Project acronym: FPIFR

Project title: Fire-Permafrost Interactions and Forest Regeneration in Siberian larch forests

Project leader: Heather Alexander, Mississippi State University, USA

Discipline: Earth Sciences & Environment

Station(s): Spasskaya Pad Scientific Forest Station, Russia

Siberian larch forests are critically important to the global carbon (C) cycle. They occupy 20% of the world's boreal forests, overlie C- and ice-rich 'yedoma' permafrost, contain half the C in Eurasian boreal forests, and depend on periodic wildfires for successful recruitment and establishment. Despite their fire-dependency, recruitment failure has been observed in recent decades, a period with increased fire activity associated with climate warming and drying. Recruitment failure often follows fires of large size or high severity and may result in a shift in functional type from trees to shrubs and/or grasses. In our previous work in larch forests of far northeastern Siberia, we documented recruitment failure in six of eight burned areas (≤ 35-year old) dominated by larch prior to burning. In the same region, we measured a range of post-fire larch recruitment (0.0 – 4 trees m-2) within a 75-year old fire scar and increased shrub/grass cover as tree density decreased. At a larger scale, we documented varying larch biomass recovery post-fire across the Kolyma River watershed, with some burned areas showing little biomass accumulation after nearly four decades. These findings suggest that increased fire activity can inhibit forest recovery and trigger forest loss, with potentially large consequences for climate feedbacks via changes in successional trajectories, and consequently, C storage and albedo.

This research builds upon past and ongoing efforts among project collaborators to understand the impacts of climate-induced changes in the fire regime on larch forests of eastern Siberia. A primary goal was to extend our efforts from larch forests near the Arctic treeline in Cherskiy, Sakha Republic, Russia to forests further south near Yakutsk. Both regions overlie yedoma permafrost, but the current fire return interval near Yakutsk (~80 years) is ~ 3-times shorter than that near Cherskiy (~200-300 years), and changes in the fire regime have been more pronounced in the Yakutsk region. The primary objective of this research was to delineate the causes of varying larch recruitment after fire and consequences for climate feedbacks via changes in C sequestration and albedo using a combination of field-based measurements, dendrochronological analysis, remotely-sensed data, and statistical modeling.

Our project addresses the following questions: 1) What factors (biological legacies, environmental conditions, and biological interactions) most influence post-fire larch recruitment in eastern Siberia? 2) What is the recent extent of larch recruitment failure and relationship to fire size and severity? 3) What are the consequences of recruitment failure and shifting successional trajectories for C pools, albedo, and regional climate forcing? We hypothesized that post-fire larch recruitment would be most constrained by available seed sources (i.e., biological legacies) but that residual soil organic layer (SOL) depth (i.e., environmental conditions) and biotic interactions (e.g., mycorrhizal colonization and competition with grasses) would impose secondary limitations on recruitment when seed sources were available. Over the

long term, we expect that larch recruitment failure will lead to successional trajectories dominated by shrubs and/or grasses, resulting in reduced C storage, higher albedo, and cooling of regional climate.

This year, a portion of our research was based out of the Spasskaya Pad Science Forest Station (SPSFS, Yakutsk, Sakha Republic, Russia). We focused on burned and unburned forests that were accessible via roads in the area. The SPSFS has long-term studies of C dynamics and energy balance in mature larch forests that provide important baseline data as we analyze shifts in C dynamics and albedo during post-fire succession. This research will complement our past and ongoing work on larch forests at the northern-most extent of their range near Cherskiy. By comparing the two regions, we aim to infer the role of climate and climate warming in the dynamics of larch forests on permafrost soils.