Healthy Forest
PARTNERSHIP

EARLY INTERVENTION STRATEGIES TO SUPPRESS A SPRUCE BUDWORM OUTBREAK

February 12, 2015 — 8:30am to 4:30pm

Hugh John Flemming Forestry Centre

"Protecting Our Forests"

Early Intervention Strategies to Suppress a Spruce Budworm Outbreak (EIS-SBW)

8:00 – 8:30 Meet and Greet

Moderator: Kristian Moore, New Brunswick Department of Natural Resources

8:30 – 8:35 Spruce Budworm Outbreak Video

8:35 – 8:45 Opening Remarks and Welcome – Minister of Natural Resources, Honorable Denis Landry

8:45- 9:00 Dr. David MacLean University of New Brunswick

Dr. David MacLean is Professor at the University of New Brunswick, where he was Dean of the Faculty of Forestry and Environmental Management from 1999-2009. Prior to that, he spent 21 years as Research Scientist with the Canadian Forest Service, researching spruce budworm impacts, modeling, and decision support. In 2008 he was awarded the Canadian Forestry Scientific Achievement Award.

"Healthy Forest Partnership – Spruce Budworm Early Intervention Strategy"

9:00 - 9:30 Jeremy Gullison, New Brunswick Department of Natural Resources

He is a native of New Brunswick. He received a MSc in Forestry from UNB in 2002. He joined DNR in 2001 as a Forest Management Planner and became a member of the Forest Pest Management Section in 2006. Currently he coordinates forest pest management activities for NB DNR and provides expertise in GIS and decision support tools.

"SBW Status in NB in 2014 and the Outlook for 2015"

The last outbreak of Spruce Budworm (SBW) in the eastern Canadian Provinces and State of Maine (1967-1990) peaked at over 50 million hectares and destroyed hundreds of millions of cubic metres of spruce-fir wood volume. The decline in SBW populations in Eastern North America in the 1980s-1990s brought a respite from the problem; however, the respite appears to be ending given the growing outbreak in Quebec. This presentation will give an update of the budworm monitoring that was conducted in NB in 2014 with an outlook of what might be expected in 2015.

9:30 - 9:45 Break – refreshments in the lobby

9:45 – 10:15 Dr. Jacques Régnière, Laurentian Forestry Centre

Jacques Régnière is a research scientist at the Canadian Forest Service's Laurentian Forestry Centre (CFL) in Quebec City. He has a degree in biology from Université Laval (1976) and a Ph.D. in entomology with a specialization in ecology and biomathematics from North Carolina State University (1980). He has been a research scientist at the Canadian Forest Service since 1980, and is also an associate professor in Université Laval's Department of Forest and Wood Science and in the Faculty of Forestry at the University of Toronto, where he supervises graduate students. He is a specialist in quantitative ecology and his research focuses on the dynamics of forest insect populations, including spruce budworm, mountain pine beetle and gypsy moth populations, as well as on integrated management, and the seasonality and impact of climate change on these organisms. He is the author of numerous scientific articles.

"Dynamics and management of Rising SBW Populations"

10:15 - 9:45 Dr. Rob Johns, Atlantic Forestry Centre:

Dr. Johns received my PhD in biology from the University of New Brunswick in 2007 and have been with the Canadian Forest Service in Fredericton since 2009. My research focuses on insect-plant interactions, population and community ecology, and the development of management strategies for forest insect pests.

"Landscape Level Impacts of EIS on SBW, Other Herbivores and Associated Natural Enemies"

The presentation provides the first year's (2014-2015) results of the research project aiming to assess the efficacy of insecticide application over large areas of very low density populations of SBW, determine the ability of moths to reinvade these areas, validate the bar coding chip and determine the non-target impact of EIS on both the parasitoid abundance and the local herbivore community. Three blocks were treated using mimic, and three blocks were used as control. Three plots with different stand age were set in each block, for a total of 18 plots, and balsam fir and white birch branches were collected in each to obtain both SBW at different stages and other herbivores. Moths were also sampled using both light and pheromone traps. Results show that the mimic treatment was efficient at reducing SBW populations. Further years' data are needed to evaluation both potential non-target impacts on insect communities and the recovery rate of the treated sites.

10:45 – 11:15 Dr. Dave Kreutzweiser (CFS-GLFC):

David Kreutzweiser is a Research Scientist and Team Leader in the Ecosystem Impacts team at the Canadian Forest Service in Sault Ste Marie. He is also an Adjunct Professor in Biology at Laurentian University and at the University of New Brunswick in Saint John, and an Associate Graduate Faculty member at the University of Guelph. He leads a research group that investigates the ecological impacts of forest management, other forest disturbances, and pest control activities on aquatic and forest ecosystems.

"Environmental risks of insecticides used in the spruce budworm early intervention strategy"

Three pest control products are being used against spruce budworm in the early intervention strategy in New Brunswick. All three products have been rigorously tested and registered for use in Canada. I briefly review the environmental toxicity profiles for each, and summarize the potential environmental risks. One product is a budworm mating pheromone (Disrupt®) that is used as a mating disruption compound. All scientific information evaluated indicates that the pheromone flakes will not pose unacceptable risk of harm to the environment or non-target organisms. A second product is the bacterial insecticide, *Bacillus thuringiensis* var. *kurstaki* (Btk or Foray®). Studies show that the effects of Btk are highly specific to budworm and related invertebrate species, and do not pose risks to other non-target organisms. Non-target lepidopterans (moths, butterflies) will be at risk if they are present in susceptible life stages during or shortly after spraying and if they consume foliage with Btk deposits. The third product is an insect molting hormone analogue, tebufenozide (Mimic®). Most studies show that at expected concentrations under operational conditions, tebufenozide will not pose risk of harm to most non-target organisms, other than lepidopteran species. There are some exceptions among aquatic invertebrates. I will present information from several studies that show that the likelihood of significant deposition on water bodies during operational spraying is low, and that the risk of significant adverse effects on aquatic systems and their biological communities from tebufenozide is minimal. Collectively, information from the laboratory and field studies.

11:15 - 11:45 Dr. Leonard Ritter (University of Guelph):

Since 1993, Dr. Ritter has been Professor of Toxicology in the Department of Environmental Biology (School of Environmental Sciences - April, 2009) at the University of Guelph, and Executive Director of the Canadian Network of Toxicology Centers, headquartered at the University as well, and has served, additionally, as coordinator of a national metals research network since 1999. From 1977 to 1993, he worked at the Health Protection Branch of Health Canada in various roles related to tobacco control, consumer product safety, environmental contaminants and the regulation of pesticides and veterinary drug residues in food. Dr Ritter has served as Chair of the AAFC Science Advisory Board, as an expert advisor to the Joint Expert Committee on Food Additives of the World Health Organization and on Boards and expert panels organized by the Royal Society of Canada, Canada's Pest Management Regulatory Agency, the National Cancer Institute of Canada, the U.S. National Academy of Sciences, the US EPA, the World Trade Organization, the International Commission on Occupational Health and the International Centre on Pesticide Safety. Dr. Ritter lectures widely on hazard, risk and exposure assessment of environmental contaminants, food additives and pesticides.

Dr. Ritter holds a B.Sc. (Hons) and M.Sc. in biology and biochemistry from Sir George Williams University in Montreal, Canada and a PhD in biochemistry from Queen's University School of Medicine, Kingston, Ontario, Canada. Dr. Ritter is a Fellow of the Academy of Toxicological Sciences and, in 2006, was awarded a medal by the UN World Health Organization in recognition of his contributions.

"Human Health"

11:45 - 12:15 Mr. Peter Amirault, Forest Protection Limited:

Obtained a Bachelor of Science in Forestry from UNB (80) and a Masters (UNB) in 84 both specializing in Forest Entomology. In between he worked for Georgia-Pacific in New Brunswick as an all-purpose Forester. After obtaining his Masters he served briefly as a Research Assistant at UNB before relocating to Alberta in 1985. In Alberta he was a Forest Insect & Disease Specialist with Forestry Canada in Edmonton (Northern Forestry Center). In 1991 it was back to NB to assume the position of Operations Manager with Forest Protection Limited, where he remains to this day.

Forest Protection Limited is a speciality air service that provides forest protection services to the Province of New Brunswick and elsewhere. As Operations Manager he is responsible for the safe and efficient delivery of pest and fire control programs.

"Aerial Application of Pesticides Including Pheromones"

In support of research objectives associated with the project Early Intervention to Suppress a Spruce Budworm Outbreak, Forest Protection Limited (FPL) conducted aerial applications in Quebec and New Brunswick. In Quebec areas with established or rising populations were treated with either Btk (Foray 76B – 4 areas) or Pheromone (Disrupt Bio-Flake SBW – 5 areas). In New Brunswick where populations were still endemic in 2014, 3 areas were treated with Tebufenozide (Mimic 240 LV). Applications were conducted as directed by product labels and as allowed under Provincial Permits. Advances in the specialized equipment used in aerial application and strategies employed in support of aerial application projects are reviewed. In addition best practices and quality control initiatives are discussed.

12:15 - 1:00 Lunch - Served in Lobby

Afternoon Moderator: Mr. JP Astorino, General Manager, Forest Protection Limited

1:00 – 1:30 Dr. Patrick James, Université de Montréal:

"Epicenter Formation and Migratory Behavior of Adult SBW: Implications for the Rise and Spread of Outbreaks and EIS"

This project addresses the role of moth migration in the context of early intervention to combat spruce budworm. Although the migratory activity of spruce budworm moths has been the subject of extensive study and discussion for more than 50 years, many questions remain unanswered regarding the role migration plays in driving the rise and spread of outbreaks. Results from the first year of this 4-year study provide some preliminary evidence of long-distance migration of spruce budworm moths from Quebec to southern New Brunswick. Evidence also indicates, however, that occurrence of these migratory events do not necessarily translate into increased population growth in areas visited by moths. Much of the processing remains underway to assess regional differences in phenological traits and genetic markers, which together should help to identify the original sources of captured moths. In 2015, there will be a significant regional expansion of moth sampling to include all of the eastern provinces and Maine, USA.

1:30 – 2:00 Dr. Eldon Eveleigh, Atlantic Forestry Centre:

Dr. Eldon Eveleigh is a Research Scientist at the Canadian Forestry Service – Atlantic Forestry Centre, Fredericton, and an Adjunct Professor at UNB.

Dr. Eveleigh did his B.Sc. and M.Sc. at Memorial University of Newfoundland in Parasitology. After completing his PhD in Ecology at the University of Toronto, he became a NSERC Post –Doctoral Fellow at the Institute of Animal Resource Ecology, University of British Columbia.

Prior to joining the Canadian Forestry Service, Fredericton, as a Research Scientist he worked for 2 years as a Research Scientist with Agriculture Canada, Ottawa.

Dr Eveleigh conducts research on the ecology of the spruce budworm to determine the mechanisms underlying outbreak processes in this forest insect pest. Part of this work involves elucidating the role of natural enemies, particularly parasitoids, hyperparasitoids and pathogens, in regulating insect populations and their potential as biocontrol agents.

"Barcoding Innovative DNA-based Diagnostic of SBW, its Natural Enemies, and other Conifer-feeding Species"

This project will produce DNA-based diagnostics for the identification of parasitic insects of the major coniferous forest pest, spruce budworm (SBW - *Choristoneura fumiferana*). The diverse web of species involved in parasitizing SBW are likely to be critical elements to how and when SBW populations outbreak. However, these species are notoriously difficult to identify and that identification can be both expensive and time-consuming. We will develop a novel genomic tool, (the BarcodeChip – a phylogenetic microarray using DNA barcode sequence data), to quantify and identify parasitism of SBW larvae and pupae that will be less expensive than insect rearing and permit the identification of parasitoids in living and dead SBW, including those SBW killed by the treatments.

We will first augment (with contemporary sampling and barcoding) and then adapt the entire library of DNA barcodes (small, standardized gene sequences) to build, test and deploy DNA-barcode based phylogenetic microarrays. This will enable the rapid identification and quantification (parasitism rates) of the many organisms - including >100 natural enemies - that interact with the SBW and form the so-called "spruce budworm food web". DNA-diagnostics like the Barcode Chip will improve the accuracy and precision of forest inventories while reducing costs and increasing the speed of data acquisition thereby enhancing the sustainable development and use of Canada's forests.

2:00 - 2:30 Dr. Peter Silk, Atlantic Forestry Centre:

Ph.D. London University, UK (1970)
B.Sc. 1967 Salford University, England (1967)
FCIC[1] (elected 1984).

- Insect Chemical Ecologist, Canadian Forest Service – Atlantic Forestry Centre, Natural Resources Canada, Fredericton, New Brunswick; Aug 2006 to present.
- Silk Biochemical Services, consulting, 2003–2006.
- Department Head, Chemical and Biotechnical Services Dept, NB Research & Productivity Council (RPC), Fredericton 1975–2003.
- Assistant Professor, University of New Brunswick, Faculty of Chemistry, 1972–1975.
- Post-doctoral Fellow: Department of Chemistry, University of New Brunswick, Fredericton. 1970–1972.

"SBW Sex Pheromones Status as a Control Option"

The known primary sex pheromone components of the spruce budworm, *Choristoneura fumiferana* (Clem.), are a blend of 95/5 *E/Z*11-tetradecenal (95/5 *E/Z*11-14: Ald). We now present evidence that in admixture with the primary components, that *Z*7-tricosene (*Z*7-C_{23}) and two trienes are synergistic sex pheromone components of the spruce budworm which represents a blend of Type I and Type II pheromone components. A series of mono-alkenes from C_{23}- C_{29} are Δ1, *Z*3, *Z*5, *Z*7, *Z*9, *Z*11-C_{23}, *Z*7, *Z*9, *Z*11-C_{25}, *Z*7, Z9, *Z*11-C_{27} and *Z*7, *Z*9, *Z*11-C_{29} mono-alkenes are present in body waxes of both sexes and two trienes which are found only in female body wax and extracts of sex pheromone glands of females; compounds were identified by GC/MS and microchemical analysis and confirmed by synthesis. Pheromonally-naïve (ie. not pre-exposed to females) males elicited strong responses to female scales but not to male scales even though alkenes were present in scales of both sexes. Males also responded to scales excised from pharate (pre-eclosed) females, indicating that the primary aldehyde pheromone components are produced by females *prior* to emergence. *Z*7-C_{23} alone and in co-addition with a C23 -triene significantly enhanced male responses to the primary sex pheromone aldehyde source similar to male responses to "calling" females in wind tunnel tests. This included higher proportions of in-flight and copulatory responses by males and significantly increased time spent on the source. The sex pheromone of the spruce budworm is, therefore, a blend of 95/5 *E/Z*11-14: Ald's and *Z*7-tricosene and a C23-triene; other components in the blend may also be present but this is not certain at this point in time.

We have also developed a feral population labelling technique using systemically-injected aqueous Rubidium chloride. Rubidium is a trace element that naturally occurs in low concentrations and is easily absorbed by plants making it a useful tool to label defoliators like spruce budworm. Balsam fir trees injected with 8g/tree and 16g/tree of RbCl showed quick uptake and distribution throughout the crown with no negative effects on tree shoot growth or spruce budworm survival and development. Adult spruce budworm (*Choristoneura fumiferana*) moths that feed as larvae on trees injected with RbCl were clearly labelled with significantly higher concentrations than the background levels found in moths and eggs that feed as larvae on control trees. Injecting trees with 8g/tree and 16g/tree of RbCl is a viable technique to label feral budworm populations in order to help distinguish local populations from immigrants in studies such as early intervention strategies (pheromone mating disruption trials) and to help with dispersal studies to track the movement of populations.

Collaborators (AFC): Wayne McKinnon, Glen Forbes, Peter Mayo, Gaetan LeClair.

2:30 – 2:45 Break

2:45 - 3:15 Mr. Greg Adams, Maritime Innovation Limited:

Greg Adams manages J.D. Irving, Limited woodlands R&D projects and the tree improvement program. He also oversees the recently formed company, Maritime Innovation Limited, which is currently focused on commercialization in the biosciences area including the development of endophyte enhanced seedlings. He has extensive experience in silviculture, nurseries, tree improvement, forest genetics and forest growth and yield.

"Use of Endophytic "Fungi in IPM against SBW"

The development of endophyte enhanced seedlings to improve tolerance of seedlings to insect damage over their life is described. Most plants host endophytic fungi which live inside their tissues. Studies of endophytes living in tree needles were studied in the most recent spruce budworm epidemic and specific strains of fungi were found in spruce and balsam fir which produce compounds with anti-insect properties. Research over the past 16 years to utilize this tree/fungus relationship to increase tolerance of spruce trees to spruce budworm defoliation is reviewed along with current research direction.

3:15 - 3:45 Bill Kidman, Leading Edge Geomatics:

Bill Kidman is the President and co-founder of Leading Edge Geomatics (LEG) which is a remote-sensing and consulting firm located in Lincoln, NB. Since founding LEG in 2007, Bill has managed significant mapping projects including coastal surveys for the United States National Oceanic Atmospheric Agency (NOAA), 1600 line kilometers of power line transmission corridors, and overseen the acquisition of LEG's aerial photography and LiDAR inventory which covers over 30,000km^2.

Prior to 2007, Bill graduated from the Canadian Forces School of Military Mapping, and served twenty years on active duty in Canada and around the world. The highpoint of his military mapping career was his deployment to Afghanistan on a joint Canadian / United States scientific mapping mission as the photogrammetry team lead. This mission collected over 300,000 km2 of aerial photography, and delivered orthorectified imagery products to coalition forces within 24hrs from acquisition.

"Assessment of SBW Defoliation Using Hyperspectral Aerial Imagery"

3:45 - 4:15 Dr. Dave MacLean, University of New Brunswick:

Dr. David MacLean is Professor at the University of New Brunswick, where he was Dean of the Faculty of Forestry and Environmental Management from 1999-2009. Prior to that, he spent 21 years as Research Scientist with the Canadian Forest Service, researching spruce budworm impacts, modeling, and decision support. In 2008 he was awarded the Canadian Forestry Scientific Achievement Award

"Decision Support System development and evaluation of SBW strategies"

The Early Intervention Strategies (EIS) against spruce budworm (SBW) project includes modelling and DSS/economic analyses, determining the mechanism of hardwood effects in reducing defoliation, and developing methods to remotely sense defoliation. PhD student Bo Zhang initiated study of the mechanism of hardwoods in reducing SBW defoliation in 27 plots representing a gradient of hardwoods in balsam fir-hardwood stands near Amqui, QC. Measurements included defoliation, SBW in 5 life stages, natural enemies, and dispersal. Development of methods for optimized operational blocking in insecticide spray programs, linked to the Spruce Budworm Decision Support System (DSS) was initiated. Remote sensing technology using LiDAR, hyperspectral scanner, and satellite imagery was used to assess a range of SBW defoliation intensities and gave promising initial results. These will be ground-proofed in an attempt to develop methods to detect very light defoliation. Study of economic analyses of EIS against SBW will begin in 2015.

4:15 - 4:30 Closing remarks by Mr. Tom MacFarlane (ADM, NBDNR)

Early Intervention Strategy to Suppress a Spruce Budworm Outbreak
Project Summary

1. **Spruce Budworm population dynamics during the rise of an outbreak**
(*Researcher: Dr. Jacque Régnière*)
The research will address questions regarding what Spruce Budworm (SBW) density to initiate an Early Intervention Strategy (EIS), what products may be most effective, and what are the consequences of control options on natural enemy populations attacking SBW in subsequent years.

2. **Impacts of EIS on SBW and associated natural enemies**
(*Researchers: Dr. Rob Johns, Dr. Veronique Martel, Dr. Eldon Eveleigh, Dr. K.S. McCann, Dr. Deepa Pureswaran*)
The research will test the efficacy of control options and evaluate possible unintended impacts on very low density Spruce Budworm (SBW) and its parasitoid complex. It will include detailed assessment of proposed Early Intervention Strategy (EIS) and other pesticide and pheromone trials of increasing sizes from 2014 to 2017.

3. **Barcoding: Innovative DNA-based diagnostic for SBW & its natural enemies**
(Researchers: Dr. Alex Smith, Dr. Eldon Eveleigh, Dr. Rob Johns, Dr. Veronique Martel, Dr. K.S. McCann)
The research will develop novel genomics tools to quantify and identify parasitism of SBW larvae and pupae. This will permit identification of parasitoids in larvae killed by treatments and explicitly evaluate the impact those treatments have on the natural enemy community of SBW. This technology will then be used in the above "SBW population dynamics" project.

4. **Aerial application of pesticides and pheromones**
(*Researchers: Mr. Peter Amirault, Mr. Jerry Cormier, Mr. Luc Amos-Binks*)
The research will begin an SBW EIS trial on 5,000 ha in northern NB in 2014 and conduct Bacillus thuringiensis (Bt) and pheromone control trials on low populations in Quebec. Continued trials using increasing sized blocks (total 15,000ha 2015, 30,000ha 2016, 80,000ha 2017) of pesticide and or pheromone will then be conducted.

5. **Epicenter formation and migratory behavior of adult SBW moths in eastern Canada**
(*Researchers:* Dr. Rob *Johns, Dr. Deepa Pureswaren, Dr. D. R. Gray, Dr. Lucie Royer, Dr. Dan Kneeshaw, Dr. Patrick James*)
The research will monitor SBW moths over large areas, and provide insight into migratory behavior from 'epicenters' and the associated formation of epicenters.

6. **SBW sex pheromone: effect of blend composition on mating**
(*Researchers: Dr. Peter Silk, Dr. Eldon Eveleigh, & others*)
The research will develop and register a more potent 4- component sex pheromone blend for use in mating disruption of SBW and evaluate whether pheromones promote dispersal of female moths.

7. **Use of endophytic fungi to reduce SBW impacts**
(*Researchers:* Mr. Greg *Adams, Miller, Dr. Dan Quiring, Dr. Andrew McCartney*)
The research will expand our knowledge of the impact of inoculating reforestation seedlings of spruces with insect toxin-producing endophytic fungi. Although a plant/fungi interaction has been commercialized for other species, this is the first application in forest trees.

8. **Modeling and DSS/ economic analyses**
(Researchers: Dr. David *MacLean, Cr. Chris Hennigar, Dr. Van Lantz, Đr. Udayalakshmi Vepakomma, Leading Edge Geomatics, Mr. Bo Zhang*)
The research will develop SBW population-derived defoliation scenarios for alternative EIS strategies, integrate insecticide efficacy models, develop and test models of SBW 'hot-spot' protection decisions and optimum operational blocking, and evaluate effects of alternative SBW control strategies in NB timber supply, cost-benefits, and economy-wide impact.

9. **Communications**
The details of the research will be communicated to the public and stakeholders. Details will include: infestation rates and locations, impacts to human health and the ecosystem, and treatment options.