

Establishment of a Global Warming Bio-Monitoring
Program in the Boreal Forest of Eastern Manitoba:
Year I

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Executive Summary

In 2004, a Bio-monitoring program was initiated in the Manitoba Model Forest area to study the potential impacts of global warming (climate change) on the forest environment. The program was designed and implemented by the Environment Department of Black River First Nation (BRFN). A unique aspect of the program was that it also involved the assistance of high school students from 3 schools in the region.

Three general study areas were chosen: near Hollow Water First Nation, Powerview and Lac du Bonnet, Manitoba. At each of the three areas, 30 x 30 m terrestrial study plots were established in a variety of forest stand types, ages and disturbance origin (fire, logging). At the Hollow Water area, study plots were established in a mature (>90 year old) fire-origin jack pine stand, and in jack pine stands that were previously harvested (clear cut) in the 1970s and 1990s. These forest stands are underlain by sandy soils, part of a relic beach ridge of glacial Lake Agassiz. Four study plots were also established at the Pine Creek Nature Trail, north of Powerview. Two of these study plots were located in lowland black spruce forests that were harvested (clear cut) in 1981 and 1948. These sites are underlain by saturated, organic (peaty) soils. One plot at the Pine Creek Trail was located in a riparian area that had no harvesting history, and one plot in an upland, mixed wood forest that was harvested using an alternate strip method of cutting. Finally, a series of study plots were established near Lac du Bonnet, in an area that experienced a wildfire in 2003. In the Lac du Bonnet site, study plots were established in a mature, lowland black spruce stand, in the 2003 burn (where all the trees were killed by a crown fire), and in a transition area (where there was only partial mortality of trees caused by a ground fire).

In 2004, baseline data were collected on vegetation (tree, shrub and herb species composition and abundance), tree height and age, small mammal species composition and abundance, air and soil temperature, soil pH and the light environment.

Data was collected from June to November, 2004 by BFRN Environment Department staff. In addition, students from Lac du Bonnet, Powerview and Wanipigow schools were involved in the data collection. Field trips with the schools to the study sites were held in June, September and October. BFRN Environment Department staff and the Manitoba Model Forest Education Coordinator provided training to the students on how to use the scientific monitoring equipment and the students collected their own data. This part of the program was very successful, with 80 students participating in the field trips. The program provided a rare opportunity for the students to learn about and participate in field research relevant to their communities. Students were very enthusiastic and appreciative of the opportunity. The data collected by the students were combined with the data collected by BFRN. Results of the monitoring are provided in detail in this report. In addition, summaries of the data are posted on the BFRN website (www.black-river.ca).

A final aspect of the program involved the development of 2 interactive educational CDs relating to the environment. One CD was developed for Kindergarten/Grade 1 level students. This CD provides a fun way to learn about water, wildlife, air, and habitat and how children can protect the environment. The CD also includes games. The other CD was developed for Grades 5/6 students, and provides detailed information and facts about the earth, its place in our solar

system, the Milky Way galaxy and the universe, as well as information on greenhouse gases, the greenhouse effect, global warming (climate change) and the ozone layer. The CD provides suggestions of how humans can reduce their environmental footprint on the earth, as well as providing educational activities and games.

The field study portion of the program (including involvement of the schools) will be continued in 2005. It is hoped that a long-term monitoring program can be established, as a proper assessment of the potential effects of climate change on forests requires long-term monitoring. Discussions will be held with Environment Canada in 2005 to consider including some or all of our study sites into the national Ecological Monitoring and Assessment Network (EMAN) program. The data collected from eastern Manitoba would then be added to a national database of monitoring plots established throughout Canada.

Acknowledgements

This program could not have been possible without the financial and in-kind assistance of many partners. Financial support was provided by the Manitoba Model Forest and Environment Canada (EcoAction Community Funding Program). We wish to thank the Model Forest for funding that allowed for the purchase of the monitoring equipment. Without this equipment, the program would not have been possible. We are also thankful for the support and involvement of Bob Austman, Manitoba Model Forest Education Coordinator. His enthusiastic participation was very much appreciated. We are also thankful for the support and encouragement received from the BFRN Chief and Council as well as the accounting support provided by the BRFN finance department.

Sunrise and Frontier School Divisions provided bus transportation for the high school students to the study sites. We also thank the high school teachers for their involvement: Jeff Richardson (Powerview), Mike Furchuk and Nick White (Wanipigow), and Paul Porrier (Lac du Bonnet), as well as the students, who clearly enjoyed their time in the forest. We look forward to working with you again in 2005.

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Introduction

Over the last several decades, Canadian citizens have been taking a more active role in the monitoring of the natural environment around them. These citizen-based monitoring programs have become increasingly popular and more widespread across the nation for several reasons. Historically, provincial and federal government agencies have held responsibility for monitoring environmental quality. As a result of budget reductions and changes in government direction, monitoring programs are now commonly a collective and collaborative responsibility that involves multiple stakeholders such as industry, Environmental Non-governmental Organizations (ENGOs), communities and/or community groups, schools and citizens. In many cases, these monitoring programs are now developed, administered and implemented by the stakeholders themselves. Greater involvement in the development and implementation of such monitoring programs can also be attributed to an increased awareness of citizens to environmental issues and problems of the day (both local, and more globally), and a heightened desire to take a more active role in environmental monitoring and advocacy.

The data derived from such monitoring programs are commonly used in environmental decision-making by government regulators, and as such, provide a low-cost, yet reliable source of much needed information. Monitoring programs can be organized and executed at local, regional, provincial or national levels and involve monitoring of a diverse suite of environmental indicators such as weather (air temperature and precipitation), ice formation/disappearance from lakes and rivers, water quality, vegetation (including trees, shrubs, herbs, lichens) and animals (frogs, earthworms, salamanders), to name only a few. In many cases, the type of monitoring conducted within a program is a reflection of the types of concerns held by local citizens.

Over the past decade there has been a heightened interest and desire by First Nations to take a more active role in management and monitoring of natural resources, particularly in their traditional lands. In some cases, the momentum for stronger participation by First Nations has been accelerated by forming partnerships between First Nation communities and resource-based industries and NGOs, or by greater inclusion in land management decisions through provincial land use planning initiatives. Black River First Nation (BRFN), an Ojibwe community that is located along the eastern shore of Lake Winnipeg, approximately 2 hours northeast of Winnipeg, Manitoba, is one such community. The community is located in the Manitoba Model Forest area which overlaps with the Tembec Forest Management License (FML).

As with all First Nation communities, BRFN wants to ensure that the natural environment in the community and their larger traditional use area is cared for and protected. The environment is an integral part of the community's culture, history, traditions and spirituality. In 2003, Chief and Council elevated the profile of the environment within the community by forming an Environment Department. Currently, the Environment Department has a staff of 4 full-time researchers, including one PhD, two BSC graduates and a community youth. BRFN not only desires to be an active participant in environmental monitoring programs, but to develop programs and lead them. Since 2003, the BRFN Environment Department has developed and implemented a regional water quality monitoring program, conducted fisheries and fish habitat inventories, created of an interpretive recreational trail in the community, has undertaken Traditional Ecological Knowledge (TEK) studies, conducted research on woodland caribou, and participated in environmental impact assessments. The present project (Local Indicators and

Biomonitoring/Global Warming) seeks to provide information on perhaps one of the most serious environmental threats to the planet.

When one considers the potential environmental and social impacts of various human-caused issues today, greenhouse gas emissions such as carbon dioxide (CO₂, a by-product of combustion of fossil fuels such as coal and gas) and its resulting effect on global climate (e.g., global warming or climate change) emerges as one of the most pressing issues of our time. The potential scope and magnitude of impacts is predicted to be on par or greater than other large-scale phenomena such as glaciation or mass extinction events, which take thousands or millions of years to occur. In the context of such long-term natural processes, climate change caused by human-induced greenhouse gas emissions is predicted to occur over a much shorter time period (decades to centuries), and the general consensus in the scientific community and among citizens is that these changes are already occurring.

Scientists have developed computer models (called Global Circulation Models or CGMs) to examine the potential impacts of elevated atmospheric CO₂ on regional climate, including temperature and precipitation patterns. On the Canadian prairies for example, including the boreal forest in eastern Manitoba, predictions are that summers are going to become hotter and drier. Winters will also become drier. The increase in aridity (dryness) may potentially result in a greater incidence of drought, forest fires and affect the amount and quality of water in lakes, rivers and streams. Climate change has the potential to significantly affect the health of the boreal forest and predictions are that changes in temperature, precipitation, fires and water availability could significantly change the boreal forests in eastern Manitoba. Monitoring of the

forest environment, before potential widespread changes happen is essential to understanding and validating climate change predictions, as well as to help develop mitigation strategies.

The Local Indicators and Biomonitoring/Global Warming project addresses some of the above issues by implementing a monitoring program in the boreal forest of eastern Manitoba. The program is coordinated by BRFN, with the financial and in-kind (technical) support of many organizations and government partners. These include: Manitoba Model Forest, Tembec Industries Inc., Sunrise School Division, Frontier School Division, Environment Canada (EcoAction Community Funding Program), Manitoba Conservation (Forestry), Manitoba Water Stewardship, Manitoba Hydro, Department of Fisheries and Oceans, and Indian and Northern Affairs Canada.

The objectives of the project are to:

- Develop a regional Biomonitoring program to evaluate the long-term impacts of climate change on the boreal forest in eastern Manitoba, including impacts on forests of fire origin (“natural forests”) and those that have been previously harvested,
- Collect quantitative data on forest ecosystem parameters that may be impacted by global warming. These include temperature (air and soil), soil pH, vegetation (species composition of the tree, shrub and herb layers, as well as growth rates of trees), and small mammals (species composition and abundance),
- Work with three high schools (Powerview, Wanipigow and Lac du Bonnet) in the Model Forest area to provide hands-on experience to Grades 10-12 science students in

environmental monitoring as it relates to parts of the ecosystem that may be affected by global warming,

- Make all data available to the schools and the public by creating web pages on the BRFN website (www.black-river.ca),
- Develop and implement two school-based interactive computer (educational) programs that deal with climate change, global warming and greenhouse gases, focusing on elementary and middle years school children,
- Communicate the project and its results in the region, in Manitoba, nationally and internationally through the media, by giving presentation and through publication of reports, and
- Foster a working relationship with all project partners, including industry, levels of government and NGOs

Methods and Materials

Study Sites

The study sites are located in the Manitoba Model Forest, an area of approximately 1 million hectares in eastern Manitoba. The sites are also located in the Tembec Forest Management License (FML), which is slightly smaller than the Model Forest area. All study sites are located close to major roads or highways, to provide for easy access for school buses. The sites are also located within a 15-30 minute drive from the schools, although this became less of an issue as the project progressed. After an initial training session at one site, the schools desired to visit all study sites, and both Sunrise School Division and Frontier School Division graciously accommodated these requests.

The study sites were selected in collaboration with the Manitoba Model Forest and Tembec. The sites reflect different forest types, ages and origin (fire, logging). In total, 3 general locations were chosen: an area south of the community of Hollow Water First Nation, the Pine Creek Nature Trail (north of Powerview along Highway 304) and an area northeast of Lac du Bonnet, along Highway 313 (Figure 1). Table 1 provides a general description of the study sites. More detailed descriptions are found in the Results section of the report.



Figure 1. Location of bio-monitoring study sites in the Manitoba Model Forest area.

Table 1. General description of study sites.

Site Name	Latitude/Longitude (degrees .xxx minutes)	Dominant Trees/General Site Type	Stand Origin/Year of Disturbance
Hollow Water	N51 10.287 W96 19.475		
Old Growth		Jack Pine/sandy soils	Fire/1912 ^{*1}
1970s Clear Cut		Jack Pine/sandy soils	Harvest/1978
1970s Clear Cut- Thinned		Jack Pine/sandy soils	Harvest/1978
1990s Clear Cut		Jack Pine/sandy soils	Harvest/1993-94
Pine Creek	N50 36.337 W96 07.889		
1980s Clear Cut		Black Spruce, Tamarack/organic soils	Harvest/1981
1940s Clear Cut		Black Spruce, Tamarack/organic soils	Harvest/1948
Riparian Forest		Black Ash, Manitoba Maple/riverine clay and silty soils	Unknown/unknown ^{*2}
Alternate Strip Cut		Trembling Aspen (leave patches), White Spruce (harvested strips)/upland clay soils	Harvest/1987
Lac du Bonnet	N50 16.820 W95 58.147		
Mature Black Spruce		Black Spruce/organic soils	Fire/unknown ^{*3}
Burn		Regenerating (formerly Black Spruce)/organic soils	Fire/2003
Transition		Black Spruce/organic soils ^{*4}	Fire/2003

^{*1} Year of fire is unknown. Year of origin in Forest Resource Inventory is 1912.

^{*2} Forest inventory data for this stand is lacking. Dominant trees in this stand are estimated to be 60-80 years old.

^{*3} Forest inventory data for this stand is lacking. Mature trees are estimated to be 80-100 years old.

^{*4} A ground fire went through this stand, resulting in only partial mortality of trees. In the Burn site, a crown fire resulted in 100% tree mortality.

Data Collection

All of the study plots were established between April 23 and June 1, 2004. Establishment of plots included laying out a 30 x 30 m study site plot within each forest stand/study site and marking the boundaries with flagging tape. Study plots were located away from the edge of the forest stands to avoid edge effect. Subplots for trees, shrubs and herbs were established at each study site, as described later.

Data collection occurred from early June to mid November. Data were collected in two ways. Firstly, data were collected during field trips with the 3 high schools in June, September and October. During these field trips, Black River First Nation (BRFN) Environment Department staff and the Manitoba Model Forest Education Coordinator provided training on how to conduct the data collection, including use of all the field equipment. The students then collected their own data. Secondly, BRFN staff revisited all study sites periodically from June to mid December.

Data collected from the school field trips were pooled together with the data collected by BRFN. Due to time constraints, data for all parameters was not collected from all sites in 2004, or few measurements for a particular parameter were made (e.g., tree age and height, soil pH). While these are mentioned in this section, data for these parameters are not shown in the report. Efforts will be made in 2005 to collect this information.

Vegetation Data

All quantitative vegetation assessments were conducted in subplots or quadrats within each 30 x 30 m study site. In addition, each 30 x 30 m study site was assessed in its entirety to identify species not occurring within the subplots or quadrats. These were recorded on a separate list.

Tree and Shrub Layer

In each 30 x 30 m main study plot, a minimum of 4 randomly located 10 x 10 m subplots were established to assess trees and shrubs. In some cases, there were up to 10 – 10 x 10 m subplots established when the student data were included. For trees (> 2 m in height), each tree was identified to species, the circumference at breast height was measured, and the status (dead, alive) of the tree was recorded. Circumference was later converted to diameter at breast height (dbh). This information was used to determine the density (number of trees per hectare) of trees by species and status (live/dead), as well as the basal area per hectare.

For shrub species and individual trees less than 2 m in height, only the number of stems were recorded, as well as the status (live/dead). This information was used to calculate density.

Age and Height of Dominant Trees

Dominant trees are those whose crown occur above the rest of the canopy. Dominant trees generally only receive sunlight on the top portions of the crown, as the lower portions are often shaded by co-dominant and intermediate trees. During the field trips with the schools, students determined the age and height of a single dominant tree in each 10 x 10 m plot. To age trees, a CFE 14 inch Increment Borer was used. Cores were extracted from each tree and the number of

rings from the centre of the tree was counted without the use of a magnifying glass. Tree height was estimated using a Sunto PM5 360 PC Clinometer.

Herb Layer

Within each 10 x 10 m subplot, a minimum of 4 – 1 x 1 m herb layer quadrats were randomly established. With the inclusion of the student data, there were as many as 25 herb layer quadrats enumerated in some of the study sites. Within each quadrat, the percent cover all vegetation as well as bare soil, water and burned ground was estimated. All vegetation was identified to species, with a few exceptions. Mosses, lichens, grasses and sedges were not identified to species. The average percent cover was calculated for all species in each study site, as well as the frequency of occurrence of the species in the quadrats.

Wildlife

Small Mammal Abundance and Species Composition

Small mammal abundance and species composition was assessed by use of small mammal live traps. A total of 8 Havahart Model 1020 Live Animal Cage Traps were placed randomly at each study site. On the day prior to the school trips and throughout the summer, the traps were baited with a combination of rolled oats and peanut butter. A small wad of cotton balls were also placed at one end of the trap to act as insulation, to keep animals warm overnight. Traps were always checked within 1 day of baiting. On many days however, traps were not set and baited due to cool weather or due to forecasted cold overnight temperatures. This prevented loss of

animals to hypothermia. Small mammals that were caught were identified to species, placed in a small cloth bag and weighed on a spring scale (± 1 g). The animals were then released unharmed.

Other Signs of Wildlife

During the school field trips, students recorded other signs of wildlife in each study area. Students recorded sounds/calls of animals, sightings, nests, signs of browsing, the existence of game trails, animal tracks, signs of rubbings on trees and scat.

Supporting Environmental Information

Current Weather

On each sampling occasion, current weather was recorded at each study site. This included air temperature (measured using a CheckTemp digital thermometer), cloud cover (sunny, partly cloudy, cloudy), precipitation (no precipitation, raining, snowing) and wind (calm, slight breeze, windy).

Air Temperature

In addition to measuring air temperature with a hand held digital thermometer, air temperature was monitored and recorded at each study site using a StowAway Tidbit Temperature Logger. The Tidbit loggers were programmed using a laptop computer to record temperature every hour. One logger was fastened to the shaded side of a tree in each study location using aircraft cable. Data loggers were deployed in early June and retrieved in mid November. Data were then downloaded from each logger using Box Car Pro software.

Relative Humidity

Relative humidity was recorded during school field trips only using a sling psychrometer. Dry and wet bulb temperature was recorded and this information was used to calculate relative humidity.

Soil Temperature

As with air temperature, hourly soil temperature was also measured using StowAway Tidbit Temperature Loggers. Tidbit loggers were buried approximately 10 cm into the soil, next to the tree containing the Tidbit air temperature logger. The soil temperature logger was fastened to the tree using aircraft cable. Soil temperature loggers were deployed and retrieved from the field at the same time as the air temperature loggers.

Soil pH

During school field trips, soil pH was measured using an ExStik PH100 digital pH meter (ExTech Instruments). The pH meters were calibrated in the field prior to use using standard buffers. To measure pH, soil from the A horizon was placed in a plastic vial and distilled, deionized water was added in order to make a paste. The pH of the paste was then measured.

Light Intensity and Crown Closure

Light intensity was measured at several locations within each 10 a 10 m plot. Light was measured using a GE Model 217 light meter. Measurements were in Foot Candles. As light intensity within the plot is not only affected by the overhead canopy, but also by the atmospheric

conditions (e.g., changing cloud conditions), measurements were also made outside of the study plots or in open areas within the plots where possible. The amount of light within the plot was then expressed as a percent of the light outside of the plot (e.g., % transmission).

Results and Discussion

General Description of Study Sites

The three main study sites (Hollow Water, Pine Creek Trail and Lac du Bonnet) are located in the boreal forest of eastern Manitoba. Two of the sites, the Pine Creek Trail and Lac du Bonnet sites, are found in the Lake of the Woods Ecoregion (Ecoregion 91). This ecoregion extends south from the southern part of Lake Winnipeg to the US border, and east to the Rainy River along the Canada-US border. The Hollow Water study site is located in the Lac Seul Upland Ecoregion (Ecoregion 90). This ecoregion covers most of the eastern side of Lake Winnipeg, as far east as the Albany River in northwestern Ontario.

The climate in the Model Forest area is characterized by warm summers and cold winters. Mean summer temperature is 13.5 to 15.5°C, although days > 30°C are not uncommon in July and August. Mean winter temperature is -14.5°C and night time lows at this time of the year can reach -45°C, although this is rare. Precipitation ranges from 500 to 600 mm, with approximately 1/3 of the precipitation falling as snow. Annual precipitation can vary significantly from year to year. The distribution of soil types is quite patchy in the region. In general, soils change from those that are dominated by exposed bedrock with little surficial deposits closer to the Ontario border, to level or gently undulating organic peat deposits overlying lacustrine clay sediments

closer to Lake Winnipeg. Areas of sand deposits, in proximity to Lake Winnipeg, are scattered across the area. These are relics of the former beach ridges from glacial Lake Agassiz.

The Hollow Water sites are all dominated by jack pine forest growing on sandy soils. The area was a former beach ridge of glacial Lake Agassiz. The Old Growth study site is 6.7 hectares in area and the year of origin is 1912 (Figure 2A). It is a fire-origin stand. Presumably, a fire burned the area sometime prior to 1912. Exact fire history data that include this stand are lacking. Two study sites (1970s Clear Cut and 1970s Clear Cut-Thinned) were chosen in a jack pine stand that was harvested in 1978 (Figure 2C&D). Both sites were left to regenerate naturally, although one site was thinned in the 1980s. The original harvested stand was 14.6 hectares in area. A fourth study site (1990s Clear Cut) was established in a recent clear cut harvest area (harvested in 1993-94) (Figure 2B). The stand is 31.1 hectares in area.

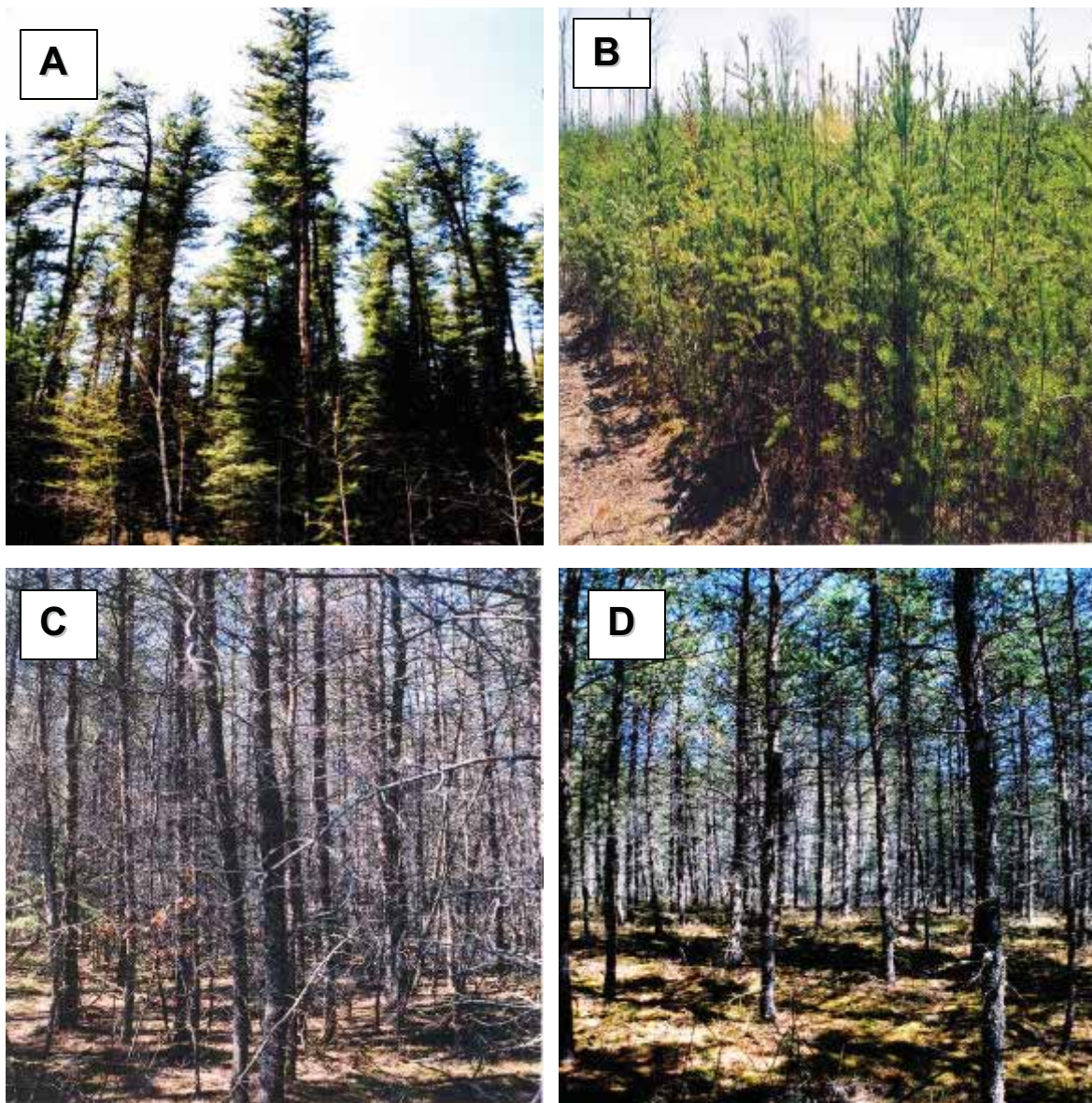


Figure 2. Photos of the study plots at the Hollow Water site. A) Old Growth, B) 1990s Clear Cut, C) 1970s Clear Cut (un-thinned), D) 1970s Clear Cut (thinned).

Four study sites were established along and adjacent to the Pine Creek Nature Trail, north of Powerview. Two sites occur on wet, organic soils, one site is located in a riparian zone along the Pine Creek, and one site is located across Highway 304 in a mixed wood, upland area.

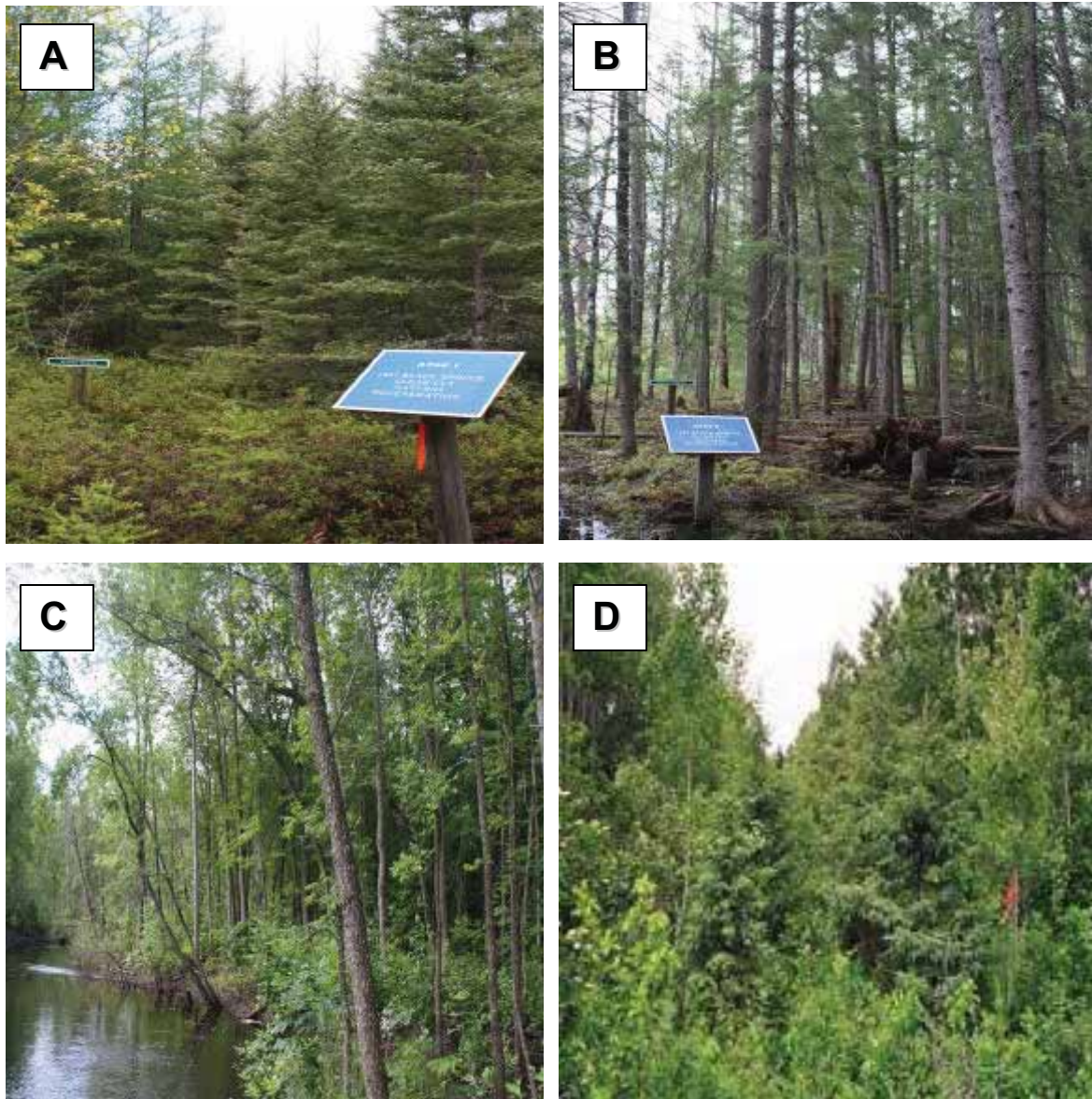


Figure 3. Photos of study plots at Pine Creek Nature Trail site. A) 1980s Clear Cut, B) 1948 Clear Cut, C) Riparian Forest, D) Mixed wood Alternate Strip Harvest.

The 1980s Clear Cut was a black spruce stand harvested in 1981, and left to regenerate naturally (Figure 3A). It occurs on saturated, organic soils and is now dominated by black spruce and tamarack.

The 1940s Clear Cut site was harvested in 1948 and left to regenerate naturally (Figure 3B). It also occurs on saturated, organic soils and is dominated by black spruce and tamarack. This stand is very similar to the 1980s Clear Cut study site, with the exception that it is 33 years older.

A study site was also established along the Pine Creek in a riparian area (Figure 3C). In 2004 due to high precipitation throughout the summer and due to beaver activity, parts of this site were under water. The site is dominated by large, mature black ash and Manitoba maple. The age of the stand is unknown, but is likely at least 60 to 80 years old. It is also likely of fire origin, although detailed fire data in the area of this stand is lacking. A fourth study site (Alternate Strip) was established across Highway 304 from the Pine Creek Nature Trail in a mixed wood forest that was harvested in 1987 (Figure 3D). In contrast to the clear cut harvesting prescriptions for lowland black spruce and upland jack pine sites, this site was harvested using an alternate strip technique. Strips were created by harvesting all trees (white spruce and trembling aspen) in strips and then shear blading the strips. Some white spruce was also harvested between the strips by equipment reaching in and harvesting the spruce, and leaving the trembling aspen. Strips were regenerated by using a light treatment of herbicide (Vision) and planting the strips with either white spruce or black spruce.

Three study sites were established in an area northeast of Lac du Bonnet. All three sites occur adjacent to each other, are all part of the same original forest stand and occur on the same type of

saturated, organic soils. The age of the Mature Black Spruce site (Figure 4A) is unknown, but is at least 80-100 years old. This will be verified in 2005. No historic fire data specific to this area exists, but it is assumed that this is a fire origin stand. In the spring of 2003 a fire occurred in the area. The fire burned 210 hectares of forest. The Burn study site experienced a severe crown fire and all of the trees were killed (Figure 4B). The stand is just starting to regenerate naturally with black spruce seedlings. As the name implies, the Transition study site is a transition area between the Mature Black Spruce site and the Burn site (Figure 4C). In contrast to the Burn site, the Transition site experienced a light ground fire. As a result, in 2004 there was a mixture of live trees, dying trees and dead trees.

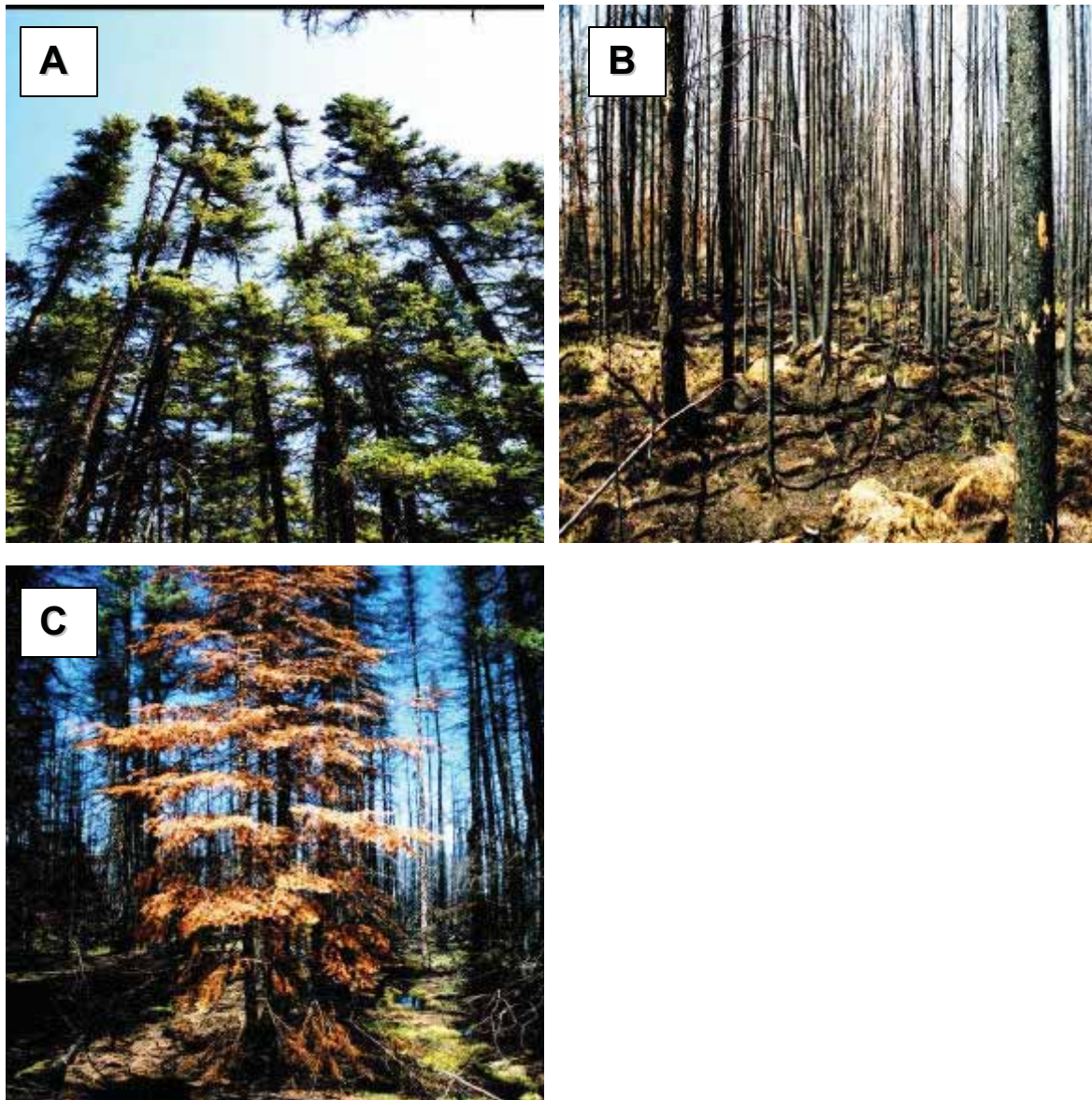


Figure 4. Photos of study plots at Lac du Bonnet site. A) Mature black spruce forest, B) Burn, C) Transition.

Participation and Training of High School Students

An integral component of this project involved the participation and training of high school students from 3 schools in the region: Powerview, Lac du Bonnet and Wanipigow schools (Figure 5). This project provided a rare opportunity for students to learn about the ecology of the boreal forest using the forest as an outdoor classroom, how forests regenerate after disturbances such as logging and fire, and how climate change may affect the productivity of the forests in eastern Manitoba. The project also provided the students with the opportunity to participate in an on-going research project and to collect their own data.

Prior to the field trips with the schools, BFRN Environment Department staff and the Manitoba Model Forest Education Coordinator visited each school and provided the class an overview of the project in a PowerPoint presentation. Presentations were made in April and May, 2004. The presentation covered the objectives of the project, project partners, study design and a hands-on demonstration of all the monitoring equipment. A general presentation on the Model Forest and their research program was also made.

In June, 2004 one class from each school participated in a one day field trip to one of the three general study locations (e.g., to Hollow Water, Pine Creek Nature Trail, Lac du Bonnet area). Field trips were held on June 2 (Wanipigow School), June 7 (Powerview School) and June 17 (Lac du Bonnet School). In total, there were 10 students and 1 teacher from Wanipigow School, 15 students and 1 teacher from Powerview School and 10 students and 1 teacher from Lac du Bonnet school that participated in the June field trips. The class was split up into 2 or more groups and each group collected data in two study sites within each general study area. Students

were provided with training from BRFN Environment Department staff and the Manitoba Model Forest Education Coordinator on how to use the monitoring equipment. Black River staff also provided all the necessary data sheets.

In the fall (September/October), a one day field trip was again held with each school to collect data. In total, 45 students and 3 teachers from the 3 schools participated in the field work. Some of the students participated in both the spring and fall sampling trips, so each school visited a different study location in the fall in order for the students to see and learn about the different forest types in the region.

The students and teachers were very enthusiastic about being able to participate in the project.

Some of the comments received back from the students and teachers included:

- I never knew that there was so much to look at in the forest. I won't look at the forest in quite the same way again!
- Using all this scientific equipment is really cool!
- Can we core just one more tree before we have to go?
- Can we come back next year and do this again?
- It was great to have Black River and the Model Forest provide all the training, the field equipment and even the data sheets. It made my job as a teacher very easy!

Figure 6 provides pictures of the students collecting data and using the monitoring equipment.



Figure 5. Students participating in the field research in 2004. Top row: Powerview School. Middle row: Lac du Bonnet School. Bottom row: Wanipigow School. Photos on the left-hand side are from field trips in June, and photos on the right-hand side are from field trips in September/October.



Figure 6. Photos of students collecting data during the field trips.



Figure 6. Continued.

Detailed Comparison of Study Sites

Vegetation

Tree and Shrub Layer

To evaluate the tree and shrub layer, 10 x 10 m plots were established in each main 30 x 30 m plot in each study site. All trees (> 2 m in height) and shrubs (tree saplings < 2 m in height and true shrub species) were identified to species and the status (live or dead) was recorded. For trees, the circumference was measured at breast height and later expressed as diameter at breast height (dbh). Density (stems per hectare) was calculated as well as basal area (m² per hectare). As mentioned in the Methods and Materials section, due to time constraints, not all study sites were assessed in 2004.

The study sites varied considerably in tree and shrub species composition. This was expected as the sites were chosen to reflect a wide gradient in forest types, ages and origin (fire, logging).

At the Hollow Water location, the Old Growth study site is classified as a jack pine stand according to the Forest Resource Inventory. The data collected indicated that the stand is dominated by balsam fir and mature (> 90 year old) jack pine, when tree abundance is considered (Figure 7A). However, based on basal area, jack pine is the dominant tree (Figure 7B). Therefore, while less numerous than balsam fir, the jack pine trees were larger (i.e., has a greater circumference or dbh) and therefore had a larger basal area. Beaked hazel and white birch was also found on the site, although to a much lesser degree. Almost 40% of the balsam fir

were dead, a result of an on-going infestation of spruce budworm. There was some minor mortality of jack pine.

There were too few plots enumerated in the 1970s Clear Cut-Thinned and 1970s Clear Cut-Unthinned study sites in 2004 to conduct any valid comparison. Visually, there were many more trees (and a high percentage of these were dead) in the Un-thinned study site, than the Thinned study site. This is expected, as trees were selectively harvested and removed from the Thinned site in the 1980s. Thinning is a forest management technique that is sometimes used in dense, regenerating stands to promote more rapid growth (in particular, an increase in the diameter and volume of the trees) by selectively removing smaller trees that compete for light, nutrients and water with the larger trees. In theory, thinning would then allow the remaining trees to grow faster and therefore shorten the rotation period (time at which the stand can be harvested again in its entirety). Insufficient data was collected in 2004 to determine whether the trees in the Thinned study site had a larger circumference/dbh than those in the Un-thinned study site. What was very noticeable however, was that there were a large number of small dying trees in the Un-thinned study site. In contrast, there were no dying trees in the Thinned study site. Thinning done by harvesting appeared to take the place of the natural thinning process that is characteristic of young, dense forest stands.

In 2004, there were no tree and shrub plots established in the 1990s Clear Cut study site. However, as shown in Figure 2D, the regenerating jack pine (approximately 5-7 years old) was extremely dense and will naturally self-thin over time as the stand matures.

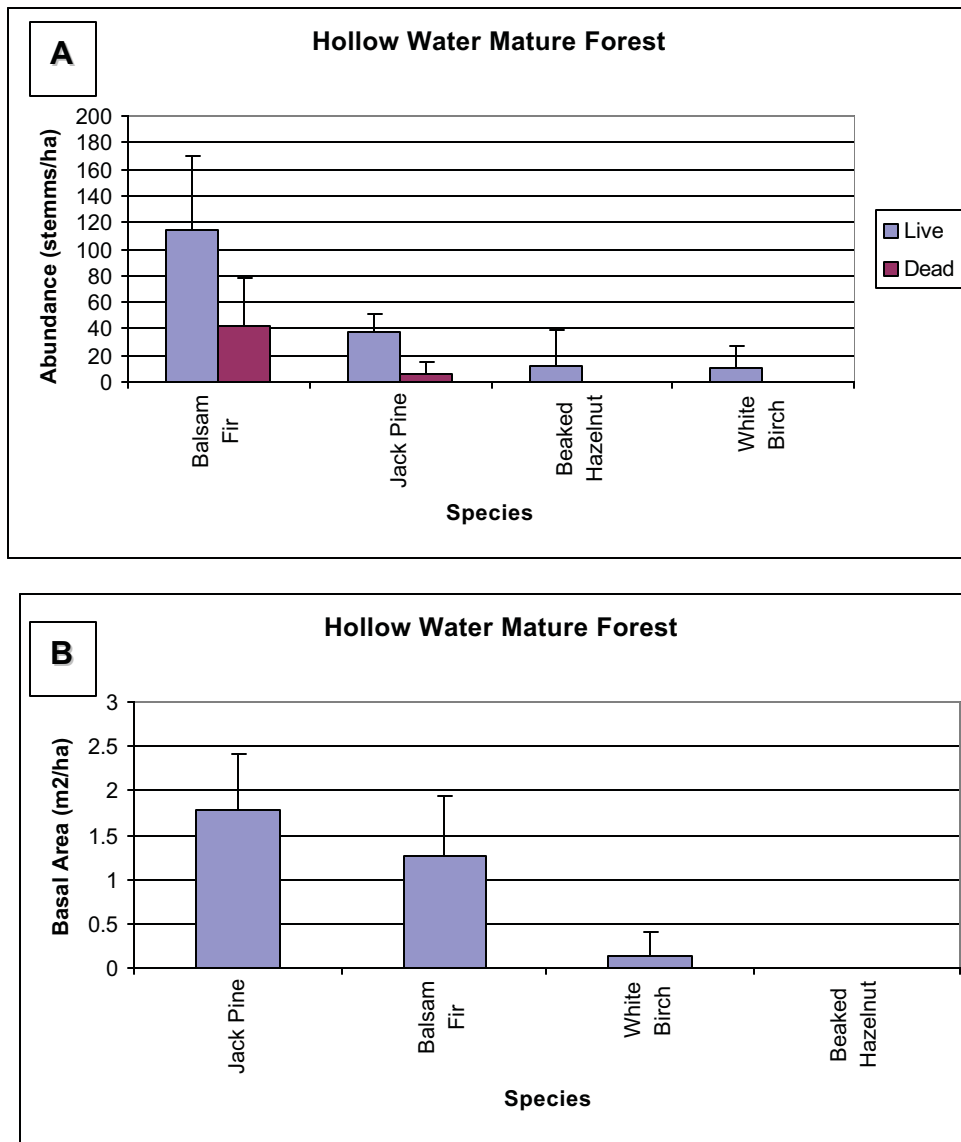


Figure 7. Abundance (A) and basal area (B) of trees and shrubs in the Hollow Water Old Growth stand. Vertical bars are one standard deviation from the mean.

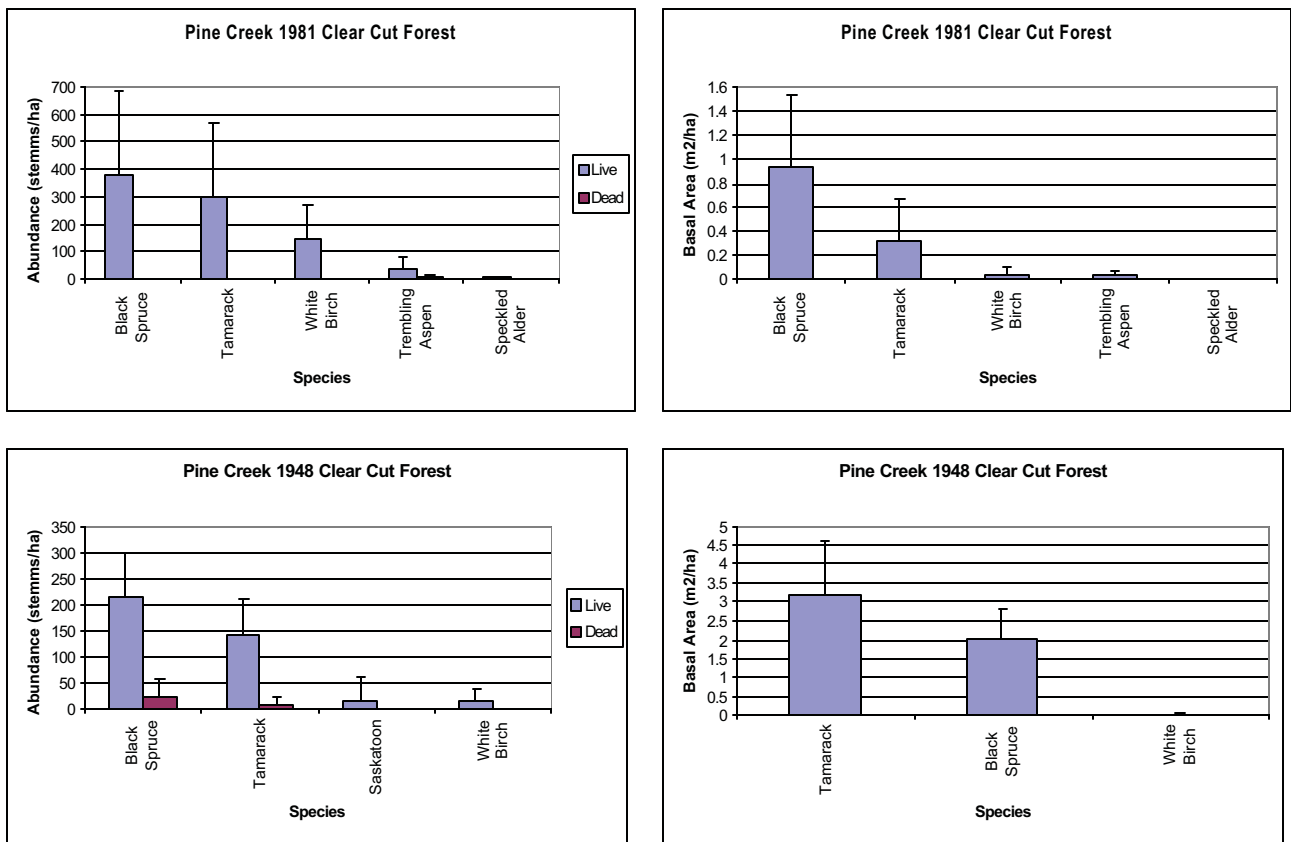


Figure 8. Abundance and basal area of trees and shrubs in the Pine Creek 1981 Clear Cut (top row) and 1948 Clear Cut (bottom row) study sites. Vertical bars are one standard deviation from the mean.

The study sites at the Pine Creek Nature Trail were very different than those at Hollow Water. The 1981 and 1948 Clear Cut study sites are black spruce/tamarack forests that are growing on organic, peaty soils. As a result, these two stands are growing on saturated (very wet) soils. Figure 8 shows that while both sites are dominated by black spruce and tamarack (in terms of abundance – left hand graphs), there is a higher density of the trees in the younger stand. As with the Hollow Water study sites, natural thinning has reduced the number of black spruce and

tamarack trees over time in the older stand (i.e., in the 1948 Clear Cut study site). Also as expected, the trees in the older stand are much larger (i.e., larger circumference/dbh) than in the younger stand. The basal area of tamarack is almost 10 times higher in the 1948 Clear Cut site than in the 1981 Clear Cut site.

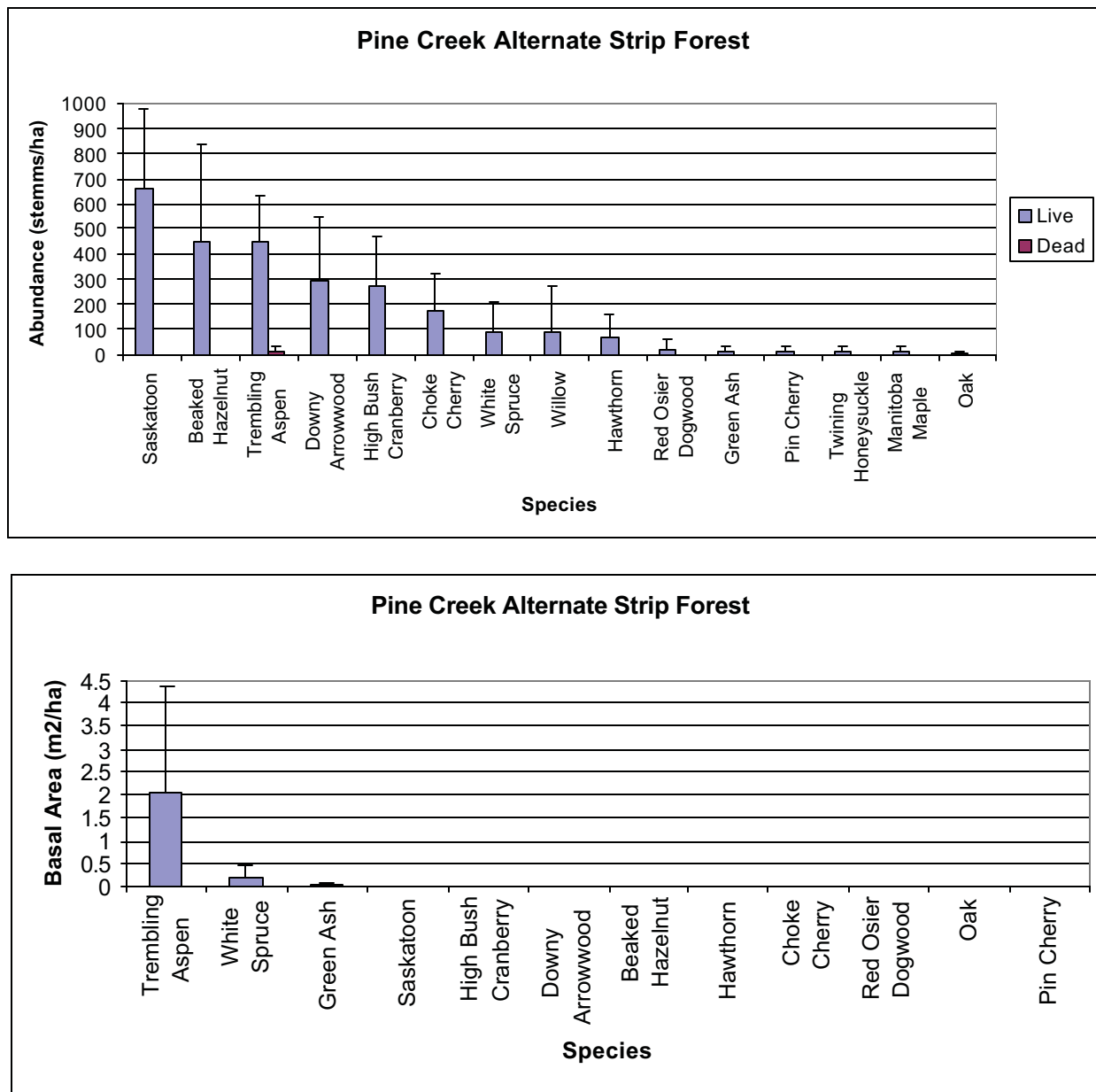


Figure 9. Abundance (A) and basal area (B) of trees and shrubs in the Pine Creek Alternative Strip Mixed wood study site. Vertical bars are one standard deviation from the mean.

The Pine Creek Alternate Strip study site is a mixed wood forest in which most of the white spruce originally growing in the stand was harvested. The harvesting was done in strips, and the harvested strips were given a low-dose treatment of Vision herbicide and then planted with white spruce seedlings. As a result, most of the spruce only occurs in the harvested strips. When conducting the tree and shrub layer assessments, an equal number of 10 x 10 m plots were placed in the harvested strips and the adjacent “leave” areas. The data were then combined. As shown in Figure 9A, there was a diverse number of tree and shrub species found in the Alternate Strip study site. While the overall stand was dominated by trembling aspen trees, the shrub layer was dominated by saskatoon, beaked hazel, downy arrow wood and high bush cranberry (Figure 10). Trembling aspen made up the majority of the basal area in the stand (Figure 9B). White spruce, while present in the harvested strips, did not contribute very much to the total basal area, as the trees were still quite young.

Trees and shrubs were not assessed in the Pine Creek Riparian study site in 2004.



Figure 10. Photos of downy arrow wood (top) and high bush cranberry (bottom), species found in the Pine Creek Alternate Strip study site.

The Lac du Bonnet location had 3 study sites which were originally part of the same forest stand. In 2003, a wildfire burned part of the forest. As a result, we established study sites in 3 distinct areas: the original mature black spruce forest, in the burned area that experienced a crown fire (where all trees were killed), and in a transition area where there was a ground fire and only partial mortality of trees. Based on abundance, the Mature Forest site was dominated by black spruce trees and by bog birch (a shrub, Figure 11A). There were few dead trees in the mature forest. Black spruce made up the majority of the basal area (Figure 11B).

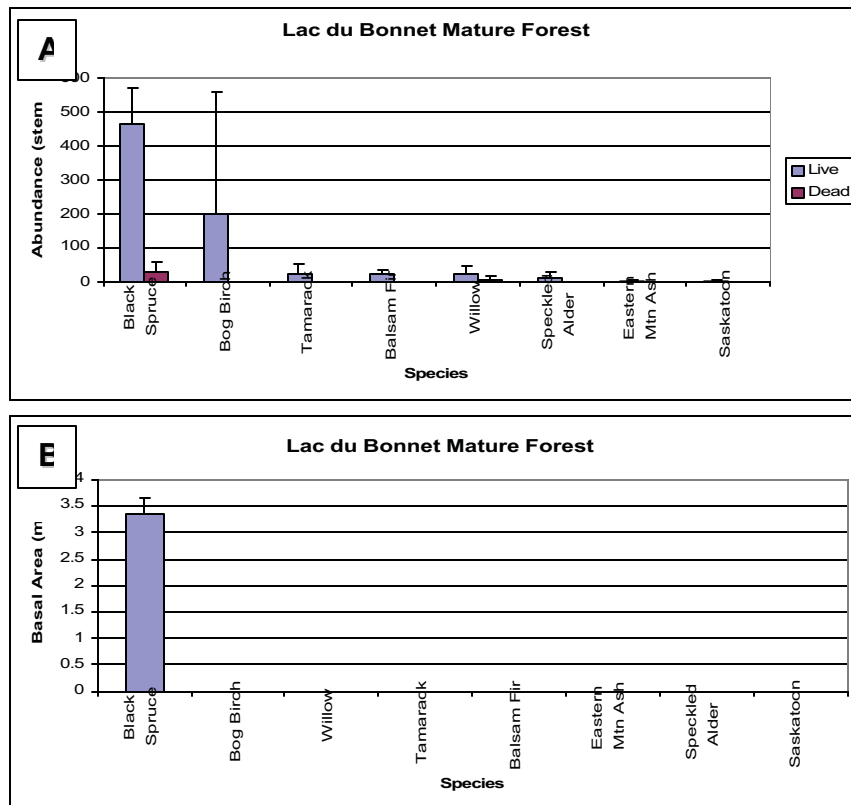


Figure 11. Abundance (A) and basal area (B) in trees and shrubs in the Lac du Bonnet Mature Black Spruce study site. Vertical bars are one standard deviation from the mean.

Not surprisingly, all tree species that were enumerated in the Burn study site were dead (Figure 12A). As it was not possible to distinguish between dead black spruce and balsam fir, both species are reported in one category in Figure 12A. There were some live shrubs (speckled alder, bog birch and red osier dogwood) in the Burn study site which re-established the year following the fire (Figure 12A). The basal area in the Burn study site was made up exclusively of fire-killed black spruce/balsam fir. Very few of the trees had begun to fall down in the study site, one year post fire.

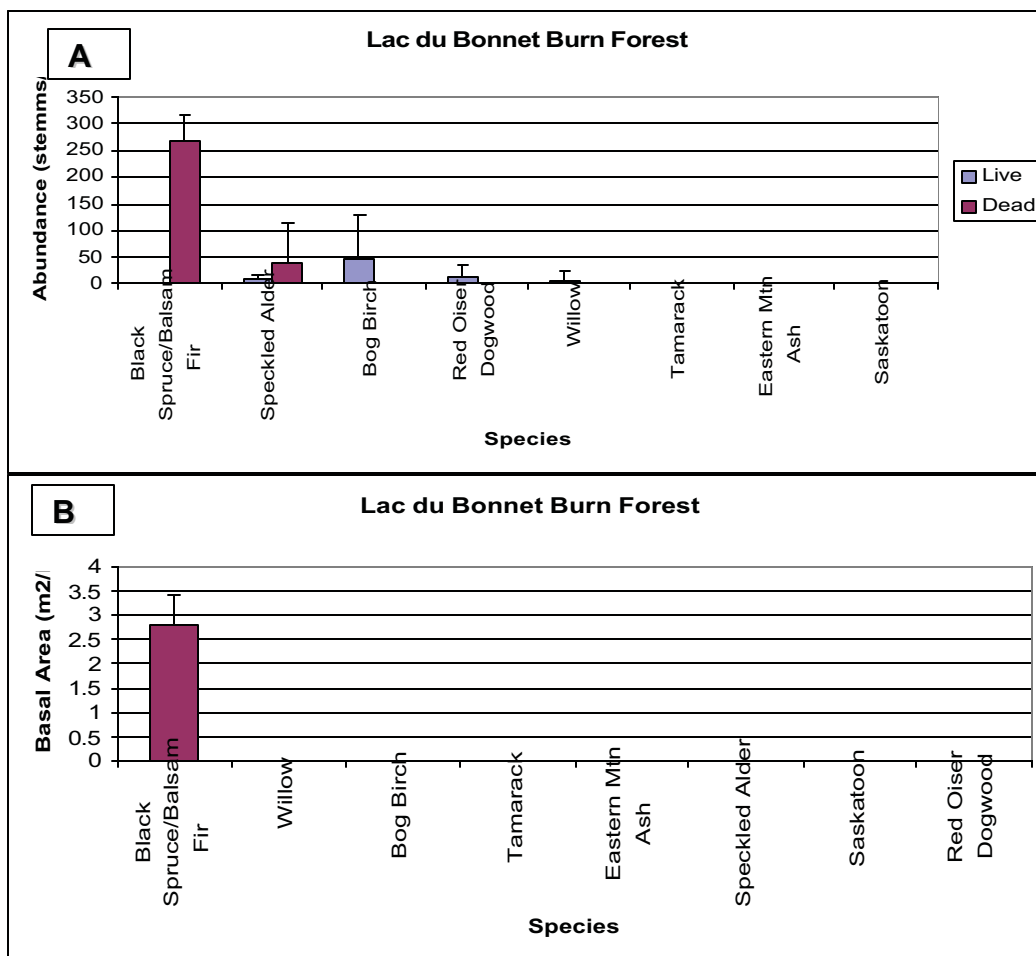


Figure 12. Abundance (A) and basal area (B) of trees and shrubs in the Lac du Bonnet Burn study site. Vertical bars are one standard deviation from the mean.

In contrast to the Burn study site, approximately 60% of the black spruce and 25% of the balsam fir in the Transition study site were alive one year post-fire (Figure 13A). In this study site, the fire burned along the ground, not in the crown of the trees, and therefore many of the trees continued to be alive. Over time, some of these trees may die due to secondary infections or wind throw. As with the Mature Black Spruce Forest study site, the majority of the basal area was made up of black spruce (Figure 13B).

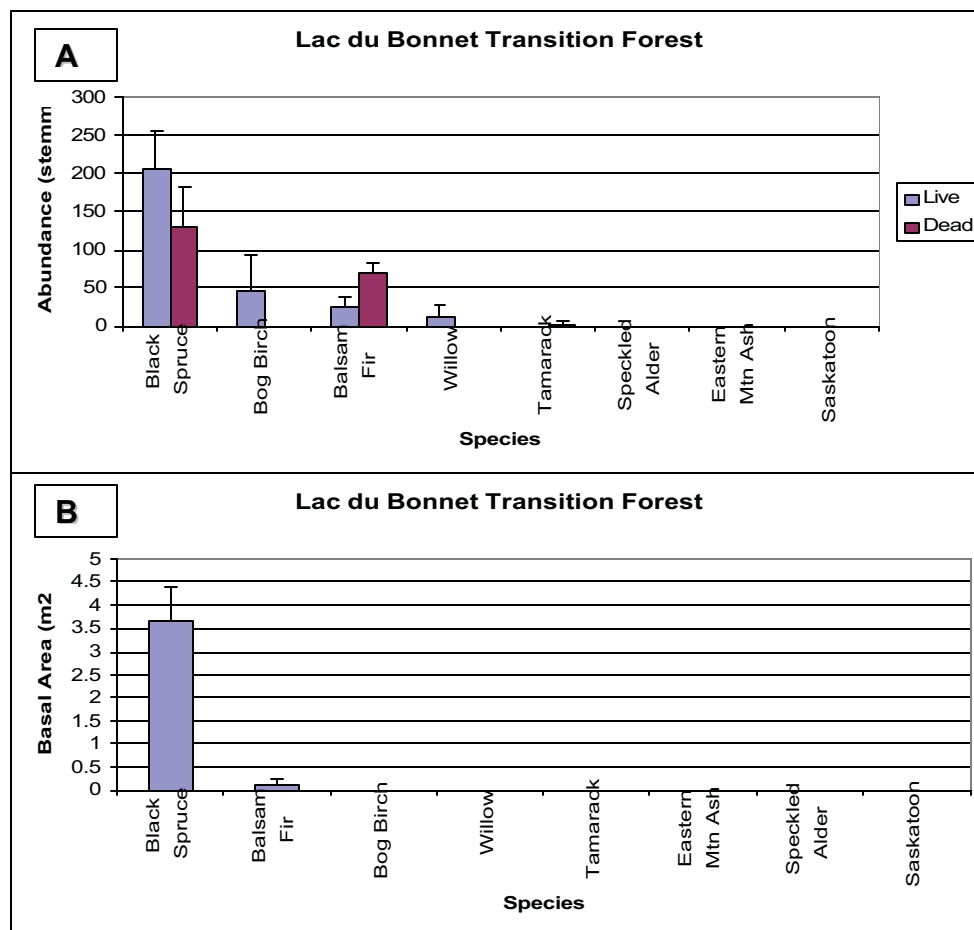


Figure 13. Abundance (A) and basal area (B) of trees and shrubs in the Lac du Bonnet Transition study site. Vertical bars are one standard deviation from the mean.

Herb Layer

The herb layer in each study site was assessed by use of 1 x 1 m quadrats. The percent cover was estimated for each species as well as for bare ground, burned ground and water. A minimum of 4 quadrats were assessed per study site. However, by including the student data, there were some study sites where up to 25 quadrats were assessed. The percent cover and the frequency (i.e., the number of quadrats that a species was found in as a % of the total number of quadrats assessed) is presented below.

In the Hollow Water Old Growth site, the dominant herbs in terms of abundance (% cover) were moss and ground cedar (Figure 14A). Other herbs included bunchberry, prince's pine and lily of the valley. These were also the species that occurred most frequently in the quadrats (Figure 14B).

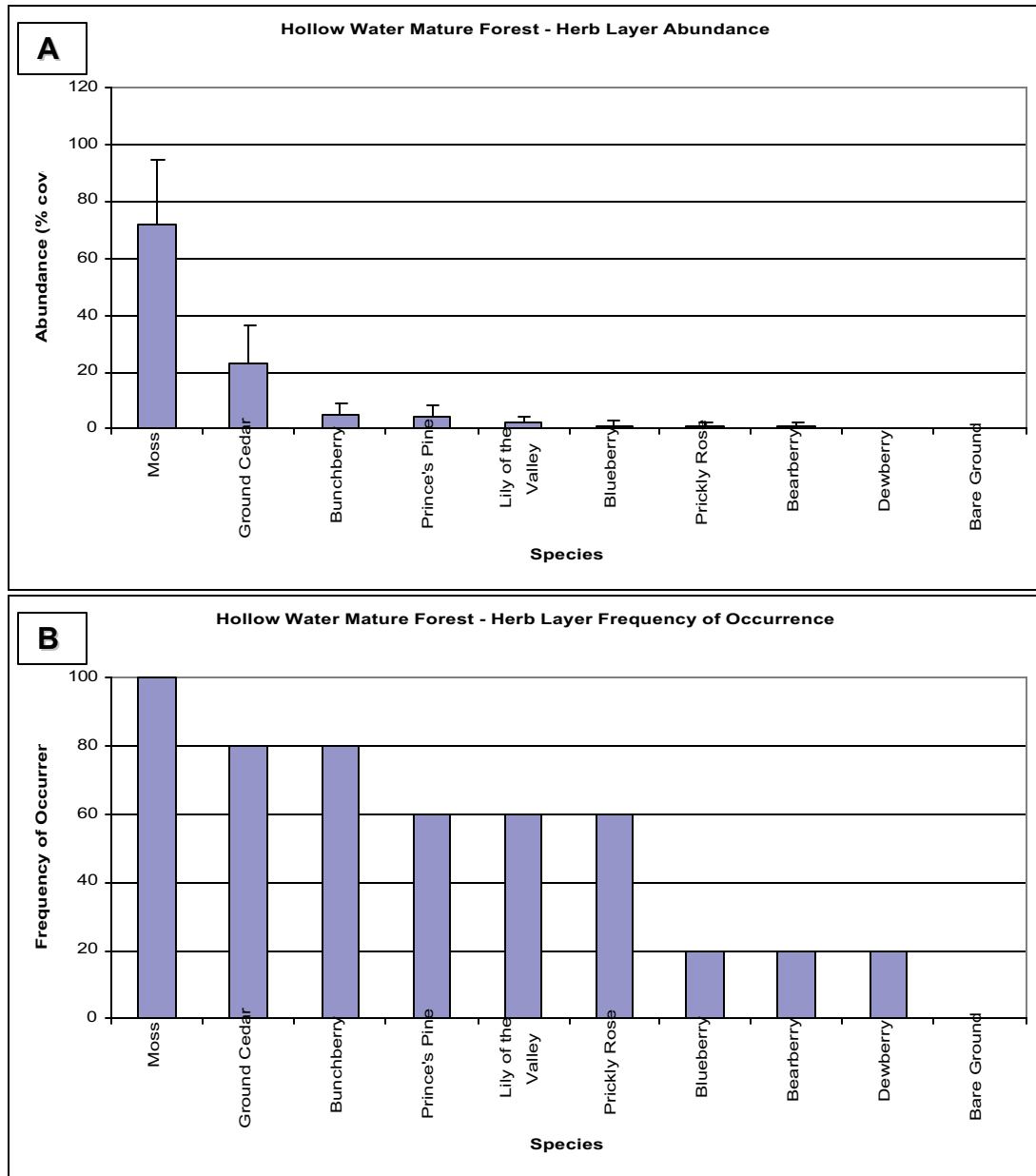


Figure 14. Abundance (A) and frequency of occurrence (B) of herb species in the Hollow Water Old Growth study site. Vertical bars are one standard deviation from the mean.

The Hollow Water 1970s Clear Cut-Thinned study site contained similar herbs to the Old Growth study site, but also had bearberry, cinquefoil and Labrador tea (Figure 15A). Moss,

bearberry, lily of the valley and cinquefoil were found in a high proportion of the quadrats (Figure 15B). Although not observed in the limited number of quadrats established in the 1970s Clear Cut-Thinned study site, stemless lady slipper (moccasin flower) was also found (Figure 16).

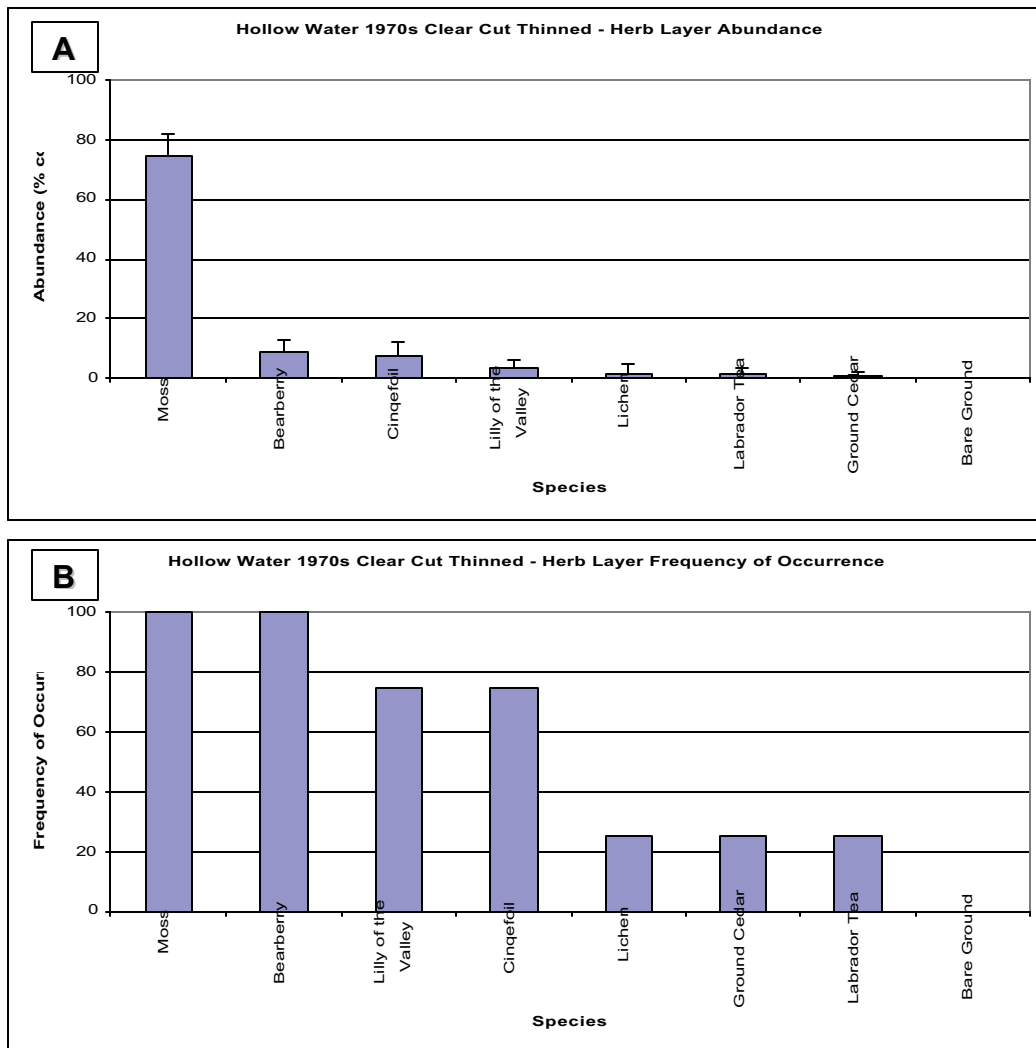


Figure 15. Abundance (A) and frequency of occurrence (B) of herb species in the Hollow Water 1970s Clear Cut-Thinned study site. Vertical bars are one standard deviation from the mean.

Quadrats were not established in the 1970s Clear Cut-Un-thinned and 1990s Clear Cut study sites in 2004.



Figure 16. Stemless lady slipper (moccasin flower), found in the 1970s Clear Cut-Thinned study site.

As with the tree species, the herb species found at the Pine Creek Nature Trail study sites were very different than those found at the Hollow Water study sites. In terms of abundance, the herb layer at the 1981 Clear Cut site was dominated by Labrador tea, lichens and sphagnum mosses (Figure 17A). Sphagnum mosses were found in all of the quadrats, and Labrador tea and lichens were found in 50-75% of the quadrats (Figure 17B). Bearberry, bog cranberry and creeping snowberry (Figure 18) were also commonly found in the quadrats (Figure 17B).

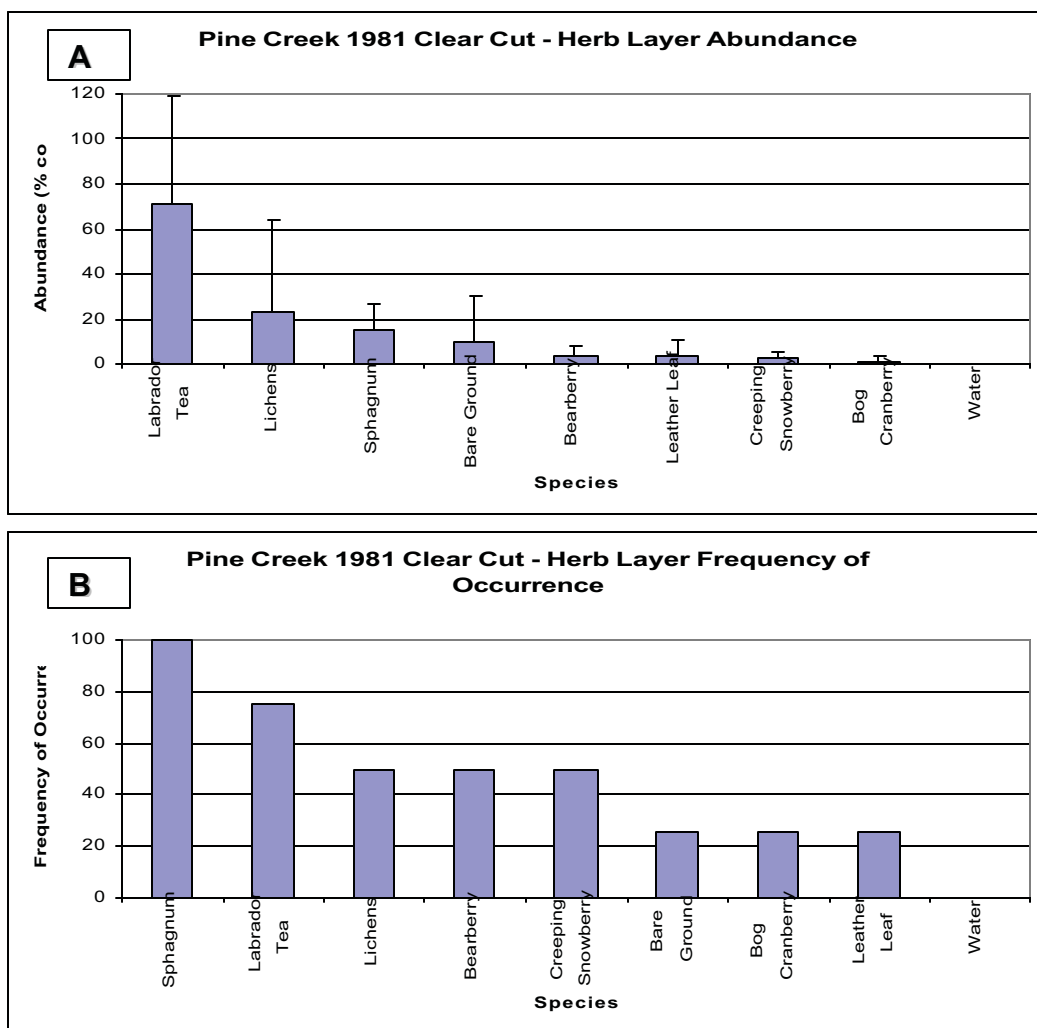


Figure 17. Abundance (A) and frequency of occurrence (B) of herb species in the Pine Creek 1981 Clear Cut study site. Vertical bars are one standard deviation from the mean.



Figure 18. Bog cranberry (top) and creeping snowberry (bottom), two herb species found at the Pine Creek 1981 Clear Cut study site.

The Pine Creek 1948 Clear Cut study site contained some herb species that were also found in the 1981 Clear Cut site. The older stand however, also contained species such as stiff club moss, blue bead lily, skunk currant, star flower and bunchberry (Figure 19A, Figure 20), species which were absent from the younger site. A distinct difference between the two sites was the noticeably higher proportion of quadrats in which bare ground was present (Figure 19B). The higher occurrence of bare ground in the 1948 Clear Cut site was likely due to the more frequent flooding that this site experiences compared to the 1981 Clear Cut site. The 1948 Clear Cut site is located next to Willow Creek, which in 2004 flooded its banks. The 1948 Clear Cut site was partially underwater for periods of the summer. The lower abundance (% cover) of most herb species and higher occurrence of bare ground in the 1948 Clear Cut site may also have been due to the much lower light levels in the older stand compared to the younger stand.

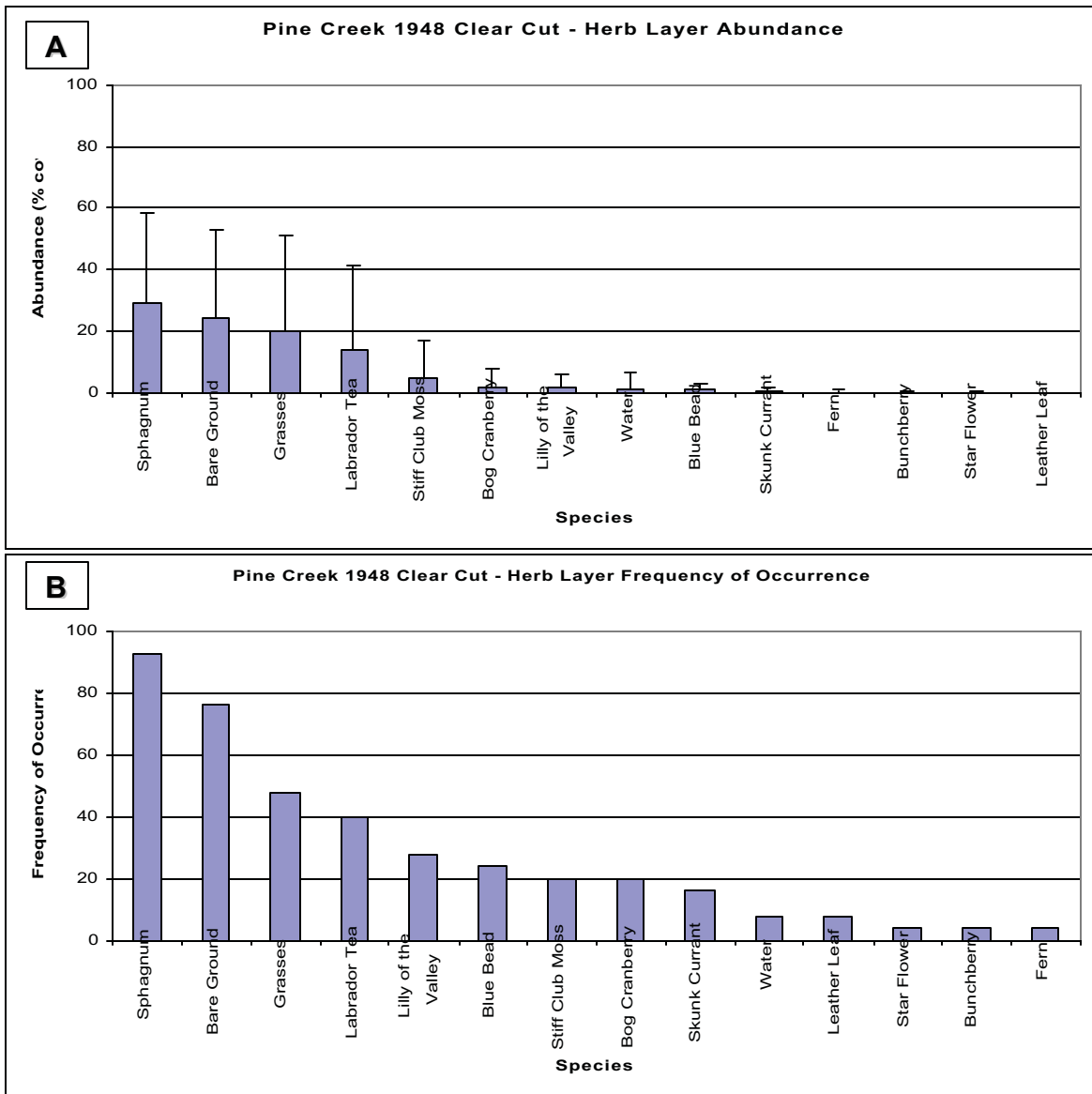


Figure 19. Abundance (A) and frequency of occurrence (B) of herb species in the Pine Creek 1948 Clear Cut study site. Vertical bars are one standard deviation from the mean.



Figure 20. Blue bead lily (left) and stiff club moss (right), two species present in the Pine Creek 1948 Clear Cut study site.

The Pine Creek Alternate Strip study site contained a very diverse assemblage of herb species, far more diverse than any of the other study sites in the project. More than 30 species of herbs and shrubs were found in the 1 x 1 m quadrats. In terms of abundance, sarsaparilla, beaked hazel and grasses were the most abundant (Figure 21A). Dewberry, saskatoon and prickly rose were also abundant. These species also tended to be found most commonly in the quadrats, as well as vetch, lily of the valley, downy arrow wood, northern bedstraw, strawberry and 3-leaved

false Solomon seal, to name a few (Figure 21B). The high diversity of herbs in mixed wood forests such as the Alternate Strip site is quite common and is partly a function of the well-drained, nutrient-rich soils.

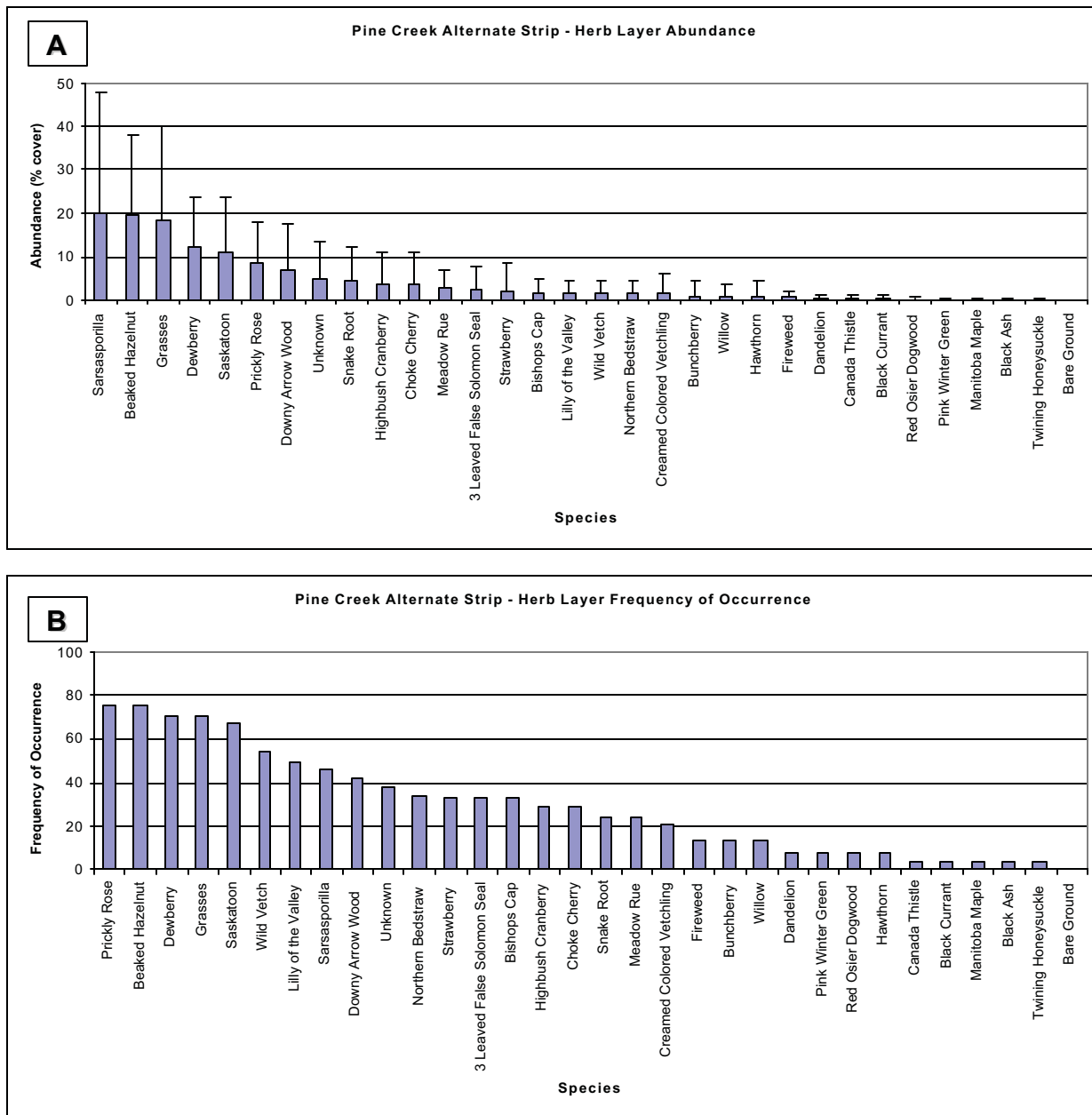


Figure 21. Abundance (A) and frequency of occurrence (B) of herb species in the Pine Creek Alternate Strip study site. Vertical bars are one standard deviation from the mean.

The Lac du Bonnet sites, particularly the Mature Black Spruce study site, contained similar herb species to that found in the Pine Creek 1981 clear cut. This is not surprising as the two sites are dominated by black spruce growing on wet, organic, peaty soils. The herb layer at the Lac du Bonnet Mature Black Spruce study site was dominated by sphagnum moss, grasses and Labrador tea (Figure 22A). Other species included leatherleaf, 3-leaved false Solomon seal, starflower, creeping snowberry and bog cranberry. Small pools of water were also present in the quadrats (Figure 22A). Vegetation such as Labrador tea, sphagnum and grasses were found in all the plots, while species such as 3-leaved false Solomon seal, small bog cranberry, bog cranberry and starflower occurred in 30-50% of the quadrats (Figure 22B).

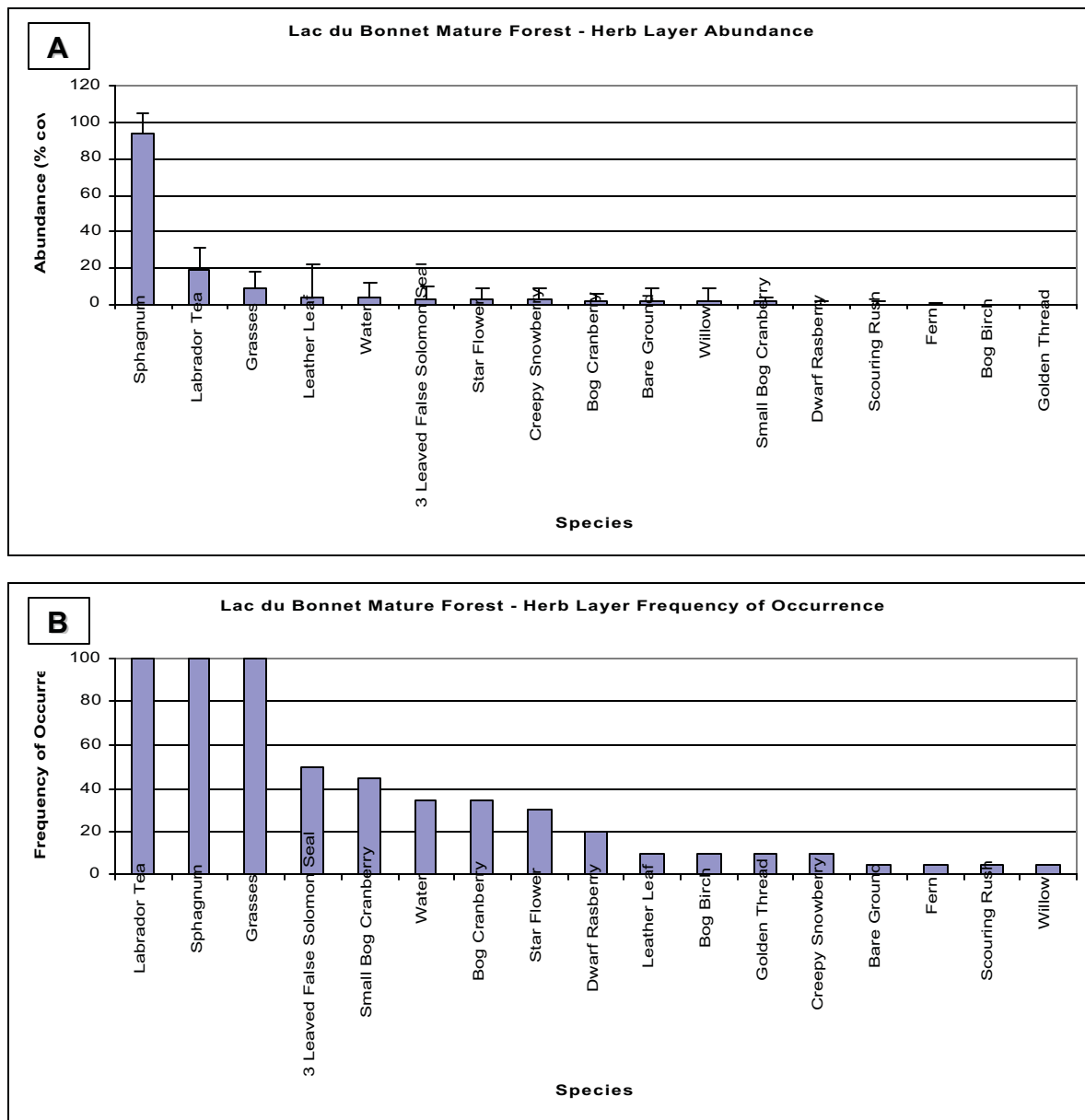


Figure 22. Abundance (A) and frequency of occurrence (B) of herb species in the Lac du Bonnet Mature Black Spruce study site. Vertical bars are one standard deviation from the mean.

The Lac du Bonnet Burn study site, in which all of the trees were killed by the fire, contained a much more diverse assemblage of herb species than the Mature Black Spruce site. There were almost twice as many species identified in the herb quadrats in the Burn site compared to the Mature Black Spruce site (Figure 23A, Figure 22A). The higher abundance and occurrence of herb species in the Burn study site was likely due to the fact that the fire created a new environment for plant species to invade. In fact, many of the species found in the Burn study site quadrats are plants that are not typical of lowland black spruce forests. Species such as long-leaved chickweed, marsh marigold (Figure 24), marsh cinquefoil, fireweed, aster, dandelion and Canada thistle are all commonly found in disturbed (from fires, land clearing, etc.) sites. Not unexpectedly, in terms of abundance (% cover) and occurrence, burned ground and water were the most common features found in the quadrats (Figure 23A, Figure 23B). Grasses and three-leaved false Solomon seal were the most common plant species. Over time, as the forest re-grows, these invading species will be replaced with species more typical of mature black spruce forests growing on organic, peat soils.

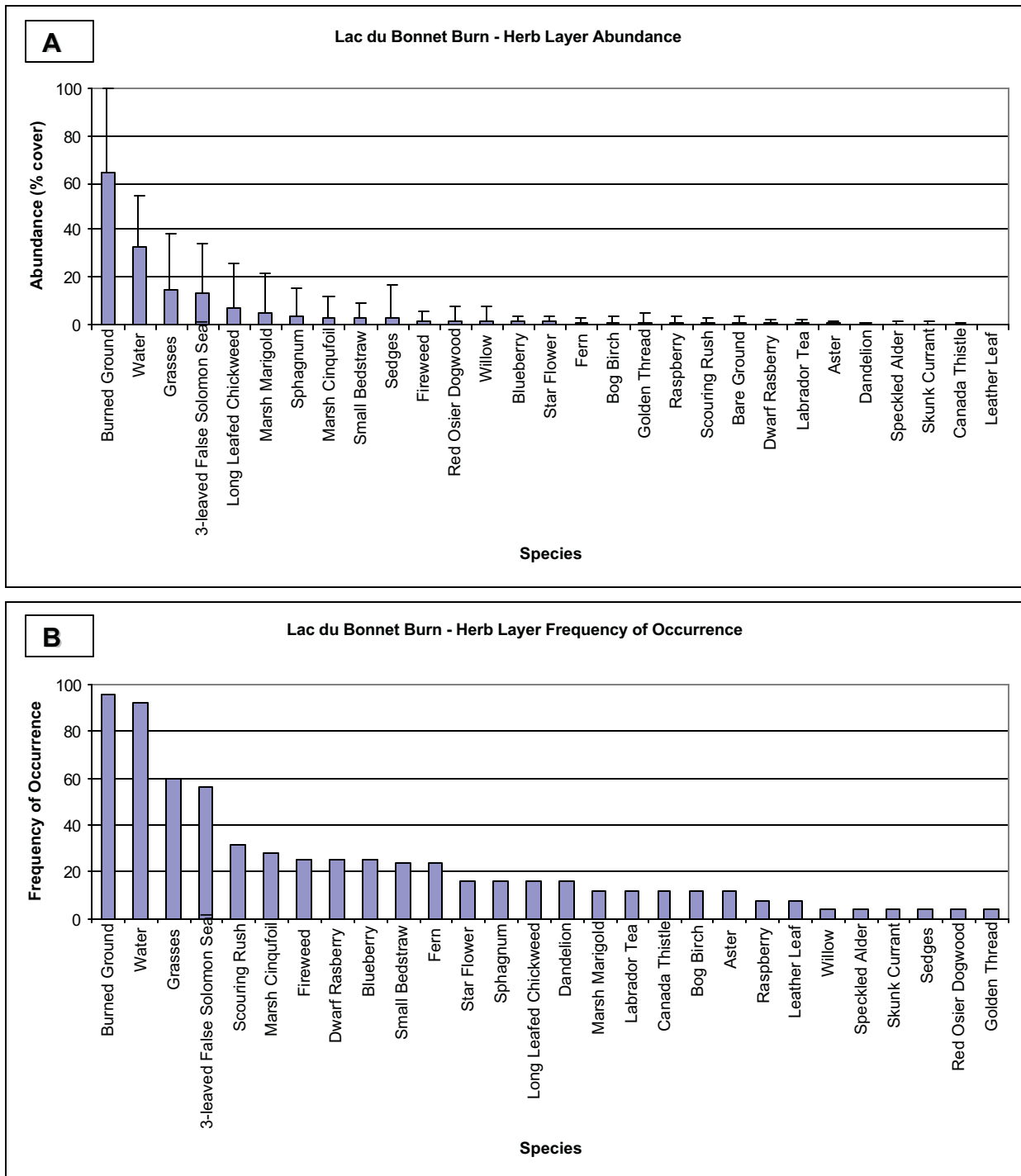


Figure 23. Abundance (A) and frequency of occurrence (B) of herb species in the Lac du Bonnet Burn study site. Vertical bars are one standard deviation from the mean.



Figure 24. Photos showing marsh marigold (top) and an unknown fungus species found in the Lac du Bonnet Burn study site.

The Lac du Bonnet Transition study site contained species typical of a mature black spruce site (Figure 25A, B). However, as with the Burn site, the Transition site quadrats also had a high % cover of burned ground, water, grasses and 3-leaved false Solomon seal. It appears that the intensity or severity of the fire in the Transition study site was not high enough to kill all trees or burn the soils sufficiently to allow the invasion of outside herb species, as was observed in the Burn study site. Many of the invading species such as marsh marigold, long-leaved chickweed, dandelion and Canada thistle, which were found in the Burn study site, were not present in the Transition study site.

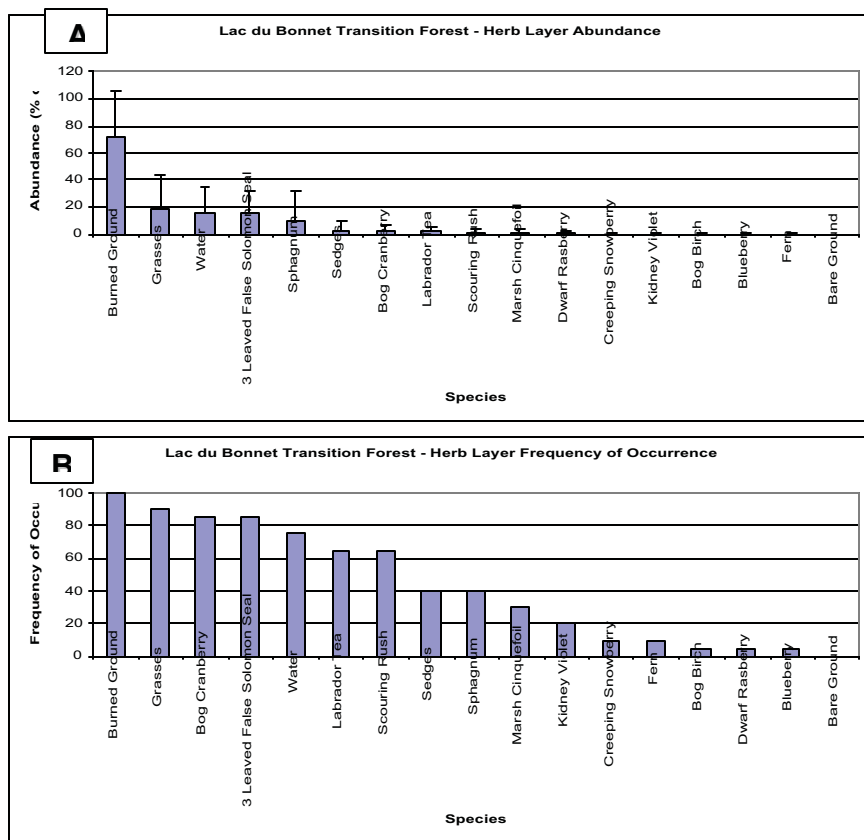


Figure 25. Abundance (A) and frequency of occurrence (B) of herb species in the Lac du Bonnet Transition study site. Vertical bars are one standard deviation from the mean.

Light Environment

Light intensity was measured in several locations within each 30 x 30 m study area. As the amount of light reaching the forest floor is affected by factors such as the amount of overhead tree and shrub canopy as well as cloud cover, simultaneous light measurements were also taken in areas with no overhead vegetation (e.g., along adjacent roads, or in open areas within study plots). Using the 2 light values, the % transmission was calculated for each study site. Figure 26 shows the % transmission of light at all study sites.

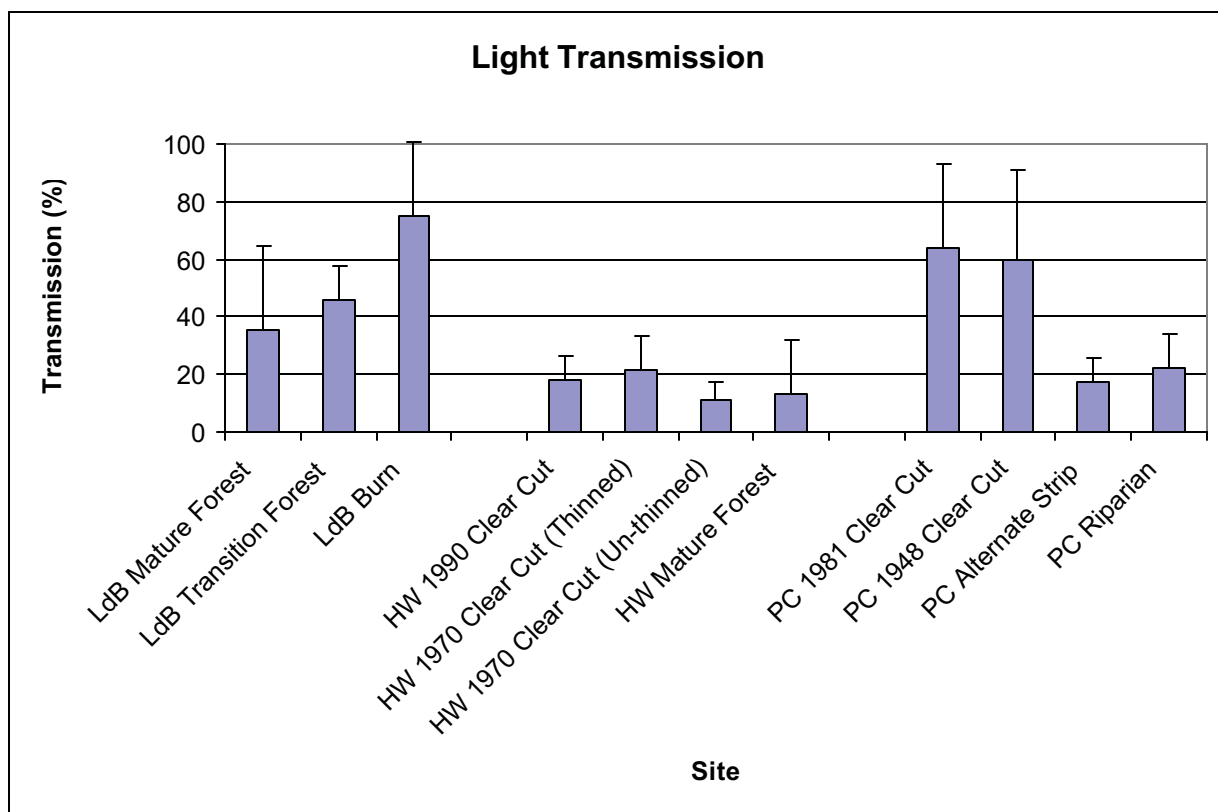


Figure 26. Light intensity, expressed as % transmission in all of the study sites in 2004. Vertical bars are one standard deviation from the mean.

Not surprisingly, the highest transmission of light was found in the Lac du Bonnet Burn study site. Although almost all of the trees remained standing in 2004, all of the branches and needles on the trees were consumed in the fire. Without the branches and needles to block the light, % transmission was approximately 75% (Figure 26). Light in the Lac du Bonnet Mature Black Spruce study site was only 35% due to shading created by the overhead trees and shrubs. Light values in the Lac du Bonnet Transition study site was in between the Burn and Mature Black Spruce study sites (approximately 46%, Figure 26). At the Pine Creek study sites, the highest light transmission occurred in the 1981 Clear Cut site (64%), followed by the 1948 Clear Cut site (60%). Light values were much lower in the Pine Creek Alternate Strip and Riparian study sites. The reduced light levels in these study sites may have been responsible for the different types of herbs growing at the sites, although other factors such as moisture and soil types undoubtedly played a large role as well. Interestingly, all sites at the Hollow Water area had fairly low light transmission (Figure 26). Apparently, the jack pine forests, whether in the short, dense stands found in the 1990s Clear Cut, or in the tall, Old Growth site effectively shaded out much of the light.

Air and Soil Temperature

Air and soil temperatures were monitored on an hourly basis using StowAway Tidbit Temperature Loggers (Figure 27). The StowAway loggers can be programmed to measure and store data at any time interval from one measurement every second to one measurement every year, or more. Using an infrared port on a laptop, the loggers were programmed to measure and store temperature every hour. Given this frequency, the loggers could in theory collect data for 3 years continuously before running out of memory. However, the loggers were placed in the field

in June and retrieved in mid November, as the units do not function below -25°C . Once retrieved from the field, the data was downloaded to a computer using BoxCar Pro software, which was then exported to Microsoft Excel. The data on the loggers was then deleted, completely freeing up the memory so that the loggers could be used the following year. The battery life for each logger is approximately 6 years.



Figure 27. StowAway Tidbit Temperature Logger. Loggers were cabled to trees to monitor hourly air temperature and also buried in the soil in order to monitor hourly soil temperature.

Air and soil temperature data are shown in the following graphs for each study site.

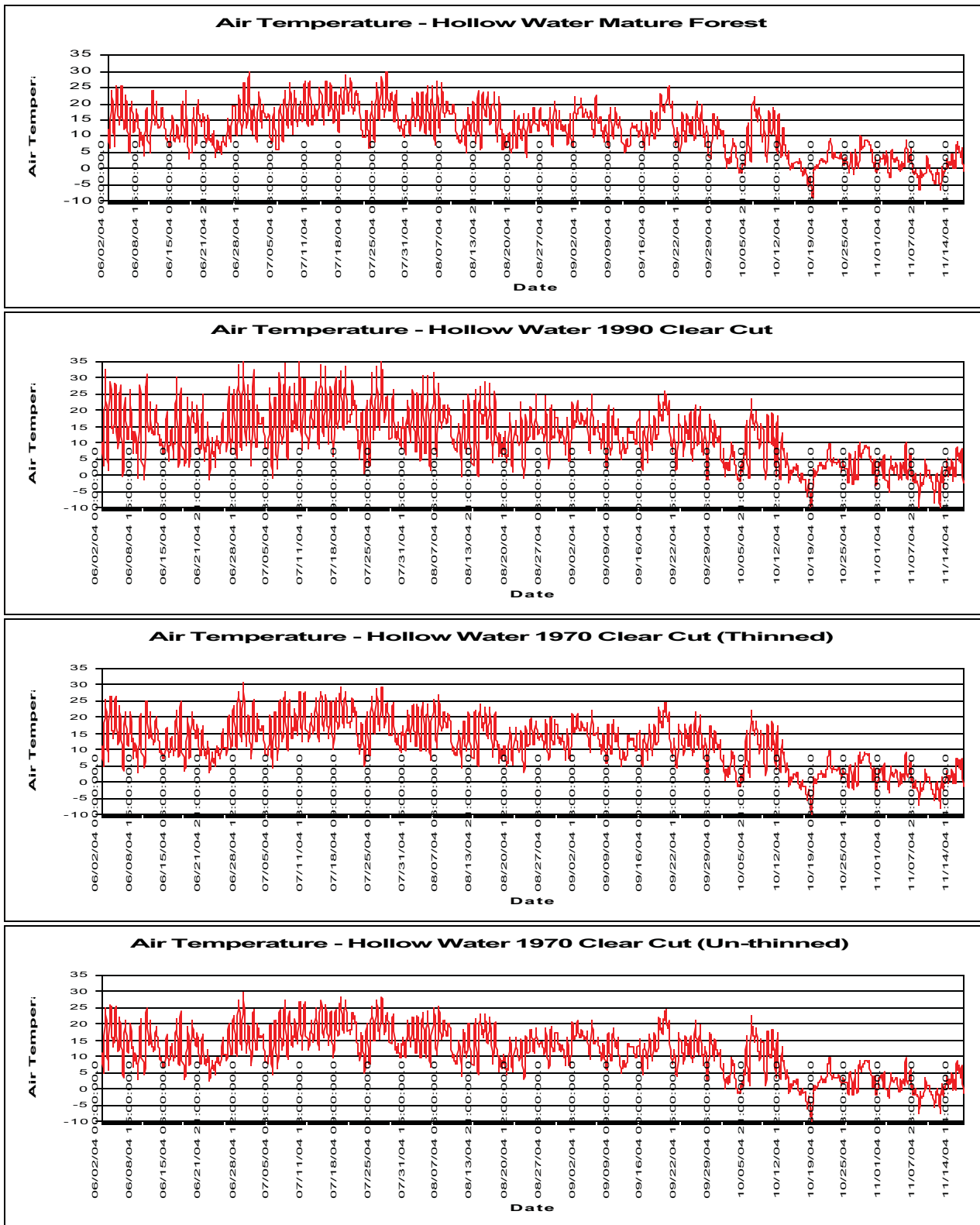


Figure 28. Hourly air temperature at the Hollow Water study sites

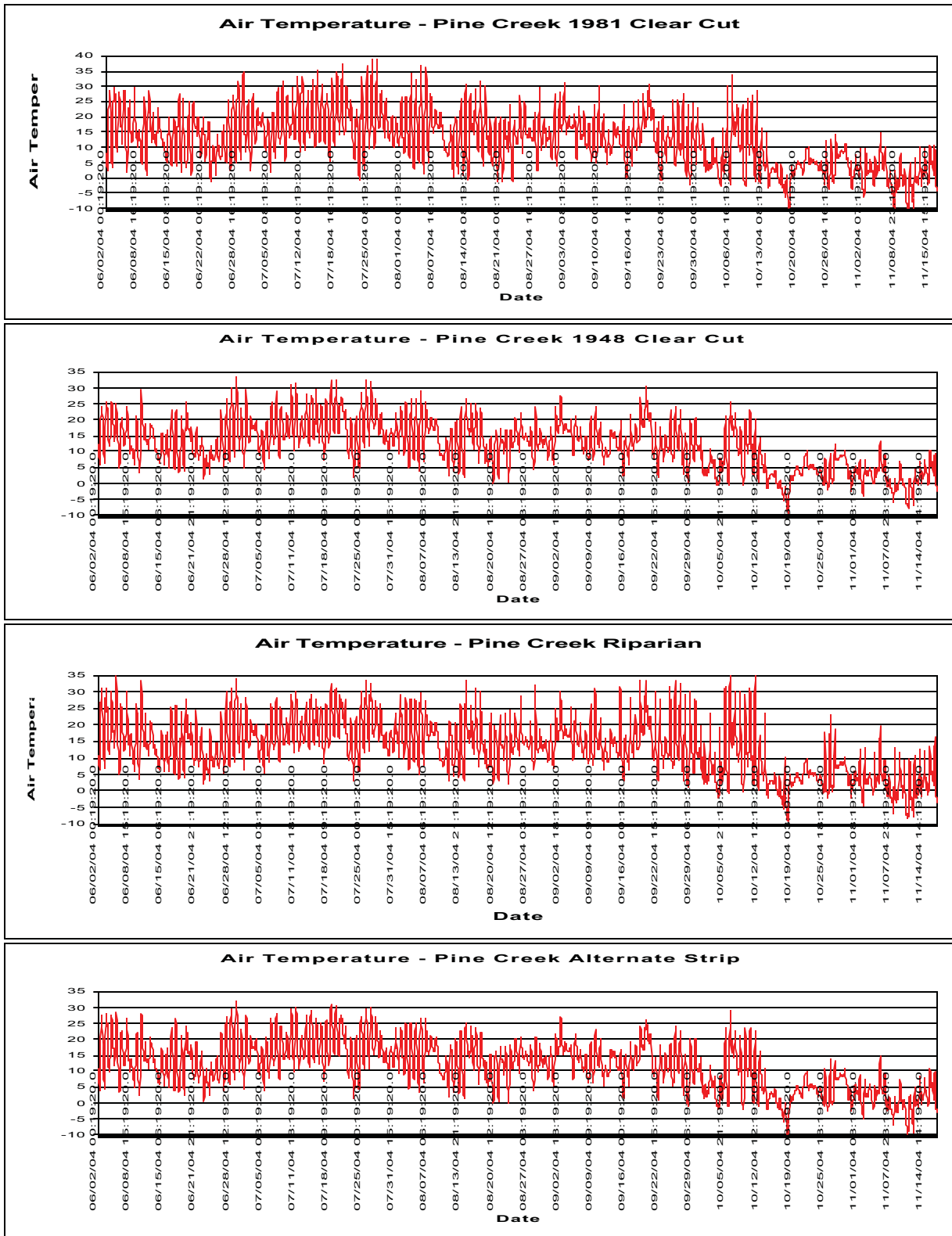


Figure 29. Hourly air temperature at the Pine Creek study sites

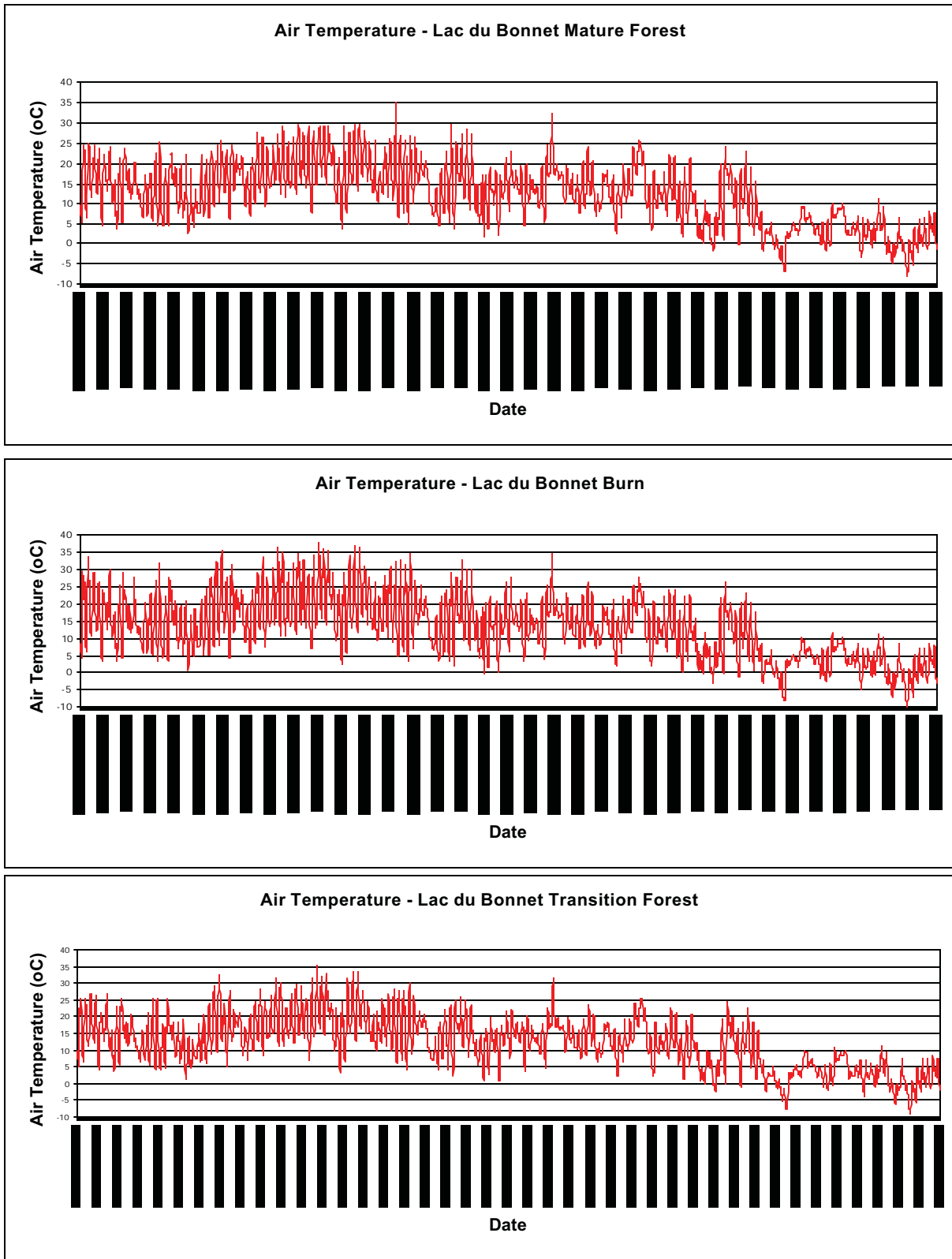


Figure 30. Hourly air temperature at the Lac du Bonnet study sites.

Figures 28-30 demonstrate the detailed information on air temperature that is obtained from the temperature data loggers. This level of detail also makes interpretation of the results more difficult. The vertical height of each red line in the graphs represents the amount of temperature variation over each 24 hour period at the sites. It is evident from the above figures that in all study sites, air temperature varied considerably throughout the day and night. In general, the greatest amount of variation in temperature occurred in forest sites that were younger or recently disturbed (e.g., Lac du Bonnet Burn and Transition, Hollow Water 1990s Clear Cut, Pine Creek 1981 Clear Cut). These sites also tended to have the warmest daytime temperatures, reaching more than 35°C. These trends can be more easily seen when daily daytime and nighttime averages are calculated.

Figure 31 depicts the average daytime (noon to 4 PM) and average nighttime (2 to 6 AM) temperature in the study sites for July, 2004. Of all the study sites, the Lac du Bonnet Burn and Transition study sites, as well as the Hollow Water 1990s Clear Cut and Pine Creek 1981 Clear Cut sites had the highest average daytime temperatures in July. The more mature forests in each of the 3 study areas had lower average daytime temperatures. This is expected as the recently disturbed sites (in particular, the Lac du Bonnet Burn and Transition sites which were covered in black ash) lack the shading effect of overhead foliage. The same sites also had the lowest average nighttime temperatures as well (Figure 31). Without the overhead canopy, more of the heat captured during the day was lost at night compared to the more mature forests.

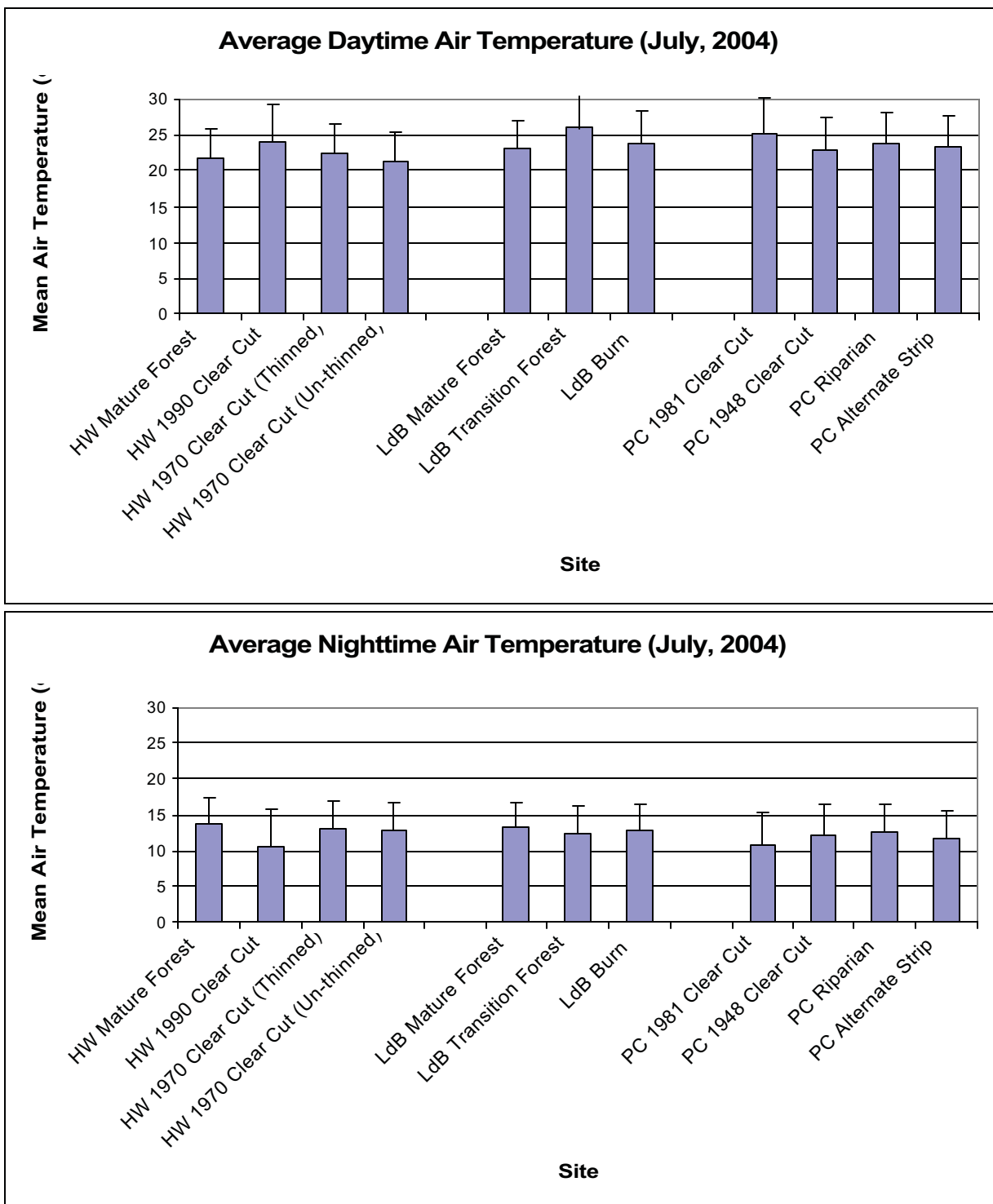


Figure 31. Average daytime (top) and nighttime (bottom) air temperature at the study sites.

Vertical bars are one standard deviation from the mean.

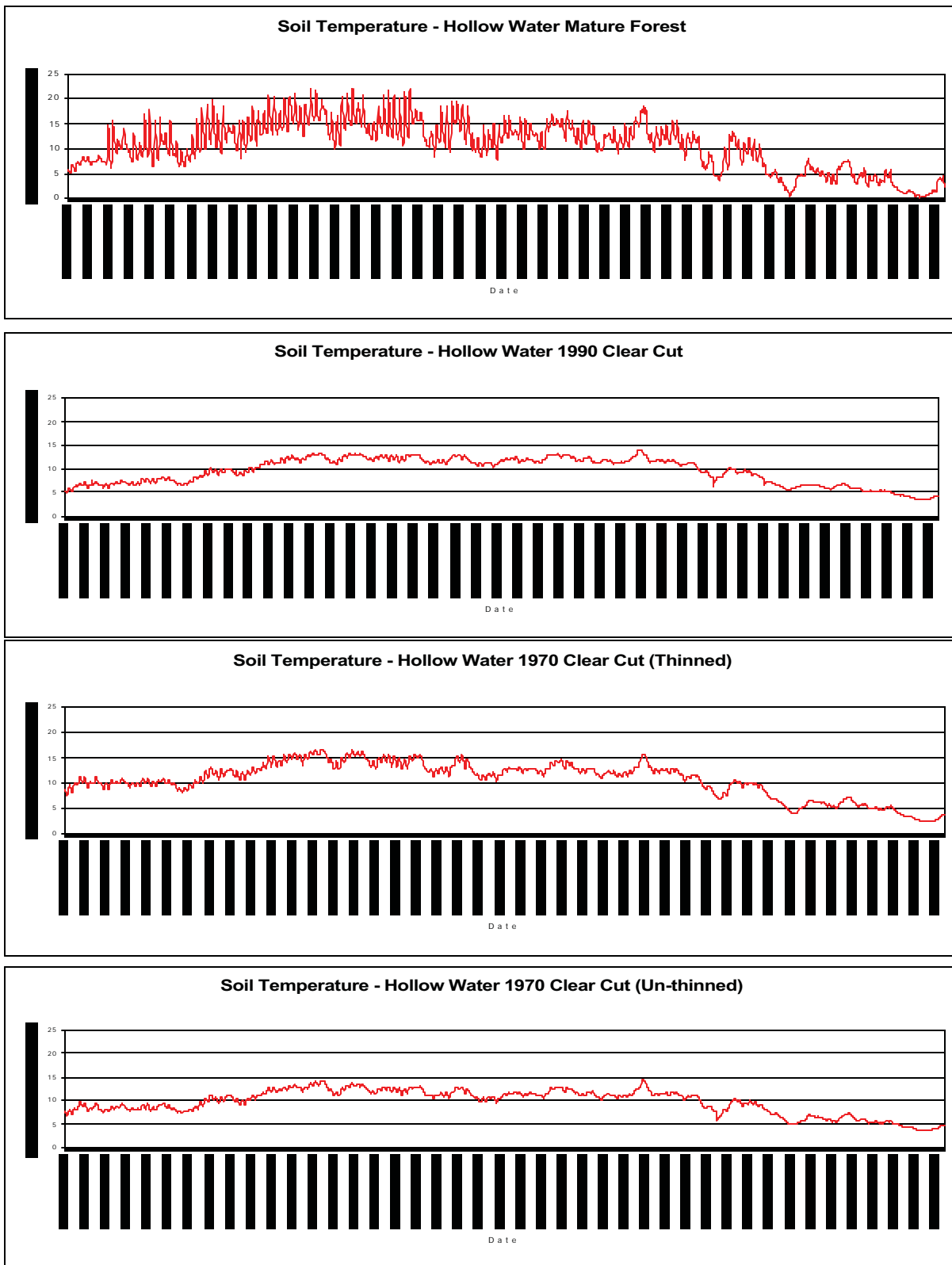


Figure 32. Hourly soil temperature at the Hollow Water study sites.

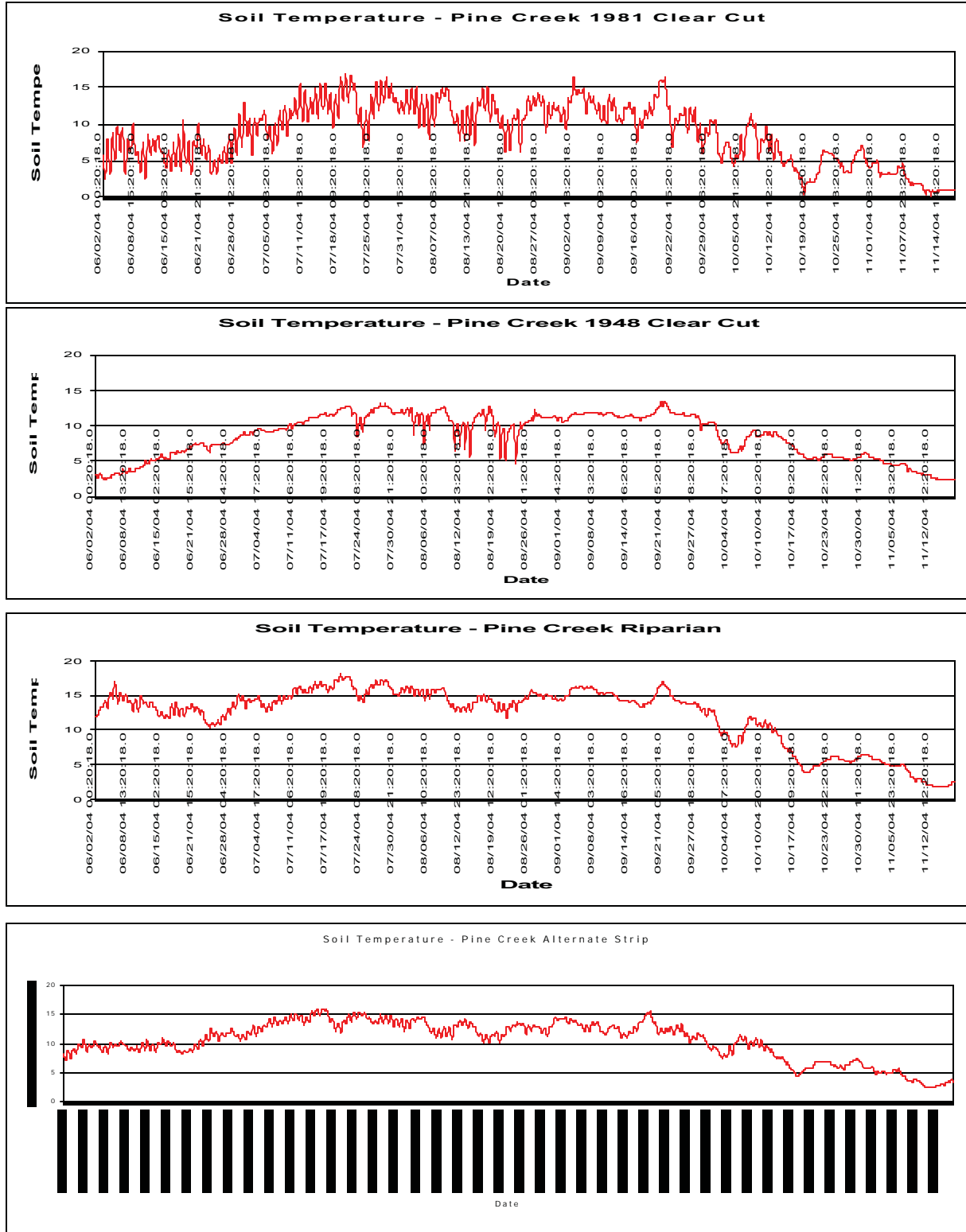


Figure 33. Hourly soil temperature at the Pine Creek study sites.

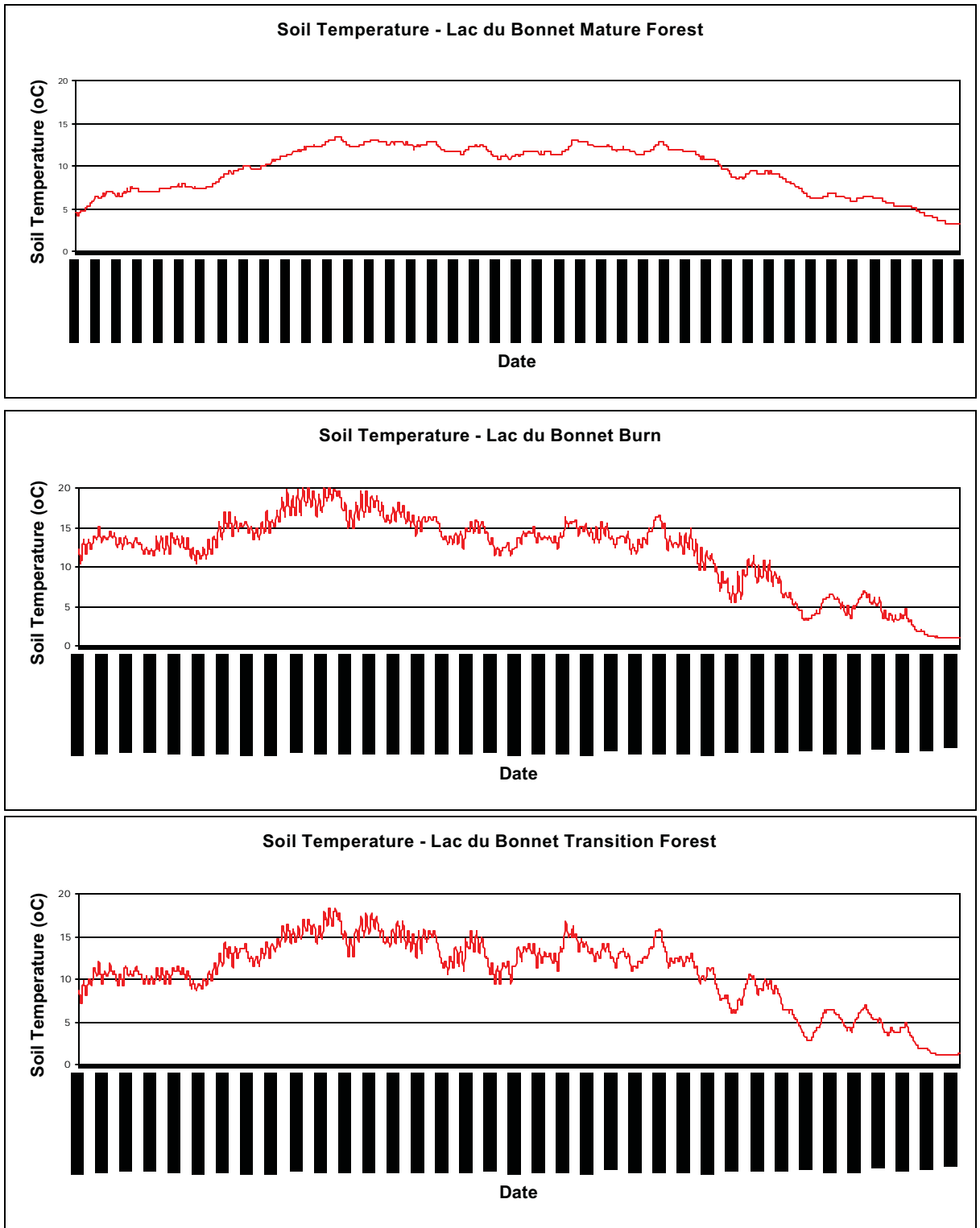


Figure 34. Hourly soil temperature at the Lac du Bonnet study sites.

Soil temperatures were always lower than the corresponding air temperatures at each site. A combination of the overhead canopy, the soils themselves and likely the moisture content of the soils kept soils cooler than the air. The daily variation in soil temperature (vertical height of the red lines) was also much smaller than for air temperature. For many of the sites, soil temperature slowly increased over the summer and then slowly decreased in the fall. Daily variation was extremely muted (Figures 32-34). There were some exceptions however. There was a significant amount of daily variation in soil temperature at the Hollow Water Old Growth site (top graph in Figure 32) and the Pine Creek 1981 Clear Cut site (top graph in Figure 33). As the Hollow Water site was a mature forest with plenty of shading, this was unexpected. The high daily soil temperature variation in the Pine Creek 1981 Clear Cut may have been a function of where the soil temperature logger was placed. The logger was placed inside an elevated sphagnum hummock, which likely was much warmer during the day and cooler at night than lower surrounding, saturated soil areas.

The soil temperature at the Pine Creek Riparian study site does not truly represent soil temperatures, as the site was inundated by the Pine Creek all summer and fall. Therefore, the temperature profile reflects more that of the creek than of the soils along the creek terrace. The influence of periodic flooding can be clearly seen in the graph for the Pine Creek 1948 Clear Cut study site, in which flooding events caused significant, temporary declines in soil temperature (Figure 33).

The soil temperature data for the Lac du Bonnet sites (Figure 34) show an interesting trend that demonstrates the effect of the forest fire. Soil temperatures in the Mature study site were lower

than the other 2 fire-affected sites, and also displayed the least amount of daily variation in temperature. In contrast, soil temperatures in the Burn and Transition study sites were much higher and displayed a larger amount of daily variation (Figure 34).

Small Mammal Abundance and Species Composition

In order to assess the abundance and species composition of small mammals, a set of 8 live traps were deployed at each study site (Figure 35).



Figure 35. Photo of the Havahart live traps used in the study.

The traps were baited with oatmeal and peanut butter. Traps were set on one day and checked the next day. On many days, particularly in the early summer and fall, traps were not set due to cool daytime or cold overnight temperatures. Each trap also contained cotton balls in which the animals could curl up and keep warm. Several of the traps were destroyed by black bears throughout the summer.

In total, traps were set for 564 trap nights. This represented approximately 14,000 trapping hours. Despite the level of trapping effort, few small mammals were caught in 2004. Figure 36 provides a summary of the mammals caught. In total, 13 deer mice and 1 red back vole were caught. With such low trapping success it is not possible to assess trends between study sites.

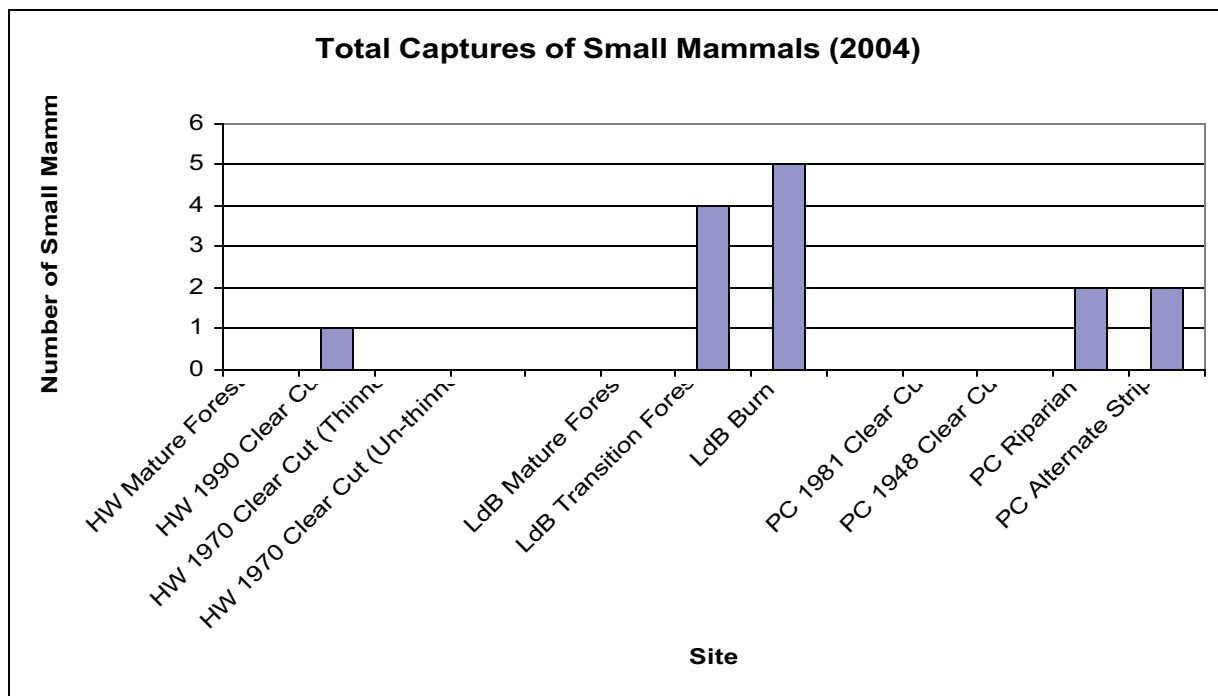


Figure 36. Total number of captures of small mammals at the study sites in 2004.

The low trapping success was likely due to three factors. Firstly, the small mammal populations in eastern Manitoba were low in 2004, and have been for several years. This, coupled with the low number of traps deployed in each study site likely contributed to the poor trapping success. The third factor was likely the weather. According to Environment Canada, June, July and August of 2004 were the coldest summer months on record. A significant amount of rain also fell and some of the study sites were either under water or very water-logged.

Availability of the Data

All data are available from the Black River First Nation Environment Department. In addition, summaries of the data (including graphs) are posted on the Black River First Nation website (www.black-river.ca). This report will also be available on the Black River First Nation website and the Manitoba Model Forest website (www.manitobamodelforest.net).

Interactive CDs: Development of Educational Tools

As part of the project, Black River First Nation has developed two interactive educational CDs that focus on the environment (Figure 37). One CD is directed at Kindergarten/Grade 1 level students, and the other is directed at Grades 5/6 level students. Prior to creation of the CDs, the Manitoba curriculum for each grade level was reviewed to ensure that the information in the CDs were age-appropriate. The K/1 CD covers general environmental topics such as water, air, wildlife, and habitat and provides suggestions for how young children can help the environment. The CD also contains environmentally-related games. The Grades 5/6 CD provides information

on interesting facts about the Earth and where our planet fits in, in the solar system, Milky Way galaxy and the universe. The CD provides detailed information on greenhouse gases, the greenhouse effect, climate change and global warming. It also provides information on the ozone layer. Lastly, the CD provides suggestions on how the students can reduce their environmental impact and footprint on the Earth, as well as containing games and activities. Information for the CDs was compiled by the Black River Environment Department and Art-A-Pix. Graphic design and production was done by Art-A-Pix. The CDs are available for free and are not to be re-sold.

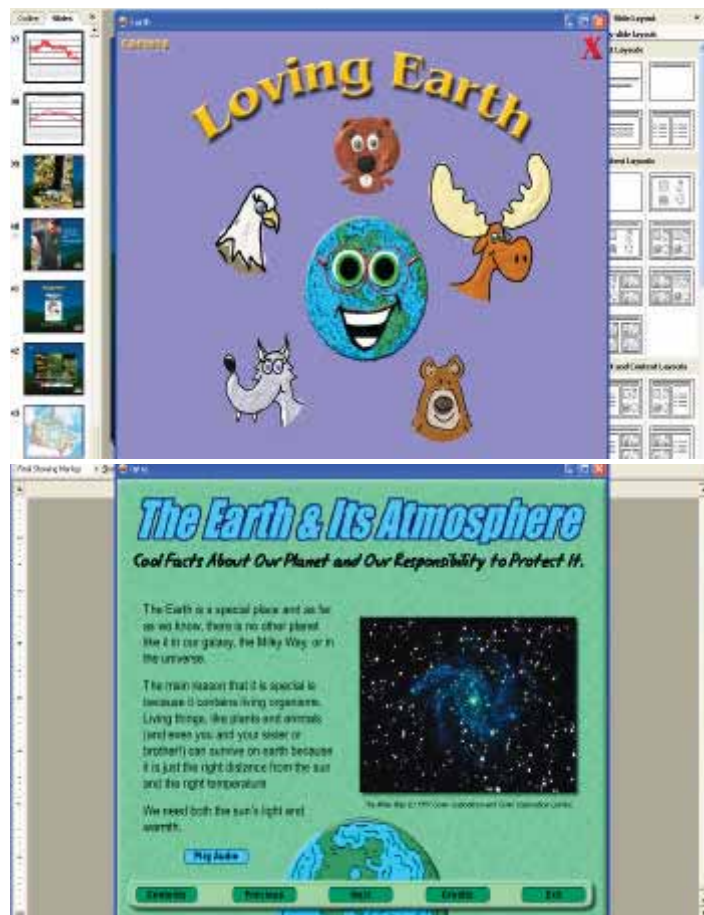


Figure 37. Opening screens for the K/1 (top) and Grades 5/6 (bottom) environmental CDs.

Recommendations

There were many positive aspects of the program that should be continued or enhanced as well as a few areas for improvement.

Firstly, long-term monitoring programs in the boreal forest are rare, and in order to assess the potential impacts of climate change on the forest, a long-term program needs to be established. Computer models indicate that the boreal forest in Manitoba may experience significant impacts as a result of climate change, and thus a long-term monitoring program should be implemented. Our study provides some baseline data and the same sites could be used as the basis for such a long-term program. In addition, to be more provincially and nationally relevant, the monitoring program should tie in with a larger monitoring network, such as the Environment Canada Ecological Monitoring and Assessment Network (EMAN). This will require a commitment of funding, and ideally this will come from a wide diversity of partners.

It was clear from the first year of our program that involvement of schools and students was very successful. The program provided a rare opportunity for students to participate in a research program and to see science in action. Future years of the program should strive to involve a larger number of schools, particularly those located in urban centers such as Winnipeg. In addition, to increase the relevance of the field work to the provincial curriculum, students should create a science report based on the data they collected. Exercises that provide guidance for this report could be developed and provided to the teachers as part of the overall monitoring program.

Lastly, there were certain aspects of the field monitoring that could be improved. In order to track long-term changes in forest tree species composition and abundance, trees should be assessed individually and tagged. Additional parameters such as soil moisture and annual decay rates could be added to examine the impact of climate change on the decomposition process in the forests. Assessments of the amount and decay class of downed woody debris should also be done. More detailed assessments of the soil types should also be undertaken in order to better characterize the sites. In order to provide a better picture of small mammal species composition and abundance, a higher level of sampling effort (i.e., more traps) is required.

Appendix I. List of Tree, Shrub and Herb Species Found in the Study Sites.

Hollow Water Old Growth Forest			
Trees and Shrubs		Herbs	
Common Name	Scientific Name	Common Name	Scientific Name
		Spagnum	<i>Sphagnum spp.</i>
Balsam Fir	<i>Abies balsamea</i>	Ground Cedar	<i>Lycopodium complanatum</i>
Jack Pine	<i>Pinus banksiana</i>	Bunchberry	<i>Cornus canadensis</i>
Beaked Hazelnut	<i>Corylus cornuta</i>	Prince's Pine	<i>Chimaphila umbellata</i>
White Birch	<i>Betula papyrifera var. papyrifera</i>	Lily of the Valley	<i>Maianthemum canadense</i>
		Blueberry	<i>Vaccinium myrtilloides</i>
		Prickly Rose	<i>Rosa acicularis</i>
		Bearberry	<i>Arctostaphylos uva-ursi</i>
		Dewberry	<i>Rubus pubescens</i>

Hollow Water 1970s Thinned			
Trees and Shrubs		Herbs	
Common Name	Scientific Name	Common Name	Scientific Name
Jack Pine	<i>Pinus banksiana</i>	Sphagnum	<i>Sphagnum spp.</i>
White Birch	<i>Betula papyrifera var. papyrifera</i>	Bearberry	<i>Arctostaphylos uva-ursi</i>
		Cinquefoil	<i>Potentilla spp.</i>
		Lilly of the Valley	<i>Maianthemum canadense</i>
		Lichen	
		Labrador Tea	<i>Ledum groenlandicum</i>
		Ground Cedar	<i>Lycopodium complanatum</i>

Hollow Water 1970s Un-thinned			
Trees and Shrubs		Herbs	
Common Name	Scientific Name	Common Name	Scientific Name
Jack Pine	<i>Pinus banksiana</i>	Club Moss	<i>Lycopodium annotinum</i>
		Skunk Currant	<i>Ribes glandulosum</i>
		Labrador Tea	<i>Ledum groenlandicum</i>
		Blueberry	<i>Vaccinium myrtilloides</i>
		Bunchberry	<i>Cornus canadensis</i>

Pine Creek 1981 Clear Cut			
Trees and Shrubs		Herbs	
Common Name	Scientific Name	Common Name	Scientific Name
		Labrador Tea	<i>Ledum groenlandicum</i>
Black Spruce	<i>Abies balsamea</i>	Lichens	
Tamarack	<i>Larix laricina</i>	Sphagnum	<i>Sphagnum spp.</i>
White Birch	<i>Betula papyrifera</i> var. <i>papyrifera</i>	Bearberry	<i>Arctostaphylos uva-ursi</i>
Trembling Aspen	<i>Populus tremuloides</i>	Leather Leaf	<i>Chamaedaphne calyculata</i>
Speckled Alder	<i>Alnus rugosa</i>	Creeping Snowberry	<i>Gaultheria hispidula</i>
		Bog Cranberry	<i>Vaccinium vitis-idaea</i>

Pine Creek 1948 Clear Cut

Pine Creek 1948 Clear Cut					
Trees and Shrubs		Herbs		Outside Plot	
Common Name	Scientific Name	Common Name	Scientific Name	Common Name	Scientific Name
Black Spruce	<i>Abies balsamea</i>	Sphagnum	<i>Sphagnum spp.</i>	Labrador Tea	<i>Ledum groenlandicum</i>
Tamarack	<i>Larix laricina</i>	Grasses	<i>Poaceae spp.</i>	White Birch	<i>Betula papyrifera var. papyrifera</i>
Saskatoon	<i>Amelanchier alnifolia</i>	Labrador Tea	<i>Ledum groenlandicum</i>	Sarsaparilla	<i>Aralia nudicaulis</i>
White Birch	<i>Betula papyrifera var. papyrifera</i>	Stiff Club Moss	<i>Lycopodium annotinum</i>	Fern	
		Bog Cranberry	<i>Vaccinium vitis-idaea</i>	Skunk Currant	<i>Ribes glandulosum</i>
		Lilly of the Valley	<i>Maianthemum canadense</i>	Grass	<i>Poaceae spp.</i>
		Blue Bead Lilly	<i>Clintonia borealis</i>		
		Skunk Currant	<i>Ribes glandulosum</i>		
		Fern			
		Bunchberry	<i>Cornus canadensis</i>		
		Star Flower	<i>Trientalis borealis</i>		
		Leather Leaf	<i>Chamaedaphne calyculata</i>		

Pine Creek Alternate Strip			
Trees and Shrubs		Herbs	
Common Name	Scientific Name	Common Name	Scientific Name
Saskatoon	<i>Amelanchier alnifolia</i>	Sarsasporilla	<i>Aralia nudicaulis</i>
Beaked Hazelnut	<i>Corylus cornuta</i>	Beaked Hazelnut	<i>Corylus cornuta</i>
Trembling Aspen	<i>Populus tremuloides</i>	Grasses	<i>Poaceae spp.</i>
Downy Arrow Wood	<i>Viburnum rafinesquianum</i>	Dewberry	<i>Rubus pubescens</i>
High Bush Cranberry	<i>Viburnum opulus</i>	Saskatoon	<i>Amelanchier alnifolia</i>
Choke Cherry	<i>Prunus virginiana</i>	Prickly Rose	<i>Rosa acicularis</i>
White Spruce	<i>Picea glauca</i>	Downy Arrow Wood	<i>Viburnum rafinesquianum</i>
Willow	<i>Salix spp.</i>	Snake Root	<i>Sanicula marilandica</i>
Hawthorn	<i>Crataegus spp.</i>	Highbush Cranberry	<i>Viburnum edule</i>
Red Osier Dogwood	<i>Cornus stolonifera</i>	Choke Cherry	<i>Prunus virginiana</i>
Green Ash	<i>Fraxinus pennsylvanica</i>	Meadow Rue	<i>Thalictrum spp.</i>
Pin Cherry	<i>Prunus pensylvanica</i>	3 Leaved False Solomon Seal	<i>Smilacina trifolia</i>
Twining Honeysuckle	<i>Lonicera dioica var. glaucescens</i>	Strawberry	<i>Fragaria virginiana</i>
Manitoba Maple	<i>Acer negundo</i>	Bishops Cap	<i>Mitella nuda</i>
Oak	<i>Quercus macrocarpa</i>	Lilly of the Valley	<i>Maianthemum canadense</i>
		Wild Vetch	<i>Vicia americana</i>
		Northern Bedstraw	<i>Galium boreale</i>
		Creamed Colored Vetchling	<i>Lathyrus ochroleucus</i>
		Bunchberry	<i>Cornus canadensis</i>
		Willow	<i>Salix spp.</i>
		Hawthorn	<i>Crataegus spp.</i>
		Fireweed	<i>Epilobium angustifolium</i>
		Dandelion	<i>Taraxacum officinale</i>
		Canada Thistle	<i>Cirsium arvense</i>
		Black Currant	<i>Ribes americanum</i>
		Red Osier Dogwood	<i>Cornus stolonifera</i>
		Pink Winter Green	<i>Pyrola asarifolia</i>
		Manitoba Maple	<i>Acer negundo</i>
		Black Ash	<i>Fraxinus nigra</i>
		Twining Honeysuckle	<i>Lonicera dioica var. glaucescens</i>

Pine Creek Alternate Strip	
Outside Plot	
Common Name	Scientific Name
Tall Lungwort	<i>Mertensia paniculata</i>
Canada Columbine	<i>Aquilegia canadensis</i>
Pin Cherry	<i>Prunus pensylvanica</i>
Bur Oak	<i>Quercus macrocarpa</i>
Trillium	<i>Trillium spp.</i>
Red Osier Dogwood	<i>Cornus stolonifera</i>
Red Raspberry	<i>Rubus idaeus</i>
Sarsaparilla	<i>Aralia nudicaulis</i>
Bunchberry	<i>Cornus canadensis</i>

Lac du Bonnet Mature Forest					
Trees and Shrubs		Herbs		Outside Plot	
Common Name	Scientific Name	Common Name	Scientific Name	Common Name	Scientific Name
Black Spruce	<i>Picea mariana</i>	Sphagnum	<i>Sphagnum spp.</i>	Scouring Rush	<i>Equisetum hyemale</i>
Bog Birch	<i>Betula glandulosa</i>	Labrador Tea	<i>Ledum groenlandicum</i>	Marsh Marigold	<i>Caltha palustris</i>
Tamarack	<i>Larix laricina</i>	Grasses	<i>Poaceae spp.</i>	Bog Laurel	<i>Kalmia polifolia</i>
Balsam Fir	<i>Abies balsamea</i>	Leather Leaf	<i>Chamaedaphne calyculata</i>	Starflower	<i>Trientalis borealis</i>
Willow	<i>Salix spp.</i>	3 Leaved False Solomon Seal	<i>Smilacina trifolia</i>	Stemless Ladyslipper	<i>Cypripedium acaule</i>
Speckled Alder	<i>Alnus rugosa</i>	Star Flower	<i>Trientalis borealis</i>	Bunchberry	<i>Cornus canadensis</i>
Eastern Mountain Ash	<i>Sorbus scopulina</i> *	Creepy Snowberry	<i>Gaultheria hispidula</i>		
Saskatoon	<i>Amelanchier alnifolia</i>	Bog Cranberry	<i>Vaccinium vitis-idaea</i>		
		Willow	<i>Salix spp.</i>		
		Small Bog Cranberry	<i>Oxycoccus microcarpus</i>		
		Dwarf Raspberry	<i>Rubus acaulis</i>		
		Scouring Rush	<i>Equisetum hyemale</i>		
		Fern			
		Bog Birch	<i>Betula glandulosa</i>		
		Golden Thread	<i>Coptis trifolia</i>		

Lac du Bonnet Burn			
Trees and Shrubs		Herbs	
Common Name	Scientific Name	Common Name	Scientific Name
Black Spruce	<i>Picea mariana</i>	Grasses	<i>Poaceae spp.</i>
Balsam Fir	<i>Abies balsamea</i>	3-leaved False Solomon Seal	<i>Smilacina trifolia</i>
Speckled Alder	<i>Alnus rugosa</i>	Long Leafed Chickweed	<i>Stellaria longifolia</i>
Bog Birch	<i>Betula glandulosa</i>	Marsh Marigold	<i>Caltha palustris</i>
Red Oiser Dogwood	<i>Cornus stolonifera</i>	Sphagnum	<i>Sphagnum spp.</i>
Willow	<i>Salix spp.</i>	Marsh Cinqufoil	<i>Potentilla palustris</i>
Tamarack	<i>Larix laricina</i>	Small Bedstraw	<i>Galium trifidum</i>
Eastern Mountain Ash	<i>Sorbus scopulina *</i>	Sedges	<i>Cyperaceae spp.</i>
Saskatoon	<i>Amelanchier alnifolia</i>	Fireweed	<i>Epilobium angustifolium</i>
		Red Osier Dogwood	<i>Cornus stolonifera</i>
* Western Mountian Ash		Willow	<i>Salix spp.</i>
		Blueberry	<i>Vaccinium myrtilloides</i>
		Star Flower	<i>Trientalis borealis</i>
		Fern	
		Bog Birch	<i>Betula glandulosa</i>
		Golden Thread	<i>Coptis trifolia</i>
		Raspberry	<i>Rubus idaeus</i>
		Scouring Rush	<i>Equisetum hyemale</i>
		Dwarf Rasberry	<i>Rubus acaulis</i>
		Labrador Tea	<i>Ledum groenlandicum</i>
		Aster	<i>Aster spp.</i>
		Dandelion	<i>Taraxacum officinale</i>
		Speckled Alder	<i>Alnus rugosa</i>
		Skunk Currant	<i>Ribes glandulosum</i>
		Canada Thistle	<i>Cirsium arvense</i>
		Leather Leaf	<i>Chamaedaphne calyculata</i>

Lac du Bonnet Burn	
Outside Plot	
Common Name	Scientific Name
Bur Oak	<i>Quercus macrocarpa</i>
Marsh Marigold	<i>Caltha palustris</i>
Skunk Currant	<i>Ribes glandulosum</i>
Labrador Tea	<i>Ledum groenlandicum</i>
Blueberry	<i>Vaccinium myrtilloides</i>
Dwarf Raspberry	<i>Rubus acaulis</i>
Canada Thistle	<i>Cirsium arvense</i>
Dandelion	<i>Taraxacum officinale</i>
Prickly Rose	<i>Rosa acicularis</i>
Marsh Ragwort	<i>Senecio congestus</i>
Arrow-leaved Coltsfoot	<i>Petasites sagittatus</i>

Lac du Bonnet Fire Transition			
Trees and Shrubs		Herbs	
Common Name	Scientific Name	Common Name	Scientific Name
Black Spruce	<i>Picea mariana</i>	Grasses	<i>Poaceae spp.</i>
Bog Birch	<i>Betula glandulosa</i>	3 Leaved False Solomon Seal	<i>Smilacina trifolia</i>
Balsam Fir	<i>Abies balsamea</i>	Sphagnum	<i>Sphagnum spp.</i>
Willow	<i>Salix spp.</i>	Sedges	<i>Cyperaceae spp.</i>
Tamarack	<i>Larix laricina</i>	Bog Cranberry	<i>Vaccinium vitis-idaea</i>
Speckled Alder	<i>Alnus rugosa</i>	Labrador Tea	<i>Ledum groenlandicum</i>
Eastern Mountain Ash	<i>Sorbus scopulina *</i>	Scouring Rush	<i>Equisetum hyemale</i>
Saskatoon	<i>Amelanchier alnifolia</i>	Marsh Cinquefoil	<i>Potentilla palustris</i>
* Western Mountain Ash		Dwarf Raspberry	<i>Rubus acaulis</i>
		Creeping Snowberry	<i>Gaultheria hispidula</i>
		Kidney Violet	<i>Viola renifolia</i>
		Bog Birch	<i>Betula glandulosa</i>
		Blueberry	<i>Vaccinium myrtilloides</i>
		Fern	

Lac du Bonnet Transition	
Outside Plot	
Common Name	Scientific Name
Spinulose Shield Fern	<i>Dryopteris austriaca</i>
Bog Birch	<i>Betula glandulosa</i>
Speckled Alder	<i>Alnus rugosa</i>
Bur Oak	<i>Quercus macrocarpa</i>
Dwarf Raspberry	<i>Rubus acaulis</i>
Starflower	<i>Trientalis borealis</i>
Scouring Rush	<i>Equisetum hyemale</i>
Skunk Currant	<i>Ribes glandulosum</i>



Environment
Canada

Environnement
Canada



BIOMONITORING FIELD DATA SHEETS

Date and Time:	
Site Location:	
Field Personnel:	

Weather Description (check all that apply)	Cloud Cover	Sunny	
		Partly Cloudy	
		Cloudy	
	Precipitation	No Precipitation	
		Raining	
		Snowing	
	Wind	Calm (no wind)	
		Slight Breeze	
		Windy	

Air Temp-°C (dry bulb)	
Air Temp-°C (wet bulb)	
Relative Humidity (from chart)	

AGE AND HEIGHT OF DOMINANT TREES

Take an increment core from 1 dominant tree of each species in the 10 x 10 m plot. Estimate their age.

Using the clinometer, determine the height of the dominant trees. Hint: picture the tree falling onto the ground. Walk that distance from the tree and look up to the top of the tree using the clinometer. Read the number on the right hand scale in the clinometer. Calculate the partial tree height based on the formula in the table below. Calculate the final tree height by adding your height to the partial tree height.

Tree Species	Age (years)		Distance from Tree (m)	Clinometer Reading (right hand scale)	Partial Height (m) = reading/100 x Dist	Your Height (m)	Tree Height = partial + your height

SOIL DATA

Measure soil parameters in the 1 x 1 m plot

Soil Temperature-°C (at 10 cm depth)	
Soil pH (at 10 cm depth)	

Dig a soil pit near somewhere in the 10 x 10 m plot

Soil Pit	LFH Thickness (cm)	
	A Horizon Thickness (cm)	
	B Horizon Thickness (cm)	
	C Horizon Thickness (cm)	
Description of Soils		

THE LIGHT ENVIRONMENT

In the 1 x 1 m plot, look up to the sky and estimate how much of the sky (i.e., what %) is blocked by the trees and foliage. This is referred to as “canopy closure”.

Measure the light intensity using the light meter in the same location. Also measure light intensity using the light meter outside the plot (where there is no tree canopy – e.g., on a road or trail)

Canopy Closure (%)	Light Reading Inside Plot	Light Reading Outside Plot	% Transmission (inside/outside)x100

SMALL MAMMALS

Trap Number	Species Caught	Weight (g)

SIGNS OF WILDLIFE

Make note of any observations related to wildlife use of the site

1. Sounds / calls
2. Sightings
3. Nests
4. Signs of browsing (chewed twigs and branches, cones at the base of trees, bark missing on trees)
5. Game trails, animal tracks, signs of rubbing on trees
6. Scat

Wildlife Observations