

## Research Summary from the Ruess Lab

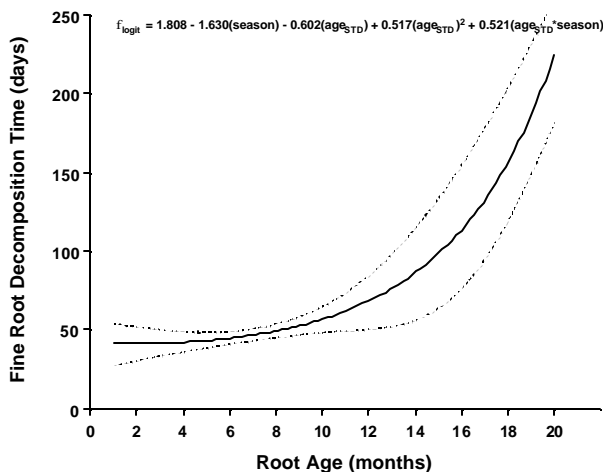
### Fine Root Dynamics

We have recently completed a synthesis of ecosystem carbon flux in mature black spruce forests from the Tanana floodplain, where fine root production, respiration, mortality and decomposition, and aboveground production of trees, shrubs, and mosses were measured relative to soil CO<sub>2</sub> fluxes (Ruess et al. submitted). Using minirhizotrons, we found that rates of root length production in black spruce are comparable to values reported for many temperate forests, with pronounced seasonal and depth distributional patterns of fine root production and mortality. Fine root survival and decomposition were measured by tracking and analyzing the fate of individual fine roots using mark-recapture techniques (Ruess et al. 1998). Survival estimates translate to mean life spans of  $108 \pm 4$  days for fine roots during growing season intervals. While these values are in striking contrast to needle longevity and rates of aboveground litter decomposition, they are similar to many values found for temperate systems, supporting the notion that there are basic morphological and physiological traits of first order roots that are common to most woody plant root systems.

During the growing season, monthly fine root decomposition rates averaged  $0.46 \pm 0.01 \text{ month}^{-1}$ , while decomposition rates over winter averaged  $0.73 \pm 0.01 \text{ winter}^{-1}$ . These growing season estimates translate to  $49 \pm 2$  days from the time a root was first observed as dead to the time it disappeared. For roots that decomposed during the growing season, those with longer life spans decomposed more slowly after death (see Figure). Comparing these results with other

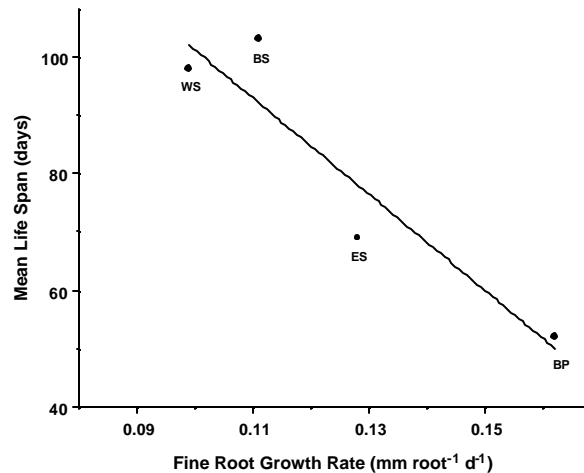
minirhizotron studies suggests that life-history traits of black spruce first order roots are similar to those from temperate (and perhaps most) forest ecosystems. Soil temperature had a strong control over root respiration ( $Q_{10} = 2.30 \pm 0.37$ ); residuals from this relationship were positively correlated with root N content.

Annual production of fine roots averaged  $228.4 \pm 74.6 \text{ g biomass m}^{-2} \text{ yr}^{-1}$ , constituting approximately 57% of total stand production. During the growing season, approximately 56% of soil CO<sub>2</sub> efflux ( $580.2 \pm 39.8 \text{ g C m}^{-2}$ ;  $Q_{10} = 2.21 \pm 0.31$ ) was derived from fine root respiration ( $323.6 \pm 23.3 \text{ g C m}^{-2}$ ). Although apparent rates of heterotrophic respiration (May - September) exceeded total production, definitive estimates of net ecosystem production at this stage are impossible given the potentially large, unmeasured components of NPP, such as root exudation and ectomycorrhizal production. Nevertheless, rates of FR production, mortality, and decomposition indicate that in these black spruce ecosystems, FRs are much more dynamic than would be



predicted from patterns of AG processes, and that C, and presumably nutrients, are cycling through FRs at rates several orders of magnitude faster than through aboveground tissues.

The synthesis chapter for the BNZ LTER book focuses on patterns of and consequences for whole-stand C allocation, emphasizing perspectives on root function from a cross ecosystem (4 ecosystems within AK) and cross-biome synthesis. We now have comprehensive data sets on growth and life history dynamics of fine roots from early successional shrub stands, balsam poplar stands, white spruce, and black spruce stands along the Tanana floodplain. This work is linked with a number of significant cross-biome syntheses that include BNZ sites and build on the notion that the position of a fine root segment on a branching system is directly related to its function and life history (Pregitzer et al. 2002; Burton et al. 2002). Alaska forests provide further evidence for the growth rate/life span hypothesis, showing that among Tanana floodplain ecosystem types, the average maximum growth rate of fine roots is inversely correlated with the mean life span of those roots (see **Figure**). Although this relationship is driven by a taxonomic distinction between angiosperms and gymnosperm-dominated stands, which may have a strong environmental component, we predict mean life span would be inversely correlated with fine root growth and respiration when scaled at the taxon, species, or individual stand level.



We are involved with a number of other fine root projects including (1) linking physiological, morphological and life history traits of fine roots among North American sites, and (2) examining the effects of N fertilization on growth and longevity of fine roots at those sites (Allen, Hendrick, Pregitzer & Ruess); (3) a study of over-winter patterns of FR growth, longevity and decomposition in black spruce forests (Ruess & Vogel); (4) growth and longevity of fine roots at treeline (Ruess & Sveinbjornsson); (5) translating minirhizotron techniques to mycorrhizal hyphal networks (Allen & Ruess); and (6) linking forest production dynamics with sub-surface hydrology on the Tanana River floodplain (Kielland, Hinzman, Jones, & Ruess).

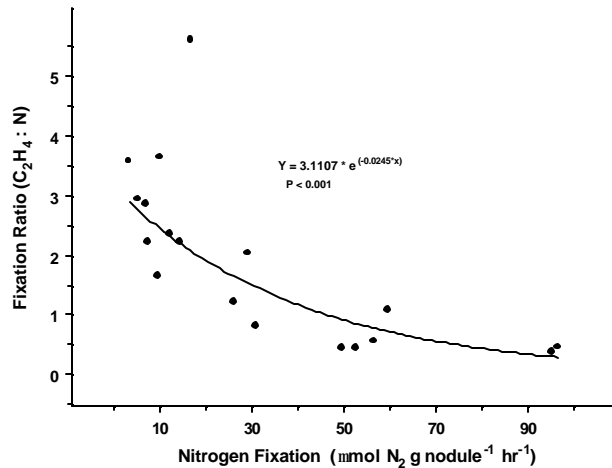
### Microbial Observatory

Jo Handlesman (Univ. Wisconsin) is heading up a Microbial Observatory project that is focused on bacterial genomics of balsam poplar soils on the Tanana floodplain (with Banfield, UCB; Metcalf, Univ. Illinois; & Ruess, UAF). The project is in its early

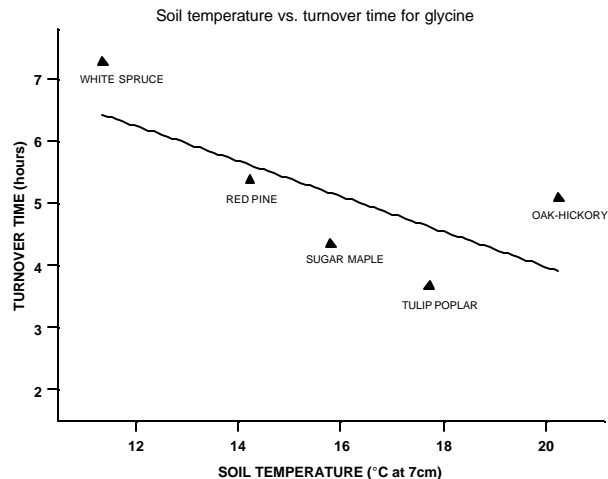
phase, but Handlesman's group has made impressive progress thanks to the efforts of Pat Schloss (Post-doc, UW) and Lynn Williamson (M.S. Student, UW). Jill Banfield's group has produced some very detailed insights into the mineralogy of reduced P compounds in these floodplain soils. A number of research summaries can be found at the project's webpage: <http://www.plantpath.wisc.edu/fac/joh/mo.htm>.

## Graduate Student and Post-Doctoral Research

We maintain an active interest in landscape patterns of and controls over  $N_2$  fixation in *Alnus tenuifolia* (Uliassi and Ruess 2002) and *Alnus crispa* (Jen Mitchell, M.S. Student). Mike Anderson (M.S. Student) has recently completed an evaluation of the ratio of  $N_2$  to  $C_2H_4$  using a new  $^{15}N_2$  method, and found a strong negative relationship between the ratio of  $N_2:C_2H_4$  and  $N_2$  fixation rates (Anderson et al. in final prep) (see Figure). He is currently focusing on how  $^{15}N_2$  fixation rates are related to genomic species richness and diversity of *Frankia* using molecular characterization methods.



Jack McFarland (Ph.D. Student) has characterized amino acid and mineral N uptake and cycling in floodplain balsam poplar stands (McFarland, in press), and has completed a cross-site (AK, MI, NC, GA) study of these processes (McFarland, in final prep). These studies have involved the use of doubly labeled compounds, and have utilized a measure of soil  $^{13}CO_2$  efflux derived from the tracer as a measure of amino acid residence time. His *in situ* data confirm results obtained by David Jones and Knut Kielland that amino acid residence time is on the order of hours, and show a strong inverse relationship between residence time and soil temperature across North American sites (see Figure).



The treeline project (Sveinbjornsson & Ruess) is studying plant growth dynamics in forest and treeline sites in 3 mountain ranges along a latitudinal gradient in Alaska. Graduate students on the project have completed a tremendous amount of work to date. Kendra Calhoun (M.S. Student) is studying the diversity of ectomycorrhizal species in treeline and contiguous forests. Trish Loomis (M.S. Student) has characterized rates of mineral and organic N production throughout the growing season and over winter using buried bags. Matt Smith (M.S. Student) is looking at seasonal patterns of carbohydrate pools in different age classes of needles at treeline and forested sites. Tumi Traustason (Ph.D.) student is studying plant growth characteristics at these sites.

Drs. Kate Doran and Amy Zacheis have begun working on the effects of airboat trails and ice roads associated with the GVEA powerline on vegetative cover, biomass, and diversity. In addition to significant reductions in these parameters in airboat trails and in the ice road associated with the GVEA powerline compared to adjacent undisturbed areas, they have found subsidence in some areas of the ice road. They will continue to monitor plots, and look at vegetative re-growth under exclosures. The next step in the project is to look at effects of these disturbances on hydrology, and on carbon and nitrogen movement through the fens

### References

- Burton, A.J., K.S. Pregitzer, R.W. Ruess, R.L. Hendrick, and M.F. Allen. 2002. Fine root respiration rates in North American forests: effects of nitrogen concentration and temperature across biomes. *Oecologia* 131: 559-568.
- McFarland, J.M., R.W. Ruess, K. Kie lland , and A. Doyle. Cycling dynamics of  $\text{NH}_4^+$  and amino acid N in soils of a deciduous boreal forest ecosystem. *Ecosystems* (in press).
- Pregitzer, K.S., J.L. DeForest, A.J. Burton, M.F. Allen, R.W. Ruess, and R.L. Hendrick. 2002. Fine root architecture of nine North American trees. *Ecological Monographs* 72: 293-309.
- Ruess, R.W., R.L. Hendrick, A.J. Burton, K.S. Pregitzer, B. Sveinbjornsson, M.F. Allen, and G. Maurer. Coupling fine root dynamics with ecosystem carbon cycling in black spruce forests of interior Alaska. *Ecological Monographs* (submitted).
- Ruess, R.W., R.L. Hendrick, and J.P. Bryant. 1998. Regulation of fine root dynamics by mammalian browsers in early successional Alaskan taiga forests. *Ecology* 79:2706-2720.
- Uliassi, D.D. and R.W. Ruess. 2002. Limitations to symbiotic nitrogen fixation in primary succession on the Tanana River floodplain, Alaska. *Ecology* 83: 88-103.