4. How are disturbance regimes in ABR changing and what processes are controlling those changes?

Although disturbances such as fire, outbreaks of insects and pathogens, and permafrost-thaw events—here termed thermokarst—have been part of the historic disturbance regimes of Arctic and boreal ecosystems, there is increasing evidence that their frequency, severity, and area affected are increasing in response to recent climate warming. At local to sub-regional scales, anthropogenic activities, especially those associated with exploration and resource extraction, are also impacting terrestrial ecosystems and the services they provide. Since these disturbances trigger a variety of responses in ecosystems and landscapes, the degree to which changes in disturbance regimes influence the vulnerability (e.g., susceptibility to change) and resilience (e.g., resistance to change) of ecosystems and landscapes is central to determining how high northern latitude biomes respond to climate change. Because of the large areas impacted by disturbances and the rapidity of their effects, they are in many cases the most important agent for initiating local changes to Arctic and Boreal ecosystems and landscapes.

Across the North American boreal forest, average annual area burned has been increasing over the past half-century. Late-season burning in Alaska has increased over the past decade, which in turn, has resulted in more severe fires. The occurrence of large fires may also be increasing in tundra. While further climate warming is likely to increase potential for burning, changes in vegetation type, at least in boreal forests, will have a negative feedback on fire activity. Based on current understanding, predicting future changes to the ABR fire regime and their impacts on both ecosystems and climate is challenging.

Both insects and pathogens are responding to climate change, but with complex host and other interactions that are difficult to forecast. The risk of large-scale disease outbreaks is likely to increase with increased climate variability because pathogens can adapt to new climate conditions faster than the shrubs and trees they affect. Many insect species respond rapidly to environmental change due to their genetic variability, short life cycle, mobility, and high reproductive potential. Owing to their physiological sensitivity to temperature, changing climate can be expected to have strongly influence the survival, development, reproduction, dispersal, and geographic distribution of forest pests and their hosts.

In many regions of Alaska and NW Canada rapid permafrost thaw is on the rise with observations of increased abundance of landslides from massive erosion of soil and sediment, formation of new thermokarst lakes and ice wedge ponds, peat plateau collapse, and rapid lake drainage due to permafrost loss or near-surface degradation. These observations are in agreement with borehole-measured permafrost temperatures that have strongly increased in northern Arctic areas by several degrees Celsius over the last three decades.

Variations in disturbance severity controlled by vegetation cover, topography, soils and ground ice content/distribution control the manner in which ecosystems respond to disturbances and create ecological heterogeneity at scales that vary from tens to thousands of meters. Even within individual stands of similar vegetation and soil characteristics, disturbance severity often varies at scales of 1 to 10 m, imparting fine-scale heterogeneity. Ultimately disturbances have a major influence on soil carbon and land-atmosphere exchange of energy, water, and carbon (CO_2 and CH_4). The dominance, form, and function of these features are also likely to change as climate does, influencing ecosystem processes. Studies are needed at all these scales to understand the impacts of these various types of natural disturbance.

Objectives for research during ABoVE will be to:

(a) Investigate and quantify the spatial and temporal patterns of the primary natural disturbances in Arctic and Boreal regions (fire, insects/disease, and rapid permafrost thaw);

(b) Identify the most important factors controlling disturbance regimes; and

(c) Understand their consequences for ecosystems and landscapes.

Research to address these objectives will include landscape to regional scale observations of disturbance area and severity derived from remotely-sensed data, as well as from land-management records. Assessing factors controlling disturbance regimes will also require geospatial data on critical land characteristics (vegetation cover/condition, permafrost/active layer depth, soils, topography, weather and climate). Ground-based observations stratified across disturbance severity and the biotic and abiotic conditions at the time of disturbance at plot scales are needed to quantify disturbance severity as well as understand the immediate impacts on ecosystems. Observations across sites that differ in time after disturbance, as well as abiotic conditions, are needed to understand the consequences of past disturbances for ecosystem and landscape processes as well as to assess whether and how current disturbance regimes and their impacts differ from that occurred during past periods of rapid change. Ground-based observations are also needed to further develop and validate disturbance products from remotely-sensed data. Long-term change in disturbance regimes can only be identified by comparing recent (i.e., the last 30 to 50 years) trends to historical records of disturbance, including regional stand age structure and paleo-ecological reconstructions from sediment records. Research is required to refine and validate a wide range of models to account for factors that control the occurrence of disturbances at landscape to regional scales and realistically represent the impacts of disturbances on ecosystem processes.