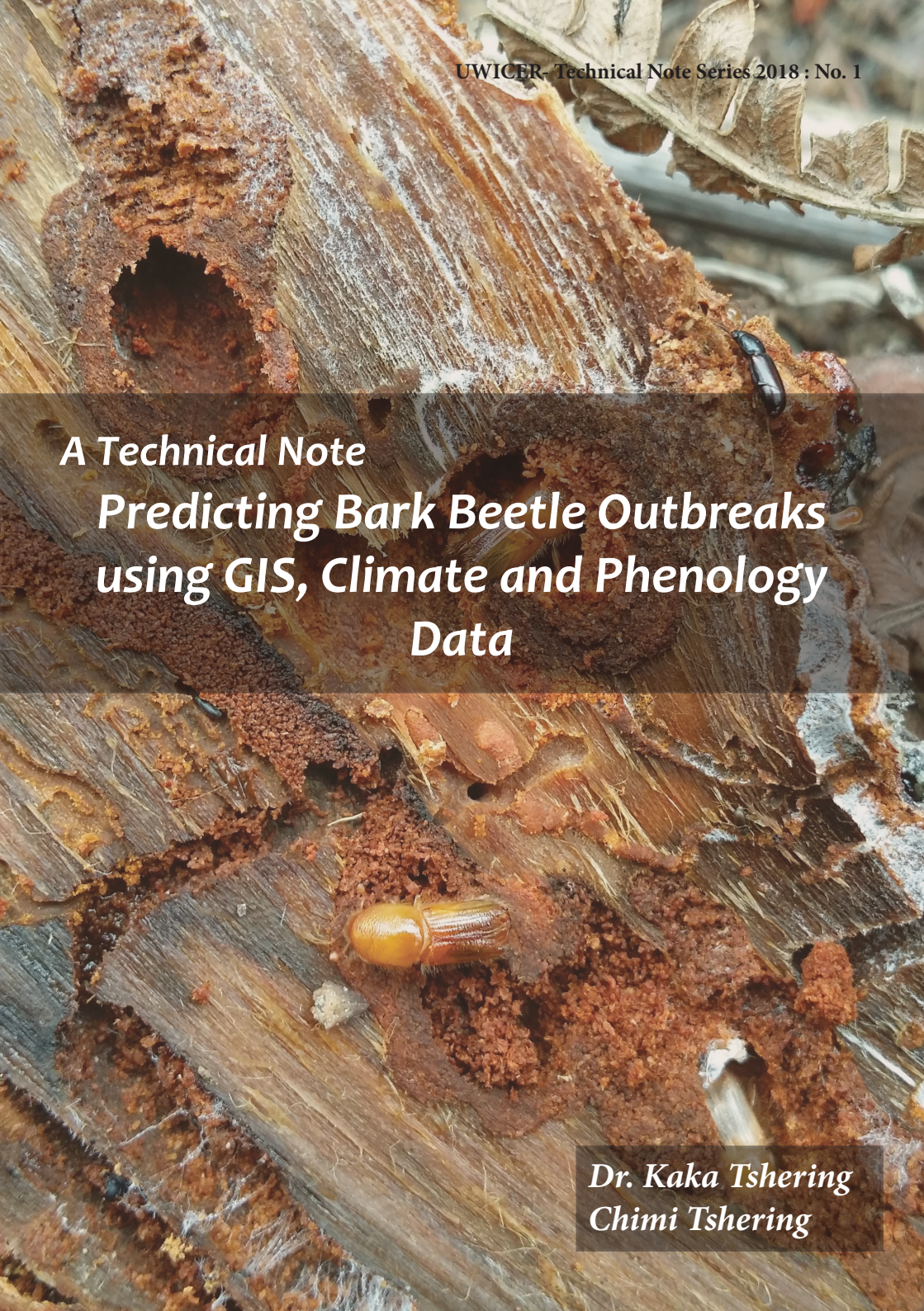
UWICER- Technical Note Series 2018 : No. 1



A Technical Note

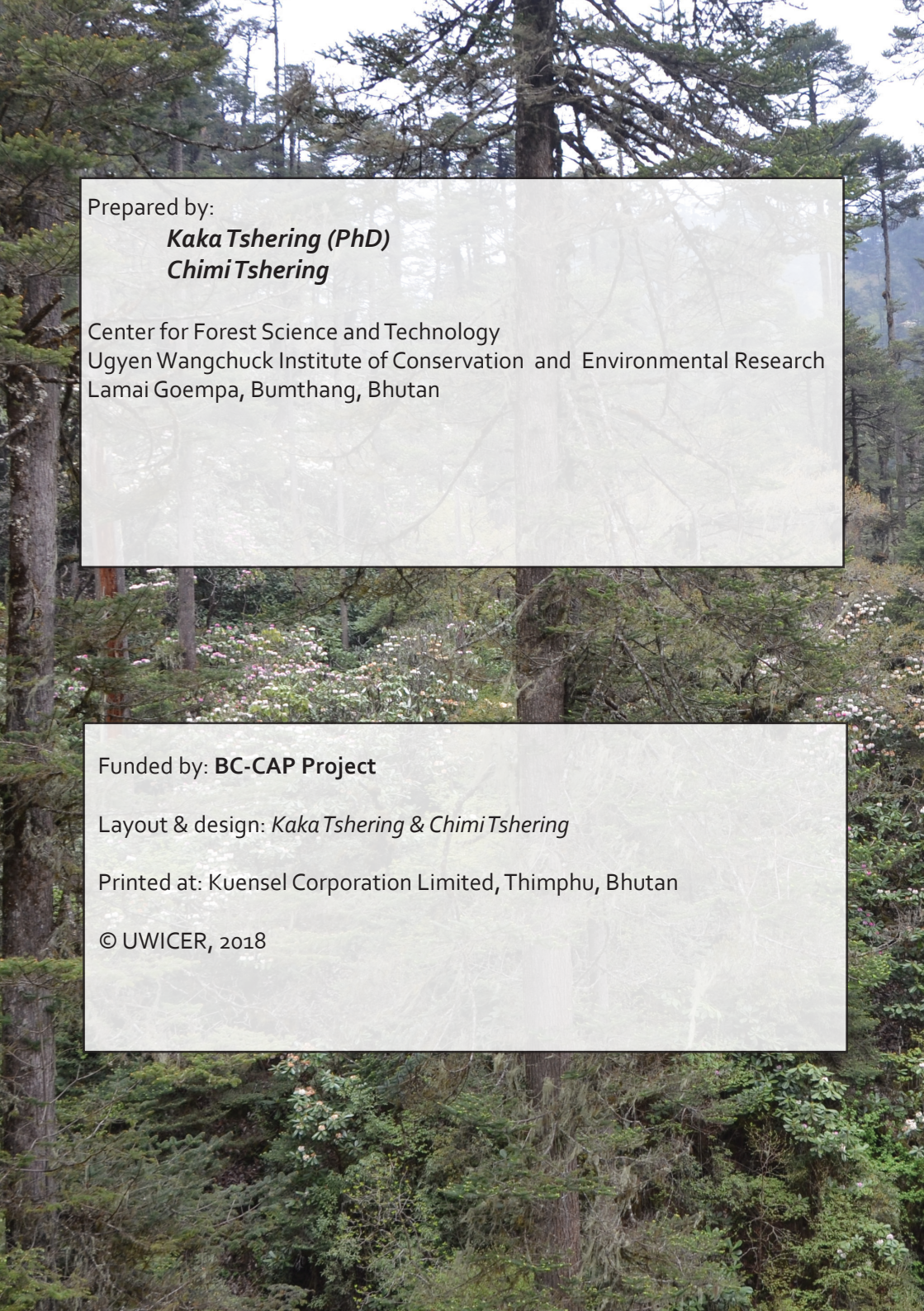
Predicting Bark Beetle Outbreaks using GIS, Climate and Phenology Data

Dr. Kaka Tshering
Chimi Tshering

Predicting Bark Beetle Outbreaks using GIS, Climate and Phenology Data

Ugyen Wangchuck Institute for Conservation and Environmental Research
Bumthang, Bhutan

University of Natural Resources & Life Sciences
Vienna, Austria



Prepared by:

Kaka Tshering (PhD)
Chimi Tshering

Center for Forest Science and Technology
Ugyen Wangchuck Institute of Conservation and Environmental Research
Lamai Goempa, Bumthang, Bhutan

Funded by: **BC-CAP Project**

Layout & design: *Kaka Tshering & Chimi Tshering*

Printed at: Kuensel Corporation Limited, Thimphu, Bhutan

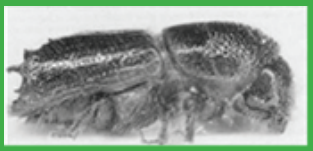
Summary

Through our study on susceptibility models for climate change relevant biotic disturbance agents, we have demonstrated that we are able to predict bark beetle outbreaks using GIS based topo-climatic model combined with Predisposition Assessment System which is a model based on expert's knowledge in the particular field of study.

Background

The threats of climate change in the Himalayas are more pronounced as the rate of warming in the Himalayan region are much greater than the global average. Such changes can directly impact the plants, animals and the functioning of entire ecosystem resulting in alteration of migration, flowering and development. The frequency, intensity and timing of drought events, forest diseases and bark beetle outbreaks may be altered which may make forest ecosystem more vulnerable against aggressive forest pests like the spruce bark beetle species *Ips schmutzenhoferi*. Under such circumstances, it is more likely that outbreaks incidence could increase in the future which necessitates appropriate monitoring tool to assess the risk of bark beetle outbreak in time and space.

As temperature is the key driver for the development and population dynamics in bark beetles, we carried out laboratory experiments



.... forest damage occurs when weakened or predisposed trees coincide with disturbances such as bark beetles....

.....As temperature is the key driver for the development of bark beetles, climate change events can directly shift the population dynamics across the natural landscape....

to understand the critical threshold temperature of the bark beetle by breeding them under different temperature conditions. Reliable knowledge on the temperature requirements of the beetle is vital for developing a comprehensive model to predict population development. Such tools are particularly necessary for mountainous countries like Bhutan where most of the forest areas are inaccessible with conducive conditions for the beetle development. Under such circumstances, simulations models provide a powerful pre-emptive tool for assessing current insect development over large spatial and temporal scale, which is a key component of the decision making process in the forest protection and management. In the selected study area in western part of Bhutan, bark beetle development over the natural landscape was simulated and predisposition assessment system as applied to understand the susceptibility of the forest stands within the selected area.

Results

Based on the beetles' development in the laboratory under various constant tempertures, the lower threshold temperature of 7^{o}C, an optimum temperature of 29^{o}C, an upper threshold temperature of 39^{o}C and a thermal sum of 705 degree days for total development were calculated. Field studies on flight activity, tree colonization, brood development, and thermal conditions in the bark of traps logs were recorded at three different altitudes of a southwestern and northeastern exposed slope for both host trees, *Picea spinulosa* and *Pinus wallachiana* to validate the phenology model.

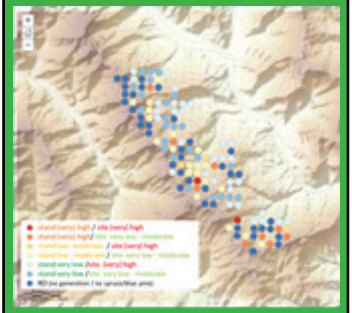
...simulation models provide a powerful pre-emptive tool for assessing current insect development over large spatial and temporal scale...

.....Predisposition Assessment System (PDAs) is predictive model based on expert's knowledge in the field of forest site and stand conditions.....

Spring flight was initiated when the maximum air temperature exceeded 14.6 °C. Trap logs were infested when daily maximum air temperature was 190C and parental beetles re-emerged, when the relative thermal sum of 36% for total development had been accumulated. Based on GIS and climate data, a topo-climatic model was developed, which allowed to simulate the life cycle events of the bark beetle for selected forests in Bhutan in 2014 and 2015.

In the study area, the predicted start of development (onset of infestation) of I. schmutzenhoferi at the valley bottom and lower elevations was very early with a date before April 1. In general cooler spring temperature in in 2015 compared to 2014 caused a later onset of infestation especially at higher altitudes on the exposed ridges, where the development of the new generation started only by early June. According to the spatial and temporal simulation of development of *I. schmutzenhoferi* within the selected area, there is potential for development of three generations of I schmutzenhoferi at the lower elevations, particularly in the valleys. On the contrary, the development of beetles was impeded at higher elevations due to low temperatures.

A predisposition assessment system was applied for the available inventory plots within Zonglela forest management unit area in western Bhutan. For the assessment, site and stand specific parameters from the forest inventory and model output from the spatial bark beetle phenology model were implemented by differential weighting of the various indicator variables.



....in general, forest within the study area was found to of low risk to bark beetle epidemics mainly due to high diversity of tree species....

.....however, Predisposition Assessment Systems (PDAs) revealed that some old spruce dominated stand are at high risk of bark beetle attack....

Photo: Dwarf mistletoe infestation on Spruce tree, which can seriously predispose spruce trees to bark beetle attacks.

The susceptibility of the selected forest stands from bark beetle infestation was generally very low due to the high diversity of tree species and natural character of the forest in that area. However, some old and spruce dominated stands are moderately or highly susceptible to bark beetle outbreaks. None of the forest stands within the selected area was very highly predisposed to infestations by *I. schmutzenhoferi.*

This frequently low stand-related predisposition was also related to widespread moderate canopy closure. Moreover, low weighting of diameter at breast height (DBH) and share of blue pine stands as well as actual low diameters of blue pines contribute to low susceptibility to bark beetle infestations of the stands. Especially at lower elevations, the stands contain a high proportion of blue pine, but these stands are too young (DBH lower than 30 cm) and may not support successful infestations by *I. schmutzenhoferi.*

Contrary to actually existing blue pine stands in this area, spruce dominated stands are generally much older (larger diameter classes). Especially, in the central and southern part of the Zonglela forest area, forests contain mature pure spruce stands, which are highly predisposed to bark beetle attacks. These stands may be "hot spots" for bark beetle outbreaks in future. However, due to the heterogenic forest structures, extended epidemics of *I. schmutzenhoferi* are currently not expected.

....under warmer climatic conditions, dwarf mistletoe can seriously predispose spruce trees to bark beetle attacks....

Wider Implications

- The model identifies forest areas at risk and support the monitoring and decision making for appropriate forest management and conservation strategies.
- The developed models can support the monitoring of bark beetle populations especially in protected, frequently inaccessible forest areas within the rugged landscapes in Bhutan. The models can improve the current understanding of naturally occurring bark beetle outbreaks and may be used for decision making in forest protection and conservation.
- In managed forests, knowledge of the phenology and generation development is essential for monitoring, the timely management of outbreaks and sanitation of infestations (curative felling, debarking, and removal of infested trees).
- The hazard assessment (PAS) is crucial for preventive forest management at the stand and landscape level that has to be focused on the optimization of silvicultural practices for the control of biodiversity, regeneration, establishment, growth, composition, health, and quality of forests to meet the diverse needs and values and to minimize hazards.
- In the field, understanding the predisposing characters at the stand and site level conditions can help identify vulnerable forest stands.

…the model identifies forest areas at risk and can support monitoring of bark beetle populations….

….knowledge on the phenology is crucial for managing outbreaks….

….hazard assessment can play a pivotal role in optimizing silvicultural options for preventing bark beetle outbreaks….

Acknowledgment

This technical note is based on the ongoing synthesis of studies carried out by researchers of the Ugyen Wangchuck Institute for Conservation and Environmental Research and the Department of Forests and Park Services under the framework of the Climate Change Adaptation Potentials of forests in Bhutan – building human capacities and knowledge base Project (BC-CAP).

This project is jointly implemented by the Department of Forests and Park Services, Royal Government of Bhutan and University of Natural Resources and Life Sciences (BOKU), Austria with funding from Government of Austria, through the Ministry of Agriculture, Forestry, Environment and Water Management. We gratefully acknowledge the generous support provided by these donors.

We also express our deep appreciation to our advisors Dr. Axel Schopf and Dr. Peter Baier , Institute of Forest Entomology, BOKU University.

For more information and any queries please contact:

Kaka Tshering(PhD)
Porgramme Director
Conifer Research Sub-center
Center for Forests Science and Technology
Ugyen Wangchuck Institute for Conservation and Environmental Research
ktshering@uwice.gov.bt
www.uwice.gov.bt

Ugyen Wangchuck Institute for Conservation and Environmental Research
Department of Forest and Park Services
Lamai Goempa, Bumthang, Bhutan
www.uwice.gov.bt
info@uwice.gov.bt

ISBN 978-99936-993-4-7