QuickNotes

Science summaries from fRI Research

Introducing: Efficient monitoring of mountain pine beetle outbreak spots using artificial intelligence applied to drone thermal imagery

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Successful management of mountain pine beetle (MPB) populations is contingent upon the detection and management of infested trees at a rate greater than MPB population increase. The most critical and challenging step is detection of the newly infested, so called 'green attack' trees. Currently a two-step process involving aerial and ground surveys is conducted by the Alberta provincial government to detect green attack trees. Aerial surveys detect red-attack trees (killed during the previous summer) and ground surveys detect new green attack trees surrounding the red attack trees. Additionally, green attack trees have to be cut and burned in a relatively short time frame (February-April) each year. All these labor-intensive activities significantly limit detection and elimination of green attack trees and cannot be conducted over larger areas due to cost limitation. Thus, development of remote sensing technology and aerial survey methods for detecting green attack trees that are widely dispersed, occurring at low densities and not in close proximity to red attack pines is highly critical.

We propose to use thermography paired with image analysis using artificial intelligence (AI) to identify trees with green crowns that are recently killed by MPB (green attack) and to produce spatial estimates of numbers of green attack pine trees infested by MPB. Unlike previous attempts, our selection of spectral characteristics and predictors of infestation is motivated by energy balance physics, tree physiology, and MPB biology.

Federal-Provincial MPB Research Partnership

Mountain Pine Beetle remains a severe threat to Alberta's pine forests despite the province making positive progress in controlling its spread within the province and reducing the risk to the rest of Canada.

Natural Resources Canada and Alberta Agriculture and Forestry have provided funding to a suite of projects with the goals of limiting the spread of Mountain Pine Beetle and mitigating damages where it has already invaded.

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The concept underlying our approach is to use the thermal signature of photosynthesis in living trees to distinguish them from green attack trees. During photosynthesis, gas exchange occurs through stomata, microscopic openings in tree leaves, which During gas exchange, a portion of plant water also leaves, which creates an evaporative cooling effect. As a result, at the end of warm days, more heat accumulates on the foliage of dead trees than in the foliage of living, photosynthesizing trees. Conversely, when ambient temperatures are cool, such as in the early morning, the foliage of dead trees is expected to be cooler and to emit less long-wave radiation than surrounding living trees. Variation in heat dissipating from the foliage of trees in the form of long-wave radiation is detectable using thermal infrared sensors. Preliminary test we conducted in Kananaskis on mechanically killed lodgepole pines confirmed these effects can be observed in drone thermal imagery.

Objectives

We hypothesize that variation in heat dissipating from the foliage of green attack and healthy trees in the form of long-wave radiation can be detectable using thermal infrared sensors. Our main objective is to develop an algorithmic approach for differentiating between recently dead pine trees with green foliage and live healthy pine trees using artificial intelligence to analyze thermal images of tree crowns.

Expected Outcomes

We propose a new approach to detect green attack trees at the leading edge of expanding MPB outbreaks. This new technology would enable informed prioritization of management efforts as well as early detection and invention, which are key to successful damage mitigation here in Alberta as well as to slow the spread of MPB to eastern pine forests. Furthermore, the design and development of novel advanced technology and processes will undoubtedly will lead to valuable contributions to basic science.

Implications for Land Management

The proposed research crosses the boundaries of three distinct fields, namely machine learning, photogrammetry and remote sensing, and pest biology. Our approach for detecting tree death before it is visible to an aerial surveyor would provide invaluable information across many other evergreen species and pest systems—even if mortality cannot be attributed to a specific tree-killing insect. The tools that we propose to develop potentially have a dual purpose of detecting tree stress. The successful completion of this research will identify green attack trees however, continued research will extend the applicability to other forest pests enabling much of the aerial reconnaissance currently conducted to be completed algorithmically at a substantially reduced cost.

Social, Economic, and Ecological Value

Our study aligns with three of the five key outcomes (Limit the spread of MPB into the eastern boreal forest; Limit the spread of MPB along the eastern slopes of Alberta; Generate knowledge and innovative management techniques through research on MPB). The significant cost reduction will not only benefit the economy but also in turn, contribute to conservation of natural resources by stopping or slowing the spread of MPB infestations in eastern pine forests.

Expected Completion Date

June 30, 2023