. timing, amount and quality), and consequently snowmobile tourism opportunities. This study is intended to provide insights into past and future responses of snowmobile trail managers/operators to changes in climate. In addition to being published in a thesis form, the outcomes of the research will be aimed at informing a set of practical strategies to meet the challenges of projected climate change. This study is being conducted by Stephen H. Gilmour, Master's Candidate – Tourism Policy & Planning at the University of Waterloo. Dr. Daniel Scott, Canada Research Chair in Global Change and Tourism is supervising the study.

In Phase III of the study, if you choose to participate, you will be asked to project your future responses to climate change scenarios for the periods 2010 to 2039 and 2040 to 2069. The interview may take approximately 1 hour of your time to complete. These scenarios were developed from information provided by senior snowmobile trail managers/operators in Phase I of the study.

All of the information that you provide will be treated with strict confidentiality. No information concerning individuals or organizations will appear in a published thesis, or any document resulting from this study. With your permission, anonymous quotations may be used in the thesis or any publications. Your participation is purely voluntary and you will be free to withdraw at any time or decline to answer any question. There are no known or anticipated risks to participation in the study. To withdraw from the study please contact me directly by telephone or email. The data collected through this study will be kept for a period of four years in a secure location and then confidentially destroyed.

Should you have any questions or concerns about the study or your involvement, please contact Stephen H. Gilmour, Master's Candidate, Tourism Policy & Planning, Faculty of Environment, University of Waterloo, 200 University Avenue West Waterloo, Ontario N2L 3G1 or Associate Professor Daniel Scott (519) 888-4567 (Ext. 35497) dj2scott@uwaterloo.ca. The study has ethics clearance through the University of Waterloo's Office of Research Ethics. Should you have any ethical concerns concerning your participation, please contact Dr. Susan E. Sykes, Director Office of Research Ethics, (519) 888-4567 (Ext. 36005) ssykes@uwaterloo.ca.

Thank you for your contribution to this study.

Sincerely,

Stephen H. Gilmour
Master's Candidate – Tourism Policy & Planning
University of Waterloo
shgilmou@uwaterloo.ca
(519) 888-4567 (Ext. 35928)

Appendix 5: Consent Form for Study Participants (Phase 3)

Study Title:	Ontario Snowmobile Tourism – Responses to Climate Variability and Change
Researchers Name:	Stephen H. Gilmour, Master's Candidate, Tourism Policy and Planning, University of Waterloo
Supervisors Name:	Daniel Scott, Associate Professor, Department of Geography, University of Waterloo

- ✓ I have read the Information Letter, and the nature and purpose of the research study have been explained to me. I understand and agree to take part.
- ✓ I was informed that I may not directly benefit from taking part in the study.
- ✓ I understand that I can withdraw from the study or decline to answer any question at any stage and that this will not affect my status now or in the future.
- ✓ I confirm that I am over 18 years of age.
- ✓ I agree to audio recording the interview.
- ✓ I was informed that the audio recording will be transcribed; both the recording and transcript will be stored securely at the University of Waterloo for four years, then destroyed, and only the research study supervisor and the researcher will have access to them. All records containing personal information will remain confidential and no information that could identify me will be released.
- ✓ Yes ___ / No ___ I agree to the use of anonymous quotations in the thesis or any publications.
- ✓ I was informed that this study has been reviewed by, and received ethics clearance through, the Office of Research Ethics at the University of Waterloo, and I may contact Dr. Susan Sykes at (519) 888-4567 (Ext. 36005) if I have concerns or comments resulting from my participation in this study.

Name of Participant ____

Signed ____

Date ____

I have explained the study to the participant and consider that he/she understands what is involved.

Researcher's Signature and Date ____________________________________

Appendix 6: Interview Questions (Phase 1)

1. What has been your personal involvement with snowmobiling in Ontario?
2. Is snowmobiling a great part of your lifestyle?
3. What role do you play in environmental stewardship and how has it evolved?
4. Describe the weather in an ideal and the worst snowmobile season you have experienced?
5. How does the weather in the snowmobile season and in the other seasons affected snowmobile trail operations?
6. Have you observed any record warm winters and how have these affected snowmobile trail operations? How much rain or freezing rain can the trail system sustain?
7. Is there an optimal temperature range for trail grooming?
8. What is the minimum snow cover required to begin trail grooming? How does this vary over different terrain? Do you have any 'rules of thumb' for trail operations?
9. What other weather and non-weather factors may affect trail operations?
10. Is the reliability of snowfall a factor for trail and club operations?
11. How does the length of the season affect trail operations?
12. How have trail operations evolved since the 1990's with respect to snowmobile tourism?
13. What have been the roles of the clubs/districts played in the development of snowmobile tourism? How have these roles evolved over time?
14. What are other major challenges affecting snowmobiling in Ontario presently and the next 5 to 10 years?

Appendix 7: Interview Questions (Phase 3)

1. After being informed of the projected climate in the periods 2010 to 2039, 2040 to 2069, and 2070 to 2099 in the Province of Ontario, what snowmobile trail management strategies do you foresee employing in each of these periods of time?
2. How will the climate in the snowmobile season and in the other seasons affected snowmobile trail operations?
3. What other climate and non-climate factors may affect trail operations?
4. During the three future time periods, is there a minimum number of grooming days in **X** out of **Y** winters necessary for sustainable snowmobile tourism?
5. How will the length of the snowmobile season affect trail operations?
6. What roles will snowmobile clubs/districts play in snowmobile tourism in these future periods of time?
7. What will be other major challenges affecting snowmobiling in Ontario during the periods 2010 to 2039, 2040 to 2069, and 2070 to 2099?

District 1 Projected Snowmobile Season Length (Days)

Baseline				INMCM3.0 B1												MIROC3.2 HIRES A1B											
				2020s				2050s				2080s				2020s				2050s				2080s			
Season	**15 cm**	**30 cm**	**60 cm**	**Season**	**15 cm**	**30 cm**	**60 cm**	**Season**	**15 cm**	**30 cm**	**60 cm**	**Season**	**15 cm**	**30 cm**	**60 cm**	**Season**	**15 cm**	**30 cm**	**60 cm**	**Season**	**15 cm**	**30 cm**	**60 cm**	**Season**	**15 cm**	**30 cm**	**60 cm**
61-62	10	0	0	**10-11**	13	0	0	**40-41**	13	0	0	**70-71**	13	0	0	**10-11**	10	0	0	**40-41**	8	0	0	**70-71**	6	0	0
62-63	14	0	0	**11-12**	6	0	0	**41-42**	4	0	0	**71-72**	4	0	0	**11-12**	1	0	0	**41-42**	0	0	0	**71-72**	0	0	0
63-64	18	0	0	**12-13**	7	0	0	**42-43**	7	0	0	**72-73**	7	0	0	**12-13**	5	0	0	**42-43**	4	0	0	**72-73**	2	0	0
64-65	73	49	0	**13-14**	52	44	0	**43-44**	51	40	0	**73-74**	51	41	0	**13-14**	41	12	0	**43-44**	37	8	0	**73-74**	31	3	0
65-66	50	0	0	**14-15**	24	6	0	**44-45**	19	7	0	**74-75**	17	5	0	**14-15**	16	0	0	**44-45**	8	0	0	**74-75**	6	0	0
66-67	72	60	2	**15-16**	55	53	9	**45-49**	54	45	3	**75-76**	53	42	3	**15-16**	54	17	0	**45-49**	26	2	0	**75-76**	4	0	0
67-68	17	1	0	**16-17**	23	14	0	**49-47**	18	0	0	**76-77**	16	0	0	**16-17**	13	0	0	**49-47**	10	0	0	**76-77**	10	0	0
68-69	46	6	0	**17-18**	40	3	0	**47-48**	39	4	0	**77-78**	40	4	0	**17-18**	36	0	0	**47-48**	27	0	0	**77-78**	19	0	0
69-70	94	51	0	**18-19**	46	29	0	**48-49**	43	0	0	**78-79**	41	0	0	**18-19**	5	0	0	**48-49**	5	0	0	**78-79**	5	0	0
70-71	72	26	0	**19-20**	61	46	0	**49-50**	60	45	0	**79-80**	58	45	0	**19-20**	50	31	0	**49-50**	39	3	0	**79-80**	15	2	0
71-72	35	5	0	**20-21**	31	16	0	**50-51**	31	16	0	**80-81**	31	8	0	**20-21**	29	5	0	**50-51**	27	5	0	**80-81**	25	0	0
72-73	45	0	0	**21-22**	23	0	0	**51-52**	25	0	0	**81-82**	21	0	0	**21-22**	21	0	0	**51-52**	22	0	0	**81-82**	22	0	0
73-74	41	3	0	**22-23**	34	3	0	**52-53**	29	3	0	**82-83**	13	0	0	**22-23**	10	0	0	**52-53**	10	0	0	**82-83**	7	0	0
74-75	83	62	6	**23-24**	66	58	36	**53-54**	63	53	34	**83-84**	60	53	34	**23-24**	56	41	0	**53-54**	42	29	0	**83-84**	37	10	0
75-76	0	0	0	**24-25**	2	0	0	**54-55**	1	0	0	**84-85**	0	0	0	**24-25**	0	0	0	**54-55**	0	0	0	**84-85**	0	0	0
76-77	56	14	0	**25-26**	58	53	28	**55-56**	56	43	8	**85-86**	54	40	5	**25-26**	45	35	0	**55-56**	36	6	0	**85-86**	11	3	0
77-78	59	35	0	**26-27**	48	32	0	**56-57**	46	30	0	**86-87**	44	30	0	**26-27**	32	11	0	**56-57**	32	1	0	**86-87**	24	0	0
78-79	27	0	0	**27-28**	20	0	0	**57-58**	18	0	0	**87-88**	17	0	0	**27-28**	0	0	0	**57-58**	0	0	0	**87-88**	0	0	0
79-80	63	55	0	**28-29**	41	9	0	**58-59**	41	8	0	**88-89**	40	8	0	**28-29**	31	0	0	**58-59**	32	2	0	**88-89**	32	0	0
80-81	0	0	0	**29-30**	0	0	0	**59-60**	0	0	0	**89-90**	0	0	0	**29-30**	0	0	0	**59-60**	0	0	0	**89-90**	0	0	0
80-81	5	0	0	**30-31**	12	0	0	**60-61**	8	0	0	**90-91**	10	0	0	**30-31**	2	0	0	**60-61**	3	0	0	**90-91**	3	0	0
81-82	40	6	0	**31-32**	4	0	0	**61-62**	6	0	0	**91-92**	4	0	0	**31-32**	3	0	0	**61-62**	1	0	0	**91-92**	0	0	0
83-84	26	0	0	**32-33**	22	3	0	**62-63**	13	2	0	**92-93**	8	0	0	**32-33**	2	0	0	**62-63**	2	0	0	**92-93**	1	0	0
84-85	60	41	0	**33-34**	41	37	11	**63-64**	38	34	9	**93-94**	37	34	11	**33-34**	32	23	7	**63-64**	23	20	4	**93-94**	17	14	0
85-86	50	33	0	**34-35**	26	20	0	**64-65**	26	20	0	**94-95**	25	20	0	**34-35**	24	14	0	**64-65**	25	0	0	**94-95**	24	0	0
86-87	4	0	0	**35-36**	9	0	0	**65-66**	11	0	0	**95-96**	9	0	0	**35-36**	8	0	0	**65-66**	8	0	0	**95-96**	9	0	0
87-88	75	54	0	**36-37**	63	52	6	**66-67**	63	47	4	**96-97**	64	50	7	**36-37**	59	45	0	**66-67**	54	33	0	**96-97**	51	29	0
88-89	66	32	0	**37-38**	25	12	0	**67-68**	18	3	0	**97-98**	14	0	0	**37-38**	10	0	0	**67-68**	7	0	0	**97-98**	1	0	0
89-90	47	0	0	**38-39**	45	25	0	**68-69**	44	19	0	**98-99**	42	23	0	**38-39**	30	0	0	**68-69**	25	0	0	**98-99**	25	0	0
Mean	**43.03**	**18.38**	**0.28**	**Mean**	**30.93**	**17.76**	**3.10**	**Mean**	**29.14**	**14.45**	**2.00**	**Mean**	**27.34**	**13.90**	**2.07**	**Mean**	**21.55**	**8.07**	**0.24**	**Mean**	**17.69**	**3.76**	**0.14**	**Mean**	**13.34**	**2.10**	**0.00**
SD	**26.79**	**22.83**	**1.16**	**SD**	**20.03**	**20.35**	**8.53**	**SD**	**19.98**	**18.60**	**6.57**	**SD**	**20.15**	**18.83**	**6.64**	**SD**	**19.08**	**13.77**	**1.30**	**SD**	**15.51**	**8.58**	**0.74**	**SD**	**13.40**	**6.07**	**0.00**

Appendix 9

District 2 Projected Snowmobile Season Length (Days)

Baseline				INMCM3.0 B1												MIROC3.2 HIRES A1B											
				2020s				2050s				2080s				2020s				2050s				2080s			
Season	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**
61-62	16	0	0	**10-11**	12	0	0	**40-41**	9	0	0	**70-71**	9	0	0	**10-11**	0	0	0	**40-41**	0	0	0	**70-71**	0	0	0
62-63	78	53	0	**11-12**	19	0	0	**41-42**	17	0	0	**71-72**	17	0	0	**11-12**	14	0	0	**41-42**	13	0	0	**71-72**	10	0	0
63-64	88	71	6	**12-13**	37	9	0	**42-43**	34	9	0	**72-73**	32	9	0	**12-13**	27	9	0	**42-43**	25	9	0	**72-73**	23	7	0
64-65	76	57	0	**13-14**	49	47	16	**43-44**	50	46	4	**73-74**	50	46	4	**13-14**	33	2	0	**43-44**	20	0	0	**73-74**	8	0	0
65-66	43	0	0	**14-15**	29	16	0	**44-45**	18	15	0	**74-75**	18	15	0	**14-15**	18	10	0	**44-45**	16	2	0	**74-75**	14	4	0
66-67	54	4	0	**15-16**	65	55	26	**45-49**	65	52	10	**75-76**	63	51	10	**15-16**	60	49	4	**45-49**	56	45	0	**75-76**	56	44	0
67-68	68	0	0	**16-17**	52	30	0	**49-47**	50	28	0	**76-77**	48	21	0	**16-17**	22	0	0	**49-47**	15	0	0	**76-77**	16	0	0
68-69	52	0	0	**17-18**	48	17	0	**47-48**	46	16	0	**77-78**	46	14	0	**17-18**	22	0	0	**47-48**	20	0	0	**77-78**	16	0	0
69-70	54	29	0	**18-19**	43	39	15	**48-49**	42	34	14	**78-79**	41	31	0	**18-19**	32	19	0	**48-49**	31	14	0	**78-79**	17	0	0
70-71	18	0	0	**19-20**	27	0	0	**49-50**	13	0	0	**79-80**	29	0	0	**19-20**	9	0	0	**49-50**	5	0	0	**79-80**	4	0	0
71-72	42	0	0	**20-21**	4	0	0	**50-51**	5	0	0	**80-81**	5	0	0	**20-21**	2	0	0	**50-51**	2	0	0	**80-81**	4	0	0
72-73	80	45	0	**21-22**	54	33	0	**51-52**	54	32	0	**81-82**	48	31	0	**21-22**	36	17	0	**51-52**	31	11	0	**81-82**	33	12	0
73-74	74	26	0	**22-23**	19	3	0	**52-53**	17	3	0	**82-83**	14	3	0	**22-23**	11	0	0	**52-53**	8	0	0	**82-83**	5	0	0
74-75	61	0	0	**23-24**	46	29	0	**53-54**	42	4	0	**83-84**	41	1	0	**23-24**	4	0	0	**53-54**	4	0	0	**83-84**	2	0	0
75-76	41	15	0	**24-25**	36	30	7	**54-55**	35	27	0	**84-85**	34	24	0	**24-25**	6	0	0	**54-55**	0	0	0	**84-85**	0	0	0
76-77	62	25	0	**25-26**	47	45	22	**55-56**	47	40	11	**85-86**	46	38	6	**25-26**	31	0	0	**55-56**	0	0	0	**85-86**	6	0	0
77-78	0	0	0	**26-27**	40	20	0	**56-57**	30	0	0	**86-87**	30	0	0	**26-27**	0	0	0	**56-57**	0	0	0	**86-87**	0	0	0
78-79	54	0	0	**27-28**	39	22	0	**57-58**	30	15	0	**87-88**	30	20	0	**27-28**	9	0	0	**57-58**	5	0	0	**87-88**	7	0	0
79-80	37	20	0	**28-29**	29	16	0	**58-59**	25	11	0	**88-89**	24	7	0	**28-29**	9	0	0	**58-59**	5	0	0	**88-89**	3	0	0
80-81	89	52	0	**29-30**	85	70	39	**59-60**	78	70	35	**89-90**	80	71	38	**29-30**	76	63	0	**59-60**	73	50	0	**89-90**	54	15	0
80-81	20	0	0	**30-31**	10	0	0	**60-61**	11	0	0	**90-91**	10	0	0	**30-31**	6	0	0	**60-61**	5	0	0	**90-91**	0	0	0
81-82	61	35	0	**31-32**	32	26	0	**61-62**	29	21	0	**91-92**	29	20	0	**31-32**	14	1	0	**61-62**	4	0	0	**91-92**	1	0	0
83-84	49	0	0	**32-33**	68	48	0	**62-63**	68	44	0	**92-93**	65	41	0	**32-33**	22	0	0	**62-63**	18	0	0	**92-93**	18	0	0
84-85	55	1	0	**33-34**	40	14	0	**63-64**	37	6	0	**93-94**	38	4	0	**33-34**	6	0	0	**63-64**	3	0	0	**93-94**	6	0	0
85-86	37	0	0	**34-35**	4	0	0	**64-65**	5	0	0	**94-95**	5	0	0	**34-35**	4	0	0	**64-65**	5	0	0	**94-95**	4	0	0
86-87	70	12	0	**35-36**	22	0	0	**65-66**	22	0	0	**95-96**	22	0	0	**35-36**	7	0	0	**65-66**	5	0	0	**95-96**	4	0	0
87-88	23	7	0	**36-37**	33	15	0	**66-67**	33	5	0	**96-97**	33	9	0	**36-37**	10	0	0	**66-67**	8	0	0	**96-97**	11	0	0
88-89	26	0	0	**37-38**	32	0	0	**67-68**	23	0	0	**97-98**	30	0	0	**37-38**	0	0	0	**67-68**	0	0	0	**97-98**	0	0	0
89-90	45	0	0	**38-39**	22	4	0	**68-69**	18	3	0	**98-99**	18	3	0	**38-39**	6	2	0	**68-69**	6	2	0	**98-99**	5	2	0
Mean	**50.79**	**15.59**	**0.21**	**Mean**	**35.97**	**20.28**	**4.31**	**Mean**	**32.86**	**16.59**	**2.55**	**Mean**	**32.93**	**15.83**	**2.00**	**Mean**	**17.10**	**5.93**	**0.14**	**Mean**	**13.21**	**4.59**	**0.00**	**Mean**	**11.28**	**2.90**	**0.00**
SD	**22.77**	**21.53**	**1.11**	**SD**	**18.86**	**19.53**	**9.77**	**SD**	**19.04**	**19.29**	**7.24**	**SD**	**18.29**	**18.92**	**7.27**	**SD**	**17.78**	**14.87**	**0.74**	**SD**	**16.99**	**12.42**	**0.00**	**SD**	**14.44**	**8.72**	**0.00**

Appendix 10

District 3 Projected Snowmobile Season Length (Days)

Baseline				INMCM3.0 B1												MIROC3.2 HIRES A1B											
				2020s				2050s				2080s				2020s				2050s				2080s			
Season	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**
61-62	30	0	0	**10-11**	16	0	0	**40-41**	8	0	0	**70-71**	8	0	0	**10-11**	6	0	0	**40-41**	6	0	0	**70-71**	6	0	0
62-63	40	0	0	**11-12**	4	0	0	**41-42**	2	0	0	**71-72**	2	0	0	**11-12**	0	0	0	**41-42**	0	0	0	**71-72**	0	0	0
63-64	50	0	0	**12-13**	9	0	0	**42-43**	6	0	0	**72-73**	1	0	0	**12-13**	0	0	0	**42-43**	0	0	0	**72-73**	0	0	0
64-65	65	1	0	**13-14**	34	6	0	**43-44**	32	3	0	**73-74**	31	1	0	**13-14**	16	0	0	**43-44**	15	0	0	**73-74**	9	0	0
65-66	29	0	0	**14-15**	34	12	0	**44-45**	34	13	0	**74-75**	34	10	0	**14-15**	30	10	0	**44-45**	27	13	0	**74-75**	29	9	0
66-67	0	0	0	**15-16**	29	3	0	**45-49**	28	3	0	**75-76**	29	1	0	**15-16**	23	0	0	**45-49**	5	0	0	**75-76**	7	0	0
67-68	15	0	0	**16-17**	37	1	0	**49-47**	23	1	0	**76-77**	22	0	0	**16-17**	7	0	0	**49-47**	0	0	0	**76-77**	0	0	0
68-69	6	0	0	**17-18**	20	0	0	**47-48**	20	0	0	**77-78**	20	0	0	**17-18**	18	0	0	**47-48**	18	0	0	**77-78**	18	0	0
69-70	0	0	0	**18-19**	8	0	0	**48-49**	10	0	0	**78-79**	5	0	0	**18-19**	3	0	0	**48-49**	0	0	0	**78-79**	0	0	0
70-71	39	0	0	**19-20**	18	1	0	**49-50**	20	1	0	**79-80**	21	4	0	**19-20**	8	0	0	**49-50**	7	0	0	**79-80**	0	0	0
71-72	48	0	0	**20-21**	5	0	0	**50-51**	0	0	0	**80-81**	0	0	0	**20-21**	0	0	0	**50-51**	0	0	0	**80-81**	0	0	0
72-73	0	0	0	**21-22**	5	0	0	**51-52**	5	0	0	**81-82**	5	0	0	**21-22**	0	0	0	**51-52**	0	0	0	**81-82**	0	0	0
73-74	10	0	0	**22-23**	0	0	0	**52-53**	0	0	0	**82-83**	0	0	0	**22-23**	0	0	0	**52-53**	0	0	0	**82-83**	0	0	0
74-75	60	8	0	**23-24**	49	30	0	**53-54**	47	5	0	**83-84**	41	4	0	**23-24**	10	0	0	**53-54**	9	0	0	**83-84**	3	0	0
75-76	0	0	0	**24-25**	9	0	0	**54-55**	5	0	0	**84-85**	5	0	0	**24-25**	2	0	0	**54-55**	1	0	0	**84-85**	1	0	0
76-77	51	0	0	**25-26**	48	40	0	**55-56**	48	40	0	**85-86**	46	36	0	**25-26**	10	0	0	**55-56**	1	0	0	**85-86**	4	0	0
77-78	29	0	0	**26-27**	21	12	0	**56-57**	20	6	0	**86-87**	19	5	0	**26-27**	10	0	0	**56-57**	7	0	0	**86-87**	5	0	0
78-79	38	7	0	**27-28**	34	27	0	**57-58**	30	21	0	**87-88**	30	21	0	**27-28**	13	0	0	**57-58**	4	0	0	**87-88**	7	0	0
79-80	43	4	0	**28-29**	11	0	0	**58-59**	7	0	0	**88-89**	5	0	0	**28-29**	2	0	0	**58-59**	0	0	0	**88-89**	0	0	0
80-81	36	0	0	**29-30**	67	47	15	**59-60**	67	44	15	**89-90**	67	46	16	**29-30**	64	39	5	**59-60**	48	26	0	**89-90**	48	22	0
80-81	7	0	0	**30-31**	4	0	0	**60-61**	1	0	0	**90-91**	1	0	0	**30-31**	0	0	0	**60-61**	0	0	0	**90-91**	0	0	0
81-82	0	0	0	**31-32**	0	0	0	**61-62**	1	0	0	**91-92**	0	0	0	**31-32**	0	0	0	**61-62**	0	0	0	**91-92**	0	0	0
83-84	66	30	0	**32-33**	61	50	0	**62-63**	59	48	0	**92-93**	59	49	0	**32-33**	27	1	0	**62-63**	18	0	0	**92-93**	10	0	0
84-85	14	0	0	**33-34**	19	0	0	**63-64**	15	0	0	**93-94**	16	0	0	**33-34**	0	0	0	**63-64**	0	0	0	**93-94**	0	0	0
85-86	2	0	0	**34-35**	0	0	0	**64-65**	0	0	0	**94-95**	0	0	0	**34-35**	0	0	0	**64-65**	0	0	0	**94-95**	0	0	0
86-87	42	0	0	**35-36**	2	0	0	**65-66**	2	0	0	**95-96**	2	0	0	**35-36**	0	0	0	**65-66**	0	0	0	**95-96**	0	0	0
87-88	37	9	0	**36-37**	23	15	0	**66-67**	20	10	0	**96-97**	20	10	0	**36-37**	3	0	0	**66-67**	2	0	0	**96-97**	2	0	0
88-89	29	0	0	**37-38**	9	0	0	**67-68**	9	0	0	**97-98**	9	0	0	**37-38**	5	0	0	**67-68**	9	0	0	**97-98**	0	0	0
89-90	0	0	0	**38-39**	3	0	0	**68-69**	0	0	0	**98-99**	0	0	0	**38-39**	0	0	0	**68-69**	0	0	0	**98-99**	0	0	0
Mean	**27.10**	**2.03**	**0.00**	**Mean**	**19.97**	**8.41**	**0.52**	**Mean**	**17.90**	**6.72**	**0.52**	**Mean**	**17.17**	**6.45**	**0.55**	**Mean**	**8.86**	**1.72**	**0.17**	**Mean**	**6.10**	**1.34**	**0.00**	**Mean**	**5.14**	**1.07**	**0.00**
SD	**21.68**	**5.95**	**0.00**	**SD**	**18.77**	**15.17**	**2.79**	**SD**	**18.71**	**13.78**	**2.79**	**SD**	**18.58**	**13.77**	**2.97**	**SD**	**13.66**	**7.41**	**0.93**	**SD**	**10.64**	**5.32**	**0.00**	**SD**	**10.48**	**4.36**	**0.00**

Appendix 11

District 4 Projected Snowmobile Season Length (Days)

Baseline				INMCM3.0 B1												MIROC3.2 HIRES A1B											
				2020s				2050s				2080s				2020s				2050s				2080s			
Season	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**
61-62	0	0	0	**10-11**	0	0	0	**40-41**	0	0	0	**70-71**	0	0	0	**10-11**	0	0	0	**40-41**	0	0	0	**70-71**	0	0	0
62-63	9	0	0	**11-12**	7	0	0	**41-42**	5	0	0	**71-72**	0	0	0	**11-12**	6	0	0	**41-42**	0	0	0	**71-72**	0	0	0
63-64	0	0	0	**12-13**	2	0	0	**42-43**	0	0	0	**72-73**	1	0	0	**12-13**	0	0	0	**42-43**	0	0	0	**72-73**	0	0	0
64-65	44	0	0	**13-14**	8	0	0	**43-44**	6	0	0	**73-74**	3	0	0	**13-14**	2	0	0	**43-44**	3	0	0	**73-74**	2	0	0
65-66	34	16	0	**14-15**	11	0	0	**44-45**	14	0	0	**74-75**	15	0	0	**14-15**	11	0	0	**44-45**	6	0	0	**74-75**	10	0	0
66-67	39	0	0	**15-16**	2	0	0	**45-49**	0	0	0	**75-76**	0	0	0	**15-16**	0	0	0	**45-49**	0	0	0	**75-76**	0	0	0
67-68	26	0	0	**16-17**	24	0	0	**49-47**	20	0	0	**76-77**	20	0	0	**16-17**	22	0	0	**49-47**	23	0	0	**76-77**	23	0	0
68-69	45	0	0	**17-18**	10	0	0	**47-48**	5	0	0	**77-78**	7	0	0	**17-18**	0	0	0	**47-48**	0	0	0	**77-78**	0	0	0
69-70	33	0	0	**18-19**	5	0	0	**48-49**	5	0	0	**78-79**	5	0	0	**18-19**	6	0	0	**48-49**	6	0	0	**78-79**	6	0	0
70-71	23	0	0	**19-20**	5	0	0	**49-50**	2	0	0	**79-80**	5	0	0	**19-20**	7	0	0	**49-50**	2	0	0	**79-80**	4	0	0
71-72	4	0	0	**20-21**	7	0	0	**50-51**	4	0	0	**80-81**	6	0	0	**20-21**	4	0	0	**50-51**	6	0	0	**80-81**	2	0	0
72-73	14	0	0	**21-22**	7	0	0	**51-52**	2	0	0	**81-82**	3	0	0	**21-22**	7	0	0	**51-52**	4	0	0	**81-82**	4	0	0
73-74	3	0	0	**22-23**	0	0	0	**52-53**	0	0	0	**82-83**	2	0	0	**22-23**	0	0	0	**52-53**	0	0	0	**82-83**	0	0	0
74-75	17	0	0	**23-24**	0	0	0	**53-54**	0	0	0	**83-84**	0	0	0	**23-24**	0	0	0	**53-54**	0	0	0	**83-84**	0	0	0
75-76	3	0	0	**24-25**	0	0	0	**54-55**	0	0	0	**84-85**	0	0	0	**24-25**	0	0	0	**54-55**	0	0	0	**84-85**	0	0	0
76-77	58	11	0	**25-26**	11	0	0	**55-56**	4	0	0	**85-86**	4	0	0	**25-26**	7	0	0	**55-56**	2	0	0	**85-86**	1	0	0
77-78	14	0	0	**26-27**	22	0	0	**56-57**	5	0	0	**86-87**	5	0	0	**26-27**	4	0	0	**56-57**	0	0	0	**86-87**	4	0	0
78-79	39	0	0	**27-28**	0	0	0	**57-58**	0	0	0	**87-88**	0	0	0	**27-28**	0	0	0	**57-58**	0	0	0	**87-88**	0	0	0
79-80	22	0	0	**28-29**	1	0	0	**58-59**	2	0	0	**88-89**	0	0	0	**28-29**	0	0	0	**58-59**	0	0	0	**88-89**	0	0	0
80-81	13	0	0	**29-30**	32	0	0	**59-60**	18	0	0	**89-90**	29	0	0	**29-30**	28	0	0	**59-60**	2	0	0	**89-90**	0	0	0
80-81	18	0	0	**30-31**	9	0	0	**60-61**	5	0	0	**90-91**	4	0	0	**30-31**	1	0	0	**60-61**	0	0	0	**90-91**	0	0	0
81-82	24	6	0	**31-32**	0	0	0	**61-62**	0	0	0	**91-92**	0	0	0	**31-32**	0	0	0	**61-62**	0	0	0	**91-92**	0	0	0
83-84	48	5	0	**32-33**	36	17	0	**62-63**	34	10	0	**92-93**	30	4	0	**32-33**	35	9	0	**62-63**	26	1	0	**92-93**	14	0	0
84-85	0	0	0	**33-34**	4	0	0	**63-64**	4	0	0	**93-94**	4	0	0	**33-34**	6	0	0	**63-64**	4	0	0	**93-94**	0	0	0
85-86	5	0	0	**34-35**	1	0	0	**64-65**	1	0	0	**94-95**	1	0	0	**34-35**	0	0	0	**64-65**	1	0	0	**94-95**	0	0	0
86-87	51	21	0	**35-36**	3	0	0	**65-66**	4	0	0	**95-96**	3	0	0	**35-36**	4	0	0	**65-66**	0	0	0	**95-96**	0	0	0
87-88	0	0	0	**36-37**	4	0	0	**66-67**	0	0	0	**96-97**	0	0	0	**36-37**	4	0	0	**66-67**	0	0	0	**96-97**	0	0	0
88-89	6	0	0	**37-38**	0	0	0	**67-68**	0	0	0	**97-98**	0	0	0	**37-38**	0	0	0	**67-68**	0	0	0	**97-98**	0	0	0
89-90	0	0	0	**38-39**	0	0	0	**68-69**	0	0	0	**98-99**	0	0	0	**38-39**	0	0	0	**68-69**	0	0	0	**98-99**	0	0	0
Mean	**20.41**	**2.03**	**0.00**	**Mean**	**7.28**	**0.59**	**0.00**	**Mean**	**4.83**	**0.34**	**0.00**	**Mean**	**5.07**	**0.14**	**0.00**	**Mean**	**5.31**	**0.31**	**0.00**	**Mean**	**2.93**	**0.03**	**0.00**	**Mean**	**2.41**	**0.00**	**0.00**
SD	**17.98**	**5.21**	**0.00**	**SD**	**9.60**	**3.16**	**0.00**	**SD**	**7.65**	**1.86**	**0.00**	**SD**	**8.15**	**0.74**	**0.00**	**SD**	**8.70**	**1.67**	**0.00**	**SD**	**6.32**	**0.19**	**0.00**	**SD**	**5.17**	**0.00**	**0.00**

District 5 Projected Snowmobile Season Length (Days)

Baseline				INMCM3.0 B1												MIROC3.2 HIRES A1B											
				2020s				2050s				2080s				2020s				2050s				2080s			
Season	15cm	30cm	60cm	Season	15cm	30cm	60cm	Season	15cm	30cm	60cm	Season	15cm	30cm	60cm	Season	15cm	30cm	60cm	Season	15cm	30cm	60cm	Season	15cm	30cm	60cm
61-62	0	0	0	**10-11**	0	0	0	**40-41**	0	0	0	**70-71**	0	0	0	**10-11**	0	0	0	**40-41**	0	0	0	**70-71**	0	0	0
62-63	67	17	0	**11-12**	10	0	0	**41-42**	10	0	0	**71-72**	5	0	0	**11-12**	0	0	0	**41-42**	0	0	0	**71-72**	0	0	0
63-64	42	3	0	**12-13**	0	0	0	**42-43**	0	0	0	**72-73**	0	0	0	**12-13**	0	0	0	**42-43**	0	0	0	**72-73**	0	0	0
64-65	27	0	0	**13-14**	3	0	0	**43-44**	2	0	0	**73-74**	1	0	0	**13-14**	3	0	0	**43-44**	0	0	0	**73-74**	0	0	0
65-66	32	0	0	**14-15**	0	0	0	**44-45**	0	0	0	**74-75**	0	0	0	**14-15**	0	0	0	**44-45**	0	0	0	**74-75**	0	0	0
66-67	0	0	0	**15-16**	17	0	0	**45-49**	9	0	0	**75-76**	0	0	0	**15-16**	0	0	0	**45-49**	0	0	0	**75-76**	0	0	0
67-68	0	0	0	**16-17**	0	0	0	**49-47**	0	0	0	**76-77**	0	0	0	**16-17**	0	0	0	**49-47**	0	0	0	**76-77**	0	0	0
68-69	46	23	0	**17-18**	28	0	0	**47-48**	28	0	0	**77-78**	28	0	0	**17-18**	29	0	0	**47-48**	30	0	0	**77-78**	19	0	0
69-70	13	0	0	**18-19**	0	0	0	**48-49**	0	0	0	**78-79**	0	0	0	**18-19**	0	0	0	**48-49**	0	0	0	**78-79**	0	0	0
70-71	6	0	0	**19-20**	0	0	0	**49-50**	0	0	0	**79-80**	0	0	0	**19-20**	0	0	0	**49-50**	0	0	0	**79-80**	0	0	0
71-72	57	33	0	**20-21**	0	0	0	**50-51**	1	0	0	**80-81**	1	0	0	**20-21**	1	0	0	**50-51**	1	0	0	**80-81**	0	0	0
72-73	0	0	0	**21-22**	0	0	0	**51-52**	0	0	0	**81-82**	0	0	0	**21-22**	0	0	0	**51-52**	0	0	0	**81-82**	0	0	0
73-74	22	1	0	**22-23**	8	0	0	**52-53**	8	0	0	**82-83**	8	0	0	**22-23**	8	0	0	**52-53**	8	0	0	**82-83**	8	0	0
74-75	53	18	0	**23-24**	9	1	0	**53-54**	9	1	0	**83-84**	8	1	0	**23-24**	10	2	0	**53-54**	7	1	0	**83-84**	9	1	0
75-76	40	29	0	**24-25**	7	0	0	**54-55**	7	0	0	**84-85**	7	0	0	**24-25**	7	0	0	**54-55**	4	0	0	**84-85**	1	0	0
76-77	33	8	0	**25-26**	7	0	0	**55-56**	7	0	0	**85-86**	5	0	0	**25-26**	9	0	0	**55-56**	2	0	0	**85-86**	0	0	0
77-78	9	0	0	**26-27**	9	3	0	**56-57**	8	2	0	**86-87**	8	2	0	**26-27**	9	4	0	**56-57**	5	2	0	**86-87**	3	1	0
78-79	18	14	0	**27-28**	10	4	0	**57-58**	10	4	0	**87-88**	9	3	0	**27-28**	10	2	0	**57-58**	6	0	0	**87-88**	4	0	0
79-80	47	30	0	**28-29**	0	0	0	**58-59**	0	0	0	**88-89**	0	0	0	**28-29**	0	0	0	**58-59**	0	0	0	**88-89**	0	0	0
80-81	56	38	0	**29-30**	42	37	0	**59-60**	40	35	0	**89-90**	41	36	0	**29-30**	41	35	0	**59-60**	39	32	0	**89-90**	33	5	0
80-81	39	0	0	**30-31**	3	0	0	**60-61**	2	0	0	**90-91**	2	0	0	**30-31**	1	0	0	**60-61**	0	0	0	**90-91**	0	0	0
81-82	44	0	0	**31-32**	0	0	0	**61-62**	0	0	0	**91-92**	0	0	0	**31-32**	0	0	0	**61-62**	0	0	0	**91-92**	0	0	0
83-84	4	0	0	**32-33**	5	0	0	**62-63**	4	0	0	**92-93**	3	0	0	**32-33**	12	0	0	**62-63**	2	0	0	**92-93**	3	0	0
84-85	47	29	0	**33-34**	13	2	0	**63-64**	9	0	0	**93-94**	10	0	0	**33-34**	9	0	0	**63-64**	2	0	0	**93-94**	2	0	0
85-86	32	6	0	**34-35**	0	0	0	**64-65**	0	0	0	**94-95**	0	0	0	**34-35**	0	0	0	**64-65**	0	0	0	**94-95**	0	0	0
86-87	10	0	0	**35-36**	0	0	0	**65-66**	0	0	0	**95-96**	0	0	0	**35-36**	0	0	0	**65-66**	0	0	0	**95-96**	0	0	0
87-88	9	0	0	**36-37**	0	0	0	**66-67**	0	0	0	**96-97**	0	0	0	**36-37**	0	0	0	**66-67**	0	0	0	**96-97**	0	0	0
88-89	0	0	0	**37-38**	0	0	0	**67-68**	0	0	0	**97-98**	0	0	0	**37-38**	0	0	0	**67-68**	0	0	0	**97-98**	0	0	0
89-90	39	12	0	**38-39**	3	0	0	**68-69**	0	0	0	**98-99**	3	0	0	**38-39**	0	0	0	**68-69**	0	0	0	**98-99**	0	0	0
Mean	**27.31**	**9.00**	**0.00**	**Mean**	**6.00**	**1.62**	**0.00**	**Mean**	**5.31**	**1.45**	**0.00**	**Mean**	**4.79**	**1.45**	**0.00**	**Mean**	**5.14**	**1.48**	**0.00**	**Mean**	**3.66**	**1.21**	**0.00**	**Mean**	**2.83**	**0.24**	**0.00**
SD	**20.78**	**12.48**	**0.00**	**SD**	**9.52**	**6.87**	**0.00**	**SD**	**8.98**	**6.51**	**0.00**	**SD**	**9.05**	**6.68**	**0.00**	**SD**	**9.39**	**6.51**	**0.00**	**SD**	**8.94**	**5.94**	**0.00**	**SD**	**7.08**	**0.95**	**0.00**

Appendix 13

District 6 Projected Snowmobile Season Length (Days)

Baseline				INMCM3.0 B1												MIROC3.2 HIRES A1B											
				2020s				2050s				2080s				2020s				2050s				2080s			
Season	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**
61-62	13	0	0	**10-11**	12	0	0	**40-41**	8	0	0	**70-71**	7	0	0	**10-11**	2	0	0	**40-41**	0	0	0	**70-71**	0	0	0
62-63	92	56	10	**11-12**	41	22	0	**41-42**	37	14	0	**71-72**	35	13	0	**11-12**	18	6	0	**41-42**	15	2	0	**71-72**	14	2	0
63-64	59	0	0	**12-13**	3	0	0	**42-43**	2	0	0	**72-73**	2	0	0	**12-13**	1	0	0	**42-43**	1	0	0	**72-73**	0	0	0
64-65	76	40	27	**13-14**	61	48	27	**43-44**	57	42	16	**73-74**	55	43	25	**13-14**	50	17	0	**43-44**	43	12	0	**73-74**	35	10	0
65-66	84	67	9	**14-15**	52	43	17	**44-45**	52	37	9	**74-75**	51	36	7	**14-15**	35	20	0	**44-45**	21	8	0	**74-75**	22	10	0
66-67	80	64	23	**15-16**	58	51	31	**45-49**	56	49	30	**75-76**	54	47	30	**15-16**	51	38	17	**45-49**	45	35	0	**75-76**	38	28	0
67-68	51	44	0	**16-17**	38	28	0	**49-47**	36	28	0	**76-77**	36	28	0	**16-17**	28	8	0	**49-47**	21	0	0	**76-77**	15	0	0
68-69	15	0	0	**17-18**	41	31	0	**47-48**	40	30	0	**77-78**	38	29	0	**17-18**	34	4	0	**47-48**	33	0	0	**77-78**	31	0	0
69-70	80	14	0	**18-19**	59	43	0	**48-49**	54	36	0	**78-79**	52	13	0	**18-19**	16	0	0	**48-49**	13	0	0	**78-79**	6	0	0
70-71	78	37	0	**19-20**	58	37	2	**49-50**	52	33	0	**79-80**	56	37	3	**19-20**	37	2	0	**49-50**	19	0	0	**79-80**	4	0	0
71-72	15	0	0	**20-21**	18	0	0	**50-51**	18	0	0	**80-81**	17	0	0	**20-21**	12	0	0	**50-51**	6	0	0	**80-81**	6	0	0
72-73	47	0	0	**21-22**	43	24	0	**51-52**	41	24	0	**81-82**	39	14	0	**21-22**	20	0	0	**51-52**	6	0	0	**81-82**	7	0	0
73-74	85	55	17	**22-23**	27	19	0	**52-53**	26	9	0	**82-83**	23	7	0	**22-23**	14	0	0	**52-53**	13	0	0	**82-83**	13	0	0
74-75	66	46	3	**23-24**	63	53	32	**53-54**	60	50	30	**83-84**	62	54	34	**23-24**	60	51	29	**53-54**	58	48	29	**83-84**	58	49	25
75-76	0	0	0	**24-25**	30	0	0	**54-55**	29	0	0	**84-85**	30	0	0	**24-25**	26	0	0	**54-55**	28	0	0	**84-85**	13	0	0
76-77	30	0	0	**25-26**	46	32	0	**55-56**	47	31	0	**85-86**	45	32	0	**25-26**	37	4	0	**55-56**	32	0	0	**85-86**	32	0	0
77-78	75	47	0	**26-27**	51	40	0	**56-57**	49	38	0	**86-87**	48	35	0	**26-27**	41	14	0	**56-57**	33	0	0	**86-87**	8	0	0
78-79	74	40	0	**27-28**	42	38	11	**57-58**	40	29	0	**87-88**	40	34	0	**27-28**	41	30	0	**57-58**	39	29	0	**87-88**	40	30	0
79-80	51	19	0	**28-29**	47	34	0	**58-59**	45	31	0	**88-89**	45	31	0	**28-29**	41	18	0	**58-59**	40	15	0	**88-89**	29	0	0
80-81	37	18	0	**29-30**	24	12	0	**59-60**	21	12	0	**89-90**	24	13	0	**29-30**	17	11	0	**59-60**	16	7	0	**89-90**	14	5	0
80-81	51	9	0	**30-31**	0	0	0	**60-61**	0	0	0	**90-91**	1	0	0	**30-31**	0	0	0	**60-61**	0	0	0	**90-91**	0	0	0
81-82	29	1	0	**31-32**	25	0	0	**61-62**	23	0	0	**91-92**	24	0	0	**31-32**	6	0	0	**61-62**	5	0	0	**91-92**	4	0	0
83-84	101	87	30	**32-33**	82	69	41	**62-63**	81	68	39	**92-93**	81	68	39	**32-33**	71	56	14	**62-63**	67	49	0	**92-93**	66	47	0
84-85	69	57	0	**33-34**	60	52	31	**63-64**	59	47	20	**93-94**	59	48	26	**33-34**	47	34	0	**63-64**	44	28	0	**93-94**	43	30	0
85-86	71	35	0	**34-35**	5	0	0	**64-65**	5	0	0	**94-95**	5	0	0	**34-35**	3	0	0	**64-65**	3	0	0	**94-95**	1	0	0
86-87	0	0	0	**35-36**	0	0	0	**65-66**	0	0	0	**95-96**	0	0	0	**35-36**	0	0	0	**65-66**	0	0	0	**95-96**	0	0	0
87-88	61	32	7	**36-37**	69	58	28	**66-67**	69	57	28	**96-97**	68	57	28	**36-37**	64	54	28	**66-67**	63	49	29	**96-97**	63	46	12
88-89	61	44	0	**37-38**	31	7	0	**67-68**	30	7	0	**97-98**	28	7	0	**37-38**	11	0	0	**67-68**	11	0	0	**97-98**	8	0	0
89-90	0	0	0	**38-39**	8	0	0	**68-69**	6	0	0	**98-99**	6	0	0	**38-39**	2	0	0	**68-69**	0	0	0	**98-99**	0	0	0
Mean	**53.48**	**28.00**	**4.34**	**Mean**	**37.72**	**25.55**	**7.59**	**Mean**	**35.97**	**23.17**	**5.93**	**Mean**	**35.55**	**22.28**	**6.62**	**Mean**	**27.07**	**12.66**	**3.03**	**Mean**	**23.28**	**9.72**	**2.00**	**Mean**	**19.66**	**8.86**	**1.28**
SD	**29.63**	**25.92**	**8.74**	**SD**	**22.46**	**21.76**	**13.21**	**SD**	**22.06**	**20.59**	**11.68**	**SD**	**21.91**	**20.89**	**12.61**	**SD**	**20.88**	**17.90**	**8.11**	**SD**	**20.10**	**16.58**	**7.48**	**SD**	**19.96**	**16.10**	**5.08**

District 7 Projected Snowmobile Season Length (Days)

Baseline				INMCM3.0 B1												MIROC3.2 HIRES A1B											
				2020s				2050s				2080s				2020s				2050s				2080s			
Season	15cm	30cm	60cm	Season	15cm	30cm	60cm	Season	15cm	30cm	60cm	Season	15cm	30cm	60cm	Season	15cm	30cm	60cm	Season	15cm	30cm	60cm	Season	15cm	30cm	60cm
61-62	41	27	0	**10-11**	31	24	2	**40-41**	30	24	0	**70-71**	29	23	0	**10-11**	25	9	0	**40-41**	23	4	0	**70-71**	20	3	0
62-63	47	43	11	**11-12**	31	21	0	**41-42**	32	12	0	**71-72**	30	10	0	**11-12**	19	7	0	**41-42**	8	0	0	**71-72**	7	0	0
63-64	54	38	1	**12-13**	30	16	0	**42-43**	29	16	0	**72-73**	29	16	0	**12-13**	19	2	0	**42-43**	16	2	0	**72-73**	14	1	0
64-65	63	47	3	**13-14**	62	48	20	**43-44**	59	44	13	**73-74**	58	44	17	**13-14**	44	23	0	**43-44**	37	4	0	**73-74**	28	2	0
65-66	73	43	0	**14-15**	61	58	38	**44-45**	61	58	34	**74-75**	60	57	32	**14-15**	54	47	4	**44-45**	38	19	0	**74-75**	27	1	0
66-67	72	49	7	**15-16**	56	43	17	**45-49**	55	39	2	**75-76**	51	33	0	**15-16**	28	1	0	**45-49**	26	0	0	**75-76**	26	1	0
67-68	28	0	0	**16-17**	32	8	0	**49-47**	30	9	0	**76-77**	25	2	0	**16-17**	3	0	0	**49-47**	0	0	0	**76-77**	0	0	0
68-69	4	0	0	**17-18**	9	0	0	**47-48**	12	0	0	**77-78**	10	0	0	**17-18**	3	0	0	**47-48**	7	0	0	**77-78**	5	0	0
69-70	81	67	41	**18-19**	58	48	37	**48-49**	58	48	34	**78-79**	57	47	21	**18-19**	56	35	0	**48-49**	53	34	0	**78-79**	18	0	0
70-71	54	1	0	**19-20**	40	15	0	**49-50**	40	7	0	**79-80**	41	23	0	**19-20**	20	1	0	**49-50**	17	2	0	**79-80**	3	0	0
71-72	0	0	0	**20-21**	0	0	0	**50-51**	0	0	0	**80-81**	0	0	0	**20-21**	0	0	0	**50-51**	0	0	0	**80-81**	0	0	0
72-73	61	41	0	**21-22**	47	23	0	**51-52**	48	24	0	**81-82**	46	16	0	**21-22**	42	0	0	**51-52**	34	0	0	**81-82**	26	0	0
73-74	57	26	8	**22-23**	25	22	0	**52-53**	25	22	0	**82-83**	24	22	0	**22-23**	20	0	0	**52-53**	10	0	0	**82-83**	0	0	0
74-75	64	43	0	**23-24**	56	44	29	**53-54**	55	44	23	**83-84**	56	45	26	**23-24**	52	43	5	**53-54**	44	32	0	**83-84**	44	28	0
75-76	25	0	0	**24-25**	19	16	0	**54-55**	19	15	0	**84-85**	18	14	0	**24-25**	16	0	0	**54-55**	16	0	0	**84-85**	11	0	0
76-77	40	2	0	**25-26**	46	38	11	**55-56**	44	37	9	**85-86**	45	38	4	**25-26**	32	19	0	**55-56**	24	9	0	**85-86**	23	1	0
77-78	89	80	12	**26-27**	70	61	22	**56-57**	67	58	20	**86-87**	68	57	19	**26-27**	65	32	0	**56-57**	55	14	0	**86-87**	22	2	0
78-79	54	3	0	**27-28**	30	4	0	**57-58**	11	0	0	**87-88**	12	0	0	**27-28**	6	0	0	**57-58**	1	0	0	**87-88**	2	0	0
79-80	56	1	0	**28-29**	58	38	0	**58-59**	58	38	0	**88-89**	59	36	0	**28-29**	56	30	0	**58-59**	39	3	0	**88-89**	33	0	0
80-81	86	78	26	**29-30**	66	58	21	**59-60**	66	57	17	**89-90**	64	56	18	**29-30**	61	46	13	**59-60**	52	34	0	**89-90**	56	36	0
80-81	53	39	0	**30-31**	33	25	0	**60-61**	32	23	0	**90-91**	28	22	0	**30-31**	18	0	0	**60-61**	19	0	0	**90-91**	0	0	0
81-82	44	18	0	**31-32**	19	10	0	**61-62**	17	9	0	**91-92**	18	9	0	**31-32**	12	2	0	**61-62**	12	0	0	**91-92**	2	0	0
83-84	86	25	0	**32-33**	52	2	0	**62-63**	40	2	0	**92-93**	52	2	0	**32-33**	22	0	0	**62-63**	17	0	0	**92-93**	16	0	0
84-85	37	0	0	**33-34**	41	22	0	**63-64**	40	30	0	**93-94**	40	30	0	**33-34**	40	22	0	**63-64**	36	20	0	**93-94**	35	4	0
85-86	71	59	11	**34-35**	31	8	0	**64-65**	30	8	0	**94-95**	29	5	0	**34-35**	29	0	0	**64-65**	29	0	0	**94-95**	18	0	0
86-87	16	5	0	**35-36**	17	0	0	**65-66**	9	0	0	**95-96**	16	0	0	**35-36**	4	0	0	**65-66**	0	0	0	**95-96**	0	0	0
87-88	67	50	0	**36-37**	53	11	0	**66-67**	51	10	0	**96-97**	51	11	0	**36-37**	17	4	0	**66-67**	12	1	0	**96-97**	12	1	0
88-89	83	38	0	**37-38**	49	21	0	**67-68**	47	21	0	**97-98**	48	21	0	**37-38**	42	11	0	**67-68**	43	11	0	**97-98**	27	0	0
89-90	13	0	0	**38-39**	8	1	0	**68-69**	6	1	0	**98-99**	6	1	0	**38-39**	1	0	0	**68-69**	0	0	0	**98-99**	0	0	0
Mean	**52.38**	**28.38**	**4.14**	**Mean**	**38.97**	**23.62**	**6.79**	**Mean**	**36.93**	**22.62**	**5.24**	**Mean**	**36.90**	**22.07**	**4.72**	**Mean**	**27.79**	**11.52**	**0.76**	**Mean**	**23.03**	**6.52**	**0.00**	**Mean**	**16.38**	**2.76**	**0.00**
SD	**24.65**	**25.52**	**9.20**	**SD**	**18.79**	**19.12**	**12.03**	**SD**	**19.24**	**19.05**	**10.33**	**SD**	**19.17**	**18.82**	**9.42**	**SD**	**19.70**	**15.95**	**2.63**	**SD**	**17.21**	**10.88**	**0.00**	**SD**	**14.72**	**8.23**	**0.00**

Appendix 15

District 8 Projected Snowmobile Season Length (Days)

Baseline				INMCM3.0 B1												MIROC3.2 HIRES A1B											
				2020s				2050s				2080s				2020s				2050s				2080s			
Season	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**
61-62	0	0	0	**10-11**	17	7	0	**40-41**	17	0	0	**70-71**	17	0	0	**10-11**	0	0	0	**40-41**	0	0	0	**70-71**	0	0	0
62-63	6	0	0	**11-12**	17	0	0	**41-42**	7	0	0	**71-72**	8	0	0	**11-12**	1	0	0	**41-42**	1	0	0	**71-72**	0	0	0
63-64	33	14	0	**12-13**	4	0	0	**42-43**	4	0	0	**72-73**	2	0	0	**12-13**	1	0	0	**42-43**	0	0	0	**72-73**	0	0	0
64-65	21	0	0	**13-14**	20	6	0	**43-44**	20	6	0	**73-74**	20	5	0	**13-14**	17	5	0	**43-44**	16	4	0	**73-74**	16	4	0
65-66	60	38	0	**14-15**	41	34	0	**44-45**	40	29	0	**74-75**	36	24	0	**14-15**	33	17	0	**44-45**	24	10	0	**74-75**	8	0	0
66-67	59	10	0	**15-16**	49	38	1	**45-49**	47	37	0	**75-76**	52	43	5	**15-16**	39	1	0	**45-49**	9	0	0	**75-76**	5	0	0
67-68	4	0	0	**16-17**	15	1	0	**49-47**	13	0	0	**76-77**	13	0	0	**16-17**	0	0	0	**49-47**	0	0	0	**76-77**	0	0	0
68-69	49	26	0	**17-18**	40	28	0	**47-48**	39	23	0	**77-78**	32	2	0	**17-18**	14	6	0	**47-48**	12	6	0	**77-78**	10	0	0
69-70	73	10	0	**18-19**	0	0	0	**48-49**	0	0	0	**78-79**	0	0	0	**18-19**	0	0	0	**48-49**	0	0	0	**78-79**	0	0	0
70-71	44	15	0	**19-20**	49	35	0	**49-50**	46	21	0	**79-80**	45	34	0	**19-20**	21	6	0	**49-50**	17	4	0	**79-80**	6	0	0
71-72	0	0	0	**20-21**	0	0	0	**50-51**	0	0	0	**80-81**	0	0	0	**20-21**	0	0	0	**50-51**	0	0	0	**80-81**	0	0	0
72-73	20	0	0	**21-22**	36	0	0	**51-52**	28	0	0	**81-82**	22	0	0	**21-22**	0	0	0	**51-52**	0	0	0	**81-82**	0	0	0
73-74	1	0	0	**22-23**	1	0	0	**52-53**	1	0	0	**82-83**	1	0	0	**22-23**	1	0	0	**52-53**	1	0	0	**82-83**	1	0	0
74-75	20	0	0	**23-24**	31	1	0	**53-54**	29	0	0	**83-84**	31	0	0	**23-24**	12	0	0	**53-54**	1	0	0	**83-84**	0	0	0
75-76	39	12	0	**24-25**	27	17	0	**54-55**	22	16	0	**84-85**	22	16	0	**24-25**	9	0	0	**54-55**	6	0	0	**84-85**	7	0	0
76-77	34	0	0	**25-26**	47	11	0	**55-56**	43	0	0	**85-86**	43	0	0	**25-26**	8	0	0	**55-56**	9	0	0	**85-86**	10	0	0
77-78	65	10	0	**26-27**	43	31	0	**56-57**	42	25	0	**86-87**	42	20	0	**26-27**	37	4	0	**56-57**	18	1	0	**86-87**	6	0	0
78-79	0	0	0	**27-28**	21	0	0	**57-58**	10	0	0	**87-88**	12	0	0	**27-28**	0	0	0	**57-58**	0	0	0	**87-88**	0	0	0
79-80	0	0	0	**28-29**	17	1	0	**58-59**	17	2	0	**88-89**	17	1	0	**28-29**	14	1	0	**58-59**	12	0	0	**88-89**	8	0	0
80-81	90	71	0	**29-30**	75	65	8	**59-60**	75	65	6	**89-90**	75	65	13	**29-30**	61	32	0	**59-60**	46	21	0	**89-90**	41	22	0
80-81	15	0	0	**30-31**	8	2	0	**60-61**	8	2	0	**90-91**	7	1	0	**30-31**	5	0	0	**60-61**	4	0	0	**90-91**	0	0	0
81-82	84	71	9	**31-32**	58	56	2	**61-62**	57	47	0	**91-92**	56	43	0	**31-32**	20	3	0	**61-62**	13	2	0	**91-92**	10	0	0
83-84	72	45	0	**32-33**	56	44	17	**62-63**	54	41	0	**92-93**	52	40	0	**32-33**	34	4	0	**62-63**	13	0	0	**92-93**	9	0	0
84-85	0	0	0	**33-34**	0	0	0	**63-64**	4	0	0	**93-94**	0	0	0	**33-34**	0	0	0	**63-64**	0	0	0	**93-94**	0	0	0
85-86	46	1	0	**34-35**	24	10	0	**64-65**	24	9	0	**94-95**	21	2	0	**34-35**	2	0	0	**64-65**	2	0	0	**94-95**	1	0	0
86-87	48	1	0	**35-36**	1	0	0	**65-66**	0	0	0	**95-96**	0	0	0	**35-36**	0	0	0	**65-66**	0	0	0	**95-96**	0	0	0
87-88	16	6	0	**36-37**	21	7	0	**66-67**	19	6	0	**96-97**	15	5	0	**36-37**	7	0	0	**66-67**	2	0	0	**96-97**	2	0	0
88-89	35	1	0	**37-38**	18	4	0	**67-68**	16	3	0	**97-98**	14	3	0	**37-38**	11	2	0	**67-68**	6	0	0	**97-98**	4	0	0
89-90	18	0	0	**38-39**	6	0	0	**68-69**	5	0	0	**98-99**	3	0	0	**38-39**	3	0	0	**68-69**	2	0	0	**98-99**	0	0	0
Mean	**32.83**	**11.41**	**0.31**	**Mean**	**25.59**	**13.72**	**0.97**	**Mean**	**23.69**	**11.45**	**0.21**	**Mean**	**22.69**	**10.48**	**0.62**	**Mean**	**12.07**	**2.79**	**0.00**	**Mean**	**7.38**	**1.66**	**0.00**	**Mean**	**4.97**	**0.90**	**0.00**
SD	**27.76**	**20.14**	**1.67**	**SD**	**20.41**	**18.97**	**3.44**	**SD**	**20.08**	**17.47**	**1.11**	**SD**	**20.18**	**17.72**	**2.56**	**SD**	**15.42**	**6.63**	**0.00**	**SD**	**10.13**	**4.37**	**0.00**	**SD**	**8.24**	**4.13**	**0.00**

Appendix 16

District 9 Projected Snowmobile Season Length (Days)

Baseline				INMCM3.0 B1												MIROC3.2 HIRES A1B											
				2020s				2050s				2080s				2020s				2050s				2080s			
Season	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**
61-62	13	4	0	**10-11**	1	0	0	**40-41**	1	0	0	**70-71**	6	0	0	**10-11**	0	0	0	**40-41**	1	0	0	**70-71**	0	0	0
62-63	72	48	0	**11-12**	10	0	0	**41-42**	7	0	0	**71-72**	10	0	0	**11-12**	8	0	0	**41-42**	5	0	0	**71-72**	0	0	0
63-64	59	13	0	**12-13**	11	0	0	**42-43**	8	0	0	**72-73**	20	0	0	**12-13**	4	0	0	**42-43**	4	0	0	**72-73**	1	0	0
64-65	59	38	0	**13-14**	27	21	0	**43-44**	24	20	0	**73-74**	28	23	0	**13-14**	14	7	0	**43-44**	12	6	0	**73-74**	0	0	0
65-66	65	41	7	**14-15**	38	0	0	**44-45**	33	0	0	**74-75**	40	10	0	**14-15**	4	0	0	**44-45**	1	0	0	**74-75**	1	0	0
66-67	69	19	0	**15-16**	53	26	0	**45-49**	45	23	0	**75-76**	55	28	11	**15-16**	28	21	0	**45-49**	23	17	0	**75-76**	22	4	0
67-68	0	0	0	**16-17**	17	3	0	**49-47**	14	0	0	**76-77**	21	5	0	**16-17**	0	0	0	**49-47**	0	0	0	**76-77**	0	0	0
68-69	65	42	0	**17-18**	59	43	0	**47-48**	56	42	0	**77-78**	60	48	0	**17-18**	41	24	0	**47-48**	37	13	0	**77-78**	37	8	0
69-70	21	0	0	**18-19**	3	0	0	**48-49**	3	0	0	**78-79**	11	0	0	**18-19**	3	0	0	**48-49**	9	0	0	**78-79**	0	0	0
70-71	77	52	0	**19-20**	45	4	0	**49-50**	50	4	0	**79-80**	61	11	0	**19-20**	0	0	0	**49-50**	0	0	0	**79-80**	0	0	0
71-72	48	21	0	**20-21**	9	0	0	**50-51**	13	0	0	**80-81**	16	0	0	**20-21**	4	0	0	**50-51**	4	0	0	**80-81**	2	0	0
72-73	51	20	0	**21-22**	24	12	0	**51-52**	23	4	0	**81-82**	25	14	0	**21-22**	4	0	0	**51-52**	0	0	0	**81-82**	1	0	0
73-74	50	33	0	**22-23**	0	0	0	**52-53**	0	0	0	**82-83**	0	0	0	**22-23**	0	0	0	**52-53**	0	0	0	**82-83**	0	0	0
74-75	58	24	0	**23-24**	43	20	0	**53-54**	43	21	0	**83-84**	50	35	0	**23-24**	12	0	0	**53-54**	9	0	0	**83-84**	8	0	0
75-76	26	7	0	**24-25**	26	13	0	**54-55**	28	13	0	**84-85**	30	19	0	**24-25**	11	6	0	**54-55**	12	0	0	**84-85**	6	0	0
76-77	62	46	0	**25-26**	43	33	0	**55-56**	43	34	0	**85-86**	48	42	20	**25-26**	3	0	0	**55-56**	0	0	0	**85-86**	2	0	0
77-78	72	41	0	**26-27**	43	33	0	**56-57**	42	32	5	**86-87**	46	36	7	**26-27**	34	8	0	**56-57**	13	1	0	**86-87**	7	0	0
78-79	31	0	0	**27-28**	29	0	0	**57-58**	21	0	0	**87-88**	36	11	0	**27-28**	3	0	0	**57-58**	2	0	0	**87-88**	0	0	0
79-80	63	49	0	**28-29**	10	3	0	**58-59**	9	0	0	**88-89**	20	3	0	**28-29**	0	0	0	**58-59**	0	0	0	**88-89**	0	0	0
80-81	63	15	0	**29-30**	56	30	0	**59-60**	55	26	0	**89-90**	63	38	0	**29-30**	23	0	0	**59-60**	19	0	0	**89-90**	21	0	0
80-81	53	5	0	**30-31**	18	0	0	**60-61**	13	0	0	**90-91**	22	0	0	**30-31**	0	0	0	**60-61**	0	0	0	**90-91**	0	0	0
81-82	58	44	0	**31-32**	29	11	0	**61-62**	28	2	0	**91-92**	35	24	0	**31-32**	6	1	0	**61-62**	6	0	0	**91-92**	0	0	0
83-84	55	42	0	**32-33**	44	34	0	**62-63**	43	24	0	**92-93**	46	36	0	**32-33**	10	0	0	**62-63**	9	0	0	**92-93**	14	0	0
84-85	36	0	0	**33-34**	20	0	0	**63-64**	9	0	0	**93-94**	28	0	0	**33-34**	0	0	0	**63-64**	0	0	0	**93-94**	0	0	0
85-86	77	63	14	**34-35**	21	11	0	**64-65**	21	11	0	**94-95**	21	12	0	**34-35**	15	1	0	**64-65**	16	0	0	**94-95**	11	0	0
86-87	77	70	6	**35-36**	19	8	0	**65-66**	12	6	0	**95-96**	19	8	0	**35-36**	9	4	0	**65-66**	7	3	0	**95-96**	8	2	0
87-88	53	5	0	**36-37**	27	3	0	**66-67**	23	0	0	**96-97**	33	9	0	**36-37**	14	0	0	**66-67**	10	0	0	**96-97**	9	0	0
88-89	19	1	0	**37-38**	10	0	0	**67-68**	6	0	0	**97-98**	10	0	0	**37-38**	6	0	0	**67-68**	4	0	0	**97-98**	0	0	0
89-90	51	34	3	**38-39**	26	13	0	**68-69**	25	8	0	**98-99**	32	13	0	**38-39**	23	4	0	**68-69**	20	4	0	**98-99**	15	4	0
Mean	**51.83**	**26.79**	**1.03**	**Mean**	**26.24**	**11.07**	**0.00**	**Mean**	**24.07**	**9.31**	**0.17**	**Mean**	**30.76**	**14.66**	**1.31**	**Mean**	**9.62**	**2.62**	**0.00**	**Mean**	**7.69**	**1.52**	**0.00**	**Mean**	**5.69**	**0.62**	**0.00**
SD	**20.26**	**21.03**	**3.04**	**SD**	**16.69**	**13.20**	**0.00**	**SD**	**16.90**	**12.65**	**0.93**	**SD**	**17.30**	**15.10**	**4.31**	**SD**	**10.83**	**5.98**	**0.00**	**SD**	**8.79**	**4.02**	**0.00**	**SD**	**8.87**	**1.78**	**0.00**

Appendix 17

District 10 Projected Snowmobile Season Length (Days)

Baseline				INMCM3.0 B1												MIROC3.2 HIRES A1B											
				2020s				2050s				2080s				2020s				2050s				2080s			
Season	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**
61-62	19	0	0	**10-11**	10	0	0	**40-41**	8	0	0	**70-71**	13	0	0	**10-11**	4	0	0	**40-41**	4	0	0	**70-71**	4	0	0
62-63	86	81	59	**11-12**	43	24	3	**41-42**	36	19	0	**71-72**	51	36	6	**11-12**	22	13	0	**41-42**	18	6	0	**71-72**	5	0	0
63-64	28	8	0	**12-13**	8	0	0	**42-43**	8	1	0	**72-73**	9	2	0	**12-13**	7	0	0	**42-43**	6	0	0	**72-73**	5	0	0
64-65	87	70	53	**13-14**	61	51	39	**43-44**	58	49	41	**73-74**	63	52	42	**13-14**	52	45	30	**43-44**	46	38	0	**73-74**	21	5	0
65-66	83	78	52	**14-15**	65	59	52	**44-45**	65	59	52	**74-75**	67	61	52	**14-15**	59	52	30	**44-45**	51	44	27	**74-75**	51	39	11
66-67	72	64	40	**15-16**	51	50	42	**45-49**	50	49	41	**75-76**	52	51	44	**15-16**	41	40	36	**45-49**	39	37	31	**75-76**	37	36	22
67-68	50	43	2	**16-17**	33	12	0	**49-47**	26	9	0	**76-77**	45	36	6	**16-17**	18	4	0	**49-47**	10	0	0	**76-77**	9	0	0
68-69	69	56	22	**17-18**	58	48	22	**47-48**	54	47	6	**77-78**	59	54	45	**17-18**	28	12	0	**47-48**	22	0	0	**77-78**	20	0	0
69-70	76	62	38	**18-19**	46	38	0	**48-49**	45	36	0	**78-79**	47	43	19	**18-19**	14	0	0	**48-49**	7	0	0	**78-79**	4	0	0
70-71	71	25	0	**19-20**	55	20	0	**49-50**	52	26	0	**79-80**	58	27	0	**19-20**	49	10	0	**49-50**	22	10	0	**79-80**	12	10	0
71-72	43	12	0	**20-21**	39	26	0	**50-51**	40	26	0	**80-81**	39	26	0	**20-21**	25	9	0	**50-51**	26	0	0	**80-81**	26	0	0
72-73	46	32	0	**21-22**	35	30	0	**51-52**	32	27	0	**81-82**	37	33	2	**21-22**	29	23	0	**51-52**	25	2	0	**81-82**	26	7	0
73-74	75	63	47	**22-23**	40	33	0	**52-53**	35	28	0	**82-83**	41	33	0	**22-23**	33	27	0	**52-53**	30	23	0	**82-83**	27	13	0
74-75	82	69	20	**23-24**	68	60	27	**53-54**	66	60	33	**83-84**	71	65	43	**23-24**	57	45	0	**53-54**	53	34	0	**83-84**	37	8	0
75-76	70	27	0	**24-25**	31	5	0	**54-55**	31	5	0	**84-85**	46	16	0	**24-25**	22	6	0	**54-55**	21	5	0	**84-85**	20	4	0
76-77	84	68	35	**25-26**	63	52	35	**55-56**	61	52	39	**85-86**	63	52	41	**25-26**	49	46	12	**55-56**	31	4	0	**85-86**	34	8	0
77-78	76	42	0	**26-27**	51	16	0	**56-57**	47	30	0	**86-87**	54	38	0	**26-27**	29	0	0	**56-57**	19	0	0	**86-87**	13	0	0
78-79	81	68	49	**27-28**	53	49	33	**57-58**	51	46	20	**87-88**	57	52	45	**27-28**	22	10	0	**57-58**	16	2	0	**87-88**	9	0	0
79-80	74	36	0	**28-29**	54	29	0	**58-59**	54	26	0	**88-89**	62	42	0	**28-29**	48	21	0	**58-59**	43	9	0	**88-89**	37	8	0
80-81	74	60	3	**29-30**	58	36	5	**59-60**	57	25	5	**89-90**	60	49	5	**29-30**	37	12	0	**59-60**	29	3	0	**89-90**	30	4	0
80-81	62	32	13	**30-31**	21	14	0	**60-61**	21	15	0	**90-91**	23	15	0	**30-31**	19	14	0	**60-61**	15	11	0	**90-91**	13	3	0
81-82	65	52	0	**31-32**	4	1	0	**61-62**	3	0	0	**91-92**	6	1	0	**31-32**	1	0	0	**61-62**	1	0	0	**91-92**	0	0	0
83-84	69	59	39	**32-33**	40	38	16	**62-63**	39	35	9	**92-93**	43	41	24	**32-33**	5	0	0	**62-63**	1	0	0	**92-93**	1	0	0
84-85	70	41	0	**33-34**	63	53	20	**63-64**	61	49	18	**93-94**	65	55	32	**33-34**	42	19	0	**63-64**	24	10	0	**93-94**	24	6	0
85-86	67	60	46	**34-35**	46	40	0	**64-65**	46	37	0	**94-95**	48	41	1	**34-35**	9	0	0	**64-65**	2	0	0	**94-95**	0	0	0
86-87	33	4	0	**35-36**	36	5	0	**65-66**	33	3	0	**95-96**	38	5	0	**35-36**	30	3	0	**65-66**	23	3	0	**95-96**	12	3	0
87-88	77	68	35	**36-37**	63	55	38	**66-67**	62	52	40	**96-97**	62	55	39	**36-37**	61	56	40	**66-67**	53	49	35	**96-97**	52	47	32
88-89	13	1	0	**37-38**	6	0	0	**67-68**	6	0	0	**97-98**	7	0	0	**37-38**	0	0	0	**67-68**	0	0	0	**97-98**	0	0	0
89-90	58	48	0	**38-39**	49	38	0	**68-69**	49	33	0	**98-99**	49	41	0	**38-39**	40	4	0	**68-69**	36	3	0	**98-99**	3	0	0
Mean	**64.14**	**45.83**	**19.07**	**Mean**	**43.10**	**30.41**	**11.45**	**Mean**	**41.24**	**29.10**	**10.48**	**Mean**	**46.03**	**35.24**	**15.38**	**Mean**	**29.38**	**16.24**	**5.10**	**Mean**	**23.21**	**10.10**	**3.21**	**Mean**	**18.34**	**6.93**	**2.24**
SD	**20.08**	**24.07**	**21.76**	**SD**	**18.62**	**19.78**	**16.74**	**SD**	**18.47**	**19.09**	**16.86**	**SD**	**18.54**	**19.64**	**19.56**	**SD**	**18.15**	**17.96**	**12.08**	**SD**	**16.12**	**15.11**	**9.67**	**SD**	**15.22**	**12.33**	**7.28**

Appendix 18

District 11 Projected Snowmobile Season Length (Days)

Baseline				INMCM3.0 B1											
				2020s				2050s				2080s			
Season	15cm	30cm	60cm	Season	15cm	30cm	60cm	Season	15cm	30cm	60cm	Season	15cm	30cm	60cm
61-62	0	0	0	**10-11**	30	10	0	**40-41**	20	4	0	**70-71**	19	0	0
62-63	114	86	28	**11-12**	89	65	33	**41-42**	87	64	28	**71-72**	85	62	20
63-64	95	75	0	**12-13**	70	18	0	**42-43**	54	5	0	**72-73**	54	5	0
64-65	91	50	0	**13-14**	81	70	46	**43-44**	79	67	33	**73-74**	76	65	31
65-66	110	81	35	**14-15**	99	85	67	**44-45**	98	81	65	**74-75**	99	81	65
66-67	117	78	3	**15-16**	96	65	23	**45-49**	95	62	21	**75-76**	96	62	21
67-68	65	0	0	**16-17**	60	50	23	**49-47**	60	50	1	**76-77**	57	48	0
68-69	79	63	1	**17-18**	73	68	50	**47-48**	72	67	50	**77-78**	74	67	49
69-70	75	43	0	**18-19**	70	59	41	**48-49**	67	57	14	**78-79**	67	57	12
70-71	40	12	0	**19-20**	36	26	0	**49-50**	35	25	0	**79-80**	34	27	0
71-72	82	45	0	**20-21**	43	18	0	**50-51**	37	20	0	**80-81**	39	18	0
72-73	105	82	0	**21-22**	78	69	0	**51-52**	76	65	0	**81-82**	77	56	0
73-74	99	59	2	**22-23**	78	58	3	**52-53**	76	46	0	**82-83**	76	46	0
74-75	96	73	23	**23-24**	80	67	51	**53-54**	79	65	49	**83-84**	79	65	48
75-76	71	7	0	**24-25**	72	63	23	**54-55**	71	62	9	**84-85**	70	61	9
76-77	63	22	0	**25-26**	87	75	40	**55-56**	87	73	40	**85-86**	84	73	36
77-78	84	64	19	**26-27**	52	43	8	**56-57**	51	43	8	**86-87**	51	43	7
78-79	76	59	0	**27-28**	73	66	46	**57-58**	74	67	44	**87-88**	72	67	43
79-80	111	91	13	**28-29**	83	60	0	**58-59**	79	54	0	**88-89**	79	54	0
80-81	81	26	0	**29-30**	80	70	42	**59-60**	81	70	40	**89-90**	80	69	43
80-81	99	96	63	**30-31**	64	61	38	**60-61**	63	59	31	**90-91**	63	56	24
81-82	93	69	42	**31-32**	82	73	54	**61-62**	81	75	55	**91-92**	82	74	55
83-84	103	68	6	**32-33**	89	55	28	**62-63**	87	52	28	**92-93**	86	51	26
84-85	77	48	0	**33-34**	65	47	32	**63-64**	61	46	30	**93-94**	61	45	30
85-86	84	17	0	**34-35**	54	19	0	**64-65**	55	20	0	**94-95**	54	20	0
86-87	90	58	0	**35-36**	63	38	0	**65-66**	58	34	0	**95-96**	62	37	0
87-88	76	55	0	**36-37**	79	70	56	**66-67**	76	68	55	**96-97**	75	68	55
88-89	99	37	0	**37-38**	17	3	0	**67-68**	15	2	0	**97-98**	13	1	0
89-90	100	75	24	**38-39**	73	62	47	**68-69**	72	61	45	**98-99**	71	60	45
Mean	**85.34**	**53.07**	**8.93**	**Mean**	**69.52**	**52.86**	**25.90**	**Mean**	**67.10**	**50.48**	**22.28**	**Mean**	**66.72**	**49.59**	**21.34**
SD	**23.73**	**27.81**	**15.94**	**SD**	**19.35**	**21.81**	**22.10**	**SD**	**20.45**	**22.45**	**21.75**	**SD**	**20.54**	**22.41**	**21.56**

MIROC3.2 HIRES A1B											
2020s				2050s				2080s			
Season	15cm	30cm	60cm	Season	15cm	30cm	60cm	Season	15cm	30cm	60cm
10-11	9	0	0	**40-41**	8	0	0	**70-71**	8	0	0
11-12	83	57	0	**41-42**	80	47	0	**71-72**	79	41	0
12-13	19	1	0	**42-43**	16	0	0	**72-73**	13	0	0
13-14	72	61	27	**43-44**	74	60	18	**73-74**	71	47	11
14-15	99	81	65	**44-45**	94	78	62	**74-75**	85	73	60
15-16	95	29	0	**45-49**	70	10	0	**75-76**	66	7	0
16-17	57	44	0	**49-47**	52	24	0	**76-77**	48	0	0
17-18	70	68	50	**47-48**	66	63	48	**77-78**	65	61	47
18-19	65	55	0	**48-49**	66	43	0	**78-79**	54	10	0
19-20	34	22	0	**49-50**	30	20	0	**79-80**	29	22	0
20-21	26	11	0	**50-51**	25	11	0	**80-81**	23	11	0
21-22	54	6	0	**51-52**	29	5	0	**81-82**	25	2	0
22-23	50	11	0	**52-53**	44	8	0	**82-83**	46	8	0
23-24	73	60	40	**53-54**	73	58	41	**83-84**	66	54	11
24-25	66	56	0	**54-55**	62	47	0	**84-85**	56	20	0
25-26	82	69	21	**55-56**	81	69	21	**85-86**	80	66	5
26-27	44	37	0	**56-57**	43	23	0	**86-87**	51	0	0
27-28	68	50	14	**57-58**	57	43	0	**87-88**	53	33	0
28-29	77	31	0	**58-59**	78	50	0	**88-89**	77	43	0
29-30	76	66	25	**59-60**	71	64	12	**89-90**	66	49	4
30-31	50	16	0	**60-61**	46	12	0	**90-91**	44	11	0
31-32	83	74	49	**61-62**	80	73	49	**91-92**	79	72	49
32-33	81	37	3	**62-63**	75	27	0	**92-93**	61	7	0
33-34	45	35	0	**63-64**	42	29	0	**93-94**	38	29	0
34-35	48	7	0	**64-65**	43	3	0	**94-95**	37	3	0
35-36	54	15	0	**65-66**	51	27	0	**95-96**	49	16	0
36-37	70	65	42	**66-67**	68	64	39	**96-97**	64	61	39
37-38	12	0	0	**67-68**	9	0	0	**97-98**	4	0	0
38-39	71	55	38	**68-69**	68	51	34	**98-99**	64	49	28
Mean	**59.76**	**38.59**	**12.90**	**Mean**	**55.21**	**34.79**	**11.17**	**Mean**	**51.76**	**27.41**	**8.76**
SD	**23.42**	**25.41**	**19.92**	**SD**	**23.07**	**25.13**	**19.08**	**SD**	**22.26**	**25.04**	**17.50**

District 12 Projected Snowmobile Season Length (Days)

Baseline				INMCM3.0 B1												MIROC3.2 HIRES A1B											
				2020s				2050s				2080s				2020s				2050s				2080s			
Season	15cm	30cm	60cm	Season	15cm	30cm	60cm	Season	15cm	30cm	60cm	Season	15cm	30cm	60cm	Season	15cm	30cm	60cm	Season	15cm	30cm	60cm	Season	15cm	30cm	60cm
61-62	56	21	0	10-11	39	24	0	40-41	40	28	0	70-71	40	25	0	10-11	39	29	0	40-41	39	33	0	70-71	38	27	0
62-63	64	36	0	11-12	40	35	0	41-42	42	36	0	71-72	42	34	0	11-12	40	33	0	41-42	40	24	0	71-72	39	17	0
63-64	47	14	0	12-13	61	34	0	42-43	62	36	0	72-73	63	33	0	12-13	64	38	1	42-43	61	36	0	72-73	62	37	2
64-65	80	60	0	13-14	71	61	33	43-44	71	63	38	73-74	75	62	38	13-14	74	63	38	43-44	72	59	30	73-74	70	58	16
65-66	94	86	0	14-15	78	74	36	44-45	76	72	42	74-75	81	78	35	14-15	78	74	29	44-45	75	73	42	74-75	74	69	25
66-67	94	56	16	15-16	75	58	40	45-49	74	56	39	75-76	85	67	46	15-16	72	57	41	45-49	67	55	39	75-76	64	52	28
67-68	65	51	5	16-17	63	55	37	49-47	63	55	37	76-77	64	57	44	16-17	65	55	39	49-47	64	56	40	76-77	64	55	39
68-69	83	57	0	17-18	67	56	19	47-48	66	55	19	77-78	68	60	26	17-18	68	60	27	47-48	65	58	29	77-78	66	54	25
69-70	100	76	0	18-19	78	44	5	48-49	79	40	0	78-79	78	47	24	18-19	64	13	0	48-49	43	0	0	78-79	36	0	0
70-71	59	32	0	19-20	60	43	0	49-50	62	47	1	79-80	61	43	0	19-20	63	33	0	49-50	60	33	0	79-80	47	14	0
71-72	68	59	0	20-21	59	51	0	50-51	58	50	4	80-81	62	54	1	20-21	42	26	0	50-51	42	24	0	80-81	40	11	0
72-73	62	39	0	21-22	55	35	0	51-52	52	35	0	81-82	57	34	0	21-22	53	35	0	51-52	53	37	0	81-82	52	37	0
73-74	93	26	0	22-23	67	4	0	52-53	45	0	0	82-83	70	15	0	22-23	17	0	0	52-53	17	0	0	82-83	5	0	0
74-75	108	85	0	23-24	94	87	48	53-54	94	87	54	83-84	95	87	52	23-24	95	85	53	53-54	94	75	48	83-84	90	70	44
75-76	46	4	0	24-25	52	26	0	54-55	54	36	0	84-85	56	36	0	24-25	54	31	0	54-55	62	31	0	84-85	47	16	0
76-77	89	47	0	25-26	88	71	23	55-56	86	74	25	85-86	90	74	29	25-26	80	70	25	55-56	79	68	21	85-86	74	64	17
77-78	97	9	0	26-27	63	16	0	56-57	68	27	0	86-87	75	35	0	26-27	53	9	0	56-57	42	2	0	86-87	36	0	0
78-79	56	13	0	27-28	50	34	0	57-58	51	39	0	87-88	50	38	0	27-28	51	40	0	57-58	54	43	0	87-88	48	37	0
79-80	96	72	2	28-29	88	75	50	58-59	88	73	49	88-89	85	74	52	28-29	84	67	48	58-59	81	66	50	88-89	77	65	40
80-81	81	64	10	29-30	70	65	31	59-60	70	65	31	89-90	74	68	35	29-30	69	64	31	59-60	64	58	31	89-90	54	44	0
80-81	97	80	30	30-31	75	59	38	60-61	75	55	39	90-91	78	64	41	30-31	76	54	42	60-61	74	50	37	90-91	73	46	28
81-82	94	70	0	31-32	58	34	0	61-62	54	30	0	91-92	62	45	8	31-32	38	0	0	61-62	35	4	0	91-92	32	2	0
83-84	62	0	0	32-33	53	35	0	62-63	53	22	0	92-93	54	41	0	32-33	51	19	0	62-63	50	13	0	92-93	52	9	0
84-85	85	30	0	33-34	83	71	1	63-64	83	37	0	93-94	85	74	3	33-34	83	54	2	63-64	75	27	0	93-94	35	12	0
85-86	90	54	0	34-35	57	44	0	64-65	57	44	0	94-95	63	44	0	34-35	55	44	0	64-65	52	43	0	94-95	52	44	0
86-87	46	11	0	35-36	44	0	0	65-66	35	0	0	95-96	48	7	0	35-36	30	0	0	65-66	33	0	0	95-96	31	0	0
87-88	44	14	0	36-37	68	51	26	66-67	67	53	25	96-97	68	52	27	36-37	70	52	25	66-67	72	57	33	96-97	71	50	28
88-89	78	56	0	37-38	58	48	0	67-68	56	47	0	97-98	57	51	0	37-38	52	13	0	67-68	51	14	0	97-98	51	13	0
89-90	53	21	0	38-39	76	44	13	68-69	80	47	13	98-99	80	49	13	38-39	77	43	14	68-69	80	49	15	98-99	72	51	14
Mean	75.41	42.86	2.17	Mean	65.17	46.00	13.79	Mean	64.17	45.14	14.34	Mean	67.79	49.93	16.34	Mean	60.59	40.03	14.31	Mean	58.48	37.52	14.31	Mean	53.52	32.90	10.55
SD	19.53	26.12	6.40	SD	14.12	20.85	17.73	SD	15.04	20.04	18.64	SD	14.25	19.15	19.23	SD	17.95	23.58	18.48	SD	17.57	23.45	18.49	SD	18.43	23.75	14.85

Appendix 20

District 13 Projected Snowmobile Season Length (Days)

Baseline				INMCM3.0 B1												MIROC3.2 HIRES A1B												
				2020s				2050s				2080s				2020s				2050s				2080s			
Season	15cm	30cm	60cm	Season	15cm	30cm	60cm	Season	15cm	30cm	60cm	Season	15cm	30cm	60cm	Season	15cm	30cm	60cm	Season	15cm	30cm	60cm	Season	15cm	30cm	60cm
61-62	46	4	0	10-11	28	20	0	40-41	29	19	0	70-71	35	21	0	10-11	19	0	0	40-41	3	0	0	70-71	0	0	0
62-63	109	92	58	11-12	72	50	0	41-42	71	43	0	71-72	74	60	13	11-12	42	13	0	41-42	40	13	0	71-72	32	1	0
63-64	72	5	0	12-13	19	0	0	42-43	24	0	0	72-73	20	0	0	12-13	14	0	0	42-43	8	0	0	72-73	2	0	0
64-65	77	63	36	13-14	53	44	35	43-44	51	43	35	73-74	57	47	39	13-14	41	37	26	43-44	40	31	4	73-74	36	35	2
65-66	100	93	18	14-15	79	62	25	44-45	79	59	23	74-75	82	76	39	14-15	60	37	0	44-45	27	0	0	74-75	35	24	0
66-67	99	90	55	15-16	80	64	40	45-49	76	61	32	75-76	85	71	46	15-16	46	0	0	45-49	11	0	0	75-76	20	0	0
67-68	70	17	0	16-17	60	38	6	49-47	59	38	1	76-77	60	40	13	16-17	21	6	0	49-47	21	0	0	76-77	6	0	0
68-69	71	33	0	17-18	66	48	0	47-48	68	49	0	77-78	68	52	17	17-18	66	49	0	47-48	65	37	0	77-78	65	41	0
69-70	76	49	6	18-19	54	34	0	48-49	50	31	0	78-79	61	48	17	18-19	20	0	0	48-49	22	0	0	78-79	1	0	0
70-71	73	27	0	19-20	35	17	0	49-50	35	22	0	79-80	42	17	0	19-20	33	17	0	49-50	33	18	0	79-80	31	12	0
71-72	72	42	0	20-21	45	16	0	50-51	48	20	0	80-81	55	26	0	20-21	28	0	0	50-51	26	0	0	80-81	0	0	0
72-73	55	22	0	21-22	38	22	0	51-52	36	21	0	81-82	37	23	0	21-22	22	4	0	51-52	14	0	0	81-82	20	4	0
73-74	82	59	0	22-23	32	0	0	52-53	27	0	0	82-83	37	0	0	22-23	12	0	0	52-53	8	0	0	82-83	2	0	0
74-75	78	49	0	23-24	54	2	0	53-54	53	12	0	83-84	67	40	0	23-24	8	0	0	53-54	8	0	0	83-84	7	0	0
75-76	77	52	14	24-25	69	39	3	54-55	65	39	3	84-85	71	58	23	24-25	54	31	0	54-55	46	24	0	84-85	51	22	0
76-77	81	35	0	25-26	63	38	0	55-56	63	41	0	85-86	68	43	2	25-26	22	0	0	55-56	7	0	0	85-86	16	0	0
77-78	91	72	0	26-27	58	29	0	56-57	58	33	0	86-87	62	46	0	26-27	37	9	0	56-57	35	7	0	86-87	25	0	0
78-79	75	60	0	27-28	54	41	0	57-58	54	41	0	87-88	56	43	0	27-28	50	33	0	57-58	37	5	0	87-88	44	21	0
79-80	70	54	0	28-29	47	5	0	58-59	36	6	0	88-89	55	10	0	28-29	15	0	0	58-59	10	0	0	88-89	6	0	0
80-81	71	59	0	29-30	65	15	0	59-60	60	4	0	89-90	70	34	0	29-30	17	2	0	59-60	8	0	0	89-90	16	0	0
80-81	94	63	5	30-31	40	3	0	60-61	36	3	0	90-91	43	8	0	30-31	22	0	0	60-61	25	0	0	90-91	21	0	0
81-82	67	22	0	31-32	19	0	0	61-62	19	0	0	91-92	29	4	0	31-32	0	0	0	61-62	0	0	0	91-92	0	0	0
83-84	83	54	0	32-33	32	4	0	62-63	28	0	0	92-93	35	4	0	32-33	19	0	0	62-63	12	0	0	92-93	18	0	0
84-85	51	5	0	33-34	63	28	0	63-64	61	25	0	93-94	64	37	0	33-34	44	1	0	63-64	23	0	0	93-94	36	0	0
85-86	88	60	0	34-35	42	28	0	64-65	40	22	0	94-95	47	31	0	34-35	30	0	0	64-65	36	1	0	94-95	0	0	0
86-87	42	29	0	35-36	20	7	0	65-66	15	5	0	95-96	34	12	0	35-36	11	0	0	65-66	12	0	0	95-96	0	0	0
87-88	69	18	0	36-37	38	11	0	66-67	39	10	0	96-97	50	14	0	36-37	32	3	0	66-67	16	0	0	96-97	33	2	0
88-89	79	65	26	37-38	57	33	0	67-68	56	31	0	97-98	60	36	7	37-38	32	0	0	67-68	44	15	0	97-98	21	0	0
89-90	68	51	0	38-39	54	34	0	68-69	55	31	0	98-99	58	49	0	38-39	19	0	0	68-69	16	0	0	98-99	17	0	0
Mean	**75.38**	**46.34**	**7.52**	**Mean**	**49.52**	**25.24**	**3.76**	**Mean**	**47.97**	**24.45**	**3.24**	**Mean**	**54.55**	**32.76**	**7.45**	**Mean**	**28.83**	**8.34**	**0.90**	**Mean**	**22.52**	**5.21**	**0.14**	**Mean**	**19.34**	**5.59**	**0.07**
SD	**15.21**	**25.12**	**16.15**	**SD**	**17.27**	**18.88**	**10.50**	**SD**	**17.28**	**18.31**	**9.42**	**SD**	**16.22**	**21.17**	**13.43**	**SD**	**16.23**	**14.36**	**4.83**	**SD**	**15.55**	**10.20**	**0.74**	**SD**	**17.28**	**11.44**	**0.37**

Appendix 21

District 14 Projected Snowmobile Season Length (Days)

Baseline				INMCM3.0 B1												MIROC3.2 HIRES A1B											
				2020s				2050s				2080s				2020s				2050s				2080s			
Season	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**
61-62	79	43	0	**10-11**	81	59	38	**40-41**	79	57	34	**70-71**	79	62	36	**10-11**	72	60	37	**40-41**	70	56	38	**70-71**	63	52	32
62-63	102	78	48	**11-12**	88	76	51	**41-42**	86	73	51	**71-72**	85	72	52	**11-12**	82	68	51	**41-42**	78	65	46	**71-72**	84	75	45
63-64	121	87	37	**12-13**	122	114	50	**42-43**	122	114	42	**72-73**	121	114	44	**12-13**	119	107	32	**42-43**	118	86	7	**72-73**	110	78	0
64-65	121	107	41	**13-14**	106	92	55	**43-44**	105	91	51	**73-74**	105	91	56	**13-14**	104	94	57	**43-44**	99	89	54	**73-74**	97	87	52
65-66	97	58	6	**14-15**	99	80	46	**44-45**	99	80	46	**74-75**	99	79	45	**14-15**	98	80	51	**44-45**	96	80	59	**74-75**	94	77	47
66-67	83	12	0	**15-16**	80	72	21	**45-49**	80	69	20	**75-76**	80	73	25	**15-16**	80	69	26	**45-49**	80	71	40	**75-76**	73	64	11
67-68	101	82	0	**16-17**	93	77	27	**49-47**	92	75	21	**76-77**	90	75	36	**16-17**	84	69	5	**49-47**	83	69	6	**76-77**	83	68	0
68-69	67	5	0	**17-18**	80	65	17	**47-48**	80	65	16	**77-78**	80	67	21	**17-18**	82	68	23	**47-48**	81	68	29	**77-78**	80	68	23
69-70	109	70	0	**18-19**	88	65	40	**48-49**	87	65	38	**78-79**	83	59	14	**18-19**	84	57	24	**48-49**	80	54	8	**78-79**	78	54	0
70-71	98	34	0	**19-20**	87	72	30	**49-50**	86	72	25	**79-80**	86	71	24	**19-20**	83	69	26	**49-50**	81	67	26	**79-80**	80	67	25
71-72	98	70	40	**20-21**	81	64	53	**50-51**	80	63	52	**80-81**	81	64	54	**20-21**	80	65	54	**50-51**	81	65	49	**80-81**	78	58	40
72-73	107	74	0	**21-22**	96	65	0	**51-52**	91	62	0	**81-82**	91	64	18	**21-22**	89	56	4	**51-52**	87	53	0	**81-82**	86	44	0
73-74	111	71	1	**22-23**	97	64	12	**52-53**	97	62	5	**82-83**	100	63	6	**22-23**	93	44	0	**52-53**	91	30	0	**82-83**	76	14	0
74-75	97	68	15	**23-24**	95	83	51	**53-54**	95	83	52	**83-84**	95	81	51	**23-24**	91	80	45	**53-54**	85	74	43	**83-84**	82	66	35
75-76	109	64	0	**24-25**	97	73	44	**54-55**	97	74	45	**84-85**	98	77	49	**24-25**	94	75	50	**54-55**	94	77	53	**84-85**	90	74	53
76-77	88	67	0	**25-26**	94	81	56	**55-56**	93	80	57	**85-86**	95	81	58	**25-26**	99	84	61	**55-56**	99	85	65	**85-86**	99	86	67
77-78	103	68	0	**26-27**	96	76	43	**56-57**	97	73	42	**86-87**	95	71	41	**26-27**	93	68	45	**56-57**	85	67	39	**86-87**	80	65	41
78-79	132	105	49	**27-28**	127	93	64	**57-58**	127	92	64	**87-88**	126	92	66	**27-28**	125	86	59	**57-58**	120	82	60	**87-88**	120	81	59
79-80	103	86	12	**28-29**	96	84	46	**58-59**	96	85	48	**88-89**	96	84	52	**28-29**	94	80	46	**58-59**	94	78	42	**88-89**	92	77	37
80-81	105	72	11	**29-30**	103	70	47	**59-60**	103	69	45	**89-90**	103	69	45	**29-30**	100	71	44	**59-60**	99	72	42	**89-90**	97	68	39
80-81	91	80	0	**30-31**	81	73	40	**60-61**	79	72	37	**90-91**	79	72	45	**30-31**	79	72	42	**60-61**	79	65	25	**90-91**	74	59	0
81-82	125	101	30	**31-32**	113	91	68	**61-62**	113	91	61	**91-92**	113	91	69	**31-32**	111	85	43	**61-62**	112	88	45	**91-92**	111	84	33
83-84	108	56	30	**32-33**	101	73	43	**62-63**	99	68	38	**92-93**	99	70	40	**32-33**	94	64	42	**62-63**	91	64	41	**92-93**	87	57	38
84-85	83	57	0	**33-34**	90	77	52	**63-64**	88	75	48	**93-94**	87	76	54	**33-34**	89	77	55	**63-64**	91	77	55	**93-94**	85	75	54
85-86	94	79	16	**34-35**	54	33	8	**64-65**	54	33	8	**94-95**	53	33	8	**34-35**	50	33	9	**64-65**	50	33	12	**94-95**	50	33	12
86-87	35	14	0	**35-36**	86	73	21	**65-66**	84	67	21	**95-96**	84	68	21	**35-36**	82	67	26	**65-66**	78	65	26	**95-96**	76	61	14
87-88	88	39	0	**36-37**	82	70	24	**66-67**	82	70	28	**96-97**	82	70	33	**36-37**	82	69	34	**66-67**	82	70	37	**96-97**	83	70	33
88-89	75	29	0	**37-38**	10	0	0	**67-68**	10	0	0	**97-98**	10	0	0	**37-38**	18	0	0	**67-68**	21	0	0	**97-98**	22	0	0
89-90	99	49	0	**38-39**	94	63	1	**68-69**	91	63	4	**98-99**	93	64	2	**38-39**	90	64	5	**68-69**	82	61	4	**98-99**	80	58	0
Mean	**97.55**	**62.93**	**11.59**	**Mean**	**90.24**	**71.66**	**36.14**	**Mean**	**89.38**	**70.45**	**34.45**	**Mean**	**89.24**	**70.79**	**36.72**	**Mean**	**87.62**	**68.31**	**34.34**	**Mean**	**85.76**	**65.90**	**32.79**	**Mean**	**83.10**	**62.76**	**27.24**
SD	**19.08**	**26.36**	**16.95**	**SD**	**20.75**	**19.55**	**19.39**	**SD**	**20.76**	**19.56**	**18.93**	**SD**	**20.79**	**19.42**	**19.30**	**SD**	**19.51**	**19.32**	**19.08**	**SD**	**18.72**	**18.86**	**20.29**	**SD**	**18.31**	**19.81**	**21.36**

Appendix 22

District 15 Projected Snowmobile Season Length (Days)

Baseline				INMCM3.0 B1												MIROC3.2 HIRES A1B											
				2020s				2050s				2080s				2020s				2050s				2080s			
Season	15cm	30cm	60cm	Season	15cm	30cm	60cm	Season	15cm	30cm	60cm	Season	15cm	30cm	60cm	Season	15cm	30cm	60cm	Season	15cm	30cm	60cm	Season	15cm	30cm	60cm
61-62	98	51	0	**10-11**	91	59	17	**40-41**	89	56	12	**70-71**	89	57	30	**10-11**	89	53	8	**40-41**	86	53	8	**70-71**	75	48	5
62-63	112	96	0	**11-12**	104	78	23	**41-42**	102	76	23	**71-72**	102	76	25	**11-12**	98	71	24	**41-42**	94	66	24	**71-72**	89	58	12
63-64	104	77	0	**12-13**	83	67	43	**42-43**	83	65	31	**72-73**	83	65	34	**12-13**	83	59	2	**42-43**	76	55	2	**72-73**	76	49	0
64-65	120	89	32	**13-14**	111	80	57	**43-44**	110	79	51	**73-74**	109	78	58	**13-14**	106	76	58	**43-44**	105	75	54	**73-74**	106	76	50
65-66	96	62	0	**14-15**	99	74	39	**44-45**	98	72	38	**74-75**	98	71	36	**14-15**	99	76	39	**44-45**	97	75	43	**74-75**	97	75	39
66-67	122	74	0	**15-16**	108	86	56	**45-49**	114	86	57	**75-76**	117	86	59	**15-16**	118	88	64	**45-49**	118	91	70	**75-76**	121	91	68
67-68	93	32	0	**16-17**	91	71	9	**49-47**	85	64	1	**76-77**	89	71	18	**16-17**	87	68	10	**49-47**	86	69	21	**76-77**	90	71	12
68-69	75	34	0	**17-18**	78	56	25	**47-48**	74	52	13	**77-78**	74	52	28	**17-18**	72	52	32	**47-48**	64	51	15	**77-78**	58	47	0
69-70	115	79	4	**18-19**	110	85	60	**48-49**	110	85	59	**78-79**	110	84	57	**18-19**	109	83	62	**48-49**	105	79	55	**78-79**	103	77	50
70-71	98	67	7	**19-20**	91	79	43	**49-50**	91	82	42	**79-80**	91	84	43	**19-20**	90	83	44	**49-50**	88	79	47	**79-80**	87	77	45
71-72	101	70	0	**20-21**	103	79	25	**50-51**	100	77	14	**80-81**	103	79	29	**20-21**	97	77	15	**50-51**	91	71	13	**80-81**	92	70	4
72-73	95	62	0	**21-22**	92	69	32	**51-52**	92	69	31	**81-82**	93	70	41	**21-22**	91	66	18	**51-52**	90	66	35	**81-82**	84	61	1
73-74	135	108	20	**22-23**	117	96	23	**52-53**	117	96	29	**82-83**	132	102	38	**22-23**	129	99	38	**52-53**	126	97	32	**82-83**	125	97	18
74-75	99	62	24	**23-24**	91	81	58	**53-54**	90	80	57	**83-84**	90	80	57	**23-24**	91	84	60	**53-54**	92	85	61	**83-84**	91	81	58
75-76	111	67	0	**24-25**	104	82	47	**54-55**	104	84	49	**84-85**	104	86	52	**24-25**	105	85	51	**54-55**	105	85	55	**84-85**	105	87	53
76-77	132	92	20	**25-26**	131	98	70	**55-56**	131	98	70	**85-86**	131	100	72	**25-26**	131	100	72	**55-56**	131	100	75	**85-86**	127	97	71
77-78	126	75	13	**26-27**	107	85	57	**56-57**	108	82	58	**86-87**	112	86	60	**26-27**	113	87	65	**56-57**	104	84	63	**86-87**	103	83	63
78-79	120	88	19	**27-28**	115	82	50	**57-58**	115	73	42	**87-88**	115	75	47	**27-28**	109	69	39	**57-58**	105	67	42	**87-88**	95	64	31
79-80	133	112	31	**28-29**	127	115	80	**58-59**	127	115	83	**88-89**	126	115	82	**28-29**	126	110	85	**58-59**	122	106	79	**88-89**	120	104	73
80-81	104	43	0	**29-30**	109	80	28	**59-60**	109	80	26	**89-90**	107	79	27	**29-30**	103	74	26	**59-60**	102	74	24	**89-90**	100	72	13
80-81	116	97	12	**30-31**	101	84	60	**60-61**	101	84	55	**90-91**	101	84	63	**30-31**	101	84	56	**60-61**	99	82	55	**90-91**	95	79	50
81-82	148	139	75	**31-32**	134	125	83	**61-62**	134	125	83	**91-92**	133	124	84	**31-32**	134	126	83	**61-62**	134	125	79	**91-92**	132	123	71
83-84	89	63	0	**32-33**	85	68	43	**62-63**	84	67	41	**92-93**	85	68	44	**32-33**	83	65	40	**62-63**	79	65	40	**92-93**	74	60	36
84-85	90	51	0	**33-34**	99	81	56	**63-64**	96	79	49	**93-94**	97	79	56	**33-34**	100	82	58	**63-64**	97	79	56	**93-94**	94	75	55
85-86	103	79	0	**34-35**	78	47	0	**64-65**	78	47	0	**94-95**	80	47	0	**34-35**	68	42	0	**64-65**	66	42	0	**94-95**	62	38	0
86-87	126	95	44	**35-36**	119	94	74	**65-66**	119	93	74	**95-96**	119	93	74	**35-36**	118	94	78	**65-66**	118	93	79	**95-96**	117	91	76
87-88	76	4	0	**36-37**	84	61	15	**66-67**	83	63	17	**96-97**	84	67	22	**36-37**	85	69	18	**66-67**	85	68	18	**96-97**	85	68	14
88-89	105	81	10	**37-38**	89	69	12	**67-68**	90	70	20	**97-98**	89	69	18	**37-38**	88	59	0	**67-68**	85	54	0	**97-98**	79	42	0
89-90	122	81	11	**38-39**	114	99	57	**68-69**	115	98	61	**98-99**	114	99	63	**38-39**	113	99	67	**68-69**	112	101	67	**98-99**	112	98	67
Mean	**109.10**	**73.45**	**11.10**	**Mean**	**102.24**	**80.34**	**42.83**	**Mean**	**101.69**	**79.21**	**40.90**	**Mean**	**102.66**	**80.21**	**45.41**	**Mean**	**101.24**	**78.62**	**41.79**	**Mean**	**98.69**	**77.14**	**41.79**	**Mean**	**96.34**	**74.45**	**35.69**
SD	**17.62**	**26.81**	**17.22**	**SD**	**15.21**	**16.52**	**22.11**	**SD**	**15.96**	**17.07**	**23.12**	**SD**	**16.34**	**17.01**	**20.64**	**SD**	**17.04**	**18.20**	**25.90**	**SD**	**17.82**	**18.41**	**25.32**	**SD**	**18.88**	**19.81**	**27.29**

Appendix 23

District 16 Projected Snowmobile Season Length (Days)

Baseline				INMCM3.0 B1												MIROC3.2 HIRES A1B											
				2020s				2050s				2080s				2020s				2050s				2080s			
Season	15cm	30cm	60cm	Season	15cm	30cm	60cm	Season	15cm	30cm	60cm	Season	15cm	30cm	60cm	Season	15cm	30cm	60cm	Season	15cm	30cm	60cm	Season	15cm	30cm	60cm
61-62	0	0	0	**10-11**	0	0	0	**40-41**	0	0	0	**70-71**	0	0	0	**10-11**	0	0	0	**40-41**	0	0	0	**70-71**	0	0	0
62-63	92	32	0	**11-12**	74	55	0	**41-42**	73	49	0	**71-72**	73	40	0	**11-12**	62	5	0	**41-42**	31	1	0	**71-72**	25	0	0
63-64	68	0	0	**12-13**	71	49	0	**42-43**	68	36	0	**72-73**	71	48	0	**12-13**	56	0	0	**42-43**	22	0	0	**72-73**	13	0	0
64-65	96	16	0	**13-14**	76	56	0	**43-44**	79	50	0	**73-74**	79	55	0	**13-14**	84	59	0	**43-44**	83	52	0	**73-74**	79	24	0
65-66	29	0	0	**14-15**	39	22	0	**44-45**	39	21	0	**74-75**	42	25	0	**14-15**	31	18	0	**44-45**	25	14	0	**74-75**	17	12	0
66-67	61	0	0	**15-16**	74	56	0	**45-49**	72	53	0	**75-76**	74	56	0	**15-16**	68	54	0	**45-49**	65	50	0	**75-76**	62	47	0
67-68	0	0	0	**16-17**	54	33	0	**49-47**	55	23	0	**76-77**	58	37	0	**16-17**	22	0	0	**49-47**	18	0	0	**76-77**	10	0	0
68-69	83	63	0	**17-18**	81	61	15	**47-48**	82	62	15	**77-78**	82	65	37	**17-18**	73	57	0	**47-48**	71	47	0	**77-78**	70	37	0
69-70	43	0	0	**18-19**	50	0	0	**48-49**	35	0	0	**78-79**	44	0	0	**18-19**	16	0	0	**48-49**	2	0	0	**78-79**	1	0	0
70-71	16	0	0	**19-20**	35	0	0	**49-50**	29	0	0	**79-80**	30	0	0	**19-20**	0	0	0	**49-50**	0	0	0	**79-80**	0	0	0
71-72	55	0	0	**20-21**	21	0	0	**50-51**	19	0	0	**80-81**	21	0	0	**20-21**	10	0	0	**50-51**	5	0	0	**80-81**	4	0	0
72-73	36	0	0	**21-22**	44	0	0	**51-52**	44	0	0	**81-82**	46	0	0	**21-22**	45	0	0	**51-52**	22	0	0	**81-82**	3	0	0
73-74	78	56	0	**22-23**	28	0	0	**52-53**	26	0	0	**82-83**	26	0	0	**22-23**	24	0	0	**52-53**	2	0	0	**82-83**	1	0	0
74-75	87	8	0	**23-24**	79	45	0	**53-54**	78	27	0	**83-84**	78	35	0	**23-24**	84	45	0	**53-54**	82	47	0	**83-84**	79	42	0
75-76	25	0	0	**24-25**	40	20	0	**54-55**	48	18	0	**84-85**	38	18	0	**24-25**	33	17	0	**54-55**	29	13	0	**84-85**	26	11	0
76-77	0	0	0	**25-26**	55	1	0	**55-56**	38	0	0	**85-86**	51	1	0	**25-26**	18	2	0	**55-56**	18	0	0	**85-86**	14	0	0
77-78	17	0	0	**26-27**	61	46	0	**56-57**	59	44	0	**86-87**	60	46	0	**26-27**	61	48	0	**56-57**	55	47	0	**86-87**	55	47	0
78-79	99	55	0	**27-28**	66	53	0	**57-58**	64	37	0	**87-88**	65	49	0	**27-28**	65	52	0	**57-58**	62	48	0	**87-88**	58	48	0
79-80	51	0	0	**28-29**	49	35	0	**58-59**	48	31	0	**88-89**	48	31	0	**28-29**	44	5	0	**58-59**	45	0	0	**88-89**	43	0	0
80-81	107	47	0	**29-30**	102	78	45	**59-60**	102	78	44	**89-90**	102	77	42	**29-30**	102	74	41	**59-60**	109	81	42	**89-90**	109	81	39
80-81	19	0	0	**30-31**	38	15	0	**60-61**	32	14	0	**90-91**	34	14	0	**30-31**	39	14	0	**60-61**	35	4	0	**90-91**	26	0	0
81-82	84	0	0	**31-32**	77	28	0	**61-62**	76	25	0	**91-92**	76	22	0	**31-32**	42	0	0	**61-62**	33	0	0	**91-92**	16	0	0
83-84	21	0	0	**32-33**	54	25	0	**62-63**	52	24	0	**92-93**	52	24	0	**32-33**	45	10	0	**62-63**	36	8	0	**92-93**	36	8	0
84-85	5	0	0	**33-34**	31	2	0	**63-64**	31	2	0	**93-94**	34	2	0	**33-34**	36	2	0	**63-64**	33	2	0	**93-94**	27	2	0
85-86	4	0	0	**34-35**	0	0	0	**64-65**	0	0	0	**94-95**	0	0	0	**34-35**	0	0	0	**64-65**	0	0	0	**94-95**	0	0	0
86-87	57	13	0	**35-36**	62	46	5	**65-66**	61	44	0	**95-96**	61	45	0	**35-36**	53	42	0	**65-66**	50	39	0	**95-96**	45	33	0
87-88	42	0	0	**36-37**	66	46	0	**66-67**	67	47	0	**96-97**	68	47	0	**36-37**	67	47	0	**66-67**	60	46	0	**96-97**	56	35	0
88-89	64	14	0	**37-38**	67	53	0	**67-68**	64	52	0	**97-98**	62	52	0	**37-38**	60	50	0	**67-68**	59	47	0	**97-98**	58	48	0
89-90	29	0	0	**38-39**	59	40	0	**68-69**	51	35	0	**98-99**	53	36	0	**38-39**	29	0	0	**68-69**	19	0	0	**98-99**	0	0	0
Mean	**47.17**	**10.48**	**0.00**	**Mean**	**53.55**	**29.83**	**2.24**	**Mean**	**51.45**	**26.62**	**2.03**	**Mean**	**52.69**	**28.45**	**2.72**	**Mean**	**43.76**	**20.72**	**1.41**	**Mean**	**36.93**	**18.83**	**1.45**	**Mean**	**32.17**	**16.38**	**1.34**
SD	**33.76**	**19.70**	**0.00**	**SD**	**23.65**	**24.00**	**8.72**	**SD**	**24.21**	**22.48**	**8.54**	**SD**	**23.87**	**23.35**	**10.21**	**SD**	**26.70**	**24.74**	**7.61**	**SD**	**28.55**	**24.43**	**7.80**	**SD**	**29.82**	**22.49**	**7.24**

Appendix 24

District 17 Projected Snowmobile Season Length (Days)

Baseline			
Season	15cm	30cm	60cm
61-62	4	0	0
62-63	110	24	0
63-64	88	0	0
64-65	93	28	0
65-66	61	32	0
66-67	20	0	0
67-68	42	0	0
68-69	73	17	0
69-70	0	0	0
70-71	20	0	0
71-72	52	0	0
72-73	68	0	0
73-74	91	53	0
74-75	103	50	0
75-76	42	0	0
76-77	61	6	0
77-78	69	0	0
78-79	49	0	0
79-80	80	0	0
80-81	98	0	0
80-81	105	72	0
81-82	0	0	0
83-84	15	0	0
84-85	58	0	0
85-86	100	2	0
86-87	61	0	0
87-88	19	0	0
88-89	62	1	0
89-90	49	0	0
Mean	**58.38**	**9.83**	**0.00**
SD	**33.33**	**19.28**	**0.00**

INMCM3.0 B1											
2020s				2050s				2080s			
Season	15cm	30cm	60cm	Season	15cm	30cm	60cm	Season	15cm	30cm	60cm
10-11	38	0	0	40-41	22	0	0	70-71	29	0	0
11-12	102	72	0	41-42	102	72	0	71-72	102	73	0
12-13	79	40	0	42-43	78	30	0	72-73	78	25	0
13-14	84	59	0	43-44	82	57	0	73-74	82	58	0
14-15	82	53	12	44-45	80	50	12	74-75	79	48	9
15-16	77	53	0	45-49	77	51	0	75-76	74	47	0
16-17	83	52	0	49-47	77	42	0	76-77	77	47	0
17-18	79	56	0	47-48	75	51	0	77-78	75	51	0
18-19	1	0	0	48-49	1	0	0	78-79	3	0	0
19-20	79	39	0	49-50	78	37	0	79-80	77	34	0
20-21	48	3	0	50-51	48	12	0	80-81	48	7	0
21-22	69	44	0	51-52	68	43	0	81-82	70	43	0
22-23	57	28	0	52-53	57	23	0	82-83	60	25	0
23-24	110	86	35	53-54	111	87	44	83-84	111	87	50
24-25	70	50	0	54-55	69	48	0	84-85	65	46	0
25-26	80	61	6	55-56	79	60	6	85-86	80	60	6
26-27	90	73	0	56-57	90	76	0	86-87	90	76	21
27-28	62	47	0	57-58	62	43	0	87-88	62	47	0
28-29	79	49	0	58-59	79	49	0	88-89	78	49	0
29-30	95	67	0	59-60	94	66	0	89-90	94	68	0
30-31	93	83	48	60-61	93	82	44	90-91	93	81	47
31-32	8	0	0	61-62	6	0	0	91-92	7	0	0
32-33	62	33	0	62-63	63	34	0	92-93	62	33	0
33-34	79	55	0	63-64	77	55	0	93-94	81	55	0
34-35	70	4	0	64-65	69	1	0	94-95	68	4	0
35-36	63	37	0	65-66	60	1	0	95-96	64	37	0
36-37	59	20	0	66-67	49	19	0	96-97	49	18	0
37-38	23	0	0	67-68	28	0	0	97-98	44	0	0
38-39	72	47	0	68-69	73	54	0	98-99	75	58	0
Mean	**68.72**	**41.76**	**3.48**	**Mean**	**67.14**	**39.41**	**3.66**	**Mean**	**68.17**	**40.59**	**4.59**
SD	**25.35**	**25.67**	**10.95**	**SD**	**26.00**	**26.51**	**11.44**	**SD**	**24.56**	**25.77**	**12.90**

MIROC3.2 HIRES A1B											
2020s				2050s				2080s			
Season	15cm	30cm	60cm	Season	15cm	30cm	60cm	Season	15cm	30cm	60cm
10-11	16	0	0	40-41	15	0	0	70-71	13	0	0
11-12	100	52	0	41-42	97	47	0	71-72	94	30	0
12-13	71	10	0	42-43	53	7	0	72-73	49	5	0
13-14	70	22	0	43-44	60	25	0	73-74	52	21	0
14-15	80	42	0	44-45	80	46	0	74-75	76	46	0
15-16	67	16	0	45-49	48	11	0	75-76	17	0	0
16-17	60	4	0	49-47	50	0	0	76-77	50	0	0
17-18	66	28	0	47-48	39	12	0	77-78	40	5	0
18-19	1	0	0	48-49	0	0	0	78-79	0	0	0
19-20	78	28	0	49-50	62	0	0	79-80	70	0	0
20-21	46	0	0	50-51	25	0	0	80-81	20	0	0
21-22	67	33	0	51-52	65	31	0	81-82	62	26	0
22-23	38	3	0	52-53	29	2	0	82-83	9	2	0
23-24	111	85	42	53-54	110	87	43	83-84	110	87	46
24-25	59	43	0	54-55	55	32	0	84-85	55	40	0
25-26	80	60	4	55-56	77	58	0	85-86	81	60	0
26-27	86	71	0	56-57	84	70	0	86-87	81	68	0
27-28	59	41	0	57-58	58	44	0	87-88	55	31	0
28-29	78	49	0	58-59	79	48	0	88-89	75	44	0
29-30	95	66	0	59-60	95	64	0	89-90	93	64	0
30-31	91	80	3	60-61	87	77	2	90-91	87	76	0
31-32	4	0	0	61-62	0	0	0	91-92	2	0	0
32-33	50	22	0	62-63	49	17	0	92-93	46	13	0
33-34	78	50	0	63-64	77	54	0	93-94	74	28	0
34-35	25	0	0	64-65	25	0	0	94-95	25	0	0
35-36	56	1	0	65-66	48	0	0	95-96	47	0	0
36-37	40	16	0	66-67	39	15	0	96-97	37	6	0
37-38	25	0	0	67-68	25	0	0	97-98	21	0	0
38-39	68	19	0	68-69	69	2	0	98-99	56	0	0
Mean	**60.86**	**29.00**	**1.69**	**Mean**	**55.17**	**25.83**	**1.55**	**Mean**	**51.62**	**22.48**	**1.59**
SD	**27.67**	**26.56**	**7.81**	**SD**	**28.35**	**27.67**	**7.98**	**SD**	**29.71**	**27.18**	**8.54**

Ontario Projected Snowmobile Season Length (Days)

Baseline				INMCM3.0 B1												MIROC3.2 HIRES A1B											
				2020s				2050s				2080s				2020s				2050s				2080s			
Season	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**	**Season**	**15cm**	**30cm**	**60cm**
61-62	25.00	8.82	0.00	**10-11**	24.65	11.94	3.35	**40-41**	21.94	11.06	2.71	**70-71**	23.12	11.06	3.88	**10-11**	17.12	8.88	2.65	**40-41**	15.47	8.59	2.71	**70-71**	13.71	7.65	2.18
62-63	71.41	43.65	12.59	**11-12**	44.53	29.29	6.47	**41-42**	42.35	26.94	6.00	**71-72**	42.65	28.00	6.82	**11-12**	35.06	19.12	4.41	**41-42**	30.59	15.94	4.12	**71-72**	28.12	13.18	3.35
63-64	60.35	23.82	2.59	**12-13**	36.24	20.41	5.47	**42-43**	34.65	18.35	4.29	**72-73**	34.88	18.65	4.59	**12-13**	28.82	13.29	2.06	**42-43**	24.12	11.47	0.53	**72-73**	21.76	10.41	0.12
64-65	74.65	42.06	11.29	**13-14**	56.41	43.12	19.29	**43-44**	55.06	41.18	16.59	**73-74**	55.47	41.82	18.24	**13-14**	48.41	30.76	13.88	**43-44**	44.82	27.24	9.41	**73-74**	38.88	21.88	7.71
65-66	67.06	40.88	7.47	**14-15**	54.71	39.88	19.53	**44-45**	53.24	38.41	18.88	**74-75**	54.00	39.76	18.82	**14-15**	47.35	33.18	12.82	**44-45**	40.35	27.18	13.71	**74-75**	38.00	25.82	10.71
66-67	65.47	34.12	8.59	**15-16**	60.29	45.47	18.00	**45-49**	58.65	43.24	15.00	**75-76**	60.00	44.59	17.65	**15-16**	51.18	28.24	11.06	**45-49**	40.47	24.94	10.59	**75-76**	36.35	22.00	7.59
67-68	40.88	15.88	0.41	**16-17**	45.59	27.82	6.00	**49-47**	42.41	24.82	3.59	**76-77**	43.59	27.47	6.88	**16-17**	29.94	15.18	3.18	**49-47**	26.65	12.82	3.94	**76-77**	24.94	11.41	3.00
68-69	54.59	25.00	1.35	**17-18**	51.59	34.12	8.71	**47-48**	50.35	33.12	7.00	**77-78**	50.65	33.24	13.12	**17-18**	42.47	25.18	7.76	**47-48**	38.65	20.88	7.12	**77-78**	36.41	18.88	5.59
69-70	61.35	32.35	5.24	**18-19**	42.29	28.47	11.65	**48-49**	40.53	25.41	9.35	**78-79**	41.47	25.24	9.65	**18-19**	29.06	15.41	5.06	**48-49**	26.00	13.18	3.71	**78-79**	19.35	8.29	2.94
70-71	52.12	19.29	0.41	**19-20**	45.94	25.53	4.41	**49-50**	44.18	24.82	4.00	**79-80**	46.76	26.88	4.12	**19-20**	34.24	17.76	4.12	**49-50**	28.35	13.88	4.29	**79-80**	23.06	12.00	4.12
71-72	48.24	21.00	2.35	**20-21**	30.18	16.06	4.59	**50-51**	29.53	16.71	4.12	**80-81**	30.82	16.59	4.94	**20-21**	23.88	11.35	4.06	**50-51**	21.59	10.35	3.65	**80-81**	18.94	8.82	2.59
72-73	52.47	24.53	0.00	**21-22**	43.88	25.06	1.88	**51-52**	42.18	23.88	1.82	**81-82**	42.18	23.41	3.59	**21-22**	34.12	14.12	1.29	**51-52**	28.35	12.06	2.06	**81-82**	26.53	11.35	0.06
73-74	65.12	37.59	5.59	**22-23**	37.06	19.41	2.24	**52-53**	34.47	17.18	2.00	**82-83**	36.88	18.59	2.59	**22-23**	27.06	10.82	2.24	**52-53**	23.35	9.41	1.88	**82-83**	19.12	7.88	1.06
74-75	72.47	39.12	5.35	**23-24**	60.82	43.94	21.59	**53-54**	59.65	39.94	22.12	**83-84**	60.88	43.12	23.24	**23-24**	48.59	36.53	16.12	**53-54**	45.35	33.53	15.59	**83-84**	42.53	29.18	12.88
75-76	42.65	16.71	0.82	**24-25**	40.65	25.53	7.29	**54-55**	40.29	25.71	6.24	**84-85**	40.82	27.71	7.82	**24-25**	33.18	20.59	5.94	**54-55**	31.82	18.47	6.35	**84-85**	28.76	16.12	6.24
76-77	60.24	26.06	3.24	**25-26**	59.65	42.88	17.12	**55-56**	57.47	41.35	15.59	**85-86**	58.71	41.76	16.41	**25-26**	43.71	28.76	11.47	**55-56**	37.00	23.47	10.71	**85-86**	36.12	22.65	9.41
77-78	63.24	31.94	2.59	**26-27**	54.41	36.24	7.65	**56-57**	52.18	35.24	7.82	**86-87**	53.47	36.82	9.12	**26-27**	44.00	23.65	6.47	**56-57**	37.06	18.76	6.00	**86-87**	30.76	15.65	6.12
78-79	60.18	30.12	6.88	**27-28**	48.53	32.94	12.00	**57-58**	45.18	29.82	10.00	**87-88**	46.41	32.47	11.82	**27-28**	37.12	24.29	6.59	**57-58**	33.29	21.35	6.00	**87-88**	31.88	20.29	5.29
79-80	64.71	37.00	3.41	**28-29**	49.24	32.53	10.35	**58-59**	47.71	31.12	10.59	**88-89**	49.35	32.06	10.94	**28-29**	42.29	24.24	10.53	**58-59**	40.00	22.18	10.06	**88-89**	37.18	20.06	8.82
80-81	70.06	37.82	2.94	**29-30**	66.41	47.06	16.53	**59-60**	64.47	45.06	15.53	**89-90**	66.65	49.29	16.59	**29-30**	57.06	38.53	10.88	**59-60**	51.29	34.47	8.88	**89-90**	48.94	28.65	5.59
80-81	55.53	33.71	7.24	**30-31**	35.88	24.65	13.18	**60-61**	34.12	24.06	12.12	**90-91**	35.24	24.53	12.94	**30-31**	30.00	19.65	8.41	**60-61**	28.88	17.71	7.00	**90-91**	25.65	16.12	4.59
81-82	62.35	37.29	9.18	**31-32**	38.94	26.76	12.18	**61-62**	38.06	25.00	11.71	**91-92**	39.65	26.88	12.71	**31-32**	27.88	17.18	10.29	**61-62**	25.65	17.18	10.18	**91-92**	22.88	16.53	9.00
83-84	62.18	31.41	6.18	**32-33**	55.41	35.18	11.06	**62-63**	53.00	31.82	9.12	**92-93**	53.65	33.65	10.18	**32-33**	39.00	16.88	5.82	**62-63**	33.24	14.35	4.76	**92-93**	30.94	11.82	4.35
84-85	49.24	21.18	0.00	**33-34**	47.71	31.82	11.94	**63-64**	45.47	28.53	10.24	**93-94**	47.41	31.71	12.47	**33-34**	38.65	23.47	7.18	**63-64**	33.76	20.35	6.76	**93-94**	30.35	16.18	6.41
85-86	60.06	32.24	5.12	**34-35**	30.18	15.53	0.47	**64-65**	30.06	14.82	0.47	**94-95**	30.59	15.24	0.53	**34-35**	21.29	8.29	0.53	**64-65**	20.88	7.18	0.71	**94-95**	16.76	6.94	0.71
86-87	47.53	19.59	2.94	**35-36**	33.29	18.12	5.88	**65-66**	30.88	14.88	5.59	**95-96**	34.18	18.35	5.59	**35-36**	27.41	13.29	6.12	**65-66**	25.47	13.53	6.18	**95-96**	23.41	12.12	5.29
87-88	48.94	21.24	2.47	**36-37**	48.94	32.06	11.35	**66-67**	47.24	30.41	11.59	**96-97**	48.35	31.88	12.41	**36-37**	40.29	28.24	11.00	**66-67**	36.82	26.59	11.24	**96-97**	37.12	24.41	9.29
88-89	52.94	23.53	2.12	**37-38**	29.47	14.71	0.71	**67-68**	27.88	13.88	1.18	**97-98**	29.12	14.12	1.47	**37-38**	21.88	7.94	0.00	**67-68**	22.00	8.29	0.00	**97-98**	17.41	6.06	0.00
89-90	46.53	21.82	2.24	**38-39**	41.88	27.65	6.94	**68-69**	40.59	26.65	7.24	**98-99**	41.35	29.18	7.24	**38-39**	33.65	17.06	7.29	**68-69**	31.47	16.06	7.06	**98-99**	26.41	15.41	6.41
Mean	**57.16**	**28.61**	**4.16**	**Mean**	**45.34**	**29.45**	**9.58**	**Mean**	**43.58**	**27.70**	**8.71**	**Mean**	**44.77**	**29.11**	**9.87**	**Mean**	**35.68**	**20.41**	**6.87**	**Mean**	**31.82**	**17.98**	**6.39**	**Mean**	**28.70**	**15.78**	**5.22**
SD	**10.92**	**8.96**	**3.41**	**SD**	**10.69**	**9.79**	**5.95**	**SD**	**10.62**	**9.42**	**5.63**	**SD**	**10.61**	**9.87**	**5.80**	**SD**	**9.79**	**8.39**	**4.19**	**SD**	**8.39**	**7.31**	**3.95**	**SD**	**8.61**	**6.59**	**3.36**