The Role of UAVs in the Early Detection of Mountain Pine Beetle Mortality

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ABSTRACT

Identification of trees killed by mountain pine beetles in the pre-visual, green-attack stage is a challenging endeavor that has so far eluded the efforts of remote-sensing scientists. However, miniaturized thermal sensors used as handheld devices or mounted on unmanned aerial vehicles could provide new opportunities for early detection, by exploiting the energy balance differences between healthy trees and those whose sapwood function has been disabled by blue-stain fungus associated with pine-beetle mortality. In this paper, we show how the physiological effects of a mountain pine beetle attack creates differences in outgoing longwave radiation – the physical property detected by thermal sensors – that could create opportunities for early detection. Two hypotheses are presented: the warm-tree effect, and the cool-tree effect. The warm-tree effect holds that following a period of positive net radiation (e.g., after a long sunny day), green-attack trees will be warmer than surrounding healthy trees. The cool-tree effect hypothesizes that after a period of negative net radiation (e.g., after a cool clear night) green-attack trees will be cooler than surrounding healthy trees. Both of these effects are created by the loss of transpiration in girdled green-attack trees, whose sapwood function has been disabled by blue-stain fungi spores. This loss of transpiration causes a reduced energy sink via latent heat flux. While other researchers have noted the potential for this effect to create opportunities for remote sensing, no studies (that we are aware of) have successfully demonstrated it; primarily due to the lack of appropriate sensing and platform technology. We present early results of a proof-of-concept study in western Alberta, Canada, wherein natural green-attack trees (technically, faders from the previous summer) were sampled with thermal imagery both on the ground and from UAVs. While the results are promising (temperature differences from 1C and 7C were observed between healthy and green-attack trees in warm-tree effect scenarios), we also encountered a series of challenges, which we present. A larger controlled experiment using simulated green-attack trees killed with physical and chemical applications is currently underway, and will be described. Early results from this work may also be available in time for the presentation.