Task D1: Effects of propagule dispersion on post-fire establishment & successional trajectories

- Johnstone, Hollingsworth, Ruess, Taylor, Mack

Summary of findings

- Role of mycorrhizal colonization: distribution of mycorrhizal taxa colonizing tree seedlings after fire, and impacts on seedling growth (PhD student Rae deVan - Taylor lab)
  - Ericoid mycorrhizae increase colonization of tree seedlings at sites with ericaceous shrubs and reduce tree growth
  - Abundance of preferred myco taxa appear to be limited (ascomycetes dominate colonization despite preference for basidiomycetes)
- Relative effects of moss microbiome, interannual climate, and canopy litter effects on moss-associated N-fixation (PhD student/PDF Mélanie Jean - Mack & Johnstone labs)
  - Distribution of N-fixing activity more limited by moss distribution than microbial availability (cosmopolitan)
- Lagged effects of environmental factors, fire history, and initial seedling recruitment on post-fire trajectories of forest canopy dominance (Johnstone, Mack, PDF Gerardo Celis)
  - Environmental controls and fire effects of broader importance than biotic interactions (herbivory, comp.)

Propagules and post-fire succession

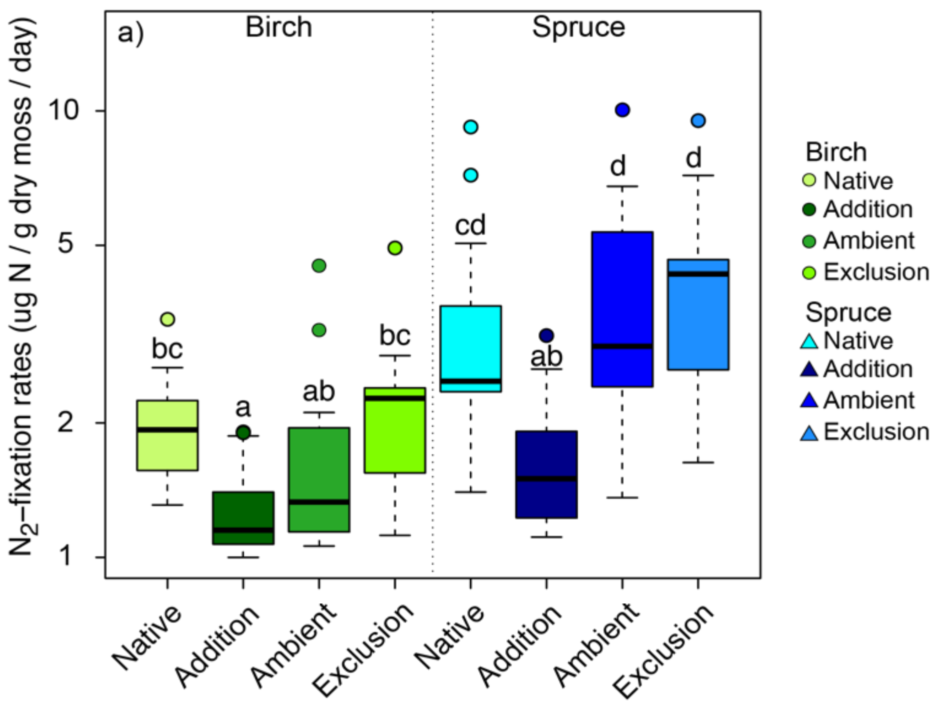
Future directions

- What are your plans moving forward?
  - Several papers are close to being submitted, Rae deVan is completing PhD thesis in 2019
  - Fieldwork: Surveys of tree growth across RSN and other existing plots to improve data needed for modelling tree growth (Johnstone and Mack collaborating with Winslow Hansen)
  - Analyses: Growth potential of alternate tree species from transplant experiments in 2004 burns
  - Modelling: application of individual-based model (iLand) to explore impacts of fire-initiated alternate successional trajectories for landscape forest composition
    - Currently in process of parameterizing iLand for Alaska (Winslow Hansen, Columbia PDF)
  - Synthesis: Interannual and tree-to-tree variability in mast seed production (Jim Clark, Duke Univ.)
- What is limiting your efforts?
  - Time & funding for personnel to complete data analyses and get papers written

Propagules and post-fire succession

Understanding cross-scale interactive effects

- Drivers of moss-associated N-fixation across scales
  - Effects of interannual climate variation > community effects
  - However, canopy litter effects on mosses and microbes distribution have strong effects on absolute amounts
  - Implies large interannual variation in N-fixation that is highly patchy according to forest type
- Mycorrhizal propagules affect post-fire tree growth
  - Not everything is everywhere - root colonization by preferred myco spp. is limited at some sites
  - Pre-fire legacy of ericaceous species can impact colonization
  - Propagule dispersal important for migrating lodgepole pine



- Temporal lags: material legacies of soil organic layer shape success of plant propagules
  - Filter for invasive species spread
  - Refugia or repository for soil microbes
  - Stabilizes plant community composition across disturbance cycles

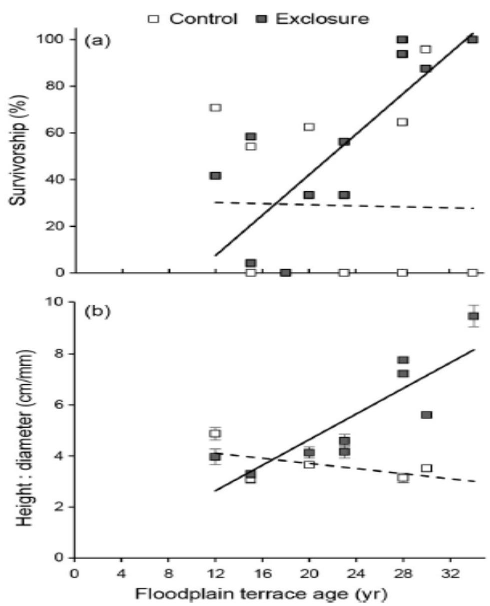
Propagules and post-fire succession

Publications

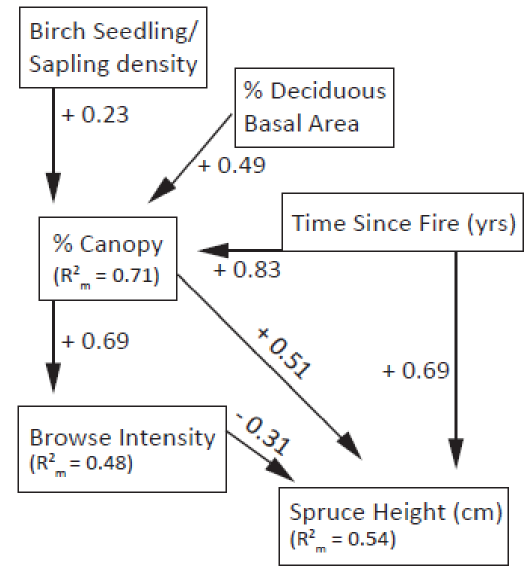
- Hewitt, R. E., F. S. Chapin, T. N. Hollingsworth, and D. L. Taylor. 2017. The potential for mycobiont sharing between shrubs and seedlings to facilitate tree establishment after wildfire at Alaska arctic treeline. Molecular Ecology 26:3826–3838.
- Walker, X. W., M. D. Frey, A. J. Conway, M. Jean, and J. F. Johnstone. 2017. Impacts of fire on non-native plant recruitment in black spruce forests of interior Alaska. PLOS ONE 12:e0171599.
- Holland-Moritz, H., J. Stuart, L.R. Lewis, S.N. Miller, M.C. Mack, S.F. McDaniel, N. Fierer. 2018. Novel bacterial lineages associated with boreal moss species. Environmental Microbiology 20(7). pp. 2625-2638. doi: 10.1111/1462-2920.14288
- Jean, M., M. C. Mack, and J. F. Johnstone. 2018. Spatial and temporal variation in moss-associated dinitrogen fixation in coniferous- and deciduous-dominated Alaskan boreal forests. Plant Ecology 219:837–851.
- deVan, R. in prep (PhD thesis, Taylor lab)
- Johnstone, J., et al. Factors shaping alternate successional trajectories in burned black spruce forests of Alaska. in prep

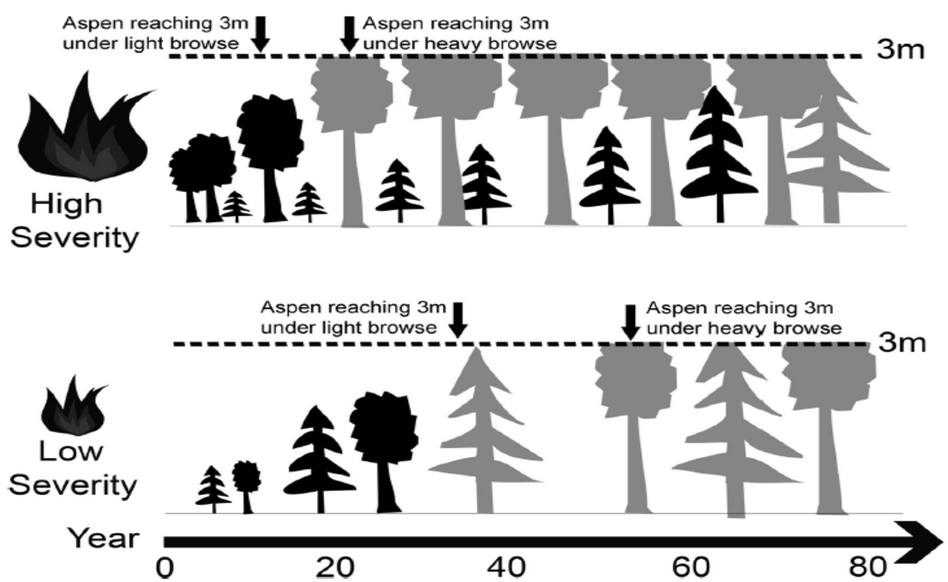
Task D2: Examine the spatial patterning and strength of plant-herbivore interactions across the post-fire landscape in relation to plant growth, species dominance, successional pathway, and biogeochemical cycling (Kielland, Ruess, Genet)

Summary



Herbivory has plethora of effects on plants ranging from small changes in foliar chemistry to major shifts in root/shoot allocation patterns or outright mortality. Much of the recent work on plant succession has focused experimental and observational studies of spruce and aspen demography and the proximate factors that allow these species to flourish or suffer.



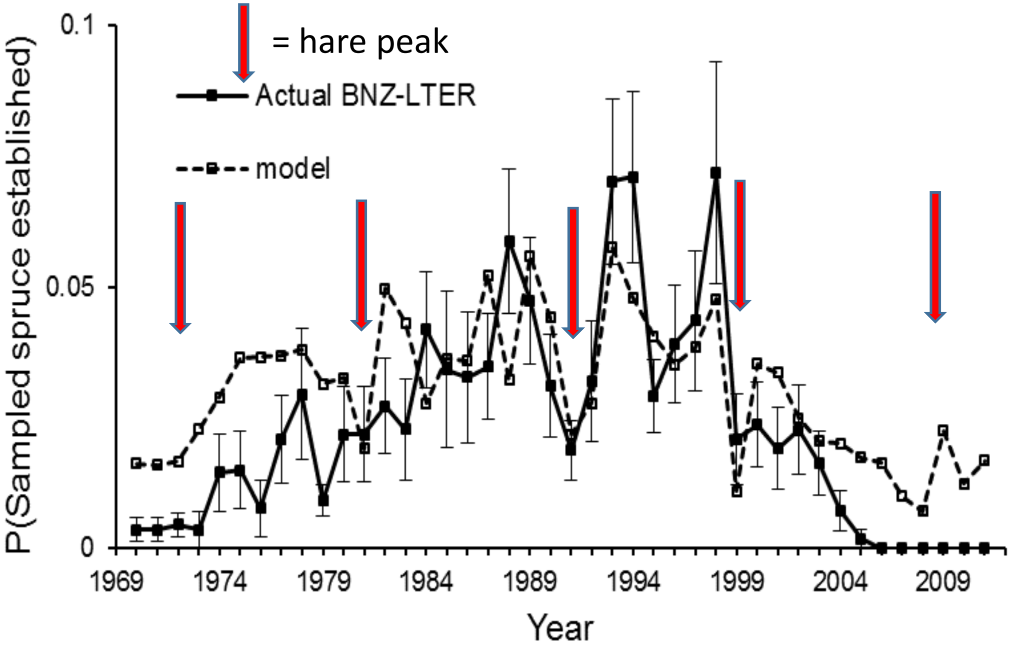


Height growth of spruce and aspen in response to herbivory is influenced by fire severity and browsing intensity.
Height growth rate below and above 3 m differed between browsing intensities. Heavy browsing had a negative effect on annual height growth when individuals were below 3 m; there was no difference between browsing intensities once trees surpassed 3 m in height (Conway and Johnstone 2017).

Salient findings

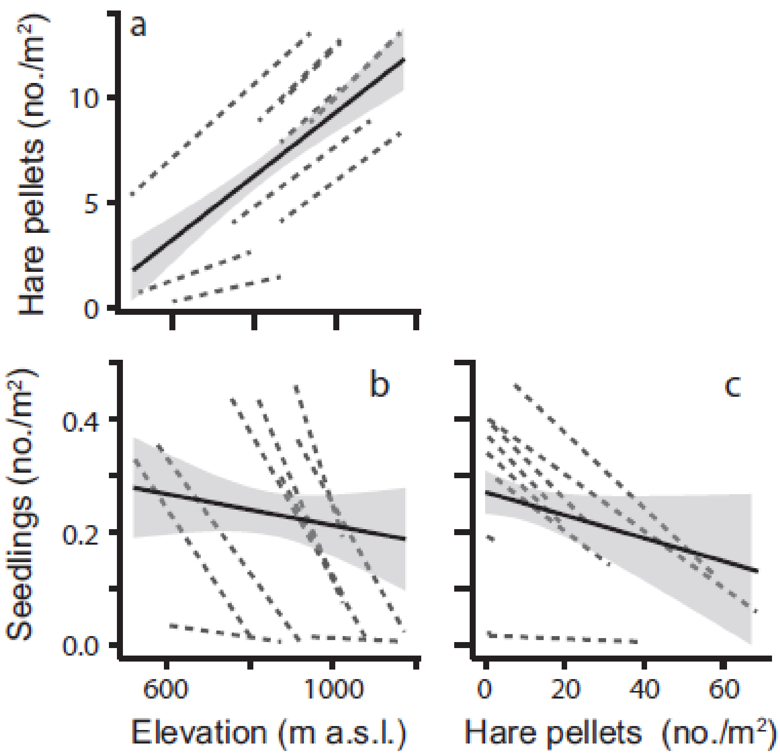
The intensity of herbivory is loosely a function of the plant-herbivore system in question; insects and snowshoe hares typically have drastic 'disturbance' effects, whereas moose exert more of a constant press (except at high densities). Herbivory may accelerate successional change (willow miners, moose) or it may reset/retard succession (hares–spruce). For example, hares can pretty near wipe out an entire (local) cohort of spruce seedlings, resetting the successional clock or slow height growth before the trees finally escape.

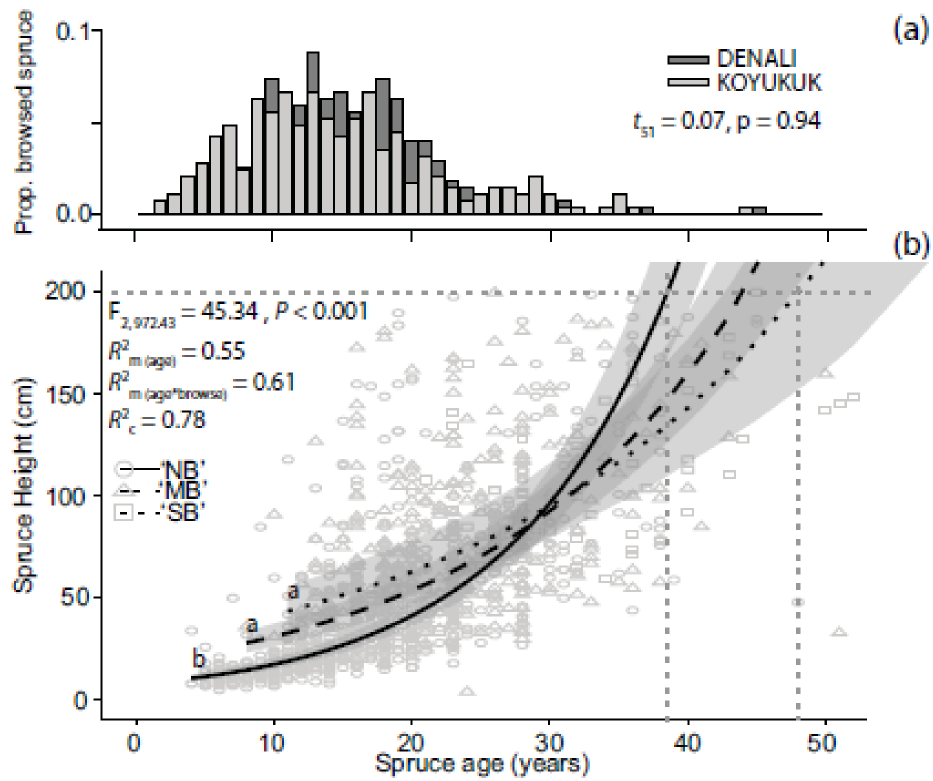
The legacy of these events can be found in the tree age structure reflecting the asynchrony in the recruitment dynamics of hares and spruce (below).



Understanding cross-scale interactive effects

Both insect and mammal herbivory unfold from the scale of a plant to the landscape, and data on long lived plants leave a ditto legacy. Snowshoe hares represent a significant filter to plant recruitment and survival under the right/wrong conditions. Whereas spruce seedlings may be especially vulnerable during post-fire succession due to increased deciduous cover, snowshoe hares also occupy habitats where spruce are increasingly expanding such as the altitudinal and latitudinal tree line.





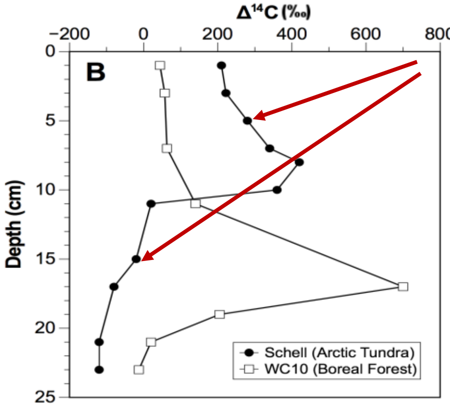
Future directions

- Recruit personnel that will continue field work related to herbivory (some of us are getting increasingly creaky (and cranky).
- Incorporate USFS aerial flight data on plant pathology and possibly remote sensing data to map insect outbreaks.
- Expand current vegetation models to include different kinds of herbivory (e.g., insects, mammals, summer, winter) in different successional/disturbance settings and climate/ecologic hot spots.

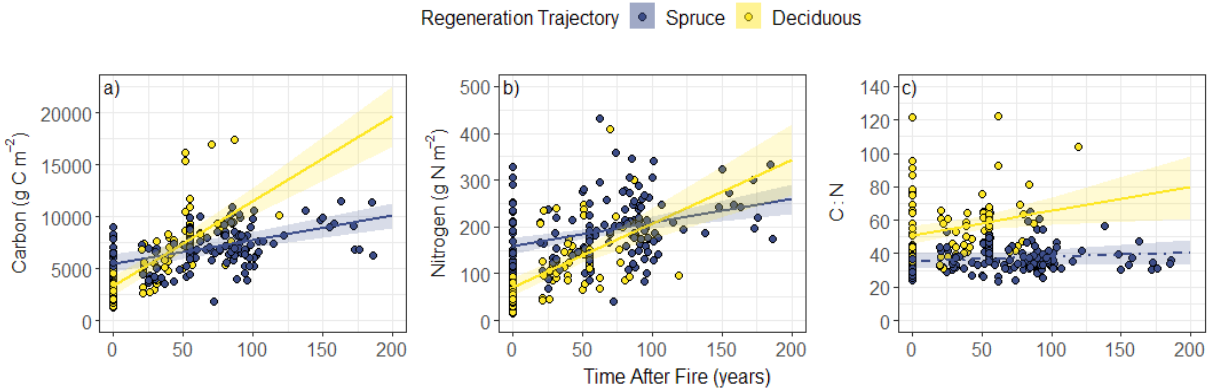
Limitations: *Maintenance support of infrastructure, field vehicles.*

Task D3. Determine the consequences of a changing fire regime and fire-driven permafrost thaw for biogeochemical connectivity between past and present ecosystems

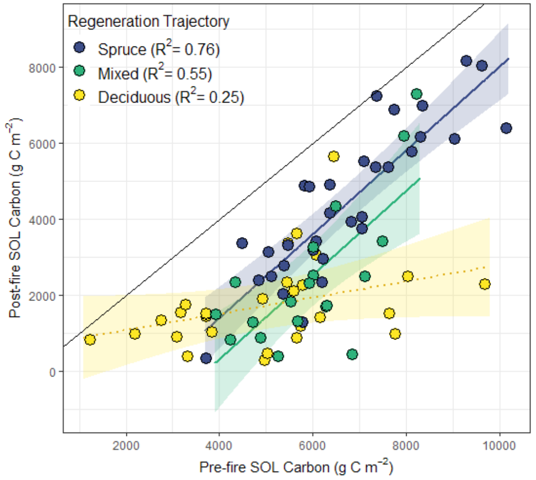
Mack, Turetsky, Schuur, Johnstone, Hollingsworth, Taylor, Harms, Genet, Walker, Melvin, Alexander, Hewitt



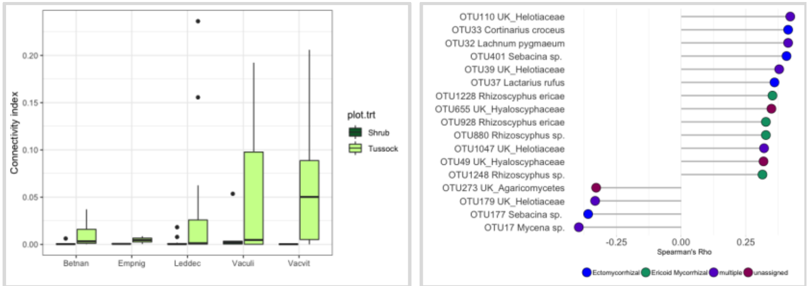
- Combustion of legacy carbon indicates 'unprecedented' disturbance severity
- Shifts NECB over the fire cycle
- Only evident in young-burned stands



- Stands that transition to deciduous store more C at 100 years despite deeper burning/greater combustion C loss
- Accumulate N faster; acquisition of deep N?



- Spruce stands that retained legacy soil organic layers returned to spruce decade after fire
- Stands that lost this legacy transitioned to deciduous dominance



- Tundra test bed at Healy and Toolik
- Rooting depth = deep N acquisition for non-myco spp
- Ericoid and ecto spp use fungi to acquire deep N

Task D3. Determine the consequences of a changing fire regime and fire-driven permafrost thaw for biogeochemical connectivity between past and present ecosystems

Future directions

- What are your plans moving forward?
  - Examine whether acquisition of permafrost N can explain rapid accumulation of N in deciduous stands
    - Evaluate rooting depth of conifer versus deciduous trees across RSN sites (young, intermediate, old)
    - Examine depth profile of mycobionts on roots and compare to deep bulk soil (Hewitt, Taylor)
    - Test for differential deep N foraging between conifer and deciduous species with root and mycorrhizae traps
- What is limiting your efforts?
  - Time, personnel, and money
  - Need to write new grant. Won't happen for another year.

Task D3. Determine the consequences of a changing fire regime and fire-driven permafrost thaw for biogeochemical connectivity between past and present ecosystems

How do these findings inform our understanding cross-scale effects, interactions or feedbacks?

- Combustion of legacy carbon crosses temporal scales; old carbon loss can shift NECB over the disturbance cycle; controls over depth of burning crosses spatial scales.
- Deep burning that removes the legacy of past ecosystems can shift successional trajectories and potential alter the coupling of deep soil with surface processes.
- Legacy nitrogen may subsidize current productivity.
- Spruce recruitment is a local process, but hardwood seed rain is a regional process.
- Biogeographic idiosyncrasies, like pine expansion, might alter these cross-scale dynamics.

Task D3. Determine the consequences of a changing fire regime and fire-driven permafrost thaw for biogeochemical connectivity between past and present ecosystems

Alexander, H. D., S. M. Natali, M. M. Loranty, S. M. Ludwig, V. V. Spektor, S. Davydov, N. Zimov, I. Trujillo, and M. C. Mack. 2018. Impacts of increased soil burn severity on larch forest regeneration on permafrost soils of far northeastern Siberia. Forest Ecology and Management 417:144-153. Doi:10.1016/j.foreco.2018.03.008

Alexander, H. D., and M. C. Mack. 2017. Gap regeneration within mature deciduous forests of Interior Alaska: Implications for future forest change. Forest Ecology and Management **396**:35-43. Doi:10.1016/j.foreco.2017.04.005

Day, N., K. Dunfield, J. Johnstone, M. Mack, M. Turetsky, X. Walker, A. White, and J. Baltzer. Submitted-a. Edaphic factors and disturbance severity reduce richness and alter composition of soil fungal communities: Implications for ecosystem resilience. Global Change Biology.

Day, N. J., A. L. White, J. F. Johnstone, S. G. Cumming, M. C. Mack, M. R. Turetsky, X. J. Walker, and J. L. Baltzer. Submitted-b. Environmental characteristics interact with fire to shape boreal forest plant community assembly: the importance of soil moisture and regeneration traits for information legacies. Ecology.

Hewitt, R. E., D. L. Taylor, H. Genet, A. D. McGuire, and M. C. Mack. 2019. Below-ground plant traits influence tundra plant acquisition of newly thawed permafrost nitrogen. Journal of Ecology 107:950-962. Doi:10.1111/1365-2745.13062

Mack, M.C., X.J. Walker, J.F. Johnstone, H.D. Alexander, April M. Melvin, S.A. Miller. In prep. Impacts of increasing wildfire severity on the long-term carbon dynamics of Alaskan boreal forests

Schuur, E. A. G., and M. C. Mack. 2018. Ecological response to permafrost thaw and consequences for local and global ecosystem services. Annual Review of Ecology, Evolution, and Systematics 49:279-301

Walker, X. J., J. L. Baltzer, S. G. Cumming, N. J. Day, J. F. Johnstone, B. M. Rogers, K. Solvik, M. R. Turetsky, and M. C. Mack. 2018a. Soil organic layer combustion in boreal black spruce and jack pine stands of the Northwest Territories, Canada. International Journal of Wildland Fire 27:125-134. Doi:10.1071/Wf17095

Walker, X. J., B. M. Rogers, J. L. Baltzer, et al. 2018b. Cross-scale controls on carbon emissions from boreal forest megafires. Global Change Biology 24:4251-4265. Doi:10.1111/gcb.14287

Walker, X., Baltzer, J., Cumming, S. G., Day, N. J., Ebert, C., Goetz, S., Johnstone, J.F., Rogers, B. M., Schuur, E. A. G., Turetsky, M., and Mack, M. In Review. Increasing wildfires threaten historic carbon sink of boreal forest soils, Nature

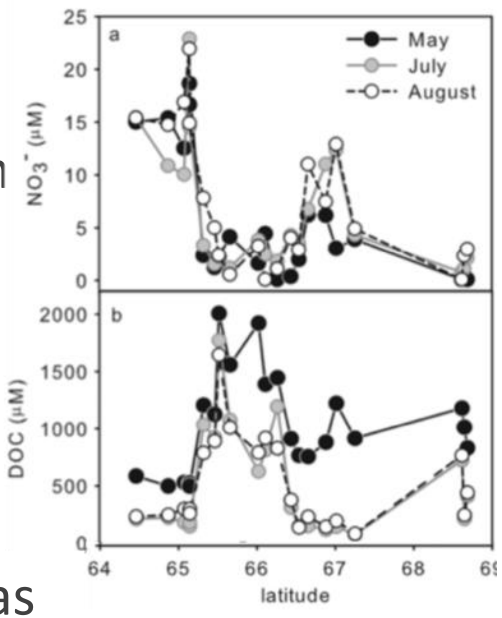
Walker, X., Baltzer, J., Barrett, K., Bourgeau-Chavez, L., Brown, C. L., Day, N. J., de Groot, W. J., Dieleman, C., Enders, S., Goetz, S., Hoy, E. E., Jenkins, L., Johnstone, J., Kane, E., Natali, S., Parisien, M., Rogers, B. M., Schuur, E. A. G., Turetsky, M., Veraverbeke, S., Whitman, E. and Mack, M. In Prep. Bottom-up controls of area-based C emissions from boreal wildfires, Nature Geosciences

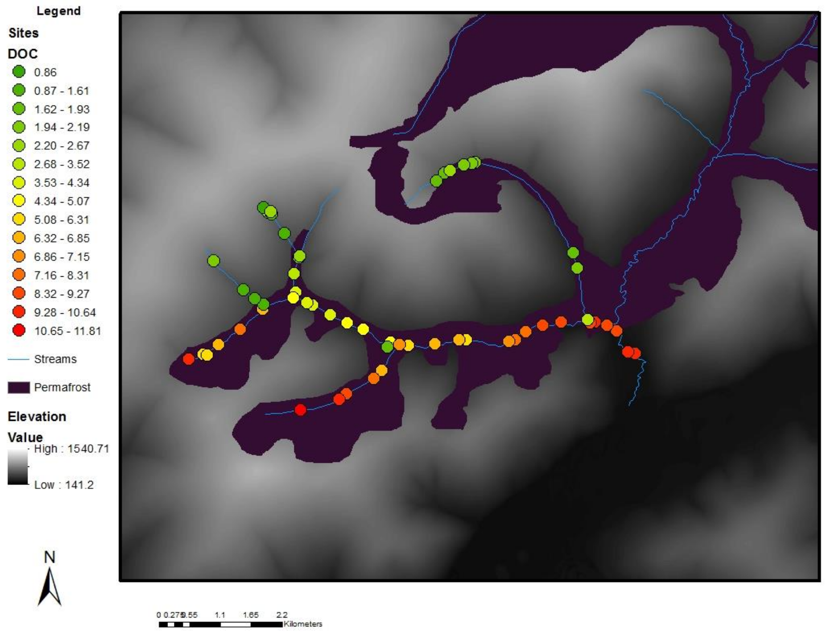
Task D4: Examine the interactions among changes in climate, permafrost, and vegetation on soil water retention, hydrologic partitioning, and stream export of C and N across upland boreal forest catchments

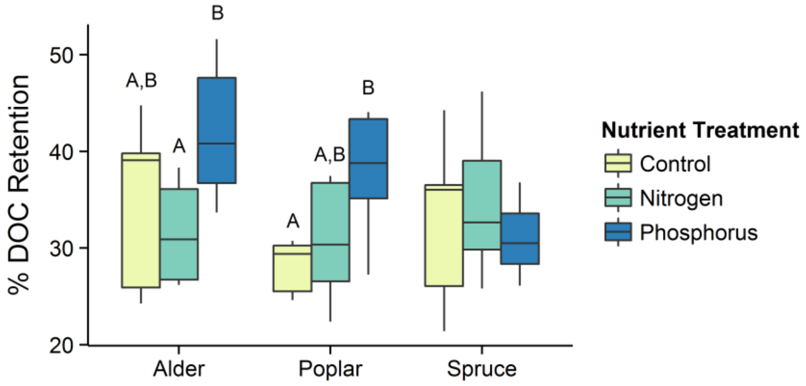
- Jones and Harms

A brief summary of findings related to the task

- Stream water chemistry is related to permafrost extent with dissolved organic carbon (DOC) concentration higher in stream draining watersheds with extensive greater permafrost extent, whereas nitrate concentration is lower.
- Wildfire in catchments results in lower DOC concentration and elevated nitrate.
- Across interior AK, DOC concentration is inversely related to catchment slope, whereas nitrate concentration is directly related (Harms et al. 2016).
- Within streams, DOC retention is greatest for DOM enriched in phosphorus (Mutschlecner et al. 2017)







Task D4: Examine the interactions among changes in climate, permafrost, and vegetation on soil water retention, hydrologic partitioning, and stream export of C and N across upland boreal forest catchments

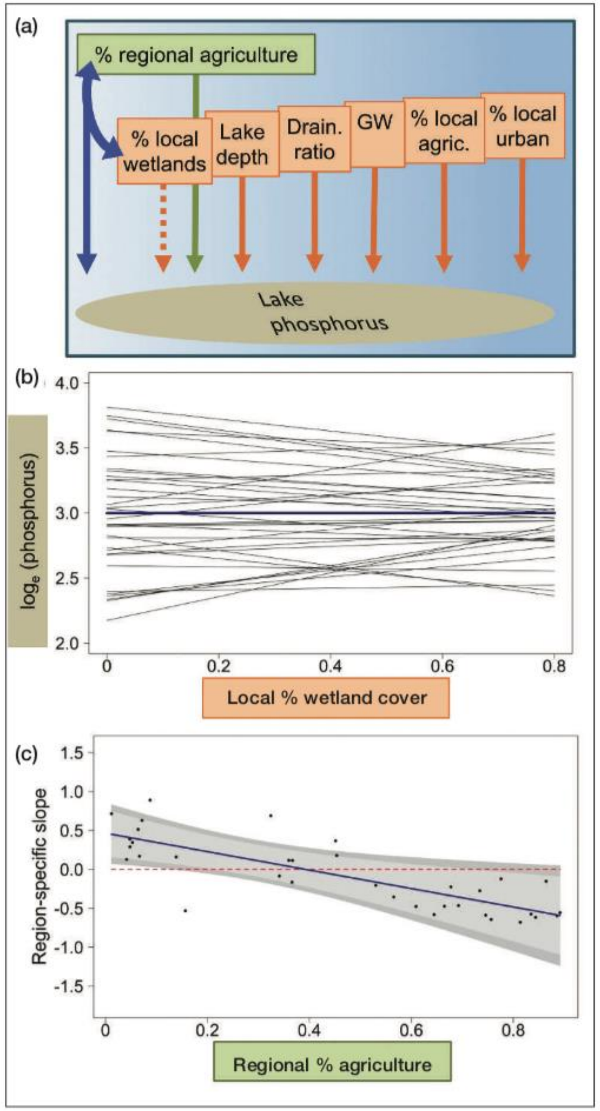
Future directions

- What are your plans moving forward?
  - Nitrous oxide (N_2O) emissions from the boreal forest (M.S. student Melanie Burnett)
  - The interactive effects of inorganic nutrient, dissolved organic matter, and light availability on autotrophic and heterotrophic activity (M.S. student Sophie Weaver)
  - Interaction between nutrients and ectoenzymes on dissolved organic matter decomposition (M.S. student. Marie Schmidt)
  - Long-term trends in steam water chemistry in the boreal forest (Christina Baker and Jones)
  - Temporal trends in stream chemistry across biomes (NCEAS working group)
  - Hydrologic partitioning in boreal forest catchments
- What is limiting your efforts?
  - Funds to support high-throughput analysis of trace gases and isotopic analysis of N_2O

Task D4: Examine the interactions among changes in climate, permafrost, and vegetation on soil water retention, hydrologic partitioning, and stream export of C and N across upland boreal forest catchments

How do your findings inform understanding cross-scale interactive effects?

- Thaw influence on nitrate export from upland streams may result in fertilization and increased productivity of coastal ecosystems
- Permafrost/vegetation distributions and wildfire history at larger spatial scales determine spatial and temporal dynamics of stream chemistry and biotic communities



From Soranno et al. 2014

Task D4: Examine the interactions among changes in climate, permafrost, and vegetation on soil water retention, hydrologic partitioning, and stream export of C and N across upland boreal forest catchments

Publications and datasets

- Farrell, K. J., Rosemond, A. D., Kominoski, J. S., Bonjour, S. M., Ruegg, J., Koenig, L. E., et al. (2018). Variation in detrital resource stoichiometry signals differential carbon to nutrient limitation for stream consumers across biomes. *Ecosystems*, *21*(8), 1676–1691. http://doi.org/10.1007/s10021-018-0247-z
- Mutschlecner, A. E., Guerard, J. J., Jones, J. B., & Harms, T. K. (2018). Regional and intra-annual stability of dissolved organic matter composition and biolability in high-latitude Alaskan rivers. *Limnology and Oceanography*, *63*(4), 1605–1621. http://doi.org/10.1002/lno.10795 (accompanying dataset: http://www.lter.uaf.edu/data/data-detail/id/664)
- Mutschlecner, A. E., Guerard, J. J., Jones, J. B., & Harms, T. K. (2018). Phosphorus enhances uptake of dissolved organic matter in boreal streams. *Ecosystems*, *21*(4), 675–688. http://doi.org/10.1007/s10021-017-0177-1 (accompanying dataset: http://www.lter.uaf.edu/data/data-detail/id/665)
- Song, C., Dodds, W. K., Ruegg, J., Argerich, A., Baker, C. L., Bowden, W. B., et al. (2018). Continental-scale decrease in net primary productivity in streams due to climate warming. *Nature Geoscience*, *11*(6), 415–420. http://doi.org/10.1038/s41561-018-0125-5
- Harms, T.K., J.W. Edmonds, H. Genet, I.F. Creed, D. Aldred, A. Balser, J.B. Jones. 2016. Catchment influences on nitrate and dissolved organic matter in Alaska Streams across a latitudinal gradient. Journal of Geophysical Research: Biogeosciences.
- Rüegg, J. et al. 2015. Baseflow physical characteristics differ at multiple spatial scales in stream networks across diverse biomes. Landscape Ecology
- Rinehart, A.J., J.B. Jones, and T.K. Harms. 2015. Hydrologic and biogeochemical influences on carbon processing in the riparian zone of a subarctic stream. Freshwater Science
- Ding, Y., Y. Hamashita, J. Jones, and R. Jaffé. 2014. Dissolved black carbon in boreal forest and glacial rivers of central Alaska: assessment of biomass burning versus anthropogenic sources. Biogeochemistry

Planned publications

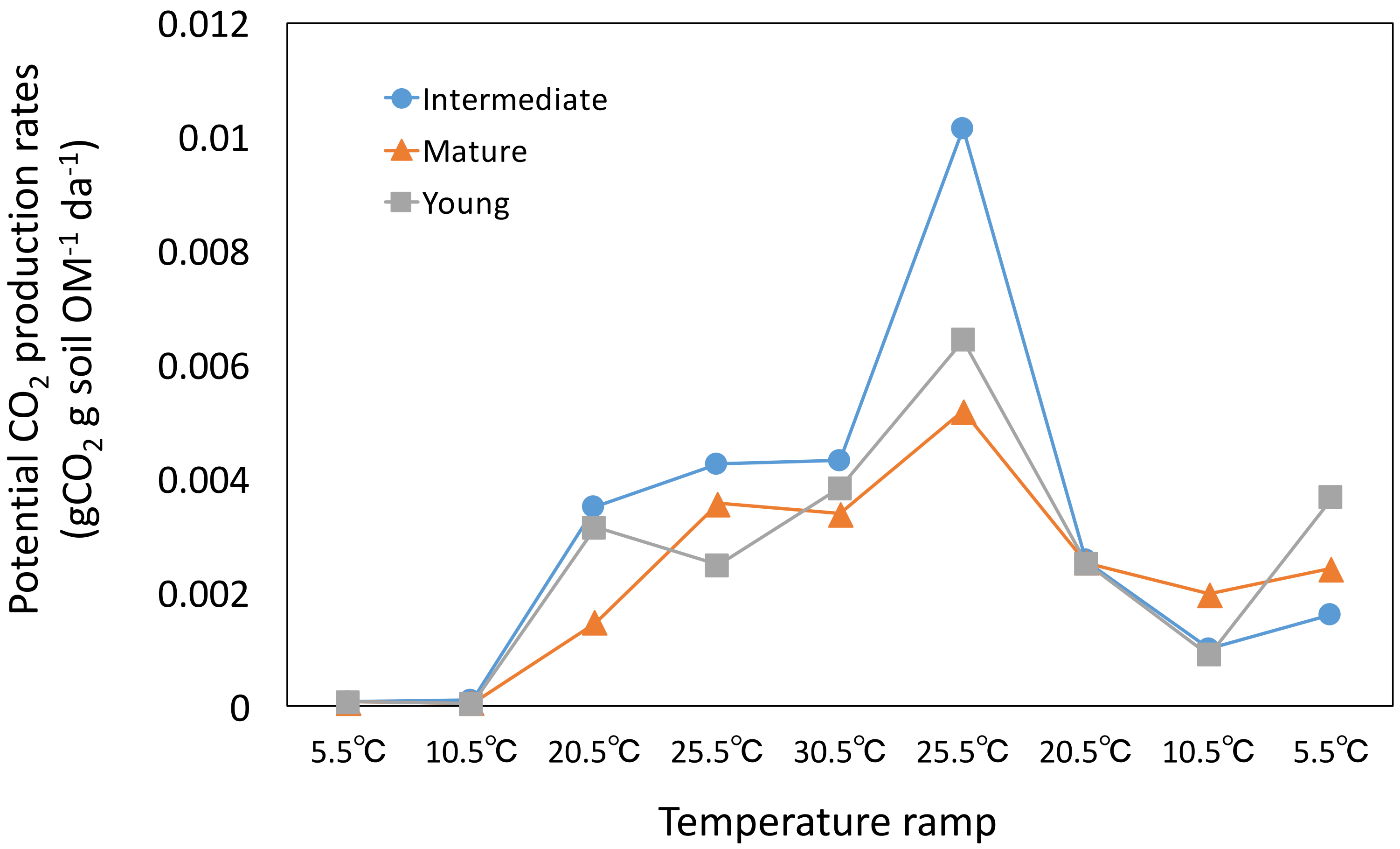
- J.A. Jones, P.M. Groffman, J. Blair, F. Davis, H. Dugan, E. Euskirchen, S. Frey, T.K. Harms, E.L. Hinckley, M. Kosmala, S. Loberg, S. Malone, K. Novick, S. Record, A.V. Rocha, B. Ruddell, E. Stanley, C. Sturtevant, A. Thorpe, T. White, W. Wieder, L. Zhai, K. Zhu. The age of network science: Synergies between NEON and LTER in the US, in revision, *Bioscience*
- Webster et al.: Permafrost and fire influence on temporal patterns in biogeochemistry of boreal headwater catchments
- Webster, Harms, Chapin, Johnstone, & others: Catchment hydrobiogeochemistry indicates ecosystem resilience

Task D5: Determine influences of vegetation and permafrost thaw on soil C storage and soil water retention and hydraulic properties (Turetsky, Schuur, Mack, Kane)

The goals of this task are to

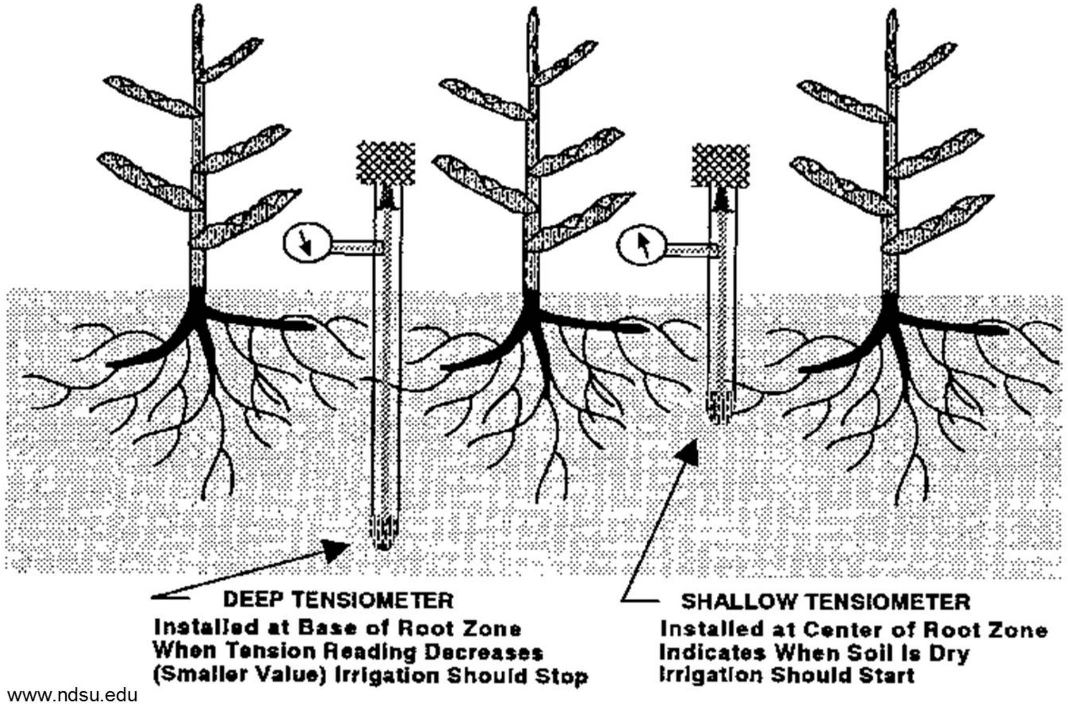
1) Build from D4 activities at CPCRW and extend across the site network
2) Explore relationships between soil carbon and water storage and how this relates to the temperature and moisture sensitivity of soil carbon mineralization
3) Serve as a tool for integration between D3 and D4

Ongoing activities: series of short and long-term incubation experiments to explore variation in soil organic matter quality across the site network. Need to link these results into D3 results.



Future activities: Build a soil hydrophysical database for boreal soils, starting with the site network. Start with site attributes and soil properties that relate to soil hydrology. Start to quantify water retention under lab and field conditions.

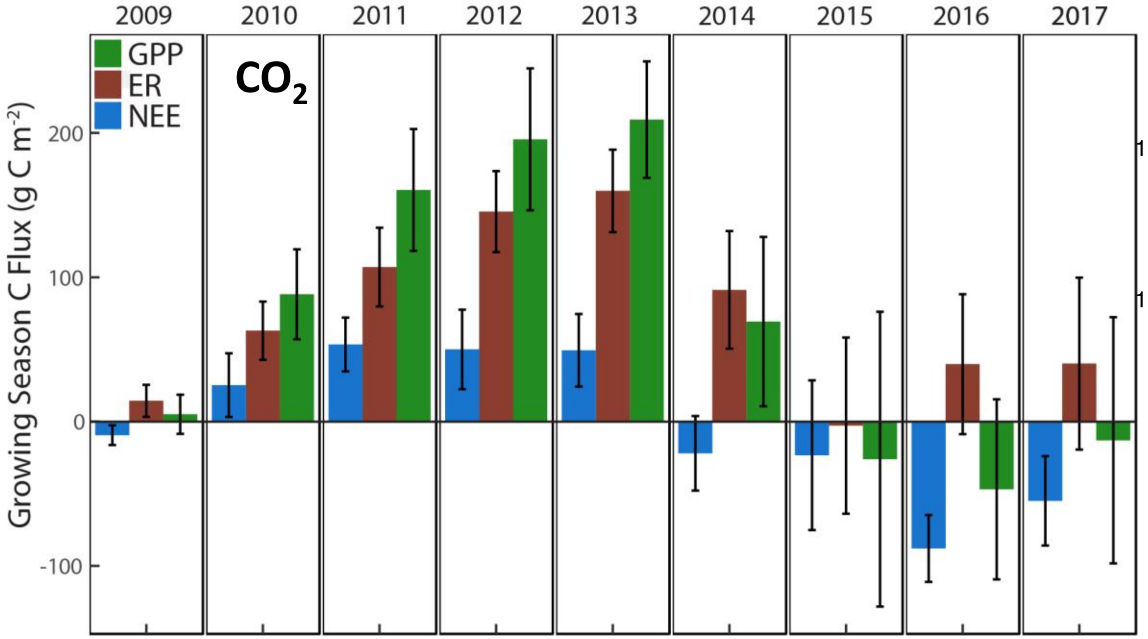
Lab based soil water retention curves (pressure plate method)

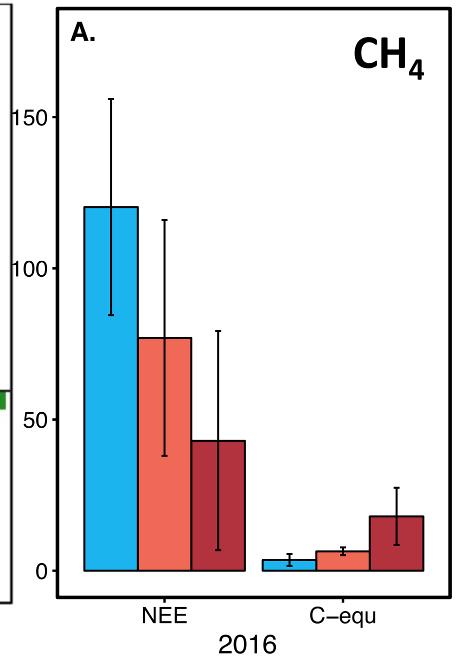


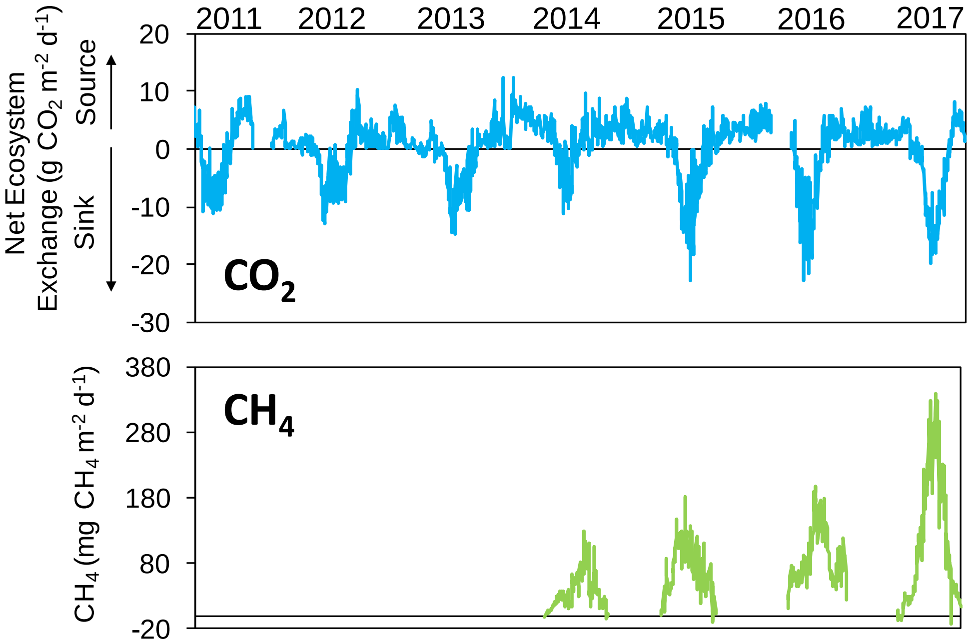
Monitor soil moisture with depth for representative soil profiles under field conditions

D6: Use global change experiments situated in contrasting upland and lowland ecosystems to determine ecosystem responses to changes in permafrost extent and surface hydrology

Schuur and Turetsky







CO_2 and CH_4 exchange: Upland tundra (CiPEHR; warming, drying), and fen (APEX; lower water table, interannual var.)

Upland: Ecosystem C balance net uptake first stimulated by warming, then net release; CH_4 persistent

Wetland : Ecosystem C balance resilient to flooding and drought cycles

D6: Use global change experiments situated in contrasting upland and lowland ecosystems to determine ecosystem responses to changes in permafrost extent and surface hydrology

Future directions

- **CiPHER**: Transition point in experiment. New proposal for final phase submitted to DOE TES Mar 2019; (LTREB, ANS)
- **APEX**: New infrastructure upgrades; LTREB; …
- What is limiting your efforts?
  - Good field work is hard; good field manipulations are harder

D6: Use global change experiments situated in contrasting upland and lowland ecosystems to determine ecosystem responses to changes in permafrost extent and surface hydrology

Cross-scale interactions: Experiments and observations identify interactions between warming, permafrost thaw, surface hydrology across geomorpological gradients

D6: Use global change experiments situated in contrasting upland and lowland ecosystems to determine ecosystem responses to changes in permafrost extent and surface hydrology

2018 Publications:

158. Feng, J., C. R. Penton, Z. He, J.D. Van Nostrand, M.M. Yuan, L. Wu, C. Wang, Y. Qin, Z.H. Shi, X. Guo, **E.A.G Schuur,** Y. Luo, R. Bracho, K.T. Konstantinidis, J.R. Cole, J.M. Tiedje, Y. Yang, J. Zhou. 2019. Long-term warming in Alaska enlarges the diazotrophic community in deep soils. mBio. 10(1) DOI: 10.1128/mBio.02521-18
157. van Gestel, Z Shi, KJ van Groenigen, CW Osenberg, LC Andresen, JS Dukes, MJ Hovenden, Y Luo, A Michelsen, E Pendall, PB Reich, **EAG Schuur**, and BA Hungate. Nature Climate Change, submitted.
156. Turetsky, M. **EAG Schuur** et al. 2018. Abrupt thaw amplifies the permafrost carbon feedback through upland erosion and methane hotspots. Nature, submitted.
155. Natali, SM, **EAG Schuur** et al. 2018. Winter respiration in tundra ecosystems. Submitted.
154. Hale, L., **EAG Schuur** et al. 2018. Tundra microbial community taxa and traits predict decomposition parameters of stable, older soil organic carbon. ISME Journal, submitted.
153. Hutchings, J, **EAG Schuur** et al. 2018. Millenial-scale carbon accumulation and molecular transformation in a permafrost core from Interior Alaska. Geochimica and Cosmochimica Acta, submitted.
152. Mauritz, M., G. Celis, C. Ebert, J. Hutchings, J. Ledman, S.M. Natali, E. Pegoraro, V.G. Salmon, C. Schaedel, M. Taylor, & **E.A.G. Schuur.** 2018. Using Stable Carbon Isotopes of Seasonal Ecosystem Respiration to Determine Permafrost Carbon Loss. JGR Biogeosciences. 124(1): 46-60. DOI: 10.1029/2018JG004619
151. Pegoraro, E., M. Mauritz, R. Bracho, C. Ebert, P. Dijkstra, B.A. Hungate, K.T. Konstantinos, Y. Luo, C. Schaedel,J.M. Tiedje, J. Zhou, **E.A.G Schuur.** 2019. Glucose addition increases the magnitude and decreases the age of soil respired carbon in a long-term permafrost incubation study. Soil Biology and Biochemistry. 129: 210-211. DOI: 10.1016/j.soilbio.2018.10.009
150. **Schuur, E.A.G.**, and M.C. Mack. 2018. Ecological response to permafrost thaw and consequences for local and global ecosystem services. Annual Reviews of Ecology, Evolution, and Systematics. 49: 279-301.
149. Plaza, C., Mauritz, M., Bracho, R.G., Salmon, V.G., Webb, E., Hutchings, J.A., Natali, S., Crummer, K.G., Schaedel, C., **E.A.G. Schuur**. 2018. Rapid changes in the permafrost soil carbon pool in response to warming. Submitted.
148. Kwon, M., S.M Natali, C.E. Hicks Pries, **E.A.G. Schuur,** A. Steinhog, K.G. Crummer, N. Zimov, S.A. Zimov, M. Heimann, O. Kolle, M. Gocked. 2019**.** Drainage enhances surface soil decomposition but stabilizes old carbon pools in tundra ecosystems. Global Change Biology. 25(4): 1315-1325. DOI: doi.org/10.1111/gcb.14578
147. Prevey, J.S., C. Rixen, N. Ruger, T.T. Hoye, A.D. Bjorkman, I.H. Myers-Smith, I.W.A. Elmendorf, N. Cannone, C.L. Chisholm, K. Clark, E.J. Cooper, B. Elberling, A.M. Fosaa, G.H.R. Henry, R.D. Hollister, I.S. Jonsdottier, K. Klanderud, C.W. Kopp, E. Levesque, M. Mauritz, U. Molau, S.M. Natali, S.F. Oberbauer, Z.A. Panchen, E. Post, S.B. Rumpf, N.M Schmidt, **E.A.G. Schuur,** P.R. Semenchuk, J.G. Smith, K.N. Suding, O. Totland, T. Troxler, S. Venn, C.H. Wahren, J.M. Welker, S. Wipf. 2018. Warming shortens flowering seasons of Arctic and alpine plant communities. Nature Ecology and Evolution. 3: 45-52.
146. Schaedel, C, C Koven, DM Lawrence, G Celis, AJ Garnello, J Hutchings, M Mauritz, SM Natali, E Pegoraro, H Rodenhizer, VG Salmon, M Taylor, EE Webb, WR Weider, and **EAG Schuur**. 2018. Divergent patterns of experimental and model-derived permafrost ecosystem carbon dynamics in response to Arctic warming. 2018. Environmental Research Letters 13: 105002
145. Plaza, C, C Zaccone, K Sawicka, AM Mendez, A Tarquis, G Gasco, GBM Heuvelink, **EAG Schuur**, and FT Maestre. 2018. Soil resources and element stocks in drylands to face global issues. Scientific Reports 8:1 13788.
144. Salmon, VG, C Schaedel, R Bracho, E Pegoraro, G Celis, M Mauritz, MC Mack, and EAG Schuur. 2018. Adding depth to our understanding of nitrogen dynamics in permafrost soils. JGR Biogeosciences. https://doi.org/10.1029/2018JG004518
143. Taylor, M., G. Celis, J.D. Ledman, R. Bracho, and **E.A.G. Schuur**. 2018. Methane efflux measured by eddy covariance in Alaskan upland tundra undergoing permafrost degradation. JGR Biogeosciences. https://doi.org/10.1029/2018JG004444
140. Liang, J., J. Xia, Z. Shi, L. Jiang, S. Ma, X. Lu, M. Mauritz, S.M. Natali, E. Pegoraro, C.R. Penton, C. Plaza, V.G. Salmon, G. Celis, J.R. Cole, K.T. Konstantinidis, J.M Tiedje, J. Zhou, **E.A.G. Schuur,** & Y. Luo. 2018. Biotic responses buffer warming-induced soil organic carbon loss in arctic tundra. Global Change Biology. 24(10): 4946-4959. DOI: **doi.org/10.1111/gcb.14325**
139. **Schuur, E. A. G.,** A. D. McGuire, V. Romanovsky, C. Schädel, and M. Mack, 2018: Chapter 11: Arctic and boreal carbon. In Second State of the Carbon Cycle Report (SOCCR2): A Sustained Assessment Report [Cavallaro, N., G. Shrestha, R. Birdsey, M. A. Mayes, R. G. Najjar, S. C. Reed, P. Romero-Lankao, and Z. Zhu (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 428-468, https://doi.org/10.7930/ SOCCR2.2018.Ch11.
137. Liang, J., C. Huo, Z. Shi, J.R. Cole, K.T. Konstantinidis, Z. Luo, C. Ryan Penton, **E.A.G. Schuur**, J.M. Tiedje, Y.-P. Wang, L. Wu, J. Zhou, Y. Luo. More Replenishment than Priming Loss of Soil Organic Carbon with Additional Carbon Input. 2018. Nature Communications 9:1 3175.
135. Yuan, M.M., J. Zhang, K. Xue, L. Wu, Y. Deng, J. Deng, L. Hale, X. Zhou, Z. He, Y. Yang, J.D. Van Nostrand, **E.A.G. Schuur**, K.T. Konstantinidis, C.R. Penton, J.R. Cole, J.M. Tiedje, Y. Luo and J. Zhou. 2018. Microbial functional diversity covaries with permafrost thaw-induced environmental heterogeneity in tundra soil. Global Change Biology 24:297-307.
134. van Gestel, N., Z. Shi, K.J. van Groenigen, C.W. Osenberg, L.C. Andresen, J. Dukes, M.J. Hovenden, Y. Luo, A. Michelsen, E. Pendall, P.B. Reich, **E.A.G. Schuur**, and B.A. Hungate. Predicting soil carbon loss with warming. 2018. Nature 554: E4-5. doi:10.1038/nature25745

BNZ LTER Submitted Datasets: 75+

+ all of Merritt's/APEX that I don't have on here

Task D7: Characterize patterns and drivers of recent changes in regional distributions of key plant pathogens, assess pathogen effects on plant growth, community composition, and successional dynamics, and predict future impacts on ecosystem function at regional scales. (Ruess, Lori Winton, USDA State and Private Forestry; Gerry Adams, U Nebraska)

Inventory of >18,000 trees across 8 ecoregions indicates that:

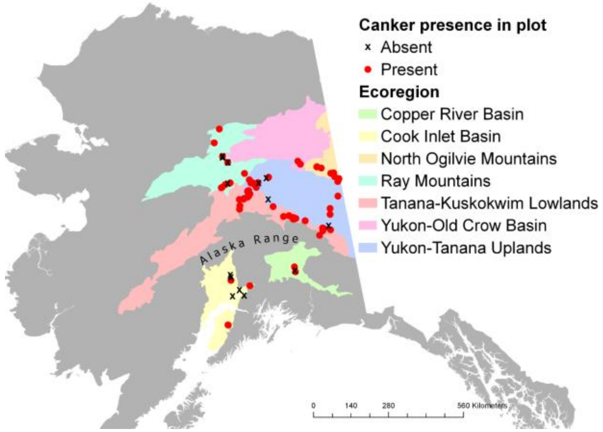
Infection is widespread across interior AK

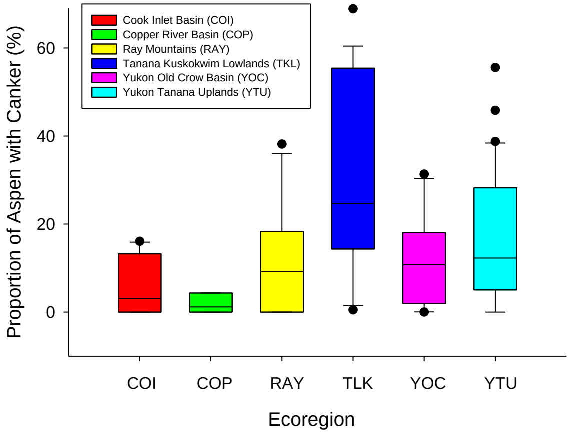
Infection is higher on smaller DBH trees, and increases with total aspen basal area and average aspen DBH, which is our best indicator of stand age.

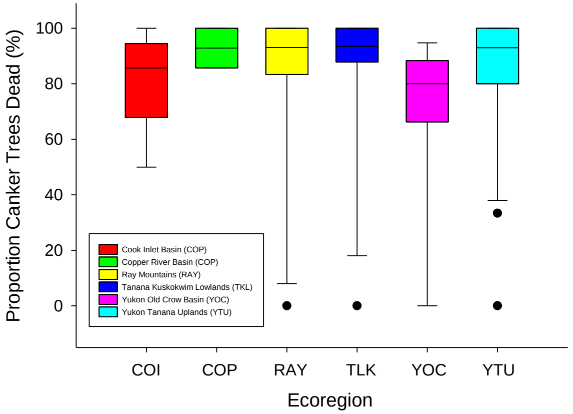
Smaller diameter trees in older stands are particularly vulnerable to the canker, and most are dead from the disease. However, small diameter trees in younger stands are almost completely devoid of canker.

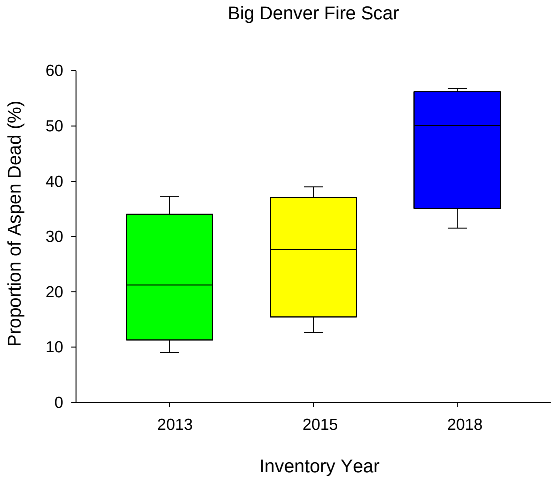
Most of trees with canker are either dead or dying

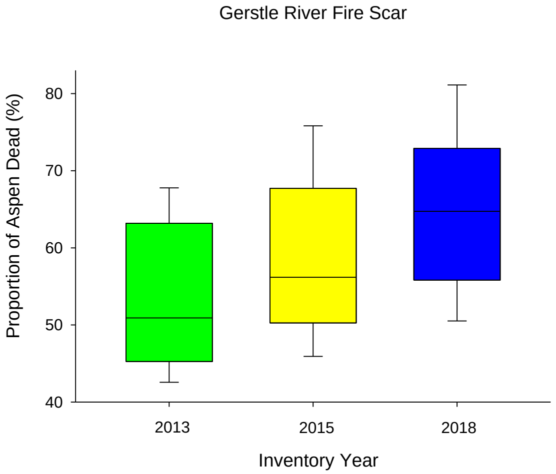
Reinventory of RSN plots suggest the disease was likely well underway when plots were first inventoried, and is still spreading within stands.











Task D7: Characterize patterns and drivers of recent changes in regional distributions of key plant pathogens, assess pathogen effects on plant growth, community composition, and successional dynamics, and predict future impacts on ecosystem function at regional scales.

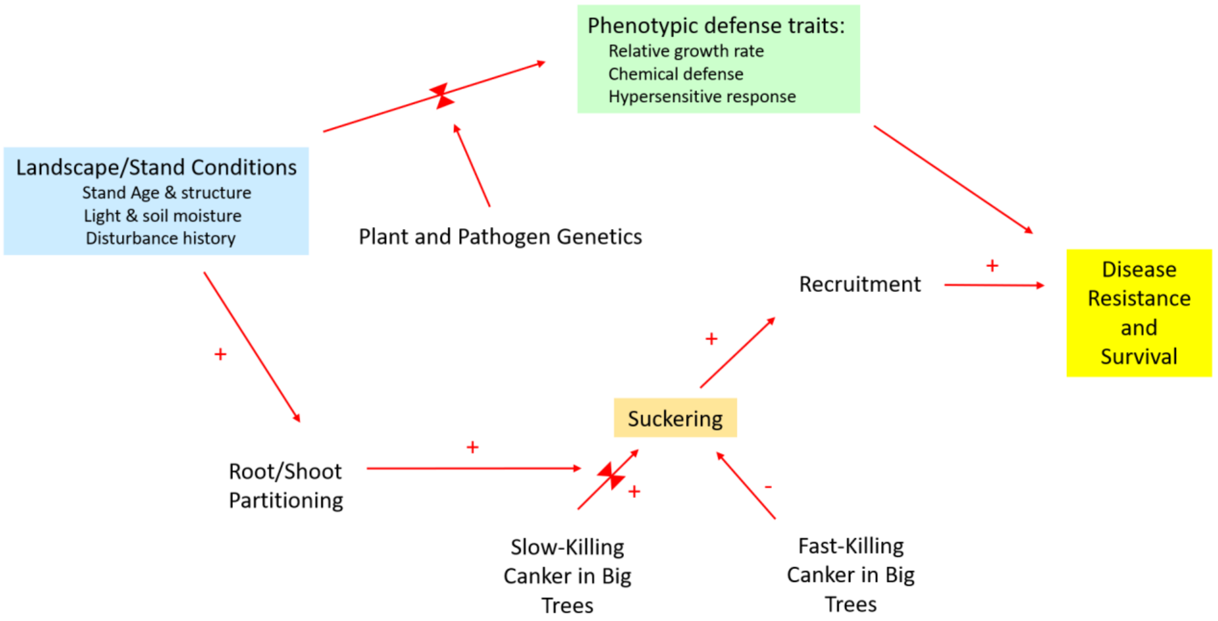
Fungi isolated from infected trees, grown in culture, and DNA sequenced suggest *Nakazawaea wyomingensis* as a putative causal agent. Additionally, microbial community analysis using metagenomics also shows this yeast abundant in cankers yet absent in healthy trees. We have initiated greenhouse experiments infecting boles with culture isolates, and will be infecting trees within experimental plots this summer.

We have initiated an experiment to test whether shade increases vulnerability to infection among young trees in young stands. In 2018, replicate plots (20 x 25 m) were set up, and spring 2019, 30% shade cloth will extended above the canopy at a height of 15m. Damage/inoculation treatments will be imposed in TRMT and CTL plots this summer. Disease and AGNPP are being monitored in all plots; would like to use transcriptomics to assess the up- and down-regulation of defensive chemistry.

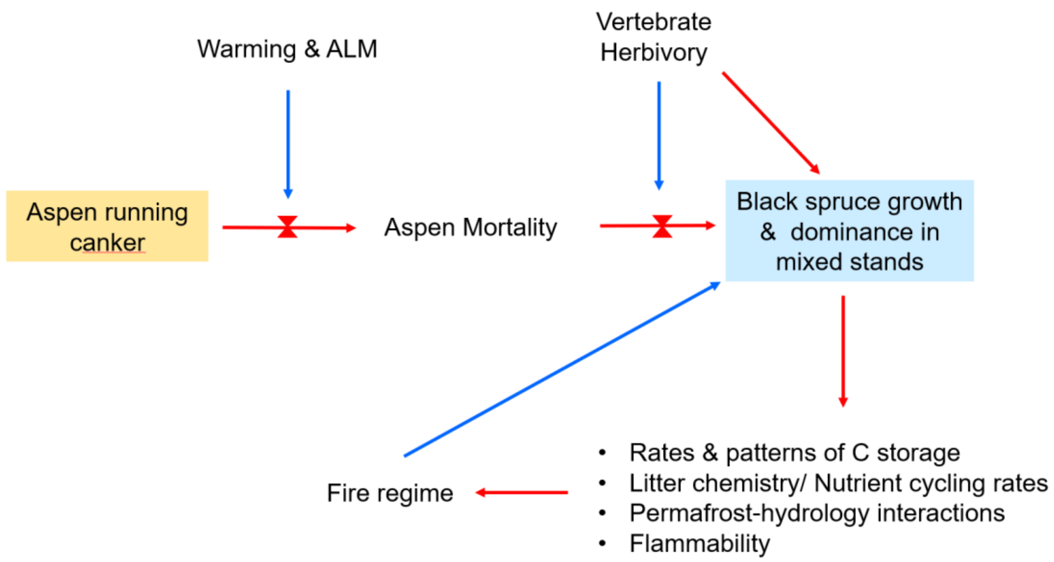
During the summer of 2019, we will begin measurements of shoot growth rates of black spruce in Gerstel River RSN plots to assess how changing aspen overstory is influencing dominant understory species.

Task D7: Characterize patterns and drivers of recent changes in regional distributions of key plant pathogens, assess pathogen effects on plant growth, community composition, and successional dynamics, and predict future impacts on ecosystem function at regional scales.

Disease spread / aspen resistance and survival



Long-term impacts on ecosystem function

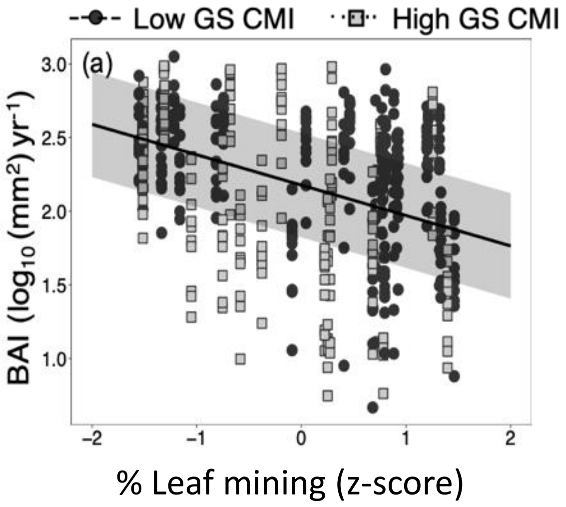


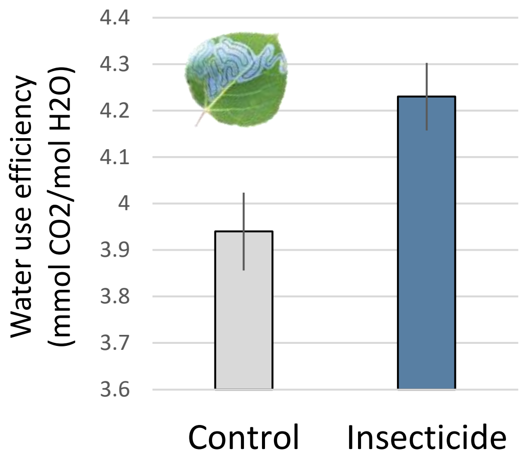
Task D7: Characterize patterns and drivers of recent changes in regional distributions of key plant pathogens, assess pathogen effects on plant growth, community composition, and successional dynamics, and predict future impacts on ecosystem function at regional scales.

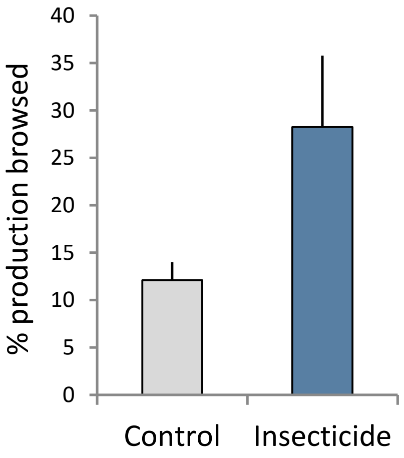
Data sets: yes, not uploaded
Manuscripts: in prep

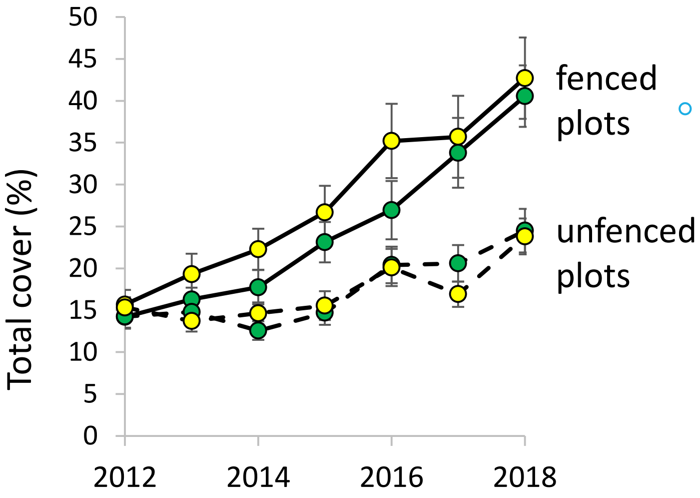
Task D8: Examine the direct and interactive effects of insect herbivores and vertebrate browsers on plant growth, biogeochemical cycling, and vegetation development in early successional stands

Diane Wagner, Knut Kielland, Roger Ruess









- Direct effects of herbivory
  - Ongoing monitoring of aspen insect herbivory (since 2004)
  - Tree ring, remote sensing: aspen leaf miner (ALM) reduces photosynthesis and growth (Boyd et al. 2019 in rev; Juday et al. in prep.)
  - ALM damage has negative effect on water status (Wagner, Burr in prep)
  - Willow leaf blotch miner also decreases growth of susceptible host species (Wagner & Doak 2018)
  - Browsing effects on aspen growth depend on fire severity (Conway, Johnstone 2017)

- Interactive effects of insect herbivory and browsing
  - Insect herbivory initially reduced productivity & offtake by browsers (Allman et al. 2018)
  - Vertebrate browsers exert much stronger control over community development than insects

Task D8: Examine the direct and interactive effects of insect herbivores and vertebrate browsers on plant growth, biogeochemical cycling, and vegetation development in early successional stands

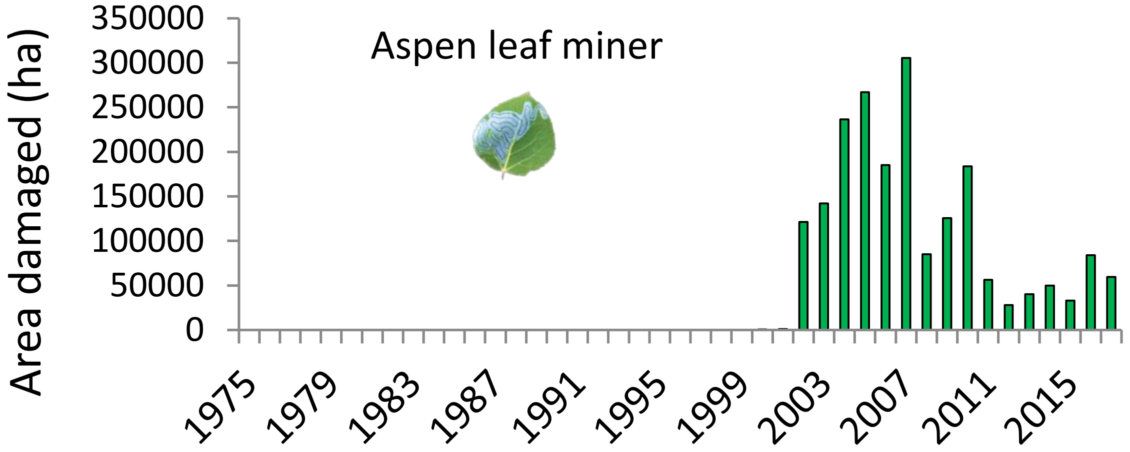
Future directions

- What are your plans moving forward?
  - Impacts of aspen leaf mining across range of water availability
  - Continued collaborative work on physiological effects of leaf mining
  - Browsing x insect herbivory experiment – continuation ~3 years max

Task D8: Examine the direct and interactive effects of insect herbivores and vertebrate browsers on plant growth, biogeochemical cycling, and vegetation development in early successional stands

How do your findings inform understanding cross-scale interactive effects?

- Dynamics of herbivory have changed over time
- Pattern and impact of herbivory may respond to, and be dependent on, landscape position and climate
  - Conway & Johnstone 2017; Boyd et al. in prep.
- Herbivory and pathogen impacts on aspen may oppose environmental changes favoring aspen expansion
- Aerial forest damage surveys now include LTER sites, will help us apply results at larger scales



Source: Forest Health Conditions Reports

Task D8: Examine the direct and interactive effects of insect herbivores and vertebrate browsers on plant growth, biogeochemical cycling, and vegetation development in early successional stands

Publications

Boyd MA, Berner LT, Doak P, Goetz SJ, Rogers BM, Wagner D, Walker XJ, Mack, MC. Impacts of climate and insect herbivory on productivity and physiology of trembling aspen (*Populus tremuloides*) in Alaskan boreal forests. *Ecological Research Letters*, in review.

Wagner D, Burr SJ (in prep.) Damage to aspen caused by the outbreak leaf miner *Phyllocnistis populiella* increases vulnerability to water stress.

Allman BP, Kielland K, Wagner D. (2018) Leaf herbivory by insects during summer reduces willow browse overwinter browsing by moose. *BMC Ecology* 18:38.

Wagner D, Doak P (2018) The effect of an outbreak by the leaf miner *Micrurapteryx salicifoliella* on the performance of multiple *Salix* species in interior Alaska. *Botany* 96: 491-497.

Conway AJ, Johnstone JF (2017) Moose alter the rate but not the trajectory of forest canopy succession after low and high severity fire in Alaska. *Forest Ecology and Management* 391: 154-163.

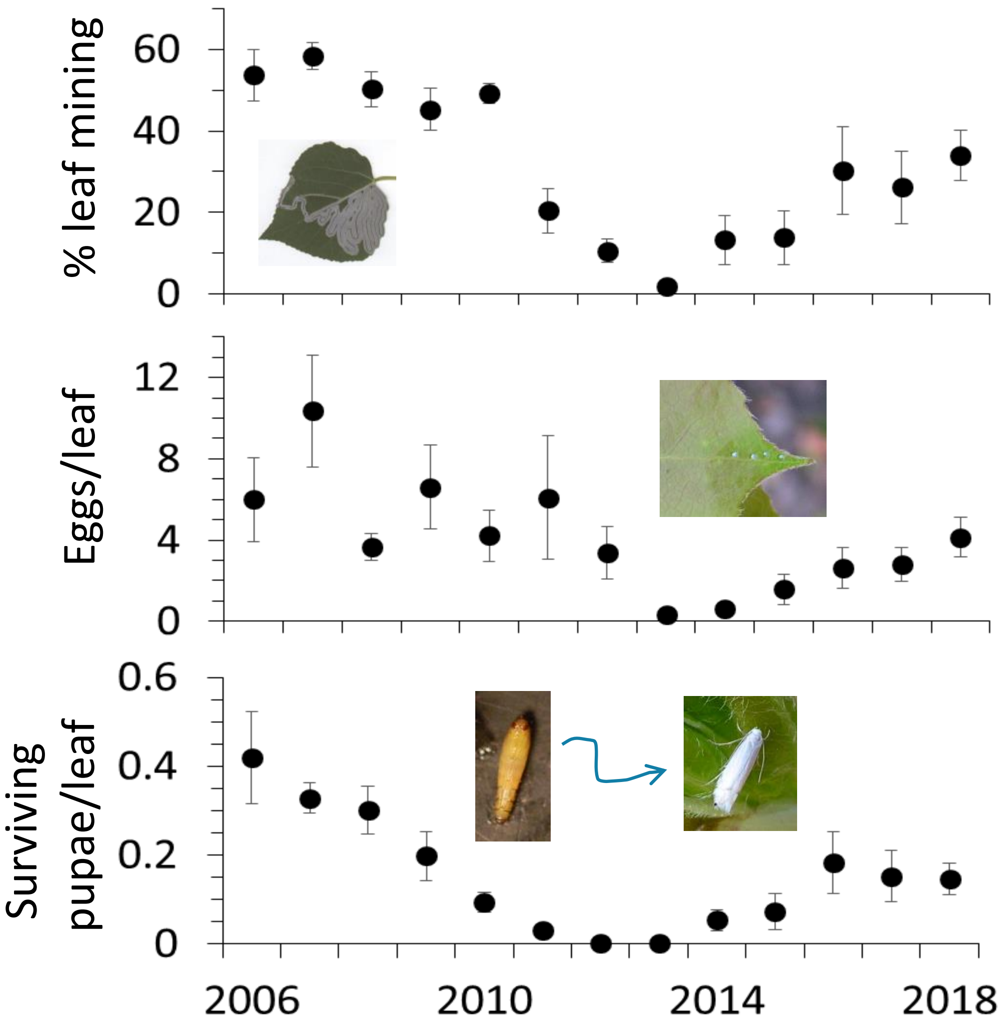
Wagner D, Doak P (2017) Oviposition, larval survival and leaf damage by the willow leaf blotch miner, *Micrurapteryx salicifoliella*, in relation to leaf trichomes across 10 *Salix* species. *Ecological Entomology* 42: 629-635.

Wagner D, Doak P (2013) Long term impact of a leaf miner outbreak on the performance of quaking aspen. *Canadian Journal of Forest Research* 43(6): 563-568.

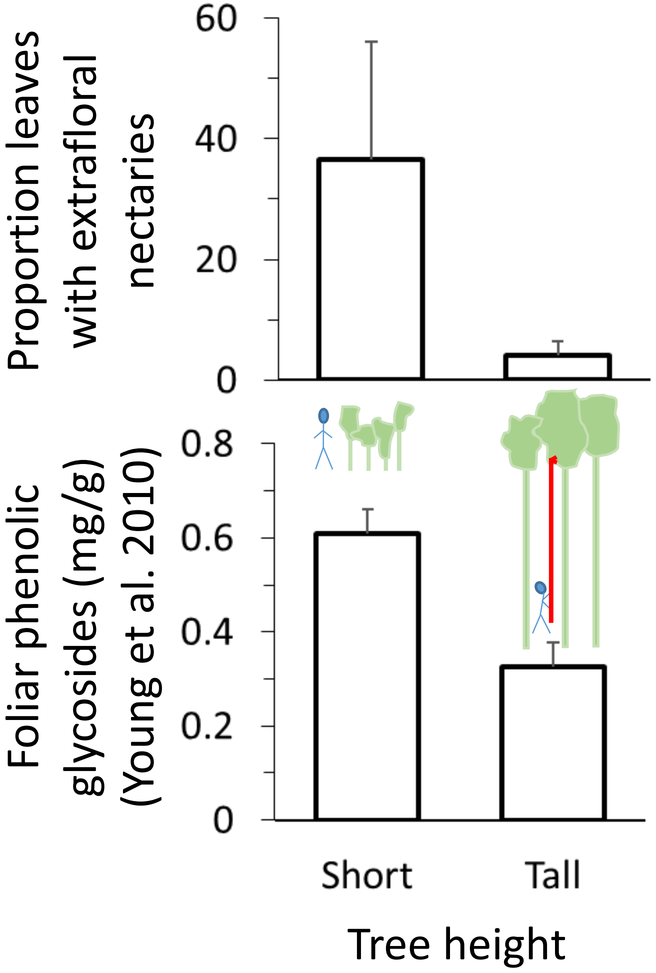
Task D9: Determine how post-fire stand age and area influence aspen's susceptibility to insect herbivory and impact the population dynamics of an outbreak insect herbivore.

P. Doak & D. Wagner

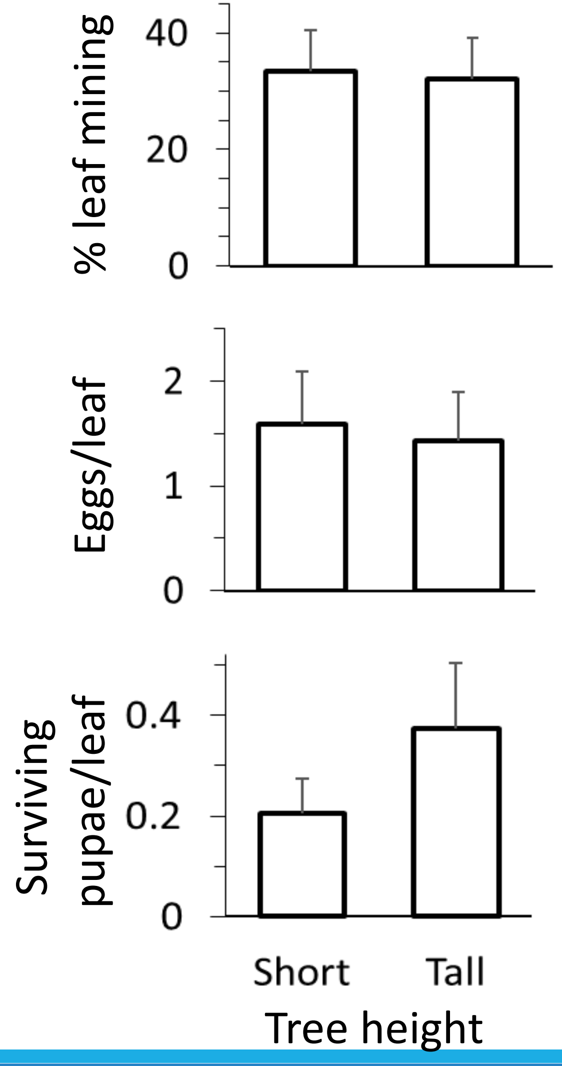
Aspen leaf miner population trends



Aspen defense differs with tree size



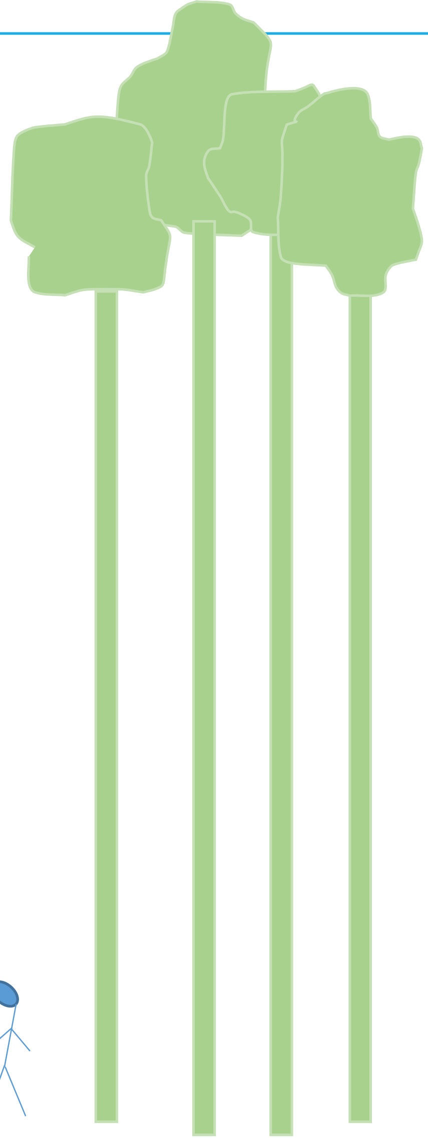
Leaf miner survival differs with tree size



Task D9: Determine how post-fire stand age and area influence aspen’s susceptibility to insect herbivory and impact the population dynamics of an outbreak insect herbivore

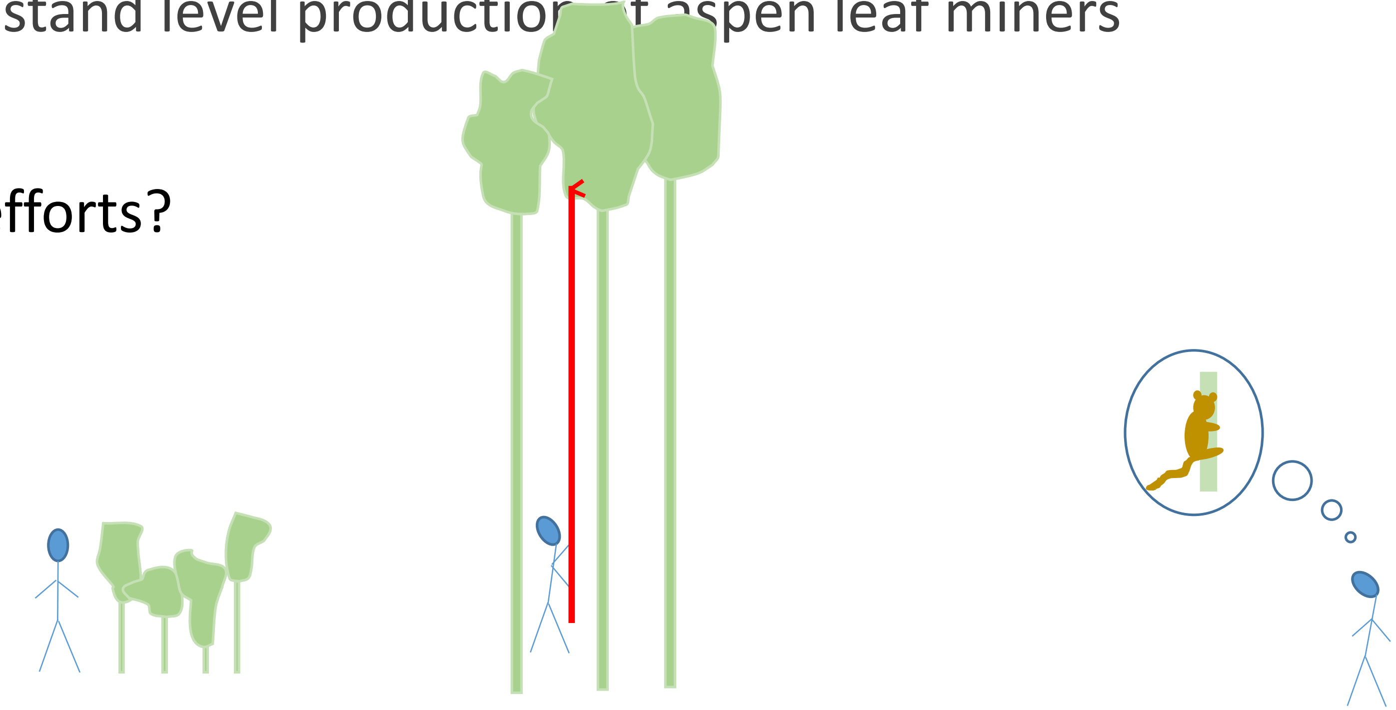
Future directions

- Within stand differences between short and tall
- Aspen leaf miner oviposition, survival and production across stand types
  - Geographically paired early and late successional stands in interior Alaska
- Scaling: leaf level to stand level production of aspen leaf miners



What is limiting your efforts?

Money – yes
Personnel – yes
Time – yes
Field vehicles – yes
Logistics – yes



Task D9: Determine how post-fire stand age and area influence aspen’s susceptibility to insect herbivory and impact the population dynamics of an outbreak insect herbivore

Cross-scale interactive effects.

Differences in aspen defenses
Differences in phenology
Proximity to overwintering sites

Aspen leaf miner abundance
Herbivore pressure
Aspen resilience to damage

Task D9: Determine how post-fire stand age and area influence aspen's susceptibility to insect herbivory and impact the population dynamics of an outbreak insect herbivore

Publications

Tundo G, Doak P & Wagner D. *In prep*. The impact of tree developmental stage on oviposition and survival of the aspen leaf miner.

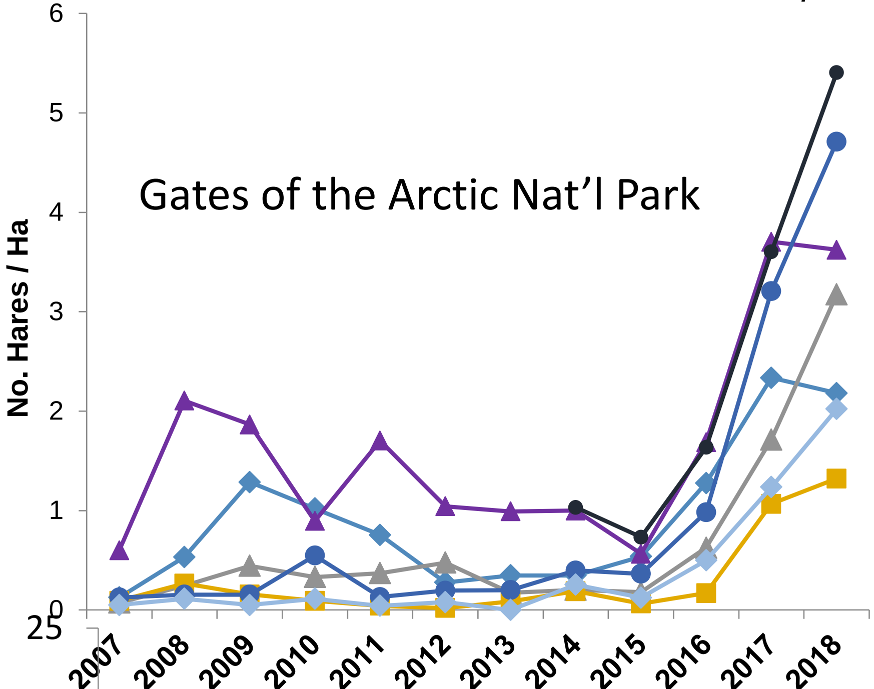
Wenninger A, Hollingsworth T & Wagner D. 2019. Predatory hymenopteran assemblages in boreal Alaska: associations with forest composition and post-fire succession. *Écoscience*, pp.1-16.

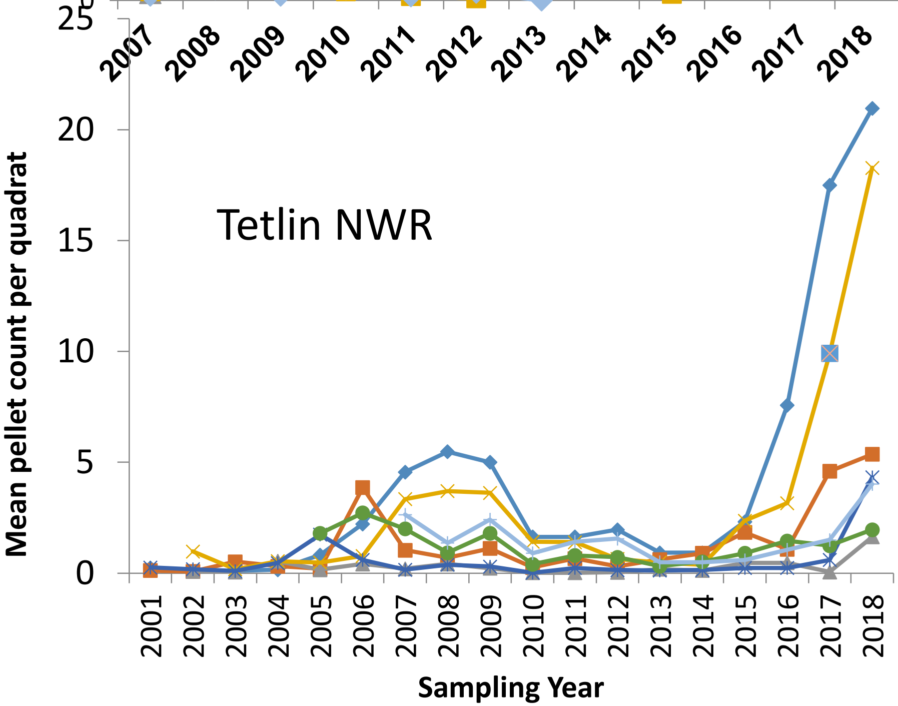
Doak P & Wagner D. 2015. The role of interference competition in a sustained population outbreak of the aspen leaf miner in Alaska. *Basic and Applied Ecology* 16:434-442.

Wagner D & Doak P. 2013. Long-term impact of a leaf miner outbreak on the performance of quaking aspen. *Canadian Journal Forest Research* 43:563-569.

Young B, Wagner D, Doak P, & Clausen T. 2010. Within-plant distribution of phenolics glycosides and extrafloral nectaries in trembling aspen, *Populus tremuloides*. *American Journal of Botany.* 97:601-610.

Task D10: Examine population dynamics of snowshoe hares and their spatial synchrony across a latitudinal boreal transect in relation to the abundance and space use of their primary mammalian predators (Kielland)

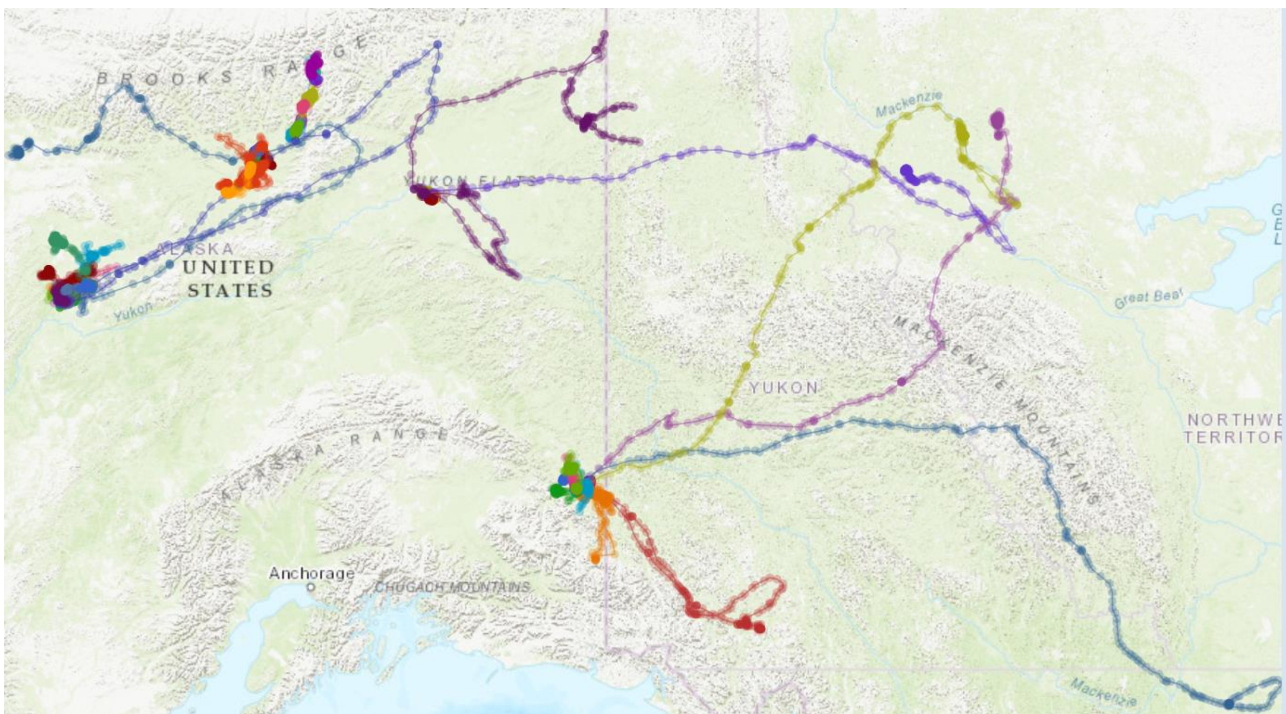




The trajectories of snowshoe hare abundance regarding the amplitude and period are quite similar across the monitoring areas from the north (GAAR) to the south (Tetlin). Maximum density estimates from both pellet plots and MRC range from 1-5 hares/ha, but the pellet grids (7 grids x 50 plots) exhibit substantial variation within a given site.

Understanding cross-scale interactive effects

- Our animal population studies have both temporal (~20 years) and spatial dimensions (~1000 km) across physiographic and climate gradients.
- Across the study areas in the eastern Interior to the Brooks Range snowshoe hares respond to similar environmental cues in terms of breeding and molting, but the greater variability of weather patterns (and climate warming?) in the North render hares more vulnerable to both camouflage- and trophic mismatch.



Data accumulating from the Lynx Project where BNZ LTER collaborate with F&WS and NPS illustrate the scale of movements by these animals. We hypothesize that such large-scale movements represent an important factor in the population dynamics of lynx in Alaska.

Future directions

The work on animal population ecology has an inherent monitoring component - long-term population dynamics - but within this frame work we are addressing a range of ecological issues:

Snowshoe hares:

- Seasonal variation of nutritional status of hares in relation to survival
- Camouflage mismatch of hares in relation to climate change
- Controls over spatial distribution of hares in relation to resource supply (food, minerals)

Lynx:

- Model habitat use and spatial ecology in relation to fire scars
- Identify the frequency and magnitude of lynx dispersal and the characteristics of movement corridors
- Model movement behavior of lynx in relation to life history events
- Model energetics of foraging behavior of lynx in different habitats
- Abundance estimation of unmarked animals using remote cameras

Limitations (besides imagination):

These activities are resource intensive in terms of implementation, personnel, data acquisition, and equipment.

Publications (2017 – present) Data sets: see http://www.lter.uaf.edu/people/personnel-detail/id/97

Kielland, K., D. DiFolco, and C. Montgomerie*. 2018. Dining dangerously: Geophagy in snowshoe hares. *Ecology* DOI: 10.1002/ecy.2555
Allmann*, B., K. Kielland, and D. Wagner. 2018. Leaf herbivory by insects during summer reduces overwinter browsing by moose. *BMC Ecology* DOI:10.1186/s12898-018-0192-x
Brown*, C. L., K. Kielland, T. Brinkman, E. Euskirchen, and S. Gilbert. 2018. Resource selection and movement of male moose in response to varying levels of off-road vehicle access. *Ecosphere*
Cameron*, M.D., K. Joly, G.A. Breed, L.S. Parrett, K. Kielland. 2018. Movement-based methods to infer parturition events in migratory ungulates. *Canadian Journal of Zoology*, DOI: 10.1139/cjz-2017-0314
Olnes*, J., K. Kielland, H. Genet, G. P. Juday, and R. W. Ruess. 2018. Functional responses of white spruce to snowshoe hare herbivory at treeline. *PLoS ONE* doi.org/10.1371/journal.pone.0198453
Brown*, C.L., K. Kielland, E. S. Euskirchen, R. W. Ruess, T. J. Brinkman, K. A. Kellie. 2018. Fire-mediated patterns of habitat use by male moose in Alaska. *Canadian Journal of Zoology* 96:183–192
Ludwig*, S., H.D. Alexander, K. Kielland, P.J. Mann, S.M. Natali, R.W. Ruess. 2018. Fire Severity Effects on Soil Carbon and Nutrients and Microbial Processes in a Siberian Larch Forest. *Global Change Biology* DOI: 10.1111/gcb.14455
Koyama, L. A. and K. Kielland. 2018. Black spruce assimilates nitrate in boreal winter. *Tree Physiology* doi:10.1093/treephys/tpy109
Olnes*, J., K. Kielland, G. P. Juday, D.H. Mann, H. Genet, and R.W. Ruess. 2017. Can snowshoe hares control treeline expansions? *Ecology* 98:2506-2512
Zhou*, J., L. Prugh, K. Tape, G. Kofinas, and K. Kielland. 2017. The role of vegetation structure in controlling distributions of vertebrate herbivores in Arctic Alaska. *Arctic, Antarctic and Alpine Research* 49:291-304
Olnes*, J.R. and K. Kielland. 2017. Asynchronous recruitment dynamics of snowshoe hares and white spruce in a boreal forest. *Forest Ecology & Management* 384: 83–91