Policy Brief:

Adaptation of Asia-Pacific Forests to Climate Change

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Executive Summary

The project *Adaptation of Asia-Pacific Forests to Climate Change* focused on developing knowledge and technology to increase the resilience of forest and forest-dependent communities to climate change throughout the Asia-Pacific region, including Western Canada. This international collaboration run out of the University of British Columbia has produced cutting-edge knowledge, models, and technology, which will greatly improve sustainable forest management practices, knowledge of the impacts of climate change on forest ecosystems, and the adaptive capacity of all countries involved. The outputs of this project will be invaluable to British Columbia, and the Asia-Pacific region as a whole, as they will help to ensure a thriving forestry industry, and continued socio-economic and environmental benefits from forests in the face of climate change.

Introduction

According to the Intergovernmental Panel on Climate Change (IPCC), Asia-Pacific ecosystems are particularly vulnerable to a changing climate, which is a major threat to the sustainability and vitality of forests, and may decrease the capacity of forest landscapes to provide ecological, economic, and social services. This region contains 20% of the world's forests, including some of the last remaining primary rainforests, which are among the most complex and threatened ecosystems in the world. Several countries strongly depend on forest resources for socio-economic benefits, making them particularly vulnerable to changes in forest ecosystems and reductions in forest stability. Canada is not excluded from this social and economic instability associated with a changing climate. In British Columbia, the impacts are already evident with the outbreak of mountain pine beetle decimating over 16 million hectares of forest. Comprehensive scientific knowledge and tools are required to fully understand the consequences of climate change, and to develop strategies for managing and adapting vulnerable resources, such as BC's forests.

Adaptation of Asia-Pacific Forests to Climate Change was a project developed and funded through The Asia-Pacific Network for Sustainable Forest Management and Rehabilitation (APFNet). It aimed to generate new knowledge and technology to increase the resilience of forests and forest-dependent communities in the Asia-Pacific, particularly in relation to tackling changing climate, deforestation, and forest degradation for a vast array of ecosystems. These objectives were achieved by developing a strong network of scientists, stakeholders, and policy makers from around the world; cutting edge technologies and methods of analysis; state-of-the-art climate models; and scientific tools to support research, policy making, adaptation strategies, and the development of sustainable forest management practices.

Research projects such as this are critically important for Canada to achieve its goals of reducing greenhouse gas emissions, while ensuring environmental and economic benefits for all Canadians. Until this project, there was insufficient quality information available to policy makers and resource managers to develop science-based strategies that would enable forests and forest-dependent communities to adapt to

climate change. APFNet and this project's research team have changed that. Overall, the outcomes of this project should increase the resilience of natural forests, plantations, and forest-dependent communities, which are essential to maintaining a thriving forestry industry, and socio-economic and environmental stability in British Columbia, and countries throughout the Asia-Pacific region.

Approaches and Results

APFNet is an international body connecting researchers, government bodies, and non-governmental organizations from countries throughout Asia and the Pacific. *Adaptation of Asia-Pacific Forests to Climate Change* is one such initiative that has helped to achieve their goals to promote and improve sustainable forest management in order to highlight the multiple functions of forests, help mitigate and adapt to climate change, and meet the changing socio-economic and environmental needs of the region. The entire Asia-Pacific region was the focus of this study, with pilot study research sites located in British Columbia, Australia, and China. These were used in the development of tools and models, and to investigate the impacts of climate change on specific forest tree species.

A highly skilled team of scientists, stakeholders, policy makers, and graduate students from Canada, United States, Australia, and China participated in this project. Dr. John Innes, Dean of the Faculty of Forestry at UBC, was the project leader. Additionally, Dr. Guangyu Wang, Assistant Dean of the Faculty of Forestry at UBC, and Dr. Tongli Wang, Associate Director of the Centre for Forest Conservation Genetics at UBC, acted as project managers.

Results

This project was broken down into several major outputs. All contributed to the ultimate goals of furthering the knowledge of climate change and its impacts on forest ecosystems, and developing tools to generate the best possible adaptation and mitigation strategies for forests in the Asia-Pacific. Outputs can be broadly categorized as improving the current levels of knowledge surrounding climate change impacts on forest and their associated policies; providing regional level tools; and providing management level tools.

Improving Scientific Knowledge about Climate Change

Assessment of Climate Change Science and Forest Management Practices

Dr. Judi Kryzanowski was the leading analyst for the project. She conducted a review of current literature to assess the existing science of climate change and forest management practices in the Asia-Pacific region. Two reports were produced – *Climate Change and Forestry in the Asia-Pacific* and *Climate Change and Forest Policy in the Asia-Pacific* – providing the background for all other project endeavors. Both are available through the APFNet Bulletin.

These comprehensive reports delivered by Dr. Kryzanowski have contributed to the understanding of the impacts of climate change in the Asia-Pacific region. They highlighted gaps in knowledge and technology needed to develop effective forestry policies, which were addressed in the project's subsequent outputs. Forest policy was examined at the global, multi-national, national, and domestic levels, and in detail for twelve Asia-Pacific countries, including Canada. The reports indicate how current forest policies can be improved to take advantage of the opportunities presented by climate change, and to adapt management such that forests will survive and flourish.

Training and Knowledge Exchange

This project achieved one of the foundational element of projects headed by APFNet, which is capacity building through training workshops, symposiums, and cooperation between various organizations and research institutions to generate the exchange of information and practical skills to improve forest management throughout the Asia-Pacific region. One component of this was the development of a strong network connecting scientists, forest managers, and policy makers throughout the Asia-Pacific region. The UBC team was very active in this network, providing technical support to all group members, often travelling over seas to lead training workshops and to assist with technical challenges. Additionally, UBC hosted six visiting scholars from multiple universities in China. This international collaboration benefited UBC, British Columbia, and Canada as a whole, as well as all other researchers, institutions, and countries involved. This immense transfer of knowledge strengthened collaborative research and decision-making regarding forest management responses to climate change, and allowed the best-available solutions to be developed for this complex problem.

Survey of Experts' Opinions Regarding Climate Change

A questionnaire was developed to evaluate how experts' on forestry and climate change from the Asia-Pacific region differ in their perspectives and knowledge of the issue. The questions focused on the impacts of climate change and forest adaptation in the Asia-Pacific region, the implications/recommendations for adapting forests to climate change, and the challenges climate change will pose. Participants included government officials, professors, researchers, and community and Non-Governmental Organizations, from countries throughout the Asia-Pacific region. This survey gave insight into climate change impacts of key concern, and exposed the diversity of challenges between regions and professions to adapting forests to climate change. **Regional Level Outcomes**

ClimateAP

Dr. Tongli Wang led the development of a cutting edge, high-resolution climate model for the entire Asia-Pacific region – ClimateAP. This was built upon his previously developed models for western Canada (ClimateBC) and North America (ClimateWNA). ClimateAP is so far the best and easiest to use tool for generating high-resolution climate data, making it an invaluable tool for climate change research. It

has a straightforward, user-friendly interface, and requires no installation or mapping programs/abilities, making it accessible to people of various levels of climate modelling knowledge. Users can obtain data for multiple locations and multiple years with a few clicks – a process that was previously not possible as a single model could not be applied to multiple locations. ClimateAP generates more accurate predictions of tree health and productivity than previous models, leading to more useful climate maps than ever before. This will help develop more targeted and effective management strategies to deal with climate change at any location throughout the Asia-Pacific region.

Niche-based and process-based models

Niche-based ecological models were also developed by Dr. Wang to predict the impact of climate change on the distribution of tree species, based on the most up-to-date climate scenarios from IPCC Assessment Report Five. The species of interest included Chinese fir, Chinese pine, Masson pine in China; Blue Gum in Australia; and Douglas fir in western North America, however it can be applied to other species and ecosystems. The projection maps indicate regions that will no longer be hospitable, and regions where there is potential for range expansion. These will provide the scientific basis for developing adaptation strategies for many forest management activities including tree species selection, pest and disease control, fire control, and silvicultural practices. Until now, there has been a lack of studies related to this in the Asia-Pacific. These models are crucial to understanding the viability of tree species, which is essential to maintain healthy, productive ecosystems that continue to supply socio-economic benefits and ecosystem services.

Dr. Nicholas Coops and Yuhao Lu of UBC utilized the Physiological Principles in Predicting Growth model (3-PG), a process-based model, to predict the future productivity and distribution of Chinese fir in southern China, and Douglas fir at UBC's Malcolm Knapp Research Forest (MKRF). This model can be used to enhance the understanding of the reasons for habitat loss, and can yield even more in-depth knowledge of the potential shift in species distribution when coupled with the aforementioned niche-based models. 3-PG can be applied to tree species other than those examined in this project, which represents huge potential benefit for the BC forestry sector.

Management level Outcomes

Adaptation strategies in management practices were developed based on the integration of the ecological model predictions with observations made at four pilot sites: UBC's Malcolm Knapp Research Forest (MKRF), BC; Central Highland of Victoria, Australia; Research Institute of Insect Resources of Yunnan, China; and the Fujian site, China. This research has increased the knowledge of how environmentally and economically important forest species will be impacted by climate change, leading to recommendations for management practices that will increase the resilience of forests, forestry industry, and forest-dependent communities throughout BC and the Asia-Pacific region.

Application of Process based models

- FORECAST climate

Dr. Brad Seely of UBC developed the FORECAST Climate model, which is able to simulate the impacts of climate change on the growth and development of a species at the stand level. Dr. Seely and Haijun Kang used this in conjunction with a landscape-scale model - the Landscape Summary Tool (LST) - to evaluate the potential impacts of alternative management strategies on the trade-offs between fiber production and ecosystem services in the context of climate change. For the LST, several management indicators are individually scored, such as harvest volume and soil fertility, which are then used to calculate an overall score for each management strategy. This allows forest managers to determine which strategy is best not simply based on the overall ranking, but also the importance of each factor according to their forest management purpose. These tools developed by Dr. Seely and Mr. Kang will enable the most economically and environmentally beneficial management strategies to be carried out.

- Eco-hydrological model

Dr. Baozhang Chen of UBC developed the eco-hydrological model DLM-Ecohydro. It is used to project changes in temperature, water movement and storage in the system, as well as gross and net primary production under different climate change scenarios. This model has an easy to use interface, and although it was applied to the watersheds in Fujian and MKRF for this project, it can be applied to any location. The unique integration of hydrology and ecology employed by this model generates more accurate predictions of water movement than its predecessors, and is a great advancement in the field of hydrological modelling. Forest resource managers can use the model's projections and maps to develop adaptation strategies to maintain healthy forest ecosystems despite potential environmental stresses associated with climate change.

- 3-PG

Dr. Coops and Mr. Lu applied 3-PG in tandem with LiDAR – a remote sensing tool –at MKRF to yield high accuracy forest inventory data in the context of climate change. This method provides a better understanding of the current state of managed forest ecosystems, allowing the best possible management strategies to be developed to deal with the potential changes associated with climate change. At the local scale, understanding and quantifying the potential climate change impacts on tree species will aid forest managers in developing management strategies that are best suited to the future climates. At the provincial or national level, distribution patterns and forest productivity will assist policy makers in generating more accurate and scientific-based policies.

- Carbon Dynamics

Dr. Qinglin Li of BC Ministry of Forests, Lands, and Natural Resource Operations, analyzed ecosystem carbon storage and fluxes under various climate change scenarios for the Pitt River Wastershed, which encompasses the MKRF, BC. This can be applied to a variety of ecosystems, and can be used by forest managers in tradeoff analyses of management practices, which will help to achieve sustainable timber harvesting. This will also allow the necessary steps to be taken to ensure forests act as a carbon sink in order to help mitigate climate change.

- Model Integration for Decision Making

Several niche- and process-based models were integrated with social and environmental indices to analyze the optimal strategies for balancing ecological, social, and economic aspects of forest management under different management practices and climate scenarios. Dr. Li applied this framework to MKRF, however it can be applied to other locations. This framework provides managers and decision makers straightforward methods to quantify the individual or combined benefits and tradeoffs of multiple, potentially conflicting objectives. This will lead to more sound decisions regarding sustainable forest management under the changing climate that balance economic and environmental benefits.

- Online interactive tools for visualization and data access

Dr. Wang developed an interactive, map-based web tool by integrating ClimateAP and climate niche projections with Google Maps. This easy to use, interactive visual displays climate predictions in an easy to understand manner, and is freely available to anyone around the world. This allows scientists, stakeholders, policy makers, and curious citizens easy access to the most up-to-date information and knowledge on climate change for anywhere in the Asia-Pacific. This will facilitate and improve the quality of future research on climate change in the Asia-Pacific region, and help to develop more targeted and effective management strategies for forest ecosystems.

Conclusion

Adaptation of Asia-Pacific Forests to Climate Change has produced extensive scientific knowledge on tree species, ecosystems, and current and future climate impacts in the Asia-Pacific region, as well as increased scientific capacity through cutting-edge models and tools for local predicted climate change scenarios, forest adaptation strategies, and ecosystem dynamics. This work will facilitate and promote the study of climate change in the region, allowing the identified lack in science, technology, and policy with respect to adapting forests to climate change to continue to be addressed. The success of this project is due in large part to the funding, guidance, and support provided by APFNet. Overall, this project's achievements will not only address climate change and its related issues, but will enhance biodiversity, reduce carbon emissions, improve forest ecosystems, and improve the ability of forests to provide social-economic benefits to forest-dependent communities throughout the Asia-Pacific region.

Recommendations

To maximize the adaptation and mitigation potential of forests in Canada and the entire Asia-Pacific region, there needs to be a commitment to improving research and knowledge around the interactions between the changing climate and vitality of forests. The foundation laid by this project needs to be built upon by continuing research and development of the tools required to implement the best possible mitigation and adaptation strategies to maintain healthy, productive forests well into the future. A second phase of the project has been proposed and approved by APFNet, and will need the support of the BC government to ensure it can be developed to its full potential.