Impact of Silviculture on Four Medicinal Plants in Northwestern Ontario

A Graduate Thesis Submitted
in Partial Fulfillment for the Degree Master of Science in Forestry

Shibi Chandy ©
Faculty of Forestry
Lakehead University
955 Oliver Road
Thunder Bay, Ontario
P7B 5E1

May, 2000

In Memory of Dida (Mrs. Beatrice Storm)

ACKNOWLEDGMENTS

I would like to thank my supervisor **Dr. David L. Euler** for introducing me to an area in forest ecology which I enjoy learning. I am very grateful for his encouragement, support, the trust he has in me about my capabilities, and finding funds to carry out my work here. Over the two years I have known him, he has become a father figure to me. I would also like to thank **Gail**, for her support and the numerous hours she has spent with me helping me in the various aspects of my life in Thunder Bay.

F. Wayne Bell, for allowing me to use Falling Snow Ecosystem Project, the tremendous encouragement, helping me design a project, and work with statistics in a language I understand.

Dr. K. M. Brown for his help with statistics and giving me a 'life long contract' for any problem with statistics.

Dr. Connie H. Nelson. I am glad I got to know her, when she finally had some time. It was a pleasure to know her, work with her on my thesis, and share the different aspects of life we have in common.

Dr. Peggy Tripp. For her insight, and the different perspective she has about forestry.

I appreciate the valuable comments made by **Dr. Gina H. Mohammed (external examiner)** and the time she took to review my work.

A special thank you, to **Brian Moore** for helping me with data collection, despite the fact that he does not like graduate students. I would also thank **Steve Elliot** for the helping me in the fieldwork.

Special thanks, to **Lynn Gollat,** graduate studies assistant, for her wonderful smile, support, and great Italian suppers.

The library especially **Nancy Pazianos and Tracy Muldoon** deserves credit for handling of all the requests of inter-library loans. Special credits to **Lori Fleming** and **Becky Hurley**, from the bookstore who have rushed material on time for me.

Dida (Late. Mrs. Beatrice Storm) will be in my thought everyday for her caring personality that helped me get though the not so good days of university.

My parents for giving me a good start in life the best of education and the best of everything, sometimes even more that the share I deserve. Saving money for my dowry, which they let me use for an education in North America. I would like to say thank you to my **brother (Shibu)** for his unconditional support.

I would also like to thank all my **friends (especially Frances, Kathryn, and Kevin)** in Thunder Bay, who have been very supportive and have given me numerous breaks over the two years. I could probably write another thesis about my friends in Thunder Bay.

CONTENTS

List of Figures

TABLES

ABSTRACT

Chandy, S; 2000. Impact of silviculture on four medicinal plants in Northwestern Ontario.

Key words: aerial application, *Cornus*, ethnobotany, *Epilobium*, medicinal use, mechanical treatments, *Pteridium*, *Rubus*, vegetation management.

Vegetation management to release conifers from competing angiosperms is practiced throughout Canada. Aerial herbicide application, mechanical cutting, and site preparation are some of the techniques used to suppress competing vegetation. Scientific evidence demonstrates that these techniques allow conifers to establish in the first few years after planting. One of the issues that arise, especially from the public, is concern that aerial herbicide applications have on other values. Hence, there is pressure on managers to find alternatives for the chemical control of vegetation that hinders early conifer growth.

In this thesis, the abundance in distribution of *Cornus*, *Epilobium*, *Pteridium*, and *Rubus* was computed, seven years after the silvicultural treatments were applied in the area. All four species studied show potential medicinal ingredients both from ethnobotanical, and pharmaceutical perspectives. A single application of herbicides or mechanical treatments did not show any statistical difference from the control plots in the abundance of the above species. However, the trends show slight variation. By using mechanical methods for controlling these species, the medicinal values can be made available for development by the pharmaceutical companies, without contributing to any environmental degradation that may result from aerial herbicide application.

1.0. INTRODUCTION

1.1.1. MEDICINAL USE OF PLANTS AND LINKAGE TO FORESTRY

Medicinal plants from forested areas have the potential to increase the value of forests. Freedonia Group (1998) infers that selling medicinal plants, especially those derived from natural products, is a lucrative venture. They estimate, for example, they will sell approximately 8.2 billion (U.S) dollars worth of herbal plant preparations by 2002 in the global market. A recent study by Mohammed (1999) also reveals revenue collected in 1997 from medicinal plants, ornaments, and essential oil in Canada alone was about $ 340 million. Cox (1994) estimates that twenty-five percent of prescription drugs in the USA and Canada are bioactive compounds derived from or based on chemical structures that occur naturally in plants. A historical review of the ethnobotanical literature indicates that these modern drugs are derived from unmodified natural plant products, e.g. digitalis, and modified natural or synthetic substances based on a natural product, e.g. aspirin (Cox 1994).

Herbal and pharmaceutical drugs derived from natural products help to increase the net worth of forests (Iwu 1994). Balick (1994) suggests that new drugs, developed from plant derivatives, will be of value to conservation efforts because plant derivatives have a potential to impact the economy of the country, as policies and people are directed to such incentives. Balick (1994) further explains that economic incentives are valuable as the regional, national and international herbal and pharmaceutical activities are interlinked.

1.1.2. Vegetation Management

In North American forestry, a common goal of vegetation management is to reduce angiosperm competition with conifers, either in plantations or in naturally regenerated stands (Sullivan *et al.* 1996). There has been a paradigm shift in forestry, from unregulated exploitation and resource depletion to a view of forestry that considers environmental consequences of forestry related activities, and works to satisfy diverse social needs (Kimmins 1991; 1995). While acknowledging ecosystem management is necessary to achieve sustainability and multi-use of the forests, Kimmins (1995) recognizes ecological considerations do not always include the role of forests in the cultural fabric of different societies, and this issue should be addressed to achieve a balance between social, cultural and ecological considerations. Wagner (1994) expresses similar views emphasizing the need to integrate vegetation management that traditionally has silvicultural objectives with plant ecology, which can have a wide range social and economic impact.

The Vegetation Management Alternative Program (VMAP), part of OMNR's (Ontario Ministry of Natural Resources) sustainable forestry initiative, began in 1991. The goal of the project is to "reduce the dependence on herbicides in Ontario's forest by developing alternatives and gaining better understanding of forest ecosystems through research, education, and field delivery" (Wagner 1992 p.3). VMAP was designed to ensure that forest vegetation management practices on Crown Lands were socially acceptable and consistent with the emerging principles of ecosystem management. VMAP research is dedicated to the understanding of the ecosystem dynamics associated with conventional and alternative forest vegetation management practices (Lautenschager *et al.* 1997; Wagner 1992).

1.1.3. Purpose statement

The purpose of my study was to evaluate the impact of four different silvicultural treatments on selected medicinal plants in Northwestern Ontario. The Falling Snow Ecosystem Project was chosen for the study, because specific vegetation management practices were prescribed in this area (Bell *et al.* 1997a). This study will help in broadening the understanding of vegetation management practices already prescribed in this study area by integrating traditional and alternative approaches in managing the ecosystem.

2.0. LITERATURE REVIEW

2.1.0 MEDICINAL PLANTS AND FOREST MANAGEMENT

According to McKenney and Sarker (1994), in 1989 alone, Ontario's forests produced $128 billion in wood products, stumpage and trade surplus. However, Mitchell (1998) points out that in the past decade there has been an increased focus on non-timber values associated with forestry; especially the demand for "natural", "wild", organic food and pharmaceuticals have increased the value of new products from forests. With the increase in public demand for more non-marketed products and services (Carrow 1997), the cost benefit analysis of non-wood services from the forest must be included in the national economy (McKenny and Sarker 1994). Mohammed (1999) advocates sustainable harvest of non-timber forest products, which could generate local employment, diversify the local economy, and thereby raise the standard of living within local settings.

Forests all over the world provide more than just wood (McKenney and Sarker 1994). With the coining of the words sustainable development through the Brundtland Commission (Carrow 1997), there is an increasing trend to incorporate non-timber values; values such as recreation, remote tourism and the use of medicinal plants (McKenney and Sarker 1994). Carrow (1997) quotes Doug Little about sustainability; "the concept of sustainable management provides a new framework for renewal and management. One that invites diverse approaches to meet the goals of economic, social and environmental stability".

Although, it is difficult to estimate the non-timber value of forests, McAllister (1991) emphasizes that many pharmaceutical products such as anti-malarial quinine from cinchona bark and aspirin developed from willow bark (*Salix* spp) are of tremendous demand in the pharmaceutical industry all over the world. Recent studies indicate that taxol (*Taxus brevifolia*) is of great scientific interest, as it seems to have properties to fight cancer (McAllister 1991).

McAllister (1991) claims that most Canadian species are "taxonomically well known, identification is easier and their pharmaceutical potential is relatively well known from indigenous, folk and modern medical sources". McAllister (1991) restates his view about the value of the forests to the pharmaceutical industry when he says "if logging companies were to investigate the potential uses of bark and foliage of certain forest species, they might earn the name of forest product companies".

2.1.1. Medicinal and Other Uses of Plants Chosen for Study

Red-osier dogwood (*Cornus stolonifera* Michx., synonym *serecia*), fireweed (*Epilobium angustifolium* L), bracken fern (*Pteridium aquilinum* (L.) Kuhn), and red raspberry (*Rubus idaeus* L. var. *stringosus* (Michx.) Maxim) were chosen for this study. They are common throughout all forest regions of Canada, and are generally considered weed species that interfere with the growth of conifers. In recent years, these plants have been studied for their medicinal values both from the ethnobotanical and pharmaceutical perspectives. In many parts of North America, they are even classified as special forest products, or non-timber forest products (Mitchell 1998; Mohammed 1999). Since the early 90's, these special forest products have been gaining popularity. For example, in the Pacific Northwest of the United States the special forest product industry is growing at the rate of twelve percent annually (Freed 1996). Freed (1996) also points out, once these products are valued they will become part of the planning process along with timber management.

2.2.0. ECOLOGY AND MORPHOLOGY OF RED-OSIER DOGWOOD

Cornus stolonifera Michx., synonym *serecia,* is commonly called red-osier dogwood because of its red stems. Soper and Heimburger (1982), describe the bright red stems in winter as a "pleasing sight along roadsides and in open low ground" (p.359). This shrub is usually erect, the branches may be prostrate and form thicklets that can grow up to two or three meters. The leaves are lanceolate-ovate, simple, opposite and deciduous. Flowers are small, white, flat topped and usually in clusters. White berry like drupe fruits appear in August and September. The genus gets its name from the type of fruit it bears, stolonifera, i.e. bearing stolons (Soper and Heimburger 1982).

2.2.1 <u>Medicinal Uses of Red-Osier Dogwood</u>

The Fishermen Lake Slave First Nation collected the ripe fruits of red-osier dogwood to prepare a decoction after boiling it for half an hour. This decoction was used as a treatment for tuberculosis (Lamont 1977). Many of the Ojibwa First Nations used an infusion of the bark to treat diarrhea and poison ivy rashes; a decoction of the roots was used to wash sore eyes (Meeker *et al.* 1993). Black (1990) also noted similar uses of the bark and roots by Chippewa First Nations in Michigan. The First Nation of River Desert used the shavings from the bark to stop bleeding (Black 1990; Moerman 1998). Because of its ability to stop bleeding, Thompson First Nation women drank the decoction of leaves and bark just after childbirth (Moerman 1998). Among the Okanagan-Colville First Nation of British Columbia and Washington, women who were approaching the time of childbirth were given a decoction of alder (*Alnus crispa* and *A. tenuifolia*) leaves, after childbirth red-osier dogwood was added to the decoction. This decoction was taken for at least ten days after the delivery. Water boiled with red-osier dogwood wood and bark, or mixed with choke-cherry (*Prunus virginiana*) wood and bark was used to rinse hair, scalp, and skin. This treatment reduced dandruff and hair loss, and also stopped itchiness of the scalp. A poultice made from the inner bark, either by itself or mixed with goose oil was used to treat children with chest congestion or cold (Turner *et al.* 1980). Moerman (1998) working with different First Nations people for over twenty-five years provides evidence of more than ninety uses of this plant as a drug. A recent study by Marles *et al.* (1999) indicates that a tea made from the roots of red-osier dogwood can by used to treat dizziness.

2.2.2. Other Traditional Uses of Red-Osier Dogwood

The Okanagan First Nation of British Columbia used the dried powdered bark with resin of Cottonwood buds to make a red paint. Scewepemc of British Columbia used the flexible branches to make rims of birch-bark to line cooking pits and to make handles for steaming baskets, as well as fishing traps and weirs. Still in practice is the use the branches as skewers for barbecuing salmon; this imparts a smoky flavor to salmon. Red-osier dogwood branches do not blacken the fish and meat during the drying process, so they are quite popular among the Secwepemc First Nation as a wood fuel for smoking and drying meat and fish (Turner 1998). The smoked bark was used in certain ceremonies and as a part of smoking mixture or *kinnikinnick* (Black 1990; Meeker *et al.* 1993). To prepare the *kinnikinnick*, (a tobacco mixture) branches of red-osier dogwood having a diameter of three-quarters of an inch and about four to five feet long were cut. The outer barked was scraped with a warm knife. The knife was then used to remove the inner stem by pressing the knife and drawing it upward for six to eight inches. The fiber was wound around the pit of the branch. The branch was then roasted over hot coal till dry. Equal portions of the dried red-osier dogwood bark were mixed with tobacco to make the smoke mixture (Johnston 1970).

2.3.0. ECOLOGY AND MORPHOLOGY OF FIREWEED

Epilobium angustifolium L., is commonly called fireweed because "it blazes whenever a forest fire has raged" (Coffey 1993 p. 136), and is found mostly in disturbed and open sites. It belongs to the family Onagraceae, the genus gets its name from two Greek words, epi, meaning "upon", and lobos, meaning "a pod" or capsule; since the "flowers stand on the top of the long, thin pod-like seed vessels that look like thick flower stems" (Leek 1975 p.20).

This herb is perennial, and grows over a meter in height. The leaves are alternate, lanceolate tapering at the base. The flowers are born on a terminal spike with 4 petals that are usually purple in colour. Fruit are capsules; they burst open to release seeds. The silky hairs attached to the seed aid in dispersion (Baldwin and Sims 1997).

2.3.1. Medicinal Uses of Fireweed

The Blackfoot First Nation of Alberta powdered the inner cortex stem tissue and applied it to the exposed parts especially the face and the hands to protect them from the bitter winters. They also rubbed the flowers on raw hides and mittens to waterproof them (Hellson and Gadd 1974; Turner 1998; Moerman 1998). The Abnaki First Nations used the roots as cough medicine; Iroquis First Nation used a compound decoction as a remedy for tuberculosis (Moerman 1998). According to Lamont (1977) the Fishermen Lake Slave First Nation of Saskatchewan used the flowers as a confection item. The Flambeau Ojibwa and the Chippewa First Nations removed the rind from the roots and pounded it to make lather. A poultice from the lather of pounded root was used to cure a boil or abscess in the skin. Furthermore, Chippewa and the Ojibwa First Nation moistened fresh or dried leaves to remove slivers (Coffey 1993; Meeker *et al.* 1993; Moerman 1998). The Iroquois First Nation used the infusion of the bark as a remedy for pain. For example, a decoction of the root was taken for any internal injury caused by heavy work especially lifting. An infusion of the root was usually prescribed to men with urinary problems and kidney related diseases (Moerman 1998). In addition, Smith (1932) traced the use of fireweed among early settlers, who used the roots to reduce swelling, as a demulcent, tonic and astringent. Infusion made from roots was a remedy for a sore throat by the Snohomish First Nation (Moerman 1998).

A survey by Mater Engineering Ltd, (1993) indicated that the flavnoid from leaves of *Epilobium* had 10 times more anti-inflammatory effect than indomethacin in rats. Another western Canadian company, Fytokem, has been developing a line of products from aqueous extract of fireweed. Fireweed is one of the ingredients of their cosmetic and therapeutic products (Canadian Agricultural New Uses Council 1998). Studies by Fytokem show that an aqueous extract of fireweed reduces skin redness from inflammation by forty-one percent in twenty-four hours (Canadian Agricultural New Uses Council 1998). Fireweed extract also contains properties to safeguard against ultra-violet rays of the sun as it contains SPF 4 (Sametz and Hiermann 1998).

2.3.2. Nutritional Information

Baldwin and Sims (1997) state early European settlers fermented the older stems of fireweed to make ale. The young shoots can be used as an "asparagus-like vegetable" Dandelion leaves and flowers, as well as the tender flower shoots of fireweed have a potential to be marketed as a salad mixture (Mater Engineering LTD, 1993). Their study also revealed that gourmet salad mixture containing exotic greens, and edibles are worth as much as $12 a pound (Mater Engineering LTD 1993).

One hundred grams of fireweed leaves contain 76 grams of water, 6.5 grams of protein, 2.9 grams of carbohydrates, 1.4 and 1.8 grams each of crude fiber and ash; 88 mg of vitamin C, 22 mg of vitamin A RE (retinol equivalents). Other mineral nutrients constituting 100 grams of *Epilobium* leaves are calcium (175 mg), phosphorus (132 mg), sodium (50 mg), potassium (404 mg), magnesium (70 mg), copper (2 mg), zinc (0.9 mg), iron (2.7 mg) and less than 0.1 mg each of molybdenum and chloride (Kuhnlein and Turner 1991).

2.3.3. Other Uses of Fireweed

First Nations of the Northwestern United States used the tough stems of fireweed to make fishnets (Coffey 1993). Apiarists in the coastal regions of Oregon and Washington followed logging operations, moving every five to seven years where fireweed was abundant (Coffey 1993). The Tanana First Nation used the plant to prepare smoke for smoking fish and also as a mosquito repellent (Moerman 1998). The Haida First Nation used the inner stem as part of their diet. The outer stem-fibers were peeled and dried. Later the dried fibers were soaked in water and then twisted to make fishing nets and cordage (Turner 1998).

2.4.0. ECOLOGY AND MORPHOLOGY OF BRACKEN FERN

Pteridium aquilinum (L.) Kuhn, commonly called bracken fern, is a relatively ancient species, which can be traced from the beginning of the Quaternary in Europe (Dolling 1996). According to Dolling (1996) the increase of *Pteridium aquilinum* is a direct consequence of human activities such as felling and burning of natural forests since Neolithic times.

Pteridium belongs to the family Polypodiaceae (Baldwin and Sims 1997), some authors place it under family Hypolepidaceae (Dolling 1996). The frond arises singly from deep seated branched rhizomes. Due to the extensive branching of the rhizome, the fern often occurs in patches (Baldwin and Sims 1997). The frond lamina is single in the shape of a triangle or a delta. They are tri-pinnate, opposite in arrangement on the rachis, with a single upper pinna smaller and undivided (Dolling 1996; Baldwin and Sims 1997). Spores are produced on the underside of mature pinnulets (Balwin and Sims 1997). The spore production is common after the plant is three to four years old, by this time the rhizome growth is restricted. The spores germinate to form prothalli male and female gametophytes. The gametophytes give rise to sporangia, which later disperse to form the sporelings (Dolling 1996). Dolling (1996) points out that development of prothalli is difficult under natural conditions, especially under its own shade. However, there are reports of prothalli development in fire disturbed soil, and brickwork (Dolling 1996). Conway and Stephens's study in 1957 showed a high germination rate of prothalli when enriched with potassium and ammonium ions.

2.4.1. Medicinal Uses of Bracken Fern

The rhizome of bracken fern is the most popular part used in medicines. The Cherokee First Nation used the roots probably as a health tonic, as an antiseptic, for treating children infected with intestinal worms, and for treating cholera (Hamel and Chiltoskey 1975; Moerman 1998). Thompson First Nation used the inner tissue as a cure for intestinal worms (Turner *et al.* 1990). A poultice prepared by pounding the rhizome was plastered over broken bones to mend them; the fronds were also used to help mend bones, or applied to sores. An infusion made from the rhizomes was said to be a good medicine for vomiting caused by internal injuries. A decoction made from the rhizome was also used as a treatment for common cold and lack of appetite. To cure arthritis, a person laid on top of fronds placed over a steaming pit. The steaming pit was filled with an infusion made by boiling leaves of bracken fern (Turner *et al.* 1990). The Costanoan First Nation used a decoction of the root for rinsing the hair. A paste made from the root was rubbed in the scalp. This therapy promoted growth of hair (Moerman 1998; Bocek 1984). The Carrier First Nation used the steam cooked rhizome as an accompaniment with fish or meat. Makah First Nation of North America uses fiddleheads as a remedy for toothaches. The Pomo, Kashaya First Nations use the curled frond juice as body deodorant (Moerman 1998).

2.4.2. Nutritional Information

Kuhnlein and Turner (1991) suggest that 100 grams of fresh root of bracken fern contain about 9 grams of protein. An equal portion of the stems, leaves and shoots contains about 1250 RE of vitamin A. Most First Nations warn people of using the older fronds as food because the older fronds contain carcinogenic compounds. Pakeman and Marrs (1992) state that there is a correlation between the high occurrence of this species and cancer and Lyme disease in humans. This species is considered to provide habitat for sheep ticks, which are responsible for the spread of various diseases among sheep and grouse (Pakeman and Marrs 1992).

2.4.3. Other Uses of Bracken Fern

Throughout North America, the rhizome is boiled and eaten, while fiddleheads and the rhizome are popular in the Orient (Baldwin and Sims 1997). The Pemberton Stl'atl'imx First Nation gathered the rhizomes in early spring when they were just sprouting and roasted them in hot coals to remove the outer rhizome. The inner tissues were pulverized to remove the fibrous parts; after this process the pulverized part was either turned into a loaf, or eaten as candy (Turner 1997). The Thompson First Nation of

British Columbia also harvested the rhizome during fall and spring. Rhizomes were then dried and roasted over fire, then the outer bark was removed. The inner tissues were used as an accompaniment with fish (Turner *et al.* 1990). The Nuu-chah-nulth, Kwakwaka'wakw, and Oweekeno used the dried fibrous, non-edible rhizome as "slow matches". When bound with cedar bark or enclosed within clamp shells, the fibers from the rhizome can hold fire for many hours and sometimes even days (Turner 1998).

2.5.0. ECOLOGY AND MORPHOLOGY OF RED RASPBERRY

Rubus idaeus L. var. *stringosus* (Michx.) Maxim, commonly called red raspberry is a common shrub found all over Canada and the Boreal Forest. This biennial shrub grows to a height of 1.5 meters (Soper and Heimburger 1982). The first year vegetative stems are called primocanes and the second year stems bearing fruits are called floricanes (Soper and Heimburger 1982). The stems are reddish in colour and are thorny (Naegele 1996).

Leaves are alternate, pinnately compound, and deciduous. The primocanes usually have three, five, or seven leaflets, while the floricanes are trifoliate (Soper and Heimburger 1982). The flowers develop at the end of the branch either in terminal clusters of two or five, or single later (Soper and Heimburger 1982; Balwin and Sims 1997). The flowers appear in June and July, the petals are white to greenish in colour. The fruits mature by July- August and are red in color (Balwin and Sims 1997).

2.5.1. Medicinal Uses of Red Raspberry

Most of the medicinal properties of red-raspberry are contained in its leaves. A decoction, or tea, made from the leaves is an astringent and is also as a treatment for diarrhea and dysentery especially for children in summer (Leek 1975; Erichsen-Brown 1979; Naegele 1996; Mabey 1988). The fruit when chewed removes tartar deposits from the teeth. Tea made from the leaves and used as a gargle alleviates soreness throat and irritation (Nagele 1996). Tea made either from the leaves or roots can be used as a wash to heal wounds and sores (Nagele 1996).

Rubus is the herb most suited for women (Leek 1975; Mowrey 1986). Tea made from the leaves "aid in parturition" (Leek 1975, Mabey 1988) if taken regularly during pregnancy. A study conducted by Mowrey (1986), showed that smooth uterine muscles were relaxed if the muscle was in contraction and visa versa if it was in tone. Mabey (1988), and Naegele (1996), suggest raspberry leaf taken during the last three months of pregnancy aids in labour free of muscular spasms. An infusion made from raspberry leaves and drank like tea also "enriches and encourages the flow of mother's milk" (Mabey 1988 pp. 105). According to Meeker *et al.*(1993), Ojibwa First Nations used a decoction made from the root to treat dysentery, measles, and stomach pain. Also in Chinese medicine, the fruit are used to strengthen the functioning of the kidneys and to treat enuresis (Mabey 1988). An infusion of root bark was used by the Ojibwa First Nation as well as the Potawatomi First Nations, for washing the eyes, probably to treat conjunctivitis (Naegele 1996; Meeker *et al.* 1993).

According to Bisset and Wichtl 1994, and Naegele 1996, syrup made from the fruits is an official pharmaceutical preparation. The roots have pharmaceutical properties that can be sold to the drug companies. Syrup made with leaves and fresh juice of the fruits taken with white wine is said to have beneficial properties to the heart (Lust 1974).

2.5.2. Nutritional Information

The fruit is rich in vitamin C and iron (Mabey 1988), 100 grams of the fruit contain about 1 mg of iron and 22.3 mg of vitamin C (Kuhnlein and Turner 1991). One hundred grams of the fruit contains 65 kcal of food energy, 83 grams of water, 0.6 grams of protein, 0.8 grams of fat, 15.8 grams of carbohydrates, 4.5 grams of crude fiber, 0.03 mg of thiamin, 0.09 mg of riboflavin, 0.1 gm of niacin and 13 RE of vitamin E. Other important mineral constituents are calcium 36 mg, phosphorus 38 mg, sodium 0.4 mg, copper 0.5 mg, zinc 0.6 mg, manganese 2.8 mg and less than 0.01mg of molybdenum (Kuhnlein and Turner 1991). The fruit also contains high levels of tannin and polypeptides (Naegele 1996).

2.6.0. VEGETATION MANAGEMENT

The genesis of vegetation management can be traced to agriculture, where the unwanted plants or "weeds" were eliminated. More recently, vegetation management has been associated with forest vegetation management where the focus is to reduce the influence of weeds by manipulating crop and non-crop populations. Vegetation management is a tactical discipline of weed control that recognizes that a plant species considered weeds in one situation many be a desirable species in another (Walstad and Kuch 1987). Walstad *et al.* (1987) state "vegetation management should consider both the positive and negative aspects of controlling vegetation….represents a reasonable balance between relatively short-term production goals and longer term ecological stability"(p. 37).

The use of herbicides can be traced from 146 A.D. where English and Roman farmers realized that certain substances could be used to control vegetation. Salt was used to reduce unwanted crops in agriculture, e.g., salt was used to sterilize soil and selectively kill thistle in a wheat field (cited in McLaughlan *et al.* 1996). Similarly in forestry today, there has been an increased use of herbicides to control species considered not valuable to the timber industry. The approach followed by the agriculture sector has been adopted by the forest industry i.e. to rely on herbicides.

Wagner (1994) indicates, vegetation management has concentrated on enhancing the survival and growth of desired species. This manipulation could alter the path of forest succession, thus directly or indirectly affecting the ecosystem. Wagner (1994) recommends consideration of the effects on other ecosystem components when prescribing treatments for vegetation management.

2.6.1. Herbicide Use and Public Response

For nearly half a century, foresters have been managing northern conifer forests and big game habitat with the use of herbicides (Sullivan *et al.* 1996). However, public uproar in the past two decades has led to the restriction of herbicide use in five Canadian provinces (Wagner 1994). For example, in Alberta, between 1980-84, 891 hectares of forested land were treated, compared to only four hectares in 1988. In contrast, areas treated manually or mechanically increased from 3105 hectares to 9946 hectares during the same period (Ehrentraut and Branter 1990). In Manitoba, forest managers have also restricted the use of herbicides thus gaining public acceptance for this treatment (Campbell 1990).

According to a study conducted by Campbell (1990), Ontario topped the list in 1988, for magnitude and intensity of herbicide use in forest management followed by New Brunswick. In 1994, Wagner *et al.* conducted a survey throughout Ontario to gain an understanding of public perceptions of risks on issues surrounding vegetation management, and the continuing use of herbicide in the forest industry. Based on this study, Wagner *et al.* (1998) conclude, although the public in Ontario supported vegetation management that assists the growth of commercially important species, they are selective about the method chosen to limit "weed species". The public rated the use of herbicides as the most unacceptable method. They perceive potential risks to humans and wildlife; and herbicides limit the forest from its own process of recovery after disturbances. Alternatives to herbicide, such as manual cutting, animal grazing, cover crops, and mulches were more acceptable methods to control unwanted vegetation. Buse *et al.* (1995) identifies some reasons why public involvement is important in forestry issues. The public wants to be a participant in decisions involving public land. Their views are an important aspect of social science, influencing decisions in many aspects of forestry. Besides these reasons, decisions taken with public cognizance provide authority, legitimacy for decisions, and can provide creative solutions to certain problems.

2.7.0. HERBICIDE GLYPHOSATE AND ITS ACTION

In Ontario alone, about twenty-one herbicides are registered for use in the forest industry. In 1989-1990, out of these twenty-one herbicides, glyphosate, and 2,4-D, hexazinone and simazine accounted for 99.5 % of use (Campbell 1990). Glyphosate has gained popularity in the forest industry. It is a broad spectrum herbicide useful for controlling annuals, perennials, and wood species. Glyphosate is applied when the target species are actively growing, and there have been good results from fall applications just before frost turns the colour of the leaves (McLaughlan *et al.* 1996).

Glyphosate (GLYPH) is N-(phosphonomethyl) glycine, a broad-spectrum, non-selective, post emergent herbicide. It can be used on most annual and perennial species. Glyphosate is considered to be environmentally safe as it adheres to the soil particles, and is metabolized by soil microorganisms to produce phosphoric acid, ammonia, and carbon dioxide (Franz 1985; Sutton 1978). Depending on the microbial activity in soil, glyphosate will dissipate in soil within a few days; glyphosate in soil has an average half-life of about 60 days (Chourmouzis *et al.* 1996). Roy *et al.*'s (1989) study shows glyphosate is non-leachable recovering ninety-five percent from 15-30cm of the organic soil layer.

However, a recent study by Cox (1998) shows glyphosate products containing ammonium sulfate or benzisothiazolone can cause permanent eye damage in humans. Glyphosate can impact the ecology and habitat of several non-targeted species probably due to destruction of their habitat by the herbicide. For example, in North Carolina wheat field populations of large carabid beetles declined after treatment with glyphosate product and their population did not recover until 28 days after treatment (Cox 1998).

2.7.1 Mode of Action of Glyphosate

The action of glyphosate is associated with the inhibition of meristematic activities. Translocation of glyphosate takes place through the leaves and other chlorophyll containing parts. Translocation within the plant involves cell-to-cell movement, symplastic movement (movement through the plasmodesmata) within the phloem tissues and apoplastic movement (movement through the cell wall space) within the xylem system. This way the herbicide is transported throughout the meristematic tissues of the plant system. Accumulation of glyphosate in the meristem of the plant inhibits all other activity of the plant and thus kills the plant (Caseley and Coupland 1985).

Glyphosate is only effective on actively growing plants (Chourmouzis 1997). The raspberry endosperm is protected by a thick endocarp. This helps the seed to remain viable in soil for many years (Lautenschlager 1991). A study by Lautenchlager (1991) indicates that freshly collected raspberry seed from the wild has a low germination rate. It takes at least five years of alternate exposure of heat and cold to stimulate germination in raspberry seed. A six-year study conducted by Freedman *et al.* (1993) in Nova Scotia after a clearcut area was sprayed by glyphosate, shows that raspberry regeneration from the natural seed bank even after glyphosate spraying could be prolific. The seed banks are exposed, the raspberry seeds survive for a long time in the soil, and only mature plants are killed by glyphosate action in the year they are sprayed. During the postspraying succession years, the raspberry re-establishes itself (Freedman *et al.*1993). Under suitable conditions of temperature and soil, the species spreads in quick succession with the establishment of rhizomes and sprout from the root collar (Freedman *et al.* 1993).

2.7.0. HERBICIDE TRICLOPYR AND ITS ACTION

Triclopyr is an auxin type of post-emergent herbicide belonging to the pyridine family (Roy *et al.* 1990). It provides good control of woody annual and perennial broadleaf species considered weeds. The foliage or stems absorb the esters of triclopyr, under Canadian environmental conditions. The exact mode of its action is not clear yet, but studies show that triclopyr, is transported both through the xylem and phloem tissues of the plant and collects at the meristematic tissues. Triclopyr is very effective in controlling broad-leafed vegetation, although it has been in use for some time in the northern forests of United States, it is just beginning to gain popularity with users in Canada (Roy *et al.* 1990). A study by Morash and Freedman (1988), suggests triclopyr is absorbed by the roots and foliage, and that a high concentration (> 50 ppm) affects the germination of seeds from seed-banks. However, in silvicultural application such high concentrations are not used (Morash and Freedman 1988).

Triclopyr is not effective for grasses (McLaughlan 1996; Stephenson *et al.* 1990). Buse and Bell's (1992) study indicates red-osier dogwood, red raspberry, and fireweed are susceptible to triclopyr; while bracken fern is quite resistant to this treatment. In the United States, triclopyr has been in use for quite some time, however, in Canada, its use as a herbicide is quite recent (Roy *et al.* 1990).

2.8.0. EFFECT OF MANUAL CUTTING ON SELECTED PLANTS

The Falling Snow Ecosystem Project used two different types of manual cutting, one using Stihl and Husquavarna professional cleaning saws also known as brush saws, the other using a Silvana Selective/Ford Versatile cleaning machine which consists of modified Ford Versatile model 9030 bidirectional tractor and Silvana Selective cutting head supported by a parallelogram broom (cited in Bell *et al.* 1997a). The brush saw and Silvana were effectively used to remove vegetation between 18 cm and 33 cm above the ground level respectively (Bell *et al.* 1997b). The difference between the two types of mechanical cutting is the type and height of cut. The brush saw has a cleaner cut than the Silvana Selective; the cutting head of Silvana Selective shatters the stem at the point of impact, leaving a ragged cut and damage extending 7.4 cm mean with a standard error of (±) 4.8 down from the height of the cut (Bell *et al.* 1997b). This method reduces the stem's ability to heal and is therefore susceptible to fungal infections. The cuttings in this project were done between October and November of 1994, i.e. late in the growing season (Bell *et al.* 1997b). Buell (1940) advises the best time to achieve results to favor silvicultural efforts is to cut during July or August; however, for obtaining high quality of dogwood, winter cutting is the best. Archambault *et al.*(1998), conducted a study of forest succession after clear cutting over a 20-year period in eastern Quebec and noticed reduction of red raspberry from sixty percent, five years after harvest to a mere two percent in twenty years. During the same period, fireweed decreased from twenty percent to virtually nothing. These two species are early colonizers and compete with conifers in the first ten years after logging. Once the canopy is formed they will be conspicuously absent from the site (Archambault *et al.*1998).

3.0 MATERIALS AND METHOD

3.1. Study Area and Treatments

The Falling Snow Ecosystem Project is located 60 km southwest of Thunder Bay, Ontario, (48.8^0-13'N, 89^0.49-53W at 380 to 550 m above sea level) in Fraleigh Township, Section L 11, a transition zone in the Great-Lakes-St. Lawrence Forest Region (Rowe 1972). There are four blocks in the project site, each varying between 28–52 ha, designed as completely randomized blocks. Within each block there are four conifer release treatments, and a control. The four conifer release treatments are: 1) motor-manual release (brushsaw); 2) mechanical release with Silvana Selective /Ford Versatile; 3) aerial applied Release®, a silvicultural herbicide whose main ingredient is triclopyr; 4) aerially applied Vision®, another silvicultural herbicide, glyphosate being its main component; 5) control, no treatment (Bell *et al.* 1997b). All the blocks were harvested between 1986 and 1990; then planted between 1987 and 1991, with bareroot stock of *Picea mariana* (Mill.) B.S.P. in block one, and *Picea glauca* (Moench) Voss in blocks two, three, and four (Bell *et al.* 1997b; Simpson *et al.* 1997). Conifer release treatments in the four blocks were applied in 1993 (Bell *et al.*1997 a).

4.1.2. Sampling Methods

Field work and sampling were done from the middle of June to the end of August, 1999. For the purpose of this thesis, I sub-sampled within each block for the abundance of the chosen species (Figure 1). Within each block, line transects two meters wide, running north to south, or vice versa were drawn with a random start. Care was taken to avoid transects between treatments.

In block one and block three, I selected six (60m X 60 m) plots at random within each treatment as each of these blocks were the largest at 37.3 ha and 51.8 ha respectively. Block two and four are 27.7 ha, and 32.1 ha respectively. In these later blocks, I selected four (60 X 60 m) plots at random within each treatment. Within each of the 60m X 60m plots, a 2 meter wide transect was laid, on the north or south edge (Figure 1). Each of the 60 X 2 m transect was sub-divide into thirty, 2m X 2m sub-plots. 2X2 meter sub-plot was best suited to cover a considerable area for sampling in all the four blocks. Square plots were also ideal for using adaptive cluster sampling described by Thompson (1991). A total of 3,000 sub-plots were covered in the four blocks. The percentage cover for *Epilobium*, *Pteridium*, and *Rubus* was estimated visually within the sub-plots.

For measuring *Cornus stolonifera*, I used adaptive cluster sampling with primary and secondary sampling plots as shown in Figure 2 (Thompson 1991). Red-osier dogwood generally is clumped due to extensive vegetative reproduction. Thompson (1991) used adaptive cluster sampling to sample animal species that tend to remain in a group e.g. schools of whales. An initial criterion has to be chosen, in this study the average number of stems in one clump was ten. So, for the purpose of this study, an initial criteria of ten stems of red-osier dogwood per 2m X 2m was used. Within the transects, at the site of the first occurrence of ten stems of red-osier dogwood, the first sampling plot was selected (primary sampling plot). Additional plots called secondary sampling plots were added to this primary sampling plot, until no more plots with 10 stems of red-osier dogwood were available around the primary sampling plot. Plots not containing dogwood species were also added; these were called the edge plots and formed the boundary for each network of plots. A network consists of primary, secondary, and edge plots as illustrated in Figure. 2 (Thompson 1991).

One way analysis of variance (ANOVA) was computed using Excel and Data desk to find any statistical difference between the treatments for fireweed, bracken fern, red raspberry and red-osier dogwood. ANOVA residuals for normality and homogeneity of variance were tested. Based on the tests it was decided that arcsine squareroot transformation was best suited for species fireweed and bracken fern, while log transformation was suitable for red raspberry. This transformation was done to reduce variation between the treatment averages. For the species red-osier dogwood, no transformation was required.

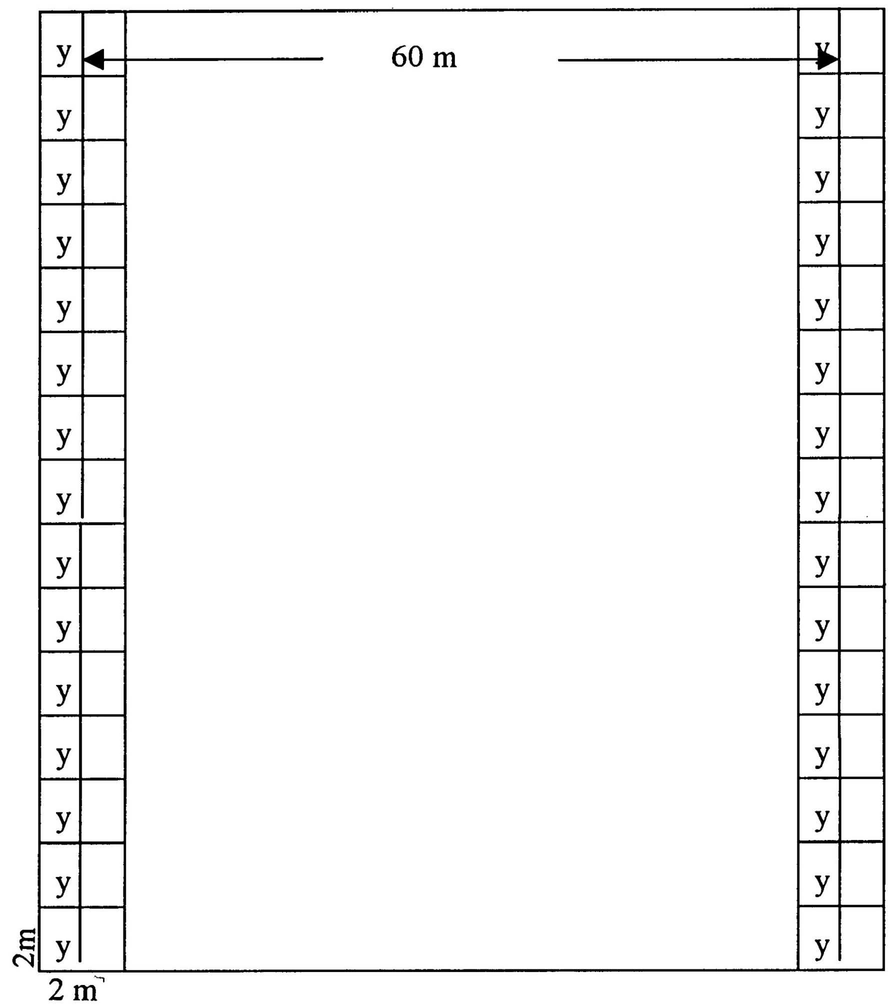

Figure. 1. Sampling plots for measuring *Epilobium*, *Pteridium*, and *Rubus*. y=2X2 m sampling plots

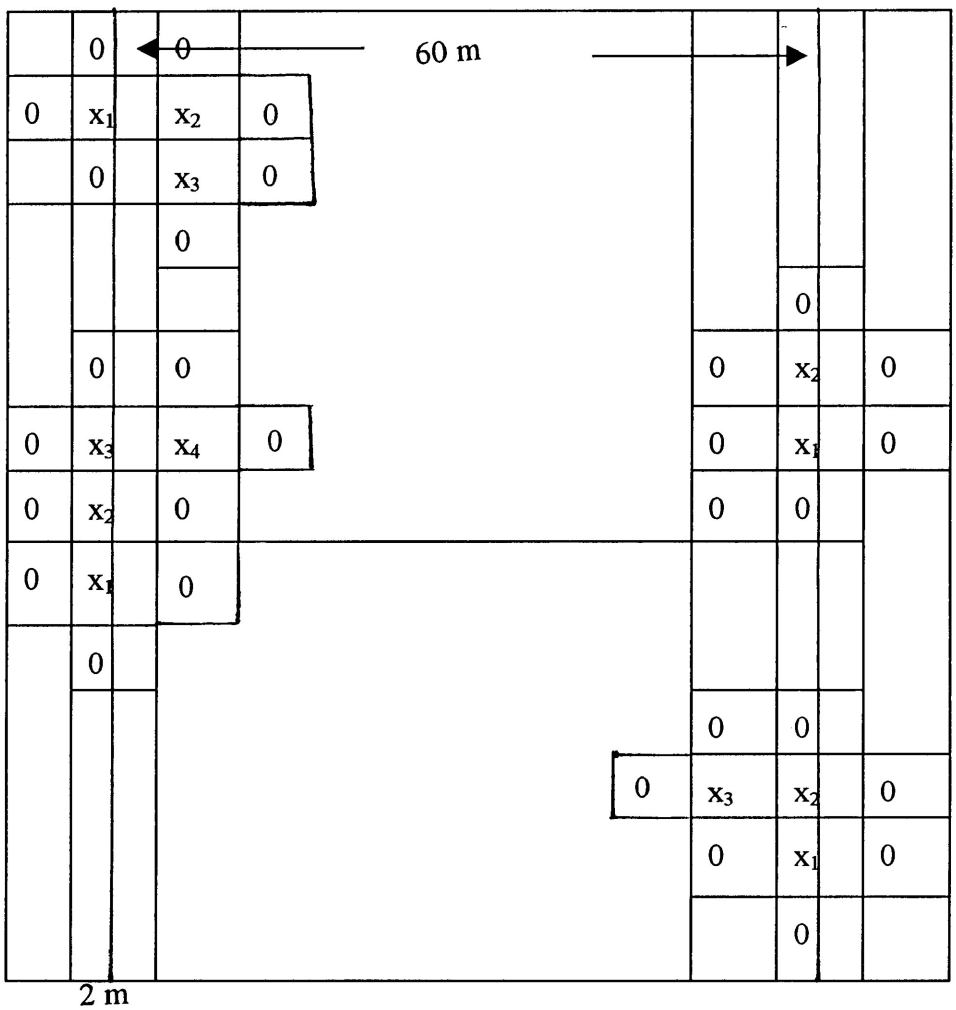

Figure 2. Networks describing adaptive cluster sampling with primary and secondary plots (Thompson 1991). x_1 = primary sampling plot, x_2, x_3..= secondary sampling plots, 0 = edge plots.

4.0 RESULTS

4.1. Analysis and Results

The results of one way ANOVA both with and without the transformation are summarized in tables 1-11.

Table 1. Estimated foliar cover of *Epilobium angustifolium* by treatment and block (without transformation)

Treatment	Block 1	2	3	4	Treatment average [%] cover	Variance
Vision	9.633	5.125	1.567	2.292	4.654	13.376
Release	6.483	1.300	1.217	0.108	2.277	8.158
Brushsaw	8.011	3.558	0.600	1.750	3.480	10.608
Silvana	0.872	1.817	2.400	1.433	1.631	0.414
Control	4.289	4.517	0.578	1.583	2.242	3.856
Block average	5.858	3.263	1.272	1.433	2.957	----
Variance	11.650	2.768	0.574	3.856	----	----

Table 2. Estimated foliar cover of *Epilobium angustifolium* by treatment and block (with arcsin squareroot transformation)

Treatment	Block 1	2	3	4	Treatment average [%] cover	Variance
Vision	0.074	0.052	0.016	0.023	0.041	0.0007
Release	0.065	0.013	0.012	0.001	0.023	0.0008
Brushsaw	0.082	0.036	0.006	0.018	0.035	0.0011
Silvana	0.009	0.018	0.024	0.014	0.016	0.00004
Control	0.043	0.046	0.006	0.016	0.028	0.0003
Block average	0.055	0.033	0.013	0.014	0.029	----
Variance	0.0008	0.0003	0.00005	0.000006	----	----

Table 3. ANOVA of arcsin squareroot abundance of *Epilobium angustifolium* in response to four silvicultural treatments in all four blocks of Falling Snow Ecosystem Project

Source of Variation	df	SS	MS	F	P-value	F-critical
Block	3	0.0058	0.0019	no test	----	----
δ	0	no est	no est	no test	----	----
Treatment	4	0.0015	0.0004	1.3011	0.3241	3.2591
Error	12	0.0036	0.0003	----	----	----
Total	19	0.0109	----	----	-----	-----

δ = Restriction error; est = estimate.

Table 4. Estimated foliar cover of *Pteridium aquilinum* by treatment and block (without arcsin squareroot transformation)

Treatment	Block 1	2	3	4	Treatment average [%] cover	Variance
Vision	1.433	4.050	8.061	3.854	4.351	7.537
Release	0.000	0.000	8.183	19.700	6.971	86.896
Brushsaw	0.644	4.592	3.983	9.425	4.661	13.098
Silvana	0.694	4.592	3.983	9.425	6.153	13.707
Control	1.339	4.733	0.450	9.400	3.981	16.460
Block average	0.822	4.402	5.542	10.127	5.223	----
Variance	0.341	9.388	10.976	33.871	----	----

Table 5. Estimated foliar cover of *Pteridium aquilinum* by treatment and block (with arcsin squareroot transformation)

Treatment	Block 1	2	3	4	Treatment Average [%] cover	Variance
Vision	0.014	0.041	0.086	0.039	0.045	0.0009
Release	0	0	0.087	0.2022	0.072	0.0092
Brushsaw	0.005	0.047	0.040	0.095	0.047	0.0014
Silvana	0.007	0.087	0.0727	0.084	0.063	0.0014
Control	0.014	0.048	0.005	0.095	0.040	0.0017
Block Average	0.042	0.223	0.291	0.514	0.053	----
Variance	0.00003	0.00010	0.00126	00.00362	-----	-----

Table 6. ANOVA of arcsin squareroot abundance of *Pteridium aquilinum* in response to four silvicultural treatments in all four blocks of Falling Snow Ecosystem Project

Source of Variation	df	SS	MS	F	P-value	F-critical
Block	3	0.0229	0.0077	4.4704	-----	-----
δ	0	no est	no est	no test	----	
Treatment	4	0.0029	0.0007	0.4259	0.7872	3.2591
Error	12	0.02057	0.0017	-----	-----	-----
Total	19	0.04648	-----	-----	-----	-----

δ= Restriction error; est = estimate

Table 7. Estimated foliar cover of *Rubus idaeus* by treatment and block (without transformation)

Treatment	Block 1	2	3	4	Treatment average [% cover]	Variance
Vision	9.483	5.758	5.867	5.008	6.529	4.024
Release	22.483	5.875	1.344	2.658	8.090	95.693
Brushsaw	8.094	5.292	1.278	3.950	4.654	8.046
Silvana	12.172	3.825	3.222	4.642	5.965	17.461
Control	9.044	5.967	2.989	0.925	4.731	12.551
Block average	12.256	5.343	2.940	3.437	5.994	----
Variance	34.981	0.788	3.489	2.775	----	----

Table 8 . Estimated foliar cover of *Rubus idaeus* by treatment and block (with log transformation)

Treatment	Block 1	2	3	4	Treatment average [%]cover	Variance
Vision	0.977	0.760	0.768	0.700	0.801	0.015
Release	1.352	0.769	0.129	0.420	0.669	0.276
Brushsaw	0.910	0.720	0.110	0.600	0.584	0.118
Silvana	1.090	0.580	0.510	0.670	0.711	0.067
Control	0.960	0.780	0.480	-0.03	0.543	0.187
Block average	1.056	0.722	0.397	0.471	0.662	----
Variance	0.032	0.006	0.078	0.091	----	----

Table 9. ANOVA representing abundance of *Rubus idaeus* in all four blocks of Falling Snow Ecosystem Project

Source of Variation	df	SS	MS	F	P-value	F-critical
Block	3	1.326	0.442	no test	-----	-----
δ	0	no est	no est	no test	----	----
Treatment	4	0.168	0.042	0.763	0.569	3.259
Error	12	0.661	0.055	-----	-----	-----
Total	19	2.155	-----	-----	-----	-----

δ= Restriction error; est = estimate

Table 10. Estimated foliar cover of *Cornus stolonifera* by treatment and block (without transformation)

Treatment	Block 1	2	3	4	Treatment Average [%] cover	Variance
Vision	27.5	20	38.57	43.33	32.35	111.765
Release	10	38	32.08	0.00	20.02	323.308
Brushsaw	43.85	27.5	31.72	20	30.78	99.558
Silvana	11.67	21	51.11	0.00	20.95	478.216
Control	3.33	17.5	34.22	31.92	21.74	205.430
Block average	19.27	24.8	37.54	19.05	25.27	----
Variance	267.422	68.075	64.980	370.466	----	----

Table 11. ANOVA of abundance of *Cornus stolonifera* in response to four silvicultural treatments in all four blocks of Falling Snow Ecosystem Project

Source of Variation	df	SS	MS	F	P-value	F-critical
Block	3	1127.091	375.670	no test	-----	-----
δ	0	no est	no est	no test	----	----
Treatment	4	556.021	139.005	0.6560	0.6315	3.259
Error	12	2527.740	210.645	-----	-----	-----
Total	19	4210.851	-----	-----	-----	-----

δ= Restriction error; est = estimate

Figures 3-6 represents the percentage covered in all the four treatments and plots which were obtained as a result of random sampling. For details of percentage cover is given in APPENDIX (I-IV).

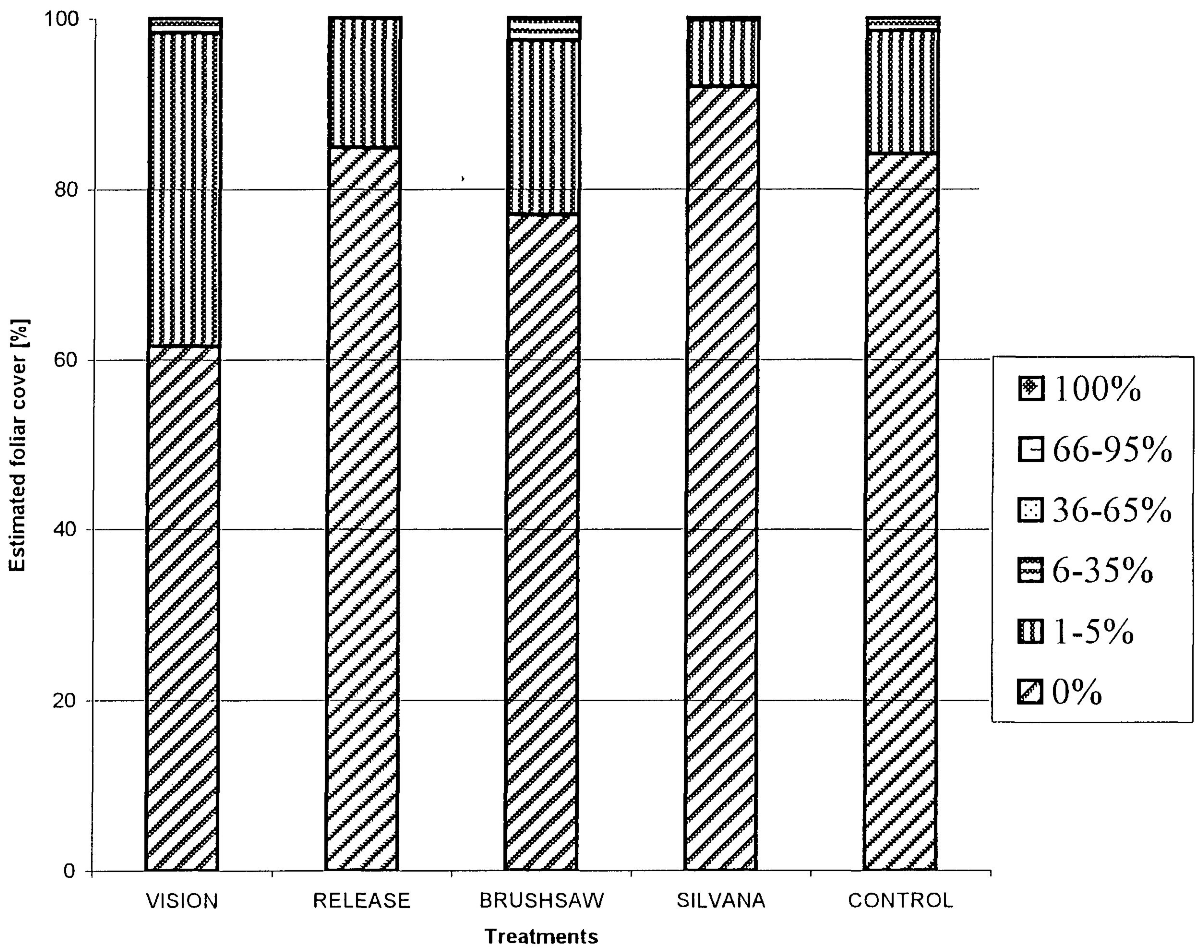

Figure 3. Estimated average foliar cover [%] for fireweed in all the four treatments and control in Falling Snow Ecosystem Project

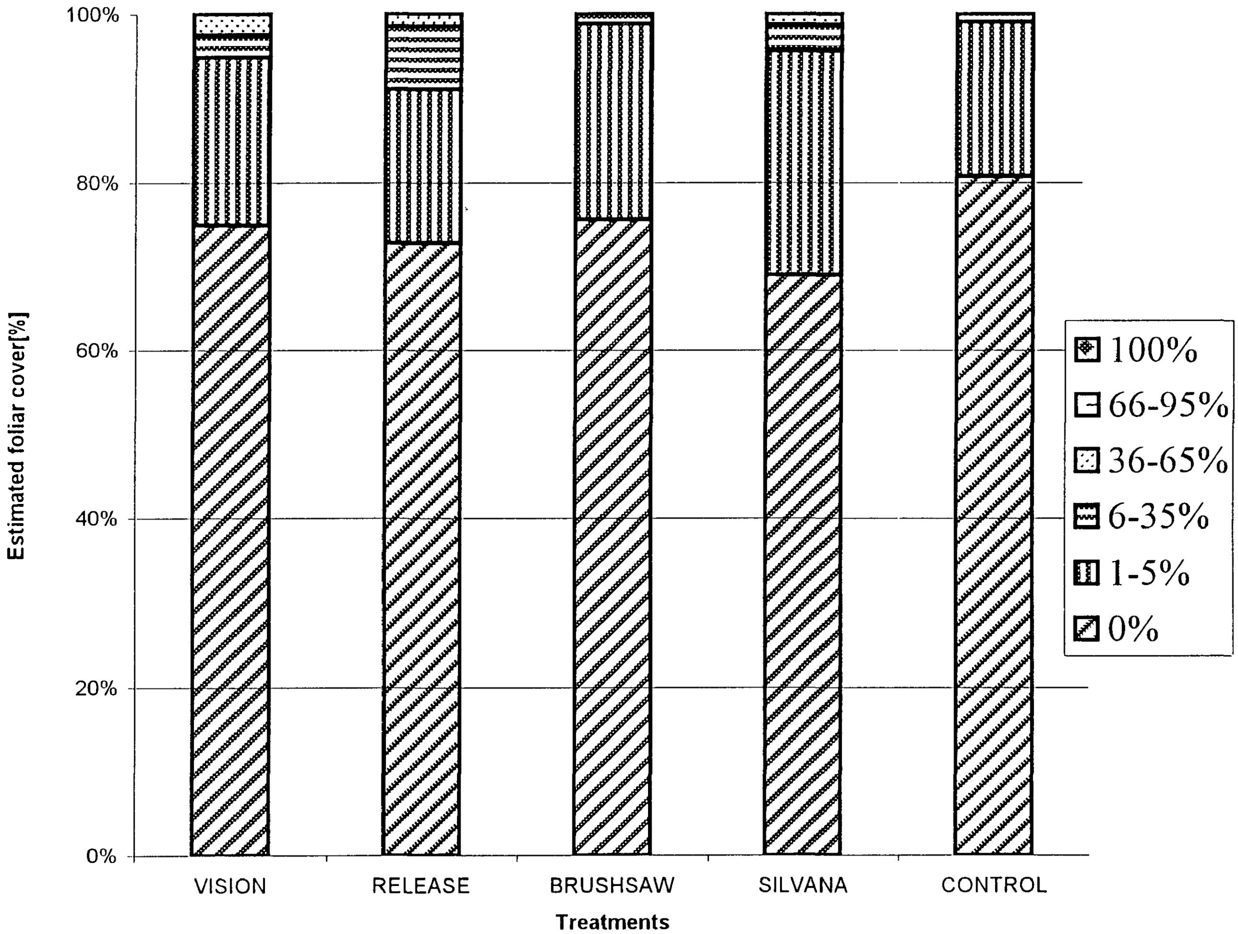

Figure 4. Estimated average foliar cover [%] for bracken fern in all the four treatments and control in Falling Snow Ecosystem Project

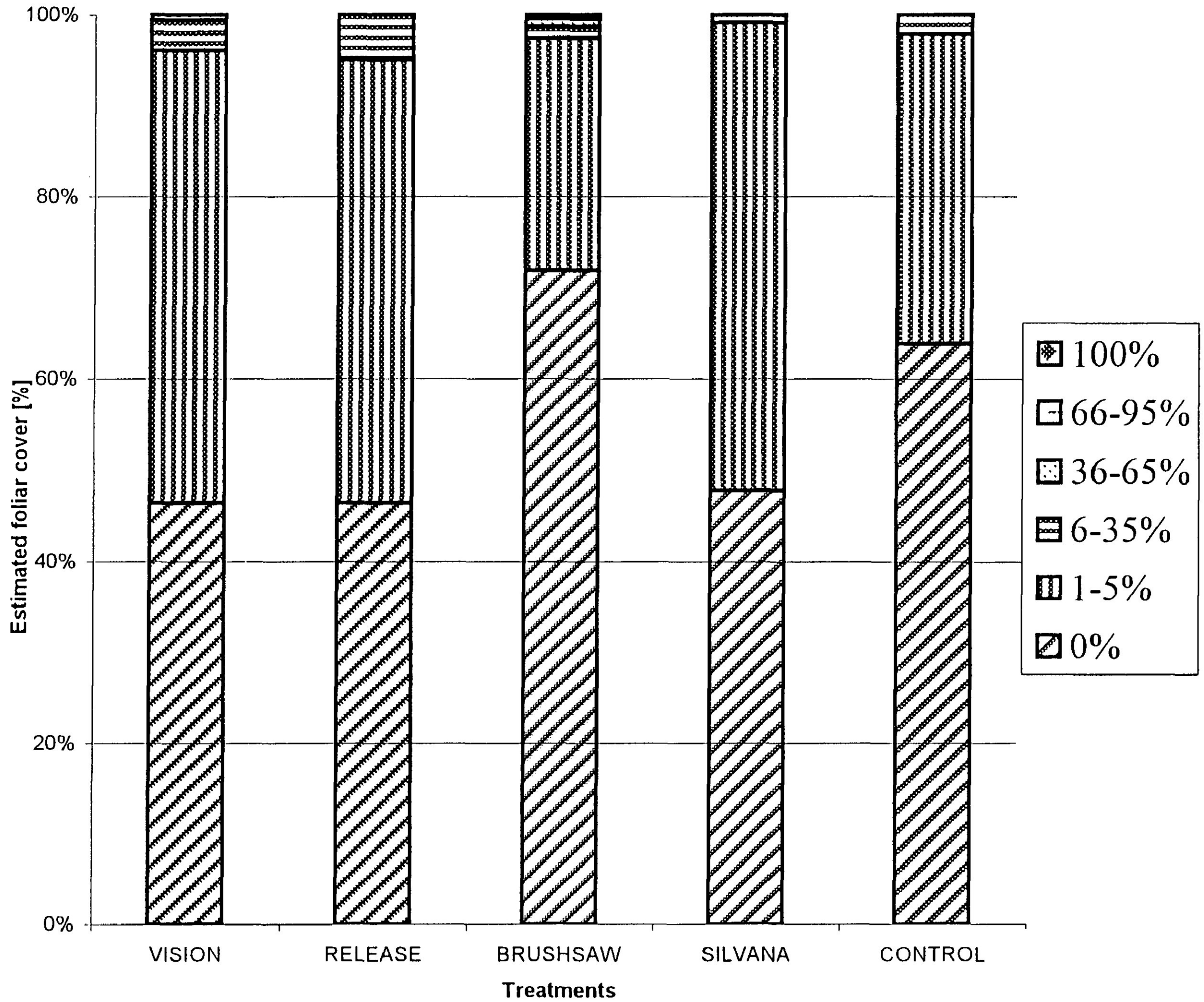

Figure 5. Estimated average foliar cover [%] for red raspberry in all the four treatments and control in Falling Snow Ecosystem Project

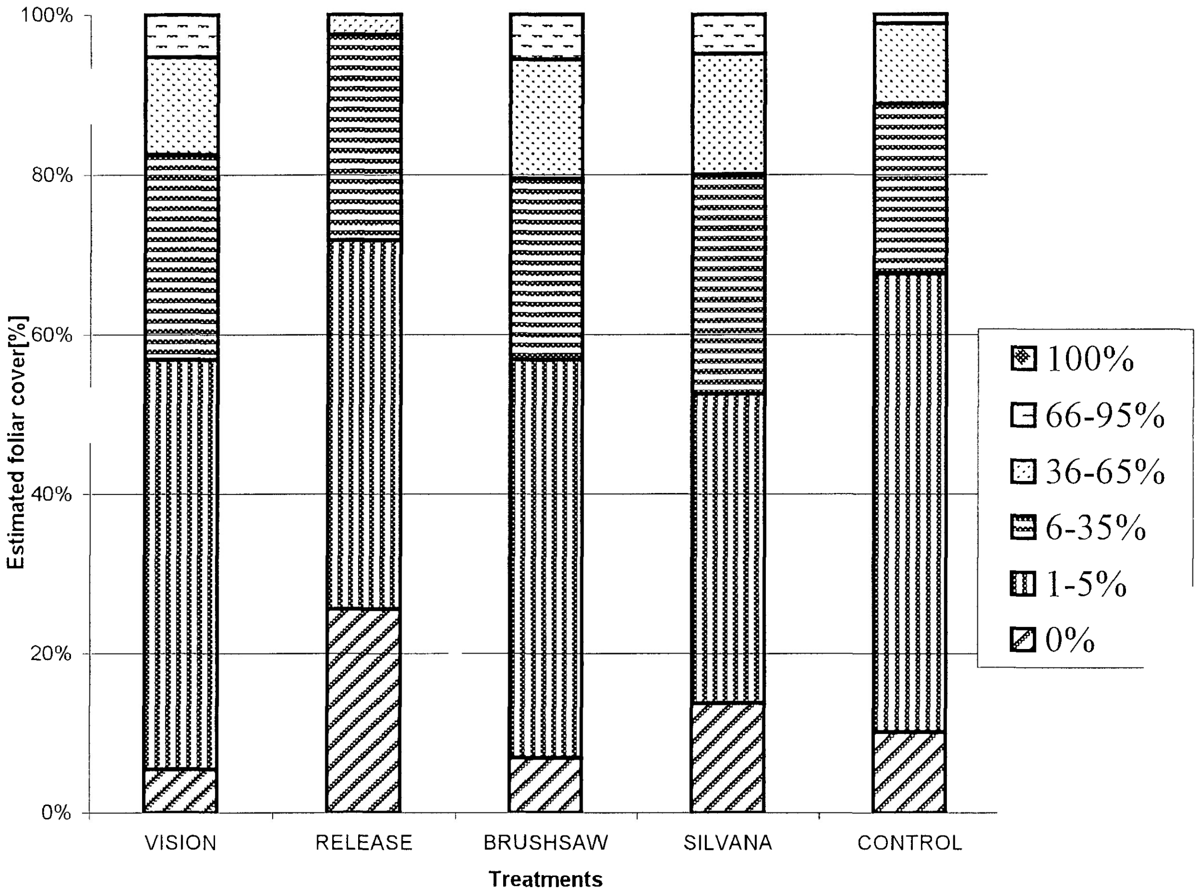

Figure 6. Estimated average foliar cover [%] for red-osier dogwood in all the four treatments and control in Falling Snow Ecosystem Project

One way analysis of variance (ANOVA) shows no difference by treatments in the percentage cover value for, fireweed, bracken fern, red raspberry, and red-osier dogwood at the 95% confidence level. Because of the pioneering nature of the study, the statistical significance may have limited value in forwarding the understanding of these selected species by the chosen treatments. Therefore knowing the percentage distribution of each of these selected species can be valuable for future research. The following paragraphs discuss the percentage distribution of each of the selected species provided in Figures 3-6.

Figure 3 shows the percentage distribution pattern of fireweed in the four treatments and control. For example, in the vision treated area, fireweed shows a slight abundance. This finding supports research (Sullivan *et al.*1996) that glyphosate (an active ingredient in Vision) is effective in controlling both herbs and shrubs thus creating open areas where fireweed can thrive. Hence, creating an abundance of fireweed in glyphosate treated areas.

Figure 4 shows the distribution of bracken fern in the four treatments and the control. This Figure shows relatively no difference in the distribution pattern except in the control area where the distribution appears less than the treated areas. This is probably due to the canopy cover in the control, which does not allow bracken fern to grow back with vigor.

Figure 5 shows the percentage distribution of red-raspberry in the four treatments and the control. This species appears to be resilient as almost 50% show a 1-5% distribution for Vision, Release and Silvana. Studies have shown seeds of red-raspberry can remain viable in the soil for a long time (Lautenschager 1991). However, in the brushsaw area values for the 1-5% distribution are lower but the distribution of cover between 36-65% is higher than the other treatments. This may be a result of brushsaw not being uniformly used when applying this treatment. Thus, the brushsaw treatment may be most similar to the control.

Figure 6, confirms the result that triclopyr (active ingredient in Release) is effective in controlling broad-leaf vegetation e.g. red-osier dogwood (Roy *et al*. 1990; Buse and Bell 1992). The fact that the difference is not statistically significant is probably because the treatments were only applied once to the Falling Snow Ecosystem Project.

5.0. DISCUSSION AND CONCLUSIONS

5.1. Effect of Different Silvicultural Treatments on Selected Medicinal Plants

The Falling Snow Ecosystem Project was established using four different conifer release techniques to examine the effects of alternative silvicultural treatments on productivity, costs, efficiency, and ecosystem components in young spruce plantations. This experiment compared different silvicultural treatments in order to choose one method that would ultimately affect ecosystem attributes (Bell *et al.* 1997 a).

Based on my study, there is no clear difference in abundance in the four species selected, on the areas where four different silvicultural techniques were applied and the control. It is clear that each silvicultural treatment had a similar impact on the four species i.e. no negative impact was observed on the abundance of these plants in this areas after six years of experimenting with the different silvicultural treatments. This is significant, as the Falling Snow Ecosystem Project was initiated to compare the difference between mechanical methods and herbicides and make comparisons to the control. This finding is important from the perspective of forest management, because it gives managers more latitude in choosing the best silvicultural treatment.

Glyphosate and triclopyr are considered very effective in controlling vegetation (Morash and Freedman 1988; Campbell 1990; and Bell *et al.* 1997). Glyphosate is the most widely used herbicide owing to its minimal toxicity to animals, and its capacity to adhere to soil allowing microbial degradation (Sprankle *et al.* 1975; Ogner 1987; and Morash and Freedman 1988). Triclopyr, on the other hand is very effective in controlling broad-leafed vegetation, although it has been in use for some time in the northern forests of United States, it is just beginning to gain popularity with users in Canada (Roy *et al.* 1990). A study by Morash and Freedman (1988), suggests triclopyr is absorbed by the roots and foliage, and that a high concentration (> 50 ppm) affects the germination of seeds from seed-banks. However, in silvicultural application such high concentrations are not used (Morash and Freedman 1988).

Horseley's (1994) work comparing the abundance of competing angiosperms on glyphosate, shows no difference between treated and reference plots. Instead, his study shows an increase in diversity of herbaceous species on the treated areas. Fireweed showed an increase in abundance in the sprayed plots perhaps because this species is wind-dispersed and regenerates vigorously in any open space. Sullivan *et al.* (1996) studied the influence of glyphosate on vegetation on three successional stages i.e. "herb", "shrub", and "shrub-tree" in Nova Scotia. The herb stage consisted mainly of fireweed, bracken fern, twisted stalk (*Streptopus streptopoides*), and similar species. Red raspberry, thimbleberry (*Rubus parviflora*), willow (*Salix* spp), dominated the shrub layer, while, paper birch (*Betula papyrifera*), and spruce (*Picea* spp) were dominant in the tree layer. Five years of study on the successional pattern on these species and the effect of glyphosate showed no difference in the number of herb and shrub species between control and the treated areas. There was also no difference in species diversity between the controls and the treated areas (Sullivan *et al.* 1996). Freedman *et al.* (1993) study also shows no difference between treatments after five to six years. Moola *et al.* (1998) study on single treatment of glyphosate on blueberries (*Vaccinium* spp) did not show any adverse effect on it's dry mass, fresh mass, or number of fruits.

However, the use of herbicides in forestry has evoked social concern due to the fear of: 1) epidemiological consequences caused by exposure to herbicides; 2) reduction of jobs; 3) conifer dominating monoculture forests; and 4) degradation of wildlife habitat and other ecological attributes (Freedman 1995; Mallik *et al.* 1997). Vegetation control using methods that are safer and environmentally friendly are socially desired (Conway-Brown 1984). Due to these concerns, forests managers are faced with the challenge to find alternatives to release conifers from competing angiosperms during the early regeneration phase (Brunell 1940; Mallik *et al.* 1997).

Alternatives to herbicides do exists; for example, the Provinces of Alberta and Saskatchewan uses site preparation and mechanical release to control vegetation; and these methods have proven effective (Ehrentraut and Branter 1990). In the Falling Snow Ecosystem Project, two mechanical methods (Brushsaw and Silvana select) were used to compare different types of brushsaws. However, this was used late in the growing season, possibly accounting for the fact that there was no statistical difference between the treatments, and allowing the woody species to grow back with vigor. According to Harrington (1984) trees cut from April through October, would probably have a greater mortality rate. Brunell (1940) suggests controlling the vegetation by cutting at different heights. However, this would be very expensive and not enough is known about the autoecology of all the competing species (Bell 1991; Zasada 1991; Mallik *et al.* 1997).

In Canada, vegetation management is primarily focused on controlling vegetation to aid conifer growth. Aerial application of herbicides, site preparation by mechanical methods or fire is generally used once to suppress the competing vegetation (Wagner and Zasada 1991). Wagner and Zasada (1991) propose a projected increase to intensify forest management in future along with the increasing pressure to reduce herbicide use. This is also concurrent with the social movement emphasizing protection of aspects like wildlife, water quality, and development or, expansion of recreational opportunities.

From the perspective of forest management and the use of medicinal plants this study is important. The four species studied in this project have shown numerous accounts by First Nations using these plants as medicines, important source of food and essential in their traditional. Recent studies by Duke (1998); Mohammed (1999); Freedonia group (1999), have shown *Cornus, Epilobium, Pteridium,* and *Rubus* have potential medicinal values. With the increasing demand for non-timber forest products, these plants have the potential to contribute to both the local and regional employment and economy.

The main finding of this study is that all four silvicultural treatments had no impact on the abundance of the four plants chosen for the study. Therefore silvicultural treatments can be chosen to reflect other values. This is welcome news because it gives forest managers the opportunity to incorporate medicinal plant ecology in their planning and implementing process.

6.0 RECOMMENDATION

In my study, mechanical release is as effective as aerial applications of herbicides, as there was no statistical difference between treatments. I would recommend the following for conifer release.

- **Further studies need to be conducted in the area.**

  Future studies need to be conducted on the impact of silviculture on plants with medicinal properties especially the autoecology of plants. This would help increase understanding of how these plants affect conifer growth.

- **Increase the number of blocks for the experimental design.**

  Increasing the number of blocks in the study area would give a better comparison of the treatment effect.

- **Reduction of aerial application of herbicides.**

  Conifer release treatment is usually applied once to suppress competing vegetation, and there was no statistical difference between treatments, mechanical methods could be used for suppressing vegetation for conifer release.

LITERATURE CITED

Alcorn, J.B 1995. The Scope and aims of ethnobotany in a developing world p23-39 in R.E. Schultes and Siri von Reis (eds) "Ethnobotany: Evolution of a Discipline" Dioscorides Press, Portland, Oregon. 414 pp.

Archambault L., J. Morissette and M. Bernier-Cardou. 1998. Forest succession over a 20-year period following clearcutting in balsam fir-yellow birch ecosystems of eastern Quebec, Canada. Forest Ecology and Management 102: 61-74.

Baldwin, K.A and R.A. Sims. 1997. Field Guide to the Common Forest Plants in Northwestern Ontario. Ontario Ministry. Natural. Resources., Northwest Science.& Technology. Thunder Bay, Ont. Field Guide FG-04. 359pp.

Balick, M.J. 1994. Ethnobotany, drug development and biodiversity conservation-exploring the linkages. pg 4-24 in P.T. Ghillean and D.M. Chadwick(ed) "Ethnobotany and the Search for New Drugs". John Wiley & Sons Chichester, New York. 280pp.

Bell, F.W., K.R. Ride., M.L. St-Amour and M. Ryans. 1997(a). Productivity, cost, efficiency and cost effectiveness of motor-manual, mechanical, and herbicide release of boreal spruce plantations. The Forestry Chronicle 73 (1): 39-46.

Bell, F.W., R.A. Lautenchlager., R.G. Wagner., D.G. Pitt., J.W. Hawkins and K.R. Ride. 1997(b). Motor-manual, mechanical, and herbicide release affect early successional vegetation in northwestern Ontario. The Forestry Chronicle 73 (1): 61-68.

Bisset, N.G and M. Wichtl. 1994. Herbal Drugs and Phytopharmaceuticals. A handbook for practice on a scientific basis.. CRC Press Boca Ranton xvi + 566pp

Black, M.J. 1990. Algonquin Ethnobotany: An interpretation of aboriginal adaptation in Southwestern Quebec. Canadian Ethnology Service paper No. 65. National Museums of Canada. Ottawa. 266pp.

Bocek, B.R. 1984. Ethnobotany of Costanoan Indians, California, Based on Collections By John P. Harrington. Economic Botany 38 (2): 240-255.

Buell, J.H. 1940. Effect of season of cutting on sprouting dogwood. Journal of Forestry 38: 649-650.

Buse, L.J and F.W. Bell. 1992. Pocket guide to: Critical silvics of selected crop and competitor species in northwestern Ontario. Northernwestern Ontio Forest. Technology. Development. Unit, Ontario. Ministry of Natural. Resources, Thunder Bay On. 138 pp.

Buse, L.J., R.G. Wagner and P. Perrin. 1995. Public attitudes towards forest herbicide use and the implications for public involvement. The Forestry Chronicle 71 (5): 597-600.

Canadian Agricultural New Uses Council. 1998. Functional foods, pharmaceuticals and skin care products: Fytokem finds new uses for northern plants. BioInnovations 4 (4): 5-6.

Campbell, R.A. 1990. Herbicide use for forest management in Canada: Where we are and where are we going? The Forestry Chronicle 66 (4): 355-360.

Carrow, J.R. 1997. Canada's quest for forest sustainability: Options, obstacles and opportunities. The Forestry Chronicle 73 (1): 113-120

Caseley, J.C. and D. Coupland. 1985. Environmental and plant factors affecting glyphosate uptake, movement and activity 92-123 pp, in Lund-Hoie-K; E.Grossbard (eds) The herbicide glyphosate. Butterworths London xvi+490pp.

Chourmouzis, C., C. Hollstedt., F.W.Bell., D. Myketa. and A.M. Gordon. 1996. Effect of Vision on Seed Germination of Red Raspberry from the Soil Seed Banks. NWST Technical Report. Ontario Ministry of Natural Resource Thunder Bay, On TR-107.8pp.

Coffey, T. 1993. The History and Folklore of North American Wildflowers. Houghton Mifflin Company. Boston. xxiv+356 pp

Conway, E. and R. Stephens. 1957. Sporeling establishment in *Pteridium aquilinum*: effects of mineral nutrients. Journal of Ecology 45: 389-399.

Cox, A. 1998. Herbicide factsheet. Glyphosate (Roundup). Journal of Pesticide Reform. 18(3): 3-16.

Cox, P.A. 1994. The Ethnobotanical approach to drug discovery: strengths and Limitations. pg 25-41 in P.T. Ghillean and D.M. Chadwick(ed)"Ethnobotany and the Search for New Drugs". John Wiley & Sons Chichester, New York. 280pp.

Dolling, A. 1996. *Pteridium aquilinum* (L.) Kuhn. Ecology and Interference Effects on Regeneration of Hemiboreal Forests in Southern Sweden. Doctoral thesis. Swedish University of Agricultural Sciences. Umea 49 pp.

Davis, E.W. 1995. Ethnobotany: An old practice, a new discipline pg 40-51 in in R.E. Schultes and Siri von Reis (eds) "Ethnobotany: Evolution of a Discipline" Dioscorides Press, Portland, Oregon. 414 pp

Duke, J.A. 1998. Phytochemicals and ehtnobotanical databases. Agricultural Research Service. http://www.ars-grin.gov/cgi-bin/duke/ as on Jan 6 '00

Ehrentraut, G. and K. Branter. 1990. Vegetation management by manual and mechanical means in Alberta Boreal forests. The Forestry Chronicle 66: 366-368.

Erichsen-Brown, Charlotte. 1979. Use of Plants. Breezy Creeks Press, Aurora, Canada. 512pp.

Franz, J.E. 1985. Discovery, development and chemistry of glyphosate.3-17 pp in Lund-Hoie-K; E.Grossbard (eds) The herbicide glyphosate. Butterworths London.xvi+490 pp.

Freed, J. 1996. Certification of wildcrafters in the Pacific Northwest. International Journal of Ecoforestry 12 (1): 153-155.

Freedman, B., R. Morash. and D.MacKinnon. 1993. Short-term changes in vegetation after the silvicultural spraying of glyphosate herbicide onto regeneration clearcuts in Nova Scotia, Canada. Canadian Journal of Forestry Research 23: 2300-2311.

Freedonia Group. 1998. World nutraceuticals to 2002. Cleveland, Oh. http://freedonia group.imrmall.com. as on Jan 6, `00

Harrington, C.A. 1984. Factors influencing initial sprouting of red alder. Canadian Journal of Forestry Research 14: 357-361.

Hamel, P.B and M.U. Chiltoskey. 1975. Cherokee plants and their uses-a 400 year history. Herald Publishing Company, Sylva, N.C. 65pp.

Hellson, J.C. and M. Gadd. 1974. Ethnobotany of the Blackfoot Indians. Canadian Ethnology Service Paper No. 19. National Museums of Canada. 138p.

Horseley, S.D. 1994. Regeneration success and plant species diversity of Allegheny hardwood stands after Roundup application and shelterwood cutting. Northern Journal of Applied Forestry 11: 109-116

Iwu, M.M 1994. African medicinal plants in the search of new drugs based on ethnobotanical leads.pg 116-129 in Ethnobotany and the Search for New Drugs. John Wiley & Sons Chichester, New York. 280pp.

Johnston, A. 1970. Blackfoot Indians Utilization of the Flora of the Northwestern Great Plains. Economic Botany 24: 301-324.

Kimmins, J.P. 1991. The future of the forested landscapes of Canada. The Forestry Chronicle 67 (1):14-18.

Kimmins, J.P. 1995. Sustainable development in Canadian forestry in the face of changing paradigms. The Forestry Chronicle 71 (1):33-40.

Kuhnlein, H.V. and N.J. Turner. 1991. Traditional Plant Foods of Canadian Indigenous Peoples Nutrition, Botany and Use. Gordon and Breach Science Publishers. Philadelphia. xi+633pp.

Lamont, S.M. 1977. The Fisherman Lake Slave and their Environment- a Story of Floral and Faunal Resourses. Unpublished. M.Sc. thesis, University of Saskatchewan, Saskatoon. 233pp.

Lautenschager, R.A. 1991. Red raspberry ecology and the effect of raspberry and other forest bush on white spruce. CFRU Information Report 25. University of Maine 7pp.

Lautenschager, R.A; F.W.Bell; R.G.Wagner; and J.A.Winters. 1997. The Falling Snow Ecosystem Project: Comparing conifer release alternatives in North Western Ontario. The Forestry Chronicle 73 (1): 35-38.

Leek, S. 1975. Herbs medicine and mysticism. Henry Regnery Company. Chicago, Illinois. 255 pp.

Lust, J. 1974. The Herb book. Bantham Books. New York.xii+659pp.

Mallik, A.U., F.W. Bell. and Y. Gong. 1997. Regeneration behaviour of competing plants after clear cutting: implications for vegetation management. Forest Ecology and Management 95: 1-10.

Marles, R.J., L. Monteleone., N.Tays. and D. Burns. 1999. Aboriginal plant use in Canada's Northwest Boreal Forest. UBC Press Vancover B.C. 368pp.

Mabey, R. 1988. The new age herbalist. Simon & Schuster Inc. 288pp.

Mater Engineering; LTD. 1993. Special Forest Products Market Analysis. Canadian Forest Service. Prince Albert, Saskatchewan.xix+99pp.

McAllister, D.E 1991. Estimating the pharmeceutical values of forests, Canadian and tropical. Canadian Biodiversity 1(3): 16-25.

Mckenny, D and R..Sarker.1994. An overview of non-wood valutation efforts in Ontario. The Forestry Chronicle 70(1): 47-54.

McLaughlan, M.S., Myketa, D. and F.W.Bell. 1996. Managing vegetation with herbicides: A review of glyphosate, 2,4-D, hexazinone, triclopyr and simazine. Northwest Sci. & Technol. TN-37, 12 pp. in Bell, F.W., M. McLaughlan and J. Kerley (compilers). Vegetation Management Alternatives-A Guide to Opportunities. Ontario Ministry Natural Resources., Thunder Bay. Ont.

Meeker, J.E., J.E. Elias.and J. A. Heim. 1993. Plants used by the Great Lakes Ojibwa. Great Lakes Indian Fish and Wildlife Commission, Odanaha, WI. 440 p.

Mitchell, D.A 1998. Non-timber forest products in British Columbia: The past meets the future on the forest floor. The Forestry Chronicle 74 (3): 359-362.

Moerman, D.E 1998. Native American Ethnobotany. Timber Press. Portland, Oregon.927pp

Mohammed, G.H. 1999. Non-Timber Forest Products in Ontario: An Overview. Ontario Forest Research Institute. Ontario Ministry of Natural Resources, Sault Ste. Marie, On. iv+64pp.

Moola, F.M., A.U. Mallik,., and R.A. Lautenchlager. 1998. Effects of conifer release treatments on the growth and fruit production of *Vaccinium* spp. In northwestern Ontario. Canadian Journal of Forest Research 28: 841-851.

Mowrey, D.B. 1986. The Scientific Validation of Herbal Medicine. Keats Publishing Inc. New Canaan, Connecticut. 316pp.

Naegele,Thomas A.D.O. 1996. Edible and Medicinal Plants of the Great Lakes Region. Wilderness Adventure Books Davisburg, Michigan. 423pp.

Ogner, G. 1987. Glyphosate application in forest-ecological aspects. Scandinavian Journal of Forest Research 2: 509-516.

Pakeman, R.J and R.H. Marrs. 1992. The conservation value of bracken *Pteridium aquilinum* (L.) Kuhn-dominated communities in the UK, and an assessment of the ecological impact of bracken expansion or its removal. Biological Conservation 62: 101-114.

Rowe, J.S. 1972. Forest regions of Canada. Can. Dept. Environ., Can. For. Serv., Ottawa, Ontario. Publication No. 1300. 172pp.

Roy, N.D., S.K. Konar., S. Banerjee., D.A. Charles., D.G. Thompson and R. Prasad. 1989. Persistence, movement, and degradation of glyphosate in selected Canadian Boreal Forest Soils. Journal of Agricultural Food Chemistry 37: 437-440.

Smith, H.H., 1932. Ethnobotany of the Ojibwe Indians. Bulletin of the Public Museum of the City of Milwaukee 4 (3): 327-525

Soper, J.H. and M.L.Heimburger. 1982. Shrubs of Ontario. Royal Ontario Museum, Toronto xxi+495 pp

Sprankle, P., W.F. Meggitt. and D. Penner. 1975. Rapid inactivation of glyphosate in the soil. Weed. Science 23 (3) 224-228.

Steel, R.G.D. and J.H. Torrie. 1980. Principles and Procedures of Stastistics: A Biometrical Approach. McGraw-Hill Book Company. New York xxi+633pp.

Stephenson, G.R., K.R. Solomon., C.S. Bowhey. and K. Liber. 1990. Persistence, leachability, and lateral movement of Triclopyr (Garlon) in selected Canadian forestry soils. Journal of Agriculture Food Chemical 38: 584-588.

Sullivan, T.P., R.A. Lautenchlager. and R.G. Wagner. 1996. Influence of Glyphosate on vegetation dynamics in different successional stages of Sub-Boreal spruce forests. Weed Technology 10: 439-446.

Sutton, F.R. 1978. Glyphosate herbicide: An assessment of forestry potential. Journal of Forestry. (2): 24-28.

Thompson, S.K. 1991. Adaptive cluster sampling: Design with primary and secondary units. Biometrics 9: 1103-1115.

Turner, N.J. 1998.Plant technology of First Peoples in British Columbia. UBC Press Vancover, B.C. 256 pp.

Turner, N.J. 1997. Food Plants of Interior First People. UBC Press. Vancover, B.C. 215p.

Turner, N.J., L.C. Thompson.and M.T. Thompson, A.Z York. 1990. Thompson Ethnobotany.Knowledge and Usage of Plants by the Thompson Indians of British Columbia Memoir No 3. Royal British Columbia Museum. Vancover 335 pp.

Turner, N.J., R. Bouchard. and D.I.D. Kennedy. 1980. Ethnobotany of the Okanagan-Colville Indians of British Columbia and Washington. Occasional Papers of the British Columbia Provincial Museum. No 21. British Columbia Provincial Museum, Victoria. 179pp.

Wagner, R.G and J.C. Zasada. 1991. Integrating plant autecology and silvicultural activities to prevent vegetation management problems. The Forestry Chronicle. 67 (5): 506-513.

Wagner, R.G 1992. Vegetation Management Alternatives Program. Program Prospectus. Ontario Forest Research Institute. Sault Ste. Marie, On. 18pp.

Wagner, R.G. 1994. Towards integrated forest vegetation management. Journal of Forestry. (4): 26-30.

Wagner, R. G., J. Glynn., R. Gregory., C.K. Mertz. and P. Slovic. 1998. Acceptable parctices in Ontario's forests: Difference between the public and forestry professionals. 1998. New Forest 16 (2): 139-154.

Walstad, D., P.J. Kuch. 1987. Forest Vegetation Management for Conifer Production. John Wiley & Sons. New York. 523pp.

APPENDIX I

Percent cover for *Epilobium* by treatment and block

Treatment	Block	0%	1-5%	6-35%	36-65%	66-95%	100%	Total
Vision	1	8	64	3	0	0	0	75
	2	13	28	2	0	0	0	43
	3	97	12	0	0	0	0	109
	4	69	8	0	0	0	0	77
Total		187	112	5	0	0	0	304
Mean		46.75	28	1.25	0	0	0	76
% of Total		61.5	36.8	1.7	0	0	0	100

Treatment	Block	0%	1-5%	6-35%	36-65%	66-95%	100%	Total
Release	1	13	47	0	0	0	0	60
	2	72	3	0	0	0	0	75
	3	122	7	0	0	0	0	129
	4	110	0	0	0	0	0	110
Total		317	57	0	0	0	0	347
Mean		79.25	14.25	0	0	0	0	93.5
% of Total		84.8	15.2	0	0	0	0	100

Treatment	Block	0%	1-5%	6-35%	36-65%	66-95%	100%	Total
Brushsaw	1	68	52	10	0	0	0	130
	2	37	18	0	0	0	0	55
	3	137	2	0	0	0	0	139
	4	68	8	0	0	0	0	68
Total		302	80	10	0	0	0	392
Mean		75.5	20	2.5	0	0	0	98
% of Total		77	20.4	2.6	0	0	0	100

APPENDIX I (cont...)

Treatment	Block	0%	1-5%	6-35%	36-65%	66-95%	100%	Total
Silvana	1	143	3	0	0	0	0	146
	2	53	1	0	0	0	0	54
	3	99	20	1	0	0	0	120
	4	66	7	0	0	0	0	73
Total		361	31	1	0	0	0	393
Mean		90.3	7.8	0.3	0	0	0	98.3
% of Total		91.9	7.9	0.2	0	0	0	100

Treatment	Block	0%	1-5%	6-35%	36-65%	66-95%	100%	Total
Control	1	66	37	0	0	0	0	103
	2	45	12	5	0	0	0	62
	3	139	1	0	0	0	0	140
	4	57	3	0	0	0	0	60
Total		307	53	5	0	0	0	365
Mean		76.75	13.25	1.25	0	0	0	91.25
% of Total		84	14.5	1.5	0	0	0	100

APPENDIX II

Percent cover for *Pteridium* by treatment and block

Treatment	Block	0%	1-5%	6-35%	36-65%	66-95%	100%	Total
Vision	1	145	12	0	0	0	0	157
	2	80	23	0	0	0	0	103
	3	93	37	14	13	0	0	157
	4	66	30	0	0	0	0	96
Total		384	102	14	13	0	0	513
Mean		96	25.5	3.5	0	0	0	128.25
% of Total		74.9	19.9	2.7	2.5	0	0	100

Treatment	Block	0%	1-5%	6-35%	36-65%	66-95%	100%	Total
Release	1	180	0	0	0	0	0	180
	2	120	0	0	0	0	0	120
	3	136	37	20	0	0	0	203
	4	36	81	28	0	0	0	145
Total		472	118	48	10	0	0	648
Mean		118	29.5	12	2.5	0	0	162
% of Total		72.8	18.2	7.5	1.5	0	0	100

Treatment	Block	0%	1-5%	6-35%	36-65%	66-95%	100%	Total
Brushsaw	1	162	5	0	0	0	0	167
	2	73	22	5	0	0	0	100
	3	102	38	1	0	0	0	141
	4	47	53	0	0	0	0	100
Total		384	118	6	0	0	0	508
Mean		96	29.5	1.5	0	0	0	127
% of Total		75.6	23.2	1.2	0	0	0	100

APPENDIX II (cont…)

Treatment	Block	0%	1-5%	6-35%	36-65%	66-95%	100%	Total
Silvana	1	157	6	0	0	0	0	163
	2	48	53	0	0	0	0	101
	3	116	41	11	7	0	0	175
	4	57	46	6	0	0	0	109
Total		378	146	17	7	0	0	548
Mean		94.5	36.5	4.3	1.8	0	0	137
% of Total		69	26.6	3.1	1.3	0	0	100

Treatment	Block	0%	1-5%	6-35%	36-65%	66-95%	100%	Total
Control	1	158	4	0	0	0	0	162
	2	80	28	6	0	0	0	114
	3	170	6	0	0	0	0	176
	4	38	63	0	0	0	0	101
Total		446	101	6	0	0	0	553
Mean		111.5	25.3	1.5	0	0	0	138.3
% of Total		80.7	18.3	1	0	0	0	100

APPENDIX III

Percent cover for *Rubus* by treatment and block

Treatment	Block	0%	1-5%	6-35%	36-65%	66-95%	100%	Total
Vision	1	11	88	0	0	0	0	99
	2	40	28	0	0	0	0	68
	3	76	40	10	0	0	0	126
	4	41	24	2	2	0	0	69
Total		168	180	12	2	0	0	362
Mean		42	45	3	0.5	0	0	90.5
% of Total		46.4	49.7	3.3	0.6	0	0	100

Treatment	Block	0%	1-5%	6-35%	36-65%	66-95%	100%	Total
Release	1	14	158	15	0	0	0	187
	2	24	29	0	0	0	0	53
	3	120	40	10	0	0	0	170
	4	77	19	0	0	0	0	96
Total		235	246	25	0	0	0	506
Mean		58.8	61.5	6.3	0	0	0	126.6
% of Total		46.4	48.6	5	0	0	0	100

Treatment	Block	0%	1-5%	6-35%	36-65%	66-95%	100%	Total
Brushsaw	1	63	61	0	0	0	0	124
	2	20	20	2	0	0	0	42
	3	111	4	0	0	0	0	115
	4	86	15	3	3	2	0	109
Total		280	100	5	3	2	0	390
Mean		70	25	1.3	0.8	0.5	0	98.6
% of Total		71.8	25.6	1.3	0.8	0.5	0	100

APPENDIX III (cont…)

Treatment	Block	0%	1-5%	6-35%	36-65%	66-95%	100%	Total
Silvana	1	16	109	3	0	0	0	128
	2	39	14	0	0	0	0	53
	3	71	18	0	0	0	0	89
	4	35	32	0	0	0	0	67
Total		161	173	3	0	0	0	337
Mean		40.3	43.3	0.8	0	0	0	85.4
% of Total		47.8	51.3	0.9	0	0	0	100

Treatment	Block	0%	1-5%	6-35%	36-65%	66-95%	100%	Total
Control	1	35	72	9	0	0	0	116
	2	43	32	0	0	0	0	75
	3	84	30	0	0	0	0	114
	4	95	3	0	0	0	0	98
Total		257	137	9	0	0	0	403
Mean		64.3	34.3	2.3	0	0	0	100.9
% of Total		63.8	34	2.2	0	0	0	100

APPENDIX IV

Percent cover for *Cornus* by treatment and block

Treatment	Block	0%	1-5%	6-35%	36-65%	66-95%	100%	Total
Vision	1	2	6	8	4	1	0	16
	2	2	3	1	1	0	0	7
	3	0	21	10	5	2	0	38
	4	0	6	4	2	1	0	13
Total		4	38	19	9	4	0	74
Mean		1	9.5	4.8	2.3	1	0	18.5
% of Total		5.4	51.5	25.7	12.1	5.4	0	100

Treatment	Block	0%	1-5%	6-35%	36-65%	66-95%	100%	Total
Release	1	5	2	1	0	0	0	8
	2	1	4	3	1	0	0	9
	3	0	12	6	0	0	0	18
	4	4	0	0	0	0	0	4
Total		10	18	10	1	0	0	39
Mean		2.5	4.5	2.5	0.3	0	0	10.8
% of Total		25.6	46.2	25.6	2.6	0	0	100

Treatment	Block	0%	1-5%	6-35%	36-65%	66-95%	100%	Total
Brushsaw	1	3	10	7	6	2	0	28
	2	2	4	2	1	1	0	10
	3	0	28	11	6	2	0	47
	4	1	2	0	0	0	0	3
Total		6	44	20	13	5	0	88
Mean		1.5	11	5	3.3	1.3	0	23.1
% of Total		6.8	50	22.7	14.8	5.7	0	100

APPENDIX IV (cont…)

Treatment	Block	0%	1-5%	6-35%	36-65%	66-95%	100%	Total
Silvana	1	5	1	1	1	0	0	8
	2	1	3	1	1	0	0	6
	3	0	27	20	10	4	0	61
	4	5	0	0	0	0	0	5
Total		11	31	22	12	4	0	80
Mean		2.8	7.8	5.5	3	1	0	19.4
% of Total		13.7	38.8	27.5	15	5	0	100

Treatment	Block	0%	1-5%	6-35%	36-65%	66-95%	100%	Total
Control	1	5	1	0	0	0	0	6
	2	3	1	1	1	0	0	6
	3	0	31	12	6	1	0	50
	4	0	13	4	1	0	0	18
Total		8	46	17	8	1	0	80
Mean		2	11.5	4.3	2	0.3	0	20
% of Total		10	57.5	21.3	10	1.2	0	100