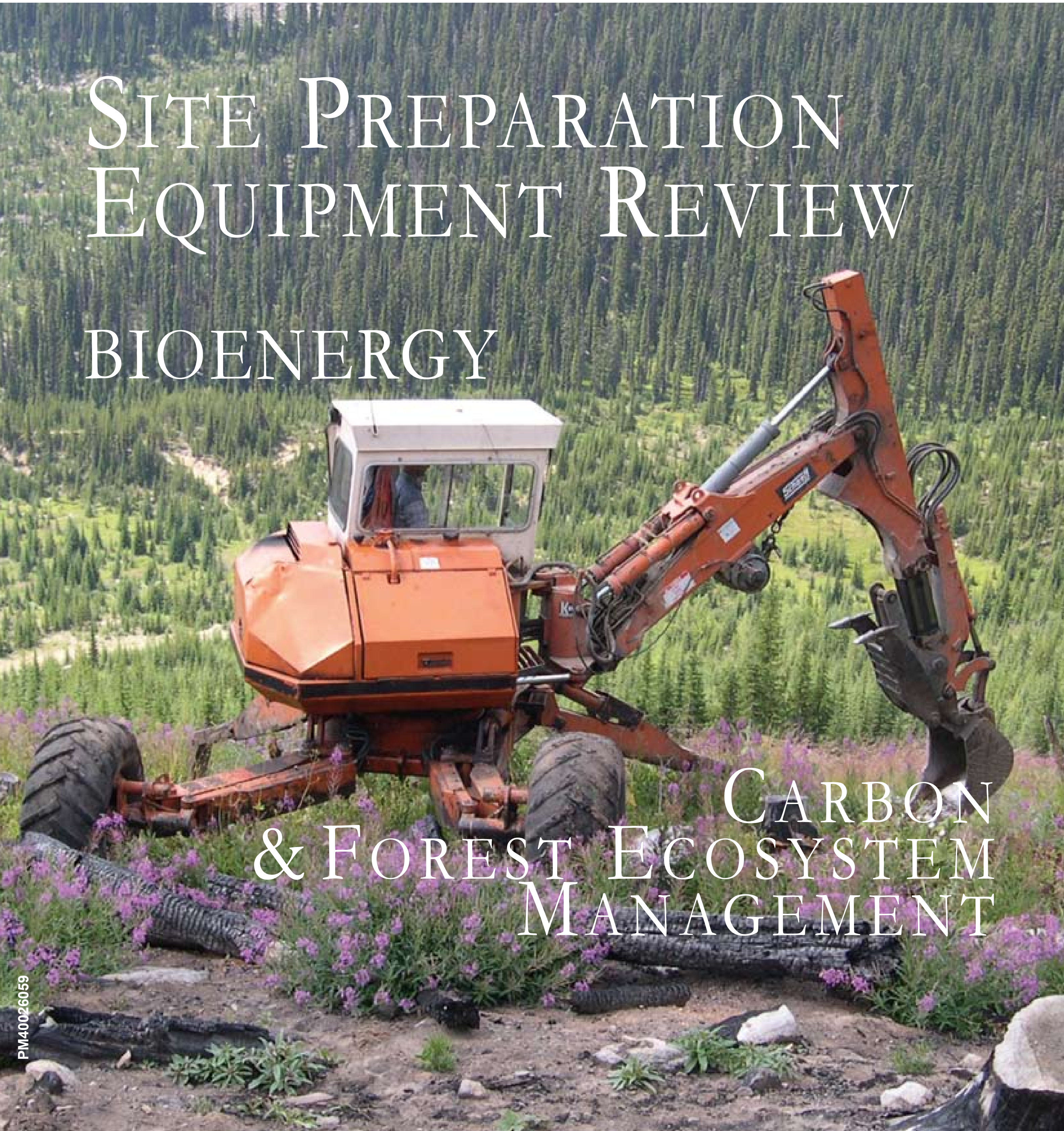
CANADIAN

SILVICULTURE

SUMMER 2005



Site Preparation Equipment Review

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Editorial

by Dirk Brinkman

Reforestation Market Turbulence Forcing Change

After a decade of gradual price decline some of the main factors influencing the treeplanting industry are converging into a singular conclusion - higher prices. Following are the contributing factors.

Increasing planting

The decade of decline in trees being planted may have bottomed out because:
- a booming Asia increased forest market demand and area logged;
- increasing forest mortality from fires, pests and diseases added area salvaged and planted or rehabilitated;
- lack of cold stratification for seed reducing natural regeneration and increasing artificial reforestation;
- climate change stressing species or provenance requiring alternate phenotypes to be planted;
- New Brunswick, Quebec and BC policy reviews recommend more planting;
- carbon (Forest 2020) and seismic reforestation is beginning;
- fibre supply "fall down" pressures shorter regeneration lags and improved quality for increased growth.

Fitness decline

Contractors are experiencing production decline effects from youth fitness being in decline, and reforestation demands hard, physical work. This divergence between fitness decline and planting difficulty may continue because:
- over 80% of Canadians live in urban centers with declining opportunities for exercise;
- repetitive strain injuries and immune system stress make this particularly hard work less acceptable (who wants to do a triathlon competition every day to cite Dr. Delia Roberts' comparison).

Planter productivity compensation

Foresters and contractors have worked to increase production, through
- site preparation and uniform stock size;
- fitness training and injury reduction (Dr. Roberts' program may increase production 12-20% and reduce injuries 30-40%);
- new custom tools adapted to personal styles and site types;
- less screefing and more F and H planting across more site types;
- reduced or simplified standards and stock.

However, there are human limits to this process.

Fewer planters

This year reforestation contractors experienced a reduction in applicants, fewer returnees and increased no-shows that had been hired. The double cohort (grades 12 and 13) coming out of Ontario and foreign students getting visas more easily offers temporary relief, but this trend may continue because:
- there is a steady decline in the student entry population over the past 20 years;
- low unemployment is raising labour rates in competing markets for young workers;
- urbanites' narrower career goals are less oriented to wilderness life adventures;
- greying baby boomers exiting the workforce are opening careers for new entrants.

Shorter seasons

The goal of once again extending the season through adding summer programs may also have limits, while finishing later is only tolerated if the spring is wet. Longer spring and summer programs may be limited by trends towards earlier, longer, hotter, and drier summers.

Increasing costs

Operating costs are increasing with the booming economy, which is especially driving up the cost of fuel. This has translated into vehicles, supplies and equipment all taking a bigger bite out of the declining planting price.

Increasing unprofitability

The reduced work and workers, lower production and increasing costs have resulted in some contractors stopping (sometimes abruptly) and leaving the industry. This has resulted in some consolidation. Contractors do not report reduced competition as much as a higher proportion of unprofitable contracts. The simple result is an increasing determination to drop the unprofitable portion of their services, thereby raising average prices.

First Nations a solution

One logical solution to these trends is to shift reforestation work to First Nations whose
- rural population is growing;
- proportion of young people is growing;
- unemployment is high.

However, other remote resource industries are competing for the same aboriginal workforce, especially youth. Aboriginal participation in reforestation will require focus and reasonable earnings.

Each project is influenced differently by these market trends creating turbulence for planters, contractors and forest managers. The contractor's job is to keep cool under the extreme pressure in projects - the enormous weather and operational variability is standard fare in treeplanting. However, some contractors sometimes keep too cool under the extreme pressures of bidding, pushing prices to where they regret it.

Like other sectors, for reforestation to attract and keep good planters, contractors will have to pay well. For forest managers to keep good planters, they may have to weigh awarding a contract to the lowest bidder against the hidden costs of late completion, inexperience or later free growing.

'Coming of age' through the wilderness experience of reforestation will remain attractive to the unique personalities that thrive on treeplanting - there are more treeplanters in Canada than Canadian Armed Forces - but the market correction that will keep Canada's 'greenkeeping' army strong now seems to be inevitable.

MECHANICAL SITE PREPARATION EQUIPMENT REVIEW

by Craig Evans

Mechanical site preparation after forest harvesting is commonly used by forest stewards to prepare a forest site for planting or enhanced natural regeneration. The site preparation method chosen depends on the silvicultural objectives for a particular site. Site preparation objectives should be developed during preparation of silvicultural prescriptions prior to harvest when consideration is given to the ecological and management factors affecting the site. Only then can site treatment options be determined and evaluated according to operational feasibility, social acceptability, and sustainability of site productivity. This article provides a brief overview of common mechanical site preparation equipment and techniques used in western Canada.

Mechanical site preparation equipment can be divided into general categories based on the treatment desired such as mounding, trenching, spot scarifying, drag or blade scarifying, piling, and stumping.

Mounding

Mounding machines can be classified by the prime mover to which the mounding implement is attached. In western Canada, it is generally a mid-size tracked excavator or rubber-tired skidder, and in isolated cases it is a six-wheel forwarder.

An excavator-based mounding machine is preferred where the treatment areas are small, dispersed and wet, or in a partial cutting application where the machine must work around residual trees. The mounding attachment, usually a toothed bucket with a hydraulic thumb (Figure 1), is located at the end of the boom and creates one mound at a time. Excavators are generally used on slopes less than 40% and can cover 1.2–1.5 ha/PMH at a cost of $472/ha using a Komatsu PC200LC machine.

Figure 1. Toothed bucket with a hydraulic thumb used for mounding

When a skidder is the prime mover, the mounding attachment is carried in place of the grapple. An exception is the Dual Path Mounder described later which is towed behind a skidder. Mounds are created in parallel rows, two at a time, as a revolving mounding impeller flips over the soil to create the mound. A skidder-based machine is preferred in larger, flatter areas and where soils are drier, or could have a higher incidence of rocks or a thick humus layer. Compared to an excavator, a John Deere 640 skidder (90 kW) will result in a slightly lower productivity of 0.9 ha/PMH and much lower costs of $145/ha. Examples of skidder-based mounding equipment currently used in western Canada include the Dual Path Mounder, Terra Technology Mounder, and BräckeDonaren.

Figure 2. Dual Path Mounder

The Dual Path Mounder (Figure 2) has been designed primarily for winter mounding in the northern boreal forest and is pulled by a mid-size rubber-tired skidder. Two rows of large mounds in frozen ground are produced, created by the forward movement of the skidder and independent action of newly developed mounding spades. The machine has been under development for several years with one unit in existence at this time. If demand increases for this machine, a second unit is planned for development. The machine was developed on the initiative of Canadian Forest Products Ltd in Hines Creek, Alberta and is currently in use in northern Alberta. Productivity is 0.9 ha/h or 200–300 ha/month.

The Terra Technology mounder is a two-row scarifier attachment which mounts to the back of a rubber-tired skidder. It has a single triple-tooth mattock wheel mounted on each of two independent adjustable arms. The mattock wheels turn with hydraulic assistance and temporarily stops at a predetermined angle, creating a mound as the skidder moves forward. This machine creates inverted mounds with a hinge attaching the mound and the underlying undisturbed soil. The mounder can treat 0.76 ha/h at a cost of $145/ha when a John Deere 640D skidder is used. Purchase price for the mounder attachment is approximately $120,000. The unit is designed and built by Terra Technology in Alberta, Canada.

Figure 3. Donaren 870 H mounder

The BräckeDonaren mounder is another example of a two-row scarifier commonly used in western Canada. This machine is built in Sweden by Robur Maskin AB. Productivity of a previous model, the Donaren 870 H (Figure 3), ranged from 1.2 to 1.7 ha/h and its costs ranged from $86/ha to $122/ha when a Timberjack 480C prime mover was used. A three-row machine is also available.

Disc Trenching

Disc trenching machines create a continuous trench with a raised berm on which trees are planted. Current machines can create two continuous trenches through the use of two large angled cog-like discs with teeth around the circumference. The discs are hydraulically driven in a circular fashion and are independently adjustable for trench spacing and depth. A continuous trench can be an aid to tree planting operations as it offers more selection for a plantable spot, creates a favourable microsite for tree growth, and can speed planting productivity. As with mounders, disc trenchers can be mounted to the rear of skidders, crawler tractors or in some cases, forwarders. The type of prime-mover chosen is usually based on the topography in the operating area.

Figure 4. Donaren 180 disc trencher

The Donaren 180 disc trencher (Figure 4) is commonly used in western Canada. It can treat 1.3 ha/PMH using a John Deere 748E skidder at a cost of $105/ha. The purchase price for a Donaren 180 disc trencher is approximately $100,000.

Spot Scarifying

Spot scarifying is a site preparation method used to remove the vegetation or slash to expose the mineral soil beneath, and is used on sites that have heavy herbaceous competition. Spot scarification is carried out using a variety of methods such as manual power tools, blading using crawler tractors or skidders, and excavators with spot scarifying attachments. Many of these attachments are custom-made and can mulch or crush slash, or can mix the soil to create a plantable spot. Excavator attachments which have been used for spot scarifying in western Canada include, but are not limited to: the VH Mulcher developed by Tim Van Horlick of West–NorthWest Forestry Ltd, Lillooet, the Grizz R-ex, a concept machine developed by the Canadian Forest Service, and the Mixing Mounder developed by NSR Site Prep Ltd. of Prince George. Some attachments that were originally designed for other applications have been used for spot scarifying including the Mitsui Miike rock-grinding tool and the D & M Slashbuster. The Meri Crusher manufactured by Suokone OY of Finland and distributed in Canada by Hakmet Ltd. of Dorion, Que., can be mounted either on an excavator or a skidsteer loader. One specialized excavator attachment to note is the Bräcke Planter. It can produce a mound and plant a tree on the mound in one pass. Treatment results vary greatly among the attachments, with costs ranging from $300 to $1200/ha and productivities ranging from 0.1 to 0.4 ha/h.

Dragging Tools

A common scarification technique for areas which are to be naturally restocked is to drag various implements behind a skidder or crawler tractor. For natural restocking success, the seed source must be prominent (i.e., cones distributed by harvesting activities). In western Canada, common implements are steel anchor chains with spikes welded on, and anchor chains, used in combination with rotating sharkfin barrels (Figure 5). The anchor chains churn the debris on the ground to spread the seed and cones, while the barrels rotate to move the debris around. This method of site preparation is suitable for areas that are not too steep, and for large clearcuts or clearcuts with reserves with room for a machine to turn with the implement. Low slash and stumps are also important factors to consider. Chain drag productivity can range from 0.6 to 0.8 ha/h with costs averaging $192/ha when using a Komatsu D65EX crawler tractor.

Figure 5. Crawler tractor pulling chains

Stumping

Stumping is a site preparation method that is used to control root disease in the immediate area of treatment. Stumps are pulled from the ground and piled or overturned in the remaining hole to expose the roots to the air, consequently killing the pathogen. Excavators with thumb attachments and either rakes or buckets are used for this activity (Figure 6). Stumping productivity varies with the size and number of stumps removed, the size of the machine, and the terrain. ✦

Figure 6. Stumping with an excavator.

Craig Evans is with FERIC, Western Division, in Vancouver, BC. He can be reached at 604-228-1555.

SPECTRUM RESOURCE GROUP INC

A Holistic Approach to Forest Management

Spectrum Resource Group Inc. was created on April 22, 2005 with the amalgamation of Bugbusters Pest Management Inc. and Silvarado Silviculture Ltd. forming one of the largest and most diversified silviculture companies in Canada. Spectrum's expertise has led to the creation of a company capable of overseeing the entire process of seedling establishment from silviculture prescription development to free growing fulfillment. In addition, the company is an industry leader in forest health, pest management and vegetation management.

Spectrum's organizational structure and services delivery model has evolved over the past two decades to reflect the natural progression of silviculture treatments necessary to achieve free growing. The company's 8 partners specialize in a variety of silviculture disciplines providing knowledge bases related to each segment of silviculture.

One of Spectrum's key strengths is the manner in which the partners unite their skills to form a multi-functional team. Spectrum is able to bring together a diversity of experience and knowledge gained by working with clients throughout Western Canada including government agencies and other resource users. Its team provides unique and effective turnkey solutions for silviculture management.

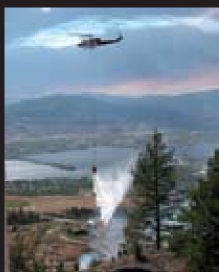
This holistic approach to silviculture management results in economies of scale and a reduced time commitment from a client's staff. But most significant are the efficiencies gained in relation to planning and treatment integration. By being involved in the entire series of silviculture treatments, Spectrum gains familiarity with each unique forested landscape allowing the fine-tuning of each treatment to maximize results.

Spectrum's Reforestation Department is led by Brian Hartford, and has planted over 10 million seedlings in each of the past 20 seasons, with a high of 17 million in 2005. Their experienced planters have worked in some of the most remote and difficult-to-access areas in the province, using all forms of transportation, including ground, air and water.

The Stand Tending Department is split into separate divisions of manual and herbicide applications. Greg MacFarlane heads up the manual stand tending and cut stump applications and brings over 20 years experience to the position. Cut stump herbicide treatments are completed with Spectrum's unique cut-stump applicator. This patented attachment to the brush saw applies a controlled volume of herbicide on the stump to control for suckering and re-sprouting. Spectrum's cut stump applicator represents a new innovation in the field of silviculture as the volume of product applied is more controlled. The reusable sealed herbicide containers minimize the potential for spills, and the delivery system is more user-friendly, thereby increasing worker efficiency. Historically, Spectrum completes 1,000+ ha of manual brushing/cut stump applications per year. Spectrum has completed challenging manual projects in Chilliwack, Squamish, Prince George, and the Queen Charlotte Islands. Future projects are in the Robson Valley, Peace Region, and Alberta.

Spectrum is the largest and most experienced contractor in Canada in relation to the ground application of herbicides for site preparation and crop tree release. They annually complete over 5,000 ha of backpack foliar, spot, hack & squirt, and basal bark applications and have treated over 75,000 ha of ground application since 1986.

Spectrum offers integrated herbicide applications using one coordinated system, due to strategic alliances with several aerial herbicide applicators. In support of its knowledge and



expertise in the field of vegetation management, Spectrum's General Manager, Peter Mohammed is on the board of the IVMA (Integrated Vegetation Management Association of British Columbia). The IVMA of BC liaises with government and industry in regards to vegetation management practices in BC. Spectrum is also represented in the WSCA (Western Silvicultural Contractors' Association) by the acting president, Crawford Young.

The Technical Forestry Department is led by Blake Phillips and Trish Stevens who oversee the consulting side of the company's operations. Post-harvest treatment regimes are developed for over 40,000 ha of ground annually through silviculture surveys or walk-through assessments. The technical department acts as the unifying force within Spectrum, merging the various treatments required into a concise and efficient sequence tailored for each landscape.

Spectrum has a division dedicated to industrial vegetation management, led by Mike Deliman and has contracts with oil and gas, hydro and communication companies. Clearing powerline right-of-ways, communication tower installations, and other industrial sites is a growing area of the company's operations.

Years of research have provided Spectrum with the knowledge and procedures necessary to combat forest infestations and prescribe the best possible course of treatment. While the Mountain Pine Beetle has received a tremendous amount of attention recently, it is by no means the only insect threat in western Canada's boreal forests today. Spectrum has programs designed to address Spruce Bark Beetle, Lodgepole Pine Bark Beetle, Douglas-fir Beetle, Western Balsam Bark Beetle, Spruce Budworms, Hemlock Looper, Douglas-fir Tussock Moth, and others. With the recent announcement from the federal government to commit $100 million to the Mountain Pine Beetle epidemic, companies such as Spectrum are well positioned to provide sound science and practical solutions to the problem.

Advances in entomology in the last several years have meant looking at forest health in a totally different way. In the past, Spectrum has worked with research facilities at a number of government and academic centres such as Simon Fraser University, Canadian Forest Service and the Ministry of Forests. Jon Mullan, head of Spectrum's entomology department, has a Masters degree in Pest Management and has conducted

in-depth research resulting in an array of treatment options.

Safety is a critical concern at Spectrum. It has developed an extensive Occupational Health and Safety Plan, which has been refined over years of practical experience. Internal and external training programs continue to be offered to more than 50 full-time and 400 seasonal employees.

The lifecycle of the forest is complex. By taking a holistic approach to the management of our forests, Spectrum Resource Group Inc. is providing clients with practical, results-oriented solutions. From reforestation to complete stand management, Spectrum can help you manage the forest more effectively and produce better results.

The company's head office is in Prince George, BC. The satellite operation in Chetwynd, BC is managed by Blake Phillips. In Chilliwack, BC, coastal operations are managed by Duane Maki, and in Slave Lake, AB, operations are managed by Tim Wright and Ken White. For more information, visit www.spectrumresourcegroup.com or call 250-564-0383.

Spectrum
RESOURCE GROUP INC

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Reforestation Coordinator

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Area Manager – Peace Region

Ken White, B.Sc. For, FIT
Area Manager - Alberta

Tim Wright, B.Sc. For.
Area Manager - Alberta

Crawford Young, RPF
Vice President

Forest Health

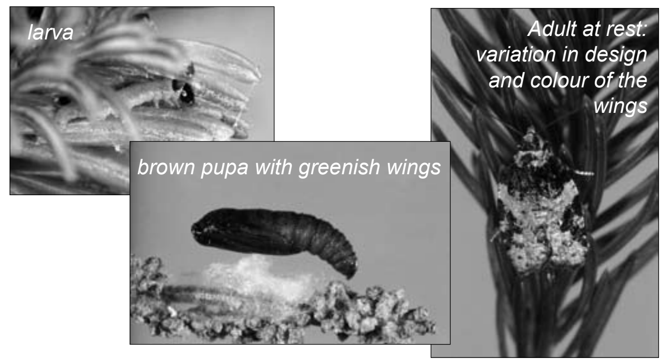
by Don Cameron

Introducing the next dreaded budworm attacking Nova Scotia trees

"We are what we repeatedly do.
Excellence, then, is not an act, but a habit."
Aristotle

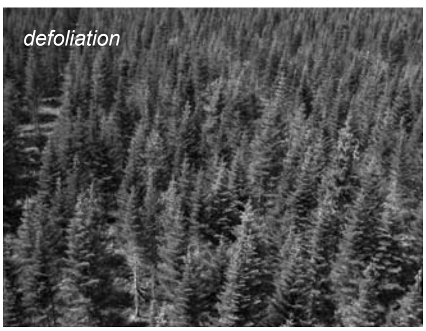
Just when things were starting to ease somewhat with respect to hearing about forest insects, here comes another budworm out of left field. The eastern spruce budworm became a well-known critter through the 1970's and 1980's. And then there was the gypsy moth, cankerworm, and white-marked tussock moth infestations of the 1990's. In recent years there has been major alarm and eradication efforts regarding exotic pests such as the HRM brown spruce longhorned beetle. The year 2005 may become known as the year we started hearing about action taken to fight the infestation of a cousin of our traditional spruce budworm forest pest - the blackheaded budworm.

The blackheaded budworm (Acleris variana) is native to and occurred in our Canadian forests for centuries. The first identified outbreak occurred in 1929. According to DNR Information Leaflet IPM-7, a series of outbreaks occurred in the Maritimes from 1945 to 1950. Over the last 50 years there have only been small, localized infestations occurring every 10 to 15



years, usually in mature and over-mature balsam fir forests. Although the blackheaded budworm is known to feed on as many as 20 different conifer trees across Canada, it greatly prefers balsam fir, which is similar to many other forest pests. Other preferred tree hosts are white spruce and black spruce. As fate would have it, and as a result of past spruce budworm attacks, most of the Cape Breton Highlands forests are composed of balsam fir. The balsam fir forests regenerated naturally throughout the Highlands after the previous forest cover was defoliated and/or harvested. Therefore, the fir and spruce forests (both plantations and naturally occurring) would make an ideal food kitchen for this seemingly new budworm on the block.

History has shown that a heavy infestation of blackheaded budworm can completely defoliate trees in one year, resulting in loss of growth and death of trees. Usually the larvae (caterpillar stage) appear in mid-May from the over-wintered egg masses looking for food. The voracious feeders first snack on the new growth and then move on and down to older growth until they literally eat themselves out of food. They will feed on young or old trees - they are not fussy.


defoliation

Since the huge forest losses to the spruce budworm in the 1970's, which resulted in nearly $38 million spent to rehabilitate the forest, the highlands forest has been regrowing very well. The natural regeneration of balsam fir and spruce plantations are now well stocked and in the range of 9 to 15 metres tall. Most are not yet at or near the harvest stage, except for perhaps some commercial thinning in selected forest stands.

During the fall of 2004, insect surveys determined that approximately 114,000 ha of balsam fir forest in the Cape Breton Highlands contained higher than normal populations of the blackheaded budworm. Given the past trends and perfect food source availability, entomologists believe that there will be a major infestation starting this year that is projected to continue for four years unless something acts to stop it in the meantime. This could be in the form of natural predators, viruses and/or bacteria. However, as things stand now, there is nothing standing in the way of this little worm defoliating tens of thousands of hectares of forest this coming spring and summer. Another worrisome aspect is the fact that it is commonly believed in the science field of pest detection that the blackheaded budworm is a precursor to our native spruce budworm. This one-two punch could be devastating to our forest resources and the forest industry, which as the backbone to our provincial economy, produces almost $1.5 billion in annual sales and creates thousands of well-paying jobs across the province. Therefore, the obvious question arises, what if anything should be done to protect the highland forests from this impending budworm feeding frenzy?

To answer this and other related questions regarding the blackheaded budworm, the Nova Scotia Department of Natural Resources (DNR) has signed a research and development agreement with the Canadian Forest Service (CFS) to do the following:

1. Develop a monitoring tool to be used as an early warning system;
2. Study the effect of natural predators and diseases on the insect;
3. Conduct a spray trial using Bacillus thuringiensis var. Kurstaki (Btk),a naturally occurring soil bacteria;
4. Use the above research to develop forest management tools for the future.

According to DNR Information Circular IPM-4, Btk affects only lepidopteran insects (moths) and is licensed for use in organic farming. In fact, organic gardeners can use Btk on their crops while maintaining their "organic" designation. It can also be used safely on residential areas, greenbelts, parklands and urban areas and has no known effect on wildlife, fish, birds or humans. It has been safely used in Nova Scotia for 25 years protecting forests from defoliating insects such as the spruce budworm, hemlock looper and whitemarked tussock moth.

A maximum of 5000 ha will be sprayed with Btk during the trial period between mid June and mid July, weather permitting. Timing and weather conditions are important operational factors. It has been suggested that the estimated value of the finished forest products, if permitted to grow to maturity in the 5000 ha treatment area, is in the vicinity of $60-100 million.

More information on the topic is available from www.gov.ns.ca/natr/protection/ipm/sheets/ipmbhbworm.htm, or by calling 902-424-5239.

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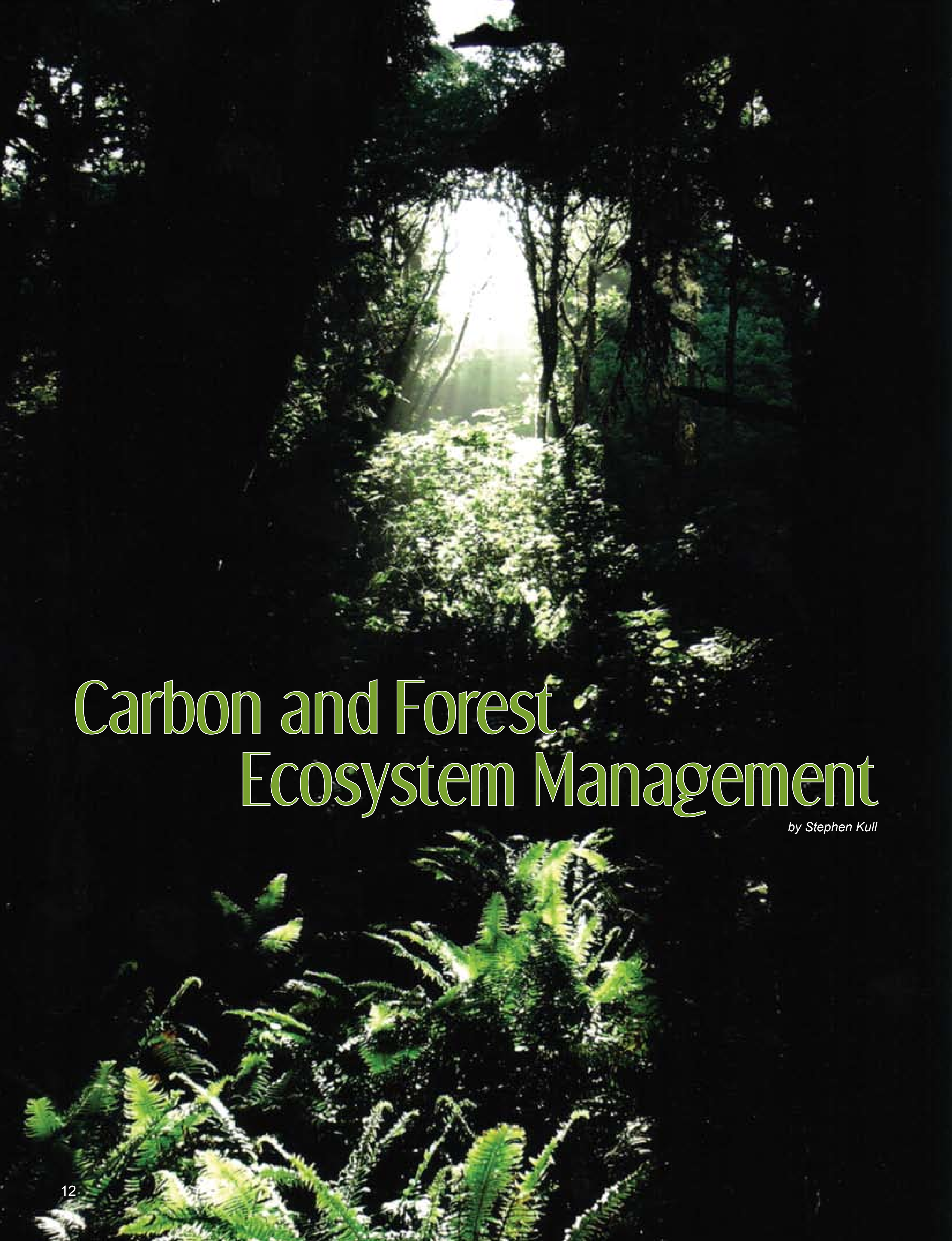


Carbon and Forest Ecosystem Management

by Stephen Kull

We have all been hearing about the element carbon and how we need to start managing it in our ecosystems. Carbon is one of the basic building blocks of all life forms on this planet and has been around on the planet since its formation.

It is found in the atmosphere, biosphere and oceans of the world - amounts in each depend on complex exchanges between these pools. Researchers have studied the carbon cycle for decades, working to unravel its mysteries, intricacies and human-induced changes.

In the atmosphere, carbon is found in gaseous form, mostly as carbon dioxide (CO_2) with trace amounts of other gases such as methane (CH_4). In the biosphere, carbon is sequestered from the atmosphere by vegetation through the process of photosynthesis, and stored in biomass. For example, four cubic metres of wood contain approximately one tonne of carbon. This biomass may be eaten and stored by other living organisms, which eventually transfer the carbon to the atmosphere and biosphere. Biomass carbon may also move back to the atmosphere or into soil after forest fires, or become stored in wood products after they are harvested. Biomass carbon that survives such events eventually decays, returning some carbon to the atmosphere and some to soils.

Over time, most of the carbon in this decaying organic matter is released to the atmosphere over hundreds to thousands of years. Under the right conditions, and in combination with other geological and physical processes, a small amount of the buried organic matter will transform into coal, petroleum and other fossil fuels over thousands to millions of years.

Ice-core research, which studies earth's climatic and atmospheric history, and other research examining recent measured data have shown that atmospheric CO_2 concentrations in this century are at their highest levels in the last 420,000 years—possibly in the last 20 million years. Scientists from around the world on the United Nations Intergovernmental Panel on Climate Change (IPCC) have examined this research and determined the main sources of this increase of atmospheric carbon to be results of human activities—mainly the burning of fossil fuels and deforestation. Carbon in the earth's atmosphere contributes to climate change by acting with a number of other greenhouse gases to trap solar radiation and raise global temperatures.

For Canada and for other countries around the globe, climate change is expected to significantly affect the environment. Rapid ecological and habitat shifts, habitat and species losses, melting of permafrost and ice sheets, shoreline erosion due to rising sea levels, increased frequency of storms and floods, increased severity and frequency of forest fires, insect and disease outbreaks, and drought are all possible because of climate change.

Although the primary focus for mitigating climate change is on reducing fossil fuel burning, natural resource management also plays a role. Foresters can, through forest and ecosystem management, protect existing carbon stocks in forests and sequester additional carbon from the atmosphere. They can also prepare and manage forests and ecosystems for the expected impacts of climate change.

A few strategies that foresters and others can use to sequester more carbon from the atmosphere into forest ecosystems include:

- Afforestation of previously forested agricultural lands and other non-forested lands,
- Using harvest techniques that reduce damage to residual trees and minimize soil disturbance,
- Rapid replanting following harvest,
- Increasing forest productivity,
- Increasing forest protection against fire, insects and disease outbreaks,
- Extending rotation lengths for stands producing lumber,
- More intensive forest management for pulpwood stands,
- Permanent retention of large old canopy trees in selectively cut forests,
- Intensively managing stands on poor soils through soil preparation, weed control, and nitrogen fertilization,
- Leaving logging slash on sites,
- Thinning to increase vigor and protect against insect pests and disease,
- Switching from clearcut logging to shelterwood or selection logging,
- Giving preference to the regeneration of trees used in long-lived wood products
- Replanting forest lands covered by species with low carbon sequestration abilities with species that sequester higher amounts of carbon,
- Increasing the protection and use of natural regeneration.

Foresters can help mitigate impacts of climate change while sequestering additional carbon with strategies such as:

- Planting species adapted to conditions predicted under climate change,
- Planting drought-resistant (deep-rooting) species in drought-prone habitats,
- Planting species that are more efficient at carbon sequestration,
- Establishing plantations that help species migrate with climate shifts,
- Establishing gene-bank plantations to assess genetic variations and ability to adapt to climate changes,
- Maintaining genetic and biological diversity,
- Using climate-based seed zones.

Of course, these strategies must be weighed against sustainable forest management practices, other management objectives, impacts on other forest values, and financial costs versus benefits.

Tools are becoming available to enable forest managers to assess impacts of management strategies on carbon stocks and carbon-stock changes on their lands. Natural Resources

managing natural resources within an

ecosystem context

is challenging

Canada, Canadian Forest Service's Carbon Account Team, in partnership with the Canadian Model Forest Network, has developed the operational-scale Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3). With this complex but user-friendly tool, users apply their own stand (or landscape) level forest management information to calculate carbon stocks and stock changes for the past (monitoring) or into the future (projection). Users can also create and simulate various forest management scenarios in order to assess impacts on carbon.

Results of forest ecosystem carbon analyses using the CBM-CFS3 can be used for various types of reporting requirements. In Canada, many jurisdictions require reporting on criteria and indicators, which include carbon indicators, for forest management plans in order to comply with sustainable forest management guidelines. CBM-CFS3 results can also be used to report on carbon in a similar way in order to acquire forest certification. For example, the Canadian Standards Association requires values, objectives, indicators and targets for ecosystem contributions to global ecological cycles, as well as reporting on carbon uptake and storage, in order for a managed forest to meet sustainable forest requirements of certification.

Managing natural resources within an ecosystem context is challenging. An understanding of interactions among climate change, ecosystems and the carbon cycle is becoming increasingly important for successful forest ecosystem management. Further study into the intricacies of the carbon cycle will continue, including research into better forest management methods and silvicultural techniques for carbon sequestration, impacts of managing carbon on other forest values, risk and uncertainty associated with carbon management, and the long-term effects and economics of carbon management. The IPCC warns that climate change is probably irreversible in any time of direct human interest; however, efforts by foresters across Canada to manage and sequester greater amounts of carbon in our forest ecosystems, when summed together with other greenhouse gas emission strategies, can play a significant role in mitigating potential impacts of climate change on our planet, our forest ecosystems and our lives.

The author would like to acknowledge Dr. Mike Apps, Dr. Werner Kurz, Tina Schivatcheva and Ed Banfield for their comments. Stephen Kull works at the Northern Forestry Centre with the Canadian Forest Service. He can be reached at T 780-435-7304, F 780-435-7259 or skull@nrcan.gc.ca.

Focus on Safety

By Ontario Forestry Safe Workplace Association

Dehydration, Heat Exhaustion and Sunburn

Preventing dehydration is a lot easier than treating it, so tree planters need to be very aware of their body's fluid levels as they work. Don't rely on thirst as an indicator of your need to absorb fluids—thirst is a late response to low fluid levels. The colour and amount of your urine is a better indicator. A lot of light-coloured urine means that your body is well hydrated. Smaller amounts of dark urine tell you your body is trying to hoard its remaining fluid.

Dehydration-related illnesses take one of three forms:

• Heat syncope or fainting spell is a mild form of heat exhaustion. Symptoms include faintness, dizziness, headache, nausea and even a brief loss of consciousness. The planter should lie or sit down, preferably in the shade, with feet elevated, and should slowly be given water to drink. No vigorous work in the heat should be undertaken until fluid levels and urinary flow have returned to normal.

• Heat exhaustion is a more serious form of dehydration. Symptoms include pale and clammy skin, increased heart and respiratory rate, decreased urination, weakness, dizziness, nausea and vomiting. The recommended rehydration treatment is the same as for heat syncope, but the planter should be even more cautious about resuming physical work. Examination by a physician is recommended before resuming work.

• Heat stroke (also known as sunstroke) is a medical emergency caused by a dramatic increase in body temperature, usually due to fluid depletion. If the body temperature is not brought down, the victim can die within minutes. A key sign of heat stroke is hot, dry skin. Heart and respiratory rates are sped up, the pupils may be dilated and the victim may have seizures and lapse into unconsciousness. Move the victim gently but immediately to a cooler location, remove their clothing and pour water on their extremities. If possible, immerse them entirely in cool (not cold) water. After the body temperature has come down to 39 degrees (103 Fahrenheit), stop any active cooling of the body, monitor the victim closely and prepare for evacuation to a hospital.

In hot and humid weather, tree planters lose more fluid through sweating than they normally would as a result of their exertion, so water intake is even more important. Take short, frequent sips rather than big gulps. Remember that it is nearly impossible to drink and absorb as much water as you're losing while working. Be sure to bring enough to last you the whole day.

Rising rates of skin cancer and increased awareness of the hazards of over-exposure to the sun's ultraviolet rays make precautions against sunburn a high priority for all outdoor workers. Wear a wide-brimmed hardhat, a long-sleeved shirt with a high collar and a light scarf around the neck. Apply a broad-spectrum sunscreen with a high Sun Protection Factor (SPF) to any exposed skin. Even waterproof sunscreen can come off when you sweat, so it will need replenishing. If you do get sunburned, apply skin-care lotion or aloe gel and try to reduce your exposure to the sun until the skin heals. If the sunburn is severe enough that blisters form, seek medical attention.

The Ontario Forestry Safe Workplace Association (OFSWA) recently launched SafePlanting.com, a comprehensive online health and safety training course for tree planters. For more information about the program and other health and safety resources for tree planters, contact OFSWA at 705-474-7233 or info@ofswa.on.ca.

WESTERN SILVICULTURAL CONTRACTORS' ASSOCIATION

by John Betts

Are we due for a correction in bid prices?

There were several indicators this spring that the planting market may have bottomed out. A late crop of BCTS contracts, tendered while the spring 2005 season was in full swing, came in anywhere from 10-20% above what similar work went for during the fall 2004 viewing season. This was as much a product of ill-timed tendering as rampant bidder confidence but could be a sign of the beginnings of a market correction, or at least a leveling off of prices. Reports came in from around the province that fewer inexperienced workers applied for jobs while the number of "no shows" increased. The WSCA did a straw poll that was not statistically valid by any rigorous scientific standards but still concise enough to establish that low wages in the silviculture industry coupled with low unemployment nationwide was impacting the efficiency of some contractors.

Markets must eventually correct themselves. However, contrary to the Newtonian Law of Gravity ("That which goes up must come down"), there is a point where, if wages are too low and other more attractive opportunities exist, it becomes impossible to attract new skilled workers, which can have a negative effect on the overall market.

One of the great ironies of our industry is that even in the context of rock-bottom pricing for silviculture work, the best values are still realized by attracting skilled workers to do an exceptional job by paying slightly above market cost. In most cases this substantially reduces overall related project costs and effectively controls unexpected long-term costs. Along with the strategy of securing experienced workers with reasonable wages, many forward thinking contractors have also been supplying additional services such as surveys, allocations and stock coordination as part of the bid price. The value-added approach helps to maintain client loyalty while bringing related efficiencies to both the contractor and the licensee. This growing professionalism by some of the industry's more progressive operators has helped promote new state-of-the-art silviculture software tools such as Plant Wizard. These new dynamic tools have facilitated an increase in organizational capacity and enabled unprecedented data tracking and information flow.

It would be difficult to evaluate the positive impact of this progressive part of the silviculture industry unless longer-term expenses are diligently tracked to free growing and there is meaningful science done in weighing the host of variables that can affect plantation vigour. Unfortunately, investors with short attention spans and foresters forced to meet unrealistic targets for quarterly expenses often don't have the time to do meaningful evaluations. Even with a lack of long-term costing models it is safe to say that those licensees that have taken care to maintain high standards and prioritize good contractor relations will be proven to have the most enviable costs to free growing. The corollary of this is: Any market adjustment next year may affect those licensees who have favoured the low bid option. A history of reaping the short-term benefits of ever declining bid prices at the expense of good contractor relations will cost more in a rising market and restrict access to skilled workers.

The moral of the story? It may be time for licensees to treat preferred contractors with a little more reverence, and hold the line on asking for bid price reductions or offer a marginal increase in acknowledgement for a job well done!

ASSOCIATION DES ENTREPRENEURS DE TRAVAUX SYLVICOLES

par Fabien Simard, ing.f., Directeur général

Le positionnement de l'AETSQ face aux coupures de 20 % de la possibilité forestière des régions du Québec

Dans les régions du Québec, on ne parle que de la coupure de 20 % de la possibilité forestière, décision du ministère des Ressources naturelles et de la Faune. En effet, le gouvernement prétend que pour sauver le capital forêt, il est nécessaire de procéder à ces baisses d'approvisionnement. D'autre part, des voix régionales s'élèvent arguant les effets dévastateurs de cette recommandation pour les emplois en région ainsi que sur la viabilité des usines de transformation. Selon l'AETSQ, une étude d'impact aurait permis au MRNFQ de trouver une solution équivalente et qui aurait respecté les trois volets du développement durable que sont les volets : économique, social et environnemental. D'ailleurs, cette façon d'équilibrer les trois dimensions du développement durable existe déjà en forêt. Prenons, par exemple, la construction d'infrastructures (routes, barrages, camps), elles contribuent largement au développement économique et social d'une région. Toutefois, dans ce genre de développement, les forestiers sont également tenus de mettre en place des mesures de mitigation servant à réduire l'impact sur l'environnement. A priori, la décision de réduire de 20% les approvisionnements en bois semble compatible avec les concepts de précaution et de développement durable. Cette façon de ménager permettrait de continuer à perpétuité l'exploitation de nos forêts. Toutefois, la réduction des approvisionnements n'est pas nécessairement une décision optimale.

Dans une perspective de développement durable qui tient compte de la réalité économique, le principe de précaution commande plutôt de poser des gestes qui, non seulement permettent de conforter les approvisionnements à long terme, mais qui procurent aussi des avantages concurrentiels significatifs aux entreprises forestières (grandes ou petites) de nos régions et du Québec. En effet, la survie et la pérennité de notre industrie forestière ne seront assurées que dans la mesure où nous posons des gestes concrets visant l'amélioration de notre compétitivité.

Également, nous pouvons nous inspirer de l'exemple des pays scandinaves. Ces derniers, lorsque confrontés à des ruptures de stocks, n'ont pas réduit les approvisionnements et fermer leurs usines; ils ont plutôt investi massivement dans la productivité des forêts en intensifiant les travaux sylvicoles. Plutôt que de « ménager » leurs forêts, ils les ont « aménagées » ! Aujourd'hui leurs forêts et leurs usines sont des modèles de productivité.

L'intensification de la sylviculture : la solution sur mesure pour le développement forestier durable des régions ressources

L'intensification des travaux sylvicoles vise d'abord à renforcer la compétitivité des utilisateurs de la ressource. Par exemple, des investissements en travaux sylvicoles permettent de créer des avantages concurrentiels sans pour autant présenter les mêmes lacunes qu'une baisse pure et simple de l'approvisionnement:

• **Baisse des coûts de récolte**
Il a été démontré par les chercheurs chez FÉRIC que les coûts de récolte dans des forêts éclaircies sont significativement inférieurs à ceux des forêts non éclaircies;

• **Baisse des coûts de transformation des bois**
Il a été démontré que les coûts de transformation de bois issus de forêts éclaircies sont inférieurs à ceux de bois issus de forêts non éclaircies (Forintek);

• **Augmentation de la valeur des produits.**
Des études ont démontrées que la valeur des produits forestiers issus de forêts éclaircies est supérieure à celle de forêts non éclaircies.

• **Création de valeur.**
Des études financières ont démontré que de tels investissements peuvent créer de la valeur économique en présentant des taux de rendement internes de plus de 15%.

Au cours des dernières années, notre industrie forestière a vu ses principaux avantages concurrentiels disparaître : coût de l'électricité, disponibilité de matière première, taux de change, libre accès au marché américain du bois d'œuvre, le prix des redevances. Dans ce contexte, il est impératif de se doter de moyens qui permettront de retrouver ces avantages.

Encore une fois, force est d'admettre que la solution au point de vue environnemental ne réside pas uniquement dans la réduction des approvisionnements, mais aussi dans l'intensification des travaux sylvicoles.

QUEBEC TRANSLATION

by Fabien Simard, RPF, Executive Director

The AETSQ Stance on the 20% Cuts in Quebec's Regional Forestry Potential

In Quebec, there is much talk about the 20% cut in forestry potential decided on by the Ministry of Natural Resources and Wildlife. The government claims, in effect, that it is necessary to undertake these reductions in supply in order to conserve forest capital. On the other hand, regional spokespersons are heard protesting the devastating effects of this recommendation on jobs in the regions and on the viability of processing mills. According to the AETSQ an impact study would have allowed the Ministry to arrive at an equivalent solution that would have respected the three essentials of sustainable development: the economic, social and environmental factors.

Moreover, this means of equating the three elements of sustainable development already exists in the forest setting. If we take, for example, the creation of infrastructures such as roads, dams and camps, the latter contribute sizably to the economic and social development of a region. Furthermore, in this type of development, foresters are also obliged to implement mitigating measures designed to reduce the environmental impact.

At first sight, the decision to reduce the timber supply by 20% seems to be compatible with the ideas of prudence and sustainable development. This type of husbandry should allow our forests to be worked in perpetuity. However, reducing supply is not necessarily the most desirable decision.

From the viewpoint of sustainable development based on economic reality, a policy of prudence demands rather the taking of steps that not only favour long-term supply, but also provide significant competitive advantages to forestry companies (large and small) in the regions and in Quebec as a whole. In fact, the survival and durability of our forestry industry will be assured only insofar as we take concrete steps to improve our competitiveness.

We might also draw on the example of the Scandinavian countries. They, when confronted by interruptions in supply, did not reduce their stockpiles and close their mills; instead, they invested massively in the productivity of their forests by intensifying their silvicultural practices. Rather than "husbanding" their forests, they "managed" them! Today their forests and mills are models of productivity.

Silvicultural intensification: a made-to-measure solution for the lasting development of forestry in our resource regions.

The intensification of silvicultural practices aims first and foremost at increasing the competitiveness of the users of the resource. For example, investments in silvicultural practices allow the creation of competitive advantages without involving the drawbacks of a pure and simple reduction in supply:

- **Lowered harvesting costs**

It has been demonstrated by the FÉRIC researchers that harvesting costs in thinned forests are significantly lower than those in forests that have not been thinned;

- **Lowered wood processing costs**

It has been shown that processing costs for wood produced in thinned forests are lower than for wood grown in forests that have not been thinned (Forintek);

- **Increased value of wood products**

Studies have shown that the value of forest products from thinned forests is higher than from forests that have not been thinned;

- **Enhanced value**

Financial studies have proven that such investments can enhance economic value by offering internal rates of return of more than 15%.

Over the past few years, our forest industry has seen its principal competitive advantages disappear: low electricity costs, availability of raw materials, favourable exchange rates, free access to the American lumber market, low tax levels. In these circumstances, it is imperative that we seek ways of recovering these advantages.

Once again it must be admitted that the obvious environmental solution does not consist only in reducing supply, but also in intensifying silvicultural practices.

NEW BRUNSWICK

AGFOR REPORT

by Gaston Damecour

New Brunswick Minister of Natural Resources Sets the Course

The Jaakko Pöyry report, released in 2002, led to a great production of further reports, articles, commentaries, briefs and responses. Hundreds of submissions in response to the Jaakko Pöyry report were received by the all-party Select Committee on Wood Supply and contributed greatly to the final report of that committee in September 2004.

On June 1, 2005, Natural Resources Minister Keith Ashfield presented the New Brunswick government's action plan in response to the report of the Select Committee on Wood Supply. Every indication was that this was not – and should not have been – an easy task.

What Ashfield put on the table is a process leading to a significant rethinking of how the Province of New Brunswick will oversee the management of its Crown lands. While nothing was rejected outright, some issues remain nebulous and unresolved.

Industry did not get the increased wood supply guarantee it wanted immediately. Industry reacted swiftly and hotly with charges of inaction against the government and raising the portent of mill closures without a firm increased wood supply objective.

Ashfield responded by saying that unlike Quebec and Ontario, New Brunswick would not reduce wood allocation. As Minister, Ashfield reaffirmed that stance with a strong commitment to maintain the current wood allocation level.

The main thrust of the government's response to the report of the Wood Supply committee is to engage the public in meaningful and informed participation in an ongoing process. This is both feasible and practical in Canada's most rural province with a population of 750,000 people. Most residents and businesses in New Brunswick have an economic attachment to the forest. To set an increased wood supply objective now - without the public's involvement - would be misleading and contradictory.

The government's response includes many vague and undefined bits of government-speak and committees: implementation committee, advisory committee, stakeholder committees and a task force. It also includes an independent external expert and a pilot project that at first read suggest a weak response.

Obviously, the proof of this pudding will be in the execution and the government's determination to hold to its main thrust: public participation.

New Brunswick brought wood supply modelling to the forefront of international forestry. New Brunswick now has the opportunity to do the same, on the world stage, for meaningful public involvement in the forest industry.

This government's success will depend on the open, transparent and engaged participation of industry leaders in what is a closed shop to most, including to many forest industry players.

The Minister did commit to the current $18.6-million Crown land silviculture program, although that is short of what is needed to meet resource management plan targets. He said that funding levels would be set for the 2007-2012 management period and that a dedicated Crown silviculture fund would be established to receive funds generated as a result of royalty increases. The commitment to silviculture on private lands remains at $7.2 million.

Our next report will look at mechanical pre-commercial thinning in remote and high-stem, or wall-to-wall, count sites. The first New Brunswick trials are 4 years old. The effectiveness of this approach, and perhaps lessons to be learned, are about to emerge.

Gaston Damecour is a registered professional forester in New Brunswick and Nova Scotia. He is the senior consultant and principal of AGFOR Inc., based in Fredericton, NB. AGFOR has been instrumental in bringing about significant changes in the forest sector by representing governments and industries on such issues as health and safety, standards for forestry equipment, industrial relations, wood allocations and forest management policy.

BIOENERGY

BIOMASS TO RICHES:
The shortest distance between a good idea and an energy solution

By Luc C Duchesne, PhD

On a sweltering hot day in June, the Ontario power demand peaked to capacity while oil traded at a record high of US $60 a barrel.

The rising cost of energy is whipping the energy sector into a frenzy. We need to find alternatives in renewable forms of energy. Wind seems to come to mind, but wind power is but one of the many solutions available to us.

In the Winter 2004 issue of Canadian Silviculture we wrote about the bioeconomy and how forests should jockey Canada into a position of strength. On paper, half of Canada's energy needs could be met by forest and agricultural biomass.

Going from mathematical models to substituting fossil fuels cost-effectively is proving a difficult task with many obstacles. Biomass for energy does not grow on trees. At least not the trees with which we are familiar.

Trees across Canada are spoken for. They are the dedicated feedstocks of industrial forestry and it would make no economic, social and political sense to destroy an industry to support the emergence of the bioenergy industry.

Don't think about productive farmland either. They too are spoken for. Perhaps the best example of this comes from the budding biodiesel industry. Worldwide, there are a number of effective technologies that transform vegetable oil into biodiesel. In turn, biodiesel can be used as a substitute to petro-diesel. But the biodiesel industry is haunted by the commodity pricing of vegetable oil. Canola oil, an abundant feedstock from western Canada, is used by the food industry. At roughly sixty cents per litre, this feedstock is grabbed by the food industry and cannot compete with petro-diesel. Sure enough, there will be a point where the cost of crude oil will be such that canola oil will be a price-competitive feedstock. But what about the food industry? Where will it draw its feedstock from? In the short-term it means that farmlands will continue to be dedicated primarily to foodstuff production. However, straw and other waste products can contribute to the energy sector.

But what about the forests? If forestlands are dedicated to the production of wood fiber, how can we generate new energy sources?

Over the past 5 years the forest industry has turned its attention to its industrial waste as energy sources. On the one hand, the so-called industrial waste is seen as an in-house solution to offset the rising cost of energy. These are now used in different types of single or co-generation applications, which mostly generate heat, process steam and/or power. On the other hand, most woody residues (sawdust and shavings) of good quality have been commoditized such that they too are tied up by a

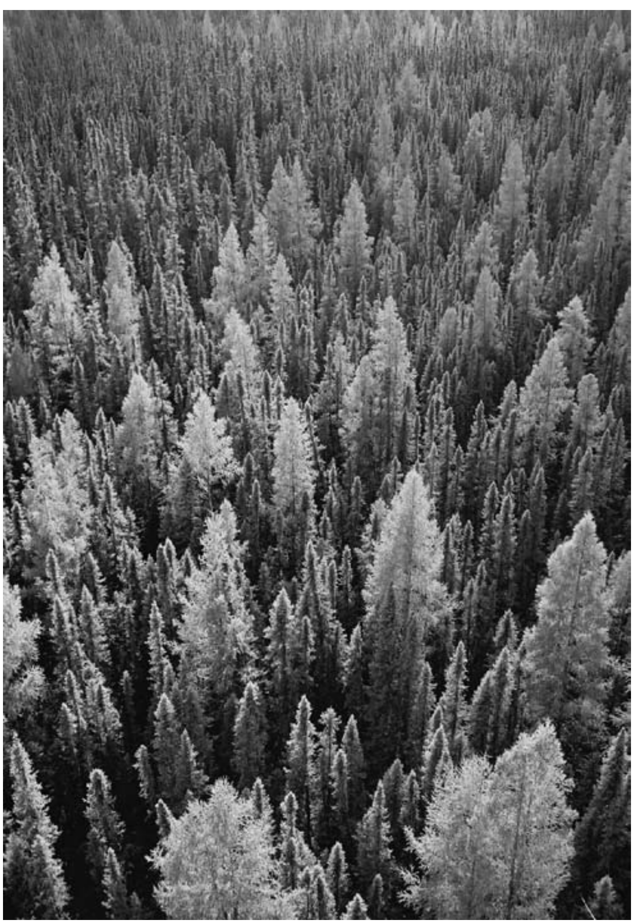
there may be

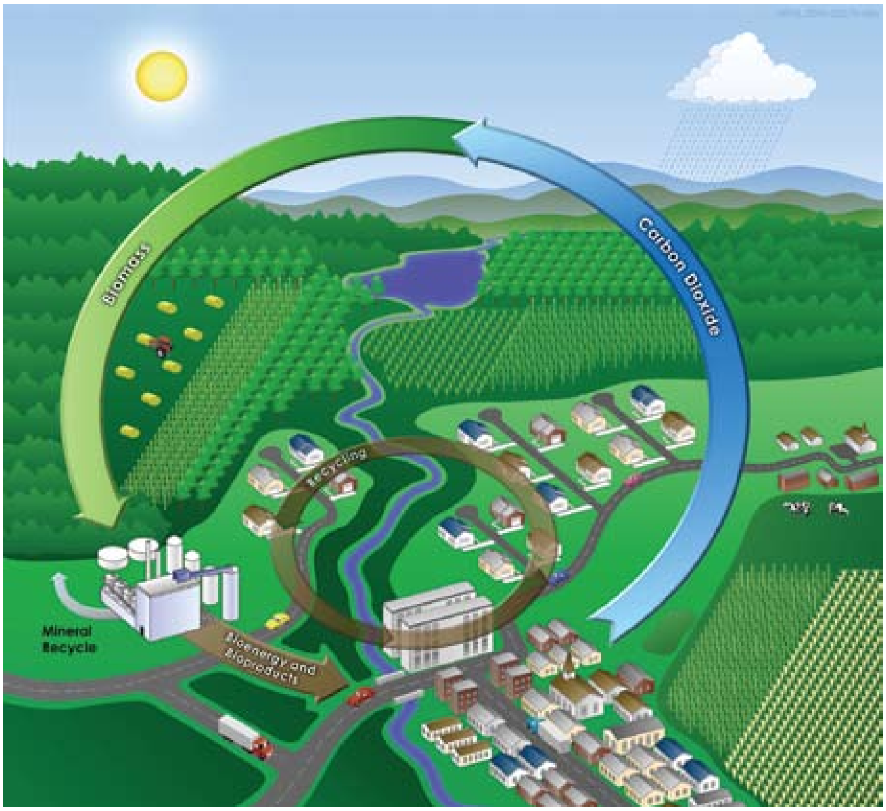
ecological risks

stable industrial sector, a cluster of secondary industries with as much credibility and legitimacy as the primary forest industry.

Although logging slash appears as a likely provider of energy, this material carries both ecological and financial liabilities. The jury is not out yet, but arguably there may be ecological risks associated with exporting a significant amount of nutrient offsite. Nevertheless, this practice is now economically feasible in Canada and logging slash is used for hog fuel (see Table 1) as it provides energy at a cost that is competitive with fossil fuel expressed in Gigajoules (GJ). The average Canadian house necessitates 115 GJ per year of which 70 GJ are for space heating, 25 GJ for hot water heating, 15 GJ for appliances, and 5 GJ for lighting.

Agroforestry is showing promise as a likely candidate to help solve our collective feedstock problem. It should help us find ways to cultivate dedicated feedstocks for bioenergy using





lands that are not used by the forestry and the agricultural sectors.

Take New Brunswick as an example. With 35,000 ha of abandoned farmland in the province and assuming an optimistic yield of 10 bone-dry tonnes of biomass per hectare per year, there is potential to generate 350,000 tonnes of biomass. In turn, this material contains the equivalent of 6,300,000 GJ (at an average energy density of 18 GJ per bone dry tonne), which would account for 3.4% of the provincial energy budget of approximately 187,500,000 GJ. By making use of the power transmission corridors (33,000 ha) we could possibly add a significant amount to the province's energy budget.

Finding the right biomass species to grow is now a challenge, though much research has been done. Poplars and willows have been suggested as suitable species. However, they cannot be used safely under power lines, and their growth is highly dependant on soil fertility, which then adds to the cost of biomass.

Perennial grasses seem to offer a suitable alternative. Among the perennial grasses, switchgrass has received the most attention from crop scientists and plant breeders for use as a biofuel. As a result, several improved varieties have been developed and are classified as either upland (i.e. high and dry) or lowland (i.e. floodplain). Switchgrass can grow to 3 m tall and has an equally deep, extensive root system - enabling it to acquire water and nutrients under periods of drought. It propagates by seed and rhizome, and once established a stand can persist indefinitely. Since the early

1990s, Resource Efficient Agricultural Production (www.reap-canada.com) at McGill University has conducted extensive work on the species.

Switchgrass is a C4, warm season perennial grass native to and widely distributed across North America. It occurs in a range of climates and soils and has been successfully grown as a forage and energy crop. It is adapted to marginal soils typified by drought and low fertility, which generally do not support cash crops such as corn and soybean.

In general, switchgrass grows very well at low pH and shows minimal response to fertilizer application. The switchgrass crop is usually overwintered and is mowed and baled in late May. Although yields can be cut by 25%, overwintering is cost-effective – it improves winter survival, suppresses weed growth, reduces fertilizer requirements and eliminates the need for field drying prior to baling. It also improves combustibility by reducing ash content.

Trials in eastern Canada show that switchgrass production peaks in the third growing season. The first and second crops will produce 30-40% and 70-80% of the maximum yield, respectively. Once established, a switchgrass stand could last 10 years or more, consistently yielding 8-13 t/ha of biomass (Table 1).

Table 1: Comparative pricing of different biomass feedstocks for bioenergy

Energy source	Productivity/ha	Cost per tonne	Cost per Gigajoule
Oil—US 60/barrel	--	--	$11.8
Switchgrass	10 tonnes/ha	$68	$3.78
Poplar	6.5 tonnes/ha	$85-135	$4.72-7.50
Logging slash	--	$55-100	$3.0-6.0

Table 1 demonstrates that the cost of energy feedstocks is deceptively lower than that of fossil fuels and in practice there is no guarantee that these feedstocks are economical to use. For one thing, transport costs can easily add $2-4/GJ. As well, the substitution of fossil fuels with biomass may be associated with high capital costs. However, the cost of fossil fuels is pushing us toward a point where it will be economically feasible to grow biomass as bioenergy feedstocks.

Added to the economics of biomass are potential subsidies from government as well as carbon credits, which may dramatically increase the financial returns on these investments. These bioenergy opportunities await entrepreneurs to solve the remaining unknown factors and bring more biomass into Canada's energy programs.

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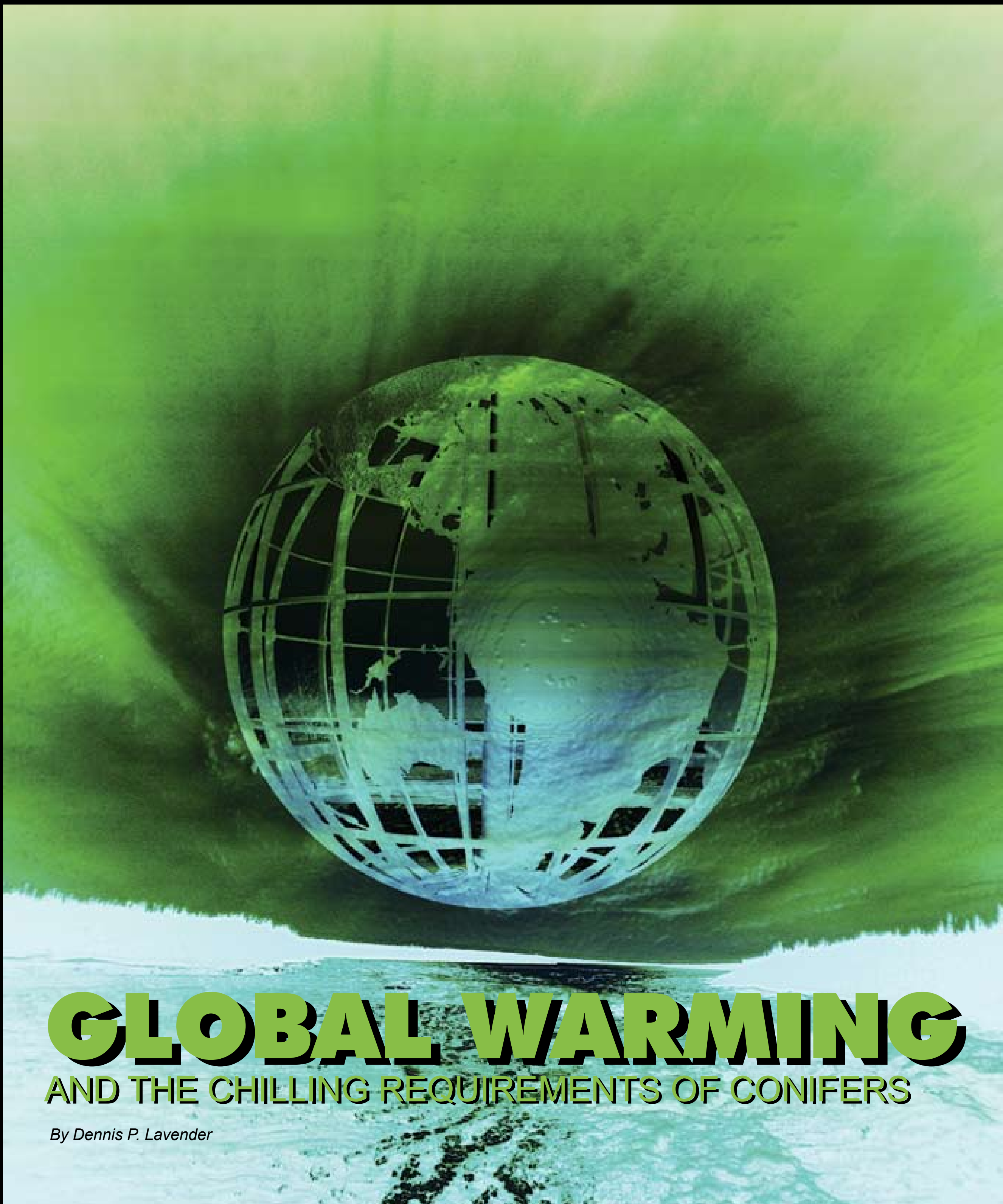

GLOBAL WARMING

AND THE CHILLING REQUIREMENTS OF CONIFERS

By Dennis P. Lavender

Fully one third of BC's Ministry of Forest's Research Branch finds itself engaged in analyzing climate change driven, stock shifting requirements in various ecosystems. Dennis Lavender's unpublished 1989 article gives us a clear understanding of one of the factors we now have to consider.

The role of low temperatures in breaking dormancy was first discovered in 1801, but workers did not investigate this phenomenon in woody plants until the early 20th century. Then, although delayed foliation in peaches was reported in Georgia in 1890, low temperatures generally were not related to breaking of dormancy until 1907, when it was recognized that peaches differed in their rest period, and 1920, when Colville investigated the chilling requirements of a number of woody species.

The term "chilling requirement" currently refers to the temperature (commonly around 5 degrees C.) and duration of exposure necessary to prepare the apical meristems of temperate perennial plants to resume growth when temperatures become favourable in the spring. Confined largely to plants that are exposed to freezing temperatures during the winter, such a requirement serves to prevent active shoot growth during brief warm spells in winter months, when such growth would be damaged by subsequent low temperatures.

The horticultural literature of the thirties and forties has a number of references to the chilling requirements of perennial horticultural species and, in fact, the distribution of perennial crop plants in the central valley of California is largely dictated by the number of days of low temperatures at a given location. One of the tools in responding to the predicted greenhouse effect with regard to the implication of global warming upon the pattern of winter temperatures necessary to fulfill the chilling requirements of forest trees.

Table #1 - Chilling Requirements of some western North American forest tree species

SPECIES	Chilling Requirements (Weeks)
Douglas-fir (Psuedotsuga Meziesii)	13
Douglas-fir (Psuedotsuga Glauca)	17
Western Hemlock (Tsuga Heterophylla)	4
White Spruce (Picea Glauca)	4-8
Englemann Spruce (Picea Engelmann)	6-8
Red Osier Dogwood (Cornus Sericea)	3

This tool is reflected in the data in table 1 – the chilling requirements of several species are relatively short and their distribution may well be affected more strongly by other aspects of climate change, and some species in the table are boreal, and even the greatest possible warming will not result in a winter temperature limitation in their present ranges. However, the principal timber species of Western North America, Douglas-fir Pseudotsuga menziesii not only has a substantial chilling requirement but has a present range which is predicted to experience a significant warming in the next 50-100 years. That Douglas-fir is definitely at risk over much of the more productive portion of its current range was already evidenced by the Copes report, in 1983, which documents the decline of a Douglas-fir seed orchard composed of seedling root stock and mature scion material established in the Monterey Bay region of California a decade ago. The rationale for location of the seed orchard in this area was that there were no natural Douglas-fir to contaminate orchard pollen even though the climate seemed favourable. The reason there were no natural Douglas-fir became evident within three years of the establishment of the orchard when understock material and the scions demonstrated a growth habit compatible with that of plants which have received insufficient chilling. The mean temperature of the three coldest winter months in the Monterey Bay area is currently about 11 degrees C. The mean temperature of these same months in much of western Oregon below three hundred meters is 6-7 degrees C.

Although studies in controlled environment chambers may be criticized on the basis that the environments maintained do not adequately represent natural weather patterns, it is virtually impossible to determine the chilling requirements of a plant by exposing it to the natural temperature sequence during winter because: a) the relative efficiencies of temperatures which differ only slightly, upon the satisfaction of a given species' chilling requirement, may be great, i.e. 10 degrees C. has been shown to be only 50% as effective in satisfying the requirements of Prunus persica as 6 degrees C.; b) the internal bud temperature and not the air temperature is the effective temperature for the chilling requirement and, therefore, sunny days with low air temperatures may not be effective in satisfying the chilling requirement; and c) it is not clear what effect periods of warm temperatures, i.e. 15 – 20 degrees C., may have on the sequence of physiological changes associated with the satisfaction of the chilling requirement.

Controlled environment chamber studies with Douglas-fir demonstrated that this species has a chilling requirement of from 12 to 14 weeks at 5 degrees C. and, further, that this requirement was consistent for a range of seed sources from western Washington and Oregon at both low and high elevations. When a constant 7 degrees C. or 9 degrees C. temperature was employed to satisfy the chilling requirements, the growth response of the seedlings in a subsequent favourable environment was delayed significantly with reference to that which occurred after the 5 degree C. treatment. Long-term weather data for a range of stations in western Oregon demonstrate that the mean temperature for the three coldest months of the year at

global warming

will adversely affect Douglas-fir

stations below 300 meters is in the range of 5-7 degrees C. It is evident then, if global warming results in an increase of winter temperatures of 5-7 degrees C. in northern California, Oregon and Washington as currently predicted, that Douglas-fir will be eliminated from the productive forest stands below 300 meters and possibly even higher.

I do not have detailed weather data for British Columbia, however the number of chilling hours reported for Whalley and Campbell River, 10 and 17 weeks respectively, suggest that global warming will adversely affect Douglas-fir in the lower mainland and on Vancouver Island perhaps as far north as Comox.

The above discussion is concerned with long-term effects. Of more immediate concern is the probable effect of increased winter temperatures upon the viability of planting stock. The majority of nurseries in Oregon and Washington (and northern California) which grow Douglas-fir seedlings are located in relatively warm areas in winter. If the predicted temperature trends do, in fact, occur the incidence of temperatures greater than the mean is such that very arguably we shall experience a winter with mean temperatures 5 degrees C. greater than the present long-term average before the year 2000. Should such an event occur, the majority of the stock in these nurseries will receive insufficient chilling and have, consequently, a very low survival potential.

A second major probable effect of global warming upon trees in western North America is described very elegantly by Cannell. Working with data from weather stations maintained continuously over one hundred years in Scotland, he shows that for species whose chilling requirements will continue to be satisfied by even the warmest predicted climates, i.e. lodgepole pine and white spruce in interior British Columbia, or species subject to a continental climate in the western U.S., the date of mean bud break will occur at a lower mean temperature than is true presently. Accordingly, these species will be subject to a much greater risk of frost damage from late spring cold events.

Dennis P. Lavender is Prof. Emeritus, Forest Sciences Department, University of British Columbia.

CANADIAN SILVICULTURE

BUYER'S GUIDE

Additions

We apologize that the following companies were missing from the alphabetical listing in the Buyer's Guide published in the spring.

Alpha Tent & Awning T 604-298-3636
201-2984 Norland Ave, Burnaby BC V5B 3A6 F 604-298-7275
www.alphatentandawning.com

Homesteader Meats T 250-563-1002
20-556 North Nechako Rd, Prince George BC V2K 1A1 F 250-563-1535

Pelton Reforestation T 604-465-5411
12930 203 St, Maple Ridge BC V2X 4N2 F 604-465-7719
www.pelton.com

Pro Mac Manufacturing Ltd. T 250-746-5181
294 Jacob Rd, Duncan, BC V9L 6W4 F 250-746-4799
www.promac.bc.ca

Risley Equipment T 780-532-3282
9024 108 St, Grande Prairie AB T8V 4C8 F 780-538-1808
www.gorisley.com

Rotobec Inc. T 418-383-3002
200 Industrial St, Sainte-Justine QC G0R 1Y0 F 418-383-5334
www.rotobec.com

Shindaiwa Inc. T 503-692-3070
11975 SW Herman Rd, Tualatin, Oregon 97062 F 503-692-6696
www.shindaiwa.com

Stihl Ltd. T 519-681-3000
Box 5666, London ON N6A 4L6 F 519-681-1603
www.stihl.ca

TerraLink Richardson Seed T 604-864-9044
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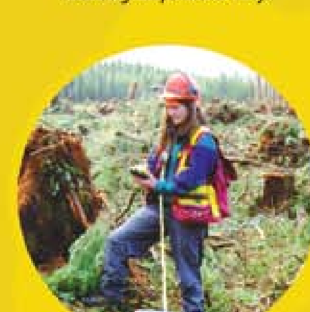

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