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Canadian Forest Service – Great Lakes Forestry Centre

Modelling and mapping risks as tools to better manage invasive forest pests

INTRODUCTION

Invasive species of forest insects, diseases and plants have threatened Canada's forested areas and urban environments for well over a century. Historically, pests such as chestnut blight and Dutch Elm Disease for example, have had severe impacts on the population of certain native Canadian tree species, in some cases almost eliminating them. The emerald ash borer, first observed in Canada in 2002, poses a serious threat to ash trees across North America. Strategies to eliminate or slow the spread of these destructive pests can be costly, so tools for assessing risk and best directing mitigation efforts can help ensure that resources are deployed most effectively at a time when decisions may need to be made quickly.

GREAT LAKES FORESTRY CENTRE (GLFC) RESEARCH

Experts in quantitative modelling at GLFC have developed a range of spatial models to calculate risks from alien invasive forest species such as emerald ash borer, Asian longhorned beetle, oak splendor beetle and the sirex woodwasp. The models recreate a dynamic process of pest invasion across large, geographically diverse areas, based on what is known about the current locations of the pest, points of entry, distribution of susceptible hosts and potential human-assisted movement pathways along major transportation corridors. The resulting maps give a picture of the predicted rate and pattern of spread. These models help in estimating risks at large spatial scales, but can also identify geographic hotspots, thus providing managers with an important decision support tool for immediate control or slow-the-spread measures. The information generated can also be useful in raising awareness about new invasive pests.

To generate plausible risk estimates, modelers require as much information as possible, such as details about the pest's life cycle, its likelihood of survival in the North American climate and anticipated expansion through the landscape. Generally this type of knowledge about the behaviour of a recently established invasive pest is scarce, which makes the development of risk models particularly challenging. Given the wide range of possible background information, there is no standard analytical methodology to undertake risk mapping.

Mapping risks and uncertainties of new invasive threats

Recently, GLFC scientist Denys Yemshanov, in collaboration with researchers from USDA Forest Service, North Carolina State University and Technion (Israel Institute of Technology), developed new risk mapping techniques that incorporate knowledge gaps about the invasive pest of interest. The new approach makes use of information gap decision theory, which takes into consideration what is known and what has to be known about the pest to make reliable assessments. It estimates how much uncertainty the risk maps could tolerate without losing their value for decision making. In addition to the standard model of invasion, the new methodology also incorporates an uncertainty model that characterizes what is believed to be unknown about the new threat. The analyses take into account the potential knowledge gains from unexpected finds of the invasive organism. These surprising detections that were not predicted by the standard risk model are very useful pieces of information for improving the reliability of the risk prediction model and also help managers determine where best to concentrate their surveillance efforts and control strategies. This type of information leads to more effective decisions as well as better allocation of resources for pest management. The new approach has been used to map risks and broad-scale surveillance priorities for Sirex woodwasp in eastern North America (Figure 1).

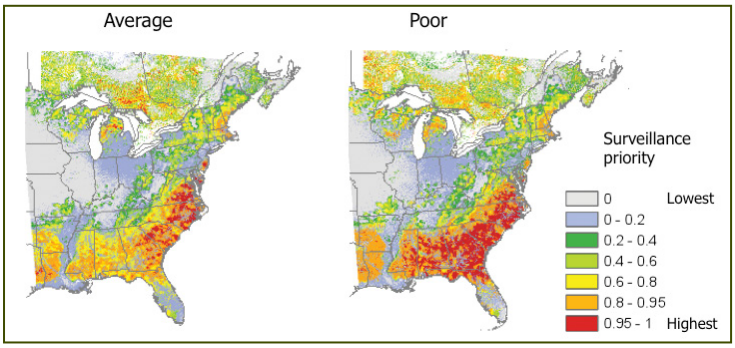

Figure 1. Broad-scale surveillance priorities for Sirex woodwasp in eastern North America. A comparison of the two maps shows that as knowledge about the pest increases (from poor to average), surveillance priorities change.

Human-assisted spread of invasive pests

As a result of successful collaboration with researchers in the US, maps that portray potential dispersal of alien invasive species across both Canada and the US have been developed. These models take into account human-assisted movement of invasive pests through transportation corridors, as a result of international and domestic trade and other economic activities. These analyses become particularly helpful in finding ways to mitigate human-assisted introduction and movements of new invasive pests. The results identify critical gateways where the human-assisted movement of invasive pests is most likely, information that is essential for prioritizing surveillance and regulation efforts once a pest has arrived or is anticipated to enter North America. These maps can also assist in regulatory decisions such as potential international trade restrictions or domestic quarantines.

One of the outcomes of this modelling exercise was an estimate of the rate at which new invasive forest insects could be introduced into North America based on recent historical trade statistics and phytosanitary regimes. The anticipated North American-wide estimate is close to two new invasive pests a year, while in Canada alone, the introduction rate could be at least one significant pest about every 30 years, due to the lower volumes and different geographical composition of pest-specific overseas imports.

Assessing economic impacts

Another important component in risk assessment is the development of bio-economic models that can help predict the critical points at which an outbreak becomes economically threatening. In addition to currently used probabilistic risk estimates, Yemshanov and colleagues developed a forest-sector risk metric for alien species invasions that quantifies the impact of the invasion on present-day economic activities that may be threatened by an outbreak. In a recent study they examined the possible infringements on regional annual allowable cut levels as a way to estimate the potential economic impact of the invasive pest to the forest products sector. Their dynamic model for Sirex woodwasp takes into account invasion spread, host tree mortality, wood supply distribution and present-day harvest activities and can be adjusted as new information about the pest becomes available. The point when the infestation starts threatening sustainable forest harvesting levels at a broad scale could become an important policy indicator for decision-makers and regulators, particularly with regards to developing and instigating control measures.

Future Work

While the use of new risk mapping techniques still requires significant technical expertise, work is underway to develop more practical, user-friendly risk mapping tools that could help analysts, forest practitioners, agencies and regulators to better estimate risks and uncertainties of new invasive threats. Ideally these models will also be capable of incorporating future changes in climate, economic activities, changes in regulations, levels of international and domestic trade and the availability of new biological control techniques.

CONCLUSION

The use of risk assessment and mapping tools can lead to more effective decisions, better allocation of resources for pest surveillance and control and the development of sound policies for dealing with new and anticipated invasive pests. Well designed risk models enable the prediction of distribution patterns, rates of spread and potential economic impacts of new invasive organisms. Collaboration with US agencies and academia has been invaluable in the understanding of invasive species spread patterns across the continent.

PRINCIPAL COLLABORATORS

- North Carolina State University
- United States Department of Agriculture Animal and Plant Health Inspection Service (USDA APHIS), Plant Protection and Quarantine Division, Center for Plant Health Science and Technology
- USDA Forest Service, Forest Health Monitoring National Research Team
- Centre for Global Change and Earth Observations, Michigan State University
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