EMEND Research 1999

(Interim Report 1999)

Prepared by: Alyssa Bradley, Chad Grekul, and John Spence

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Ecosystem **M**anagement by **E**mulating **N**atural **D**isturbance

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CONTENTS

Interim Progress Report on the EMEND Project

Research Activities 1 April 1999 - 30 September 1999

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The past 6 months of EMEND research have focused on i) re-establishing the plot infrastructure lost as a result of application of the harvest treatments, ii) collecting the post-harvest treatment data for both core and graduate student research projects and iii) working to ensure that at least some of the burns are brought off during 1999. The attached documents, prepared by Ms. Alyssa Bradley (Project Data Manager) and Mr. Chad Grekul (Project Coordinator) summarize the important aspects of field-camp use and research progress (i.e., summary of projects and personnel receiving support from Canfor/DMI and/or using the EMEND camp, activities of the Research Corps [Core Crew]).In this initial section of the interim report, I provide a brief overview of ongoing research and address several additional items that may be of interest.

Overview of EMEND research. It is important to re-emphasize that field research comprising the EMEND project has two main components: 1) collection of experiment-wide data, mainly by the Core Crew, required to ensure that comparisons of treatments can be made over all 4 forest types, and 2) research planned and executed by researchers interested in using part of the EMEND experiment as a template for their work. Work done under category 2 includes projects by graduate students and research scientists interested in questions other than those addressed in the core experiment. Support provided my FRIAA is aimed mainly at the core work though support is provided for category 2 projects by i) core crew assistance to individual projects (see summary of core crew work) and ii) limited top-up grants for researchers working at EMEND.

Overall, 22 principal researchers and 72 associated research personnel (14 graduate students, 58 technicians, assistants, volunteers) used the EMEND facilities during the past summer (see EMEND FIELD RESEARCH CAMP 1999) in addition to the 15 people associated with the "core crew".

The experiment-wide work conducted during the past summer included re-establishing access routes to each compartment through a series of "baselines" and the six hundred 40 x 2 m strip plots (6 per compartment) for mensurational characteristics. A new set of 72 20 x 40 "growth and yield" plots were established. In addition, the core crew made regular collections of epigaeic arthropods and flying insects from all stands. See EMEND CORE FIELD RESEARCH 1999 for details about these activities.

Research falling into category 2 spanned a wide range of projects, including plant and animal biodiversity, forest health, fire studies, soil studies, hydrology, silviculture and meteorology. At present 14 graduate students are actively involved in research at EMEND. This is an increase of 80% from last year. See "A list of researchers and their field research team" for details. Projects underway are summarized individually under "EMEND RESEARCH 1999".

Changes to project design and methodology. There have been no significant changes to project design or overall methodology. To date, it has been possible to get off only one burn, that to a Cdom compartment on 4 August. We remain hopeful that more burns will be possible this fall.

Administrative and organizational items. The website is revised periodically to release new information that characterize EMEND research. The website may be viewed at: http://www.biology.ualberta.ca/emend/emend.html.

During 7-8 October 1998 a series of presentations were made to personnel of Canfor, DMI and Manning Diversified, Alberta LFS and other forest companies interested in EMEND. A tour was run in early February to allow researchers and industrial people to view the harvest activities. In June there was an information session for SFMN, CFS and industrial personnel. In August, the Poplar Council of Canada was given a tour of the site and introduction to the project as a part of their annual meeting in Edmonton. A silvicultural tour is scheduled for mid-October 1999. These tech-transfer and information sessions have been greatly facilitated by the efforts of Derek Sidders (CFS).

Apart from organizing the work schedule of the core crew and developing guidelines for use of the research camp that were presented to EMEND personnel as a written document this year no additional administrative or organizational matters have been undertaken.

EMEND Research 1999

The main areas of research are listed as follows:

Biodiversity
Fire Ecology
Genetics
Hydrology and Microclimate
Silviculture
Soils and Nutrient Cycling
Forest Productivity
Dynamics of Coarse Woody Material

Biodiversity

Plants

Derek Johnson; Canadian Forest Service

Understory Vegetation Biodiversity Study

Objective: To complete an understory vegetation (biodiversity) study post-harvest and pre-treatment of various compartments at the EMEND site.
Background: All treatments and compartments at the EMEND site have been measured in terms of the understory vegetation. The total number of compartments is 100 and the total number of plots (at 6 plots per compartment) is 600.
Technical Description: A 5m by 5m tree/tall shrub plot with a nested 2m by 2m low shrub/graminoid/forb/moss/lichen plot was laid out at the midpoint of the 40m length of the 2m by 4m CFS-Forest Health plot. In each plot, species were assessed for percent ground cover; 5m by 5m plot for trees and tall shrubs (over 1.5m tall): 2m by 2m plot for low shrubs (less than 1.5m tall), graminoids, forbs, mosses and lichens. If species absent from the 2m by 2m plot were found in the 5m by 5m plot a presence value of P was given. Tall and low shrubs were also assessed for average height. A count of understory tree regeneration was completed in the 5m by 5m plot species. Collections of species were made for identification and verification. Plots will be monitored over time to assess the direction and rate of change following the various treatments, as well as the long term impacts on species biodiversity. Plots in the harvested compartments were assessed for disturbance (summer 1999) using a 5-point scale based on the area of the 2m by 2m plot that had been damaged by harvesting activities.
Progress 1999: Core crew completed establishment and measurement (cover of shrubs, grasses, forbs, mosses and lichens) of ground vegetation permanent sample plots associated with the tree strip plots in the treatments that were not surveyed in 1998, i.e., the 10%, 20%, and 75% residuals and the low burns, a total of 48 compartments and 288 plots. Plant collections are currently being identified and once this is completed, the 1999

data will be combined with the data entered into the computer for 1998 and a preliminary community analysis will done for the EMEND site. Remeasurement of the plots surveyed in 1998 is contemplated for the year 2000 (but could be postponed to 2001).

Suzanne Mills; University of Alberta; M.Sc. Candidate
Supervisors: Ellen MacDonald and Dale Vitt

<u>The distribution of bryophyte species diversity in relation to microsite and moisture availability at 2 scales within conifer dominated boreal forests.</u>

<u>Objective:</u> Test the link between available substrate and bryophyte species richness. Is this link dependent on environmental factors (light, temperature and moisture)? At what light, temperature and moisture levels do we begin to see a decrease in bryophyte species richness? From this we can make predictions about how changes in these environmental variables, as a result of forest harvesting, will affect bryophyte species richness.
<u>Background:</u> Habitat is the likely key determinant of byrophyte species diversity (Wetson, 1980, Soderstrom, 1988, Vitt et al., 1995). Many byrophyte species require specialized substrates such as logs, large tree bases or disturbed soils. Bryophytes are also vulnerable to water stress, which is dependent on light, topography, temperature, and relative humidity. The combined effect of these habitat factors on byrophyte species richness has not been explored.
<u>Hypothesis/Anticipated Results:</u> Bryophyte species richness is positively related to microsite availability and moisture regime within the stand.
<u>Technical Description:</u> Within each of the 3 stands and mesosites, plots were randomly placed. In each of these 5 microsites, plots were selected randomly. The area of available substrates types was determined and environmental variables were measured (light and moisture) within these. Sucrose vials were placed at logs, trees, and disturbed/ undisturbed patches within the microsite plots, to measure temperature. Data loggers were placed at each mesosite to measure relative humidity and temperature. Species richness at the microsite, mesosite and stand levels will be determined. The relationship between species richness and environmental conditions will also be determined.
<u>References and Interpretations:</u>
(1) Soderstron, L.,1988. The occurrence of epixylic bryophyte and lichen species in an old, natural and managed forest stand in NE Sweden. Nord. J. Bot. 8:89-97.
(2) Watson, M.A.,1980. Patterns of habitat occupation in mosses-reference to considerations of the niche. Bull. Torrey Bot. Arb1007 (3):346-372.
(3) Vitt, D.H.Y.L., and R.Bellard, 1995.Patterns of bryophyte diversity in peatlands at continental western Canada. The Bryologist 98 :218-227.

René Martin; University of British Columbia; M.Sc. Candidate
Supervisor: Pam Krannitz

Reproductive Responses of Bunchberry (*Cornus canadensis*) to Disturbance in a Managed Boreal Forest

Objective: To study a possible gradient effect occurring along lines running from the interior of buffer zones to the interior of harvest treatments (50% and 75%) on the reproductive biology of bunchberry (*Cornus canadensis*) located in conifer dominated forests.

Background: Bunchberry is a ubiquitous herb found in the understory of forests. It is rhizomal and insect pollinated (Barrett & Helenurm, 1987). Because bunchberry is so common, fast growing, and interacts with insects, it was chosen as a study species in order to help to understand any gradient effects that might be occurring along the forest floor running from the interior of an unharvested buffer zone to the interior of a harvested (50% or 75% retention) area located in a conifer-dominated stand. These gradient effects may manifest as differences along the gradient in microclimatic variables (e.g. light levels, soil moisture, insect behaviour) that result in differences in reproductive success of bunchberry (e.g. fruit set). Understanding these gradient effects may help to understand the impact harvesting has on the understory both in harvested and adjoining unharvested forests.

Technical Description: Measurements of bunchberry reproductive biology were taken at each plot. These consist of a) insect visitation rates; b) types of insects visiting bunchberry; c) number of inflorescence/plot; d) number of rammets/plot; e) number of flowers/inflorescence; f) amount of pollen deposited by insects/flower; g) amount of initiated fruits/inflorescence; h) amount of mature fruits/inflorescence; i) weight of fruits/inflorescence. Measurements were taken at each plot for various microclimatic factors. These consist of a) below canopy light levels; b) ambient temperature; c) vegetation type and cover class for all species within the plot; d) surrounding (i.e. 2.5m from centre of plot) tree measurements of height, dbh and distance from plot; e) soil moisture. All of the above factors will be analyzed to test for differences along the gradient and between treatments.

Progress 1999: In the summer of 1999, I completed the field work component of my M.Sc. in Applied Conservation at the University of British Columbia. This encompassed collecting information on bunchberry reproduction within each plot (see design) as well as microclimatic information within and surrounding each plot. All the data collected this summer was entered while in camp, and some preliminary analyses were done as well.

References:

Barrett, S.C.H. and K. Helenurm. 1987. The reproductive biology of boreal forest herbs. I. Breeding systems and pollination. Canadian Journal of Botany. 65: 2036-2046.

Treena Fenniak; University of Alberta; M.Sc. Candidate
Supervisor: Ellen MacDonald

Understory vascular plant regeneration with reference to site conditions following disturbance

Objective: To determine a) what site conditions exist following various types of disturbance, including soil temperature, nutrient and moisture availability, suffice soil disturbance, removal of organic matter, residual live and dead canopy, and creation of litter and downed coarse woody material; and b) the structure and biodiversity of the understory vascular community before and following disturbance. Results will be used to elucidate relationships between postdisturbance site conditions and vascular plant regeneration in its earliest stages.
Background: Immediately following disturbance, harvesting and fire provide different site conditions for plant establishment. Establishment occurs with respect to production, dispersal and successful germination of seed or other reproductive organs. The regeneration niche provided by site conditions determines which plant may establish and succeed on a given site. This niche could be extremely influential in succession, since early establishment may be more important than competitive ability in determining community history. Since understory plants are the first to establish, and their presence can be strongly linked to subsequent forest composition, studying early post disturbance conditions and understory regrowth could provide a unique perspective on succession.
Technical Description: Sampling will focus on conifer-dominated, aspen-dominated and mixedwood forest types, with the following disturbance treatments: clear-cut, 20% partial cut harvest, 75% partial cut harvest, and burn. Preharvest data (which will be used as control data) were collected in the summer and fall of 1998; postdisturbance data will be collected for two consecutive years, in the summers of 1999 and 2000. Plots were selected using a stratified random sampling design, placing them in leave strips and in the residual leave patches, a minimum of 100m away from the edge of the block. Twelve plots were selected in each partially thinned stand, 8 in thinned areas and 4 in residual patches, while 8 randomly placed plots were selected within clear-cut and burned stands. I will use the same permanent plots where preharvest data were collected to provide comparative data. Environmental parameters investigated will include surrounding snag and live tree cover, soil temperature at 10 and 30cm, moisture and nutrient availability, rate of decomposition, disturbance intensity, and germination substrate. In both shrub and herb plots, vascular plant species cover will be recorded.
Progress 1999: In the summer of 1999, the first postdisturbance season was documented, with vegetation surveys completed for all plots in the 39 compartments used in this study, including unburned fire compartments. Environmental data was also collected for all plots.

Steve Kembel; University of Alberta; M.Sc. Candidate
Supervisor: Mark Dale

Spatial patterns of boreal canopies, understory communities and tree regeneration.

Objective: To determine how the spatial structure of canopy tree populations affect the fine scale patterns of understory community structure and tree regeneration in boreal mixedwood forests.
Background: Canopy gaps provide increased light to the understory and influence temperature, moisture and nutrient availability. Canopy structure is known to influence understory communities and tree regeneration patterns in many forest types, but studies of canopy influence on small scale patterns of understory vegetation/tree regeneration are generally lacking in the boreal forest.
Technical Description and Progress 1999: This summer, I established 7, 70m x 70m study plots in EMEND control and burn forests (2 Adom, 2 Mx, 3 Cdom) with a 10 m buffer around a 50m x 50m 'core area'. Within each plot, I mapped all trees (approx. 1000-3000 per plot), all individual fireweed stems (approx. 3000 per plot) in the 'core area', measured vegetation in 521 quadrats (50cm x 50 cm quadrat) per plot and measured light conditions at 121 locations per plot. Transects 100m in length (200 contiguous 50cm x 50cm quadrats) oriented perpendicular to machine corridors in 5 of the 75% treatment compartments (851, 890, 906, 921 and 912) were set up to measure effects of canopy removal on spatial patterns of understory vegetation. All plots and transects were permanently marked to allow revisitation in future field seasons. Data are currently being entered and analyzed.
References: Kembel, S. 1999. EMEND Research Proposal.
Kuuluvainen, T. et al. 1993. Can. J. For. Res. 23:2101-2109.

Fungi

Lisa Cuthbertson; University of Alberta; M.Sc. Candidate
Supervisors: Ken Mallett and Ellen MacDonald

Spatial Patterns of *Armillaria*

Objective: To describe the pattern of occurrence of *Armillaria* in the soil, on coarse woody debris, and on trees, snags, and stumps in mixedwood stands.
Background: *Armillaria* is a common forest pathogen that can cause significant loss of merchantable timber by weakening the butt of trees and making them susceptible to windthrow.
Hypothesis/Anticipated Results: It is expected to find areas of high concentration of disease in a clumped pattern on the landscape.
Technical Description: There are 9, 40m by 40m plots in the control and burn (control for this summer) sites. The tree composition for the plot ranges from pure aspen, aspen

with white spruce understory, aspen and spruce, and pure spruce. Blocks include 948, 958, 928, 918, 930, 904, 856, 937, and 938.

Progress 1999: All trees, snags, and stumps were mapped in 40 x 40m plots in nine compartments; one aspen stand, three conifer stands, three mixedwood stands, and two aspen with white spruce understory stands. These trees were inspected for the presence of Armillaria root rot. Pieces of coarse woody debris greater than 7cm were inspected for the presence of Armillaria root rot in five 40m transects per plot. Trap logs (aspen stakes) were used to trap for the presence of Armillaria root rot in the soil. In addition 15 soil samples were taken to assess for the presence of Armillaria root rot in the soil.

References and Interpretations: Cuthbertson, L., 1999. Proposal.

Lance Lazaruk; University of Alberta; M.Sc. Candidate
Supervisors: Ellen Macdonald and Damase Khasa

The impact of silvicultural practices on the abundance and biodiversity of ectomycorrhizae in a boreal forest ecosystem.

Objectives: 1) to quantify the impact of various silvicultural practices on the biodiversity of ectomycorrhizae, 2) to determine whether alternative harvesting techniques will affect the types and abundance of ECM fungi present and capable of colonizing regenerating white spruce seedlings.

Background: The high incidence of failure when late-successional conifer species such as white spruce (*Picea glauca*) are replanted in disturbed forest sites is a considerable problem and may be linked to the reduced ECM inoculum present in disturbed forest soils. For example, past research has shown that the diversity of ECM fungi is significantly lower in clear-cut sites compared to unharvested control sites[1].

Hypothesis/Anticipated results: As the level of disturbance is increased there should be a corresponding decrease in the diversity and abundance of ectomycorrhizae as the ECM fungal community becomes dominated by "early stage" ectomycorrhizae.

Technical description and Progress 1999: In the conifer dominated stands a total of 360 sampling locations will be located throughout the control; clear-cut; 20%, 50% and 75% residual; and medium burn sites. At each of the sampling locations a soil core (4cm diameter x 30 cm deep) will be obtained (to assess the ECM fungal community present in the forest soils) and a non-mycorrhizal white spruce seedling will be outplanted (to determine what types of ectomycorrhizae are capable of colonizing the regenerating seedlings).

The sampling locations were established and the 1st year post harvest soil cores were obtained for analysis (winter 99/00).

References: 1. Hagerman SM et al. (1999) Canadian Journal of Forest Research 29:124-134

Arthropods

Jane Park; University of Calgary; M.Sc. Candidate
Supervisor: Mary Reid

Movement and Settlement of Bark Beetles in a Heterogeneous Landscape

Objective: To determine the effects of stand type and density on the movement and settlement of bark beetles.
Background: The dispersal and habitat selection by bark beetles is largely influenced by habitat availability, stand composition and density. The need for improved forest management requires that beetle outbreaks be monitored in order to estimate the biological and economic impacts of infestations.
Hypothesis/Anticipated Results: Beetles may be found to search more efficiently (use less energy) for suitable habitat in stands with a high proportion of suitable habitat (conifer dominant) and appropriate density for flight (optimizing temperature).
Technical Description: Two 12-funnel Lindgren traps will be placed in each of 48 compartments . The compartments include the 4 stand types Cdom, Adom, Adom with white spruce understory and Mixedwood with 4 treatment types (control, 10%, 20% and 50%). All beetles caught in traps will be identified and counted. A subsample of common species will be measured and sex and fat content will be noted to assess the costs of movement through various treatments. Habitat availability will be determined with 40m by 2m transects where suitable habitat will be examined for tree species and abundance of any bark beetle.
Progress 1999: From April 19th to August 17th I collected samples from 12-funnel lindgren traps which were set up in each of the 10%, 20%, 50% and controls of all stand types. These traps were approximately 60-100m from the edges of the compartments and the ellipses, as well as 30m apart from each other. Also, I examined all compartments that I am using for suitable habitat for bark beetles. For each piece of suitable habitat, I looked for the presence of bark beetles. If present, I would excavate (remove the bark) from a 800cm^2 area, count and collect all beetles, and note the number of beetle galleries and arms within galleries, in another area of 800cm^2, I would pin all entrance holes and count them. By pinning the entrance holes, I may be able to get a rough estimate of reproductive success next year by counting exit holes.
References:
(1) Bartos, D.L. & G.D. Booth, 1994. Effects of thinning on temperature dynamics: Mountain Pine Beetle activity on a lodgepole pine stand. Res. Pap. INT.RP-479. Ogden. UT, USDA Forest Service, Intermountain Research Station.
(2) Gustafson, E.J. & R.H. Gardner, 1996. The effect of landscape heterogeneity on the probability of patch colonization. Ecology 77:94-107.

Louis Morneau; University of Alberta; M.Sc. Candidate
Supervisors: John Spence and Jan Volney

Lepidoptera diversity of residual forest stands following fire and harvesting in a boreal mixedwood forest of Northern Alberta.

Objective: 1) To compare diversity of macrolepidoptera, including significant forest pests, in different undisturbed forest types. 2) To compare the impacts of fire and forest harvest on a boreal lepidopteran community.
Background: Moths and butterflies (Order Lepidoptera) play key functional roles in the ecosystem, such as vegetation consumers in their larval stage, food source for birds, mammals and other insects, and they act as pollinators. They are good indicators for study of biodiversity as they are taxonomically well described, well studied ecologically, numerous, easily sampled and most importantly, sensitive to disturbance.
Hypothesis/Anticipated results: Species assemblages will differ between undisturbed forest types in terms of both species presence and relative abundance. It is reasonable to expect that the lepidopteran community will reflect changes in ecosystem integrity following disturbance. Environmental modifications (temperature, light, wind cover) and small-scale forest fragmentation will affect the use of the habitat by different species. Thus, specialist species should be more negatively affected than generalist species.
Technical Description: 1. Light trapping is conducted in 24 sites (8 in each forest stand type) every 9-10 days in the control, 20% and 50% residuals and the low intensity burn compartments. Light traps (UV light) are setup on 2m high tripods and run on 12V batteries.
Progress 1999: Treatment compartments sampled in 1998 were sampled again in 1999 using light trapping. Sorting and identification of the specimens from both years are almost done.
References and Interpretations: Morneau, L., 1999. Proposal.

Louis Morneau, Julia Dunlop; University of Alberta; M.Sc. Candidates
Supervisors: John Spence, Jan Volney, Dave Langor (CFS)

Aspen and spruce defoliators' population and their associated parasitoids

Objectives: 1) Identify defoliators associated with aspen and spruce at EMEND, 2) Identify their parasitoids and the parasitism rate of a few major forest pests, 3) Link defoliators' population in the canopy with light trapping study
Background: Defoliators (caterpillars, sawfly larvae) play an important role in the forest's natural processes (nutrient cycling, decrease in wood fiber production etc.). However, their diversity and population numbers are still unclear. Also parasitoids, which are believed to keep defoliators population at a non-epidemic level by killing their host, are

poorly known. Impacts of partial harvesting on those two organisms are also investigated on the two major tree species in northern Alberta: trembling aspen and white spruce.
Hypothesis/Anticipated results: Assemblages of species will largely differ between aspen and spruce. The parasitoid community is mostly unknown but will comprise both generalist and specialist species. Large numbers of specimens are expected.
Technical description: Aspen and white spruce are felled on a tarp laid on the forest ground to collect defoliators. Larvae are then reared in a field laboratory on fresh foliage to obtain adults or parasitoids. Each species is photographed to build a reference guide. Vegetation data is also taken on every tree to establish relationships about larval density, parasitoid population and foliage quantity in the canopy.
Progress 1999: Aspen and white spruce defoliators collected and reared in the laboratory link the summers of 1998 and 1999. Sorting and identification of the specimens from both years are almost done.
References: M.Sc. Proposals of Julia Dunlop and Louis Morneau

Julia Dunlop; University of Alberta; M.Sc. Candidate
Supervisors: John Spence, Dave Langor (CFS)

Effects of forest harvesting on Spruce Beetle (*Dendroctonus rufipennis*) parasitoids

Objective: To study Spruce Beetle (*Dendroctonus rufipennis*) parasitoid response to control, clear-cut, and 20 and 50% residual harvesting practices.
Background: Spruce beetles (SB) are important forest decomposers, however, elevated populations can kill live mature spruce. Parasitoids are known to parasitise SB larvae, but their effect is not well known. After these parasitoids parasitise SB larvae, the parasitoid larvae consumes the beetle host and develops in place of the host.
Technical Description: Located in all three replicates of the 20, 50% residual, clear-cut and control Cdom treatments are 3m white spruce (*Picea glauca*) bolts. These bolts contain developing SB larvae. Every 2 weeks, 4 x 10cm² bark samples are removed from each bolt (top, 2 sides, and bottom) to assess the beetle larvae development and portion of parasitised beetle larvae. Observations of parasitoid behavior are also attained. All parasitised beetle larvae are maintained in a colony and provided with media to allow parasitoids to reach adulthood for identification.
References: M.Sc proposal of Julia Dunlop

David Langor, Daryl Williams; Canadian Forest Service

Population Dynamics of Spruce Beetle Study

Objective: To study the effects of forest disturbance on the abundance and spatial distribution of the spruce beetle, *Dendroctonus rufipennis* (Kirby).
Background: Adult spruce beetles under most conditions are known to attack trees that have been windthrown or are under stress from a previously occurring agent. However, at times in the past spruce beetle populations have increased to outbreak levels, during

which beetles may attack, suppress, and kill healthy standing trees (Brandt 1995). A possible cause for this change is the occurrence of disturbance, which causes a significant localized increase in downed wood.

Technical Description: Spruce beetle populations were assessed by examining 500 meter transects, 2 meters wide, laid at random through CDOM and Mixed compartments. All trees, and pieces of freshly downed material (including stumps) greater than 20cm in diameter were assessed for the presence and intensity of spruce beetle larvae and adults. Bark area, and bark area infested by spruce beetle, of each piece of downed woody material was estimated.

Interpretations: It was found that a very large majority of spruce beetle breeding in 1999 occurred in fresh stumps left by the harvesting operation. Beetles resident in these stumps may well provide a source population for infestation of windthrown or standing trees in subsequent years.

References: Brandt, J.P. 1995. Forest insect and disease conditions in west-central Canada in 1994 and predictions for 1995. Natural Resources Canada, Canadian forest Service, Northwest Region, Edmonton AB. Information Report NOR-X-340.

John Spence, David Langor, Greg Pohl, David Shorthouse

Arthropod Biodiversity Study

Objective: To monitor changes in arthropod communities over time in harvested versus burned stands.

Background: Many species of arthropods are known to have highly specific habitat requirements. Hence, changes in the composition of arthropod communities (both kinds and relative abundance of species) may be linked to changes in habitat following forest disturbance.

Technical Description: Arthropod communities were sampled from May until September using pitfall and window traps associated with permanent sample plots located in each compartment. Insects were collected and sorted into major taxonomic groups, to be later identified and counted. Insects collected in window traps are reported on here. Pitfall traps were run by Mr. Shorthouse and will be reported on separately.

Window traps were placed on 'snags' in 2 decay classes. Snags classed DC1 were created by manually girdling living, mature aspen and spruce trees adjacent to permanent survey plots. Snags classed DC2 were selected from previously dead material in the vicinity of plots. Snags of these two classes will be compared across all harvest types and all four-stand types. No windows were run in compartments to be burned.

There are no interpretations as yet since the insects collected have only been preliminarily sorted.

David Shorthouse*; University of Alberta; Ph.D Candidate
John Spence; University of Alberta
Greg Pohl; Canadian Forest Service
(*principle investigator)

Boreal spiders as bioindicators of forest disturbance and management

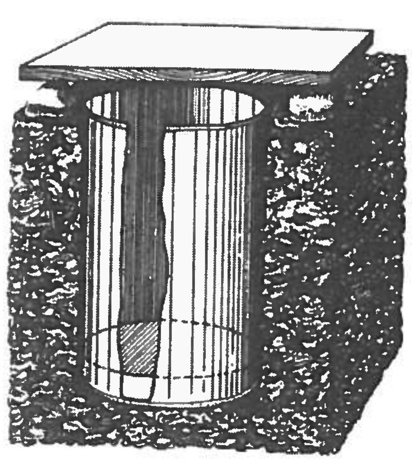
Objective: Each participant in this project has applied the same sampling design and technique, but are examining different, yet ecologically important taxa. John Spence and Greg Pohl will be examining the biodiversity of two families of beetles (Carabidae and Staphylinidae, respectively), whereas I chose to assess the sustainability of the EMEND treatments by examining the succession and biodiversity of ground-dwelling spiders. I will attempt to answer four broad questions by examining the spider fauna in the context of EMEND. These are:

1) How comparable are the spider assemblages before and after disturbance?
2) How comparable are the spider assemblages during recovery from fire to those found in the harvested treatments?
3) What species or groups of species show measurable population responses to disturbance and what species or groups of species are the best indicators of disturbance and recovery?
4) What habitat characteristics of harvested and burned stands are most tightly linked to the structure of spider assemblages?

Background: The spider (Order: Araneae) fauna in any terrestrial region of the world may be as suitable for the characterization of habitats as are vascular plants (Clausen 1986). For example, Barnes (1953) wrote, "Spiders constitute one of the best indexes for the investigation of community structure, stratification, and succession." This optimism about the value of spiders as bioindicators is supported by three observations. First, spiders are generally abundant in terrestrial communities ensuring large enough samples for numerical analyses. Second, they have a variety of forms to fulfill a variety of ecological niches. And third, the order is small enough so that a working knowledge of the taxonomy is not beyond the capabilities of a single worker.

Spiders have been studied in relation to clear-cutting (McIver *et al.* 1992), fire (Johnson 1995, Koponen 1995, Koponen 1993, Aitchison-Benell 1994, Hauge and Kvamme 1983, Huhta 1971), managed forests (Pajunen *et al.* 1995), and succession (Bultman 1980). However, integrated experimental studies tying all these processes together have not been published.

Technical Description and Progress 1999: Pitfall traps are the most common means of collecting epigeal arthropods and many variations in design have come into existence (Spence and Niemelä 1994). They are effective tools for assessing activity but not necessarily density. However, continuous long-term trapping serves to equalize the activity-related effects of weather (Uetz and Unzicker 1976) and density may be estimated.



Prior to harvesting and burning, spiders and beetles were pitfall trapped at the stand level throughout summer 1998. Comparing pre-treatment to post-treatment spider assemblages will answer my broad question 1 (see above).

In 1999, a total of 703 pitfall traps were installed in tree plots within the 100 EMEND compartments and emptied of their contents once every three weeks from May to August. All four stand types (ADOM, ADOMU, MX and CDOM) and harvest/burn treatments were sampled (Table 1). Results from biodiversity analyses will answer my broad questions 2 and 3 (see above).

Table 1. EMEND experimental design used in the present study.

Treatment (X 3)	Controls (X 3)
clear-cut	no harvest
10% residual	high burn (X 1)
20% residual	medium burn
50% residual	
75% residual	low burn

Spider biodiversity data will be linked to compartment dendometry, such as coarse woody debris, tree diameter, and tree height. These results will answer my broad question 4 (see above) and may contribute to forest management decisions.

Anticipated results: I am anticipating upward of 15 families of spiders, *ca.* 45 genera, and *ca.* 150 species and over 10,000 individuals. This richness and abundance of material combined with the rigorous design of this project will contribute to a basic understanding of boreal forest spider biology and diversity, to an assessment of the natural disturbance model, and hopefully to the aging socio-political discussion about forest sustainability.

References:

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Ralph Cartar; University of Lethbridge

Habitat use by bumble bees in response to logging.

Objective: This study examines changes to the density of species of understory plants commonly visited by bumble bees, and in the use of these plants by different species and castes of bumble bees, following different levels of logging and burning.
Background: Logging and burning change the structure of boreal forests, presumably including the understory plant community and its pollinators, of which bumble bees are a major component.
Technical Description and Progress 1999: Between 15 June and 15 August 1999, we studied the densities of bumble bees, and of their floral resources, in all of the ADOM and ADOM-U stands (n=8) at the EMEND site. All of the baseline transects, in each of the stands, were surveyed by walking slowly along each, two to three times during the summer. In each survey, bumble bees were counted and identified to species and sex, and the number of open flowers (for plant species visited by bumble bees) were counted over a 2m wide band along the baseline. Flower counts can be converted into a estimate of nectar profitability by estimating 24 h nectar production rates in a sample of flowers of each species.

These data have 2 primary applications: they will allow an among-stand comparison of bumble bee use of available floral resources, and they will provide a short-term comparison with 1998 baseline data for effects of habitat manipulations on the pollination community. As long as the baseline transects are identifiable over the years, censusing them in a similar manner will allow a quantitative evaluation of how long logging and burning affected the pollination community.

Birds

Bruce Harrison; University of Alberta; M.Sc. Candidate
Supervisor: Fiona Schmiegelow

The Response of Boreal Forest Birds to Experimental Harvest and Burning: A Test of the Natural Disturbance Model

Objectives: 1. To monitor the immediate response of forest birds (at the community and species levels) to varying levels of harvest and intensities of fire. 2. To compare the effects of harvest and fire on the forest bird community. 3. To document the pattern of colonisation/recolonisation of disturbed areas by forest birds (settlement patterns may be used to infer habitat quality). 4. To explore potential mechanisms for bird community response using data from other EMEND researchers on vegetation and invertebrate response.
Background: Among vertebrates, birds represent the most diverse taxa in the boreal forest, and in general they are good indicators of forest condition. Also, their enhanced mobility allows them to respond more rapidly than other vertebrates to disturbances. Much recent research on boreal songbirds has focused on the northeast portion of boreal Alberta, but it is not clear to what degree these results can be extrapolated to Northwest Alberta, and to date there have been no studies of the relative effects of harvest and fire.
Hypothesis/Anticipated Results: The goal of this study is to provide site-specific and empirically-based guidelines to managers about residual tree and patch management. In addition, the data collected will complement other efforts in the province to develop statistical models of bird distribution that may be linked to landscape-scale simulators of boreal forest dynamics.
Technical Description and Progress 1999: Pre-disturbance data were collected in 1998 by establishing point count stations in the various treatments and controls. Each station was sampled three times during the breeding season. During each visit, observers recorded all birds seen or heard within a 50 and 100-meter radius around the station, during a 5-minute sampling interval. Some data on the vegetation immediately surrounding each point count station were also collected.
In 1999, stations were revisited for post-treatment sampling. The first year of post-treatment sampling was conducted using the same methodology (point count surveys) at all stations established in 1998. Each station was sampled four times during the breeding season, between late May and early July. In addition, one set of visits was conducted in mid May to document patterns of settlement of disturbed areas by forest birds. An assessment of wildlife tree occurrence was introduced in selected site types to study species such as woodpeckers, which are difficult to monitor using point count surveys. Features such as tree morphology, decay stage, disease/insect infestation and wildlife use were measured at sample sites.
In 2000, a second year of post-treatment point count sampling will be conducted at the same stations, and the wildlife tree assessment may be expanded. Limited post-treatment vegetation surveys will be conducted at the same sites as in 1998.

References and Interpretations: Schmiegelow, F.K.A., Machtans, C.S. and S.J. Hannon. 1997. Are boreal birds resilient to forest fragmentation? An experimental study of short-term community responses. Ecology 78: 1914-1938.

Bats

Krista Patriquin-Meldrum; University of Calgary; M.Sc. Candidate
Supervisor: Robert Barclay

Can human caused disturbances mimic natural disturbances? The impacts of fire and forest harvesting on the foraging ecology of forest dwelling bats.

Objective: Although the impact of logging on bats has recently received considerable attention, most studies are anecdotal, few studies have approached this question experimentally. Therefore, the objective of this study is to experimentally examine the impacts of natural and human caused disturbances on the foraging behavior of bats. The species of bats present in the boreal forest as well as their reproductive chronology will be documented, as very little is known about bats in the northern regions.
Background: Bats play an integral role in forest dynamics, as they are major predators of nocturnal, flying insects. Prey (insects) availability, risk of predation and the ability to fly in an area, dictate the foraging behavior of bats. These factors are in turn influenced by forest stand structure, which is clearly influenced by fire and logging.
Hypothesis/Anticipated Results: I predict that foraging activity by bats will be highest along edges of openings, whether natural or human caused, and decrease as the percentage of residual trees increases. The converse will be true of foraging activity in the centre of compartments. However, different species will be affected differently by the thinning treatments due to morphological differences between species. Finally, foraging in burnt treatments will more closely resemble activity in thinned treatments than clear-cuts.
Technical Description: 1. In 1999 I will measure relative foraging activity of bats in clear-cuts, 20% and 50% residual compartments in each of the aspen and conifer dominant and mixedwood stands and monitor activity in natural openings in the three stand types. 2. In 2000 I will measure foraging activity using Anabat11 bat detectors, which will convert the ultrasonic calls produced by the bats into audible and visual displays. Each species of bat produces a specific call pattern, which will allow for the determination of which species are foraging in the treatments. Samples will be taken in the buffer associated with each compartment, the edge of the buffer and thinned compartment, and the centre of each compartment. With the aid of mist nets and harp traps, bats will be captured for species identification. As well, reproductive chronology, such as timing of pregnancy, lactation and post lactation, will be assessed.

Fire Ecology

Bill DeGroot, Brian Amiro; Canadian Forest Service

Fire Behaviour and Effects in White Spruce-Aspen Forests

Objectives: 1) To collect critical data on fire spread, fuel consumption and fire intensity over a range of burning conditions in white spruce, aspen and mixedwood stands to incorporate into the FBP System fire behaviour database; 2) To collect postfire data on tree mortality and seedling recruitment of white spruce and aspen, and sprouting of aspen for comparison with other EMEND treatments; 3) To correlate tree mortality and regeneration with fire behaviour characteristics to develop fire effects models for white spruce and aspen.

Background: The Canadian Forest Fire Behavior Prediction (FBP) System is an empirically based model developed by the Canadian Forest Service for assessing fire behaviour. Estimates of fire intensity, fuel consumption, rate of fire spread and fire growth are based on fuel type, topography and weather conditions as measured by component values of the Canadian Forest Fire Weather Index (FWI) System. The current FBP System database contains very limited fire behaviour information in white spruce and aspen fuel types, and there is no direct fire behaviour data for mixedwood fuels.

The CFS is currently also in the process of developing a national fire effects module to complement the current FWI and FBP Systems of the Canadian Forest Fire Danger Rating System (CFFDRS). This requires collection of postfire mortality and recruitment data for major Canadian tree species and establishing relationships to fire behaviour. The EMEND Project will provide the opportunity to collect valuable fire behaviour and fire effects data in support of CFS fire research initiatives.

Technical Description: A series of prescribed burns have been proposed for the EMEND Project. Each of the four stand types will have compartments burned at low, moderate and high intensity treatment levels. Low and moderate burns will be replicated three times in each stand type for 7 burn treatments per stand type and a total of 28 burns in the Project. Burn treatment classes were based on head fire intensity and fuel availability criteria.

Fuels data were collected in the burn compartments during 1998 and 1999. This included sampling of surface duff by depth classes for bulk density and measuring of dead and downed woody material. Available surface fuel was calculated for each compartment. Burn prescriptions estimating fuel consumption, fire intensity and flame lengths for each burn compartment were calculated using the fuels data and FWI System criteria (see appended EMEND Burn Treatment Summary). Field survey data on height to live tree crown were used in the burn prescriptions to ensure the critical surface fire intensity does not exceed the crown fire threshold. Therefore, all burns will be either a surface fire, or a surface fire with varying degrees of intermittent torching.

Pre-burn photos will be made along several fuel lines in each compartment for later comparison with post-burn photos. Weather conditions, flame lengths and rate of fire spread will be recorded during the burns; depth of burn and surface fuel consumption will be measured after each burn is completed. Tree mortality, seedling recruitment and suckering will be surveyed along the original fuel lines.

A fire weather station was set up at the EMEND camp to record local burning conditions through the 1999 field season. One compartment (926) was burned on Aug. 4.

E. A. Johnson, M. B. Dickinson; University of Calgary

Fire Behavior and Effects in the Mixedwood Boreal Forest.

Objective: The goals of our research efforts have been to use physically-based models to develop a better understanding of (1) fire behavior and (2) fire effects on trees in the mixed-wood boreal forest. We believe that our physically-based modeling approach provides a strong scientific basis from which to gain insight into the processes of interest and to develop tools for forest management.
Background: Predicting fire effects on trees requires the development of a series of linked models (e.g., Dickinson and Johnson, in review). First, one must understand how variability in both fuel characteristics across a landscape and long-term weather affect fire behavior. Second, fire behavior must be linked with tissue necrosis in trees (e.g., bole vascular cambium necrosis, foliage necrosis, etc). Linking fire behavior with tissue necrosis requires that one predict both heat transfer into trees from the flame and plume and tissue response to that heating. Finally, once one has estimates of tissue necrosis, a tree physiological model can be used to predict tree death. All of these models require development and testing for the Boreal forest.
Technical Description: As a means of improving our understanding of fire behavior, we sampled surface and crown fuels in 56 Boreal forest stands that spanned the range in both species composition (e.g., aspen, aspen/spruce, spruce, jack pine) and time-since-fire. Also, we assembled long-term weather records. Next, we will use physically based surface and crown-fire models to make predictions of fire behavior (e.g., intensity, rate of spread) under different fuel and weather conditions.
In order to link fire behavior with tissue necrosis, we have developed heat-transfer models that can be used to predict the necrosis of (1) vascular cambium when tree boles are bathed in flame and (2) foliage, buds, and branches when tree crowns are heated by plumes above fire lines (see Dickinson and Johnson, in review). Also, to link heat transfer during fires to bole vascular cambium necrosis, we have collected data that describe the relationship between temperature and rates of cell death in the live bark of aspen and spruce trees.
Progress 1999: During the summer of 1999, our group made progress on several fronts related to modeling fire behavior and effects. We have assembled the required data and begun using physically based fire-behavior models to relate fuel and weather variability to fire behavior. Also, we have developed physically based heat-transfer models that can be used to predict tissue necrosis in fires. Finally, we have collected data relating cell death to temperature pulses such as those experienced by the vascular cambium in the boles of trees during fires.

References: Dickinson, M. B., and Johnson, E. A. Fire effects on trees. In: "Forest Fires: Behavior and Ecological Effects" (E. A. Johnson and K. Miyanishi, Editors). In review.

Hydrology and Microclimate

Graham Hillman; Canadian Forest Service

Effects of Fire and Timber Harvesting on Soil Temperature, Soil Water Content and Evapotranspiration

Objective: 1. to determine the effects of fire and different levels of timber harvesting in coniferous stands, on soil temperature and water content and on evapotranspiration
2. to establish relationships between precipitation, soil water content and evapotranspiration on treed areas and on cutovers and between plant variables and seasonal soil water and temperature conditions.
Background: Information of the effects of fire and timber harvest on soil temperature, soil water content and evapotranspiration in the boreal forest is generally lacking. We propose to evaluate these effects at the EMEND project.
Hypothesis/Anticipated Results: For both soil temperature and soil water content: clear-cut>10%>20%>50%>75%>control. For evapotranspiration: control>75%>50%>20%>10%>clearcut areas with trees>cutovers
Technical Description: Instrumentation was installed on the treed and cutover areas on the control, clear-cut, 10%, 20%, 50% and 75% residual sites. Each of these instrument stations consists of a datalogger connected to eight thermistors and eight soil moisture sensors, which will provide duplicates or triplicates per treatment (i.e., cutover and treed areas). A similar installation will be established on the medium burn following treatment.
Progress 1999: Re-established dataloggers, soil moisture and soil temperature instrumentation in five timber-harvested compartments in a coniferous dominant stand (CDOM ST. 314 REP 2). Installed similar instrumentation in the 10% residual compartment and monitored soil moisture and soil temperature in all six compartments. Completed surveys to determine i) the locations of all dataloggers, sensors, and transects, ii) the topography, and iii) the crown closure and tree species composition, in each compartment of CDOM ST. 314 REP 2. Installed a groundwater well to 3-m depth and a piezometer nest at 1.8-m to 5-m depths in each compartment, and measured hydraulic head and hydraulic conductivity in each system. Soil profile descriptions were obtained from the soil cores.
References and Interpretations: Hillman, G., P.A. Hurdle, C.C. Feng, 1998. Effects of Timber Harvesting and Subsequent Re-Growth on Season Soil Water Content, Soil Temperature and Evapotranspiration-Progress Report.

Brian Amiro; Canadian Forest Service

Carbon Flux to the Forest

Objective: To measure whole ecosystem carbon fluxes and determine the effect of harvesting on carbon fluxes compared to a mature forest.
Background: Present mathematical models estimate that carbon is released from ecosystems for many years following harvesting.
Hypothesis/Anticipated Results: To directly measure the difference in carbon flux between harvested and mature sites.
Technical Description and Progress 1999: Towers are placed in control and harvested stands. The carbon flux is measured using a covariance technique which involves measuring vertical wind velocity and carbon dioxide concentration above the forest, at a high sampling frequency. Half-hour average fluxes are computed and compared simultaneously between sites. Typically data is collected for one week. Whole-ecosystem carbon dioxide fluxes were measured over a control aspen forest and one-year-old harvested aspen site for a period of nine days. The harvested site had night-time respiration fluxes that were similar to the control site, but the day-time photosynthetic rate was much lower. This suggests that carbon continues to be lost from the ecosystem through root respiration at the harvested sites, probably because the cut root-stocks are still alive and support the newly growing aspen sucker shoots.
References and Interpretations: This is part of a larger study on the effect of disturbance on the forest floor. Refer to proposal.

Silviculture

Derek Sidders; Canadian Forest Service

(1) Silviculture System Wind-Throw Monitoring

Objective: To monitor the impact of winds, post-harvest, on the partial-harvest treatments of conifer dominated, mixed wood, and aspen with conifer understory stands and to access blowdown patterns based on stand type and retention levels.
Background: The EMEND project, as the harvesting operations were completed, provided the opportunity for a study relating to the effects of wind (blowdown). Three stand types with four different percentages of trees left in the retention strips will be monitored.
Hypothesis/Anticipated Results: Blowdown will increase as retention levels decrease; there will be more blowdown on the east than the west side of the compartments.
Technical Description: - transects begin on the east side of each of the selected blocks running directly from east to west. (898, 896, 895, 881, 875, 900, 887, 907, 905, 903, 908, 920, 919, 917, 913, 934, 933, 931, 929, 951, 950, 949, 947, 939, 961, 939, 961, 954)
-along the transects all trees within 5 m of each side of the transect line is marked with an orange X and tagged with a number

-trees over 2m will be measured with the exception of understory hardwoods
-each of the tags is placed on the tree at breast height/where the diameter of the tree was taken.
-a tally sheet records the following information:
-tree number/species
-tree diameter
-tree location
-tree height
- harvest damage class (bark removal, branch removal, degree leaning)
-health class (healthy, blown over, standing dead)
Progress 1999: 27 Windthrow Silviculture System Monitoring Transects established in 10, 20 and 50 % retention treatments within softwood dom., mixed and aspen with understory blocks - transects are 10 metres wide and run east-west at the mid point (effective area) of the treatment blocks.
References and Interpretations: Sidders, D., 1999. Wind-throw Monitoring Guide.

(2) Silviculture Research Study: Regeneration on Prepared and Natural Seedbeds in Clear-cut, 50%, and 75% Retention Treatments

Objective: To establish and monitor response of seedlings (artificial and natural) on prepared and natural seedbeds within clear-cut, 50% and 75% retention treatments.
Background: Microsites available after major disturbances such as wildfire, windthrow, etc allow for the natural regeneration of both aspen and white spruce seral vegetation species.
Hypothesis/Anticipated Results: Aspen regeneration from root suckers is expected in each of the forest types with density and vigor relative to tree retention level more than the forest type.
Technical Description: (1) No artificial site preparation: the two mixedwood forest types and various levels of burns will have 50m by 25m plots established. These will be split into two equal sections to be treated with seed or seedlings. Assessments of pre and post harvest plot characteristics are to be completed to accurately classify ecological and physical ground characteristics. (2) Artificial Site Preparation: the forest types classed as >70% hardwood and >70% softwood have one half ha plots (100m by 50m) established within each (3 rep's per forest type of the clear-cut, 50% and 75% retention). The 1/2 hectare plots will be divided into 4 quadrants to accommodate the prescribed microsite treatments (scalp, mound, mix and no treatment) and again in 2 sections to allow for the two regeneration treatments, seeding and planting. These plots will be assessed pre and post harvest.
Progress 1999: Detailed pre and post treatment assessment has been completed on all plots.
References and Interpretations: Sidders, D., 1999. EMEND proposal and Site Preparation - Silviculture Research study: Operational Description.

(3) Silviculture Research Study: Site Preparation Treatments

Objective: To establish various microsites within the silviculture regeneration research plots (hardwood and softwood dominant clear-cut, 50% and 75% retention treatments).
Background: The layout is a 100m wide (E-W) by a 50m long (N-S) block within the EMEND softwood and hardwood dominant harvest blocks. The site preparation blocks are divided into 50m by 25m quadrants and randomly identified for treatment type. All blocks have a different treatment arrangement. The four treatments are: 1. mound, 2. mixing, 3. scalping, and 4. no treatment. Dimensions of the microsites are as follows: 1) mound - 80cm wide mineral soil cap, 100cm long mineral soil cap, 10-15cm deep at center: 2) scalp - 100cm by 100cm wide, exposed mineral soil: 3) mix - 140cm wide (size of meri crusher), 100cm long, 12-18cm deep mix, scrape aside slash only, 4) no treatment. Treated blocks include 892, 922, 932, 850, 864, 941 (clear-cuts), 898, 921, 920, 853, 863, 953 (50% retention), and 890, 931, 921, 851, 859, 907 (75% retention).
Technical Description: All machine travel will be limited to the skid trails on the 50% and the 75% retention blocks. One entry and exit trail will be used on the clear cuts to minimize ground disturbance. On retention blocks, the excavator will prepare the retention strips by reaching from the skid trails and will only complete the skid trails when the machine no longer needs to travel on it. Boom or tail swing should not damage trees adjacent to the skid trails. On the clear-cut blocks the excavator will enter the treatment block and complete the preparation from the center to the outside edge. No travel will be permitted on the no treatment quadrant. A 5 meter area along the border of the site prep. block can be used to finish treatment blocks and traverse around them. The operator will attempt to align the microsites, regardless of the treatment, in a regular pattern. Microsite assessments will be completed pre and post site preparation treatment.
Progress 1999: 36 silviculture plots installed in Clear-cut, 50 and 75% retention treatments; 18 (100mX50M) in softwood and hardwood dominant with 4 site prep. treatments (Mix, Mound, Scalp and no treatment) all with 100 White Spruce 415B seedlings and 50-100 seed/spot direct seeding microsites per site prep. treatment or block quadrant; and 18 (25mX50M) in mixed and aspen with understory blocks - all without prep and 100 White spruce seedlings and 100 seeded spots (100 seeds /spot) at 2mx2m spacing. Total units: Site Prepared: 9 hectares, Planted: 9000 seedlings and 5400 Seeding Spots.
References and Interpretations: Sidders, D., 1999. EMEND proposal and Site Preparation - Silviculture Research study: Operational Description.

(4) Silviculture Research Study: Regeneration Establishment

Objective: To complete the regeneration portion of the silviculture regeneration plots through the planting of white spruce seedlings.
Background: Boreal forest sites similar to the EMEND are regenerated under present management applications through site preparation and planting. To naturally regenerate white spruce it is necessary to have an acceptable microsite and seed source. Site prepared and non site prepared harvested sites were planted and seeded to evaluate regeneration options in the various treatment areas.
Technical Description: White spruce seedlings were planted in all silviculture plots, both site prepared (7200 trees) and non site prepared (1200 trees) between the time of the 22nd and 31st of July. The stock number was 1-0, 415 B's. There were 400 trees (100 each

treatment) planted in the prepared sites and 100 in the non prepared sites. The northern portion of these non prepared sites were planted while the south will be seeded in September. When planting an L slit was used and seedlings were placed 1- 2cm below the surface. Planted areas include, for the treated blocks, 892, 922, 932, 850, 864, 941 (clear-cut), 898, 921, 920, 853, 863, 953 (50% retention), and 890, 931, 921, 851, 859, 907 (75% retention) and the non treated blocks 899, 906, 903, 911, 912, 914, 947, 950,961, 957, 955, 881, 882, 880, 873, 908, 909, 946, 961, 957, 955. Monitoring of the annual survival and growth response will be completed on all blocks.
References and Interpretations: Sidders, D., 1999. EMEND Silviculture Installation Plan

Jim Stewart; Canadian Forest Service

Regenerating White Spruce in Partial Cut Mixedwood

Objective: 1. Quantify the influence of overstory retention and site preparation on microenvironment and relate this to physiology and growth of softwood seedlings
2.Determine suitability of different site preparation methods for providing receptive seedbeds under partial harvesting regimes
3. Evaluate the influence of canopy position and degree of release on production of cone crops
Background: Existence of residual canopy modifies microclimate and competitive environment on forest floor and disturbed sites.
Hypothesis/Anticipated Results: Residual canopy moderates microclimate; differences among site preparation treatments under canopies will be less as compared to the more extreme conditions in the clear-cut. As well, residual canopy will reduce and/or delay production of cones.
Technical Description: 1. Microclimate: continuous time series measured in one replication of aspen dominant and conifer dominant clear-cut, 50% and 75% retention. Periodic spot measurements in all 3 replications.
2. Annual growth and physiology measurements.
3. Seeding in alternate years; annual survival evaluations.
4. Annual count of cone crop by crown class and degree of release. Measurement of seed rain in plots.
References and Interpretations: Stewart, J., 1998. White Spruce Regeneration in Mixedwood Forests of the EMEND Project-Proposal.

Ivor Edwards; Canadian Forest Service
Ken Greenway; Alberta Research Council

Deciduous Regeneration Study

Objective: To assess, on a compartment level, the effect of different levels of partial harvest on aspen and balsam poplar regeneration in mixed, and mixed with conifer understory, stands. This protocol may be adapted for other species and stand types.

Hypothesis/Anticipated Results: There will be more regeneration in the skid trails than in the retention strips.
Technical Description: 2% of 3ha for each 10ha compartment will be surveyed. This is 600m² total in 5m² plots or 120 plots. Each plot will be a circle with a radius of 1.23m spaced approximately 5m centre to centre and aligned so that every fourth plot is in a machine corridor. Where wind throw transects have been implemented the plots will be put in along the centre line of the transect and additional lines will be established parallel to the transect until there are 120 plots. If there is no wind throw transect, the transect will be put at the widest part of the block. The first line will always go from east to west and stay 1 tree height away from compartment boundary whenever possible. The first line should be approximately 30m south of the ellipses. Each line will start with a plot in a machine corridor and end with a plot in a retention strip. The 2nd line will go from west to east and so on back and forth. The beginning of the line will be marked with a post with orange and blue flagging tape and the end with a post with only blue flagging. All aspen and poplar suckers will be counted separately within a 1.26m radius of the centre and the height and damage code of the tallest 3 of each species, will be recorded. Advanced regeneration will not be counted.
Progress 1999: The regeneration of aspen and balsam poplar was assessed for the 0%, 10%, 20%, and 50% residual treatments in all Aspen Dominant stands. The methodology used a series of transects that ran perpendicular to the machine corridors and residual strips. Along each transect, the count of suckers, and the height and condition of the three tallest suckers of each species were recorded in circular plots (radius = 1.26 m). One plot was located on each machine corridor and three plots, 5 m apart, were located on each residual strip. Beginning on the east side of each compartment and at least 30 m south of the nearest forested ellipse, counts and measurements were made along east-west and west-east transects, alternatively, until a total of 100 circular plots were assessed.
References and Interpretations: Refer to proposal.

D.W. Gilmore, K.L. Haiby; University of Minnesota

Modeling early regeneration processes in mixed-species boreal forests of Alberta

Objectives:
1. To initiate a long-term record of natural regeneration processes, and
2. To assemble the above data into a database that can be used for modeling aspects of forest regeneration for the mixed-species boreal forest of Alberta.
Background: Although much is known about securing regeneration of desirable species, few predictive tools currently exist to deal with observed annual variation in seed crop, seed predation, germination success, early survival, and seedling growth. Even when a conscious decision is made to impose treatments conducive to regeneration of target species, the composition and density of the realized seedling community frequently departs from expectation. Without better understanding of early regeneration processes, our future forest will occur by default rather then by plan.
Anticipated Results and Application: The project will document the amount of seed available following different harvest intensities in boreal mixed-woods.

Technical Description: Initial installations focused on establishment of seed collection traps in unharvested control and partially harvested mixed-wood stands (Table 1).

Table 1. Cover type and treatment in which seed collection traps were installed during July 1999.

Cover type	Treatment	No. locations	No. traps installed
Aspen dominated	Control	3	17
Mixed wood	Control	2	12
Mixed wood	50% retention	1	6
Mixed wood	75% retention	1	6
Conifer dominated	Control	2	12

Brent Frey; University of Alberta; M.Sc. Candidate
Supervisors: Vic Lieffers, Allison Munson

Effects of forest floor disturbance and canopy removal on soil nutrient dynamics and response of *Calamagrostis canadensis, Epilobium angustifolium*, and *Picea glauca* seedlings.

Objective: To compare the effects of canopy removal and forest floor disturbance on the growth of *C.canadensis*, *E.angustifolium* and *P.glauca* and on the rates of mineralization.
Background: *C.canadensis* & *E.angustifolium* are adapted to disturbed environments and affect regeneration of *P.glauca*. Therefore it is important to determine how different disturbance types affect their growth.
Hypothesis/Anticipated Results: 50% canopy removal should reduce growth of *C. canadensis* and *E.angustifolium* but not *P.glauca* and should create lower rates of mineralization. The scalped and burned areas should favor growth of *E.angustifolium* over *C.canadensis*.
Technical Description:
2 canopy levels:50% (3 reps) and clear-cut (3 reps)
6 forest floor disturbance levels: -mix, -mound, -scalp, -low intensity burn, -high intensity burn, -control
Design: forest floor split plot with canopy level as main plot factor. Each canopy replicate (3 for 50% and 3 for clear-cut) will have a block of forest floor disturbance plots. These plots are generally located adjacent to the silviculture plots.
References and Interpretations: Frey, B., 1999. Proposal.

Soils and Nutrient Cycling

Barb Kishchuk; Canadian Forest Service

Soil Nitrogen Availability: Buried Bag Incubations

Objective: Estimation of net nitrogen mineralization rates over the growing season as an index of Nitrogen availability under different harvesting treatments and cover types.
Background: Soil Nitrogen availability is a factor of stand productivity. We are looking at relationships among nitrogen availability, foliar nutrition, and productivity across all disturbance types in all stands.
Hypothesis/Anticipated Results: Soil nitrogen availability is expected to increase following disturbance. It is not known (1). at which level of canopy removal measurable changes in soil nitrogen availability will occur and (2). whether similar changes in nitrogen availability will occur under harvesting and fire.
Technical Description: Intact cores of forest floor and mineral soil were placed in plastic bags that allow gas exchange but no loss of soil solution. The cores were replaced in the soil during the growing season. Extractable NH4 and NO3 were determined on adjacent soils. The difference between the initial and final N values is an estimate of the net N mineralization rate of these soils.
References and Interpretations: Kishchuk, B., 1999. Nutrient Dynamics Under Disturbance at the EMEND site. Canadian Forest Service.

Barb Kishchuk; Canadian Forest Service

Changes in Soil Nutrient Capital Under Disturbance

Objective: To determine changes in soil nutrient concentration and nutrient content following disturbance.
Background: Changes in soil nutrient availability following disturbance may affect long-term site productivity. Nutrient availability is controlled by nutrient capital (the amount of nutrients on the site) and the rate of nutrient turnover.
Hypothesis/Anticipated Results: In this study we are following changes in nutrient capital under a full tree harvesting system where litter inputs are reduced; and under burning where biomass and forest floor losses are occurring.
Technical Description: Soil nutrient concentrations and soil mass are being determined in each tree plot throughout the experimental area. Sampling is done at three depths: 1) forest floor (L,F,H), 2). 0-7cm mineral soil, and 3). 10-17cm mineral soil. A 15cm by 15cm quadrant is used for determining forest floor mass and a 500cm soil core is used for

determining mineral soil mass. Nutrient concentrations and soil mass will be used to determine soil nutrient content (kg/ha) as an estimate of site soil nutrient capital.
References and Interpretations: Kishchuk, B. , 1999. Nutrient Dynamics Under Disturbance at the EMEND site. Canadian Forest Service.

Forest Productivity

Jan Volney, Ken Mallett; Canadian Forest Service
John Spence; University of Alberta

Response of forest net primary productivity to harvesting and fire.

Objective: Determine the long-term net primary productivity forest response to treatments.
Background: Net primary productivity is one component of forest sustainability.
Hypothesis/Anticipated Results: Net primary productivity over the long-term should be unaffected by treatments. Over time the productivity of treated areas should converge to that of the checked areas.
Technical Description: Biomass of standing vegetation is being determined using tree plots and allometric relatives - linking tree dimensions to foliage, branches, stems and root. Heights of trees, shrub and litter layer biomass will be determined by clipping and weighing components. There are 6 randomly placed plots in each of the 100 compartments that make up the EMEND study sites. Each individual plot is 2mby 40m. These plots were visited before the treatments were applied and will be visited periodically after treatments are applied. Assessments include coarse woody debris, tree height, DBH, and plant identification.
Progress 1999: All plots were revisited and/or re-established after harvesting over winter 1998-99. Surviving trees were noted and coarse woody material was sampled. Trees on all control plots were remeasured to check on inconsistencies with volume estimates from CANFOR. A single 20 x 40m 'growth and yield' plot was established in each stand; all trees were located, identified and measured for DBH and height to live crown. In August pairs of trees representing the dominant species (white spruce, trembling aspen or balsam poplar) in each of the original stand polygons were felled and disced at metre intervals. The branches (and foliage) were sampled from bottom, mid- and top of the crown of each tree, bagged and dried to provide estimates of biomass. It is hoped that stumps can be pulled for all trees. This fall, analysis of these essential baseline data is pending approval of funding.
References and Interpretations:

The regrowth of forest stands after a burning series is a method against which stands, cut at different levels, can be compared. Refer to proposal.

Dynamics of Coarse Woody Material

Dave Langor, Jan Volney; Canadian Forestry Service
John Spence; University of Alberta

Abundance and Size Distribution of Coarse Woody Debris (CWD) Study

Objective: To study the structure of coarse woody debris as a habitat for arthropod communities.
Background: A significant change occurs in the amount and nature of coarse woody debris in a forest stand following disturbance. Detectable changes in ground-dwelling arthropod communities following disturbance may be in part a response to changes in CWD placement, size, decay class, and abundance.
Technical Description: Temporary 'star' plots were laid within existing permanent sample plots by EMEND core crew members. Three equidistantly separated 5-meter transects were laid out from a plot center, and the diameter of each piece of coarse woody debris greater than 7 cm that intersected each transect was measured. Each piece was also assessed for decay class.
Interpretations: Examination of the data has not been completed, but visual inspection of permanent sample plots suggests that there has been a significant increase of coarse woody debris in harvested stands (in the form of slash) as compared to control.

EMEND CORE FIELD RESEARCH 1999

1) Re-established baselines
2) Re-established tree plots
3) Plots
    a) tree tags
    b) coarse woody material
    c) vegetation assessment
    d) tree mensuration in controls
4) New plots
5) Growth and Yield plots
6) Arthropod collections
7) Soil work
8) Productivity

1) **RE-ESTABLISHED BASELINES**

A baseline system to organize and direct research traffic was re-established in May of 1999.

The baseline systems are walking trails through each 10 ha compartment. In order to make the baselines more visible, wooden stakes spray painted pink were put in every 20 m beside the directional pigtails from last year.

2) **RE-ESTABLISHED PLOTS (40 x 2 m)**

Using a real-time GPS unit, plots were re-located in clear-cuts. The 2m width of the plots were then re-painted.

Touch ups with pink paint were also done on the 6 plots in each of the 100 compartments. To allow greater visibility of the plot boundaries, wooden stakes painted pink were put in at the start and end of all the plots. Solid aluminum redi-rods with a length of approximately 3 feet were also pounded into the ground. The intent of the metal rods is to make a more permanent marking of the plots so that they can be re-located in the future.

3) **PLOTS**

a) Tree Tags

There are 100, 10 ha compartments in the EMEND study. In each of these compartments, 6 randomly located 40 x 2 m tree plots were set up in the summer of 1998. The trees within each of these plots were numbered with pink spray paint. Trees this year are identified with a unique number imprinted on an aluminum tag. Tags are attached to electrician's wire wrapped and tide loosely around the diameter at breast height (dbh) of the tree. A correspondence table was created to match last year's tree numbers with this year's tree tags. The core crew tagged trees for the first 2 weeks in July. The intent of the tree tags is to create a more permanent marking of the trees and to give each tree a unique number. In the field, tree tags are in sequential order from plot 1 to plot 6 within a compartment. For each tree, the status and the species was recorded.

b) Coarse Woody Material (CWM)

For each plot, the core crew measured the CWM. Three star plots were placed randomly down the length of the tree plot. Each star plot consisted of 3 lines, 5 m long separated by 120 degrees. All CWM greater then 7 cm in diameter was measured. For each piece of wood, the species, the diameter and the decay class was recorded.

c) Vegetation Assessment

Last summer Derek Johnson (CFS) and his crew started the assessment of vegetation plots. The core crew this summer completed the plots which was roughly half of the compartments. Percent cover of herbs, shrubs and trees were assessed. It is felt that the combined data set will be sufficient to save as the pre-treatment baseline for the experiment because responses of the ground vegetation will require several years.

d) Controls

Trees in the plots of all control compartments were re-measured. Height, dbh, species, status, height to live crown, and length of dead top if present was recorded. The intent of re-measuring the controls is to compare this year's data with the data taken from last year.

4) NEW PLOTS

Due to some plots being in unsuitable locations such as landings, haul roads and silviculture plots, new plots had to be set up. Replacement plots were numbered from P7 and up to give each plot a unique number within the compartment. A table was constructed to match destroyed plots with their replacement plots. The new plots are GPSed and tree mensuration was done on them.

5) GROWTH AND YIELD PLOTS (40 x 20 m)

One tree plot was randomly selected in each compartment and a 40 x 20 m growth and yield plot was set up using the plot as the north tip. The species, dbh, height, status, height to live crown and the length of the dead top if present were recorded. Trees are identified with unique numbers on aluminum tree tags. Tags are attached to electrician's wire that was wrapped and tied loosely around the dbh of the tree.

6) ARTHROPOD COLLECTIONS

The core crew helped Dave Shorthouse (Ph.D Cand) set up and monitor pitfall traps. Sixteen pitfall traps were present in all aspen dominated compartments and 6 traps in all other compartments for a total of 850 traps to be collected every three weeks.

A yogurt container is placed in a hole dug into the ground. An inner collection cup is inserted inside the container and filled with ethylene glycol, a killing and preserving agent. Both are level with the ground surface. Ground dwelling insects, such as carabid beetles, staphylinid beetles and spiders are captured by the pitfall traps. A 20 x 20 cm wooden roof is placed an inch above the trap. This prevents large debris from falling into the trap and acts as a rain guard.

Window traps were set up at the end of April 1999 by Greg Pohl, Daryl Williams and Grant Hammond (CFS). Traps were set up in all control compartments for a total of 92 traps.

A 15 x 30 cm piece of Plexiglas, attached to a cloth funnel is tied with wire perpendicular to the tree. At the bottom of the funnel, a plastic whorl bag half full of ethylene glycol is attached. Flying insects are captured when they hit the glass and fall into the collection bag.

Window traps were tied at a height of approximately 1.5 m from the ground on two types of trees:
1) a decay class one tree which involved girdling a live tree (peeling away the bark a couple of inches around the tree)
2) a decay class two tree which involved a snag

Window traps were put on the dominant tree species in the compartment. For mixed-wood stands, traps were put on both aspen and spruce.

7) SOIL WORK

A 1 cubic metre soil pit was dug by the core crew in all 24 stands. A monolith, a 15 x 15 cm soil sample, was taken from each pit and bagged into 3 categories: organic layer, 0-30cm layer and 30-100cm layer. Drawing the roots of a section 15 cm across on a sheet of acetate was also done prior to digging the monoliths. Barb Kishchuk (CFS) did soil classification.

8) PRODUCTIVITY WORK

The core crew helped Jan Volney (CFS) and John Spence (U of A) with the collection of data for the productivity study. Selected trees in each compartment were felled. A sample of branches were taken as well as tree disks at 1 metre intervals.

Table 1. Summary of core crew assistance to EMEND researchers from May 1 – August 31, 1999.

Researcher	Project	Description of Work	Total Number of Person-Days of Core Crew Help Provided
David Shorthouse	Spiders	Pitfall trap collections	72 person-days
Julia Dunlop	Spruce Beetles	Placing spruce logs in treatment compartments	12 person-days
Lisa Cuthbertson	*Armillaria* study	Soil work	5 person-days
Jane Park	Bark Beetles	CWM surveys	6 person-days
Paul Christiansen (Barb Kishchuk)	Soil study	Soil sampling	47 person-days
René Martin	*Cornus canadensis*	Veg work	2 person-days
Suzanne Mills	Moss study	Veg work	2 person-days
Mike Hobbs	Fire Research	Duff sampling	4 person-days
Rob Taylor (Derek Sidders)	Silviculture Research	Flagging silviculture plots	7 person-days
Cecilia Feng	Hydrology	Densiometer work	4 person-days
Jim Stewart	Silviculture	Planting trees	3 person-days
Jan Volney/John Spence/Ken Mallett	Productivity	Felling trees and bucking them up	22 person-days
		Total:	186 person-days

EMEND FIELD RESEARCH CAMP 1999

A tally of the number of days that researchers used the EMEND camp

A total of **119 people** used the EMEND camp facilities (April-Aug).
The total number of days spent in camp for all EMENDers= **3727**

EMEND Personnel	**Title**	**Project**	**Association**	***April***	***May***	***June***	***Ju***
				Number of days spent at the EMEND camp			
Agnes Wong	Volunteer	Veg.	U of A	~	~	2	
Al Nanka	~	Silv.	CFS	~	~	~	
Alison Munson	Researcher	Silv.	Lavalle (Quebec)	~	6	~	
Alyssa Bradley	Co-coordinator	Core	U of A	~	~	26	1
Amar Varma	~	Silv.	ARC	~	~	~	
Andu Yohannes	Tech.	Prod.	CFS	~	~	~	
Annette Coderre	Assistant	Climate	CFS	~	~	~	1
Athena Mckown	Assistant	Veg.	U of A	~	~	7	
Barb Kishchuk	Researcher	Soils	CFS	~	~	~	
Betty Bradley	Volunteer	Core	~	~	~	~	
Bill DeGroot	Researcher	Fire	CFS	~	~	2	
Brent Frey	M. Sc. cand.	Silv.	U of A	~	~	18	1
Brent's guest	Volunteer	Silv.	~	~	~	~	
Brett Purdy	Visitor	Veg.	U of A	~	4	~	
Brian Amiro	Researcher	Climate	CFS	~	~	4	1
Bruce Harrison	M.Sc. cand	Birds	U of A	~	19	24	1
Bruce Robson	Tech.	Hydro.	CFS	~	~	11	
Carmen Gibbs	Assistant	Veg.	U of A	5	24	26	2
Cecilia Feng	Tech.	Hydro.	CFS	~	~	11	
Chad Grekul	Coordinator	Core	U of A	~	26	22	
Charity Briere	Assistant	Insects	CFS	~	~	10	
Chris Guest	~	Silv.	ARC?	~	~	~	
Chris Smit	M.Sc.cand.	Veg.	Holland	~	~	25	
Christine Decker	Assistant	Insects	U of A	~	29	18	3
Coen Remann	Volunteer	Veg.	Holland	~	~	4	
Corry Dow	Core crew	Core	U of A	~	22	22	
Damase Khase	Researcher	Fungi	U of A	~	~	~	
Dan Gilmore	Reseacher	Silv.	U of Minnesota	~	~	~	
Daryl Williams	Tech.	Insects	CFS	5	~	~	
Dave Bradley	Volunteer	Core	~	~	~	~	

Dave Shorthouse	Ph.D cand.	Insects	U of A	~	22	16	1
Denis Araki	~	Forestry	FERIC	~	~	3	
Derek Johnson	Researcher	Veg.	CFS	~	~	7	
Derek Ottem	Volunteer	Core	U of A	~	~	5	
Derek Sidders	Researcher	Silv.	CFS	~	~	2	
Diane Carlson	Assistant	Silv.	CFS	~	~	15	1
Doug Macauley	Assistant	Prod.	CFS	~	~	~	
Ellen McDonald	Researcher	Veg.	U of A	~	4	~	
Erin Flynn	Assistant	Veg.	U of A	1	31	22	2
Ernst Stjernberg	Researcher	Silv.	FERIC	~	1	~	
Fiona Schmiegelow	Researcher	Birds	U of A	~	~	2	
Fiona's guest	Visitor	~	~	~	~	2	
Gavin Kernagham	~	Fungi	U of A	~	~	~	
Graham Hillman	Researcher	Hydro.	CFS	~	~	6	
Graham Purdy	Visitor	~	~	~	4	~	
Grant Hammond	Assistant	Insects	CFS	5	~	~	
Greg Pohl	Researcher	Insects	CFS	5	~	~	
Greg Taylor	Assist.	Hydro.	CFS	~	~	5	
Gunther Tondeleir	Core crew	Core	U of A	~	26	22	2
Ivor Edwards	Researcher	Soils	CFS	~	~	2	
Jacqueline Pollard	Assistant	Fungi	U of A	1	24	20	
Jake Walfe	~	Silv.	Dillman	~	9	~	
Jan Volney	Researcher	Prod.	CFS	~	~	2	
Jane Park	M.Sc. cand	Insects	U of C	9	24	23	2
Jason Macheny	Assistant	Insects	CFS	~	~	~	
Jeremy Bluetchen	~	Silv.	ARC	~	~	~	
Jim Cuthbertson	Volunteer	Fungi	U of A	~	~	10	
Jim Stewart	Researcher	Silv.	CFS	~	3	~	1
Joanna Murdrum	Volunteer	Veg.	New Zealand	~	~	22	2
Joe Crumbaugh	Assistant	Veg.	CFS	~	~	7	
John Dale	Assist./Core crew	Veg./Core	U of A	~	24	25	2
John Deornbos	Visitor	~	CFS	~	~	2	
John Elfson	Tech.	Prod.	CFS	~	~	~	
John Spence	Researcher	Prod.	U of A	~	~	2	
Jrki Jalonen	Volunteer	Core/Veg.	Finland	~	~	~	2
Julie Dunlop	M.Sc. cand	Insects	U of A	5	18	25	2
Julie's mom	Volunteer	Insects	~	~	~	~	
Julie's dad	Volunteer	Insects	~	~	~	~	
Julie's brother	Volunteer	Insects	~	~	~	~	
Kathy Haiby	Assistant	Silv.	U of Minnesota	~	~	~	
Ken Mallet	Researcher	Fungi	CFS	~	~	2	
Kim Lambe	Assistant	Silv.	CFS	~	11	16	1
Krista Patriquin-Meldrum	M.Sc. cand	Bats	U of C	~	14	30	1
Krista's dad	Visitor	~	~	~	~	~	

Lance Lazaruk	Assist./M.Sc. cand	Silv./ Fungi	U of A	~	11	26
Leah Strilchuk	Core crew	Core	U of A	~	22	26
Lisa Christiansen	Assist./Core crew	Birds/ Core	U of A	~	19	24
Lisa Cuthbertson	M.Sc. cand	Fungi	U of A	5	26	20
Logan Purdy	Visitor	~	~	~	4	~
Louis Morneau	M.Sc. cand	Insects	U of A	7	31	23
Marie-Christine Adam	Assistant	Silv.	CFS	~	~	~
Mark Benson	Assistant	Insects	U of A	~	22	13
Mark Dale	Researcher	Veg.	U of A	~	~	2
Marlene Boissoneau	~	Silv.	ARC	~	~	~
Marty Siltanen	Tech.	Veg.	CFS	~	~	7
Mary Reid	Researcher	Insects	U of C	~	~	4
Max	Assistant	Forestry	Paprican	~	~	5
Michelle Dias	Assistant	Insects	U of A	~	18	25
Michelle Christensen	Assistant	Prod.	CFS	~	~	~
Mike Hobbs	Tech.	Fire	CFS	~	7	~
Mike Logan	Assistant	Insects	U of C	9	24	30
Mike Stroppa	Assistant	Soils	CFS	~	~	~
Nick	Assistant	Forestry	Paprican	~	~	5
Paul Christiansen	Assistant	Soils	CFS	~	1	21
Pete Bothwell	Tech.	Silv.	CFS	~	~	~
Pete Dyson	~	~	FERIC	~	~	3
Peter Volney	Core crew	Core	U of A	~	26	22
Raheem Ismaili	Assistant	Silv.	CFS	~	~	4
Ralph Cartar	Researcher	Insects	U of Lethbridge	~	~	4
Rene Martin	M.Sc.cand	Veg.	UBC	~	~	25
Richard Elhert	Tech.	Insects	U of Lethbridge	~	~	11
Rick Hurdle	Researcher	Weather	CFS	~	~	4
Robin (Gunther)	Volunteer	Core	~	~	~	4
Robin Taylor	Tech.	Silv.	CFS	~	20	22
Rod Kusick	Tech.	Silv.	ARC	~	~	~
Shanelley Pitts	Tech.	Forestry	Paprican	~	~	5
Sheena Adamson	Core crew	Core	U of A	~	22	22
Sherri Dunne	Assistant	Silv.	CFS	~	~	~
Steve Kembel	M.Sc. cand	Veg.	U of A	1	28	25
Susan Cassidy	Assistant	Soils	CFS	~	1	21
Suzanne Mills	M.Sc. cand	Veg.	U of A	~	26	26
Tom Patocka	Core crew	Core	U of A	7	27	23
Travis Meldrum	Assistant	Bats	U of C	~	14	30
Travis Jones	Assistant	Soils	CFS	~	~	~
Treena Fenniak	M.Sc cand	Veg.	U of A	~	26	20
Valerie Chenard	Assistant	Fungi	U of A	~	~	~
Valerie Moore	Core crew	Core	U of A	~	26	22
Wenonah Fraser	~	Silv.	ARC	~	~	~

65	**650**	**1051**	**1(**