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Coming Spruce Budworm Outbreak:

Initial Risk Assessment and Preparation & Response Recommendations for Maine's Forestry Community

Jointly presented by:

Cooperative Forestry Research Unit (CFRU), University of Maine

Maine Forest Products Council

Maine Forest Service

About this Report

The Maine Spruce Budworm Task Force was formed in summer 2013 by the University of Maine's Cooperative Forestry Research Unit (CFRU), Maine Forest Service (MFS), and Maine Forest Products Council (MFPC) to begin preparing for the next outbreak of the eastern spruce budworm. The following report was prepared by:

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[1]Abbreviations used in this report can be found in section VI of this report.

Overview

The forests of eastern Quebec are currently experiencing a severe outbreak of the eastern spruce budworm (SBW) that has now defoliated spruce-fir stands on over 15 million acres. The defoliation is moving south and is currently within a few miles of Maine's northern border. Insect traps across northern Maine and New Brunswick have been capturing steadily increasing numbers of SBW moths over the past several years, indicating the start of a new outbreak in both jurisdictions.

The last SBW outbreak during the 1970s–80s grew quickly, killed millions of acres of spruce-fir stands, and cost the region's economy many hundreds of millions of dollars. Although it is not possible to predict exactly when defoliation of balsam fir and spruce will begin, how severe the next outbreak will eventually become, or how long it will last, it is vital that Maine's forestland owners and stewards begin preparing before widespread defoliation begins.

To proactively respond, the University of Maine, Maine Forest Service, and Maine Forest Products Council formed a joint SBW Task Force during the summer of 2013. Task teams composed of more than 65 experts on various aspects of the issue were assembled to address key issues of the coming outbreak, including: wood supply & economic impacts; monitoring & protection; forest management; policy, regulation, & funding; wildlife habitat; public communications & outreach; and research priorities. This report includes an initial risk assessment of the coming SBW outbreak, and provides key recommendations for how Maine's forestry community can begin preparing for and responding to the coming outbreak.

An earlier draft of this report was distributed for public review and comment during late 2014 and early 2015. Significant changes and additions were made to this report based on this public review.

The following report is not intended to be a definitive plan for Maine's response to the entire SBW outbreak, which could span a 10- to 20-year period. As the outbreak unfolds, it will be vital to periodically reassess and readapt response strategies that make biological and economic sense, as well as meet the overall needs of the State. We hope this report will provide a strong foundation for an effective response.

Executive Summary

The eastern spruce budworm (SBW), which returns every 30–60 years in a natural cycle, has been a part of Maine's spruce-fir forest for thousands of years. Despite being a natural part of the forest, the SBW can be devastating to the health of spruce-fir stands as well as to the wildlife and people that depend on them. The last outbreak during the 1970s–80s killed millions of acres of spruce-fir stands, cost the state's economy hundreds of millions of dollars, and helped "set the stage" for political conflict over Maine's forestry practices during the decades that followed.

The current outbreak has caused severe defoliation to more than 15 million acres of spruce-fir forest in Quebec and is growing. Insect traps in northern Maine and New Brunswick have captured steadily increasing SBW moth counts over the past several years and defoliation of spruce-fir stands is approaching Maine's northern border.

To prepare for the coming outbreak, leaders from the University of Maine's Cooperative Forestry Research Unit, Maine Forest Service, and Maine Forest Products Council formed a joint SBW Task Force with leading experts on the SBW and various aspects of Maine's forest resource to address key aspects of the coming outbreak:

- Wood supply & economic impacts
- Monitoring & protection
- Forest management
- Policy, regulation, & funding
- Wildlife habitat
- Public communications & outreach
- Research priorities

This report describes the findings of the SBW Task Force. An initial risk assessment for the coming SBW outbreak is provided, and key recommendations made for how Maine's forestry community can begin preparing for and responding to the coming outbreak.

Projected Wood Supply & Economic Impacts

As tree defoliation by the SBW crosses Maine's northern border, 5.8 million acres of spruce-fir stands containing 27.3 million cords of merchantable balsam fir are at risk of defoliation, leading to reduced growth and mortality to balsam fir and spruce trees over wide areas. Spruce-fir stands dominated by balsam fir and white spruce are at greatest risk, with stands dominated by red and black spruce also at some risk of damage.

Two studies on the potential impact of a SBW outbreak on spruce-fir wood supply in northern Maine were recently completed. Although both studies each used different methodologies, data sources, and measures of forest impact in their analyses, there was strong agreement between them on the general impact:

- A 15% to 30% maximum annual reduction in spruce-fir volume growth or standing biomass from moderate and severe SBW outbreaks, respectively, can be expected.
- A slow (40-year) recovery of the spruce-fir forest will follow the peak impact of the outbreak.
- The predicted effects of the next SBW outbreak on spruce-fir volume or biomass (both in severity and rate of recovery) were similar in both studies, regardless of when the outbreak begins over the next few decades.

The projected *total volume* loss over the next 40 years following an outbreak modeled to start in 2013 is 12.7 million cords from a severe outbreak to 6.4 million cords for a moderate outbreak half of that intensity. The maximum annual volume loss during the next outbreak is projected to be 494 thousand cords per year for a severe outbreak (similar to the one in the 1970s–80s) and 247 thousand cords per year for a moderate outbreak half of that intensity. This volume loss, without any forest management mitigation effort, is projected to have a **total economic impact of $794 million per year during a severe outbreak and $397 million per year for a moderate outbreak.** Estimated annual job loss in the forest products sector would translate to 1,196 jobs and 598 jobs for severe and moderate outbreaks, respectively. Higher total job losses would be expected due to the multiplier effect of forest products jobs.

The wood supply model also indicated that it is possible to significantly reduce the spruce-fir wood volume and associated economic loss by:

1. **Adapting harvest** activities in the coming years before or as early as possible into the outbreak to reduce the area available in high-risk stands (i.e., those with high balsam fir and white spruce composition),
2. **Applying insecticide** to protect foliage in high-risk and high-value stands that are not ready for harvest, and
3. **Salvage logging** of dead and dying trees where they occur.

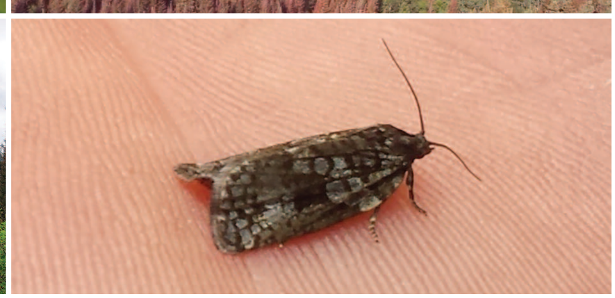
About 10% of the reduction in volume loss came from shifting future harvest plans toward high-risk stands. An additional 8% came from protecting foliage with insecticides such as B.t.K. (*Bacillus thuringiensis* var. *kurstaki*; B.t.K. was assumed in this model) on 20% of the affected area (little additional reductions in loss resulted from treating more than 20% of the susceptible area). Salvage logging using clearcut harvesting to capture dead and dying trees reduced the remaining 10% of the loss. Therefore, by aggressively implementing these three mitigation strategies forest landowners can substantially reduce the negative impacts of the coming outbreak on spruce-fir volume losses.

Differences Between 1970s Outbreak & Coming Outbreak

For Maine's forest industry, government, and the university to effectively respond to the coming outbreak, it is important to understand how key factors and conditions have changed since the last outbreak in the 1970s–80s. These differences provide insight into the potential impact as well as the preparation and response strategies that will be needed relative to the last outbreak.

A quantitative and subjective assessment of changes in 43 factors (including spruce-fir forest condition, wood supply, forest management, forest products manufacturing, logging industry, SBW monitoring capability, available protection measures, policies and regulations, political environment, available funding, and staffing levels) between today and when the last outbreak began in 1970 indicated more favorable circumstances in 55% of the factors, less favorable circumstances in 40% of the factors, and equal or unclear differences in 5% of the factors. Based on this analysis, the coming SBW outbreak will occur under very different circumstances than the last outbreak; as a result, the impact of and response to this outbreak will be different.



Summary of Recommendations

SBW Monitoring

Thorough monitoring of SBW populations will be required for a clear understanding of how the outbreak is progressing and for predicting how much and where damage to spruce-fir forests will occur. Effective monitoring also is the first requirement in deciding when and where to harvest high-risk stands or prescribe insecticide applications to protect valuable stands that are not ready for harvesting. As SBW population levels build over the next several years, it will be vital to intensify both short- and long-term monitoring efforts. Strong collaboration between forest landowners and the Maine Forest Service will be crucial in this effort.

Key specific recommendations for intensifying monitoring efforts include:

- Engaging the public in SBW monitoring by educating them and encouraging their direct participation in monitoring efforts.
- Increasing the number of pheromone traps in host forest types across northern Maine.
- Investigating the use of new remote-sensing technologies for improved monitoring.
- Sharing and comparing monitoring data and predictions with neighboring jurisdictions (US and Canadian) to improve internal and partner analyses.
- Conducting egg mass or L-2 larval surveys in areas where pheromone trapping and/or defoliation surveys indicate a high probability of significant population intensification or in areas where land managers request such information to better determine the need for insecticide applications.
- Assessing strengths and weaknesses of ongoing trapping efforts and making adjustments as needed, especially with regard to partnership agreements, trapping density and locations, and overall data quality.
- Reviewing landowner progress in adapting harvesting efforts to reduce the availability of high-risk stands and identifying high-risk stands that landowners may want to protect using insecticide applications.

Forest Management Strategies

Although experience from previous outbreaks shows that forest management strategies are not a panacea to protecting the forest from a SBW outbreak, it is important to begin developing proactive forest management strategies to reduce the area of high-risk stands before the outbreak begins. Identifying high-risk and high-value stands that may need foliage protection also is vital to mitigating damage by the SBW. To do this effectively requires that landowners categorize stands based on SBW risk on their property. A 6-level system for categorizing stands based on SBW risk is provided in this report.

Key forest management recommendations for forest landowners to prepare for the coming SBW outbreak include:

- Mapping the location, condition, and concentration of high-risk stands on their forestlands.
- Shifting harvesting now and in the coming years towards merchantable higher-risk stands.
- Stopping precommercial and commercial thinning within three years of the outbreak in stands where balsam fir and white spruce make up more than 50% of the composition, or where red spruce will be greater than 50% of the post-thinned stand.
- Preparing action plans to salvage (or pre-salvage) trees that will likely be lost through SBW mortality.
- Seeking and encouraging markets for low-value trees from pre-salvage and salvage operations.
- Regularly communicating with government agencies and other landowners to understand how the infestation is moving and to develop plans to minimize the impact.

It is imperative that these recommendations be implemented as soon as possible before the outbreak begins because mitigating stand damage by adapting short-term harvest plans will be more difficult once the outbreak is in full force. Delays in implementing these forest management measures also may force greater reliance on more expensive aerial insecticide treatments later when response options are greatly reduced.

Protection Options

As the outbreak develops, forest landowners with high-risk and high-value stands, especially those that have received thinning and contain high proportions of balsam fir and white spruce, may choose to protect them. Foliage protection using aerially applied insecticides has been shown to be effective in reducing tree damage from SBW. Twelve insecticide products with three active ingredients (B.t.K., tebufenozide, and carbaryl) whose labels specifically address aerial application to control SBW over naturally regenerated forests are registered with the Maine Board of Pesticides Control. Additional insecticides are also registered for controlling SBW under special circumstances, including forest plantations, Christmas trees, tree nurseries, and seed orchards.

Based on successful use in Maine during the 1970s–80s outbreak and the continued research, development, widespread use, efficacy, and general public acceptance over the past 30 years, it is anticipated that the biological insecticide B.t.K. (applied as Biobit, Dipel, or Foray insecticide products) will likely be the first choice for foliage protection for many forest landowners. Tebufenozide (an insect growth regulator specific to Lepidoptera) is another option likely to be favored. B.t.K. and tebufenozide are currently being used by Canadian researchers in a new research program to develop an early intervention strategy for SBW in the Atlantic Provinces.

Financing and coordination of the state's SBW insecticide program will likely be substantially different than it was during the 1970s–80s when state and federal government agencies played a large role in financing and coordinating insecticide applications. The insecticide program developed during the coming outbreak is expected to be delivered in the same way that aerial herbicide treatments have been financed and coordinated on private lands over the past few decades. There are also a number of other assumptions under which the SBW insecticide program will be developed that are presented in this report.

Key recommendations for SBW protection preparation include:

- Forest landowners should assess and map high-risk and high-value stands on their lands that they may consider protecting with insecticide application during the SBW outbreak.
- The Maine Forest Service should develop plans for providing technical assistance on SBW management to landowners.
- The Maine Forest Service, Maine Forest Products Council, Maine Board of Pesticides Control, and UMaine should work collaboratively to develop a communications strategy about SBW, its effects, and the need for insecticide applications for forest protection in some situations.
- The Maine Forest Service and UMaine's Cooperative Forestry Research Unit should be actively engaged with US Forest Service and Canadian counterparts to ensure that Maine landowners and policy makers have access to the latest information for controlling SBW damage.

Policy, Regulation, & Funding

Successfully preparing for and responding to a SBW outbreak involves a number of governmental policy and regulatory issues that must be addressed. Determining how responsibilities for monitoring and protection programs will be divided among state government, federal agencies, and private landowners present a special challenge. It is vital that all relevant policy, regulatory, and funding issues be identified and addressed as soon as possible.

Key recommendations for the policy, regulatory, and funding issues related to the next SBW outbreak, include:

- Reviewing the Spruce Budworm Management Act to determine whether any changes are needed given likely changes in roles and responsibilities between the state government and private landowners in managing the next SBW outbreak.
- Maintaining an open dialogue among private landowners, state government, and the ENGO community.
- Determining the personnel, funds, and timing needed to implement the required SBW monitoring within the Maine Forest Service, and how supplemental labor and financial assistance from forest landowners will be provided.
- Exploring options for developing a cooperative organization for coordinating and delivering aerial insecticide applications among large landowners anticipating the need for insecticide applications.
- Working with the Maine Board of Pesticides Control to identify and address any obsolete or other policy issues associated with delivering aerial insecticides to large areas of forestland.
- Preparing legislation defining the regulatory process for determining an expedited response for areas categorized as high SBW risk where there is a strong likelihood of increased SBW activity.

Wildlife Habitat

Because the SBW generally has a substantial impact on forest composition and structure over large areas, provides a food source for birds and other species, and changes harvest patterns of forest landowners, major outbreaks have a significant influence on wildlife habitat over a long period of time. Four specific aspects of the coming SBW outbreak that could affect wildlife and wildlife habitat include: mortality of mature spruce-fir, changes in harvest patterns, non-target impacts of insecticides, and increased forest fire risk.

Understanding the overall impact of the coming SBW outbreak on wildlife will depend largely on how species most closely associated with spruce-fir forest habitat will be influenced. Of special interest are those species and habitats of special conservation value (e.g., species listed as rare/endangered/special concern) as well as game species of economic and recreational importance.

Seven wildlife issues were identified as being of greatest concern during the coming SBW outbreak:

- Mature softwood songbirds and mammals,
- Deer wintering areas,
- Riparian habitats and aquatic systems (including coldwater fish habitat),
- Early/mid-successional species of concern (lynx/snowshoe hare/moose),
- Rare species (including northern butterflies),
- high-elevation habitats and bird species, and
- Old-growth softwood and mixedwood forest.

The assumptions, potential positive effects, and potential negative effects related to the coming outbreak are presented for each of these issues, and specific recommendations for forest and wildlife managers are provided.

Public Communications & Outreach

A vital part of responding successfully to the coming SBW outbreak will include effective public communications, especially regarding progress of the outbreak, damage caused to the forest and wildlife, economic impacts, what actions are being taken to mitigate and respond to the damage, and how the forest is recovering. The goals and objectives for public communications for the next outbreak should include: identifying key communications issues associated with SBW, building a communications infrastructure for the entire SBW effort, and building stakeholder understanding of SBW.

To meet these communications goals and objectives, it is recommended that:

- Maine Forest Service, Maine Forest Products Council, and University of Maine work together to develop and implement a comprehensive SBW communications strategy for the Maine public that will be implemented before, during, and after the outbreak.
- Specific communications programs should be designed for:
    - Public media
    - Family forest owners
    - Schools
    - Environmental NGOs
    - Government
    - Forest industry
    - Recreation and tourism groups

Details about the background, framing, messages, outreach methods, and timing and timelines that should be used when developing communication strategies for each of these groups are presented in this report.

Research Needs

The approaching SBW outbreak means there is an urgent need and opportunity for new research by US and Canadian researchers in the region. Short- and mid-term research early in the outbreak will help forest managers more effectively and efficiently respond during the outbreak. Furthermore, the coming outbreak will provide ample opportunity for longer-term research that will help inform those managing future SBW outbreaks.

The highest priority research questions were solicited from the task teams that prepared this report and from researchers who have been working on SBW in the US and Canada. Short-, mid-, and long-term priorities for improving SBW monitoring, protection, forest management responses, and wildlife management are presented as a guide for university and government researchers in the region.

Table of Contents

I. Introduction 9

II. Background 10
- A. Spruce Budworm: A Naturally Occurring and Damaging Insect 10
- B. Impact of 1970s–80s SBW Outbreak in Maine 10
- C. Status of Current SBW Outbreak 12

III. Risk Assessment 17
- A. Forest Areas at Greatest Risk 17
- B. Severity of Coming Outbreak 18
- C. Projected Wood Supply Impacts 22
- D. Projected Economic Impacts 27
- E. Differences Between 1970s Outbreak & Coming Outbreak 29

IV. Preparation & Response Recommendations 35
- A. Monitoring Strategies 35
  - 1. Background 35
  - 2. Baseline monitoring 36
  - 3. Short-term monitoring 36
  - 4. Longer-term monitoring 37
- B. Forest Management Strategies 38
  - 1. Background 38
  - 2. Categorizing stand risk 39
  - 3. Recommendations 40
- C. Protection Options 41
  - 1. Insecticides 42
  - 2. Early intervention strategy 43
  - 3. Assumptions under which Maine SBW protection program will be developed 44
  - 4. Recommendations 44
- D. Policy, Regulation, & Funding 45
  - 1. Maine Spruce Budworm Management Act 45
  - 2. Resource needs for monitoring SBW populations and damage 46
  - 3. Resource and regulatory needs for aerial insecticide program 47
  - 4. Streamlined approval process for adaptive harvesting and salvage cutting 48
- E. Wildlife Habitat 49
  - 1. Mature softwood songbirds and mammals 50
  - 2. Deer wintering areas (DWAs) 51
  - 3. Riparian habitats and aquatic systems (including coldwater fish habitat) 52
  - 4. Early/mid-successional species of concern (lynx/snowshoe hare/moose) 53
  - 5. Rare species (including northern butterflies) 54
  - 6. High-elevation habitats and bird species 54
  - 7. Old-growth softwood and mixedwood forest 55
- F. Public Communications & Outreach 56
  - 1. Recommendations 56
  - 2. General public 57
  - 3. Family forest owners 58
  - 4. Schools 60
  - 5. Environmental NGOs 61
  - 6. Government 62
  - 7. Forest industry 63
  - 8. Recreation and tourism groups 65
- G. Research Priorities 67
  - 1. Monitoring 67
  - 2. Protection 67
  - 3. Forest management 68
  - 4. Wildlife habitat 68

V. References 69

VI. Glossary of Abbreviations 72

APPENDIX A — Spruce Budworm Management Act 73

I. Introduction

The eastern spruce budworm (SBW), which returns every 30–60 years in a natural cycle, has been a part of Maine's spruce-fir forest for thousands of years. Despite being a natural part of the forest, the SBW can be devastating to the health of spruce-fir stands as well as to the wildlife and people that depend on them. The last outbreak during the 1970s–80s killed millions of acres of spruce-fir stands, cost the state's economy hundreds of millions of dollars, and helped "set the stage" for political conflict over Maine's forestry practices during the decades that followed.

The next SBW outbreak is at Maine's doorstep. The current outbreak began in Quebec around 2006 and to date has caused severe defoliation of more than 15 million acres of spruce-fir forest. The defoliation is moving south and is now within a few miles of Maine's northern border. Insect traps across northern Maine and New Brunswick have been capturing steadily increasing numbers of SBW moths over the past several years, indicating the start of a new outbreak in both jurisdictions.

To proactively respond, leaders from the University of Maine's Cooperative Forestry Research Unit (CFRU), Maine Forest Service (MFS), and Maine Forest Products Council (MFPC) formed a joint SBW Task Force in the summer of 2013.

Leading authorities on the SBW and various aspects of Maine's forest resource were assembled into seven task teams to address key aspects of the coming outbreak:

- Wood supply & economic impacts
- Monitoring & protection
- Forest management
- Policy, regulation, & funding
- Wildlife habitat
- Public communications & outreach
- Research priorities

This report describes the findings of these task teams. An initial risk assessment for the coming SBW outbreak is provided, and key recommendations made for how Maine's forestry community can begin preparing for and responding to the coming outbreak.

This report is not intended to be a definitive plan for Maine's response to the entire SBW outbreak, which could span a 10- to 20-year period. It is not possible to know exactly how the next outbreak will develop biologically or what specific impact the outbreak will have on Maine's forest and forest products industry. As the outbreak unfolds, it will be vital to periodically reassess and readapt response strategies that make biological and economic sense, as well as meet the needs of the state.

The primary purpose of this report is to raise awareness about the potential adverse effects of the coming SBW outbreak among forest landowners and managers, members of the forest products industry, state and federal government officials, wildlife biologists, forest researchers, the news media, community leaders, and interested members of the public; as well as identify how we can best prepare for and respond to these effects. There is much to learn from Maine's previous experience with the SBW. We hope that this report will help Maine's forestry community learn from previous successes, avoid past mistakes, and take advantage of new opportunities.

II. Background

A. Spruce Budworm: A Naturally Occurring and Damaging Insect

The eastern spruce budworm (*Choristoneura fumiferana* Clemens) is a naturally occurring insect that causes major damage to Maine's spruce-fir forest on a regular cycle. The insect severely affects Canadian forests from the Yukon to Newfoundland. During major outbreaks, infestations will extend southward into Maine, Vermont, New Hampshire, and New York, as well as the Lake States. The affected forest area during large outbreaks can exceed 100 million acres (Blais 1983). Therefore, the spruce budworm (SBW) is arguably among the most damaging forest insects in North America (Gray and MacKinnon 2006).

Despite spruce being part of its common name, the SBW is actually most damaging to balsam fir (*Abies balsamifera*). The insect causes damage when the larval stage of the insect feeds on the buds and new foliage of trees. Complete defoliation of balsam fir trees can occur four years after a SBW outbreak begins and trees will begin dying by the fifth year (Gray and MacKinnon 2006). Wood volume growth of balsam fir can be reduced by as much as 20% after a single year of defoliation (Piene 1980), and stem diameter growth can be reduced as much as 75% after several years of severe defoliation (Miller 1977). Spruce is affected to a lesser degree than fir, with more defoliation occurring on white spruce (*Picea glauca*) and less on red (*Picea rubens*) and black (*Picea mariana*) spruce (Hennigar et al. 2008). During the last SBW outbreak in northern Maine, defoliation of balsam fir led to 84% to 97% mortality, while only 30% to 66% mortality was found for red spruce 12 years after the start of the outbreak (Solomon et al. 2003).

Eight major SBW outbreaks have occurred in Quebec during the last 450 years (Boulanger and Arseneault 2004). This pattern suggests that regular SBW outbreaks occur every 30 to 40 years over its range (Royama 1984). There is evidence that the frequency, extent, and severity of SBW outbreaks have increased over the past century relative to the previous century (Blais 1983). In Maine, five major outbreaks were identified from tree-ring records dating back to the early 1700s, suggesting a longer return interval of 30 to 60 years in Maine forests where balsam fir occurs in more mixed species stands than in Canadian forests (Fraver et al. 2007). In modern times, major SBW outbreaks in Maine have occurred during the 1910s, 1940s, and 1970s, with the 1910s and 1970s outbreaks being quite severe.

B. Impact of 1970s–80s SBW Outbreak in Maine

The SBW outbreak of the 1970s–80s is well etched in the memories of those managing Maine's forests at the time, and it defined the early careers of many senior forest managers today. The last SBW outbreak, which lasted from 1967 to 1993, covered about 136 million acres across eastern Canada and Maine at its peak (Blais 1983). Irland et al. (1988) provide a detailed description of the impact of Maine's last outbreak. The outbreak was severe and produced dead and dying stands of trees (Figure 1) that could be seen to the horizons in some areas (Figure 2). This outbreak defoliated fir and spruce trees across most of the northern half of Maine (Figure 3), killed between 20 and 25 million cords of spruce and fir (Maine Forest Service 1993), and resulted in hundreds of millions of dollars in lost revenue to the state's forest-based economy. Efforts to protect the forest during this period launched a wave of aerial insecticide spraying across millions of acres, with the area sprayed exceeding a million acres per year at peak times during the outbreak (Figure 4). These protection efforts cost state and federal governments, as well as private landowners, many additional millions of dollars and resulted in conflicts over how the costs would be shared.

In addition to these immediate impacts, the SBW outbreak drastically changed forest structure and composition across northern Maine and had ripple effects on forest management, politics, public policy, and the forest-based economy over the next 40 years. For example, salvage logging to capture dead and dying trees caused landowners to increase the use of clearcut harvesting during the 1970s. These clearcuts had a large visual impact on the forest landscape, which caused substantial public controversy. This controversy led to passage of the 1989 Forest Practices Act (FPA), which defined and heavily regulated clearcut harvesting. Three failed state referenda to ban clearcutting between 1996 and 2000 cost both sides millions of dollars. Efforts by landowners to reduce the use of clearcutting after implementation of the FPA in 1991 were very successful. Clearcutting as a proportion of forest harvesting fell from 45% in 1989 (the year the FPA was passed) to less than 8% by 1996, and has hovered between 2% and 6% every year since that time.

Various forms of partial harvesting (including shelterwood and selection systems) that were common before the FPA rapidly expanded to dominate 94% to 98% of all forest harvesting that occurs today. This rapid shift to partial harvesting nearly doubled the annual "harvest footprint" from about 250,000 acres in 1988 to about 500,000 acres per year in 1994 to obtain the same 6 to 7 million cords of wood per year that supplied the state's forest products industry. The levels of harvest area and volume have remained relatively constant from 1994 to today. The widespread use of partial harvesting practices is visible today in aerial photos across the northern tier of Maine, and was successful in easing public concerns about forest harvesting.

Concern over the loss of future spruce-fir wood supplies during the 1970s–80s SBW outbreak led to the first computerized wood supply model for the state (Sewall Company 1983; Seymour et al. 1985). The model's prediction of future spruce-fir wood supply shortages encouraged intensification of

Figure 1 - Spruce-fir stand several years after being killed by SBW during the 1970s–80s.

Figure 2 - Color photograph taken from the Knife Edge Trail on Mt. Katahdin in 1980 showing large area of trees killed by SBW. (Source: Photo by Dr. David Field, University of Maine)

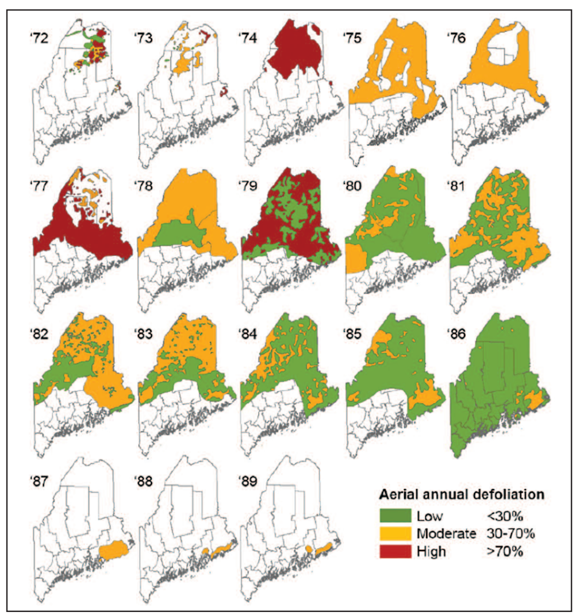


Figure 3 - Annual SBW defoliation of spruce-fir stands in Maine from 1972 to 1989. Maps were digitized from the Maine Forest Service sketch maps. (Source: Hennigar et al. 2013a)

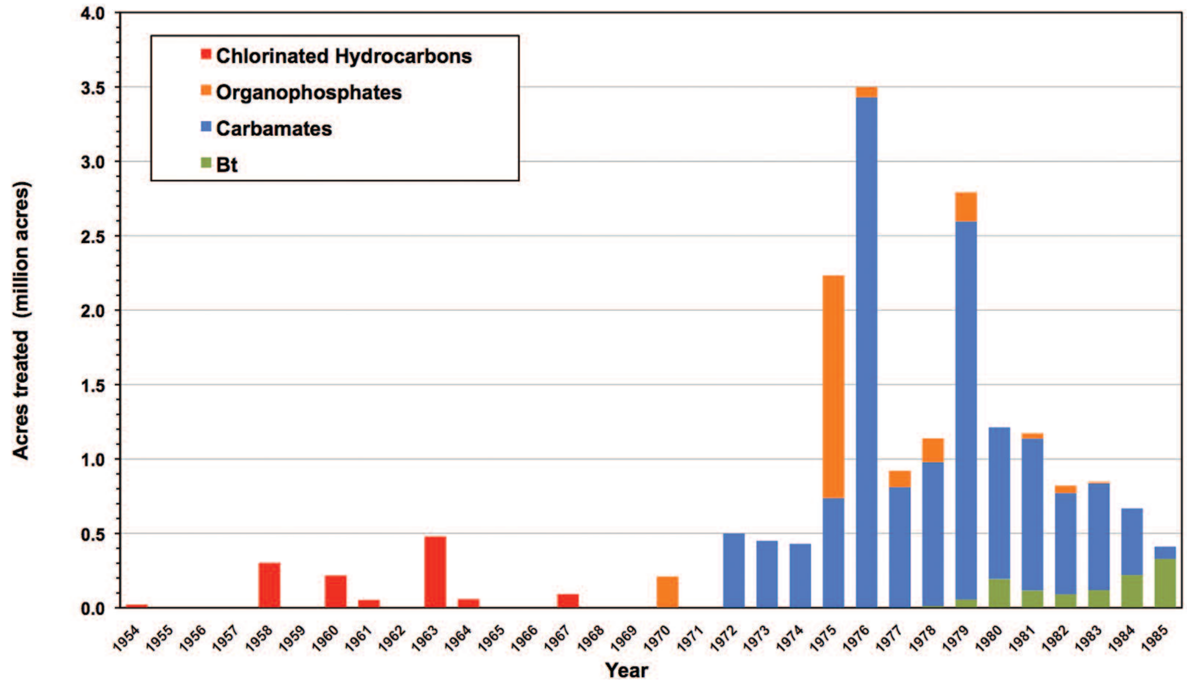


Figure 4 - Area sprayed with insecticides under MFS program during SBW outbreaks in Maine. (Source: Maine Forest Service)

silviculture to more quickly replace the spruce-fir stands lost during the outbreak. This concern led to increased tree planting by large forest landowners. Planting was followed by a wave of herbicide spraying on just over a million acres between 1983 and 2000 to release regenerating spruce-fir from competing vegetation (Maine Forest Service Silvicultural Activities Reports). Herbicide spraying was then followed by a wave of precommercial thinning (PCT) of overstocked softwood regeneration on nearly 400,000 acres between 1987 and 2007.

An unforeseen positive consequence that followed the 1970s–80s SBW outbreak was a significant increase in snowshoe hare populations across northern Maine. Not known to wildlife biologists at the time was the fact that snowshoe hare, a primary prey species of Canada lynx and other major forest carnivores, preferred habitats with high densities of young conifer regeneration. These conditions were produced in abundance by the clearcutting and subsequent herbicide spraying that followed the salvage cutting of SBW-killed stands. These increases in hare numbers over time were followed by substantial increases in Canada lynx populations (Simons-Legaard et al. 2013), and produced the largest lynx population in the lower 48 states. As a result, the U.S. Fish & Wildlife Service classified most of northern Maine as critical lynx habitat in 2005. Ironically, the shift away from clearcutting and herbicide spraying to partial harvesting systems over the past 10 to 15 years due to the clearcutting controversy is related to a substantial projected decline in lynx habitat between 2012 and 2026 (Simons-Legaard et al. 2013).

These dramatic, broad, and unforeseen impacts of the 1970s–80s SBW outbreak highlight why it is vital that the state plan and prepare wisely for the next SBW outbreak. Therefore, it is crucial that Maine's forest landowners, forest products industry, state legislators, rural community leaders, environmental groups, and general public understand the history and the potential long-term consequences that could come from the next SBW outbreak.

C. Status of Current SBW Outbreak

The province of Quebec has been experiencing a rapidly growing SBW outbreak since 2006 (Figure 5). By the end of 2015, the area of spruce-fir defoliation had grown to over 15 million acres (Figure 6). Although trees in Maine and New Brunswick have shown little or no signs of defoliation, SBW traps in northern New Brunswick (Figure 7) and Maine (Figure 8) have captured steadily increasing numbers of moths over the past several years. Pheromone traps across northern Maine captured a substantial increase in moths from 2014 to 2015 (Figure 9). Northern Maine appears to be lagging about two years behind New Brunswick, with the rapid rise of moth catches in New Brunswick beginning in 2008 and Maine in 2010. Maine's light trap catch, however, reached the same level in 2013 as the trap catch in 1967 just before the start of the 1970s–80s outbreak. We know from this history that defoliation and mortality of fir and spruce begin several years after a rapid rise in SBW trap numbers (Figure 8).

SBW defoliation of fir and spruce in Quebec has moved south and has recently crossed the New Brunswick border (Figure 6). Large moth flights have been observed moving south by the Canadian Forest Service using Doppler weather radar (Healthy Forest Partnership 2015). As a result, New Brunswick began its first insecticide application in June 2014. To assist with this effort, the Canadian federal government dedicated $10 million dollars (CDN) over four years (starting in 2014–15) to explore early intervention strategies (EIS) that might prove effective at preventing the spread of SBW in Atlantic Canada and Quebec. The New Brunswick provincial government and forest industry have contributed an additional $8 million dollars (CDN) to this effort.

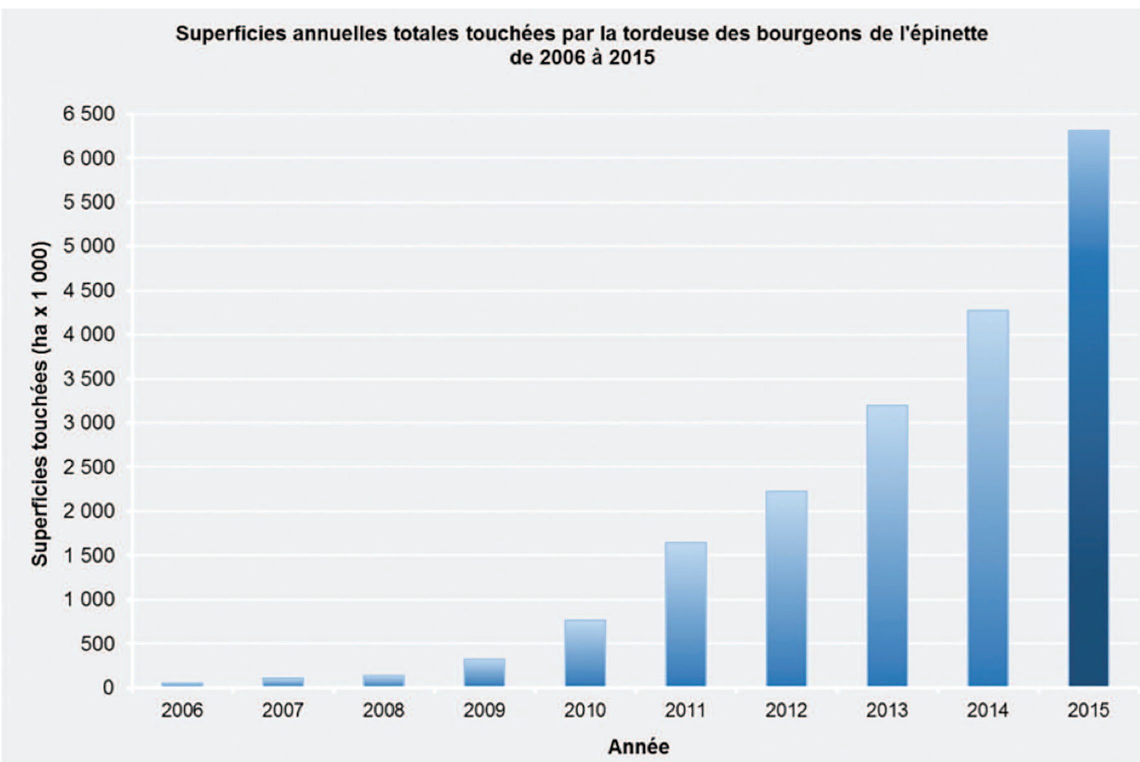


Figure 5 - Area of spruce-fir defoliation by SBW in the province of Quebec from 2006 to 2015. (Source: Ministère des Forêts, de la Faune et des Parcs 2015)

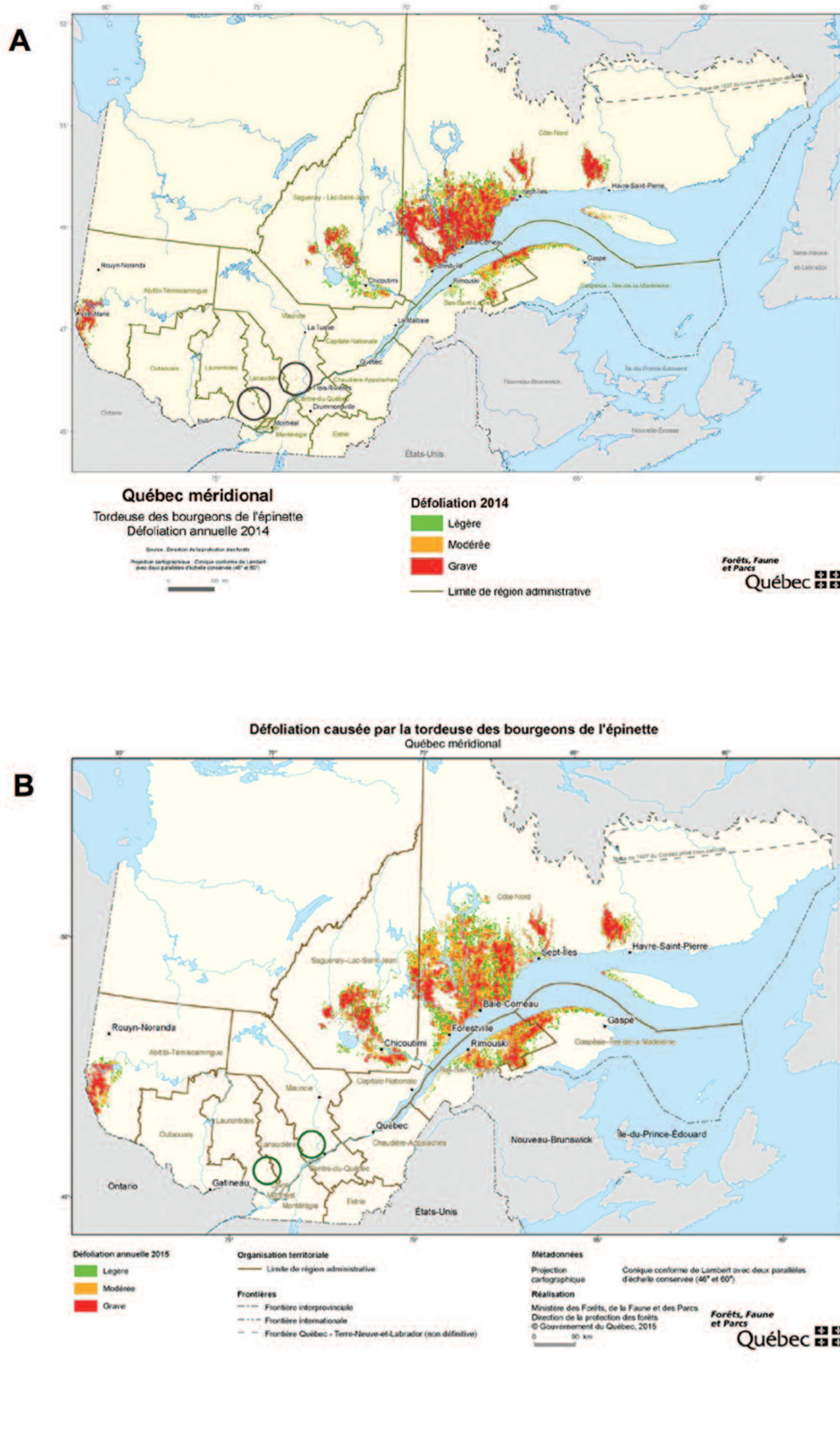


Figure 6 - Spruce-fir defoliation area from SBW in Quebec in 2014 (A) and 2015 (B). Note 50% expansion of defoliation area in one year, and significant southern expansion toward New Brunswick and Maine. (Source: Ministère des Forêts, de la Faune et des Parcs 2014 and 2015)

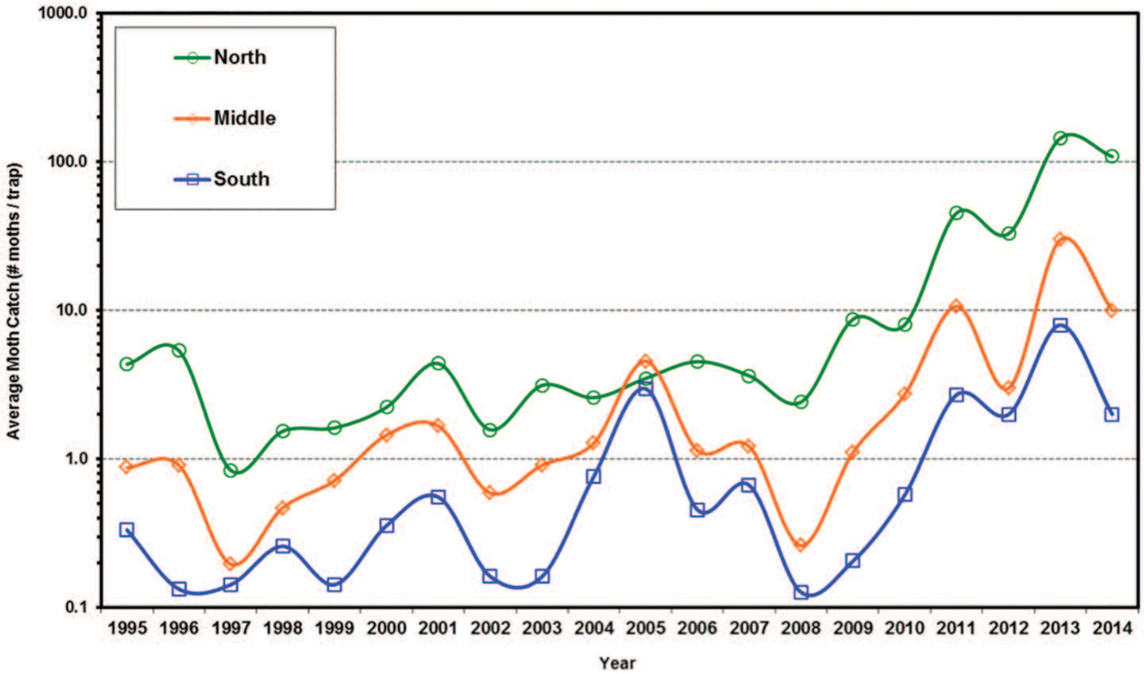


Figure 7 - Average SBW moth trap catches in north, middle, and south zones of New Brunswick from 1995 to 2014. (Source: New Brunswick Department of Natural Resources)

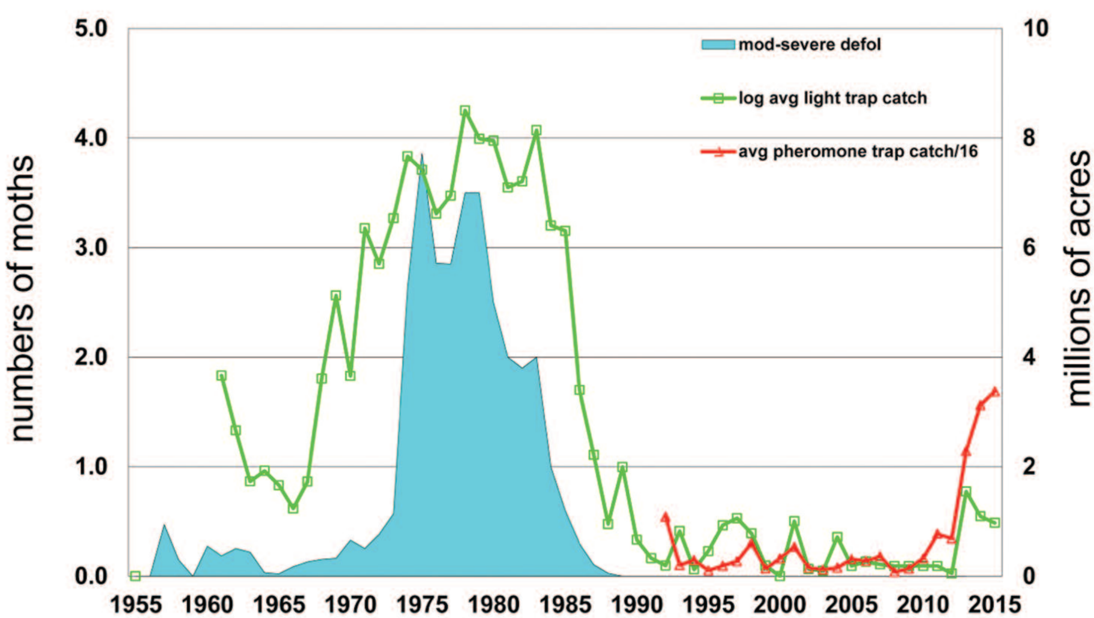


Figure 8 - SBW moth trap catches and area of moderate to severe spruce-fir defoliation in Maine from 1955 to 2015. (Source: Maine Forest Service)

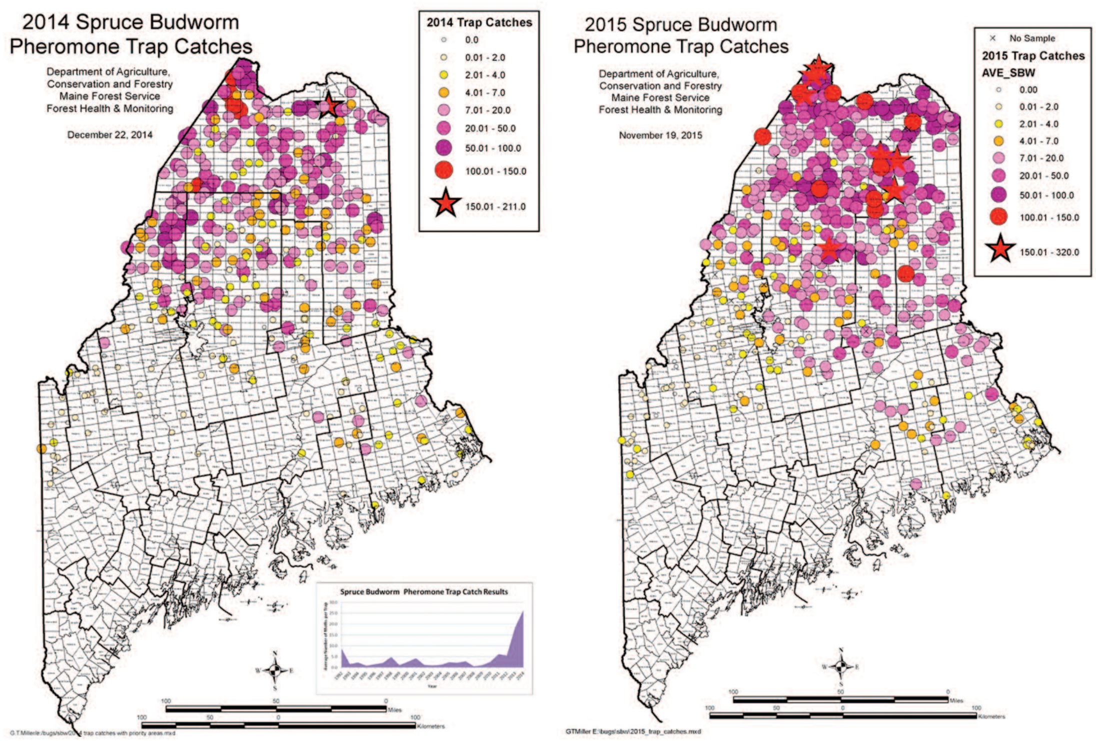


Figure 9 - SBW moth catches in pheromone trap locations across northern Maine during 2014 and 2015. Note increased catches from northern Maine trap locations. (Source: Maine Forest Service)

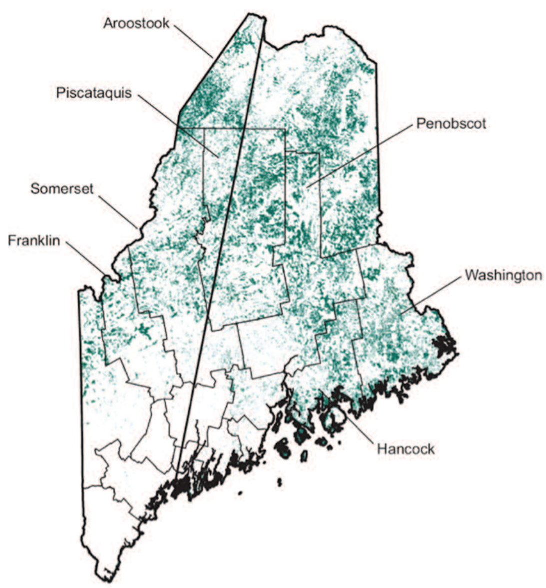


Figure 10 - Distribution of Spruce-Fir Forest Type in Maine counties, 2008. (Source: McCaskill et al. 2011)

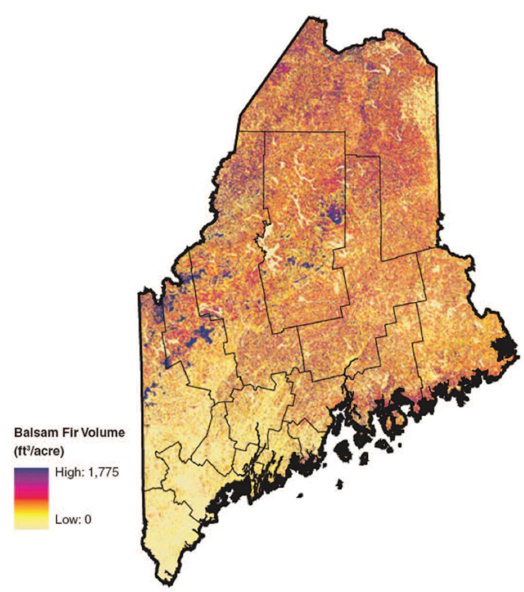


Figure 11 - Balsam fir concentrations by average volume (ft^3/acre) by county in Maine, 2008. (Source: McCaskill et al. 2011)

III. Risk Assessment

A. Forest Areas at Greatest Risk

As tree defoliation by the SBW crosses Maine's northern border from Quebec, all spruce-fir stands across the state are at some risk of defoliation. A distribution map of Maine's spruce-fir forest and the areas likely to be affected during the next outbreak are shown in Figure 10. This area represents about 5.8 million acres statewide (McCaskill et al. 2011). Spruce-fir stands dominated by balsam fir are at greatest risk (Figure 11) as they can experience about 80% defoliation (Hennigar et al. 2008). Balsam fir is also the most abundant tree by number in Maine (8.7 billion, >1 inch stem diameter), with 565 million being merchantable with stem diameters at least 5.0 inches in size (K. Laustsen, MFS, personal communication). To date, there are 27.3 million cords of merchantable volume of balsam fir in Maine at risk of loss.

White spruce is the second most susceptible species to SBW in spruce-fir stands, but is far less abundant than balsam fir and generally experiences about 72% of the defoliation of balsam fir. Red and black spruce, which are quite common in spruce-fir stands, are also susceptible to damage by SBW. However, they experience only 41% and 28%, respectively, of the defoliation of balsam fir (Hennigar et al. 2008). Spruce and fir trees in mixed hardwood-softwood stands, which tend to be more abundant in Maine than other parts of the Acadian Forest, are at lower risk of SBW defoliation (MacLean 1980; Hennigar et al. 2008). A major reason for the reduced risk of spruce and fir trees in mixedwood stands is that these stands contain more diverse communities of parasitoids that infect SBW larvae (Cappuccino et al. 1998; Su et al. 1996; MacKinnon and MacLean 2004; Quayle et al. 2003).

A detailed SBW risk map for northern Maine was recently developed by Legaard et al. (2013) using satellite imagery of a 10-million-acre area in northern Maine to classify stands in five levels of SBW defoliation risk based on the abundance of susceptible tree species (Figure 12). Using this map, they were able to calculate the acreage at risk from SBW defoliation in the four northern Maine counties (Table 1).

	High SBW Risk	⟵		⟶	Low SBW Risk	No SBW Risk		
County	**Mature balsam fir/white spruce**	**Young balsam fir/white spruce**	**Red/black spruce**	**Mixed with balsam fir/white spruce**	**Mixed with red/black spruce**	**Non-host forest**	**Water/no data**	**TOTAL**
Aroostook	665,100	122,400	249,800	385,300	230,800	1,261,000	1,452,400	**4,366,800**
Penobscot	193,800	20,600	108,100	129,600	113,600	503,300	1,204,500	**2,273,500**
Piscataquis	382,500	110,200	291,400	215,100	309,200	737,300	754,500	**2,800,200**
Somerset	298,800	90,200	123,700	195,400	99,500	609,200	1,201,600	**2,618,400**
TOTAL	**1,540,200**	**343,400**	**773,000**	**925,400**	**753,100**	**3,110,800**	**4,613,000**	**12,058,900**
Percent	**13%**	**3%**	**6%**	**8%**	**6%**	**26%**	**38%**	**100%**

Table 1 - Area in four northern Maine counties classified into five levels of risk for defoliation by the SBW based on tree species composition. Classification was derived based on remote sensing of 10-million-acre study area (see Figure 11). Only counties that overlapped the study area by >10% were included. Overlapping of study area and county boundaries ranged from 60% to 90%. (Source: Erin Simons-Legaard, University of Maine)

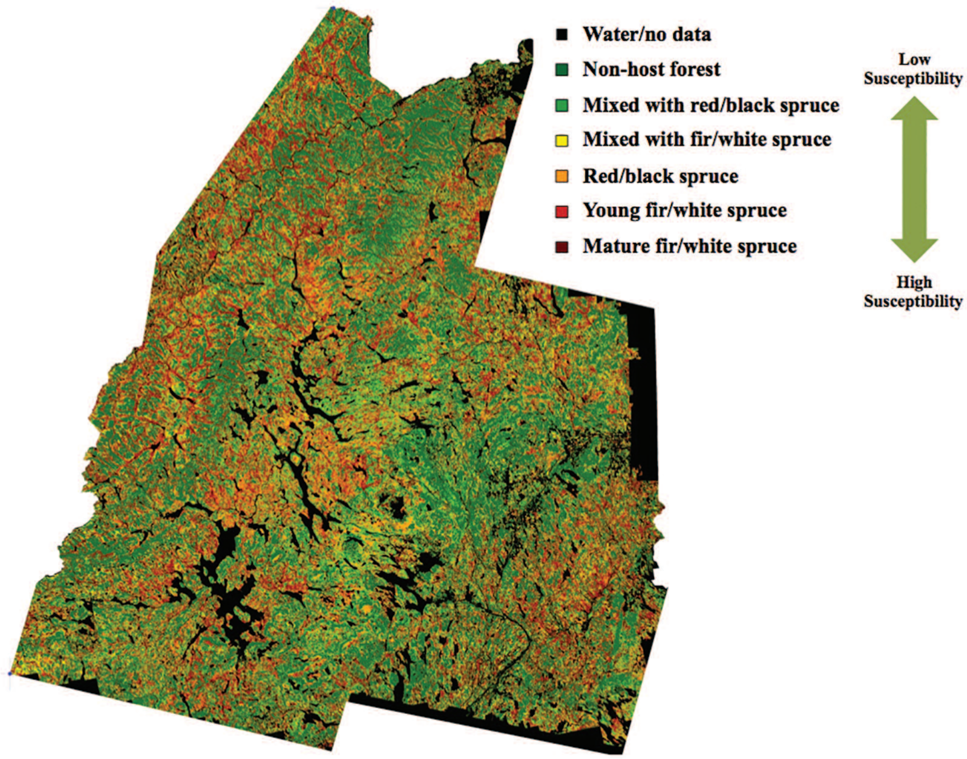


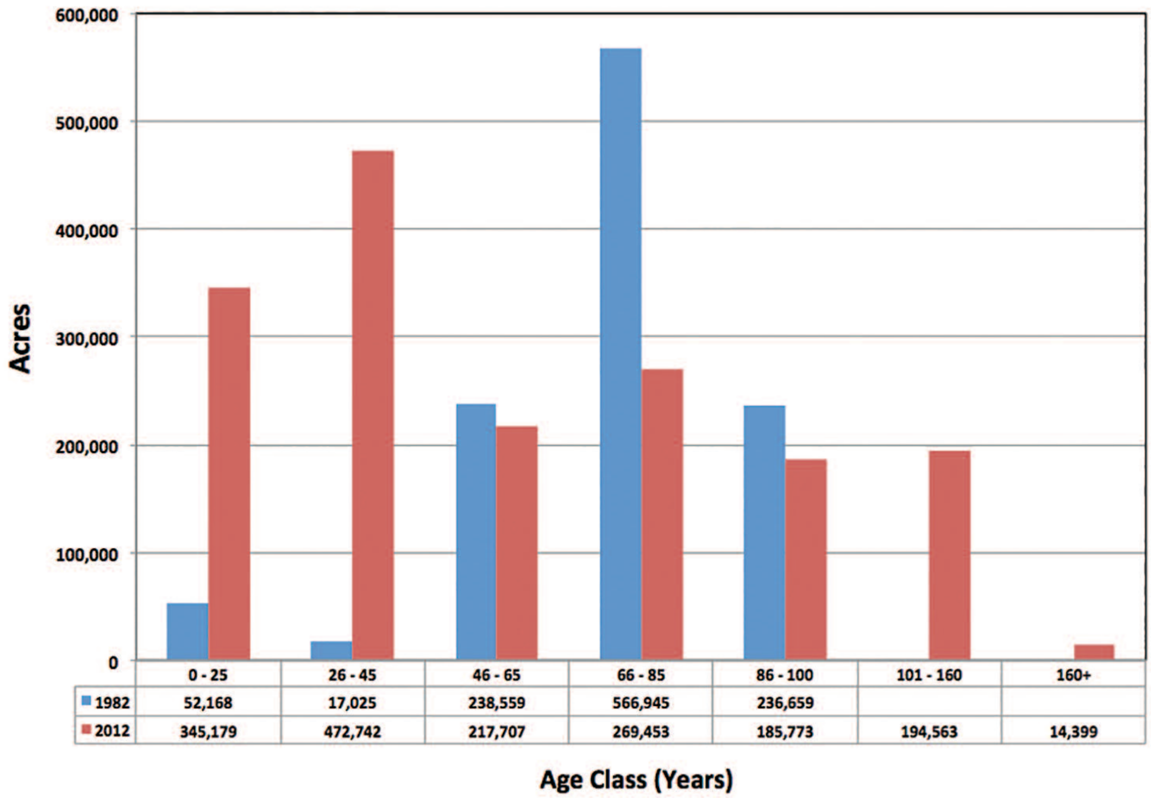
Figure 12 - Map of approximately 10 million acres of northern Maine showing areas of forestland classified based on susceptibility to defoliation by SBW. Data that generated this map were used to calculate areas at risk by county shown in Table 1. (Source: Legaard et al. 2013)

B. Severity of Coming Outbreak

There is no way to predict exactly when defoliation of balsam fir and spruce will begin in Maine, how severe the outbreak will eventually become, or how long it will last. If the pattern of the 1970s–80s outbreak is any indication, once the next outbreak begins it is reasonable to assume that levels of tree defoliation will grow quickly during the first 5 years, reach a peak that lasts 5 to 10 years, and then decline rapidly over the next 5 to10 years.

Although defoliation from the current outbreak in Quebec is quite severe due to the relatively high volumes of mature balsam fir stands in the province, it is reasonable to speculate based on several factors that the coming outbreak in Maine may not be as biologically or economically as severe as the 1970s–80s outbreak:

- There is less total area in the spruce-fir forest type today than there was at the start of the last outbreak in 1970. The spruce-fir forest type in Maine occupied about 8 million acres in 1971 (Pistell and Harshberger 1979) compared to about 6 million acres in 2008 (McCaskill et al. 2011).
- Balsam fir stands in northern Maine are younger than they were during the 1970s. Mature fir is thought to be more vulnerable to SBW (MacLean 1980). For example, spruce-fir stands in Aroostook County were substantially younger in 2012 than they were in 1982 (Figure 13). Most stands in 1982 were between 46 and 100 years old, while in 2012 most spruce-fir stands were less than 65 years old.



	0 - 25	26 - 45	46 - 65	66 - 85	86 - 100	101 - 160	160+
1982	52,168	17,025	238,559	566,945	236,659		
2012	345,179	472,742	217,707	269,453	185,773	194,563	14,399

Figure 13 - Age class distribution of spruce-fir forest type in Aroostook County in 1982 and 2012. Table under graph shows acres in each age class. (Source: K. Laustsen, MFS, personal communication)

- Reductions in spruce-fir stands during the 1970s–80s SBW outbreak, combined with widespread use of partial harvesting since the implementation of the Maine Forest Practices Act in 1991, has increased hardwood dominance in northern Maine's forests (K. Laustsen, MFS, personal communication; Lombardo 2014). As a result, there is more area in mixedwood and hardwood stands that contain more diverse communities of SBW parasitoids (Cappuccino et al. 1998; Su et al. 1996; MacKinnon and MacLean 2004; Quayle et al. 2003), which will likely result in lower SBW damage to spruce and fir that occur in mixed species stands.
- Although there are only a few modern outbreaks to learn from, there is some indication of alternating severe and moderate outbreaks during the past century. For example, the 1910s outbreak was quite severe and was followed by a more moderate outbreak in the 1940s. The next outbreak in the 1970s was severe. Therefore, the next outbreak may be more moderate. However, SBW dynamics are complex and not completely understood. This alternating pattern, if it exists to any degree over long periods of time, may be related to natural forest dynamics where the SBW outbreak after a severe one encounters a younger mixed forest that does not provide as large a source of food to sustain another severe outbreak (Baskerville 1975; Miller and Rusnock 1993).
- Although there is some scientific controversy as to whether SBW outbreaks develop at an "epicenter" and then spread outward to surrounding areas, the movement of moths to other areas experiencing a local outbreak can accelerate the rate at which an outbreak increases (Royama

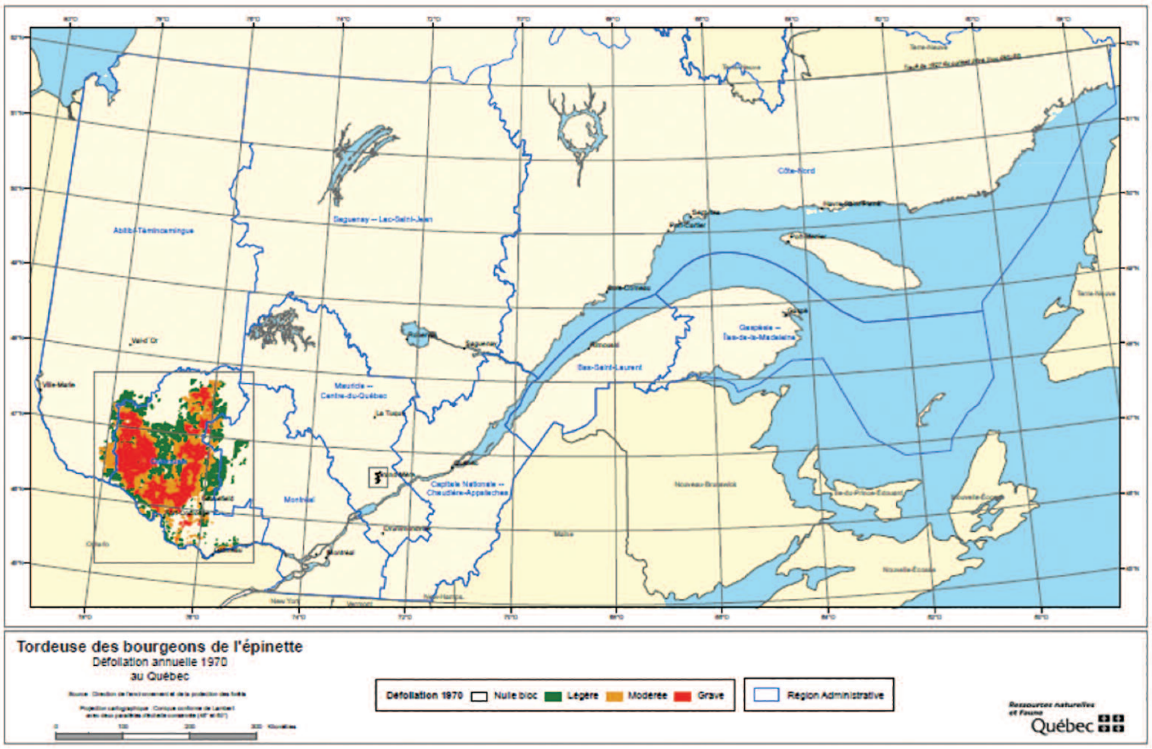


Figure 14 - Spruce-fir defoliation from SBW origin in Quebec in 1970. Compare more southern and western origin of outbreak than in 2014 in Figure 6. (Source: Resources Naturelles et Faune)

1984; Régnière and Lysyk 1995; Bouchard et al. 2014; Régnière et al. 2013). Given that the 1970s outbreak in Quebec occurred further southwest (Figure 14) than the current outbreak north of the Gaspé Peninsula (Figure 6), there may be some moderating influence on the rate of spread (and perhaps eventual severity) because the prevailing winds would tend to carry major moth flights in a northeasterly direction away from Maine.

- Although evidence is still being developed based on current climate models and knowledge about SBW biology, Régnière et al. (2012) and Cooke (2014) have shown that favorable climatic conditions for SBW outbreaks may be shifting northward. Climate models suggest that conditions today may not be as favorable for a SBW outbreak in Maine as they were in the early 1970s when the last outbreak began. However, the current outbreak in Quebec is as severe as the one in the 1970s–80s (D. MacLean, UNB, personal communication), suggesting that Maine still has the potential for major SBW activity as the current outbreak expands southward.
- In addition to biological reasons, the impact of the coming outbreak will likely not be as severe economically because of a significant shift in tree species preference by Maine's forest products industry since the 1970s. The amount of annual spruce-fir sawlog and pulpwood harvest has declined from 2 to 3 million cords in the 1970s–80s to between 1.5 and 2 million cords during the past decade (Figure 15). Much of this reduction has resulted from an increased reliance on hardwood pulp over spruce-fir pulp to support much of Maine's paper industry (Figure 16).

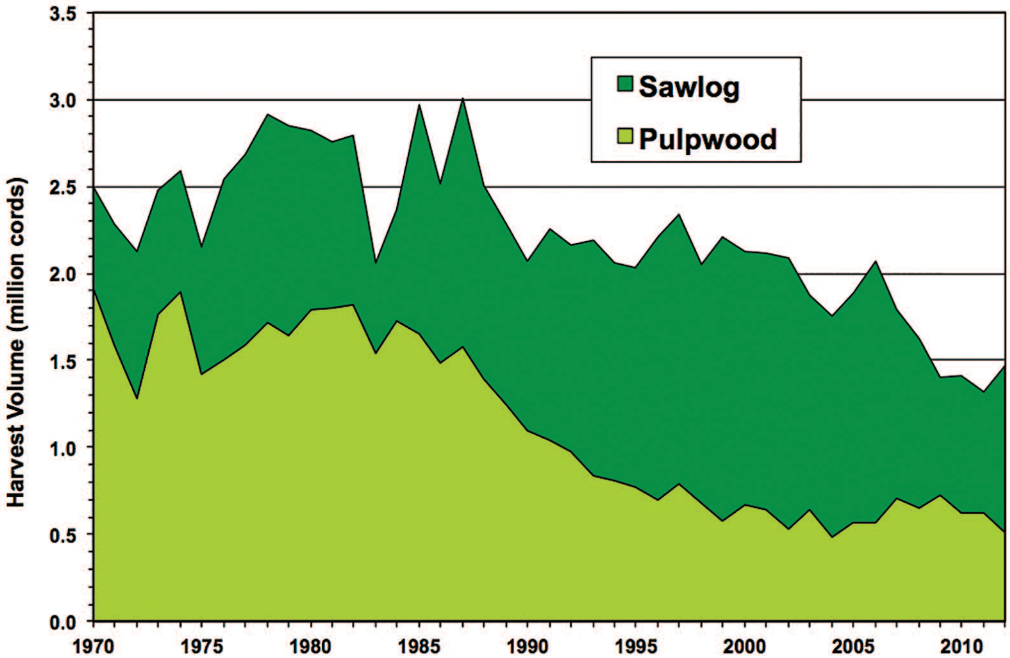


Figure 15 - Spruce-fir harvest volume in Maine from 1970 to 2012. (Source: K. Laustsen, MFS, personal communication)

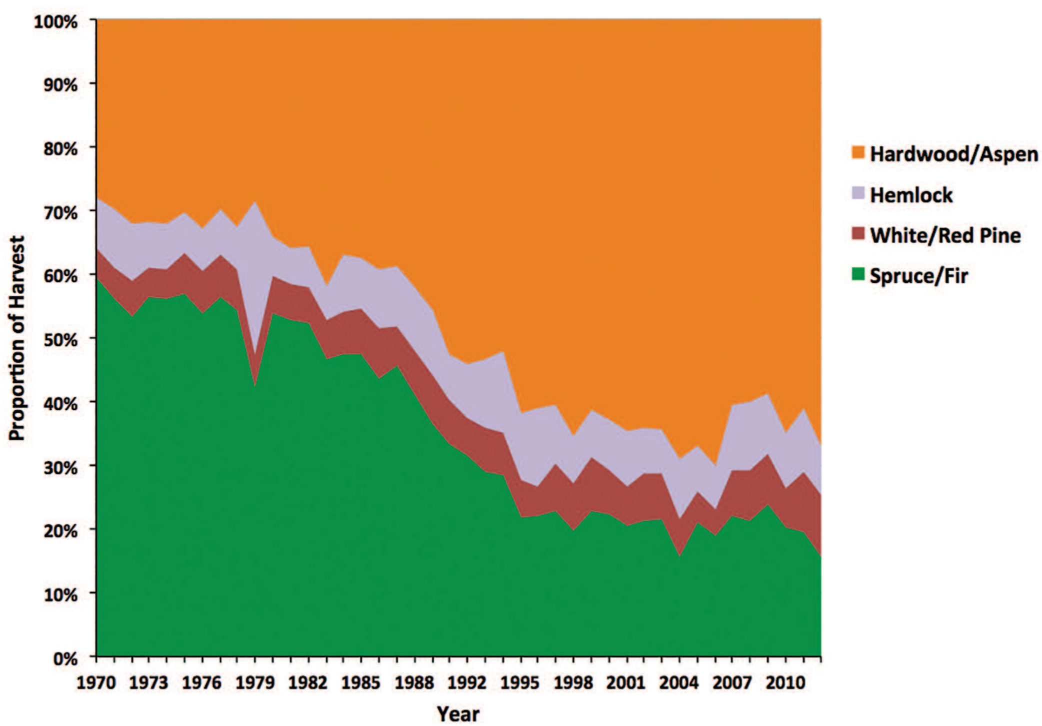


Figure 16 - Proportion of pulpwood harvest (cord basis) by major tree species in Maine from 1970 to 2012. (Source: K. Laustsen, MFS, personal communication)

C. Projected Wood Supply Impacts

Two recent studies on the potential impact of a SBW outbreak on spruce-fir wood supply in northern Maine were recently completed. In the first study, Legaard et al. (2013) simulated the effect of periodic SBW outbreaks across a 10-million-acre study area in northern Maine (Figure 12). Using the forest landscape model LANDIS-II (LANDscape DIsturbance and Succession), they projected the impact of various timings and outbreak intensities from 2010 to 2110 on spruce-fir biomass (Figure 17). The authors projected a range of potential outbreak scenarios under current harvesting patterns and found, regardless of when the next SBW outbreak occurs, that the combined influence of tree mortality and salvage harvesting will cause a 10% to 30% maximum annual reduction in spruce-fir biomass for moderate to severe outbreaks, relative to the current harvesting regime with no SBW outbreak. Every outbreak scenario was followed by a slow 40- to 70-year recovery of spruce-fir biomass depending on the timing and severity of the outbreak. The findings also indicated that the impact of the next outbreak would not be strongly influenced by when the outbreak occurred during the coming decades. They also showed that spruce-fir biomass in Maine would increase gradually over the coming century if current harvest patterns continued without a SBW outbreak.

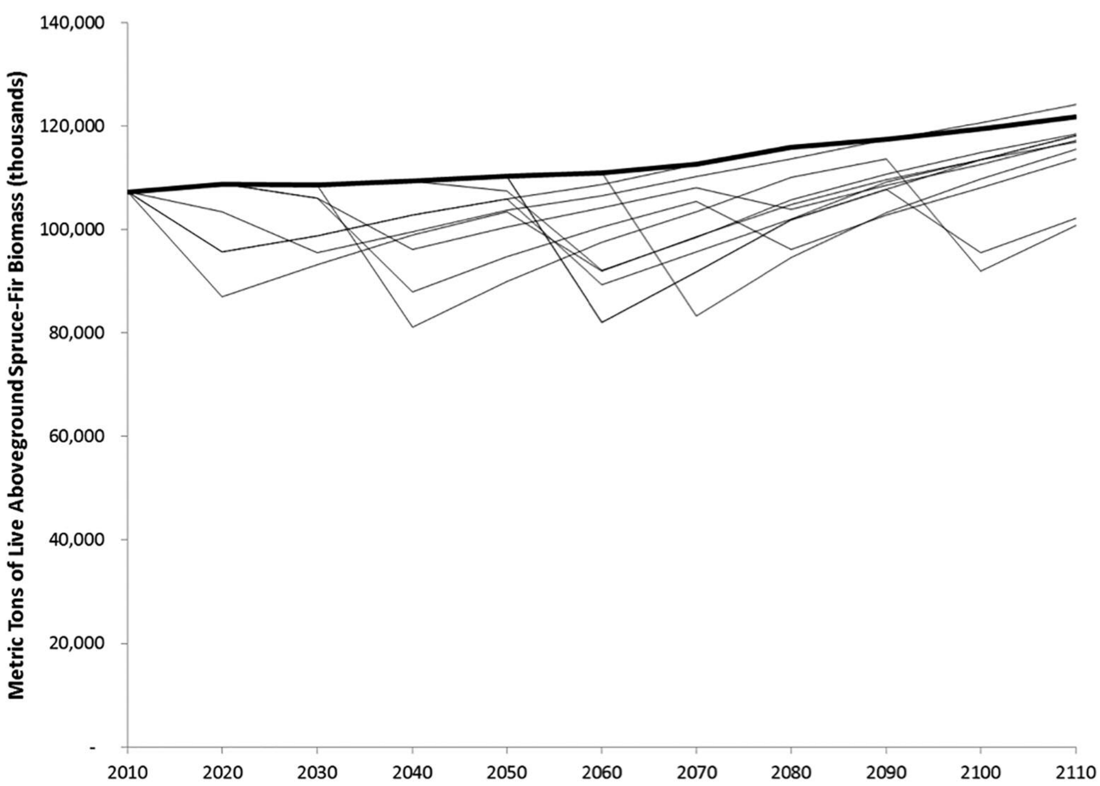


Figure 17 - Projected spruce-fir biomass under current harvesting regime over a 10-million-acre area of northern Maine (Figure 12) without SBW outbreak (bold line) and biomass reduction and recovery under various SBW outbreak timings and intensities (thin lines) from 2010 to 2110. (Source: Legaard et al. 2013)

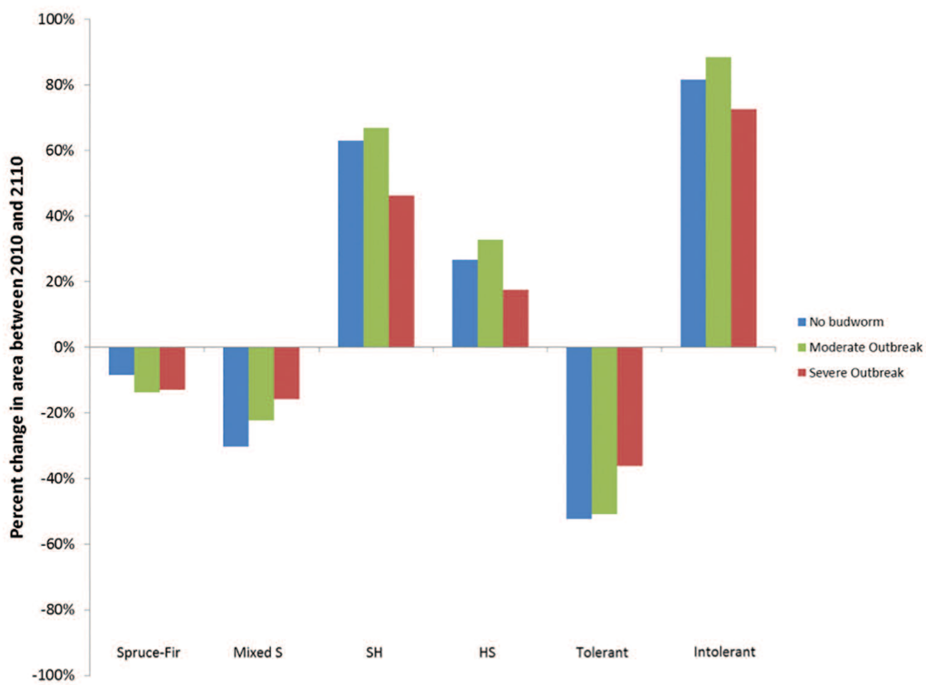


Figure 18 - Projected changes in forest type over a 10-million-acre area of northern Maine (Figure 12) following no SBW outbreak, a moderate outbreak, and severe outbreak from 2010 to 2110. Types include spruce-fir, mixed softwood (Mixed S), softwood-dominated mixedwood (SH), hardwood-dominated mixedwood (HS), tolerant hardwood (Tolerant), and intolerant hardwood (Intolerant). (Source: Legaard et al. 2013)

Legaard et al. (2013) also showed that the combined effects of harvesting and SBW influences would alter the future species composition of the forest (Figure 18). Without a SBW outbreak, softwood-dominated stands and tolerant hardwood type would decrease, while the area of mixedwood and intolerant hardwood forest type would increase. Both moderate and severe SBW outbreak scenarios will cause additional loss of the spruce-fir forest type; mixed-softwood and tolerant hardwood forest types would still decline, but to a lesser degree compared to the no outbreak scenario.

In the second study, Hennigar et al. (2013a) quantified the spatial and temporal pattern of SBW population levels and defoliation severity during the 1970s–80s SBW outbreak on Maine's northern forest. By customizing New Brunswick's SBW Decision Support System (SBW-DSS) for Maine and using northern Maine's current forest conditions as described by USFS Forest Inventory & Analysis (FIA) data, they developed a non-spatial, timber supply model using typical silviculture systems, SBW outbreak patterns, and defoliation-impact relationships to project future spruce-fir wood supply impacts if a 1970s–80s outbreak scenario were to occur again.

Results from their analysis concluded that the **maximum potential reduction in annual spruce-fir harvest level would be 33% in a severe outbreak** (similar to the 1970s–80s) if it began in 2013, and a **22% reduction if a moderate outbreak were to occur** at the same time (Figure 19A). Projected maximum annual reductions were from 27–28% for all potential outbreak start dates tested. It was estimated that the "*maximum spruce-fir inventory impacts in future outbreaks are most likely to fall within the range of ≈15–30%, assuming no foliage protection.*"

As was found by Legaard et al. (2013), the annual harvest impacts predicted by Hennigar et al. (2013a) were also relatively insensitive to the timing of the outbreak, suggesting that there would be no significant change in forest vulnerability or impact over the next 40 years.

While the 1970s–80s outbreak in Maine and in eastern Canada was considered severe and persistent compared to the 1910s and 1950s outbreaks, Hennigar et al. (2013a) suggest that their estimates "*most likely represent above average outbreak estimates of future spruce-fir harvest impacts in Maine";* it was further concluded that the *"general temporal and spatial trends provide a plausible scenario for wood supply impact and mitigation planning analysis.*"

It is important to note that the Legaard et al. (2013) and Hennigar et al. (2013a) studies each used different methodologies, data sources, and measures of forest impact in their analyses. Despite these differences, three points of agreement between the studies provide some confidence about the projected effects on the spruce-fir resource from the coming SBW outbreak:

- Both studies indicated a 15% to 30% maximum annual reduction in spruce-fir volume growth or standing biomass from moderate and severe SBW outbreaks, respectively. Although the two measures of spruce-fir impact were not the same, the general magnitude of the effect on forest growth and standing biomass were similar.
- Both studies showed a slow (approximately 40 years) recovery following the peak impact of the outbreak.
- Both studies indicated that the susceptibility and response of the spruce-fir forest is approximately the same over a long period time. Therefore, the effects of the next SBW outbreak on spruce-fir volume or biomass (both in severity and rate of recovery) will likely be similar regardless of when the outbreak occurs over the next several decades or more.

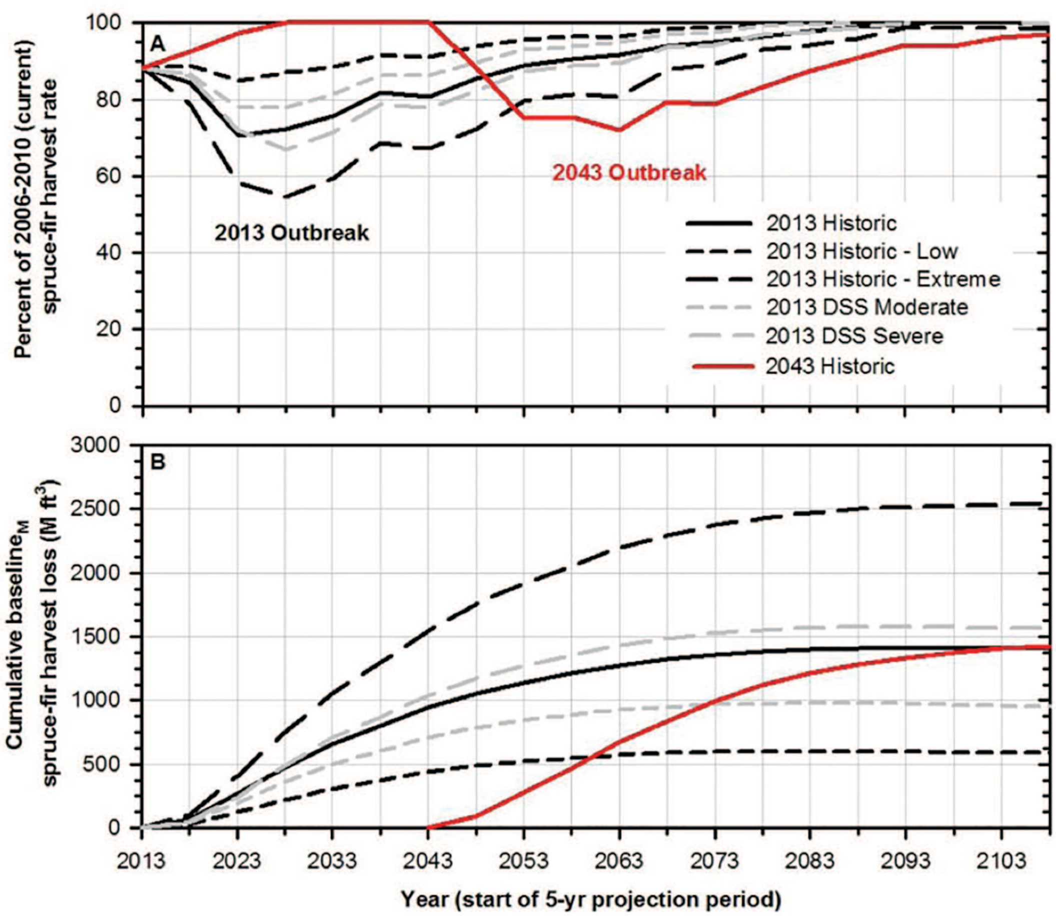


Figure 19 - Spruce-fir harvest with the 1970s–80s Maine outbreak beginning in 2013 or 2043, and alternative 2013 outbreak scenarios (SBW-DSS Moderate and Severe, historic-extreme and historic-low), expressed as (A) percentage of 2006-2010 harvest rates and (B) million board feet of cumulative harvest loss with no mitigation. (Source: Hennigar et al. 2013a)

Of particular value in the Hennigar et al. (2013a) analysis was their quantitative assessment of various mitigation approaches, including: (1) adapting future harvest activities toward high-risk stands, (2) insecticide treatment with the biological insecticide B.t. (*Bacillus thuringiensis*), and (3) salvage logging of dead and dying trees (Figure 20). The authors emphasize that these "what if" scenarios are difficult to predict and only estimate the maximum possible impact reduction under optimum planning conditions, which in many cases may not be operationally feasible to implement to the degree projected. Their principal value is in understanding the maximum degree of mitigation possible if these management approaches were applied with maximum effectiveness, what the relative tradeoffs might be when developing a strategic plan, and identifying which forest policies may need to be addressed when responding to the next SBW outbreak.

From these results, it is clear that forestland managers can substantially reduce the negative impacts of an outbreak that begins in the next several years if they are able to (1) adapt future harvest plans toward high-risk stands before or as early as possible into the outbreak, (2) apply foliage protection to the highest risk and valuable stands using B.t., and (3) salvage log dead and dying trees where they occur. About 10% of the gain comes from shifting future harvest plans toward high-risk stands (mature fir and mature fir-spruce). An additional 8% comes from also applying insecticide treatment to 20% of the remaining high-to moderate-risk stands (immature fir-spruce, mature red-black spruce), which will be important to preserve now to sustain the post-outbreak wood supply. Hennigar et al. (2013a) found little additional gains from treating more than 20% of the susceptible area. Salvage logging of dead or dying trees using current partial harvesting approaches did not provide any additional mitigation. However, clearcut harvesting to salvage dead and dying trees mitigated the remaining 10% of the loss, and even increased future harvest levels somewhat due to replacement with higher-yield stands.

The projected mitigation levels come from the complete execution and success of these management approaches alone and in combination. Therefore, these projections represent only a theoretical maximum reduction in harvest losses through the next outbreak. Actual reductions are

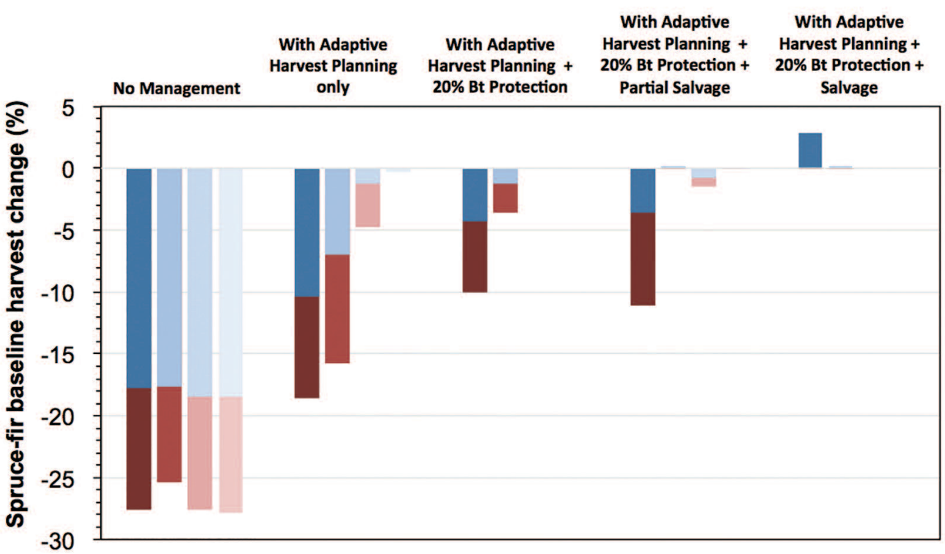


Figure 20 - Projected cumulative and maximum spruce-fir harvest change over 40 years from year of historic outbreak start (2013, 2023, 2033, or 2043) and maximum benefit of directing future harvest activities toward high-risk stands (Adaptive Harvest Planning), insecticide treatment with the biological insecticide B.t. to 20% of infested area (20% B.t. Protection), and the salvage logging of dead and dying trees using current partial harvesting methods (Partial Salvage), and clearcut harvesting (Salvage). (Source: Hennigar et al. 2013a)

likely to be lower than shown. For example, the authors identify a significant constraint to implementing adaptive harvest planning (or re-planning) because many of the high-risk stands may not be able to support a financially viable harvest operation due to small stem diameters or inaccessibility of stands.

Using the percentage losses estimated by Hennigar et al. (2013a), the worst-case scenario and half that of the worst-case scenario for potential cumulative volume reductions for spruce-fir (relative to 2006–10 harvest levels) over the next 40 years following an outbreak that begins in 2013 is shown in Figure 21. These results indicate **a total volume loss during the next outbreak of 12.7 million cords from a severe outbreak (similar to the one in the 1970s–80s) and 6.4 million cords for an outbreak half that intensity.** As shown in Figure 21, potential reductions to these losses result from progressive management actions taken by forest landowners (including adaptive harvest planning, insecticide application, and salvage operations).

Using the same approach as in Figure 21 we calculated the potential maximum annual volume reductions for spruce-fir (relative to 2006–10 harvest levels) over the next 40 years following an outbreak that begins in 2013 (Figure 22). The maximum annual volume loss during the next outbreak is 494 thousand cords per year from a severe outbreak and 247 thousand cords per year for a moderate outbreak of half that intensity. Potential reductions to these annual volume losses from management actions are also shown in Figure 22.

Using a similar approach to modeling a SBW outbreak in northern Maine, Hennigar et al. (2013b) quantified the harvest impacts of moderate and severe outbreak scenarios, as well as the effect of the same mitigation strategies, for 7.4 million acres in New Brunswick. Cumulative harvest reductions were 18% and 25% by 2052 under moderate and severe defoliation patterns relative to the no defoliation case, respectively. They demonstrated that upwards of 30% to 50% of the projected harvest reductions could be mitigated using insecticide treatment depending on the outbreak scenario. Salvage and harvest re-planning reduced harvest reductions up to 20% in the short term (20 to 25 years), but produced little gain over the long run (40+ years). Using aggressive implementation of all mitigation measures, they found that harvest impacts of at least 10% were unavoidable from 2017 to 2042, regardless of outbreak scenario.

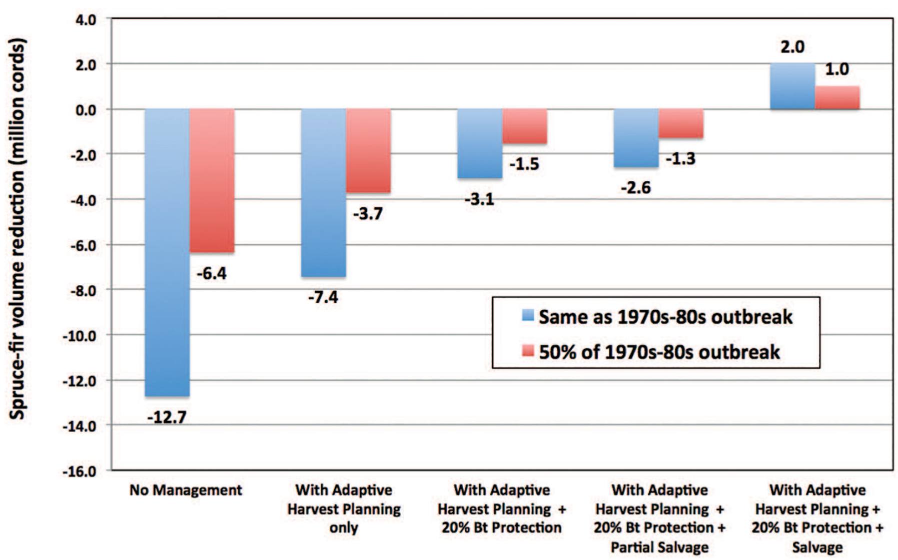


Figure 21 - Projected cumulative spruce-fir volume reduction (cords) relative to 2006–10 harvest levels for severe (similar to the one in the 1970s–80s) and moderate (50% of 1970s–80s outbreak) SBW outbreaks beginning in 2013, and potential maximum benefit of directing future harvest activities toward high-risk stands (Adaptive Harvest Planning), treatment with the biological insecticide B.t. to 20% of infested area (20% B.t. Protection), and the salvage logging of dead and dying trees using current partial harvesting methods (Partial Salvage), and clearcut harvesting (Salvage). (Source: Calculated from Hennigar et al. 2013a)

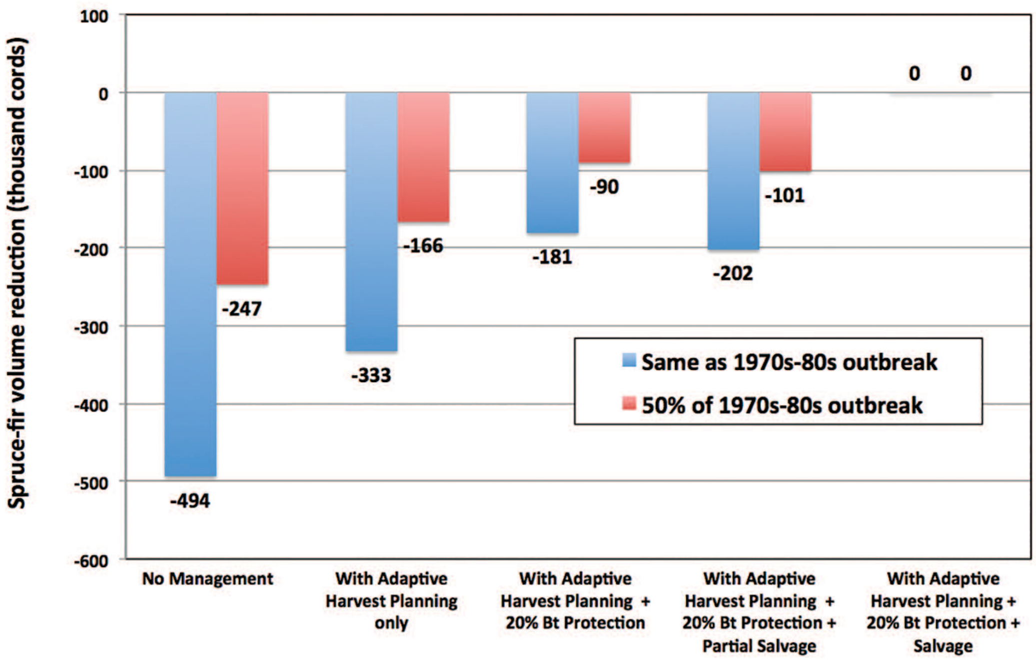


Figure 22 - Projected maximum annual spruce-fir volume reduction (cords) relative to 2006–10 harvest levels for severe (similar to the one in the1970s–80s) and moderate (50% of 1970s–80s outbreak) SBW outbreaks beginning in 2013, and potential maximum benefit of directing future harvest activities toward high-risk stands (Adaptive Harvest Planning), treatment with the biological insecticide B.t. to 20% of infested area (20% B.t. Protection), and the salvage logging of dead and dying trees using current partial harvesting methods (Partial Salvage), and clearcut harvesting (Salvage). (Source: Calculated from Hennigar et al. 2013a)

D. Projected Economic Impacts

We estimated the maximum annual economic impact of the next SBW outbreak using the: (1) projected maximum annual spruce-fir volume reduction levels under the two SBW outbreak scenarios and five forest management response scenarios presented in Figure 22; (2) statewide stumpage prices for spruce-fir sawlogs and pulpwood in 2010–12; (3) statewide harvest of these species and products to estimate the total stumpage value of Maine forest harvest in 2012; and (4) economic contribution of Maine's forest products sector to the overall Maine economy in 2011 (Maine Forest Products Council 2013).

This estimate of economic impact represents the worst-case scenario for the year during the next outbreak when the maximum losses would occur under moderate and severe outbreak scenarios. It also assumes that no substitutions are made for lost spruce-fir volume during the outbreak, no change in market price of spruce-fir wood with increased supply during the outbreak, and no real price change in spruce-fir stumpage over time. Each of these assumptions is unrealistic. In addition, the estimates are based on the annual economic contribution of the Maine forest products sector in 2011 (Maine Forest Products Council 2013), which may have changed due to several recent pulp and paper mill closures in the state. This estimate is intended only as an illustration of the potential maximum annual economic impact that the next SBW outbreak might have during the worst year of the outbreak under these scenarios. As it would be very difficult to reasonably calculate the economic impact of the projected cumulative spruce-fir volume reduction over the life of the outbreak as shown in Figure 21, we focused our economic impact assessment only on the maximum potential annual impact.

Table 2 - Economic assumptions used to estimate the maximum annual economic impact of the next SBW outbreak.

Assumption	Value
Average statewide stumpage price for 1 cord of spruce-fir in 2010–12[1]	$45.63
Total stumpage value of Maine wood harvested in 2012[2]	$225,995,477
Total direct economic output impact of Maine's forest products sector[3]	$5,063,915,031
Total indirect economic output impact of Maine's forest products sector[3]	$2,911,542,758
Total economic output impact of Maine's forest products sector[3]	$7,975,457,789
Total direct employment impact of Maine's forest products sector[3]	12,003
Total indirect employment impact of Maine's forest products sector[3]	26,786
Total employment impact of Maine's forest products sector[3]	38,789
Total direct labor income impact of Maine's forest products sector[3]	$721,541,907
Total indirect labor income impact of Maine's forest products sector[3]	$1,145,095,798
Total labor income impact of Maine's forest products sector[3]	$1,866,637,705

[1]2010–12 average price for 1 cord of combined spruce-fir sawlogs at $61.07/cord and pulpwood at $24.32/cord harvested over 2010–12; average ratio for the State of Maine of 58% sawlog and 42% pulpwood. (Source: K. Laustsen, MFS, personal communication)

[2]Source: K. Laustsen, MFS, personal communication.

[3]Source: Todd Gabe, University of Maine. Reported for 2011 in Table 1 of Maine's Forest Economy Report (Maine Forest Products Council 2013).

Using the assumptions in Table 2, the potential maximum annual economic and job impact from two SBW outbreak and five forest management response scenarios is presented in Table 3. These estimates indicate that the **maximum annual spruce-fir stumpage loss, without any forest management mitigation efforts, could be $11 million per year during a moderate outbreak and upwards of $22 million per year during a severe outbreak.** This would translate, based on 2011 estimates of the annual economic contribution of the forest products sector, to a **potential total annual economic impact during the next SBW outbreak (without any forest management response) from $397 million per year for a moderate outbreak to upwards of $794 million per year during a severe outbreak.** The estimated annual job loss in the forest products sector would translate to 1,196 jobs and 598 jobs for severe and moderate outbreaks, respectively. Higher total job losses would be expected due to the multiplier effect of forest products jobs (Table 3). These job impacts would largely occur in many of Maine's rural counties, which are already struggling under substantial economic pressure. As discussed in the Projected Wood Supply section of this report, however, these maximum annual economic and job impacts can be substantially reduced or nearly eliminated if forest management actions (shifting harvests to high-risk stands, protecting foliage with insecticide, and removing dead and dying trees) are taken before and during the outbreak (Table 3).

It will be necessary to conduct regular economic impact analyses based on market adjustments and spruce-fir substitutions that will inevitably occur throughout the course of the outbreak. A clear understanding of the overall economic impact will help guide management and policy decisions that will be needed to mitigate the economic impacts of the outbreak.

It also will be important to provide forest managers with decision-support tools to guide forest management actions for individual stands and forest properties. A recent study by Chang et al. (2012)

Table 3 - Potential maximum annual economic and job impact from two SBW outbreak and five forest management response scenarios presented in Figure 22. Assumptions for analysis are presented in Table 2.

SBW Outbreak Scenario	Forest Management Response Scenario	Estimated Spruce-fir Cord Reduction	Potential Spruce-fir Stumpage Value Lost in 2013	Total Spruce-fir Stumpage Value Loss as % of Total Maine Stumpage Value Harvested in 2012	Estimated Total Direct Economic Impact to Forest Products Industry	Estimated Total Indirect Economic Impact to Maine	Estimated Total Economic Impact to Maine	Estimated Total Direct Job Loss for Forest Products Industry	Estimated Total Indirect Job Loss for Maine Economy	Estimated Total Job Loss for Maine Economy	Estimated Total Direct Labor Income Impact to Forest Products Industry	Estimated Total Indirect Labor Income Impact to Maine Economy	Estimated Total Labor Income Impact to Maine Economy
Approximately 50% of 1970s-80s outbreak on current forest	No Management	-246,776	-$11,260,132	-5.0%	-$252,307,484	-$145,066,420	-$397,373,904	-598	-1,335	-1,933	-$35,950,529	-$57,053,927	-$93,004,456
	With Adaptive Harvest Planning only	-166,306	-$7,588,350	-3.4%	-$170,033,304	-$97,762,153	-$267,795,457	-403	-899	-1,302	-$24,227,530	-$38,449,386	-$62,676,916
	With Adaptive Harvest Planning + 20% Bt Protection	-90,306	-$4,120,555	-1.8%	-$92,329,913	-$53,085,900	-$145,415,813	-219	-488	-707	-$13,155,809	-$20,878,430	-$34,034,239
	With Adaptive Harvest Planning + 20% Bt Protection + Partial Salvage	-101,035	-$4,610,126	-2.0%	-$103,299,803	-$59,393,136	-$162,692,939	-245	-546	-791	-$14,718,876	-$23,359,035	-$38,077,911
	With Adaptive Harvest Planning + 20% Bt Protection + Salvage	0	$0	0.0%	$0	$0	$0	0	0	0	$0	$0	$0
Same as 1970s-80s outbreak on current forest	No Management	-493,553	-$22,520,263	-10.0%	-$504,614,968	-$290,132,841	-$794,747,809	-1,196	-2,669	-3,865	-$71,901,058	-$114,107,854	-$186,008,912
	With Adaptive Harvest Planning only	-332,612	-$15,176,699	-6.7%	-$340,066,609	-$195,524,306	-$535,590,914	-806	-1,799	-2,605	-$48,455,061	-$76,898,771	-$125,353,832
	With Adaptive Harvest Planning + 20% Bt Protection	-180,612	-$8,241,111	-3.6%	-$184,659,825	-$106,171,801	-$290,831,626	-438	-977	-1,414	-$26,311,619	-$41,756,860	-$68,068,479
	With Adaptive Harvest Planning + 20% Bt Protection + Partial Salvage	-202,071	-$9,220,253	-4.1%	-$206,599,606	-$118,786,272	-$325,385,878	-490	-1,093	-1,583	-$29,437,752	-$46,718,071	-$76,155,823
	With Adaptive Harvest Planning + 20% Bt Protection + Salvage	0	$0	0.0%	$0	$0	$0	0	0	0	$0	$0	$0

that assessed the potential economic impact of a SBW outbreak in New Brunswick forests provides an excellent example of the kind of study that will be needed for Maine. Chang et al. estimated market and non-market benefits and costs of six alternative scenarios for controlling future SBW outbreaks on Crown forestlands in New Brunswick. Under severe outbreak conditions, the highest benefit-cost ratio (4.04) occurred when protecting 10% of the high-risk areas, and the highest net present value occurred when protecting 20% of the susceptible area. Under moderate outbreak conditions, the highest benefit-cost ratio (3.24) and net present value occurred when protecting 10% of the susceptible area. Therefore, the maximum level of foliage protection needed for high-risk stands found by Hennigar et al. (2013a) for Maine's wood supply was similar to that found for protecting the economic values of New Brunswick's Crown lands. Chang et al. also found that including non-market values in the analysis generally increased the benefit-cost ratios and net present values of SBW control programs, as well as increased the area of control that was needed.

E. Differences Between 1970s Outbreak & Coming Outbreak

In order for Maine forest industry and government to effectively respond to the coming outbreak, it is important to understand how key factors and conditions have changed since the last outbreak in the 1970s–80s. These differences can provide insight into preparation and response strategies that will need to be adjusted relative to the last outbreak to effectively plan for various aspects of the coming outbreak. Table 4 summarizes these key differences.

A quantitative and subjective assessment of changes in 43 factors (including spruce-fir forest condition, wood supply, forest management, forest products manufacturing, logging industry, SBW monitoring capability, available protection measures, policies and regulations, political environment, available funding, and staffing levels) between today and when the last outbreak began in 1970 indicated more favorable circumstances in 55% of the factors, less favorable circumstances in 40% of the factors, and equal or unclear differences in 5% of the factors. Based on this analysis, the coming SBW outbreak will occur under very different circumstances than the last outbreak.

As a result, the impact of and response to this outbreak will be very different than the one during the 1970s–80s. In general: the spruce-fir forest is in a more favorable condition; the spruce-fir wood supply effects will be somewhat less favorable; forest management conditions are substantially more favorable; forest products manufacturing effects will be more positive or negative depending on the product; challenges for the logging industry will be somewhat higher; SBW monitoring and protection will be positive and negative depending on the factor involved; and the political, funding, and staffing conditions will be relatively more challenging than during the last outbreak.

Table 4 - Difference in key factors and conditions in Maine at start of 1970s SBW outbreak and today that are likely to affect the relative risk of and response to the coming SBW outbreak.

Factor / Condition	1970	Today	Implication for responding to the next SBW outbreak	Relative difference today vs. 1970 Better (+) Worse (–) Same (=) Unclear (?)
Spruce-fir Forest Conditions:				
Area	8 million acres	6 million acres	More mixed hardwood-dominated stands than mature fir and spruce stands reducing area of high-risk stands	+
Balsam fir content	48%	37%	Lower fir content reduces overall impact of stand defoliation	+
Age	Older	Younger	Younger fir and spruce stands slightly less susceptible	+
Wood Supply:				
Merchantability	Most stands merchantable	Fewer merchantable stands due to younger ages and smaller diameters	May make harvesting of high-risk stands and salvage logging less feasible in some areas	–
Inventory	126 million cords in spruce-fir	73 million cords in spruce-fir	Less spruce-fir inventory at risk	+
Sustainable annual harvest	Annual net growth of spruce-fir was 3.0 million cords greater than removals from 1959–1970	10% decline in spruce-fir harvest level over next 20 years required before returning to current harvest level	Small reduction in annual harvest level needed for spruce-fir	–
Forestland ownership	Forestland owned largely by pulp & paper companies that also owned mills	Forestland owned largely by timberland investors that do not own mills, but some do have long-term wood supply agreements with mills	Incentives for protecting stands from SBW today is somewhat less than when pulp & paper companies owned forestland and needed to supply their own mills	–
Forest Management:				
Road System	Limited road access for SBW monitoring, managing high-risk stands, and salvage logging	Entire land base is accessible by road for SBW monitoring, managing high-risk stands, and salvage logging	Greater road access will allow management operations in nearly all areas during the outbreak	+
Forest certification	Did not exist	Third-party certification of 8 million acres by SFI and FSC	Stronger forest management context for assessing and managing impact of next outbreak	+
Rare/threatened/endangered wildlife species and ecosystems	Little emphasis or knowledge by state agencies or landowners	Development of E/T species programs, WAP, ecoregional studies, MNAP, etc.	Greater knowledge and management of sensitive habitats within northern forests	+

continued

Table 4 - *continued*

Factor / Condition	1970	Today	Implication for responding to the next SBW outbreak	Relative difference today vs. 1970 Better (+) Worse (–) Same (=) Unclear (?)
Forest Management *continued*				
Wood supply impacts	No wood supply models	Sophisticated computer software available (e.g., Woodstock and Stanley software)	New computer software allows rapid incorporation of outbreak impacts and response options for spatially explicit management	+
Modeling capability	Limited to simple stand growth projection methods; no computer models available	Sophisticated computer modeling (e.g., FVS) that is widely accessible to forest managers at every level	Ability to assess outbreak and impacts, and assess the effectiveness of various management options, now available	+
Geospatial capability	Simple analog mapping from surveying and aerial surveys	Digital GPS and GIS mapping of many forest variables simultaneously	Ability to monitor, map, and quantify outbreak, impacts, and treatments with substantially more accuracy and in shorter time	+
Remote sensing	Limited to aerial photos and visual surveys from airplanes	Multi-spectral imaging, satellite imagery, LiDAR, airborne radar	Technological options for quantifying SBW impacts in space and time far more sophisticated	+
Forest Products Manufacturing:				
Diversity	Good pulp & paper and sawmill processing capability	More diverse pulp & paper, sawmill, and biomass processing capability	More diverse forest products manufacturing diversity to process high-risk and salvage material	+
Mill Capacity:				
Sawlog	329 sawmills with production of 423,235 MBF	127 stationary and 85 portable sawmills that processed 616,324 MBF in 2012	Fewer sawmills with higher total processing capacity	+
Pulpwood	18 pulp & paper mills with capacity of 7,430 tons per day	10 operating pulp & paper mills that produced 19,607 tons per day in 2012	Fewer pulp & paper mills with higher total processing capacity *(Note: 3 mills closed in 2015 further reducing capacity)*	?
Biomass	Undeveloped bioenergy, co-generation, and pellet capacity	>20 bioenergy, co-generation, and pellet facilities that processed 6,123 green tons per day in 2012	Greater capacity to process lower grade and small dimension material	+
Preferred species	Fir and spruce 60% of harvest	Hardwoods 60% of harvest	Less market for fir and spruce	–
Market Demand:				
Sawlog	Stronger	Weaker	2008 building recession reduced demand for solid-wood products; market still recovering	–
Pulp & paper	Stronger	Weaker	Market demand lower for some grades of paper	–
Biomass	Weaker	Stronger	Good market demand for electrical generation, co-generation, and pellets	+
Merchantability standards	Higher	Lower	Will make harvesting some smaller diameter stands at risk or for salvage more economically feasible	+

Table 4 - *continued*

Factor / Condition	1970	Today	Implication for responding to the next SBW outbreak	Relative difference today vs. 1970 Better (+) Worse (–) Same (=) Unclear (?)
Real Prices:				
Sawlog	$48/MBF for spruce-fir (Adjusted to 1982 dollars)	$61/MBF for spruce-fir (Adjusted to 1982 dollars)	Higher sawlog prices more attractive for harvesting high-risk stands with larger diameters before outbreak and during salvage	+
Pulp & paper	$13/cord for spruce-fir (Adjusted to 1982 dollars)	$13/cord for spruce-fir (Adjusted to 1982 dollars)	No real price difference suggests no more or less price incentive to harvest spruce-fir pulpwood	=
Biomass	No market	$30/ton	Higher financial incentive and ability to harvest small dimension and low-value fir-dominated stands in most areas except northwestern portion of state	+
Cost pressures	Lower	Higher	Higher cost pressures in logging and manufacturing produce relatively tighter operating margins on all activities	–
Employment	Higher numbers of employees in mills	Lower numbers of employees in mills	Fewer forest products industry jobs at risk, but those jobs have relatively higher wages today	+
Logging Industry:				
Technology	Falling and skidder	Computerized cut-to-length, feller-buncher, and forwarders	More sophisticated technology for harvesting small dimension material more effectively	+
Capacity	Higher	Lower due to rapidly aging workforce	Will be a challenge to respond to outbreak in coming years as workforce availability declines	–
Cost pressures	Lower	Higher	Higher operating costs and tighter margins make logging more risky and could reduce capacity	–
Monitoring Capability:				
Technology	Light trapping	Pheromone trapping and emergent remote sensing capabilities	More sophisticated SBW trapping technology and remote-sensing options will greatly improve outbreak assessment	+
Available labor	More state government and private sector employees to engage in trapping and assessment	Fewer state government and private sector employees to engage in trapping and assessment	Less staff time to dedicate to monitoring activities than last outbreak	–
Funding	More state, federal, and private funding available for trapping and other monitoring activities	Less state, federal, and private funding available for trapping and other monitoring activities	Less state, federal, and private funding to support monitoring activities	–

continued

Table 4 - *continued*

Factor / Condition	1970	Today	Implication for responding to the next SBW outbreak	Relative difference today vs. 1970 Better (+) Worse (–) Same (=) Unclear (?)
Protection Measures:				
Insecticides	Limited to organophosphate and carbamate chemical insecticides (e.g., Fenitrothion, Mexacarbate, Carbaryl, Trichlorofon, Acephate)	New biological insecticides available (e.g., B.t.K. and tebufenozide growth regulating hormone)	More biologically based, lower non-target impact, and lower toxicity materials may reduce public opposition to insecticide applications where needed	+
Insecticide application technology	Large aircraft with application restricted to large areas for broadcast spraying	Small aircraft with satellite navigation for very accurate and small-scale application capabilities	Smaller and more accurate aircraft technology will provide for more targeted, smaller-scale applications that are far more accurate	+
Pest management expertise	Large number of state, federal, and university forest entomologists	Smaller number of state, federal, and university entomologists	There will be less entomological expertise to draw on for assessment, planning, and research during next outbreak	–
Costs	$5 per acre	$25–$50 per acre	Real cost of insecticide and application will be higher during next outbreak	–
Strategies	Only large-scale insecticide application for foliage protection	Smaller, targeted, early intervention strategies now available with IPM approach	Overall protection strategies and management is more sophisticated and environmentally sensitive today	+
Policy and Regulation:				
Policy & Regulation	Less forest management and pest control regulation	Higher level of regulation (e.g., MBPC, Chap 51 aerial application rules, Forest Practices Act, Maine Spruce Budworm Management Act)	Greater regulatory structure and constraints in place to develop and implement new protection measures and harvest high-risk and dying stands	–
Political Environment	Low public interest, sensitivity, and political action on forest resource issues	High public interest, sensitivity, and political action on forest resource issues	Political environment will be more challenging, especially insecticide spraying and salvage logging using clearcutting	–
Funding Levels in State Government, Federal Government, and Private Sector	Higher	Lower	Lower financial flexibility for state, federal, and private sector funding for monitoring, protection, and research	–
Staffing Levels in State Government, Federal Government, and Private Sector	Higher	Lower	Lower staffing levels in state agencies will make it more difficult to develop and implement monitoring, protection, and management responses	–

IV. Preparation & Response Recommendations

A. Monitoring Strategies

1. Background

Monitoring SBW populations is required to understand how the outbreak is progressing and for predicting how much and where damage to spruce-fir forests will occur. Effective monitoring also is the first requirement in deciding when and where to harvest high-risk stands or prescribing insecticide applications to protect valuable stands that are not ready for harvesting. Intensive monitoring is central to implementing integrated pest management (IPM) strategies.

Figure 8 shows the recent and historical results of SBW monitoring in Maine during the last and current outbreaks. Monitoring is clearly an effective early indicator of an imminent outbreak, which is closely correlated with the level of defoliation damage to fir and spruce. Monitoring also allows forest managers to map a SBW outbreak accurately over time. Methods of monitoring focus on both the insect population and the host tree species abundance and damage in both space and time.

Available methods for monitoring SBW populations include:

- Pheromone trapping for male moths
- Light trapping for male and female moths
- Spring larval/pupal samples of current year population and associated damage, which is also used to assess presence and levels of any SBW parasites or disease
- Egg mass surveys for predicting size of next generation, mortality factors such as egg parasites, and associated damage
- L-2 survey for predicting size of next generation and associated damage

Available methods for monitoring availability of host tree species abundance and their condition include:

- Maps showing the location and density of high-risk balsam fir and spruce stands (Figure 10 and Figure 11)
- Maps classifying stands by risk level based on the proportion of high-risk species (Figure 12)
- Defoliation survey maps of current year and cumulative levels of damage to fir and spruce stands using satellite, aerial, or ground methods.

2. Baseline monitoring

Baseline monitoring has been used continuously by MFS since the last SBW outbreak to monitor annual population levels. This monitoring includes pheromone trapping for male moths, light trapping for male and female moths, and aerial surveys for possible damage. Pheromone traps are the most sensitive sampling tool available and have proven effective for monitoring low population levels of SBW. Light traps are more expensive and labor intensive to operate than pheromone traps, but are able to provide additional information about sex ratios, fecundity, and female size (an indicator of population health).

Recent results from both pheromone and light trapping in Maine are shown in Figure 8. Although SBW populations have increased in recent years, the levels are still relatively low in absolute terms. Population levels are also expected to remain relatively low (and non-damaging) during 2016. At current levels, systematic branch sampling during the spring is unlikely to detect larvae or pupae (i.e., spring larval/pupal surveys would be inefficient and ineffective in predicting population levels). These low population levels also indicate that efforts to monitor mortality factors such as parasitism, disease, and overwintering mortality across northern Maine would be cost prohibitive and ineffective. It may be possible, however, to find individual stands where populations have increased to a level where people working in the woods may encounter late instar SBW larvae and/or pupae.

3. Short-term monitoring

As SBW population levels continue to build over the next several years, it will be vital to begin intensifying monitoring efforts. Intensified monitoring will be important for:

- Engaging the public in monitoring efforts
- Identifying high population centers for possible management intervention by forest landowners
- Providing researchers with input data for predictive models of SBW population development and forest damage

Recommendations for short-term monitoring:

- *Engaging the public in SBW monitoring by educating them and encouraging their direct participation in monitoring efforts by:*
    - *Producing "what-to-look-for" brochures/posters showing both insects and tree defoliation damage*
    - *Encouraging local media (TV, newspapers) to produce news stories describing the SBW and showing how the public can participate in monitoring SBW activity*
    - *Provide an easy online, mail, and phone reporting system that the public can use to report SBW insects and defoliation damage*
- *Increasing the number of pheromone traps in host forest types across northern Maine to increase precision of SBW population estimates, provide township-level data, and identify specific locations with high population densities.*
    - *Local areas with high SBW populations should be identified and resurveyed in subsequent years to monitor population trends.*
    - *A subset of the pheromone traps need to be visited periodically (daily/weekly) across the potential moth flight period to track seasonal population flux (indicating local vs. in-flight moths.)*
    - *Pheromone traps and supplies need to be acquired so that 400–500 site samples can be made.*
    - *MFS and forest landowners need to develop a collaborative monitoring agreement for pheromone trap deployment:*
        - *MFS personnel will have primary role in coordinating and training for monitoring efforts, as well as deploy 10–15% of traps.*
        - *Forest landowners will use their stand maps and local knowledge to identify candidate host stands for trapping locations, and will deploy 85–90% of traps under supervision and verification by MFS.*
- *Continuing current light trapping system across northern Maine.*
- *Conducting targeted aerial surveys (plane-based observers) across northern Maine.*
- *Investigating new remote-sensing technologies for improved monitoring (e.g., FHTET: Disturbance tracker / Eastern Forest Environmental Threat Assessment Center: ForeWarn, etc.).*
- *Sharing and comparing monitoring data and predictions with neighboring jurisdictions (US and Canadian) to improve internal and partner analyses.*
- *Sharing monitoring results and predictions with*

Maine forest stakeholders and general public.
- *Identifying substantive unresolved questions and additional needs, and explore possible survey augmentations to address identified gaps.*
- *Conducting egg mass or L-2 larval surveys in areas where pheromone trapping and/or defoliation surveys indicate a high probability of significant population intensification or in areas where land managers request such information to better determine the need for insecticide applications.*
- *Assisting with regional Population Flux monitoring (in-flights vs. local moths) based on current and ongoing regional discussions, possibly including:*
  - *Augmenting operational pheromone trapping to provide a distributed subset of traps that are monitored daily/weekly (i.e., flux monitoring sites)*
  - *Providing data to CFS, USFS, and university researchers*
  - *Maintaining a light trapping network where recovered insects are forwarded to CFS and other researchers to:*
    - *Determine sex ratios*
    - *Determine "remaining fecundity" in females (by dry-weight/wing-area measurements)*
    - *Determine lipid content (indicator of distance traveled)*
    - *Determine frequency of phoretic mites and Nosema fumiferanae (a disease)*
    - *Perform genomic analyses*

4. Longer-term monitoring

Longer-term objectives and timing for the monitoring program will depend on how the outbreak develops. Results from the short-term monitoring efforts, as well as monitoring results from Quebec and New Brunswick during the coming few years, will be vital for developing longer-term monitoring strategies, improving management decisions by landowners, supporting public communication efforts, and contributing to ongoing research projects. Recommendations for developing monitoring strategies beyond 2017 are:

a. Baseline monitoring
- *Summarizing and analyzing reports from previous public monitoring efforts to determine whether any changes are needed in approach to improve the quality and utility of data being collected.*
- *Assessing strengths and weaknesses of ongoing pheromone trapping efforts and making adjustments as needed, especially with regard to partnership agreements, trapping density and locations, and overall data quality:*
  - *If pheromone trapping results suggest intensifying "hot spots":*
    - *Conduct limited egg mass or L-2 sampling around hot spots during current fall/winter season to define population levels*
    - *Locally intensify pheromone trapping following year*
    - *If population increase substantiated based on egg mass and/or L-2 sampling, conduct:*
      Localized spring larval surveys
      Parasitism/disease sampling
      Targeted foliar damage surveys
  - *If no major up-welling (i.e., relatively low/non-damaging conditions) has occurred, repeat sampling procedures with any improvements identified from review process*
- *Assessing strengths and weaknesses of ongoing light trapping efforts and make adjustments as needed.*
- *Reviewing need for spatially explicit monitoring with forest landowners based on trapping results.*
- *Conducting targeted aerial surveys using MFS plane-based observers across northern Maine to quantify and map the health and vigor of spruce-fir stands, both commercial timberlands and reserved forest lands, to provide an overview of current year damage (and trends on managed and unmanaged forests), allowing landowner/managers to develop response plans for coming year.*
- *Developing SBW-specific damage/condition codes that can be appended to FIA measurements conducted by MFS crews.*
- *Testing and implementing new remote sensing methods for quantifying damage to spruce-fir stands.*

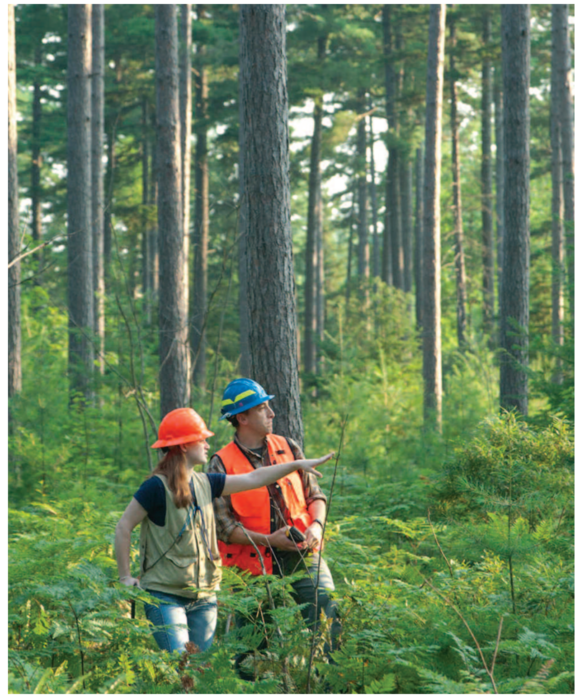
b. Monitoring for possible management intervention
- *Reviewing landowner progress in adapting harvesting efforts to reduce the availability of high-risk stands and identifying high-risk stands that landowners wish to protect using insecticide applications.*
- *Using baseline monitoring results to increase pheromone sampling in specific locations as*

needed to facilitate landowner decisions regarding adaptive harvesting and protection.

- *Where baseline monitoring indicates that SBW populations have increased to a level where L-3 or older larval populations are detectable, encouraging landowners to conduct ad hoc stand-level larval and damage surveys (under the guidance of MFS) to reprioritize harvest plans using their own staff or outside contractors.*
- *Where baseline monitoring indicates that SBW populations have increased to a level where protection using aerial insecticide treatments is needed and where readapting harvest plans is not possible, supporting landowner efforts if they elect to intensify egg mass and/or L-2 surveys on their lands using their own staff or outside contractors.*

c. Monitoring for population predictions and research

- *Maintaining an active role in developing and supporting regional SBW research and technology development by:*
  - *MFS, MFPC, and CFRU maintaining close communications with USFS and CFS research efforts on SBW, especially the latest research results on monitoring needs for early intervention strategies being tested in New Brunswick and elsewhere,*
  - *CFRU working closely with landowners on monitoring efforts by developing research proposals and communicating latest SBW research findings with landowners, and*
  - *MFS seeking ways to improve analyses and reporting of SBW monitoring data to support landowner decision making, public communications, and research efforts.*



B. Forest Management Strategies

1. Background

Words of wisdom from those who researched the effects of forest management on the 1970s–80s SBW outbreak in Maine, include:

> *"Know how both the insect and the forest will respond to management, play the long-term and short-term hand that's dealt with both the axe and pesticide with thought and skill, and trust that the natural forest ecosystem is our friend."* (Mott 1979)

> *"Silviculture may not 'budworm-proof' the forest, but it can make the forest both easier and less expensive to protect, and more worth protecting."* (Irland et al. 1988)

> *"The time to manage SBW damage is between outbreaks, not during an outbreak."* (Seymour 2009)

Although experience from previous outbreaks shows that forest management strategies are not a panacea to protecting the forest from a SBW outbreak, developing proactive forest management strategies to reduce the area of high-risk stands before the outbreak begins is important to mitigating damage from SBW (see Wood Supply Impacts section of this report).

2. Categorizing stand risk

Depending on the size of the forest ownership, it is important to clearly identify stands at high risk and rank them for spraying and/or intervention (management) based on their value. As time and financial resources are generally the most limiting factors, it is critical to know where to most effectively prioritize activities. Therefore, statewide SBW risk categorization of stands as determined by species composition, productivity, age, value, access, and location is vital. The following ranking of forest conditions based on SBW risk and financial value should be considered when reviewing landscape vulnerability:

- **Level 1:** Intensively managed stands that have been precommercially and/or commercially thinned with high balsam-fir composition, or spruce plantations that are free-to-grow.

  These stands are clearly a high priority due to previous financial investments to increase their productivity and value. Stands that are currently merchantable should be considered for pre-salvage harvesting, while unmerchantable stands should be scheduled for insecticide spraying.

- **Level 2:** Stands with overstory comprised of predominately balsam fir and white spruce (50% of trees >60 years old). Norway spruce and red spruce, though less vulnerable, should also be closely scrutinized. Black spruce is regarded as SBW tolerant (it may undergo some defoliation associated with high survival rates).

  This stand condition is exacerbated by the presence of older (>12-foot tall) advanced regeneration. Feeding larvae will become photo-negative and "drop" down into the understory when new foliage of the year is depleted before larvae reach maturity and pupate. This event can be undesirable when there is a preponderance (>50%) of balsam fir regeneration. However, it can also produce a desirable purge of fir when there is a desirable stocking level of spruce, pine, etc. in the understory. This may be the explanation for the high spruce content age class that followed the 1910s outbreak and the balsam fir that originated in the understory following spruce harvests in the preceding decades that were purged and developed to produce abundant spruce conditions from the 1950s to 1970s. When advanced regeneration is shorter in height, the protective predation by mice will tend to reduce fir purging—even though mice will readily climb they tend to stay close to the ground (mouse populations also become abundant in the outbreak dynamic). The loss of understory balsam fir can be undesirable when trees are close to merchantability ingrowth and when there is inadequate stocking of desirable alternative species. Serious consideration should be given to forest stands that are within 10 years of merchantability. In merchantable stands, pre-salvage is an advisable option, particularly where there is older advanced regeneration present. The presence of the overstory can draw adult moths during egg laying, thus producing feeding larvae the following year allowing them to 'drop' down into the understory. The absence of overstory may, in fact, help mitigate the presence of feeding larvae, thus sparing the understory.

- **Level 3:** Natural stands with overstory comprised of mature balsam fir, red and white spruce, and >50% hardwoods or non-host conifers (including cedar and white pine).

  These mixedwood stands tend to be less vulnerable to growth loss, top damage, and tree mortality because the non-host species "absorb" larvae during dispersal periods of L-1 and L-2 stage budworms. In addition, mixedwood stands have been shown to contain more diverse communities of SBW parasitoids (Cappuccino et al. 1998; Su et al. 1996; MacKinnon and MacLean 2004; Quayle et al. 2003), resulting in lower SBW damage to spruce and fir. As with Level 2, Level 3 stands are exacerbated when older (>15 feet) advanced regeneration is present. This understory situation is less likely to occur in mixedwood stands.

- **Level 4:** Natural stands with overstory of 30–50% balsam fir and white spruce with a strong component of red and/or black spruce.

  Level 4 stands are a lower priority relative to Levels 1 and 2, but may warrant consideration if the understory composition is primarily balsam fir (>50% balsam fir of height >15 feet).

- **Level 5:** Natural stands with relatively small amounts (<30%) of balsam fir and white spruce that are free-to-grow and have no overstory.

  A range of pre-outbreak and outbreak management approaches may be desirable in Level 5 stands depending on stand age and species composition. Early shelterwood or narrow-strip mechanical thinning with small timber and biomass production may be desirable pre-outbreak in conifer stands that are near merchantable age. These treatments can establish precocious regeneration, accelerated development in economic value in the overstory, and future coniferous retention on the site. In younger stands the balance of investments in precommercial thinning, growth response, and value of composition modifications against costs of protection will present a wide range of management options where optimal solutions need to be found. Similarly, a wide range of decision options will be available in stands that have low initial composition conifers. Stands at this level include a very wide range of conditions.

- **Level 6:** Natural hardwood stands with little to no balsam fir or white spruce in the overstory or understory.

  These stands are considered to be at low risk from SBW and are therefore among the lowest priorities for monitoring or intervention.

This list of SBW risk levels is meant only as a general guideline for assessing overall stand risk. A wide array of other stand conditions exist and can be evaluated relative to these general conditions.

In addition to identifying where early adaptive harvest actions can take place, these stand rankings will help determine where investments in monitoring and foliage spraying should take place. For example, Level 1 to 3 stands should be most intensively monitored using pheromone trap arrays in the general vicinity. Similarly, if L-2 surveys are a part of the monitoring program, then higher intensity surveys should focus on these stands. Stands from Levels 4 to 6 would be lower priority areas for harvest entries, monitoring, and spraying.

There are other forest conditions that should be taken into consideration. For example, past outbreaks have indicated a positive correlation with moth flights along rivers and deposition zones close to the coast. It is thought the microclimatic effect (e.g., cooler including sea breezes in summer flight periods) also play a role (Bouchard 2014). In addition, riparian corridors are frequently associated with greater abundance of mature balsam fir and white spruce.

3. Recommendations

The following forest management strategies are recommended for forest landowners to prepare for the coming SBW outbreak in order to assure a healthy forest and consistent wood supply:

- *Map the location, condition, and concentration of high-risk stands on your forestlands. Identifying stands in the aforementioned Level 1 to 4 conditions should be highest priority. These maps can be used for risk analysis to determine where reduced growth and tree mortality are most likely to occur.*
- *Shift harvesting now and in the coming years toward merchantable higher-risk stands (Levels 1 to 4) based on their rank order (i.e., Level 1 first and Level 4 last) and avoid harvesting in lower-risk stands (Levels 5 to 6). When conducting partial harvesting in higher-risk stands, tree selection should focus on removing all mature or overmature balsam fir and white spruce, and leaving higher-quality hardwoods and non-host softwoods (white pine, cedar, tamarack) and black spruce and red spruce.*
- *Stop precommercial and commercial thinning within 3 years of the outbreak in stands where balsam fir and white spruce make up more than 50% of the composition, or where red spruce will be greater than 50% of the post-thinned stand. [Berthiaume (2014) indicated that balsam fir resistance to the SBW is reduced shortly after thinning due to a reduction in monoterpene defense chemicals produced by the foliage. Within 3 to 6 years after thinning, however, thinning increases resistance of fir to SBW due to increased amounts of foliage.]*
- *Prepare action plans to salvage (or pre-salvage) trees that will likely be lost through SBW mortality. This planning includes assessing wood volume and tree sizes, road access, and ground conditions to develop seasonally relevant harvest plans. Analysis of market availability and harvesting capacity should be made to ensure that plans are feasible.*

- *Seek and encourage markets for low-value trees from pre-salvage and salvage operations.*
- *Prepare a decision tree and use it to identify areas that should be foliage protected using preferred insecticides. Understanding which areas are likely to be essential for future harvest needs and ensuring that they are located in areas that can be efficiently treated will be vital. Work with pesticide applicators to ensure that contracts can be put into place to execute a spray program at the appropriate time. Prepare for spray operations by identifying accessible aircraft landing sites.*
- *Conduct foliage protection programs for (1) pre-merchantable stands that are in high-risk categories (Levels 1 to 3); (2) merchantable stands that cannot be harvested in the short-term; and (3) other high-value stands such as seed orchards and permanent research plots, using preferred insecticides as soon as is warranted based on monitoring program information.*
- *Track annual progress of the infestation by monitoring SBW population levels and distribution. Coordinate all SBW monitoring efforts with MFS and other organizations so that sampling and reporting can be done efficiently.*
- *Regularly communicating with government agencies and other landowners to understand how the infestation is moving and to develop plans to minimize the impact. As the outbreak progresses, it will likely vary in impact across the region over time. Understanding how the outbreak is moving will allow for tactical plans to change as part of an adaptive management process.*

It is imperative that the forest management strategies discussed here be implemented as soon as possible before the outbreak begins, because mitigating stand damage by adapting short-term harvest plans will be much more difficult when the outbreak is in full force. Delays in implementing these forest management measures also may force greater reliance on more expensive aerial insecticide treatments later when response options are greatly reduced. As harvest practices shift to mitigate stand losses, it will be important to regularly calculate and adjust future sustainable harvest levels for softwoods and for the forest ownership as a whole.

C. Protection Options

Although the forest management strategies offered here can substantially mitigate the effects of the coming SBW outbreak, and are consistent with state policy to minimize reliance on pesticides (MRSA 22 §1471-X.), those efforts alone will not adequately protect high-value stands from defoliation when SBW populations reach high levels. Foliage protection using aerially applied insecticides is available in these circumstances for direct protection of high-risk and high-value stands.

Much was learned about the effectiveness of insecticide applications during the 1970s–80s SBW outbreak. Irland et al. (1988) summarized Maine's experience with insecticide spraying during the last outbreak:

> *"there is abundant evidence that in specific local situations, aggressive spraying treatments did in fact lead to considerable differences in forest condition over time and to differences in ultimate survival and tree vigor. … [T]here is no clear evidence that the spray program prolonged the outbreak as has often been considered a possibility. If spraying had any such effect, it could only have been a modest one, since the outbreak ran its course across the state in about the time period normally cited, or perhaps just a bit longer."*

Therefore, forest landowners with high-risk and high-value stands, especially stands that have received thinning and contain high proportions of balsam fir and white spruce, may want to consider aerial insecticide applications at some point during the coming outbreak.

Fortunately, there have been substantial technological advances in SBW insecticides in the 40 years since the last outbreak. For example, during most of the last outbreak the options were limited to organophosphate and carbamate chemical insecticides (e.g., Fenitrothion, Mexacarbate, Carbaryl, Trichlorofon, Acephate). Today, new insecticides (e.g., B.t.K. and tebufenozide) are available that have lower toxicity and affect a narrower range of non-target organisms, and are therefore more targeted in their environmental effects. In addition, application technology has improved substantially. During the 1970s outbreak, only large aircraft were generally available to treat very large areas. Today, very precise and accurate satellite navigation systems on smaller aircraft are available for the more targeted and smaller-scale applications that are needed for applying insecticides and for the early intervention strategies now being tested by Canadian researchers (see Early Intervention Strategy section of this report). For those situations where landowners are considering aerial insecticide treatments, the MBPC provides guidance for application of pesticides in forest settings on their website: maine.gov/dacf/php/pesticides/index.shtml.

1. Insecticides

Twelve insecticide products with three registered active ingredients (B.t.K., tebufenozide, and carbaryl) with labels specifying aerial application over naturally regenerated forests for control of SBW are registered for use in Maine by the MBPC (Table 5). Additional active ingredients (such as azadirachtin, chlorpyrifos, chromobacterium, dimethoate, flubendiamide, esfenvalerate, cyhalothrin, malathion, methoxyfenozide, naled, and spinosad) are also registered in Maine for control of SBW by ground application only or for use only over plantations, Christmas trees, tree nurseries, and seed orchards. A list of insecticide products registered for SBW control in these circumstances is available from the MBPC.

Based on successful use in Maine during the last outbreak (e.g., ~80% of 1985 spray program) and the continued research, development, widespread use, efficacy, and general public acceptance over the past 30 years, it is anticipated that B.t.K., applied as Biobit, Dipel, or Foray insecticide products, will likely be the preferred choice for foliage protection by many forest landowners. B.t.K. is a naturally occurring bacterium that is found in soil, foliage, wildlife, water, and air across most of the world (USDA 2012a). The B.t.K. insecticide products

Table 5 - Insecticide active ingredients (in italics) and products (in capital letters below each active ingredient) registered for controlling SBW in naturally regenerated forests using aerial application in Maine in 2014. (Source: Gary Fish, MBPC, personal communication)

Bacillus thuringiensis Subsp. Kurstaki (B.t.K.), Strain ABTS-351
- BIOBIT HP BIOLOGICAL INSECTICIDE WETTABLE POWDER
- BIOBIT XL BIOLOGICAL INSECTICIDE
- DIPEL DF BIOLOGICAL INSECTICIDE
- DIPEL ES BIOLOGICAL INSECTICIDE EMUSIFIABLE SUSPENSION
- DIPEL PRO DF BIO INSECT DF
- FORAY 48B BIOLOGICAL INSECTICIDE FLOWABLE CONCENTRATE
- FORAY 48F BIOLOGICAL INSECTICIDE FLOWABLE CONCENTRATE
- FORAY 76B FLOWABLE CONCENTRATE
- FORAY XG BIOLOGICAL INSECTICIDE FLOWABLE CONCENTRATE

Tebufenozide
- CONFIRM 2F INSECTICIDE

Carbaryl
- CARBARYL 4L INSECTICIDE
- NOVASOURCE SEVIN 4F

contain naturally occurring protein crystals and dormant spores of the bacterium that become insecticidal when eaten by a susceptible species of insect. Insects in the order Lepidoptera, which includes the SBW as well as other moths and butterflies, are susceptible to B.t.K. As a result, susceptible species also include the endangered Karner blue butterfly, some swallowtail butterflies, and promethea moths (see Wildlife Habitat section of this report). Because of its specific biological activity under typical conditions of use in the forest, B.t.K. presents little risk to non-Lepidoptera insects or other wildlife species, and its short half-life on foliage (~4 hours) in sun-lit conditions reduces threat to non-target Lepidoptera. A thorough risk assessment of B.t.K. was recently completed as part of the USDA's 2012 Final Supplemental Environmental Impact Statement process for the Gypsy Moth Management Program (USDA 2012a).

Another insecticide option likely to be favored by landowners for controlling the SBW is tebufenozide, which would be applied as the Confirm insecticide product. Tebufenozide is an insect growth regulator generally used to control Lepidoptera pests in fruit, vegetable, and other agricultural crops. Tebufenozide mimics the action of the ecdysone molting hormone resulting in the unsuccessful molting of Lepidoptera larvae within a few hours of ingestion. Although Lepidoptera larvae are particularly susceptible, tebufenozide is a molting disruptor that is potentially active against a wide range of arthropods. However, it was aerially applied without incident to thousands of acres of sensitive coastal areas in Maine during the state's 1992–2002 efforts to control browntail moth. Active monitoring conducted by the Maine Department of Marine Resources and the Maine Lobstermen's Association at the time detected no impacts on populations of marine organisms. Tebufenozide also has been successfully used for control of gypsy moth in Ohio, Pennsylvania, and West Virginia. Scientific evidence indicates that tebufenozide presents very low risk to humans, wildlife, and non-Lepidopteran insects under normal conditions of use (rates and timing). Details about the risks of tebufenozide can be found in the recent 2012 Final Supplemental Environmental Impact Statement for the Gypsy Moth Management Program conducted by the USDA (2012b).

In addition to the successful use of B.t.K. and tebufenozide in Maine, Canadian researchers are focusing their testing of an early intervention strategy for SBW in the Atlantic Provinces using these two insecticides (see Early Intervention Strategy section of this report). Therefore, we anticipate continued focus on the use of B.t.K. and tebufenozide for SBW control during the coming outbreak.

For Maine forestlands certified by the Forest Stewardship Council (FSC), it will be important to confirm whether pesticides being considered for use are acceptable by FSC. Neither B.t.K nor tebufenozide are listed on the 2015 FSC List of "Highly Hazardous" Pesticides (FSC 2015). Tebufenozide was delisted from the FSC HHP list in 2013 (FSC 2013, Table 1, p. 1). Those considering the use of carbaryl insecticide should note that it is currently listed on the FSC 2015 HHP (FSC 2015). Pesticides on the HHP list are prohibited from use on FSC-certified lands unless the FSC Board of Directors grants a temporary derogation. Landowners with FSC-certified lands should refer to the FSC website for details: pesticides.fsc.org.

2. Early intervention strategy

As part of Canada's Economic Action Plan 2014, the Canadian federal and Atlantic provincial governments dedicated $18 million (CDN) to research a new early intervention strategy (EIS) as the SBW crosses the Quebec border into the Atlantic Provinces. Recent research by the CFS has indicated promising preliminary results with an EIS to control SBW (David Maclean, UNB, personal communication). The focus of this new effort is to develop, test, and monitor the effectiveness of an EIS using B.t.K., tebufenozide, and SBW pheromone applications to minimize the coming SBW outbreak in Atlantic Canada. The EIS strategy involves:

- Intensive monitoring and early detection of SBW in forest stands,
- Target-specific insecticide applications to small, infested areas; and
- Using tools and techniques to disrupt SBW mating and migration in those areas to reduce or eliminate SBW development and spread.

This research is being done in close collaboration with forest industry, universities, and government agencies in Atlantic Canada. Key questions that the EIS project will attempt to answer include:

- What are the best early indicators of a SBW infestation?
- When should insecticide treatments be initiated?
- What new tools and technologies need to be developed?

The 4-year EIS research and testing project includes ten specific projects. Therefore, it will be essential for CFRU, MFS, and MFPC to maintain close communications with researchers on the EIS project as it develops and tests effective approaches that show early promise for Maine's forests. Details about the Canadian EIS program can be found on the Healthy Forest Partnership website: healthyforestpartnership.ca.

3. Assumptions under which Maine SBW protection program will be developed

- The latest wood supply model indicates that no more than 20% of the infested area would need to be treated with B.t. insecticide to achieve near maximum benefit if the coming outbreak is as severe as the one in the 1970s (see Wood Supply Impacts section of this report). Therefore, Maine's SBW insecticide treatment program during the coming outbreak will likely be much smaller than the one used during the 1970s–80s outbreak.
- Some forest landowners will choose to apply insecticides to protect high-value stands during the next outbreak.
- In contrast to previous outbreaks, insecticide applications on private forestlands will likely be funded and coordinated primarily by private landowners. Therefore, the financing and coordination of the insecticide program will be substantially different than in the 1970s–80s when state and federal government agencies played a large role in financing and coordinating insecticide applications. The insecticide program during the coming outbreak will likely be delivered and paid for much as aerial herbicide treatments have been financed and coordinated on private lands over the past 30 years. Decisions regarding treatment will be developed by individual landowners/managers after assessing costs and benefits for various management options.
- Insecticide treatment costs will be higher than they were during the last outbreak (e.g., $5/acre in 1970s to current estimates of $25–50/acre).
- Insecticide treatments are not anticipated to occur before 2017 in Maine since no SBW defoliation has been observed yet, with the possible exception of testing EIS treatments at limited locations.
- MFS responsibilities related to insecticide programs will include:
  - Providing technical support for predicting SBW populations, treatment recommendations, assessing treatment efficacy, and testing new protection methods where possible.
  - Seeking external funding support from the USFS and other federal agencies for research and testing of protection options.
  - Reviewing insecticide applications in conjunction with MBPC, including:
    - Chapter 22 pesticide drift rules regulating target delivery of chemicals
    - Chapter 51 forestry aerial application rules dictating public notification procedures
- Maine DEP will be responsible for generating and overseeing MEPDES permits issued under "distributed" EPA–NPDES authorities, including:
  - General permits
  - Individual permits for application over 6,400 acres

4. Recommendations

The following is recommended for developing a large-scale insecticide program for controlling the SBW:

- *Forest landowners should assess and map high-risk and high-value stands on their lands that they may consider protecting with insecticide application during an outbreak (see Forest Management section of this report for classifying stand risk). This assessment should include:*
  - *Crosschecking landowner stand maps with the SBW risk map developed by Legaard et al. (2013; see also Figure 12). A digital GIS version of this map is available from CFRU for landowners who are willing to sign a federal confidentiality agreement.*

- *Developing support from landowners or shareholders for the possible need to protect high-risk and high-value stands that includes the possibility of making insecticide applications on their lands.*
- *Determining the level of technical assistance that landowners want/need from the MFS before, during, and after insecticide applications and communicating those needs to the MFS. Needs that the MFS may not be able to provide should be identified and alternative plans developed to meet these needs.*
- *Ensuring that an effective communications plan is in place for neighboring landowners and nearby municipalities if insecticide applications are planned.*

- *MFS should develop plans for providing technical assistance on SBW management to landowners. This effort should include training key MFS staff who might be involved as soon as possible. Close communications with neighboring Canadian provinces should be part of this planning and training effort to learn from their experiences.*
- *MFS, MFPC, and CFRU should work collaboratively to develop a communications strategy about the SBW, its effects, and the need for insecticide applications for forest protection in some situations. Initial recommendations in this regard are presented in the Communications & Outreach section of this report.*
- *MFS and CFRU should be actively engaged with USFS and Canadian counterparts to ensure that Maine landowners and policy makers have access to the latest information and experience in controlling SBW damage.*
- *Maine forest landowners certified by the FSC should confirm that any insecticides they wish to use are not listed by FSC as "highly hazardous." If so, a temporary derogation from the FSC Board of Directors will be required (see FSC website for details).*

D. Policy, Regulation, & Funding

Successfully preparing for and responding to a SBW outbreak involves a number of governmental policies, rules, and regulations that must be addressed, especially those related to insecticide applications and harvesting practices. Determining how responsibilities for monitoring and protection programs will be divided among state government, federal agencies, and private landowners also present a special challenge. Therefore, it is vital that all relevant policy, regulatory, and funding issues be identified and addressed as early as possible.

The following key issues were identified:

- Maine Spruce Budworm Management Act
- Resource needs for monitoring SBW populations and damage
- Resource and regulatory needs for aerial insecticide program
- Streamlined approval process for adaptive harvesting and salvage cutting

1. Maine Spruce Budworm Management Act

The Maine Spruce Budworm Management Act of 1979 is defined by Maine statute Title 12, Chapter 803, Subchapter 4-A. It states "*that it shall be the policy of the State to undertake a spruce budworm management program to minimize the short-term and long-term impacts of spruce budworm insect infestations upon the state's spruce and fir forests.*" The Act addresses protection of wood supplies, program development, insecticide use, private efforts, implementation, regulatory review, and assistance programs.

During the 1970s outbreak, the MFS assumed control over the entire SBW management program, which was defined as: "*all activities undertaken by the Bureau of Forestry in connection with the short-term and long-term suppression, control and prevention of spruce budworm infestations, including without limitation, any activities undertaken in connections with spray projects, spruce budworm survey and detection activities, silvicultural, marketing and integrated pest management program, research and related activities.*"

Provisions in the Act include a declaration of emergency powers, cost-sharing formulas, and procedures between the state and federal governments and private landowners; including a taxation system for landowner funding. As described earlier, private landowners will likely take the lead in developing a protection program during the next SBW outbreak. The MFS is expected to provide an oversight role in the program, but the operations will not be coordinated by state government as they have in the past.

Therefore, it is important that the Spruce Budworm Management Act be thoroughly reviewed in the light of likely changing roles and responsibilities for coordinating a SBW monitoring and protection program.

Recommendations:

- *Review the Spruce Budworm Management Act to determine whether any changes are needed given likely changes in roles and responsibilities between the state government and private landowners in managing the next SBW outbreak. If changes are required, modifications to the Act should be presented to the State Legislature for review and passage.*
- *Maintain an open dialogue on the SBW among private landowners, state government, and the ENGO community.*
  - *A productive dialogue during the first session of the 127th Legislature in 2015 led to a better understanding of the intent of the changes to the Spruce Budworm Management Act and to recommended revisions to the original LD 870 bill that were unanimously approved by the ACF committee and the entire Legislature.*

  Recommended changes to Public Law, Chapter 314, LD 870, Spruce Budworm Management Act (effective 90 days following adjournment of the 127th Legislature, First Regular Session, unless otherwise indicated) are shown in Appendix A.

2. Resource needs for monitoring SBW populations and damage

Another key component to managing the SBW statewide is having an efficient system in place to monitor annual SBW population levels during the outbreak (see Monitoring Strategies section of this report). The current SBW monitoring program managed by the MFS includes 200 pheromone traps that have been part of their baseline monitoring efforts since the end of the 1970s–80s outbreak (Figure 8).

As the outbreak increases during the coming years, the level of monitoring required is expected to increase to at least 1,500 pheromone traps at 500 survey locations during the peak of the epidemic (i.e., approximately one survey location in every northern Maine township of interest). Depending on the effectiveness of the EIS being tested in New Brunswick (see Protection Options section of this report) and Maine landowner interest in implementing a similar program, the trapping intensity required may be higher in some areas.

The MFS has a legislated mandate through its Division of Forest Health & Monitoring "*to protect the forest, shade and ornamental tree resources of the state from significant insect and disease damage and to provide pest management and damage prevention for homeowners, municipalities, and forest land owners and managers, thereby preserving the overall health of Maine's forest resources.*" Therefore, the MFS will have responsibility for coordinating all SBW monitoring efforts during the outbreak.

It is recognized, however, that state budgets are severely constrained and thus limit the financial and labor resources available from state government to meet increased monitoring needs. As a result, private forest landowners will need to supplement required monitoring activities by providing training and field support within their organizations under the supervision and verification of MFS. Toward that end, private forest landowners began working with MFS during the 2014 field season to provide coverage and volunteer monitoring across northern Maine, and continued this effort throughout 2015.

Recommendations:

- *Verify with experts whether the proposed sampling intensity of 1,500 pheromone traps at 500 survey locations is reasonable and statistically valid.*
- *Determine the personnel, financial, and timing needs to implement the required sampling within the MFS, and how supplemental labor and financial assistance from forest landowners will be provided.*
- *Develop an effective and cost efficient process for mapping and reporting defoliation levels across the affected areas.*
- *Build and expand on MFS training programs and protocols for developing a joint state and private landowner collaborative monitoring program.*
- *Work closely with the Quebec and New Brunswick governments and forest industry to learn from and collaborate with their SBW monitoring programs.*

3. Resource and regulatory needs for aerial insecticide program

From a policy, funding, and delivery perspective, the SBW insecticide program developed for the coming outbreak will be substantially different than the program used during the 1970s–80s outbreak. The most significant changes include:

- The 1979 Maine Spruce Budworm Management Act shifted shared responsibility for aerial insecticide applications among private landowners, state government, and federal authorities, and defined new responsibilities for the operational and financial aspects of participating in a statewide insecticide program.
- Establishment of the MBPC in 1987 as the lead state agency for pesticide oversight. The MBPC is attached to the Maine Department of Agriculture, Conservation and Forestry and a seven-member, public board makes all policy decisions.
- Pesticide drift rules administered by the MBPC now regulate target delivery of pesticides.
- Chapter 51 of the MBPC rules requires public notification of all aerial applications.
- Increased demand that insecticides be applied within an integrated pest management (IPM) program.
- Major shift in capital resources available for land formerly owned by pulp mills, to lands owned largely by timberland investors that are independent of mills, with some that have long-term, wood-supply agreements with paper mills.
- Conversion of primary paper mill furnish from spruce-fir to hardwood species over the past 20 years (see Figure 15 and Figure 16)

The Maine Pesticides Control Act of 1975 requires that all pesticides distributed in the State of Maine be registered with the MBPC. Therefore, the MBPC will play a key regulatory role in forest landowners being able to protect their high-value stands from the SBW.

The preferred insecticides for foliage protection identified in Table 5 of this report must have up-to-date registrations with the MBPC. It will also be important to ensure that the public notification requirements of the MBPC facilitate spray operations so that they can be applied when and where required. With accurate monitoring and planning, sites for treatment should be identified and mapped, and abutting landowners notified in an efficient manner.

Chapter 36 of Maine's Pesticide Regulations under the MBPC defines the certification and licensing provisions for monitors and spotters of major forest insect aerial spray programs. The insecticide spray program during the last SBW outbreak relied on widespread use of monitors and spotters. It is unclear whether the certification and licensing requirements for spray monitors and spotters is up to date given the likely use of site-specific prescriptions using biological materials for targeted insecticide applications. Therefore, it must be determined whether monitors and spotters are needed for these new approaches, and if so, whether the certification and licensing provisions in Chapter 36 needs to be updated. The spotter and monitor provision contained in Sec. 14. 22 MRSA §§1471-S was eliminated (repealed) during the 127th First Legislative session at the request of the Maine Board of Pesticides Control.

In addition, the US Environmental Protection Agency (EPA) has been directed by the federal court to classify the discharge from spray booms as a point source of pollution, thus requiring all insecticide applications to have a discharge permit. A general permit for forest canopy applications of insecticide is in the process of being established with the Maine Department of Environmental Protection (DEP) by the MFPC.

Recommendations:

Given changes in the policy, funding, and delivery of insecticide programs, the following is recommended:

- *Large landowners anticipating the need for insecticide applications should consider exploring options for developing a cooperative organization for coordinating and delivering aerial insecticide applications.*
  - *Organizations like SOPFIM and FPL currently being used in Canada for SBW control can provide a model for building such an organization.*
  - *If developed, SBW population monitoring efforts by the MFS should be closely linked to this cooperative so that insecticide prescriptions are targeted based on SBW population levels, severity of defoliation, and identification of high-value stands needing protection.*
- *MBPC should prepare to provide annually updated lists of (1) registered insecticides approved for control of SBW using aerial application in forest settings and (2) Maine-licensed aerial pesticide applicators.*
- *MFS should work with insecticide manufacturers and MBPC to ensure that products currently registered in Maine (Table 5) are available in sufficient quantities, and that all state and federal regulatory compliance requirements have been met.*
- *MFS and MFPC should work with MBPC to address obsolete requirements of 22MRSA §1471-S (Requirement for spotters and monitors for aerial forest treatment projects). This requirement is outdated with the availability GPS-based navigation systems for aircraft. Interim adjustments could be addressed under MBPC Chap 36 rules. If changes are needed, consider regulatory modifications with the 127th Legislature. Note: Sec. 14.22 MRSA §§1471-S has been repealed.*
- *A MEPDES general permit has been adopted and best management practices (BMPs) developed for forest canopy pesticide treatment. Forest landowners will need to understand the requirements to comply with this permit. In general, no materials should be deposited in water, but using BMP and state rules risk should be minimized. Under this general permit, individual landowners may treat up to 6,000 acres, so instances of treatment beyond this acreage will require an individual permit. Standards are outlined in the permit. The Maine DEP has staff available to assist with permitting.*

4. Streamlined approval process for adaptive harvesting and salvage cutting

As discussed in the Wood Supply Impact section of this report, successfully mitigating damage from the SBW will require that landowners adapt harvest plans in the coming years to reduce the area of high-risk stands where possible. Due to regulations imposed by the 1989 Forest Practices Act since the last SBW outbreak, however, harvesting activity is severely limited on many thousands of acres in regulated separation zones.

Many of these separation zones are currently in high-risk SBW conditions, but forest landowners wishing to adapt their harvest plans to reduce the area in high-risk conditions cannot operate in these stands without violating the FPA. Current clearcut acreage limits under the FPA and resource protection zones also present a significant obstacle to reducing SBW losses on private lands. Therefore, a regulatory approval process will be needed to help landowners reduce SBW losses on their lands without violating the FPA.

Current assumptions about this process are:

- Salvage clearcutting ("reinitiating") will require documented presence of insects at predetermined threatening levels of infestation in identified high-risk stands.
  - Threatening levels of infestation will be determined at the township level using MFS-supervised monitoring data (i.e., townships will be declared by MFS as official high-risk areas).
  - A process for landowners to define high-risk areas and obtain prior approval by the MFS needs to be developed. Mapping data available from UMaine and landowner resources could be used to identify these regions.
- Within the Spruce-Fir Forest Protection District of northern Maine, 10 million acres were recently classified and mapped based on their susceptibility to SBW defoliation by UMaine (Figure 12). Approximately 22% of

this area was classified as being of high- to moderate-risk of SBW loss (Table 1).

- The approval process developed should be scientifically based, simple in design, efficient, and enforceable. Field determinations by MFS will be required in areas where SBW risk is unclear and a system designed where "opportunistic haggling" can be eliminated.

Recommendations:

- *Determine the best regulatory mechanism to establish a standards-based approval process that is scientifically sound and field-efficient. This mechanism can be included as part of either the Forest Practices Act or the Spruce Budworm Management Act. This mechanism also may have application for mitigating damage from other insect threats (e.g., hemlock woolly adelgid, asian long horned beetle, emerald ash borer).*
- *Prepare legislation defining the regulatory process for determining an expedited process for areas categorized as high SBW risk where there is a strong likelihood of increased SBW activity.*
- *Determine financial and labor resources required for MFS to provide forest inventory data of sufficient accuracy to report statewide inventory changes resulting from adaptive harvesting to reduce high-risk SBW stands and salvage harvesting of dead and dying trees.*
- *Ensure that the MFS oversees the SBW program to ensure public accountability and facilitate reporting.*

E. Wildlife Habitat

Because the SBW generally has a substantial impact on forest composition and structure over large areas, provides a food source for birds and other species, and changes harvest patterns of forest landowners, major outbreaks have a substantial influence on wildlife habitat over a long period of time. Four specific aspects of the coming SBW outbreak could affect wildlife and wildlife habitat:

- **Mortality of mature spruce-fir:** As shown in Figure 18, the amount of mature spruce-fir forest habitat will decline during the coming decades. The amount and length of this decline will depend on the severity of the outbreak.

- **Changes in harvest patterns:** As landowners respond to the outbreak by adapting harvests before the outbreak to reduce the area of high-risk stands, as well as salvaging dead and dying trees, there will likely be an increase in the volume per acre removed in many stands and potentially an increase in the average harvest block size. Salvage cutting also may increase the amount of clearcut harvesting over time, thus creating early successional habitat over larger areas.

- **Non-target impacts of insecticides:** A major public concern during the last SBW outbreak was the potential toxicity of widespread chemical insecticide applications to non-target organisms. As described in the Protection Options section of this report, the new insecticides that are likely to be used have lower toxicity and affect a narrower range of non-target organisms. In addition, limited funding and results from the most recent wood supply models indicating little gain from treating more than 20% of infected areas will limit the area of potential exposure and further reduce the impact of insecticides on non-target organisms.

- **Increased forest fire risk:** If large areas of SBW-killed stands remain unharvested over large areas and weather patterns during those years increase fire risk, there is a possibility of more stand-replacing fires occurring as a result of the next outbreak. However, the extensive existing road network combined with MFS and landowner firefighting preparedness will help reduce the risk of catastrophic fires.

From an ecological and wildlife perspective, forest changes resulting from SBW-caused mortality to forest stands and landowner management responses will likely be positive for some wildlife species, negative for others, and neutral for some depending on their habitat requirements. With older aged and denser stands of fir most likely to decline, wildlife species dependent most on these forest communities will decline. In contrast, species favoring earlier successional stages of softwood and mixedwood stands will see increases in habitat availability. As with any large-scale forest disturbance (insects, fire, wind, or timber harvesting), resulting changes to forest structure and composition across a forest landscape will determine wildlife habitat for decades to come.

Understanding the overall wildlife impact of the coming SBW outbreak will depend largely on how species most closely associated with the spruce-fir forest will be influenced. Of special interest are those species or habitats of special conservation value (e.g., species listed as rare/endangered or SGCN) as well as game species of economic and recreational importance. Seven wildlife issues are of most concern:

- Mature softwood songbirds and mammals
- Deer wintering areas (DWAs)
- Riparian habitats and aquatic systems (including coldwater fish habitat)
- Early/mid-successional species of concern (lynx/snowshoe hare/moose)
- Rare species (including northern butterflies)
- High-elevation habitats and bird species
- Old-growth softwood and mixedwood forest

1. Mature softwood songbirds and mammals

a. Assumptions

- The effect of SBW outbreaks on mature spruce-fir songbirds is dependent on the amount of balsam fir in the stand. The higher the fir abundance, the greater the impact on songbirds such as the blackburnian warbler and blackpoll warbler that rely on mature, closed canopies for nesting.
- High densities of SBW larvae and adults are an abundant food source for many spruce-fir canopy feeding birds and some of these species are known to increase their population densities during epidemics.
- SBW control through insecticide spraying, which generally occurs when reproducing forest birds have high energetic demands (i.e., nest and fledging stages), could temporarily reduce the available food supply for bird species that feed on Lepidoptera larvae. The effects would be largely at the stand level.
- Depending on the amount and configuration of adaptive and salvage logging, the impacts will vary for mature spruce-fir dependent bird species.
- The American marten is considered to be an umbrella species for a majority of forest vertebrates in northern Maine. While not restricted to mature softwoods, marten require closed-canopy forests to escape predators.

b. Potential negative effects

- In mature fir-dominated stands where the majority of the stand will be affected, closed canopy dependent species (e.g., blackburnian warbler, purple finch, red crossbill) may decline from loss of nesting habitat if significant defoliation or significant adaptive harvesting of high-risk stands occur.

- If most SBW-damaged stands are salvage logged, species reliant on standing dead trees (snags) such as the American three-toed woodpecker, northern flicker, and olive-sided flycatcher (all SGCN in Maine) will potentially decline from loss of nesting and foraging habitat, or show a neutral response from an increase in snags that are in restricted or inoperable portions of stands.
- Other bird species that may be negatively affected under these two scenarios are pileated woodpecker, brown creeper, sharp-shinned hawk, gray jay, boreal chickadee, and white-winged crossbill.
- Extensive salvage harvesting to remove SBW-killed stands during the coming outbreak could reduce the area of quality American marten habitat.

c. Potential positive effects

- Bay-breasted, Tennessee, and Cape May warblers benefit from SBW as a food source and may increase their populations during outbreaks.
- The increase in snags from dying firs will have a positive influence on cavity nesting mammals, birds, snag foragers, and perch-reliant species. These birds include black-backed and other woodpeckers, brown creeper, northern flicker, and olive-sided flycatchers.
- Unharvested areas that result in stands with high snag densities and dense understories will benefit American marten.
- In stands with lower proportions of balsam fir, a SBW outbreak may create forest patch openings that could positively influence birds such as northern flicker, olive-sided flycatcher, purple finch (all SGCN species), boreal chickadee, gray jay, sharp-shinned hawk, and spruce grouse.
- Bicknell's thrush and rusty blackbird (both SGCN in Maine) and other early/mid-succession species might be positively affected as the damaged stands grow back into dense, young stands they rely on for nesting. Rusty blackbirds also can benefit from the increase in snags for perching.

d. Recommendations

- *Create a mature, managed forest containing a mix of species and size classes, and with scattered openings and patches of regeneration, that will support bird populations that prey effectively on spruce budworm. (Crawford et al. 1983)*
- *Assess landscape-level impacts of SBW outbreak on stands and leave a diversity of habitats across the landscape.*
- *In stands with small amounts of balsam fir, consider salvage plans that maintain or increase the number of snags and future downed wood.*
- *Leave snags in riparian areas and pond buffers.*

2. Deer wintering areas (DWAs)

a. Assumptions

- Mature spruce-fir stands are vital to DWAs. DWAs with a high fir and white spruce composition are at highest risk of substantial loss of canopy cover and reduced fir recruitment. Currently, about 20% of DWAs in northern Maine are at high risk of SBW infestation and mortality (i.e., ≥50% of the forest within the DWA is dominated by high-risk species) and about 30% are at medium risk (i.e., 30–50% of the forest within the DWA is dominated by high-risk species). DWA habitat has been on the decline in the state in recent years.
- As closed-canopy, mature softwood habitats, DWAs likely provide habitat for a variety of other species preferring these conditions, including pine marten and several interior-nesting bird species.
- Active management within DWAs over the last 40 years has created a different forest structure. Forest fragmentation that has resulted from management of areas adjacent to DWAs may mitigate the effect of the next outbreak.
- A focus on harvesting mature balsam fir will likely limit the removal of lower-risk softwood species such as cedar, spruce, and hemlock that will need to be retained to preserve shelter value.
- In general, DWAs refer to areas with a history of deer winter use that contain vegetative characteristics (i.e., softwoods >35 feet in height and >80% crown closure) that allow deer to persist through winters in Maine. Some DWAs are regulated by the Land Use Planning Commission (LUPC) as Protected Fish and Wildlife (PFW) districts. There are several types of DWAs in the area expected to be impacted by SBW. Others are managed under Cooperative Agreements with the Maine

Department of Inland Fisheries and Wildlife (MDIFW), while other areas capable of supporting DWAs are not regulated or managed cooperatively.

b. Potential negative effects

- Decreases in DWA areas are likely to lead to higher winter mortality in deer and potential abandonment of DWAs by deer, as well as impacts on other species associated with mature, softwood-dominated canopies.
- Declines in mature spruce-fir stands will reduce the long-term availability of viable DWAs and management opportunities.
- SBW-killed stands may limit the ability of MDIFW to reach deer density goals established under Maine's Deer Management Plan.

c. Potential positive effects

- Increase in early successional habitats in proximity of DWAs with adaptive harvesting and salvage logging.

d. Recommendations

- *Since DWAs managed under PFW agreements represent only 3% of the landscape in unorganized townships, adaptive harvesting to reduce high-risk SBW areas should avoid DWAs where possible. Salvage operations within DWAs should focus on high-risk species (i.e., balsam fir and white spruce).*
- *Maintain viable, mature softwood cover within and adjacent to active DWAs where possible.*
- *Strengthen forest landowner and MDIFW communications and combine expertise to address stand- and landscape-level management of DWAs during the outbreak.*
- *Explore funding or other options for insecticide spraying to protect high-risk/high-value DWAs.*
- *Incorporate SBW impacts on long-term management of DWAs into MDIFW Deer Species Assessment and management goals.*

3. Riparian habitats and aquatic systems (including coldwater fish habitat)

a. Assumptions

- Although riparian ecosystems comprise a small proportion of the forest landscape, they host some of the greatest species richness. For example, riparian and aquatic habitats are used by over 90% of the northeastern region's vertebrate species and provide preferred habitat for over 40% of these species (DeGraaf et al. 1992).
- Coldwater fish species of concern in these habitats include: Atlantic and landlocked salmon, eastern brook trout, lake trout, arctic char, lake whitefish, round whitefish, and rainbow smelt.
- Potential stream and riparian zone wildlife conservation concerns in northern and eastern Maine include: spring salamander, wood turtle, roaring brook mayfly, Tomah mayfly, brook floater, yellow lampmussel, tidewater mucket, boreal snaketail and pygmy clubtail dragonflies, and several state rare caddisflies and stoneflies.
- The Furbish's lousewort, a federally listed plant of the St. John River, is associated with moist riverbanks afforded shade by spruce, fir, and cedar.
- Highly valued coldwater fish habitats include: State Heritage Fish Waters, Atlantic Salmon Critical Habitat, and waters that support recreational sport fisheries and their associated economies.
- Spraying with insecticides specific to Lepidoptera and during the time frame for targeting SBW will likely have little effect on aquatic systems.
- Beaver activity will likely increase in areas regenerating from SBW effects or salvage harvest operations.

b. Potential negative effects

- Drainages with high proportions (>65%) of spruce-fir that are influenced by SBW damage and/or subsequent salvage harvesting will likely experience changes in local shading and hydrology. High rates of tree loss may result in higher rates of precipitation runoff into streams, which can contribute to increased sedimentation and flash flows that may adversely affect substrate habitat and stream channel integrity. The widespread implementation of BMPs for all timber harvesting have helped substantially in reducing sedimentation in streams and will help mitigate these effects with SBW salvage harvesting.
- SBW mortality in spruce-fir stands, accelerated harvesting of high-risk spruce-fir stands, and resulting salvage harvesting of dead and dying stands will reduce mature conifer forest habitat

in forested riparian ecosystems which often serve as de facto refuges for late-successional species that prefer structural characteristics associated with mature forests. These characteristics include high crown height and closure (e.g., DWAs), abundant standing and downed deadwood (e.g., cavity-nesters, shrews, and salamanders), diverse tree species and diameter classes (e.g., bark and foliage gleaning passerines, and lichens), and well-developed pit and mound topography and windthrow (e.g., herbs, small mammals, winter wren, and other root mass nesters).
- Increased woody material inputs into streams will likely exacerbate road maintenance issues associated with undersized or poorly constructed road/stream crossings downstream from SBW affected or salvage harvested areas. Long-term recruitment of woody material inputs may be compromised in drainages with a high proportion (>65%) of spruce-fir within the riparian zone.
- Local reduction of coldwater fish species may occur in drainages with >65% loss of tree cover due to negative effects on the thermal regime (Hudy et al. 2008). This effect is primarily due to increased water temperatures that result from forest cover losses over large areas. As forests regenerate, this negative effect declines, and fish and aquatic organisms will likely recolonize the areas as temperatures moderate, assuming fish passages are not constrained at downstream crossings.

c. Potential positive effects
- Coldwater fish habitat conditions will likely improve over time in areas in riparian zones where increased addition of large, woody material occurs due to SBW mortality. Additions of woody debris to streams provide cover for fish and other aquatic organisms. In addition, large woody material assists with in-stream pool formation and retention as well as sediment sorting and aggradation, and contributes to overall in-stream habitat diversity.
- Increased wood decomposition in riparian and terrestrial habitats may increase soil and water nutrient loads. Hence, nutrient inputs into headwaters and other aquatic habitats may improve over time.
- Increased deadwood due to SBW (snags and coarse woody debris) in riparian zones can also provide excellent structural and foraging habitat for many wildlife species, including cavity-nesting waterfowl, woodpeckers, salamanders, and many beneficial forest invertebrates.

d. Recommendations
- *Carefully assess the benefits and risks when prescribing insecticide treatments in watersheds with high-value aquatic ecosystems.*
- *Encourage protection of high-risk SBW stands using B.t.K. or other appropriate insecticide applications in watersheds that are critical for coldwater fish species and to mitigate increased water temperatures resulting from heavy tree loss within the watershed.*
- *Maintain current riparian management standards in SBW-killed areas.*

4. Early/mid-successional species of concern (lynx/snowshoe hare/moose)

a. Assumptions
- Insecticide spraying for SBW will have little or no direct impact on lynx, snowshoe hare, or moose.
- Snowshoe hare need cover from predators, which is best provided by regenerating young softwoods (15 to 40 years old).
- The interface between mature timber and regenerating softwood stands may facilitate the ability of Canada lynx to hunt snowshoe hares.

b. Potential negative effects
- Severe reductions in spruce-fir stands regenerated since the 1970s–80s SBW outbreak (stands <40 years old) from the coming SBW outbreak are likely to reduce current lynx habitat.
- Light to moderate SBW infestations that do not cause widespread tree mortality in young, thrifty spruce-fir stands are likely to have less impact on lynx and marten habitat.

c. Potential positive effects
- If forest landowners focus silvicultural efforts on naturally regenerating dense softwood stands (primarily using herbicides for conifer release) following salvage logging of severely damaged spruce-fire stands, as they did

following the 1970s–80s SBW outbreak, such efforts will benefit hare, lynx, and other species that prey on hare (Simons-Legaard et al. 2013).
- The increased area of early successional habitat likely to follow the coming SBW outbreak will increase available moose browse.

d. Recommendation
- *Encourage forest landowners to naturally or artificially regenerate high-density softwood stands following clearcut salvage logging on severely damaged spruce-fir stands where possible.*

5. Rare species (including northern butterflies)

a. Assumptions
- Several rare butterfly species have habitats in northern Maine within the spruce-fir forest type. The Maine Endangered Species Act protects some of these species legislatively, and all are of state or regional conservation concern.
- None of Maine's rare Lepidoptera (butterflies or moths) is known to use balsam fir or spruce trees as larval host plants as the SBW does.
- Specific Lepidoptera of conservation concern in northern and eastern Maine include:
  - Purple lesser fritillary (Threatened)
  - Northern blue (Special Concern)
  - Crowberry blue (Special Concern)
  - Figga fritillary (Proposed Threatened)
  - Katahdin arctic (Endangered)
  - Short-tailed swallowtail (Proposed Special Concern)
  - Clayton's copper (Endangered)
  - Satyr comma (SGCN)
  - Bog elfin (SGCN)
- A number of other SGCN and rare plants are associated with northern softwood habitats or aquatic systems embedded within them.

b. Potential negative effects
- The B.t.K. insecticide is designed to minimize damage to non-target invertebrates, but can be lethal to the larval stage of many Lepidoptera. Accounting for normal variations in spring phenology, all of the rare butterfly species in northern and eastern Maine could be in vulnerable caterpillar life stages in late May or June—the period when B.t.K. is most likely to be applied.
- SBW damage and mitigation efforts in habitats supporting SGCN, rare plants, or natural communities can have negative impacts and should be considered during all forest management planning.

c. Potential positive effects
- No known positive effects of control of SBW via insecticide treatments or salvage harvesting are anticipated for Maine's rare Lepidoptera.

d. Recommendations
- *Maps showing rare butterfly habitat, SGCN locations, and rare natural communities from MDIFW and MNAP should be consulted prior to any spray or harvest operations.*
- *Consult with MDIFW regarding a potential Incidental Take Permit under Maine's Endangered Species Act when aerial insecticide applications are anticipated in areas where any state-listed butterflies are known to occur.*
- *Use caution to ensure that appropriate spray buffer distances are used when SBW insecticides are used near populations of rare northern butterfly populations. A one-quarter mile buffer is listed on the pesticide label in some cases.*

6. High-elevation habitats and bird species

a. Assumptions
- A large number of songbird species use spruce-fir forests at high elevations. There is overlap between these species and those that utilize spruce-fir habitats at lower elevations. The bird species of greatest concern is Bicknell's thrush, a globally vulnerable species being considered for federal endangered status.
- Some high-elevation forests (generally above 3,000 ft) are known as 'Fir-Heartleaf Birch Sub-alpine Forests' and ranked as 'S3' by the MNAP.
- High-elevation areas were largely overlooked during the SBW spray program of the 1970s–80s due to their inaccessibility for harvesting and low financial value.
- A significant portion of high-elevation forest is statutorily off-limits to management because of its conservation status (e.g., Baxter State Park and lands along the Appalachian Trail).

b. Potential negative effects
- Short-term loss of dense sub-alpine spruce-fir

stands damaged by SBW will have a negative effect on Bicknell's thrush. However, replacement by early succession communities may mitigate this negative effect over time.
- Although a significant amount of Maine's high-elevation spruce-fir forest has been conserved, some adaptive harvesting to reduce high-risk SBW stands in some areas could reduce the amount and configuration of mature stands.

c. Potential positive effects
- SBW-killed trees that remain standing as snags will provide cavities for the boreal chickadee, black-capped chickadee, and red-breasted nuthatch. Dead and decaying wood may increase insect populations for snag foragers (e.g., woodpeckers).

d. Recommendations
- *Assess landscape-level impacts of SBW outbreak on stands to help ensure that a diversity of habitats is maintained across the landscape.*
- *When reducing high-risk SBW areas or salvage logging in mature higher-elevation spruce-fir stands, maintain or increase the number of snags and downed wood where feasible, especially in riparian areas and pond buffers.*

7. Old-growth softwood and mixedwood forest

a. Assumptions
- SBW is a native pest species that has been documented to affect spruce-fir and mixedwood forests in Maine for centuries.
- Old-growth (OG, typically undisturbed or little disturbed sites) and late-successional (LS, older than economic maturity) forests have exceptional conservation value for forest biodiversity in Maine. They have unique structural attributes (e.g., density of large trees and large logs and volumes of coarse woody debris) and harbor hundreds of species that require LS and OG forest in order to maintain viable populations (Whitman and Hagan 2007). These are species that are much less common in managed forests and many are declining in or have been extirpated from managed forests (Hinds and Hinds 2007). OG areas harbor rare saprozylic and other old-growth specialist insects that might experience significant mortality or extirpation if these areas are sprayed for SBW. Widespread salvage harvesting of LS stands will increase the risk of extirpation to LS species. OG spruce-fir sites in Maine have an average of 22% basal area in fir (A. Whitman, unpublished data). Fir exceeds 50% of basal area on 13% of OG sites (A. Whitman, unpublished data).
- OG sites may be valuable reference sites to help determine how the ecology of managed and unmanaged sites may differ due to harvest treatments. These reference sites may help some landowners certified by FSC and SFI meet some of their certification requirements.

b. Potential negative effects
- Insecticide spraying of OG spruce-fir and mixedwood stands can reduce non-target Lepidoptera that are OG specialists.
- SBW damage and associated mitigation efforts of OG sites can diminish their ecological value and significantly reduce OG-obligate insect, moss, lichen, and liverwort species. Further, if these areas are being maintained as Type 1 or Type 2 OG under FSC Standard or as reference areas under FSC Standard, harvesting could become a certification issue.

c. Potential positive effects
- SBW-killed trees that remain standing as snags and create downed deadwood and temporally provide more late-successional habitats for saproxylic species in the short-term. However, once this pulse of new deadwood ages, this value will diminish significantly in managed areas.

d. Recommendation
- *Consider the role and effects of insecticide use and/or salvage harvesting on the values in conserved OG and LS stands.*

F. Public Communications & Outreach

A vital part to responding successfully to the coming SBW outbreak will include effective public communications, especially regarding the progress of the outbreak, damage caused to the forest and wildlife, economic impacts, what actions are being taken to mitigate and respond to the damage, and how the forest is recovering. Many of the negative political and policy consequences in the aftermath of the 1970s–80s SBW outbreak (see Background section of this report) could have been reduced or perhaps avoided with better public communications and dialogue. So, it will be important to learn from that history during the coming outbreak.

Therefore, the goals and objectives for public communications during the next outbreak should include:

- Identifying key communications issues associated with SBW outbreak and response.
- Building a communications infrastructure for the entire SBW effort by:
  - Keeping stakeholders updated before, during, and after the infestation.
  - Developing a proactive public and legislative communications strategy for all issues related to the outbreak.
  - Measuring communications progress against expectations.
- Building stakeholder understanding of SBW by:
  - Preparing the public for what is coming and what to expect over the next two or three decades.
  - Building trust among stakeholders and with the public so that everyone understands the situation and what the plan is for responding.
  - Building an effective coalition, consensus, and support for a SBW response strategy.
  - Getting ahead of any negative reactors with effective messages.
  - Preventing people from being surprised.
  - Encouraging those debating the various approaches to responding to the outbreak to keep an open mind.

The first step toward accomplishing these goals and objectives began in November 2014 with the rollout of a draft of this report intended for public review and comment. A six-month review period was provided to solicit public feedback to the draft, and this final report is the result. Presentations about the SBW were made to a number of public groups during this period, including the Joint Standing Committee on Agriculture, Conservation and Forestry; Maine Chamber of Commerce; Keeping Maine's Forests (KMF); Sportsman's Alliance of Maine (SAM); Professional Logging Contractors of Maine (PLC); Cooperative Forestry Research Unit (CFRU) members; and others. Verbal and written feedback was provided by these groups and included by the respective task teams into the finalized report where appropriate. To help the public better understand the potential impacts of the SBW on Maine's forests, a 14-minute video was produced using archived materials from the 1970s–80s outbreak as well as interviews from forest managers who witnessed the outbreak.

As the SBW outbreak unfolds during the coming years, the following are general recommendations for communications and outreach as well as more specific recommendations for various stakeholders.

1. Recommendations

- *The MFS, MFPC, and University of Maine should work together to develop and implement a comprehensive SBW communications strategy for the Maine public that will be implemented before, during, and after the outbreak.*
- *A Maine SBW website should be developed to provide a focal point for all information and communications about the outbreak.*

- *Specific communications programs should be designed for:*
  - *General public*
  - *Family forest owners*
  - *Schools*
  - *Environmental NGOs*
  - *Government*
  - *Forest industry*
  - *Recreation and tourism groups*

The following summarizes the background, framing, messages, outreach methods, and timing that should be considered when developing these communication strategies.

2. General public

a. Background

The primary method of informing the general public about the SBW will be through public media. Public "media" is a much broader and less exclusive term than it was during the last SBW outbreak. As newspapers have contracted (the smallest number of newsroom personnel since 1978) and TV stations have become more feature-oriented, there are far fewer professional journalists and far less in-depth reporting. In their place, countless blogs, websites, and community news outlets are intensely interested in everything local. Communications objectives with the media need to respond to these evolving outlets.

b. Framing

The coming SBW outbreak will be a feature story for public media because:

- It will affect most forest areas across the northern and Downeast portions of the state.
- Forests will be visibly damaged and wildlife habitat could change dramatically.
- It will have a statewide economic impact on the forest products industry.
- Recreation and tourism industries will be affected.
- Accelerated harvesting of high-risk stands and salvage logging involving clearcutting will be visually apparent and politically contentious.
- There will likely be controversy over insecticide spraying.
- There will likely be public debate over who pays for protecting the forest.
- People may find large moth flights and larvae undesirable.
- Laws may need to be changed for forest landowners to respond to the SBW.
- State agency funding and personnel might be re-allocated or increased.

c. Messaging

Initial messages should largely be informational about the history, biology, and spread of the SBW and how it can severely damage forest stands in Maine as it has in neighboring Canadian provinces. Messaging about how the SBW is a native species and occurs in natural cycles that have been affecting Maine's forests for centuries should be emphasized. Detailed stories about new biological insecticides, aerial applications of insecticides to protect valuable stands of trees, impacts on the forest products industry and local communities, and how forest landowners are responding should be developed. Personal interest stories can be generated by focusing on the impacts on family forest owners along with those of larger landowners.

d. Outreach methods

Methods of reporting will vary by type of publication, but initial steps should include assembling a list of publications and individuals who might have an interest in SBW in Maine, in nearby states, and with national publications/websites/organizations. Target outlets should be:

- TV stations
- Radio stations
- Print media, including daily and weekly newspapers, magazines, research publications, industry publications, and specialty (such as fish and wildlife) publications.
- Websites/blogs
- Facebook, Twitter, and Instagram
- ENGOs, business groups, and political organization newsletters

These outlets should be asked to disseminate accurate, fair, interesting, and timely information. The state, forest industry, and the university should assist the media by providing experts, local contacts, events, stories, photos, videos, fact sheets, websites, and maps related to the SBW.

e. Timing & timelines

Phase I (Before SBW arrives) – Alert as many media outlets as possible that the SBW is coming, how harmful it might be, and what will need to be done to mitigate damage based on details presented in this report. Compile photo and video databanks, fact sheets, and scientific articles, and set up and continuously update websites. Make direct contact with reporters, and provide photos and videos showing the current state of SBW-damaged stands in Canada and SBW-related events occurring in Maine (e.g., insect trapping). Find local stories of past SBW outbreaks and impacts through Maine Historical Society, universities, and other sources.

Phase II (SBW is here) – Same approach as Phase I, and offering stories on local dead and dying forests as the result of SBW, protection measures, wildlife impacts (see Wildlife Habitat Issue section of this report), and salvage harvesting of dead and dying stands by landowners. Organize field tours for reporters to SBW-damaged stands in Maine with appropriate experts. During this phase and depending on the severity of the outbreak, it may be desirable to have an official university or state government spokesperson designated for media events.

Phase III (SBW outbreak is over) – Focus stories on long-term changes in the forest and on wildlife habitat that were caused by the SBW. Emphasis should be placed on management actions being taken to recover from the damage and address changes to the forest. Details during this stage will depend on how severe the outbreak was.

3. Family forest owners

a. Background

About 88,000 individuals and families own 25% (or 4.5 million acres) of the private forestland in Maine (Butler et al., 2010). Although most of these family forests are located in the southern part of the state and not in areas most likely to be influenced by the SBW, it will still be important to keep family forest owners informed about the SBW and how it may affect them. This group is important because wood harvested from their lands represents about a quarter of the wood harvested in the state, and therefore has a large economic impact in Maine. In addition, family forest owners are often the opinion leaders about forestry issues in their communities and exert considerable influence on public opinion. Communication strategies developed for family forest owners need to be tailored for senior citizens, as 21% of all Maine family forest owners are 75 or older, and an additional 18% are between the ages of 65 and 74 (Butler et al. 2010).

b. Framing

The coming SBW outbreak will be important to family forest owners, especially those in the northern and Downeast areas of the state because:

- It will defoliate and kill balsam fir and spruce trees on their property.
- They may need or want to harvest dead and dying trees on their property.
- It may reduce the aesthetic value of their woodlands.
- It may reduce the price they receive on softwoods harvested from their property.
- It may increase the fire hazard on their lands in a severe outbreak.
- Even if their woodlands are not directly affected, they will most likely see the effects of the SBW in scenic changes, less recreational opportunities, changing statewide demand for forest products, and potential legislation that may adversely affect management of their forestland.

c. Messaging

Messaging should seek to make sure as many family forest owners as possible are aware of the SBW so that they are not surprised by its impact. Initial messages should largely be informational about the history, biology, and spread of the SBW and how it can severely damage forest stands in Maine and has been in neighboring Canadian provinces. That the SBW is a native species and occurs in natural cycles that have been affecting Maine's forests for centuries should be emphasized. Most importantly, messaging should emphasize the role of family forests in the economy and character of Maine, and how the SBW can affect their property and surrounding forestlands. It also will be important to underscore how southern Maine businesses are connected to the forestry economy.

Stories about how family forest owners can deal with dead and dying fir and spruce on their lands will likely be of greatest interest. Informing them of trusted information resources on the SBW (e.g., MFS, UMaine, SWOAM) will be important. Drawing similarities between the SBW and invasive pests (e.g., hemlock woolly adelgid, emerald ash borer) eating trees on their land may make the SBW more understandable to family forest owners in southern Maine.

d. Outreach methods

Considerable research has been done on how to best reach and inform family forest owners (Majumdar et al. 2008). Any outreach methods should take full advantage of this knowledge. For example, experts have identified four types of family forest owners based on their attitudes: woodland retreat owners, working landowners, supplemental income owners, and ready-to-sell owners. Each of these landowner types presents a unique challenge for natural resource educators and agencies charged with outreach and education. Using this knowledge, effective outreach efforts tend to offer recommendations that meet the specific needs of each type of landowner.

It also should be recognized that effectively reaching and educating family forestland owners is a difficult task. There is no single answer for communicating and influencing all family forest owners. Therefore, educational programs on the SBW must be developed in a way that is tailored to the specific characteristics, needs, and desires of each family forest owner type.

A targeted outreach approach that includes traditional methods of paid and earned media (e.g., news stories, press releases, newspapers articles, guest columns, public meetings, landowner group meetings and events, etc.) is recommended. These efforts also should include social media methods (including Facebook, Twitter, Pinterest, YouTube, blogs, search, and other outlets). Peer-to-peer landowner gatherings and approaches also have proven effective.

It will be vital to link family forest owner outreach efforts with trusted information sources, such as MFS, UMaine, SWOAM, UMaine Cooperative Extension, as well as other groups who are currently reaching audiences about forest-related issues. These trusted sources should develop and maintain web pages on the SBW outbreak that is targeted to family forest owners. Engaging landowners directly in the SBW outbreak, such as reporting the location of dead and dying trees, putting SBW traps on their property, posting SBW-related photos on social media, and writing stories for local newspapers or weekly newsletters could be effective tools. A contact list of knowledgeable foresters and wildlife biologists who are willing to speak to groups wanting to know more about the SBW outbreak should be made widely available.

e. Timing & timelines

Phase I (Before SBW arrives) – The MFS, UMaine, SWOAM, and UMaine Cooperative Extension should use their current communications network with family forest owners to inform them about the coming SBW outbreak. Information about the history and impact of previous outbreaks, as well as where the current outbreak is relative to their lands, should be a priority. Identifying the forest management options that small woodland owners have to mitigate SBW damage will be vital. Compiling photo and video databanks, fact sheets, and scientific articles suitable for family forest owners should be a priority. These materials should be used to establish web pages on the SBW tailored to small woodland owners.

Phase II (SBW is here) – Same approach as Phase I, with a focus on workshops and field tours featuring how family forest owners can mitigate damage to their spruce-fir forests. Articles and presentations on potential wildlife impacts (see Wildlife Habitat section of this report) will likely be of interest to many family forest owners. During this phase and depending on the severity of the outbreak, it may be desirable to have an official university or state government spokesperson designated for family forest owner questions and field calls.

Phase III (SBW outbreak is over) – Emphasis during this phase will be on how to best assist family forest owners in managing and/or replacing severely or moderately damaged stands. Details during this stage will depend on how severe the outbreak was.

4. Schools

a. Background

A communications program for schools needs to focus on informing teachers. Teacher education on forestry issues in Maine has been very effective over the past two decades through workshops and field tours sponsored by Maine TREE and Project Learning Tree. More than 1,100 educators have learned about key forestry issues over the past 17 years on Maine TREE's Forests of Maine Teachers' Tours. Armed with this information, teachers engage their students about important forestry topics in school and share information they have learned on the tours with colleagues and others in the community.

b. Framing

The coming SBW outbreak will be important to teachers and students in northern and Downeast portions of the state because:

- The SBW will affect the appearance of forests around schools and local communities.
- The SBW will affect most areas across the northern half of the state.
- The SBW is a native species and occurs in natural cycles that have been affecting Maine's forests for centuries.
- Schools and local forest owners may need or want to harvest dead and dying trees on their property.
- Harvesting of high-risk stands and salvage logging involving clearcutting may be visually apparent and politically contentious.
- There will likely be controversy over insecticide spraying.
- The forest-based economies of rural communities are likely to be affected.
- The SBW may impact family members employed in the forest industry.
- Recreation and tourism industries likely will be affected.
- Forests will be visibly damaged and wildlife habitat could change dramatically.
- People may find large moth flights and larvae undesirable.

c. Messaging

Messaging to teachers and students should focus on understanding that the SBW is a natural part of Maine's northern forests. The SBW can be compared to other natural forces like fire and wind that also can do substantial damage to the forest. Lessons about the SBW provide an opportunity for teachers to increase appreciation and understanding by their students about the forest being a dynamic system, its role in the economy of Maine, and how people work together to face big challenges. There also is an opportunity to provide lessons about the biology and history of the SBW. Messaging also can emphasize that forests recover from damage over time, and that forest management has a role in helping reduce the negative impact of SBW outbreaks on rural communities. Making teachers and students aware that there are good information resources on the SBW (e.g., MFS, UMaine) will be important.

It will be imperative to tell the SBW story using clear, simple, non-technical language for this audience. Communicating messages using photographs, drawings, and videos about the outbreak will be central to reaching this audience. It also will be important to address more controversial issues, such as foliage protection using insecticides and the use of clearcutting to remove dead and dying trees, openly and honestly.

d. Outreach methods

Fortunately, Maine has had a vigorous outreach effort to teachers through Maine TREE and Project Learning Tree for many years. Continuing these efforts will be vital during the outbreak to keep teachers informed about the issue and what is being done. Introducing the SBW as a major topic during summer tours and workshops for teachers should occur as quickly as possible. Another focus should be connecting teachers with researchers, biologists, ecologists, and economists who can provide background and reference materials for classroom use.

Lesson plans about the SBW suitable for elementary, middle, and high school levels should be developed to help teachers introduce the topic. Associated web pages with downloadable materials to support these lesson plans should be developed, along with brochures and fact sheets. Opportunities to use social media (e.g., Facebook, Twitter, YouTube, etc.) also should be used where appropriate.

e. Timing & timelines

Phase I (Before SBW arrives) – In 2014, Maine TREE began incorporating information about the coming SBW outbreak into its summer teachers' tours. The next step is to develop lesson plans, web pages, field tours, and workshops for teachers that introduce the SBW as an insect, show the progress of the current outbreak in Canada and Maine, discuss the history and impacts of previous outbreaks, and clarify how Maine is preparing to respond.

Phase II (SBW is here) – Once the outbreak has occurred, teachers should be provided web materials and lesson plans that track the outbreak in Maine using real-time maps and describe the impacts on trees, forests, and the economy. Describing the impacts of the SBW on wildlife habitat also will be important. Efforts that landowners and the state are making to respond to the SBW should be highlighted. Clearly addressing controversial subjects like insecticide spraying and salvage logging will be key during this phase. Ongoing research on the SBW that UMaine and federal researchers are conducting should be highlighted.

Phase III (SBW outbreak is over) – Teaching and web materials during this phase should focus on long-term changes in the forest and on wildlife habitat that resulted from the SBW. Describing the role that forest management actions had during the outbreak and could have on future outbreaks will be important. Providing a historical context for the SBW in Maine over the past centuries will connect recent events with the distant past for students.

5. Environmental NGOs

a. Background

Many of the forestry controversies, resulting forestry regulations, and voter referenda over the past two decades were related in some form to landowners responses to the 1970s–80s SBW outbreak. Therefore, it will be vital to maintain open communications and a productive dialogue about how Maine responds to the next outbreak with Maine's ENGOs. Every effort should be made for participatory collaboration to ensure mutual understanding about how forest landowners and the MFS are responding to damage caused by the SBW. Private landowners and state government also need to understand key issues of concern by interested ENGOs. Although challenging for those involved, there is an opportunity through our preparation and response to the coming SBW outbreak to forge mutual understanding and collaborations on a major environmental event facing the state.

b. Framing

In communicating effectively with ENGOs, it will be vital to identify issues of key ecological and environmental impact associated with the SBW. These issues include:

- The SBW will damage spruce-fir forests across the northern half of the state.
- The SBW is a native species and occurs in natural cycles that have been affecting Maine's forests for centuries should be emphasized.
- Accelerated harvesting of high-risk stands and salvage logging involving clearcutting will be visually apparent when used.
- The outcome of the SBW will be to produce younger forests and more early successional habitat.
- The SBW will negatively affect some mature softwood songbirds, deer wintering areas, riparian zones and coldwater fish habitat, and high-elevation habitats and bird species.
- Forest harvesting and foliage protection with insecticides can mitigate damage to key wildlife habitats in some cases.
- Insecticide spraying for the SBW will be substantially different during the coming outbreak than the 1970s–80s outbreak.
- The focus of protection efforts during the next outbreak will involve newer biological insecticides with targeted smaller-scale applications.
- A new early intervention strategy, based on research in Canada, may be employed in some areas.
- Laws may need to be changed for forest landowners to respond effectively to the SBW.

c. Messaging

As ENGOs are frequently well informed about issues that they address, messaging strategies will be less important than the methods and forums of collaboration and dialogue on key issues related to the SBW. Finding productive forums and organizations to identify, discuss, and debate various aspects of landowner and state responses to the SBW will be key to helping reduce controversy.

d. Outreach methods

The Keeping Maine's Forests (KMF) organization has served as an effective place where forest landowners and ENGOs can discuss issues of mutual concerns. Therefore, KMF can provide a valuable forum to foster the needed information exchange about Maine's response to the SBW. It also may be desirable for KMF to develop a SBW strategy that identifies key issues that must be addressed and how best to work together to develop a common approach.

In addition to KMF, ENGO and forest landowner representatives should be invited to present their views at each other's meetings and workshops where appropriate. Joint articles about the SBW can be published in ENGO and forest industry publications. Joint field tours of SBW-damaged areas and response strategies also could be productive.

e. Timing & timelines

Phase I (Before SBW arrives) – Recognize that the coming SBW outbreak will be a major damaging event in Maine's forests, and that landowner and state responses to mitigate the damage may generate controversy. Identify key issues likely to be of concern and open a dialogue between ENGOs and forest landowners where possible. Also identify issues of common concern, such as wildlife habitat impacts (see Wildlife Habitat section of this report) and mitigation strategies where significant common ground can be identified. KMF may provide a key start in this regard.

Phase II (SBW is here) – When the outbreak is underway, regular communications among forest landowners, the state, and ENGOs will be vital. Field tours and workshops to see SBW damage and mitigation measures will be important to promoting this exchange. Openly discussing subjects like insecticide spraying and salvage harvesting methods will be key during this phase. Ongoing research on the SBW that UMaine and federal researchers are conducting should be used to inform discussions.

Phase III (SBW outbreak is over) – Clear communications about how the aftermath forest is managed to mitigate damage and grow new forests will be crucial. Discussing the pros and cons about forest management actions taken during the outbreak will also be important. Identifying communication and collaboration strategies that worked and those that did not will help build trust and understanding for handling other forest resources issues.

6. Government

a. Background

Many of the forestry regulations and voter referenda over the past two decades followed from landowner responses to the 1970s–80s SBW outbreak. Therefore, state executive and legislative branches of government, as well as county and municipal governments in the areas affected by the SBW, need to understand the natural history of the SBW, key issues of concern regarding the forest and forest economy, and impacts to their constituents and to visitors to our state. Government officials should be aware of work being done on the assessment, preparation, and responses to SBW being conducted by MFS, UMaine, MFPC, and others in the forestry community. Since the impact will likely last decades, newly elected officials will need to be informed and updated on the SBW as they come into office.

b. Framing

In communicating effectively with state and local governments, issues of key environmental and economic concern associated with SBW need to be identified. These issues include:

- Constituents that will be affected.
- SBW will damage spruce-fir forests across the northern half of the state.
- Accelerated harvesting of high-risk stands and salvage logging involving clearcutting will be visually apparent when used.
- Laws may need to be changed for forest landowners to respond effectively to SBW.
- The economy will be affected, including forest management, forest products manufacturing, and forest-based recreation and tourism.
- The SBW will result in younger forests and more early successional wildlife habitat.

- The SBW will negatively affect some mature softwood songbirds, DWAs, riparian zones and coldwater fish habitat, and high-elevation habitats and bird species.
- Forest harvesting and foliage protection with insecticides can mitigate damage to key wildlife habitats in some cases.
- Insecticide spraying for SBW control will be substantially different during the coming outbreak than during the 1970s–80s outbreak.
- Protection efforts during the next outbreak will involve newer biological insecticides with targeted smaller-scale applications.
- A new early intervention strategy, based on research in Canada, may be employed in some areas.

c. Messaging

Initial messages should largely be informational about the history, biology, and spread of the SBW as well as how it can severely damage forest stands in Maine as it has in neighboring Canadian provinces. Messaging about how the SBW is a native species and occurs in natural cycles that have been affecting Maine's forests for centuries should be emphasized. More detailed stories about new biological insecticides, aerial applications of insecticides to protect valuable stands of trees, impacts on the forest products industry and local communities, and how forest landowners are responding should be developed. See the Policy, Regulation, & Funding section of this report for a discussion of currently identified issues.

d. Outreach methods

All legislators and officials of counties and municipalities in the affected areas should receive this report and it should be made available through mailings, pamphlets, newsletters, woods tours, one-on-one and group meetings, presentations, testimony, as well as the MFS and UMaine websites. A contact list of knowledgeable foresters and wildlife biologists who are willing to speak to groups wanting to know more about the SBW outbreak should be made widely available on a website.

e. Timing & timelines

Phase I (Before SBW arrives) – Recognize that the coming SBW outbreak will be a major damaging event in Maine's forests, and that landowner and state responses to mitigate the damage may generate controversy. Making officials aware of past history, the coming outbreak, probable economic impacts, and potential responses will be key.

Phase II (SBW is here) – When the outbreak is underway, regular communications among forest landowners and the state will be vital. Field tours and workshops to view SBW damage and mitigation measures will be important to promoting this exchange. Discussing subjects such as insecticide spraying and salvage harvesting methods will be key during this phase. Ongoing research on the SBW that UMaine and federal researchers are conducting should be used to inform discussions.

Phase III (SBW outbreak is over) – Clear communications about how the aftermath forest is managed to mitigate damage and grow new forests will be vital. Discussing the pros and cons about forest management actions taken during the outbreak also will be important. Identifying communication and collaboration strategies that worked and those that did not will help build trust and understanding for handling other forest resources issues.

7. Forest industry

a. Background

The last SBW outbreak had a tremendous impact on Maine's forest industry. It not only damaged the spruce-fir forest, but affected wood markets, jobs, mills, and overall manufacturing capacity for several decades. The outbreak also had a profound effect on forest policy and public opinion about forest management in Maine. Many of today's policies governing forest practices in Maine resulted from the industry responses to the 1970s–80s outbreak. There are now few forest managers left who were directly involved in the last outbreak. As a result, current forest managers will not have much institutional memory to draw upon as the outbreak develops. Therefore, educational opportunities and strong communications among forestry professionals will be important for current forest managers to quickly develop the knowledge needed to effectively respond.

b. Framing

In communicating effectively with the forest industry, it will be critical to identify specific issues of key importance associated with the outbreak. These issues include:

- The budworm is coming. Adaptive harvesting to reduce high-risk stands, salvage logging of dead and dying stands, and insecticide programs will be different than was done during the last outbreak.
- The outbreak will present new challenges and opportunities for companies to expand manufacturing capacities.
- Additional wood supplies generated by increased harvesting of spruce and fir will have substitution effects on markets and suppliers throughout the state.
- Markets will be needed for smaller dimension fir and spruce that may need to be harvested to mitigate losses.
- Limitation in logging capacity could result in movement of loggers and machines to SBW-affected areas, resulting in higher competition for logging services in locations not directly affected by the SBW.

c. Messaging

The forest industry is working collaboratively with the MFS, CFRU, and MFPC through this process to provide information about the impacts and best recommendations for how to mitigate the impacts (including monitoring, treatments, harvesting approaches, markets, etc.). Based on experiences from the last outbreak, the forest industry is thinking and working more holistically to communicate transparently with the Maine public and elected leaders to produce the best possible outcome. Information on how our Canadian neighbors are affected and react to the SBW will provide valuable insights into how Maine can best respond. Although much of the information provided will be technical in nature, it will be important to communicate concepts to the public using plain, non-technical language.

d. Outreach methods

- Association network communications (MFPC, CLP, FRA, SWOAM, MPPA, SIC, PLC), newsletters, websites, training sessions, regional publications (Northern Woodlands, Northern Logger).
- Agency networks, including logger and forester listserves, websites.
- University networks, such as CFRU, forums, and web resources (such as NEFIS).
- Tours and training sessions.

e. Timing & timelines

Phase I (Before SBW arrives) – This report was written and compiled by the CFRU, MFS, and MFPC to serve as the foundation for SBW communications during this phase. Updates on coordinated SBW monitoring efforts and trap counts in Maine, as well as defoliation information from Quebec and NB will be vital.

Phase II (SBW is here) – Updates on SBW population level at specific locations, defoliation rates, adaptive harvesting efforts, salvage logging, market changes, insecticide treatment efforts, results from EIS research, related policy updates, and information exchanges about successful strategies to mitigate damage will be key.

Phase III (SBW outbreak is over) – Emphasis during this phase will be on adaptive strategies for replacing severely or moderately damaged stands. Details during this stage will depend on severity of the outbreak.

8. Recreation and tourism groups

a. Background

Recreationists and tourists are users of Maine's forestlands that will likely be affected in areas with severe SBW outbreaks. Individuals and organized groups that hunt, fish, ride snowmobiles and ATVs, hike, ski, bicycle, canoe, kayak, powerboat, watch wildlife, tent and RV camp, hold camp leases, and others may have their activities limited or affected in some way during the outbreak.

b. Framing

The coming SBW outbreak will be important to recreationists and tourists in northern and Downeast portions of the state because:

- The recreation and tourism industry will be affected.
- The SBW will affect the appearance of the spruce-fir forest.
- The SBW will affect most areas across the northern half of the state.

- Forest owners may need or want to harvest dead and dying trees on their property.
- Harvesting of high-risk stands and salvage logging involving clearcutting may be visually apparent and politically contentious.
- There will likely be controversy over insecticide spraying.
- Forests will be visibly damaged and wildlife habitat could change dramatically.
- People may find large moth flights and larvae undesirable.
- Access to sites traditionally used may be affected by the outbreak.

c. Messaging

Initial messages should largely be informational about the history, biology, and spread of the SBW and how it can severely damage forest stands in Maine as it has in neighboring Canadian provinces. Messaging about how the SBW is a native species and occurs in natural cycles that have been affecting Maine's forests for centuries should be emphasized. More detailed stories about new biological insecticides, aerial application of insecticides to protect valuable stands of trees, application technology and how the recreating public will be protected during these applications, impact on the forest products and recreation industry, and how forest landowners are responding can be developed as well. Information about where the effects of the outbreak are visible, effects on wildlife species of interest, where large moth flights are occurring, and other impacts should be communicated frequently.

d. Outreach methods

A targeted outreach approach that includes traditional methods of paid and earned media such as news stories, press releases, newspaper articles, and guest columns along with public meetings is recommended. These efforts also should include social media methods (including Facebook, Twitter, Pinterest, YouTube, blogs, search, and other outlets).

Working closely with sportsmen and guide organizations such as SAM, Maine Professional Guides Association, Maine Tourism Association, and Maine Office of Tourism will be crucial. Presentations on the SBW to these groups through their meetings and events, as well as through stories in their newsletters and on their websites will be the most effective outreach methods. Work with the Maine Department of Inland Fisheries and Wildlife regarding wildlife issues described in this report, as well as with sportsmen through MDIFW registration and licensing resources. MFS, MFPC, and UMaine websites will also play a key role. A contact list of knowledgeable foresters and wildlife biologists who are willing to speak to groups wanting to know more about the SBW outbreak should be made widely available to recreation and tourist groups.

e. Timing & timelines

Phase I (Before SBW arrives) – Recognize that the coming SBW outbreak will be a major damaging event in Maine's forests, and that landowner and state responses to mitigate the damage may generate controversy. Identify key issues likely to be of concern and open a dialogue between sportsmen and tourism groups and forest landowners. Identify issues of common concern, such as wildlife habitat impacts (see Wildlife Habitat section of this report) and mitigation strategies where significant common ground can be identified.

Phase II (SBW is here) – When the outbreak is underway, regular communications among forest landowners, state government, and sportsmen and tourism groups will be crucial. Open discussion on subjects such as the effect of tree defoliation on aesthetics, insecticide spraying, and salvage harvesting will be important during this phase. Ongoing UMaine, USFS, and Canadian research on SBW should be used to inform discussions.

Phase III (SBW outbreak is over) – Clear communications about how the aftermath forest is being managed to mitigate damage and grow new forests will be vital. Discussing the pros and cons about forest management actions taken during the outbreak will be important. Identifying communication and collaboration strategies that worked and those that did not will help build trust and understanding for handling other forest resources issues.

G. Research Priorities

As the next SBW outbreak approaches, there is an opportunity to draw from and build on scientific research that has occurred since the last outbreak. Indeed, most of the information and recommendations presented in this report have been drawn from the substantial amount of research that has been done on the SBW over the past 40 years. The threat of the next outbreak underlies the urgent need and opportunity for new research by US and Canadian researchers in the region to increase our understanding about SBW biology, monitoring, control, and management. Short- and mid-term research will be needed early in the outbreak to help forest managers better respond during this outbreak. The coming outbreak also provides the opportunity for longer-term research that will help primarily in informing those managing the next SBW outbreak, which is likely to occur around 2055.

The following list of research questions for improving SBW monitoring, protection, forest management responses, and wildlife habitat management over the short- (S), mid- (M), and long-term (L) were generated from the task teams that prepared this report, as well as from researchers who have been working on the SBW in the US and Canada.

1. Monitoring

- Can existing remote sensing technologies be used to improve mapping of high-risk stands? (S)
- Can existing remote sensing technologies be used for rapid early detection of tree defoliation and/or mortality before it occurs? (S)
- What are the best designs, tools, and techniques for SBW detection and monitoring surveys when implementing an early intervention strategy? (S)
- What is the critical threshold below which SBW populations can be held in natural check, what mechanisms can maintain them at low levels, and how does the critical threshold vary with moth behavior and environmental conditions? (S)
- How often do we need to monitor high-risk stands to effectively assess when to implement a protection treatment? (S-M)
- Are there specific defoliation rating systems/protocols in place for describing feeding damage in managed stands? (S)
- How can we most effectively monitor SBW population locations, levels, and duration for inputs into the SBW Decision Support System? (S-M)
- What is the variability in SBW survival and reproduction in their area of dispersal? (S-M)
- What local environmental factors are responsible for initiating SBW outbreaks? (M)
- How do SBW infestations change in space and time in Maine forests? (L)

2. Protection

- What economic criteria should landowners use in deciding whether to protect or not protect stands that are vulnerable to the SBW? (S)
- What are the economic trade-offs for landowners who decide to protect and not protect stands in various SBW risk categories? (S)
- Can some form of crop insurance be developed for forest landowners to reduce their individual risk and fund statewide SBW monitoring and protection actions? (S)
- What are the most effective options for protecting high-risk and high-value stands? (S-M)
- How well do new aerial application technologies deliver insecticide products to the local targets? (S)
- Is an early intervention strategy using intensive pheromone trap sampling followed by rapid insecticide application to local high SBW population centers capable of reducing stand defoliation and/or preventing further spread? (S-M)

- Can aerially applied SBW pheromone disrupt mating, reproduction, spread, and stand damage by SBW? (S-M)
- Are there new insecticide or biocontrol options (e.g., baculoviruses, narrow spectrum insecticides, and fungicides) effective at controlling SBW populations? (M)

3. Forest management

- How have harvesting practices since implementation of the Maine Forest Practices Act affected the vulnerability of stands to SBW? (S)
- How will natural regeneration of high-risk species be affected by SBW population levels, stand composition, and previous patterns of harvest? (S-M)
- Does previous thinning (precommercial and commercial) of high-risk stands make them more or less vulnerable to damage by SBW, and if so, how long should thinning be terminated before the beginning of an outbreak? (M)
- In previously thinned (precommercial and commercial) stands, what is the effect of species composition, density, age, time since treatment, stress, etc. on SBW feeding and stand growth? (S-M)
- Do silvicultural activities modify the development/habits/survival of SBW larvae at the local level? (S-M)
- What is the best approach for wood supply impact monitoring and management response planning during the outbreak? (M)
- What impact does protecting or not protecting high-risk stands have on the need for treating neighboring stands or ownerships? (M-L)
- Are there silvicultural treatments that can be used before an outbreak to substantially reduce future vulnerability of stands to SBW? (M-L)
- Are uniform plantations more or less susceptible than PCT/CT natural stands? (M-L)
- How well do managed (sprayed and/or salvaged) late-successional stands maintain biodiversity compared to unmanaged late-successional and old-growth stands? (M-L)
- To what extent will the protection and adaptive harvest strategies used in the current outbreak influence subsequent SBW outbreaks? (L)
- How might climate change affect future SBW outbreak occurrence, severity, and spread, as well as the impact on forest stands? (L)

4. Wildlife habitat

- What proportion of state DWAs are at risk from the coming SBW outbreak and where are they located? (S)
- What is the most effective strategy for protecting local high-risk and high-value DWAs, and what are the constraints and limitations? (M)
- What are BMPs for determining the presence of and avoiding non-target Lepidoptera species in areas to be treated with insecticides? (M)
- How will late-successional and old-growth stands be affected by SBW? (M)
- Can B.t.K. and tebufenozide insecticides be applied in a manner to control SBW while protecting rare northern butterfly habitat? (M-L)
- What effect do various levels of SBW outbreak severity have on the temperatures, water quality, and nutrient inputs in streams with riparian zones that have high proportions of high-risk tree species? (M-L)
- What effect will SBW damage to sub-alpine spruce-fir stands have on Bicknell's thrush and other high-elevation bird species? (M-L)
- How well do managed (sprayed and/or salvaged) late-successional stands maintain biodiversity relative to unmanaged late-successional and old-growth stands? (L)

V. References

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VI. Glossary of Abbreviations

The following abbreviations were used in this report:

ATV = All Terrain Vehicle
BMP = Best Management Practice
BPL = Maine Bureau of Parks and Lands
B.t. = *Bacillus thuringiensis*
B.t.K. = *Bacillus thuringiensis* Subsp. Kurstaki
CFRU = Cooperative Forestry Research Unit, University of Maine
CFS = Canadian Forest Service
CLP = Certified Logging Professional
DEP = Maine Department of Environmental Protection
DWA = Deer Wintering Area
E/T = Endangered and Threatened
EIS = Early Intervention Strategy
ENGO = Environmental Non-Governmental Organization
EPA = Environmental Protection Agency of the United States
FHTET = Forest Health Technology Enterprise Team
FIA = US Forest Service Forest Inventory and Analysis program
FPL = Forest Protection Limited
FSC = Forest Stewardship Council
FRA = Forest Resources Association
FVS = Forest Vegetation Simulator
GIS = Geographic Information System
GPS = Geographic Positioning System
HPP = FSC Highly-Hazardous Pesticide List
IPM = Integrated Pest Management
KMF = Keeping Maine's Forests
L-1 = First instar larval stage
L-2 = Second instar larval stage
L-3 = Third instar larval stage
LANDIS = Landscape Disturbance and Succession model
LiDAR = Light Detection and Ranging
LS = Late successional
LUPC = Land Use Planning Commission
MBF = Million Board Feet
MBPC = Maine Board of Pesticides Control
MDIFW = Maine Department of Inland Fisheries and Wildlife
MEPDES = Maine Pollutant Discharge Elimination System
MFFP QC = Ministère des Forêts, de la Faune et des Parcs for Quebec
MFPC = Maine Forest Products Council
MFS = Maine Forest Service
MNAP = Maine Natural Areas Program
MPPA = Maine Pulp and Paper Association
MRSA = Maine Revised Statutes Annotated
NEFIS = Northeast Forest Information Source
NGO = Non-Governmental Organization
NPDES = National Pollutant Discharge Elimination System
OG = Old Growth
PFW = Protection Fish and Wildlife
PLC = Professional Logging Contractors of Maine
RV = Recreational Vehicle
SAM = Sportsman's Alliance of Maine
SBW = Spruce budworm
SBW-DSS = Spruce Budworm Decision Support System
SFI = Sustainable Forestry Initiative
SIC = State Implementation Committee for Sustainable Forestry Initiative
SGCN = Species of Greatest Conservation Need
SOPFIM = Société de protection des forêts contre les insectes et maladies
SWOAM = Small Woodland Owners Association of Maine
UMaine = University of Maine
UMN = University of Minnesota
UNB = University of New Brunswick
USDA = United States Department of Agriculture
USFS = United States Forest Service
WAP = Maine Wildlife Action Plan

Appendix A — Spruce Budworm Management Act

Recommended changes to Public Law, Chapter 314, LD 870, Spruce Budworm Management Act, that were made effective 90 days following adjournment of the 127th Legislature:

An Act To Amend the Maine Spruce Budworm Management Laws

Be it enacted by the People of the State of Maine as follows:

Sec. 1. 12 MRSA §8422, sub-§§1, 2 and 4, as enacted by PL 1979, c. 737, §12, are amended to read:

1. Supply of wood.
~~The protection of an adequate~~ Monitoring the status of and reporting on the present and future supply of wood to support the long-term economic needs of the State and of its forest products industries;

2. Development of program.
The development and utilization in both the public and private sectors of forest protection and management programs ~~which~~ that are cost-effective, biologically sound and responsive to the public's environmental and health concerns ~~of the public~~;

4. Private efforts; pest management.
The encouragement of private efforts to undertake a variety of integrated pest management techniques ~~which~~ that result in a long-term reduction in the ~~susceptibility~~ vulnerability of the State's forests to spruce budworm infestation and loss;

Sec. 2. 12 MRSA §8422, sub-§4-A is enacted to read:

4-A. Presalvage and salvage harvesting.
The regulation of presalvage and salvage harvesting designed to reduce losses of timber while protecting public trust resources and supporting the protection of wildlife habitat through the retention of non-susceptible tree species where silviculturally and ecologically appropriate;

Sec. 3. 12 MRSA §8422, sub-§§5 to 7, as enacted by PL 1979, c. 737, §12, are amended to read:

5. Implementation. The implementation of ~~equitable~~ methods for determining private and public participation in~~, and financing of,~~ spruce budworm ~~suppression and prevention~~ management programs, including provision for voluntary participation in future insecticide spray projects;

6. Regulatory review.
The provision for adequate regulatory review of any proposed insecticide spray projects by ~~an independent state agency~~ the Department of Agriculture, Conservation and Forestry, Board of Pesticides Control; and

7. Management options.
The provision of management ~~and utilization assistance programs~~ options for ~~small~~ forest landowners designed to minimize impacts of spruce budworm infestation and loss.

Sec. 4. 12 MRSA §8423-A, sub-§§2 and 4, as enacted by PL 1981, c. 278, §2, are repealed.

Sec. 5. 12 MRSA §8423-A, sub-§5, as enacted by PL 1981, c. 278, §2, is amended to read:

5. Forest land owners.
"Forest land owners" means persons who own forest lands ~~within the district, including, without limitation, persons owning or claiming timber and grass rights in public reserved land located within the district.~~

Sec. 6. 12 MRSA §8423-A, sub-§6, as enacted by PL 1981, c. 278, §2 and amended by PL 2011, c. 657, Pt. W, §7 and PL 2013, c. 405, Pt. A, §23, is further amended to read:

6. Management program.
"Management program" means all activities undertaken by the Bureau of Forestry in connection with the short-term and long-term ~~suppression, control and prevention~~ management of spruce budworm infestations, including, without limitation, any activities undertaken in connection with ~~spray projects,~~ spruce budworm survey and detection activities, targeting silvicultural, ~~marketing~~ and integrated pest management programs, research, methods development and

related activities and any involvement in any spray activities.

Sec. 7. 12 MRSA §8423-A, sub-§7-A is enacted to read:

7-A. Presalvage and salvage harvesting. "Presalvage and salvage harvesting" means the harvesting of trees vulnerable to damage.

Sec. 8. 12 MRSA §8423-A, sub-§§8 and 10, as enacted by PL 1981, c. 278, §2, are repealed.

Sec. 9. 12 MRSA §8423-A, sub-§11, as enacted by PL 1981, c. 278, §2 and amended by PL 2011, c. 657, Pt. W, §7 and PL 2013, c. 405, Pt. A, §23, is repealed.

Sec. 10. 12 MRSA §8423-A, sub-§13 is enacted to read:

13. Spruce budworm timber harvesting standards. "Spruce budworm timber harvesting standards" means standards for presalvage and salvage harvesting of spruce and fir stands vulnerable to and subject to spruce budworm damage.

Sec. 11. 12 MRSA §8423-B, as enacted by PL 1981, c. 278, §3, is repealed.

Sec. 12. 12 MRSA §8423-C is enacted to read:

§ 8423-C. Presalvage and salvage harvesting

1. Regulation. The Department of Agriculture, Conservation and Forestry shall regulate the presalvage and salvage harvesting of forest stands in areas that, based on the proportion of balsam fir, white spruce, red spruce, black spruce, other softwood and hardwood components present, have significant risk of damage from spruce budworm and are subject to a credible threat of imminent spruce budworm damage.

A. The assessments of risk and vulnerability of a specific forest stand must be supported by adequate data, including but not limited to:

(1) Forest stand type information; and

(2) A documented history of recent elevated spruce budworm moth presence or foliage damage from spruce budworm feeding.

B. The director shall designate areas for presalvage and salvage harvesting subject to rules adopted pursuant to subsection 5 no later than January 1st of each year. Areas designated for presalvage and salvage harvesting must be inspected and verified by a licensed forester in the employ of the bureau. The director shall seek public comment for a 30-day period prior to designating such areas.

C. A forest stand that is identified for presalvage and salvage harvesting must be located within the areas designated pursuant to paragraph B.

2. Notification. Prior to beginning timber harvesting pursuant to this subchapter, a landowner or designated agent shall notify the bureau in accordance with the notification requirements set forth in chapter 805, subchapter 5.

3. Reporting. Timber harvests conducted pursuant to this subchapter are subject to the same reporting requirements set forth in chapter 805, subchapter 5, except that the director may require additional information to be reported to satisfy the requirements of this subchapter.

4. Confidentiality. Reports filed in accordance with subsection 3 are confidential. The director may publish summary reports that use aggregated data that do not reveal the activities of an individual person or firm. Reports submitted pursuant to subsection 3 must be available for the use of the State Tax Assessor for the administration of Title 36.

5. Rules. The commissioner shall adopt rules to implement this subchapter, including rules establishing spruce budworm timber harvesting standards. Rules adopted pursuant to this subsection are major substantive rules as defined in Title 5, chapter 375, subchapter 2-A.

A. The rules must:
(1) Exclude presalvage and salvage harvesting in protection subdistricts within the jurisdiction of the Maine Land Use Planning Commission and in areas subject to timber harvesting regulation under section 8867-B;
(2) Identify the areas subject to a credible threat of imminent spruce budworm damage and the forest stand criteria needed for presalvage and salvage harvesting; and
(3) Define the size and scope of presalvage and salvage harvesting projects that will require additional review by the bureau.

B. The Commissioner of Agriculture, Conservation and Forestry shall consult with the Commissioner of Environmental Protection and the Commissioner of Inland Fisheries and Wildlife to ensure that rules adopted under this subsection are consistent with wildlife habitat and environmental protection.

C. Except as otherwise provided in this subchapter or in rules developed pursuant to this subsection, the provisions of chapter 805, subchapter 3-A do not apply to presalvage and salvage harvesting regulated under this subchapter.

D. The rules must provide that regeneration requirements adopted by rule pursuant to section 8869, subsection 1 apply to spruce budworm timber harvesting conducted pursuant to this subchapter.

6. Penalties. A person who violates this section or a rule adopted pursuant to this section commits a civil violation and is subject to the following penalties:

A. A person who violates this section or a rule adopted pursuant to this section commits a civil violation for which a fine of not less than $100 and not more than $1,000 may be adjudged for each day of that violation; and

B. A person who violates this section or a rule adopted pursuant to this section after having previously been adjudicated of a violation of this section within the previous 5-year period commits a civil violation for which a fine of not less than $1,000 but not more than $2,000 may be adjudged for each day of that violation.

If the economic benefit resulting from the violation exceeds the applicable penalties under paragraphs A and B, the maximum fines may be increased. The maximum fine may not exceed an amount equal to twice the economic benefit resulting from the violation. The bureau shall consider as economic benefit, without limitation, the costs avoided or the enhanced value accrued at the time of the violation by the violator as a result of not complying with the applicable legal requirements.

Sec. 13. 12 MRSA §8424, sub-§1, as enacted by PL 1979, c. 737, §12 and amended by PL 2011, c. 657, Pt. W, §7 and PL 2013, c. 405, Pt. A, §23, is further amended to read:

1. General authority.
In accordance with the provisions of this subchapter, the Bureau of Forestry, acting under the supervision of the director, ~~shall be empowered to~~ may plan for and undertake activities related to ~~spray projects and~~ spruce budworm management programs on behalf of the State.

Sec. 14. 12 MRSA §8424, sub-§2, as amended by PL 2011, c. 657, Pt. W, §7; c. 662, §10; and PL 2013, c. 405, Pt. A, §23, is repealed.
Sec. 15. 12 MRSA §8424, sub-§3, as amended by PL 1985, c. 58, §1, is repealed.
Sec. 16. 12 MRSA §8424, sub-§§4 and 5, as enacted by PL 1979, c. 737, §12, are repealed.
Sec. 17. 12 MRSA §8424, sub-§6, as amended by PL 1983, c. 623, is repealed.
Sec. 18. 12 MRSA §8424, sub-§§7 and 8, as enacted by PL 1979, c. 737, §12 and amended by PL 2011, c. 657, Pt. W, §7 and PL 2013, c. 405, Pt. A, §23, are further amended to read:

7. Technical assistance programs.
The Bureau of Forestry shall ~~undertake to develop and implement budworm management~~ use its authorized technical assistance programs ~~for small wood lot owners~~ to assist landowners with spruce budworm management issues.

8. Supply-demand analyses.
The Bureau of Forestry shall conduct or cause to be conducted ~~an analysis~~ analyses of future supply and demand for the spruce and fir resources of the State. ~~The purpose of such analysis shall be to determine the types and levels of future spruce budworm protection needs and strategies for such spruce and fir resources.~~

Sec. 19. 12 MRSA §8424, sub-§9, as enacted by PL 1979, c. 737, §12 and amended by PL 2011, c. 657, Pt. W, §§5 and 7 and PL 2013, c. 405, Pt. A, §23, is repealed.
Sec. 20. 12 MRSA §8425, as enacted by PL 1979, c. 737, §12 and amended by PL 2011, c. 657, Pt. W, §§5 and 7 and PL 2013, c. 405, Pt. A, §23, is repealed.
Sec. 21. 12 MRSA §8426, as amended by PL 1985, c. 664, §1; PL 2011, c. 657, Pt. W, §7; and PL 2013, c. 405, Pt. A, §23, is repealed.

Sec. 22. 12 MRSA §8427, as corrected by RR 2013, c. 2, §19, is repealed.

Sec. 23. 12 MRSA §8428, sub-§§2 and 3, as enacted by PL 1979, c. 737, §12, are repealed.

Sec. 24. 12 MRSA §8428, sub-§4, as enacted by PL 1979, c. 737, §12 and amended by PL 2011, c. 657, Pt. W, §6, is repealed.

Sec. 25. 12 MRSA §8428, sub-§5, as enacted by PL 1979, c. 737, §12, is amended to read:

5. Entry on lands.

The director or ~~his~~ the director's representatives may enter, ~~upon reasonable advance notice to the landowner, at any reasonable time and in a reasonable manner,~~ any tract of land ~~for~~ on which ~~application pursuant to section 8424, subsection 2, has been made in order to inspect the same free of any charge or cost imposed by the owner or his agentsa~~ spruce budworm management program is being conducted or is proposed to be conducted.

Sec. 26. 12 MRSA §8428, sub-§6, as enacted by PL 1979, c. 737, §12, is repealed.

Sec. 27. 12 MRSA §8428, sub-§7, as enacted by PL 1979, c. 737, §12, is amended to read:

7. Contractual authority.

The director, ~~with the approval of the commissioner, shall have the authority to~~ may enter into contracts for ~~the acquisition of insecticides, aircraft, personnel and other goods and services necessary or appropriate for~~ management programs and for other purposes related to this subchapter.

Sec. 28. 12 MRSA §8428, sub-§8, as enacted by PL 1979, c. 737, §12, is repealed.

Sec. 29. 12 MRSA §8428, sub-§10, as corrected by RR 2013, c. 1, §24, is amended to read:

10. Report.

The director shall, at the end of each calendar year, undertake a ~~complete financial~~ review of any spruce budworm management program activities undertaken that year and shall make a full report on the activities to the joint standing committee of the Legislature having jurisdiction over forestry management matters during the next session of the Legislature. The report ~~shall~~ must include, but is not ~~be~~ limited to, ~~sources of funding, private, state or federal and total expenditures broken down in the following categories: Insecticides, aircraft, monitoring, research and other appropriate categories. Also to be included shall be a statement of any remaining balance by source, private, state or federal~~ spruce budworm survey and monitoring activities and findings, outcomes of any research or methods development activities, levels and outcomes of harvest monitoring for harvests conducted under rules adopted pursuant to this subchapter, scopes of landowner assistance activities conducted and other issues as appropriate. The Department of Agriculture, Conservation and Forestry, Board of Pesticides Control must report information on spray activities related to spruce budworm management and outcomes annually to the bureau no later than March 1st. Reports required under this subsection must use aggregated data that do not reveal the activities of an individual person or firm.

Sec. 30. 12 MRSA §8428, sub-§11, as enacted by PL 1985, c. 664, §3, is repealed.

Sec. 31. 12 MRSA §8430, as amended by PL 1987, c. 183, §4; PL 2011, c. 657, Pt. W, §7; and PL 2013, c. 405, Pt. A, §23, is further amended to read:

§ 8430.Research

1. Authority.

The Bureau of Forestry, acting through its director, with the approval of the commissioner, may make grants of funds and enter into contracts for purposes of research related to forest management strategies, effects on wildlife and wildlife habitat, insecticide and spray application technologies, integrated pest management techniques, forest product marketing and utilization and other issues pertinent to the purposes of this subchapter. This research may be funded with any funds available, ~~provided that~~ as long as the cost of environmental and health monitoring of spray projects ~~shall be~~ are part of annual spray project costs and not paid out of General Fund moneys.

2. Research on public lands.

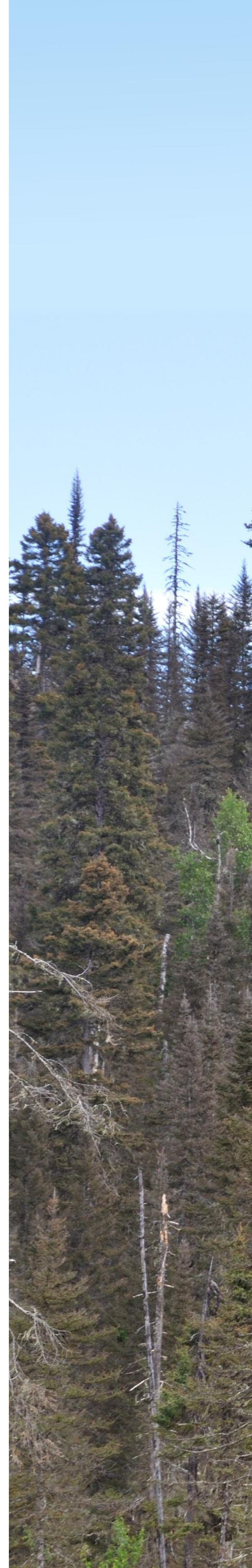
The commissioner, director or other chief executive officer of any state agency having jurisdiction over any public land may make that land over which the commissioner, director or officer has jurisdiction available on such terms and conditions as ~~he deems~~ the commissioner, director or officer considers reasonable to any public or private nonprofit entity engaged in spruce budworm control research and related silvicultural control research. The director shall likewise encourage private landowners within the State to make their lands available for the same purposes.

Sec. 32. 12 MRSA §8431 is enacted to read:

§ 8431. Effect of other laws

This subchapter does not exempt any presalvage and salvage harvesting on public reserved lands and nonreserved public lands from any other law governing management of those lands, including but not limited to management of deer wintering areas.

Sec. 33. 36 MRSA §112, sub-§8, ¶C, as amended by PL 2011, c. 548, §10, is repealed.



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