Title: Assessing wildfire burn susceptibility to invasive plant colonization in black spruce forests of interior Alaska
(awarded 2006)

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Proposal -

The responses of boreal ecosystems to a warming climate will depend on how changes in climate influence fire regime and vegetation (Goldammer and Furyacv 1996). Elevated temperatures are predicted to increase fire frequency (Flannigan et al. 2001) and consequently create more favorable conditions for invasive plant success (Harrod and Reichard 2001; Asher et al. 2001; Vitousek et al. 1996). So far, Alaska's invasive plants have largely been restricted to road corridors (Shephard 2004), but burned areas adjacent to roads offer an opportunity for invasives to penetrate pristine areas (Vitousek et al. 1996). We proposed to plant invasives in soils taken from burns of varying severity and age to predict susceptibility to invasion along the road system. Knowing susceptibility of these burned areas will allow land managers to better defend pristine areas from invasive plant colonization.

The immediate objective of this project was to assess the susceptibility of boreal forest burned areas to colonization by invasive plants. While monitoring efforts have been helpful in identifying invasion risk in Alaska's burned areas, it is essential for land managers to know more about the factors that increase the potential for invasion into pristine boreal forest. Prior to this study, no experimental data had been collected on this subject. The observational and experimental components of our project address the following questions:

- **Question 1:** *Dispersal from Road*—Are invasive plants present on roadsides adjacent to burns or within burns in interior Alaska? We hypothesized that, contrary to findings in previous surveys, invasives have dispersed from roadsides into burns.
- **Question 2:** *Burn Severity and Moisture*—Do variations in burn severity and post-fire soil moisture level influence the success of invasive plant establishment? We hypothesized sites with high burn severity and high soil moisture are more invasible due to greater resource availability.
- **Question 3:** *Burn Age*—Do variations in burn age influence the success of invasive plant establishment? We hypothesized that more recently disturbed sites are more invasible due to reduced competition and vacant niche space.

Results:

Work completed. In summer of 2006, we surveyed burned areas and adjacent roadsides for exotic plants at 18 burn sites and one unburned site throughout interior Alaska. The twelve sites that burned in 2004 varied in burn severity and moisture levels (high severity-high moisture, high severity-low moisture, low severity-high moisture, and low severity-low moisture). One of each site type was sampled along three major highways (the Steese, Dalton, and Taylor highways). To address question 3, six additional sites were sampled in the Delta Chronosequence Burns, a series of wildfire scars burned in 1987 (19 years ago), 1994 (12 years ago) and 1999 (7 years ago). A low severity and a high severity site were sampled in each of these older burns. Seeds of *Melilotus alba*, *Hieracium aurantiacum*, and *Bromus inermis ssp. inermis* (invasives of greatest threat to interior AK) were sown on soil cores from all sites and evaluated for germination, survival, growth and reproduction. Additional measurements collected to help explain variation include native plant cover and richness (at field sites and in individual cores), and soil characteristics.

Dispersal from Road: survey results

Eleven exotic plant species were found established and reproducing within burns and on roadsides adjacent to burn sites *(Agropyron repens, Bromus inermis, Chenopodium album, Crepis tectorum, Lepidium densiflorum, Matricaria discoidea, Melilotus alba, Plantago major, Polygonum aviculare, Taraxacum officinale, Trifolium hybridum).* Within burns, exotics were present in five sites. The greatest exotic abundance and richness occurred in the Delta Chronosequence burn sites. Of the 2004 burn sites, exotic plants were only found present in Dalton Highway sites.

Burn Severity and Moisture: results from the 2004 burns

Germination and survival on burned soil cores was high for all three species (Germination after one week- *M. alba* 71.1%, *H. aurantiacum* 35.8%, *B. inermis* 49.6%; Germination and survival after 4 weeks- *M. alba* 44.3%, *H. aurantiacum* 35.1%, *B. inermis* 55.5%). Germination was approximately 20% greater in burned cores than in unburned for all species and survival was 34% greater. All three species of invasive plants grown in soil cores from 2004 burns had significantly higher biomass than in the unburned site ($P<0.001$). Burn severity did not affect the final biomass for any species. *B. inermis* seedlings had significantly higher biomass in cores from high moisture sites than from low moisture sites ($P=0.004$). For two species (*H. aurantiacum* and *B. inermis*), growth was greater for soils collected from the Dalton Highway than from the other two highways ($P<0.005$).

Burn Age: results from the Delta chronosequence

For *M. alba*, both burn age and burn severity had impacts on growth, but there was no interaction: growth was greater in soils from low severity sites, and biomass was highest in 12 year old burns. Growth was also greater in soils from low-severity sites for *B. inermis*, but for both this species and *for H. aurantiacum* there was an interaction between burn age and severity: whereas for low severity sites the greatest growth occurred in cores from burns of intermediate ages (7 and 12 year old burns), in high severity sites growth was lowest in the 7 year old burns and greatest in the oldest (19 year old) burn.

Results for reproduction and correlations between site / soil characteristics and plant survival, growth, and reproduction are still being analyzed.

Discussion:

Contrary to previous survey data, exotic plants are present within burn areas. Exotic plants have dispersed into burns along the Dalton Highway and in the Delta Chronosequence. Propagule pressure alone, however, appears to be an inadequate predictor of invasion, as burn sites with large roadside exotic populations were not uniformly invaded. More extensive surveys of both burned areas and roadside populations are necessary to determine the relationships between propagule pressure and the attributes of sites where exotic plants are currently present.

In general, cores from burned sites supported much greater germination and growth of exotic plants than do cores from unburned sites, supporting the hypothesis that burned areas are particularly susceptible to invasion. Large differences in growth for soil cores from different highways in both the 2004 burn sites and the field survey suggest that regional soil conditions may affect the invasibility of a particular site. We expect the results of the site and soil characteristics (analysis in progress) to provide insight into potential mechanisms underlying these differences. Taken together, these results suggest that Alaska's invasive monitoring and control efforts should focus on regions with both high propagule pressure and good soil conditions (i.e. Dalton Highway burns).

For young burns, the severity of the burn and the moisture level appear to have little effect on the growth of invasives, although sites with higher moisture levels may be more susceptible to invasion by *B. inermis*. However, for older burns the growth of all three species was reduced in cores from sites with more severe burns, suggesting that initial burn severity may become more important to invasive plant establishment and growth over time. Furthermore, our results suggest that soil conditions become more favourable over time (more rapidly so in low severity burns than in high severity burns). In the case of *M. alba*, a more developed microbial community may be partially responsible: these older burns where the burns where native legumes were present. This suggests that monitoring for invasives should not be restricted to recent burns: when one combines the impacts of improved soil conditions to the increase in probability that seeds will reach the site (which was not a factor in this study), it appears likely that sites that burned 10-20 years ago may be most vulnerable to invasion. However, although factors in this study included competition from small plants on the soil surface, they did not include competition from larger plants or other biological interactions, such as those with seed dispersers, herbivores, or pathogens. These factors are likely to differ greatly across burns of different ages. The next step should be to determine the extent to which such interactions reduce or enhance the rate of invasion by exotic plants.

Our three focal species were selected to represent three plant families of particular concern. Although there were differences in their responses, the similarities in their responses were more striking: all three species grew better in soils from burned areas, all three species tended to grow better in soils from the Dalton Highway than from other areas, and all three tended to show reduced growth in high-severity burns in the Delta chronosequence. Thus we have some confidence that the results from this study are likely to represent general responses of many invasives and can inform management decisions with regards to monitoring.

Publications: No publications as of yet; a first paper is in progress and expected to be submitted by December 2007.

Literature Cited:

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Shephard, M. 2004. Status of Exotic Invasive Organisms in Alaska. http://www.cnipm.org/status ofinvasivesak04.pdf. USDA Forest Service. Anchorage, AK.

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Products: Villano, K.L., C.P.H. Mulder, T. N. Hollingsworth. Assessing wildfire burn susceptibility to invasive plant colonization in black spruce forests of interior Alaska. Thesis research presented at the following meetings:

- Long Term Ecological Research All-Scientists Meeting, September 20-23, 2006. Estes Park, Colorado. Poster Presentation.
- 7th Annual Alaska Statewide Noxious and Invasive Plants Management Workshop. October 26-27, 2006. Anchorage, Alaska. Poster presentation.
- Biobites Department of Biology and Wildlife Graduate Research Seminar. Nov 21, 2006. University of Alaska Fairbanks. Oral presentation.
- Bonanza Creek Long Term Ecological Research Site Symposium. February 24, 2007. Fairbanks, AK. Poster presentation.
- Western Society of Weed Science Annual Meeting. March 13-15, 2007. Portland, Oregon. Poster presentation.

Long-Term Goal/s and Continued Progress of Research –

The research funded by CIPM serves as a master's thesis project for Villano, which will be defended this fall. As it was one of the first formal documentations of invasive plants in burned wilderness areas, the field survey component of this research informed the design of a National Parks Service-NASA-University of Alaska Fairbanks collaborative project to develop a predictive model for invasive spread in interior Alaska. This summer the Mulder Plant Ecology Lab conducted a NPS-funded systematic survey in over 300 burned sites throughout interior Alaska to better understand the extent of exotic presence. Dr. Mulder will use this CIPM-funded research and the recent survey findings to write an NSF proposal further investigating the relationships between burn invasibility and exotic invasiveness in Alaska focusing on the role of biological interactions. . In addition, Dr. Hollingsworth will continue to monitor the burn sites used in this

study each year for exotic plants as a part of the Bonanza Creek Long Term Ecological Research program.

Benefits of Seed Money–

This research would not have been possible without the support of the CIPM Seed Money. It allowed us to buy necessary supplies for our greenhouse experiment, travel to field sites and provide support for Villano to finish data collection after her fellowship was completed. It also allowed Villano to present the research at the Alaska Statewide Noxious and Invasive Plant Management Conference in Anchorage. This experience has already helped inform research decisions of land management agencies and helped Villano make connections for future jobs in this field.

Advancing This Research –

Springing from her thesis research and her experience last year as a TASK Fellow (Teaching Alaskans, Sharing Knowledge, a NSF gK-12 program that places grad students in elementary schools as "scientists-in-residence"), Villano has begun to develop curriculum and hands-on, research-based activities for Alaskan elementary schools on Alaska's invasive plants. Several of the lesson were modeled after the experiments conducted in her thesis project. The curriculum emphasizes building awareness of invasive plants at a young age so that Alaska might have the chance at prevention and control of these species that wasn't possible in any other state. It also emphasizes the urgency of increasing awareness as the rapidly changing Alaskan climate creates ever more suitable habitat for these plants (through warmer winters and increases in the extent of forest fires). The end product of this outreach effort will be teaching materials kits and curriculum guides available to teachers for checkout in the Fairbanks North Star Borough School District.

We will also continue to maintain strong connections with the Alaska Committee for Noxious and Invasive Plant Management, and conduct collaborative research with NPS (Jeff Heys and Jennifer Allen), USDA-FS, and USDA-ARS (proposal development with Dr. Steven Seefeldt).

Budget –

	2006-2007
A. Materials and supplies	
Project supplies	1100
	1100
B. Travel	
Fieldwork travel	660
Conference travel	1210
	1760
C. Personnel	
Graduate student RA ($15.73/hr 20 hours a week for 5 weeks)	1575
	1575
D. Institutional Overhead (10%)	

	455
E. Total Costs	**5000**