



2011 SOIL ECOLOGY SOCIETY MEETING



THE UNIVERSITY OF BRITISH COLUMBIA
OKANAGAN CAMPUS
MAY 24 - 27, 2011



a place of mind

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CONTENTS

SOIL ECOLOGY SOCIETY.....	3
SES BOARD.....	4
LOCAL ORGANIZING COMMITTEE.....	5
ELECTION OF SES OFFICERS.....	6
SPECIAL ISSUE OF THE JOURNAL OF APPLIED SOIL ECOLOGY.....	7
AWARDS.....	8
ACTIVITIES AND EVENTS.....	9
MAPS.....	11
PRESENTER INFORMATION.....	17
ORAL PRESENTATION SCHEDULE.....	18
PROGRAM HIGHLIGHTS.....	23
PROGRAM SCHEDULE.....	25
TEACHING WORKSHOP.....	26
SILENT AUCTION.....	27
AFFAIR OF HONOUR.....	28
LOCAL TRANSPORTATION.....	29
ABSTRACTS.....	30

SOIL ECOLOGY SOCIETY

ABOUT OUR SOCIETY

The Soil Ecology Society (SES) is an international organization of researchers, students, environmental professionals, educators, and others interested in the advancement and promotion of soil biology and ecology. This arena includes, but is not limited to, soil invertebrate ecology, soil microbial ecology, soil science, soil chemistry, and physics, biogeochemistry, and nutrient cycling, root and rhizosphere ecology, plant pathology, mycorrhizal studies, hydrologic interactions with soil processes and organisms. The SES holds a biennial conference that addresses contemporary issues in the field of soil ecology and provides a forum for ecologists, soil scientists, and members of related disciplines to present original research, participate in meeting symposia and workshops, and identify priorities for future research.

SOIL ECOLOGY SOCIETY EXECUTIVE BOARD

SOIL ECOLOGY SOCIETY OFFICERS FOR 2010-2011

PRESIDENT

JOHN KLIRONOMOS

UNIVERSITY OF BRITISH COLUMBIA (OKANAGAN CAMPUS)
KELOWNA, BC, CANADA

IMMEDIATE PAST -PRESIDENT

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BRADLEY UNIVERSITY
PEORIA, IL, USA

PRESIDENT ELECT

JOHN DIGHTON

RUTGERS PINELANDS FIELD STATION
RUTGERS UNIVERSITY
USA

SECRETARY

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UNIVERSITY OF NEW HAMPSHIRE
DURHAM, NH, USA

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KEENE, NH, USA

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AGRICULTURE AND AGRI-FOOD CANADA
OTTAWA, ON, CANADA

HEIKKI SETALA

UNIVERSITY OF HELSINKI
LAHTI, FINLAND

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UNIVERSITY OF BRITISH COLUMBIA (OKANAGAN CAMPUS)
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KELOWNA, BC, CANADA

LOUISE NELSON

UNIVERSITY OF BRITISH COLUMBIA (OKANAGAN CAMPUS)
KELOWNA, BC, CANADA

SPECIAL ISSUE OF *APPLIED SOIL ECOLOGY*

TONY TROFYMOW

NATURAL RESOURCES CANADA
VICTORIA, BC, CANADA

ELECTION OF SES OFFICERS

A ballot will be provided to vote for President-Elect, Secretary/Newsletter Editor, and Members at Large. All members of SES in attendance should vote. You are a member if you have paid to attend this conference. Students are considered full members and should vote. The ballots are due by Thursday at 12:00pm and should be deposited in the ballot box located at the registration booth. The results of the election will be announced at the banquet on Thursday evening.

SPECIAL ISSUE OF THE JOURNAL OF APPLIED SOIL ECOLOGY

The Journal of Applied Soil Ecology (JASE) will have a special issue of the journal devoted to the Proceedings of the 2011 SES meeting.

At this time the JASE journal editors and publishing coordinator have expressed their provisional interest in pursuing the special issue, however will make their final decision after submission of the contribution list of authors, titles and abstracts. If the proposal is accepted by the journal, papers for the special issue would be published at no cost to authors or to the Soil Ecology Society.

The special issue would be open to submissions of papers from all oral or poster presentations made at the SES 2011 meeting. The papers would be subject to selection for suitability and peer review process of JASE, however with a Guest Editor and Editorial Board composed of members of SES Board and the SES 2011 organizing committee as well as additional peer reviewers as needed. Final acceptance of papers would be made by the JASE chief editor.

Papers would be submitted and reviewed online through the journal's online editorial system. Paper format will follow that of regular submissions, please refer to author instructions at the journals website.

Pending acceptance of the proposal the timeline for the special issue, would be as follows:

- June 3 - Provisional contribution list of titles, abstracts and authors to journal
- June 17 – Decision on JASE acceptance of proposal
- **August 31 - Submission deadline for all manuscripts, updated list of titles**
- September 23 - Manuscripts out for review.
- November 11 – All reviews in
- December 6 – Editorial Board and Journal decisions to authors and requests for revisions
- January 27, 2012 - Revisions due from authors
- February 10 - Final manuscripts to journal for production.
- April - Publication of Special Issue of JASE

AWARDS

Students who have requested to be evaluated for the oral and poster competitions will be judged by members of the Awards Committee. The judges will confer and decide on awards that will be announced after the end of the meeting. Students will be notified by mail and the awards will be announced on the SES website and in the upcoming newsletter.

The winners of the Parkinson Travel Award and the Professional Achievement Award will be announced at the banquet on Thursday evening.

INFORMATION

ACTIVITIES AND EVENTS

Breaks and Lunches

Included in your registration fee

- Breakfast on Wednesday, Thursday, and Friday
- Coffee breaks at 9:45-10:30 on Wednesday, 9:00-10:00 on Thursday, and 9:30-10:00 on Friday. Coffee breaks will take place in the atrium of the Fipke Building on the first floor
- Bagged lunch served from 12:15-1:30 on Wednesday and 12:00-1:30 on Thursday. Lunches can be picked up in the Atrium of the Fipke building
- Evening meals on Tuesday, Wednesday, and Thursday

Social Activities and Events

- **Welcome Reception**
Tuesday May 24, 5:00-8:00 pm. After registering in the Atrium of the Fipke wander across campus to the Okanagan Sun Room where you are invited to attend a conference welcome reception which will include a stand up dinner with appetizers and drinks as well as live music. All attendees will be given one free drink ticket and there will be a cash bar open for the evening.
- **Society Photograph**
Gather together in order to commemorate the SES gathering at the Banquet on Thursday evening.
- **Auction**
A silent auction will be held for the duration of the conference. Set up your chosen items that you wish to sell at the beginning of the conference during registration. Attendees will have an opportunity to bid on items by writing down their information on sheets provided beside each item. Winners of each item will be announced on Friday at the completion of the conference.
- **Affair of Honour**
Thursday May 26, 12:00-1:30 pm. Come join us on the brand new sports field at UBCO for a semi-competitive ultimate Frisbee tournament. Meet your respective teams as designated during registration and attempt to win your way to conference glory and bragging rights for the banquet later in the day!
- **BBQ Wednesday**
Wednesday May 25, 6:00-7:30pm. Come join us for a casual barbecue in the Okanagan Sun Room. Cash bar will be available.
- **Membership Meeting**
Wednesday May 25, 8- 9:30pm. The membership meeting is open to all members of the

society, if you have registered for this meeting, then you are a member. A number of topics of interest to the society will be discussed at this meeting including nominations for the executive board.

- **Board Meeting**

Thursday May 26, 12:00-1:30pm. This meeting is for SES Executive Board.

- **Banquet**

An evening of fun that is being held in the historic Laurel Fruit Packing House in downtown Kelowna. Catered by local Chef Neil Schroeter and Okanagan Street Catering, the banquet will feature appetizers and alcoholic drinks along with live music and dancing as the evening proceeds.

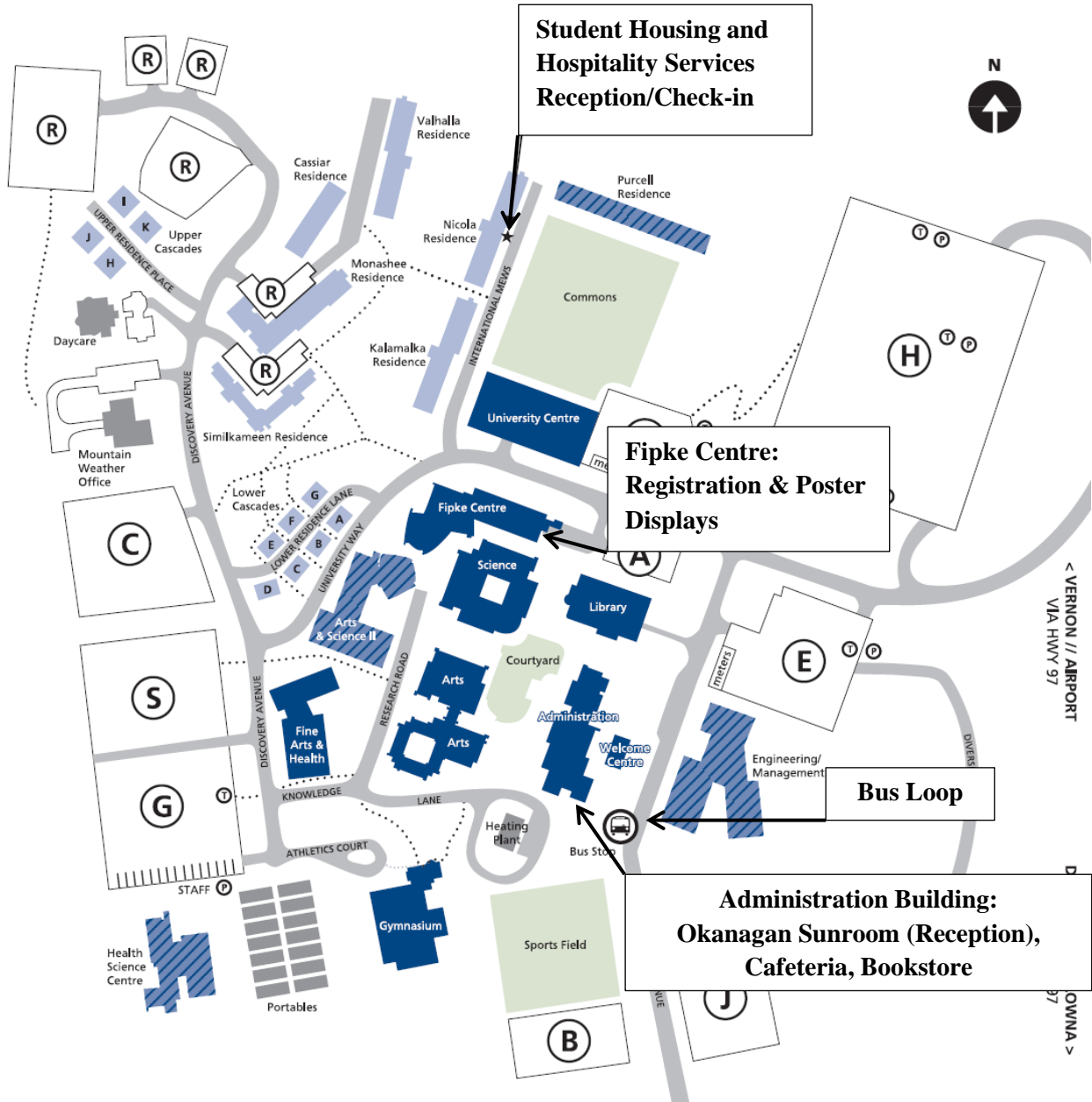
Buses will be departing from the UBCO at 5:30 in order shuttle everyone to the Laurel Packing House.

MAPS

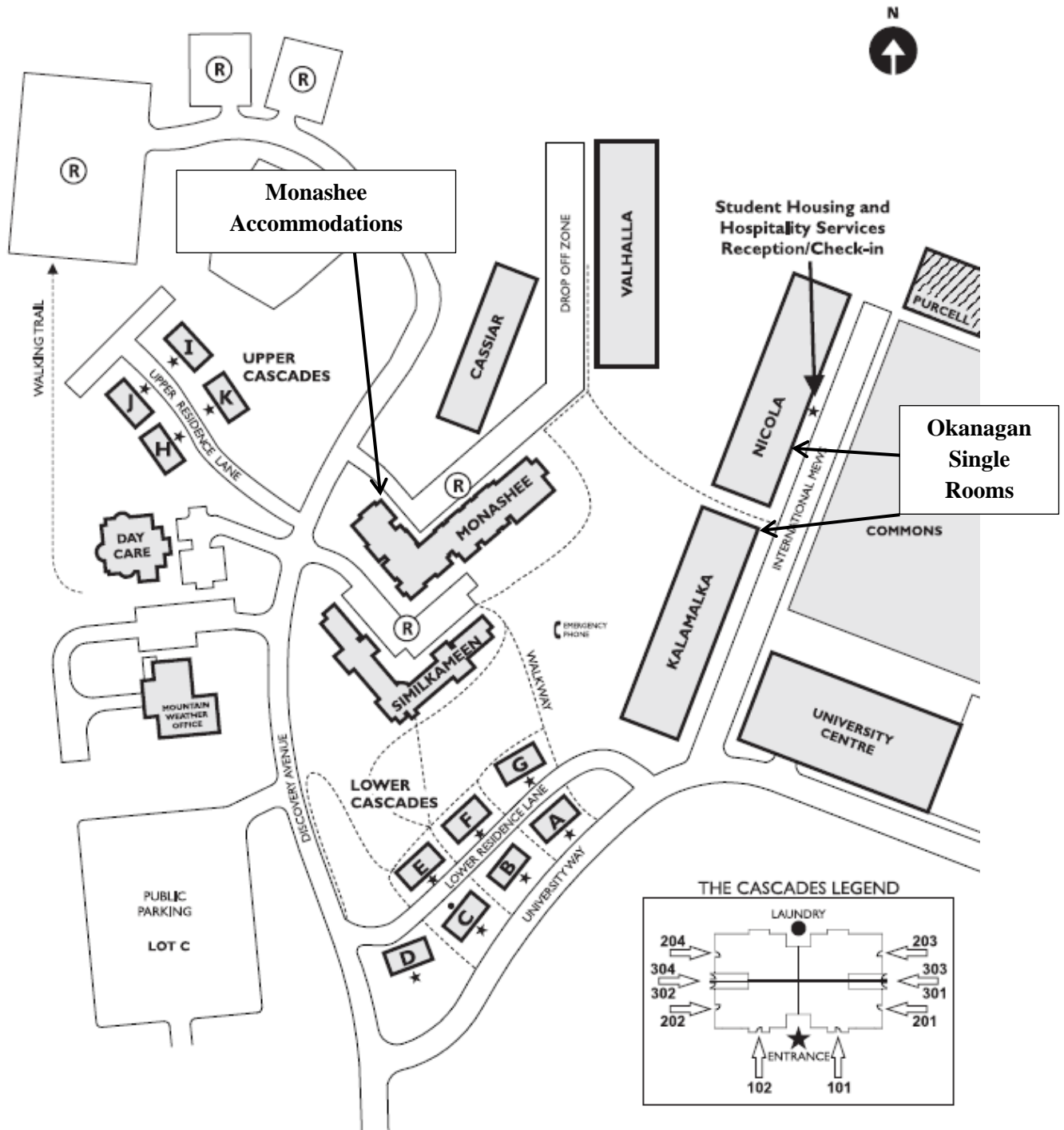
Kelowna



University of British Columbia – Okanagan, Campus Map



Accommodations Map

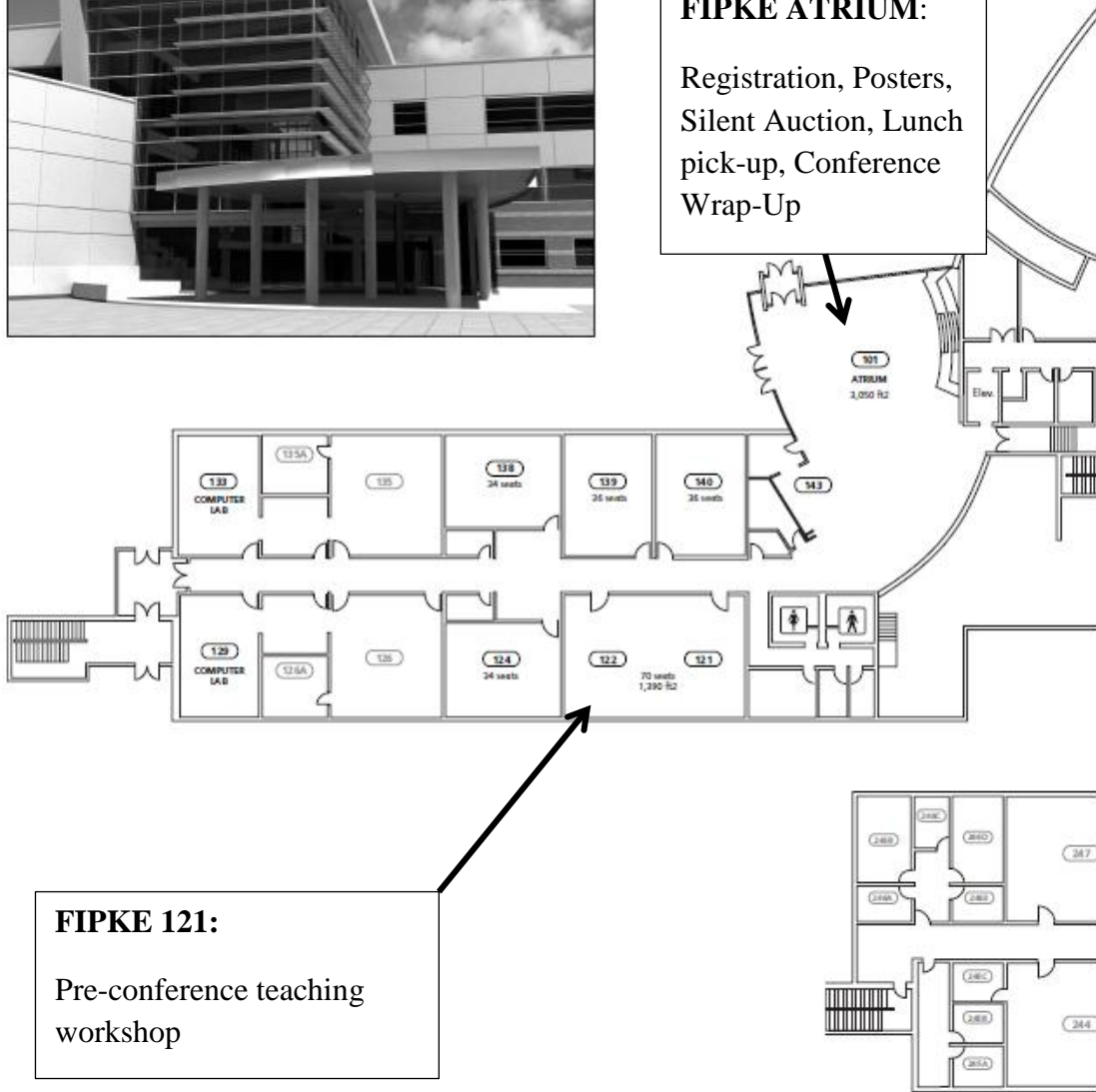


Fipke Centre

Fipke Centre – First Floor

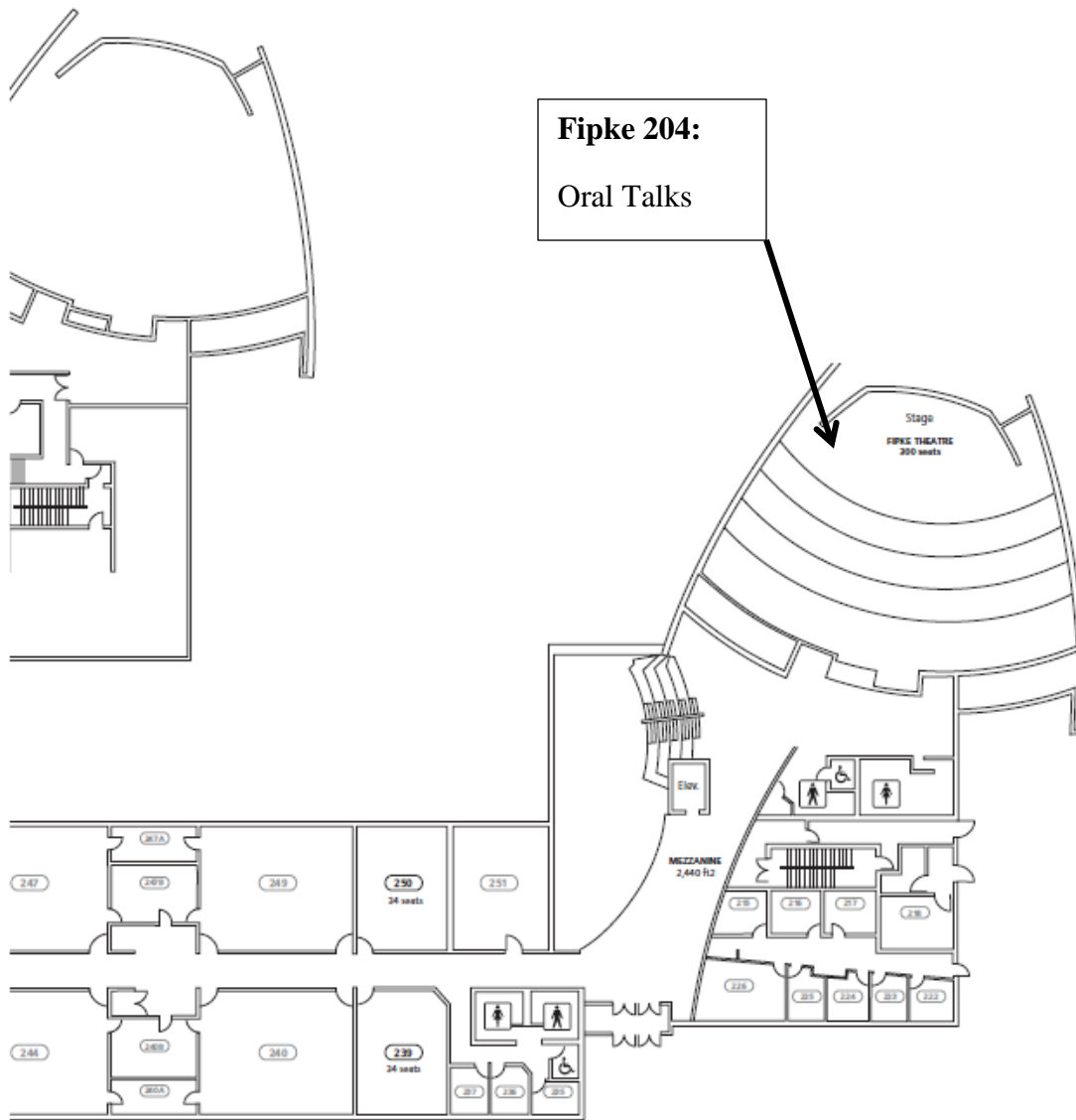


FIPKE ATRIUM:
Registration, Posters,
Silent Auction, Lunch
pick-up, Conference
Wrap-Up



FIPKE 121:
Pre-conference teaching
workshop

Fipke Centre – Second Floor

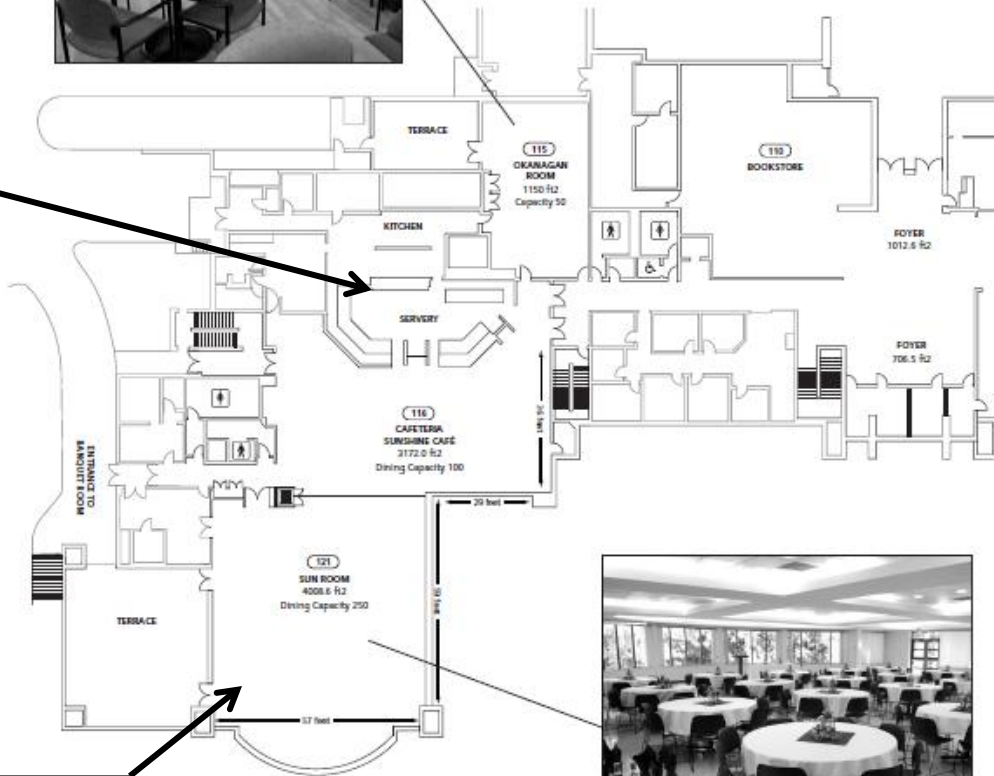


Fipke 204:
Oral Talks

Administration Building – Upper Level



Cafeteria



Okanagan Sun Room:
Reception and BBQ



PRESENTER INFORMATION

ORAL PRESENTATIONS

All presenters must arrive for their session at least 20 minutes before the session begins to ensure their presentations are loaded onto the computer.

Each presentation is allocated 13 minutes, including questions. The recommendation is a 10 minute talk followed by 3 minutes of questions.

POSTER PRESENTATIONS

Posters will be mounted Tuesday May 24th at registration in the Fipke Atrium. Posters will stay and be available for viewing throughout Wednesday May 25th, Thursday May 26th, and the morning of Friday May 27th.

ORAL PRESENTATION SCHEDULE

Wednesday May 25, 2011

Oral Presentation Session 1

Fipke 204

8:00a.m. - 9:45a.m.

- 8:00 WELCOME ADDRESS: **JOHN KLIRONOMOS**
- 8:15 ALTERED LIGNIN AND C:N RATIO OF PLANT RESIDUES: INFLUENCE UPON RESIDUE DECOMPOSITION, MICROBIAL BIOMASS CARBON AND MICROBIAL COMMUNITY STRUCTURE OF SOIL. **Gul, Shamim**, Whalen, J.K., Ellis, B.E., and Mustafa, A.F.
- 8:28 ARBUSCULAR AND ECTO MYCORRHIZAL COMMUNITIES ASSOCIATED WITH SOIL AGGREGATE SIZE CLASSES IN THE RHIZOSPHERE OF MYCORRHIZAL INOCULATED WILLOWS (*SALIX* SPP.). **Wijesinghe, Madantha A.K.**, Voroney, P., Klironomos, J.N., Hart, M.M., and Dunfield, K.E.
- 8:41 CHANGES IN THE ABUNDANCE OF NITRIFYING AND DENITRIFYING GENES ASSOCIATED WITH A FIELD-SCALE SPRING THAW N₂O FLUX. **Dunfield, Kari E.** and Wagner-Riddle, C.W.
- 8:54 CHANGING NJ PINE BARRENS FOREST TO AN ALTERNATE STABLE STATE: EFFECTS ON SOIL PROPERTIES. **Dighton, John**, Gray, D., Geng, Y., Smith, S., and Johnson, W.
- 9:07 COMMUNITY DISASSEMBLY AND TROPHIC CONTRACTION IN A BOREAL BRYOSPHERE COMMUNITY UNDER ENVIRONMENTAL CHANGE. **Lindo, Zoe** and Gonzalez, A.
- 9:20 COMPOSITION AND DIVERSITY OF ARBUSCULAR MYCORRHIZAL FUNGI IN CROPPING SYSTEM ASSOCIATED WITH DIFFERENT SOIL ZONES USING PYROSEQUENCING. **Dai, Mulan**, Hamel, C., St.Arnaud, M., Grant, C., Lupwayi, N., Janzen, H., Malhi, S., Yang, X., and Zhou, Z.

Oral Presentation Session 2

Fipke 204

10:30a.m. - 12:00p.m.

- 10:30 BUSHWHACKING THROUGH THE TANGLED BANK: EXPLORING SOIL MICROBIAL DIVERSITY AND THE CONTROLS ON MICROBIAL COMMUNITY COMPOSITION. Fierer, Noah.
- 10:43 EARTHWORMS, METHANOGENS AND METHANOTROPHS IN RIPARIAN SOILS. **Kernecker, Maria**, Whalen, J.K., and Bradley, R.L.
- 10:56 ECOLOGY OF NEMATODE SUPPRESSIVE SOILS IN MIDWEST SOYBEAN-CROPPING SYSTEMS. **Nishanthan, Tharshani** and Neher, D.A.
- 11:09 ECOSYSTEM PRODUCTIVITY AND SOIL FOOD WEB STRUCTURE - PAIRED MEADOW AND FOREST TRANSECTS ACROSS OREGON. **Colby, Samantha E.** and Moldenke, A.R.
- 11:22 ECTOMYCORRHIZAL NETWORKS IN XERIC AND MESIC INTERIOR DOUGLAS-FIR FORESTS. **Durall, Daniel M.**, Beiler, K.J., and Simard, S.W.
- 11:35 EFFECT OF INVASIVE EARTHWORMS ON LEAF LITTER DECOMPOSITION, SOIL CHEMISTRY AND WATER DYNAMICS. **Melnichuk, Ryan** and Gorres, J.
- 11:48 EFFECTS OF SIMULATED CLIMATE CHANGE AND DEFOLIATION ON RANGELAND SOIL MICROARTHROPODS. **Newton, Jeffrey S.** and Proctor, H.C.

Thursday, May 26, 2011

Oral Presentation Session 3

Fipke 204

10:00a.m. – 11:30p.m.

- 10:00 EFFECTS OF TEMPERATURE, PRECIPITATION AND DEFOLIATION ON LITTER DECOMPOSITION (MASS LOSS) IN CANADIAN GRASSLANDS. **Nyanumba, Samson M.**, Cahill, J., and Chang, S.
- 10:13 EXAMINATION OF SOIL CONTAMINANT TOXICITY TO THE MICROBIAL COMMUNITY OF BOREAL FOREST SOILS UTILIZING A SUITE OF TESTS. **Rahn, Jessica H.**, Beaudette, L.A., Kalyanasundaram, S., Hammad, A., Trevors, J.T., Lee, H., and Scroggins, R.
- 10:26 FERTILIZATION-INDUCED CHANGES IN SOIL ORGANIC MATTER

CHEMISTRY AND COMPENSATORY CHANGES IN ECTOMYCORRHIZAL FUNGAL COMMUNITY STRUCTURE AND ENZYME PROFILES. **Jones, Melanie D.**, Phillips, L., Treu, R., Ward, V., and Brockley, R.

- 10:39 IMPACTS OF FOREST POST THINNING RESIDUES ON SOIL CHEMISTRY, FAUNA AND ROOTS: PROBLEMS OF RESIDUE REMOVAL IN FINLAND. **Maghirang, Melanie**, Smith, S., Malcolm, K., Johnson, W., Quast, L., Dighton, J., Helmisaari, H-S., Gray, D., Setala, H., Starr, M.
- 10:52 MICROBIAL SUCCESSION DIFFERS DUE TO LITTER MIXING. **Chapman, Samantha K.**, Hart, S.C., and Koch, G.W.
- 11:05 MOISTURE EFFECTS ON MICROBIAL COMMUNITIES IN BOREAL FOREST FLOORS ARE STAND-DEPENDENT. **Swallow, Matthew J.** and Quideau, S.A.
- 11:18 MUTUALISM BREAKDOWN IN BREADFRUIT DOMESTICATION. **Hart, Miranda M.**; Xing, X.; and Koch, A.M.

Oral Presentation Session 4

Fipke 204

3:00p.m. – 5:00p.m.

- 3:00 MYCORRHIZAL LEGACIES OF PLANT INVASIONS - NOT ALWAYS A STORY OF DOOM AND GLOOM. **Lekberg, Ylva**, Gibbons, S.M., Rosendahl, S., Mummey, D.L., and Ramsey, P.W.
- 3:13 NEON: LONG-TERM, CONTINENTAL MONITORING FOR SOIL MICROBIAL ECOLOGY AND PRELIMINARY RESULTS FROM FOUR SITES. **Gallery, Rachel**, Docherty, K.M., and Kao, R.H.
- 3:26 ORGANIC AGRICULTURE BENEFITS FROM CONVENTIONAL AGRICULTURE. **Adl, Sina**, Iron, D., and Kolokolnikov, T.
- 3:39 PATTERNS OF SOIL RESPIRATION, MICROBIAL BIOMASS, AND BACTERIAL RESPONSES ACROSS ECOSYSTEMS UNDER N AMENDMENTS. **Ramirez, Kelly S.**, Craine, J.M., and Fierer, N.
- 3:52 PLANT DIVERSITY IMPACTS SOIL BIOTA AND SUBTERRANEAN FOOD-WEBS. **Koch, Alexander M.**, Antoninka, A., Tilman, D., Johnson, N.C., Klironomos, J.N.
- 4:05 PULSE AND WHEAT CROPS INFLUENCE ON SOIL DEHYDROGENASE ACTIVITY, SOIL NUTRIENT CONTENT AND MICROBIAL COMMUNITY. **Navarro-Borrell, Adriana**, Hamel, C., Hanson, K., McDonnald, C., Gan, Y., and

Germida, J.

- 4:18 PYROSEQUENCING ANALYSIS OF CHICKPEA RHIZOSPHERIC BACTERIAL DIVERSITY AS INFLUENCED BY FUNGICIDE APPLICATION. **Yang, Chao**, Hamel, C., Gan, Y.T., and Vujanovic, V.
- 4:31 RANKING THE RELATIVE EFFECTS OF MULTIPLE FACTORS ONO PLANT GROWTH: THE IMPORTANCE OF BREADTH. **Bennet, Jonathan A.** and Cahill, J.F. Jr.
- 4:44 REASSESSMENT OF THE ROLE OF *COCHLIOBOLUS SATIVUS* IN COMMON ROOT ROT OF CEREALS: AN ORGAN SPECIFIC FUNGAL COMMUNITY STUDY. **Taheri, Esmaeili A.**, Hamel, C., Gan, Y., and Vujanovic, V.

Friday, May 27, 2011

Oral Presentation Session 5

Fipke 204

8:00a.m. – 9:30a.m.

- 8:00 RESPONSE OF ECTOMYCORRHIZAL FUNGAL COMMUNITIES OF INTERIOR SPRUCE FORESTS TO LONG-TERM ANNUAL AND PERIODIC FERTILIZATION. **Hay, Tristyn N.**, Jones, M., and Ward, V.
- 8:13 SEMI-STABLE FRACTION FORMATION AND DECAY RATES AFTER 12 YEARS OF FOLIAR LITTER DECOMPOSITION IN CANADIAN FORESTS. **Tofymow, J.A. (Tony)**, Smyth, C., Moore, T., Prescott, C., Titus, B., Siltanen, M., Visser, S., Preston, C., and Fyles, J.J.
- 8:26 SOIL RESPIRATION RESPONSES TO TEMPERATURE ARE AFFECTED BY SUBSTRATE SUPPLY AND EARTHWORM ACTIVITIES. **Xia, Lijun** and Szlavecz, K.
- 8:39 SPATIAL VARIATION IN SOIL PROPERTIES IN NORTH AMERICAN ECOSYSTEMS: CHOOSING ROBUST SAMPLING DESIGNS FOR MEASURING SOIL PROPERTIES. **Ayres, Edward**, Loescher, H.W., Luo, H., Duffy, P., and Brunke, M.
- 8:52 THE ROLE OF BIOSOLIDS IN REPLENISHING ORGANIC MATTER IN CULTIVATED SOIL. **Tian, Guanglong**; Cox A., Granato, T., Chiu, C., and Franzluebbbers, A.
- 9:05 THE ROLE OF SYMBIONT LIFE-HISTORY STRATEGY IN COMMUNITY ASSEMBLY OF ARBUSCULAR MYCORRHIZAL COMMUNITIES IN GEOTHERMAL SOILS. **Meadow, James** and Zabinski, C.

9:18 TRACKING DENITRIFIERS THROUGH THE DRILOSPHERE WITH 454 PYROSEQUENCING AND AN ACETYLENE BLOCK ASSAY. **Prieto, Roberto**, Whalen, J.K., Driscoll, B., and Sampedro, L.

Oral Presentation Session 6

Fipke 204

10:00a.m. – 11:30a.m.

- 10:00 USING ORGANIC AMENDMENTS AND MULCHES TO PREFERENTIALLY ENHANCE BIOLOGICAL ACTIVITY AND SUPPRESS PLANT PATHOGENS IN ROOT ZONE SOIL UNDER PERENNIAL FRUIT CROPS. **Forge, Thomas A.**, Neilsen, G., Neilsen, D., Walters, T.W., and Koch, C.
- 10:13 MICROBIAL DECOMPOSITION OF LEGUME CROP RESIDUES AND N RELEASE. **Lupwai, Newton Z.** and Soon, Y.K.
- 10:26 THE ENDOPHYTE OF *SCHENODORUS PHOENIX* PROVIDES AN ADVANTAGE TO ITS HOST OVER PLANT COMPETITORS THROUGH THE ARBUSCULAR MYCORRHIZAL SYMBIOSIS. **Antunes, Pedro M.**, Lewwandowski, T., Dukes, A., Robson, J., and Newman, J.A.
- 10:39 COMMUNITY STRUCTURE OF ERICOID MYCORRHIZAS AND ROOT-ASSOCIATED FUNGI OF VACCINIUM MEMBRANACEUM ACROSS AN ELEVATION GRADIENT IN THE CANADIAN ROCKY MOUNTAINS. **Gorzalak, Monika A.**, Hambleton, S., and Massicotte, H.B.
- 10:52 AN ECOLOGICAL APPROACH TO 454 PYROSEQUENCING: ANALYSIS OF DISTRIBUTION, CO-OCCURRENCE AND DIVERSITY OF ECTOMYCORRHIZAL FUNGI IN BRITISH COLUMBIA. **Pickles, Brian J.**, Gorzelak, M.A., Egger, K.N., Massicotte, H.B., and Green, D.S
- 11:05 MULTI-SCALE VARIATION OF SOIL QUALITY INDICES AND ASSOCIATION WITH EDAPHIC PROPERTIES. **Collins, Douglas P.**, Cogger, C.G., Kennedy, A.C., Forge, T., Collins, H.P., Barry, A.I., and Rossi, R.
- 11:18 COVER CROP MIXTURES FOR PROMOTING ARBUSCULAR MYCORRHIZAL FUNGI IN PRODUCTION AGRICULTURE. **Taheri, Wendy I.**, Lehman, R.M., and Osborne, S.L.
- 11:31 COARSE WOODY DEBRIS RETENTION IN SUBALPINE CLEARCUTS AFFECTS ECTOMYCORRHIZAL ROOT TIP COMMUNITY STRUCTURE WITHIN FIFTEEN YEARS OF HARVEST. **Walker, Jennifer**, Jones, M.D., Ward, V., Paterson, C.

PROGRAM HIGHLIGHTS

TUESDAY, MAY 24, 2011

Pre-conference Teaching Workshop: <i>Dr. Loren Byrne, Roger Williams University</i>	1:00pm – 4:00pm	Fipke 121
Registration	3:00pm – 5:00pm	Fipke Atrium
Welcome Reception	5:00pm – 8:00pm	Okanagan Sun Room

WEDNESDAY, MAY 25, 2011

Oral Presentations	8:00am – 9:45am	Fipke 204
Coffee Break and Poster Presentations	9:45am – 10:30am	Fipke Atrium
Oral Presentations	10:30am – 12:15pm	Fipke 204
Lunch	12:15pm – 1:30pm	Pick-up in Fipke Atrium
Dennis Parkinson Memorial Symposium: <i>Introduction by Dr. Louise Nelson and Dr. Daniel Durall</i>	1:30pm – 1:45pm	Fipke 204
<i>Dr. David Coleman, University of Georgia</i>	1:45pm – 2:15pm	
<i>Dr. Diana Wall, Colorado State University</i>	2:15pm – 2:45pm	
<i>Dr. John Zak, Texas Tech University</i>	2:45pm – 3:15pm	
<i>Dr. Cindy Prescott, University of British Columbia</i>	3:15pm – 3:45pm	
Poster Presentations	3:45pm – 5:30pm	Fipke Atrium
Barbeque	5:30pm – 7:30pm	Okanagan Sun Room
Membership Meeting	8:00pm – 9:30pm	Fipke 204

THURSDAY, MAY 26, 2011

Plenary Seminar: <i>Dr. Ragan Callaway, University of Montana</i>	8:00am – 9:00 am	Fipke 204
Coffee Break and Poster Presentations	9:00am – 10:00am	Fipke Atrium
Oral Presentations	10:00am – 12:00pm	Fipke 204
Lunch	12:00pm – 1:30pm	Pick-up in Fipke Atrium
SES Board Meeting	12:00pm – 1:30pm	UNC 105
Poster Presentations	1:30pm – 3:00pm	Fipke Atrium
Oral Presentations	3:00pm – 5:30pm	Fipke 204

SES Banquet	5:30pm – 9:00pm	Laurel Packing House
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FRIDAY, MAY 27, 2011

Oral Presentations	8:00am – 9:30am	Fipke 204
Coffee and Poster Presentations	9:30am – 10:00am	Fipke Atrium
Oral Presentations	10:00am – 11:45am	Fipke 204
Wrap Up, Student Awards, & Good-Bye	11:45am – 12:30pm	Fipke Atrium

PROGRAM SCHEDULE

TUESDAY MAY 24

1:00pm – 4:00pm Pre-conference Teaching Workshop

How does soil ecology fit within environmental literacy and citizenship?

Dr. Loren Byrne, Roger Williams University

3:00pm – 5:00pm Registration

5:00pm – 8:00pm Welcome Reception

WEDNESDAY MAY 25

8:00am - 9:45am Oral Presentations

9:45am - 10:30am Coffee Break (and Posters)

10:30am – 12:15pm Oral Presentations

12:15pm – 1:30pm Lunch

1:30pm – 3:45pm Dennis Parkinson Memorial Symposium:

Dr. David Coleman, University of Georgia

Dr. Diana Wall, Colorado State University

Dr. John Zak, Texas Tech University

Dr. Cindy Prescott, University of British Columbia

3:45pm – 5:30pm Posters

5:30pm – 7:30pm BBQ

8:00pm – 9:30pm Membership Meeting

THURSDAY MAY 26

8:00am – 9:00am Plenary seminar:

Dr. Ragan Callaway - University of Montana

9:00am – 10:00am Coffee break (and posters)

10:00am – 12:00pm Oral Presentations

12:00pm – 1:30pm Lunch (and SES Board meeting)

1:30pm – 3:00pm Posters

3:00pm – 5:30pm Oral presentations

5:30pm – 9:00pm Banquet

FRIDAY MAY 27

8:00am - 9:30am Oral Presentations

9:30am - 10:00am Coffee break and posters

10:00am – 11:30am Oral presentations

11:30am – 12:30pm Wrap up, student awards, and good-bye

TEACHING WORKSHOP INFORMATION

Dr. Loren Byrne from the Roger Williams University will be leading a workshop on incorporating soil ecology into teach on Tuesday, May 24, from 1-4 pm.

How does soil ecology fit within environmental literacy and citizenship? Environmental education initiatives are coalescing around the concepts of environmental literacy and citizenship, ideas that focus our attention on what people should know and do about environmental issues.

As environmental scientists, soil ecologists can contribute much to the dialogue about the essential components of environmental literacy and citizenship. In this workshop, participants will explore the place of soil ecology and soil ecologists within general environmental education curricula and programs, including K-12, college, and public outreach contexts. In addition to discussing environmental literacy and citizenship issues more generally, the following questions, among others, may be discussed as part of this exploration:

How do soils and their ecology fit into the broader realm of environmental education?

What should all people know about soil ecology to be considered environmentally literate?

What behaviours should environmental citizens support and engage in with regard to soil management?

How can learners of all ages be convinced to care about soils and their ecology?

What case studies can be used to best improve people's soil ecological literacy and citizenship?

How can soil ecology be taught most effectively in non-majors science courses and public education programs?

SILENT AUCTION

A silent auction will be held for the duration of the conference. Set up your item(s) that you wish to put up for bidding at the beginning of the conference during registration in the Fipke Atrium. Attendees will have an opportunity to bid on items by writing down their information on sheets provided beside each item. Winners of each item will be announced on Friday at the completion of the conference.

SES AFFAIR OF HONOUR

Tired of being inside all day when you came to the beautiful Okanagan Valley? Come join us at lunch on Thursday May 26th for a mini-ultimate frisbee tournament that will be held on the UBCO sports field.

Four teams will be participating and have been divided at registration with designated captains to organize. Games will be 20 minutes in length with the winners of the first games playing in the Championship and the losers of the first games playing for third place (and not being the last team at SES 2011!).

A Quick Outline of the Rules

1. **The Field** -- A rectangular shape with endzones at each end.
2. **Initiate Play** -- Each point begins with both teams lining up on the front of their respective endzone line. The defense throws ("pulls") the disc to the offense. A regulation game has seven players per team.
3. **Scoring** -- Each time the offense completes a pass in the defense's endzone, the offense scores a point. Play is initiated after each score.
4. **Movement of the Disc** -- The disc may be advanced in any direction by completing a pass to a teammate. Players may not run with the disc. The person with the disc ("thrower") has ten seconds to throw the disc. The defender guarding the thrower ("marker") counts out the stall count.
5. **Change of possession** -- When a pass is not completed (e.g. out of bounds, drop, block, interception), the defense immediately takes possession of the disc and becomes the offense.
6. **Substitutions** -- Players not in the game may replace players in the game after a score and during an injury timeout.
7. **Non-contact** -- No physical contact is allowed between players. Picks and screens are also prohibited. A foul occurs when contact is made.
8. **Fouls** -- When a player initiates contact on another player a foul occurs. When a foul disrupts possession, the play resumes as if the possession was retained. If the player committing the foul disagrees with the foul call, the play is redone.
9. **Self-Refereeing** -- Players are responsible for their own foul and line calls. Players resolve their own disputes.
10. **Spirit of the Game** -- Ultimate stresses sportsmanship and fair play. Competitive play is encouraged, but never at the expense of respect between players, adherence to the rules, and the basic joy of play.

LOCAL TRANSPORTATION

Bus Schedule:

<http://www.busonline.ca/regions/kel/>

A detailed schedule can be found on the website above. Buses arrive and depart from UBCO throughout the day with service going to and from downtown Kelowna throughout the evening on the 97 express.

Airport Shuttle:

<http://www.kelownashuttle.com/airportshuttle.htm>

1-888-434-8687 - toll free / fax

250-448-5670 - local

Taxis:

Apple Supreme Cabs Ph: (250) 864-4638

Checkmate Cabs Ph: (250) 861-1111

Holiday Cab & Limo Ph: (250) 491-3050

In Town Taxi Ph: (250) 212-1212

Kelowna Cabs Ph: (250) 762-2222

Lake Country Taxi Ph: (250) 766-4440

Okanagan Designated Driver's Service Ph: (250) 808-6533

Star Taxi Ph: (250) 878-9070

ABSTRACTS

Abstracts are arranged alphabetically by first author

RECONSTRUCTING THE SOIL FOOD WEB OF A 100 MILLION YEAR OLD FOREST FROM MICROFOSSILS IN AMBER

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Over the past decade, the mid-Cretaceous amber deposits of Charentes (SW France) have been intensively studied. The fossils investigated were not only limited to arthropods preserved in amber, but also included microorganisms, plant debris and vertebrate remains. This plethora of analyses provided important data about the ecology of the overall system, including sources of litter input into the soil and of the above-ground ecology. More precisely, they showed that most of the microfossils were those of soil organisms or organisms that participated in the ecology of the forest soil. This new discovery provided the opportunity to study the ecology of the soil as preserved in the 100 million years old Charentes amber. Indeed, the trophic links of the fossil forest soil have been reconstructed on the basis of the fossil assemblage discovered in amber outcrops and overlaid on a model ecological forest soil food web. We relied on existing phylogenetic information to discuss the absence of certain taxonomic groups in the fossilized specimens. Our synthesis shows that although the organisms of this ancient forest of Charentes were different from those of modern soils, the soil food web was organized functionally the same as modern soils. It also demonstrated that trophic links of the soil community were already diverse, including various means of predation, parasitism and organic matter decomposition. The most obvious differences are the absence of evidence for symbiotic root nitrogen fixation and mycorrhizae. In addition, we identified a number of problematic descriptions of protist-like fossils, that are likely artifacts and that we call pseudo-protists. We tried to recreate experimentally early stages of fresh resin and protist fixation in an actinotaphonomic study. These results indicate there are certain definable parameters that will facilitate fixation by resin so as to enable subsequent fossilization.

ORGANIC AGRICULTURE BENEFITS FROM CONVENTIONAL AGRICULTURE

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Conventional agriculture uses herbicides, pesticides, and chemical fertilisers that have the potential to pollute the surrounding land, air and water. Organic agriculture tries to avoid using these and promotes an environmentally friendly approach to agriculture. Instead of relying on herbicides, pesticides and chemical fertilisers, organic agriculture promotes a whole system approach to managing weeds, pests and nutrients, while regulating permitted amendments. In this paper, we consider the effect of increasing the total area of agricultural land under organic practises, against a background of conventional agriculture. We hypothesized that at a regional scale, organic agriculture plots benefit from existing in a background of conventional agriculture,

that maintains low levels of pathogens through pesticide applications. We model pathogen dispersal with a diffusive logistic equation in which the growth/death rate is spatially heterogeneous. We find that if the ratio of the organic plots to conventional plots remains below a certain threshold l_c , the pest population is kept small. Above this threshold, the pest population in the organic plots grows rapidly. In this case, the area in organic agriculture will act as a source of pest to the surrounding region, and will always infect organic plots as they become more closely spaced. Repeated localised epidemics of pest outbreaks threaten global food security by reducing crop yields and increasing price volatility. We recommend that regional estimates of this threshold are necessary to manage the growth of organic agriculture region by region.

HOW DO ORGANIC MATERIALS WITH DIFFERENT NITROGEN CONTENT AFFECT MYCORRHIZAL COLONISATION?

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Arbuscular mycorrhizal fungi (AMF) are plant symbionts capable of enhancing nutrient uptake and improving soil structure for the plant. These features make the AMF especially beneficial in ecosystems with degraded soils or those highly exposed to erosion. It has been suggested that increased levels of organic material (OM) in the soil will enhance the production of AMF biomass, and that OM with high concentrations of nitrogen (N) are especially beneficial.

Here we present the results of two experiments investigating the effects of introducing different sources of N and OM into an arbuscular mycorrhizal system. The hypothesis that increased levels of N as well as larger amendments of OM will cause an increase in the growth of AMF was tested by sampling in-growth of AMF in mesh bags with different treatments. The in-growth of AMF was measured as relative biomass through analyses of a signature neutral lipid fatty acid (NLFA)-16:1 ω 5, known to be found exclusively in AMF.

Results showed a significant positive effect in AMF growth for amendments of naturally N-rich OM (alfalfa and yeast extract). Additions of low-N OM (straw) showed no positive effect, even when NH_4NO_3 was added to roughly equate the N-concentration of alfalfa. Alfalfa and yeast extract were found to have a similar effect on AMF growth when added proportionally to their N-content. These results suggest that N concentrations in OM play a role in its effect on AMF growth. There are also indications that the organic or inorganic nature of the N could determine its effect on AMF growth, something that would need to be further investigated.

THE IMPACT OF GARLIC MUSTARD ON SANDY FOREST SOILS

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Our studies have evaluated the impacts of a severe infestation of an invasive species, *Alliaria petiolata*, on soil characteristics and microbial community dynamics in a nutrient poor, sandy forest soil. We sampled areas of infestation vs. non-infestation within a sand prairie pine plantation in central Illinois over several years. Garlic mustard increased soil pH and altered C:N ratios. In situ and laboratory incubations have shown increased CO_2 efflux for soils collected from garlic mustard infested sites. Laboratory incubations of soils collected from non-infested sites showed increased CO_2 efflux when soils were amended with garlic mustard tissues

or with mustard seed meal (chemically similar to garlic mustard). There was also a significant increase in nitrogen turnover in infested soils. Preliminary studies have shown decreases in the presence of ectomycorrhizae on infested sites. As garlic mustard is currently invading forests at high rates there is a concern that changes in soil characteristics and microbial community structure will alter nutrient availability and competitive dynamics of North American forests. Our data suggests those concerns are valid and support the need for more research on the impacts of invasive species on managed systems.

THE ENDOPHYTE OF *SCHENODORUS PHOENIX* PROVIDES AN ADVANTAGE TO ITS HOST OVER PLANT COMPETITORS THROUGH THE ARBUSCULAR MYCORRHIZAL SYMBIOSIS

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Schedonorus phoenix, commonly known as tall fescue, was introduced in North America from Europe in the 1800's and can now be found dominating grasslands across the continent. This perennial bunchgrass establishes mutualistic symbiotic relationships with the endophytic fungus *Neothyphodium coenophialum* and arbuscular mycorrhizal fungi (AMF). Although these symbioses confer various competitive advantages to its host, previous research indicated an asymmetric interaction between them. As a result, the basic question we asked was: why would one mutualism counteract the other? Given that AMF interconnect plants belowground, we hypothesized that the interaction between the two symbioses can affect the competition among plants. More specifically, we investigated whether the negative effect of *N. coenophialum* on AMF can enhance the capacity of *S. phoenix* to compete with other plants. In a growth-room experiment we established all possible combinations of both symbioses in a sterile substrate by growing *S. phoenix* var. KY-31 with or without *N. coenophialum* in presence of the competitor native plant *Achillea millefolium* over a period of four months. The AMF+ treatments consisted of adding 2000 axenically cultivated spores of *Glomus intraradices* to the root seedlings of both plant species. We found that the total plant biomass produced was significantly larger in presence of the endophyte, which was driven by the growth of *S. phoenix* rather than that of *A. millefolium*. Moreover, the biomass *A. millefolium* was significantly reduced only in presence of both fungal symbioses. This indicates that the endophyte provided a competitive advantage to its host that was mediated exclusively through effects on the AMF symbiosis. We are currently investigating whether or not the endophyte caused a functional imbalance in the AMF symbiosis by shifting it towards its host relative to the competitor. Moreover, we will present preliminary data on a plant and AMF community level approach to the study of these multiple plant-microbe interactions.

THE NATIONAL ECOLOGICAL OBSERVATORY NETWORK (NEON) STRATEGY FOR SOIL MEASUREMENTS

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Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, Colorado, USA.

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The National Ecological Observatory Network (NEON) is a NSF-funded facility to monitor the impacts of climate change, land use change, and invasive species on biodiversity and ecosystem function. The 60 NEON sites throughout the US include representatives of most dominant ecosystems and every common soil type found in the US. Soil measurements at these sites fall into two broad categories: 1) measurements made by in-situ sensors that will have high temporal frequency, but limited spatial coverage; and 2) laboratory-based measurements on soil samples collected by field technicians that will have a lower temporal frequency, but greater spatial coverage.

Sensors for soil measurements will be distributed among 5 soil plots located near the NEON tower. The spacing between soil plots is based on a geostatistical analysis (i.e. semivariogram) of spatial variation in soil temperature and moisture data gathered during site characterizations. This approach maximizes the chance that soil measurements from adjacent soil plots are independent at the local scale, while minimizing the distance between plots to constrain costs. Based on this design and the site characterizations, the sensors will be able to estimate spatial (i.e. ~1 ha) soil temperature to within $1.7 \pm 0.6\%$ of the mean with 90% confidence and soil moisture to within $5.9 \pm 1.1\%$ of the mean with 90% confidence. Other sensors present in the soil plots will include minirhizotrons to estimate fine root turnover, CO₂ sensors to estimate belowground respiration, and soil heat flux sensors to estimate energy fluxes.

Lab-based measurements on soil samples will focus on microbes, root and litter stocks, and biogeochemistry. Soil microbes play key roles in many of the processes that constitute NEON's grand challenge areas. NEON's soil microbe sampling design will capture spatially explicit inter- and intra-annual variation in bacterial, archaeal and fungal biodiversity. This design will also couple microbe community composition, diversity and functional gene presence and abundance with biogeochemical characteristics, plant community composition, and above and belowground ecosystem productivity. NEON data and archived samples will help to expand the temporal and spatial understanding of microbial dynamics, with the long-term aim of capturing the drivers and feedbacks of microbial responses to climate and land use change. Measurement of belowground fine root-stocks will be distributed across each NEON site and, when coupled with fine root turnover rates, will allow estimation of key components of belowground NPP. Moreover, measurement of litter inputs and litter standing pools across each site will enable quantification of mass and energy fluxes from above to belowground systems, and will link aboveground productivity and belowground ecosystem function (e.g. C and N cycling).

All NEON data will be openly accessible. For soil-related data, NEON will produce summary analyses such as continental scale maps of soil properties (e.g. soil moisture, soil bacteria beta diversity) in near real time. In addition, soil data will be included in a variety of high level data products such as maps of ecosystem carbon, energy, and water exchange that will be produced at local (~1 km²), regional (~100 km²) and continental (~10 million km²) scales at daily resolution.

SPATIAL VARIATION IN SOIL PROPERTIES IN NORTH AMERICAN ECOSYSTEMS: CHOOSING ROBUST SAMPLING DESIGNS FOR MEASURING SOIL PROPERTIES

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⁴ Neptune and Company, Inc., 8550 West 14th Avenue, Lakewood, Colorado, USA.

Ecologists often have to decide how far apart to place long-term plots to ensure that they are representative of the surrounding area and to maximize the information that they provide. Choosing an appropriate distance between plots is important for two reasons: 1) they should be distant enough to avoid autocorrelation in measurements at a given scale, thereby maximizing the amount of information provided by a limited number of plots; and 2) they should be as close as possible to minimize costs, which typically increase with distance. Plot spacing decisions are usually based on knowledge of the ecosystem and experience, but these distances are highly subjective and difficult to justify. Geostatistical techniques, i.e. semivariograms, were used here to determine the minimum distance required for plots to be considered spatially independent at a given scale, thus maximizing representativeness while minimizing the distance among plots. We used soil temperature and moisture for these semivariograms as a proxy for other soil properties to determine how far apart to place soil plots at 59 sites across North America for the US National Ecological Observatory Network (NEON). A mean of 134 temperature and moisture measurements were taken at each site at intervals ranging from 0.3 m to at least 84 m and semivariograms were produced for each site. The range values (i.e. the distance at which measurements were no longer correlated) were then estimated from the semivariograms. The mean range was ~27 m for both soil moisture and temperature and range values were significantly related to a variety of site characteristics, including soil order, mean annual precipitation, elevation, and latitude. NEON soil plots will be spaced at the larger of the two ranges we estimated for a site if both ranges are <40 m. The maximum distance between plots is limited to 40 m due to cost constraints. In addition to estimating the range, semivariograms also provide a measure of the spatial variance in soil properties that can be used to estimate the number of samples required to measure a soil property with a given confidence and accuracy. For example, across all the sites, on average 3 samples would be sufficient to measure soil temperature to within 5% of the mean with 95% confidence, whereas for soil moisture 8 samples would be required. By combining the number of samples required at the sites with the range values we were able to evaluate the effectiveness of different potential sampling strategies. For example, 100 samples spaced 35 m apart would have been sufficient to measure soil moisture to within 5% of the mean with 95% confidence at two thirds of the sites. However, this could also have been achieved with just 15 samples spaced 55 m apart as well as other sample number/spacing combinations. Since the NEON sites are broadly representative of US ecosystems, this information can be used to design robust sampling strategies for US sites (and elsewhere) in the absence of site-specific data.

PERMAFROST MELT SEEP PATCHES INCREASE HETEROGENEITY OF SOIL GEOCHEMISTRY AND THEREFORE HABITAT SUITABILITY

Ball¹, Becky A., Virginia², Ross A.

The McMurdo Dry Valleys, a polar desert region in Antarctica, are among the most extreme terrestrial habitats on Earth. Despite the inhospitable conditions, terrestrial biological activity is possible, and the species distribution of these soil communities are generally determined by the interactions of soil chemistry, temperature and water availability. In recent decades, the dry

valleys have experienced periodic discrete warm climate events that result in meltwater pulses from ice reserves and the creation of transient new patches of inundated soil habitat. Water from the melt of the ice-cemented permafrost is drawn through the active layer to the surface by capillary action, causing the appearance of variably-sized wetted patches scattered across the landscape. Such alterations to soil moisture and geochemistry constitute a change in habitat suitability that can alter soil community abundance, composition, and distribution, and therefore the ecological processes dictated by biological activity. To begin investigating the consequences of permafrost seep patch appearance on soil geochemistry and biological activity, we sampled seep patches across one lake basin during a discrete warm year. We hypothesized that soils affected by meltwater seeps would be higher in salt content and moisture than the surrounding dry soils outside the seep patch, thereby causing a decrease in biological activity. Six permafrost meltwater seep patches of varying size were sampled at three locations along transects in each patch: the center (C) of the patch, the edge (but just inside) of the patch (E), and outside the seep patch (O) in the dry soil. At each position, we sampled at regular depths to the permafrost and measured soil water content (SWC), pH, conductivity, anion and cation content. In a laboratory incubation, biotic potential was measured as soil CO₂ flux generated from surface soils from each of the “Center” and “Outside” positions in each patch. Our data show that the presence of permafrost meltwater seep patches increased soil moisture and salt content, particularly at the soil surface. For most ions and therefore EC, the center and edge locations were similar and significantly higher than outside the patch, but the influence of position often varied by patch. This difference altered soil respiration, which differed significantly with position, as well as across patches. However, respiration was not consistently higher inside or outside of patches throughout the incubation. Our results demonstrate that, though the presence of permafrost melt seeps tends to push surface soils to more locally homogeneity consisting of high-ion content, seep patches will differ greatly from the neighboring dry soil, resulting in an increase in landscape-scale heterogeneity by mobilizing those salts from the permafrost and delivering them to the active layer. Future climate projections suggest that, as stratospheric ozone levels recover, the MDV will likely be experiencing a long-term press in increased temperatures (and therefore melt) rather than discrete warm pulses. Therefore, permafrost seep patches may become a more prevalent feature of the dry valley soil landscape, causing examples such as these to forecast the influence of this projected climate warming.

ECTOMYCORRHIZAL NETWORKS IN XERIC AND MESIC INTERIOR DOUGLAS-FIR FORESTS

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The overarching objective of this study was to compare the complexity of mycorrhizal networks (MNs), formed by *Rhizopogon* spp., between sites that differed in soil moisture regimes. This was performed to infer the relative importance of MNs in the organization of forest stand structure with increasing site water stress. We selected three plots in upper slope positions and three plots in lower slope positions with plant communities indicative of the respective soil

moisture regimes. On each plot, tubercles were sampled and microsatellite DNA was amplified from both root and fungal tissue. Needle and/or cambium tissue was sampled to provide a reference DNA library of tree genotypes for matching with tree roots isolated from *Rhizopogon* spp. mycorrhiza samples. Whether viewed from phytocentric or mycocentric perspectives, *Rhizopogon* spp. genets and interior Douglas-fir trees were highly interconnected through spatially and socially complex mycorrhizal networks. MN topologies were characteristic of hierarchical scale-free networks, suggesting the bonds between these organisms are cohesive and robust against the random loss of participants, but could be susceptible to the targeted loss of large trees and large fungal genets. Mycorrhizal network architectures were similar between mesic and xeric forest stands. This suggests *Rhizopogon* spp. linkages between trees are resilient to soil water stress and could become increasingly important for regeneration facilitation of mixed-aged interior Douglas-fir forests if climate change leads to more frequent and severe drought episodes.

RANKING THE RELATIVE EFFECTS OF MULTIPLE FACTORS ON PLANT GROWTH: THE IMPORTANCE OF BREADTH

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Many potential factors limit plant growth, both above and belowground. While the influence of some factors such as herbivory and nutrient limitation have received significant attention, the relative importance of others, including mycorrhizal associations, has yet to be established. Furthermore, the influence of each factor is likely to vary between groups of plant species, and perhaps across large taxonomic divisions. As experiments manipulating all of these factors would be logistically difficult, we currently have little knowledge of the relative importance of each of these factors in structuring natural communities. To address this issue we compiled data from multiple experiments within the same field site that manipulated many of these factors, including insects, mycorrhizal fungi, soil resources, defoliation, and light. Each treatment was categorized according to whether it occurred above or below the soil surface and according to the class of interaction (nutrient, water, insects, etc). Treatment effects were calculated for 11 graminoid species and for 31 forb species across all experiments. There was no mean difference between above and belowground factors in their effect on plant growth, and the response of graminoids and forbs also did not differ on average. However, graminoids and forbs did differ in their responses to aboveground and belowground processes, with graminoids responding strongly to belowground factors and forbs to aboveground. These differences between classes of plant species are largely unpredicted by theory. With respect to belowground factors, forbs, as a group, appear to be relatively insensitive to experimental manipulations, whereas graminoids are most limited by nutrients, followed by insects and water. For both groups, mycorrhizal suppression appears to cause the least directional change, but may differentially affect species groups at a finer taxonomic scale. This quantitative ranking of factors limiting plant growth is the first to our knowledge and provides a potential means to understand larger scale patterns influencing plant communities.

SOIL BIOTA, PLANT INTERACTIONS, AND EXOTIC INVASIONS

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Studying soil biota in the context of exotic plant invasions has led to an explosion in knowledge about the role of these organisms in ecology and evolution. Research on the broad effects of host-preferring soil pathogens in the context of exotic plant invasions has pointed to the fundamental importance of plant-soil feedbacks in community organization. Studying the effects of invasive plants on soil biota has revealed powerful mechanisms by which plants can affect soil processes. Through the disruption of soil-based mutualisms by invaders we have gained insight into the nature of mutualistic interactions in general. And through biogeographic approaches to exploring plant-soil biota interactions in the native and non-native ranges of invaders we have discovered evolutionary trajectories within communities of plants and soil organisms. Yet, tremendous potential remains for learning more from the roles of soil biota in exotic plant invasions and thus continuing to resolve key conceptual and mechanistic questions in biology.

IMPACTS OF CLIMATE CHANGE ON THE FUNCTION OF BIOLOGICAL SOIL CRUSTS IN BRITISH COLUMBIA GRASSLANDS

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The grasslands in the interior plateau region of British Columbia are unique ecosystems with high ecological and recreational value and a critical resource for the Province's ranching industry. Intensive study is needed to gain an understanding of the potential impacts of predicted climate change on these ecosystems. An important and often under-appreciated component of these grasslands is the biological soil crusts (BSC), community of lichens, cyanobacteria, green algae and mosses that occupy much of the soil surface. The BSC play many important ecological roles in grasslands, particularly in terms of nutrient cycling and nitrogen (N) and carbon (C) dynamics. The objective of this study is to assess and quantify potential climate-related changes in the function of biological soil crusts in interior B.C. BSC microclimate, including temperature, moisture and light, were measured at upper and lower elevation sites in the Chilcotin Region of British Columbia. Measurements of nitrogen fixation were taken under field conditions during different seasonal periods and under manipulations of light, moisture and temperature using acetylene reduction analysis (ARA). This study will help further the understanding of BSC function in interior B.C. grasslands and their response to climate manipulations, which will help range managers adapt to future climate change and maintain the grasslands as a resource for future generations.

DOES INVASION BY NON-NATIVE OLD WORLD BLUESTEMS REDUCE HABITAT FOR SOIL MICROFAUNAL GROUPS?

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Soil mesofaunal species, which aid in decomposition of organic matter, incorporation of organic matter into soils, and maintenance of bacterial and fungal populations are all essential to the health and ecology of grasslands. Many soil mesofauna overwinter among perennial grass crowns, near the soil surface for protection from the elements. Overwintering habitat is important in retention of diverse soil arthropod communities, and, due to their important functions, ecosystem health. Non-native Old World bluestems (*Bothriochloa ischaemum* and *B. bladhii*) have been introduced for hay production and have aggressively exceeded the bounds to which they were introduced. Old World bluestems tend to exhibit growth habits that differ from native bluestems such as little bluestem (*Schizachyrium scoparium*) and big bluestem (*Andropogon gerardii*). Vegetative cover retained by these non-native species over the winter is qualitatively different from the native bluestems. Previous researchers concluded that macro arthropod biomass was limited in Old World bluestem pastures compared to native pastures; however, the function of aboveground arthropods differs from soil mesofauna. Overwintering habitat may be different between the native and non-native bluestems, and as a result, mesofaunal communities occurring in soils dominated by either plant group may be different. Our objective was to compare soil mesofaunal numbers and ordinal diversity among these four major bluestem species in a southern mixed grass prairie. We predicted that there would be a difference in numbers of individuals and ordinal diversity present among the four grass species, and that the depth of crown matter would be significantly correlated to mesofaunal community characteristics. Numbers of individuals extracted, orders represented and ordinal diversity did not differ between crowns of the four grass species sampled. Numbers of individuals extracted was not correlated to thickness of crown material, indicating that overwintering habitat may be selected based on other variables. High levels of variability and small sample sizes likely confounded the results of this experiment. Future research will include quantification of soil organic matter, litter quality and higher levels of sampling.

MICROBIAL SUCCESSION DIFFERS DUE TO LITTER MIXING

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Microbial decomposer communities change during the course of litter decomposition, due to shifting substrate availability and biotic interactions such as competition and predation. Microbial succession has been documented repeatedly on single litter types; however, we do not yet know how microbial communities change when litter types are mixed. We extracted phospholipid fatty acids (PLFAs) from single and mixed litter bags after 10 months and 27 months of decomposition in mixed conifer forests. We investigated 1) whether litter mixing impacted fungal and bacterial succession and 2) whether microbial succession changes influenced the occurrence of faster than expected litter decomposition. We found that total PLFA concentrations were initially 70% higher on litter mixtures but equalized after two years of decomposition. Fungal:bacterial ratios on mixed versus single litter types also differed during the early stages of decomposition but converged through time. Litter mixing continued to stimulate bacterial biomass after two years. Non-additive stimulation of mixed litter decomposition

coincided with the greatest differences in microbial biomass. We conclude that litter mixing does alter microbial succession and that these microbial community dynamics may, in part, drive synergisms in litter decomposition. These findings inform our understanding of the mechanisms driving emergent effects of biodiversity at the plant-soil interface. Further, changing plant biodiversity may alter temporal microbial community dynamics in litter food webs.

EARTHWORM EFFECTS ON THE NITROUS OXIDE EMISSION IN THE GRASS AND CLOVER FIELDS

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Nitrous oxide (N₂O) is a greenhouse gas that leads to global warming and ozone layer destruction. The earthworm, as a common macrofauna in the agricultural system, has been shown to strengthen microbial activities. Previous researchers also found that earthworm gut as well as earthworm activities including casts, burrows, middens can stimulate the N₂O emission in agricultural soils, but these experiments belong to small-scale incubation ones, whether earthworm affecting the N₂O in field with plant growth is not clear. In this study, both clover and grass representing the perennial agro-ecosystems with endogeic and/or anecic earthworm treatments were designed and set up in Macdonald Farm, McGill University. During the fall of 2010, 5 times gas fluxes were collected and counted. The soil temperature and moisture were measured at the same time of gas sampling. The objectives of our studies are (1) the N₂O emission affected by earthworm abundance and species; (2) the contrast with the N₂O flux in grass and clover field; (3) the correlation among the N₂O and the soil properties. Our results showed that the field with numerous earthworms had the larger N₂O contribution, but the difference among earthworm species was not significant. The N₂O emission rate and the seasonal cumulative N₂O emission were more obvious in clover systems compared with grass fields. The regressive analysis by soil temperature, soil moisture as well as the soil temperature × soil moisture revealed their correlation with N₂O flux. These results confirm that the earthworm plays as a N₂O emission driver in agricultural systems.

ABUNDANCE AND DISTRIBUTION PATTERN OF THE GROUND DWELLING ARTHROPODS VARIED WITH AGE OF THE CLOUD FORESTS

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Subtropical montane cloud forest is a unique ecological environment and had been reported sensitive to environmental changes. However the ground dwelling arthropods in this ecosystem are rarely studied. In this study, predatory arthropods (Arachnida and Coleoptera) and their potential prey (Collembola and Oribatida) in three cypress cloud forests with different age (50, 300-400 and >400 years old) were investigated. Twenty-five pitfalls arranged in a grid system were set up in each forest to collect the arthropods in six months of 2009. The pitfalls were opened for 48 hours each month. Abundance of the predatory arthropods differed significantly among months in all three forests except arachnids in the oldest forest. Abundance of the

predators varied significantly among pitfalls in the youngest forest but not in the older forests, and they were highest in the youngest forest and were lowest in the oldest forest in June, September and November. Abundance of collembolans and oribatid mites differed significantly among months and among forests, however there were no consistent pattern in different groups. Patterns of distribution indicated by coefficient of dispersion showed that the predators and the prey distributed randomly and patchily, respectively, in the forests. Variation of the predators among pitfalls decrease with increasing forest age. Variation of the prey among pitfalls was highest in the mid-aged forest. The results indicate that ground dwelling arthropods and their microhabitats on the forest floor might change as forest grew and the responses of the predators and the prey to the growth of forest might be different.

EFFECTS OF SYNTHETIC FERTILIZER ON SOIL GLOMALIN AND COFFEE YIELDS IN COSTA RICA COFFEE FIELDS

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We explored the relationship between synthetic fertilizer applications, glomalin production, and coffee yields in a coffee agroecosystem in the Tarrazú region in the central highlands of Costa Rica, where coffee management is typically very intensive and characterized by high rates of fertilizer application. Glomalin is a highly thermostable glycoprotein produced by mycorrhizal fungi, which is critical for soil aggregation. Working in nine farms ranging from 0.3 to 2.7ha in the CoopeTarrazú farmers' cooperative, we manipulated synthetic fertilizer levels in experimental plots relative to control plots that received a standard amount of fertilizer, examining the effect on coffee yields and soil glomalin concentrations. Synthetic fertilizer levels in experimental plots ranged from a 6.9 percent increase to a 53% decrease compared with control plots at the same farm. Fertilizer reduction resulted in lower coffee yields and decreased glomalin related soil protein, but there was no significant effect on immunoreactive soil protein, a more specific measure of glomalin. In regression analyses, glomalin, as immunoreactive soil protein, was positively related to yield while slope was negatively related to yield; glomalin and slope were the strongest predictors of coffee yield of the variables tested. These results suggest that soil glomalin may be closely tied to coffee production in coffee agroecosystems, in keeping with other studies that have found glomalin to be related to ecosystem net primary productivity.

ECOSYSTEM PRODUCTIVITY AND SOIL FOOD WEB STRUCTURE – PAIRED MEADOW AND FOREST TRANSECTS ACROSS OREGON

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Food webs control the flow of energy and nutrients through an ecosystem, and soil food webs process the majority of terrestrial carbon produced by plants. The complexity and diversity of soil food webs affect the rates of nutrient release, the capacity of soils to store water, and the very stability of systems. A primary distinction among soil food webs is based on fungal versus bacterial pathways of decomposition; these are expected to differ between meadows and forests. To examine which climatic limitations imposed on net primary production (NPP) might relate to the properties of soil food webs, we selected six sites with paired forests and meadows. These are located along a transect representing a 10-fold range in NPP, along a steep climatic gradient across a 200 km swath at ~ 44 N Latitude where NPP and meteorological measurements are available.

We compared biomass of both *active* and *total* fungi and bacteria in meadows and forests in four seasons over two years. Total fungi predominate in forests, while bacteria are dominant in meadow soils after accounting for different sites and seasons. Ratios of *total* fungi to bacteria increase along the east-west transect, and are highest where NPP is highest. However, the ratio of *actively* metabolizing fungi to bacteria in these soils differ significantly by season.

These findings indicate that carbon availability influences *total* fungal biomass accumulation preferentially, whereas total bacterial biomass responds primarily to precipitation. Biomass of *active* microbes varies strongly by season in both forests and meadows. Where photosynthesis is constrained by summer drought and high evaporative demand, fungal food webs are more prominent, which likely results in a commensurate reduction in carbon cycling. When water is not limiting as in springtime, bacterial food webs dominate in meadows and wet coastal forests, which is expected to correspond with an increase in activity that releases more nutrients. If the patterns between seasonal parameters and food web properties increase in parallel, this model can serve as a basis for wider application.

UNDERSTANDING SOIL PROCESSES: ONE OF THE LAST FRONTIERS IN BIOLOGICAL AND ECOLOGICAL RESEARCH

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Soils are one of the great unknown realms on earth, despite decades of extensive research. We still see soils “through a ped darkly”. This opacity in milieu and understanding rewards innovative study, however, as soils are “complex adaptive systems” with sophisticated levels of self-organization, and key to successful biosphere function.

Historically, soil ecological studies have progressed from what major groups of biota are present, their biomass, and what major processes occur. More recent studies have delineated multi-trophic interactions, extending both above- and below-ground, as well as studies of substrates and organisms that are involved in the development and function of suppressive soils. One of the great unknowns in soil ecology is a fuller understanding of the complete array of predatory biota. Soils are teeming with organisms in all three Domains, but also include many phages and other viruses infecting Archaea, Eubacteria and Eukarya. Pursuing a more holistic approach including viral biology and ecology may enable us to more capably manage our soils that have supported the biosphere over many millennia.

Metatranscriptomics, i.e., the measurement of genomes that are active at any point in time, should be explored by soil ecologists. Using chronosequence analysis, the relationships between soil biodiversity and ecosystem function are beginning to be understood. Finally, management of the plant-soil-microbial-faunal food web shows possibilities in the study and management of suppressive soils. We need to consider suppressive and supportive roles of soils worldwide.

MULTI-SCALE VARIATION OF SOIL QUALITY INDICES AND ASSOCIATION WITH EDAPHIC PROPERTIES.

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Soil organisms are indicators of dynamic soil quality because their community structure and population density are both sensitive to management changes. However, edaphic properties and high spatial variability can also affect soil biology and confound their utility for soil evaluation. In the present study we evaluate decomposer, nematode, and collembolan communities, in conjunction with chemical and physical edaphic properties, at 81 sites across a 25-ha area of a working organic farm in Western WA. In addition we identified two areas with similar management and contrasting soil texture for field-scale (0.09 ha) analysis (42 sites per field). We built regression trees with chemical, physical, and management parameters to explain the farm-scale variation in microbial biomass ($r^2=0.74$), N-mineralization potential ($r^2=0.67$), nematode density ($r^2=0.61$), collembolan density ($r^2=0.46$), nematode structure index (SI, $r^2=0.39$), and the nematode enrichment index (EI, $r^2=0.42$). Spatial analysis of field scale biological populations indicated spatial structure (99% of variance explained by autocorrelation) for nematodes in the sandier (mean=41%), less clay-rich (mean=13%) field, but a lack of spatial structure in the less sandy (mean=14%) more clay-rich (mean=25%) field. Both bacterial to fungal biomass and collembolan density also showed more spatial structure in the sandier field, but microbial biomass was more structured in the clay-rich field. We conclude soil physical and chemical data are not a priori evidential of soil biological populations, but within certain ranges the variation in these properties can affect biological variation. Careful mapping of inherent soil quality parameters should be the first step in monitoring soil biological populations.

SOIL ALTERATIONS FOLLOWING JUNIPERUS VIRGINIANA ENCROACHMENT IN THE TALLGRASS PRAIRIE.

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The tallgrass prairie ecosystem once occupied great expanses throughout central North America. The encroachment of *Juniperus virginiana* (eastern red cedar) in the south central Great Plains of North America, due primarily to the anthropogenic removal of fire, is possibly the greatest

current threat to the remainder of this endangered ecosystem. Although *Juniperus virginiana* is native to the tallgrass prairie ecosystem, this species was historically restricted to areas protected from intense grassland fires such as rocky outcrops or shallow soil. In the absence of fire, *J. virginiana* has quickly expanded, disrupting the native tallgrass prairie ecosystem. Most previous studies assessing impacts of invasion by native or non-native species focus on aboveground parameters, with little attention given to the belowground microbial communities, although soil organisms play important roles in regulating ecosystem-level processes. Our objectives are to: 1) investigate the influence of *J. virginiana* on soil microbial communities and nutrient availability; and 2) examine these soil parameters following removal of individual *J. virginiana*. We hypothesize: A) soil bacteria:fungal ratio will decrease following *J. virginiana* invasion, as compared to non-invaded native prairie or native interstitial areas within the encroached forested areas; B) this increase in fungal biomass will be driven by increases in arbuscular mycorrhizal (AM) fungi following *J. virginiana* invasion; and C) alterations in soil microbial communities will be transient, returning to pre-invasion levels relatively quickly following *J. virginiana* removal. Soil samples were collected every three months (January, April, and July) and processed for soil nutrient (plant-available N and P and soil pH) and microbial community analyses (Phospholipid fatty acid analysis for soil microbial communities and microscopic assessment for inter-radical colonization by AM fungi). We assessed three replicate sites for each of the following: 1) interstitial open canopy area dominated by native tallgrass prairie grasses within the *J. virginiana* forested area; 2) closed canopy beneath *J. virginiana*; 3) open area resulting from removal of individual *J. virginiana* trees; and 4) adjacent native prairie grassland with no woody encroachment.

COMPOSITION AND DIVERSITY OF ARBUSCULAR MYCORRHIZAL FUNGI IN CROPPING SYSTEM ASSOCIATED WITH DIFFERENT SOIL ZONES USING PYROSEQUENCING

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Arbuscular mycorrhizal (AM) fungi symbioses with plant roots and provide multiple nutrients to their host plant. Endomycorrhizae exist naturally in agricultural soil ecosystem. However, their distribution and composition in cropping system and effect of different soil zone to their development is limited known. In this study, 83 soil samples that covered all five soil types of Saskatchewan were collected and our target 18S rDNA region was amplified by primer pairs NS1/NS4 and AMV4.5NF/AMDGR. Sequencing results show that there are more AM fungi in cultivated soil than previously thought based on traditional methods. The richness of the AM fungi population of cultivated Prairie soil varies with soil zones. AM fungi taxonomic richness and abundance is higher in the Black Soil zones, and AM fungi diversity is probably underestimated in the Gray Soil zone due to insufficient sampling.

CHANGING NJ PINE BARRENS FOREST TO AN ALTERNATE STABLE STATE: EFFECTS ON SOIL PROPERTIES

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The New Jersey pine barrens is a large tract of predominantly pitch pine and oak forest with ericaceous understory vegetation. There is a belief that in suppression of wildfire that the system may have looked different in pre-colonial times when native Indians managed the forest for game. In an attempt to move the system into an alternate stable state of forest trees at lower density and establishing a graminoid understory we have selectively thinned the canopy of an experiment site to 40% of tree canopy, repeatedly cut the ericaceous understory and effected soil disturbance by plowing. Preliminary data on the impacts of these treatments on soil parameters are presented from this factorial designed experiment. Cellulase, glucosaminase, phenol oxidase and arylsulfatase enzyme activity showed a strong correlation with active C abundance, where thinned plots were lower than either control or thin and plowed. In contrast, phenol oxidase was significantly higher in thinned plots than either control or thinned and plowed and protease activity was reduced in both treatment plots compared to the control and probably associated with loss of ericaceous root mass. There were no significant differences in acid phosphatase or glucosidase with treatment. Pine root mass showed a trend to being lower in the thinned plots than other treatments and with a higher specific root length. Although the differences are not significant there is a suggestion of contrasting root behavior between treatments. There were significant differences in ectomycorrhizal community composition between control, thinned and plowed and the reference grass understory site nearby. There were three times the number of soil microarthropods in the grass reference site than the forested sites. Within the forest treatments there was a trend for higher faunal abundance in the thinned and plowed site. It appears that even after only one year we are seeing some differences in soil parameters due to forest disturbance.

CHANGES IN THE ABUNDANCE OF NITRIFYING AND DENITRIFYING GENES ASSOCIATED WITH A FIELD-SCALE SPRING THAW N₂O FLUX

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Nitrous oxide (N₂O) is the most important greenhouse gas emitted from agroecosystems and is a byproduct of microbial nitrification and denitrification processes. In a long-term assessment measuring N₂O emissions at our field site at the University of Guelph in Ontario Canada, it was determined that using best management practices, that included no-tillage, decreased N₂O emissions significantly compared to a conventional management practice, and that the majority of the annual emissions occurred during spring thaw. In 2006 the diversity of the nitrifier and denitrifier communities was assessed by PCR-DGGE of the *amoA*, *nirS* and *nirK* genes. Statistical analysis revealed that the structure of the nitrifier and denitrifier communities associated with each management system were different, and these differences were most

obvious in the March sampling date, immediately after the spring thaw event. These results suggested that environmental conditions that lead to significant N₂O emissions from soil are also associated with alterations in N₂O producing bacterial community structure.

A recent study was designed to verify if field-scale spring thaw N₂O fluxes relate to changes in the abundance of active N₂O producing bacteria. Micrometeorological approaches were used to measure N₂O continuously throughout the year (May 2009 – May 2010) in 2 field plots where corn was grown under contrasting residue removal practices. Soil samples were collected every *ca.* 48h during spring thaw (March 5 – 19, 2010), and placed in a Lifeguard™ solution (MO Bio Labs, Carlsbad, CA), to preserve nucleic acid integrity for extraction of RNA/DNA after transport to the lab. Gene copies (*amoA*, *nirS* and *nosZ*) were quantified with real-time PCR. Active populations of both nitrifiers and denitrifiers were measured during this time period, providing evidence of *denovo* denitrification. Furthermore, a larger N₂O flush from one of the field plots was associated with a delay in expression of *nosZ*, the gene responsible for the conversion of N₂O to N₂ gas during denitrification. Suggesting that at our field site differences in the magnitude of N₂O released during spring thaw may be due to soil conditions that support incomplete denitrification. This is the first work to relate changes in abundance of active of nitrifiers and denitrifiers to field-scale measurements of N₂O spring thaw.

MICROBIAL COMMUNITY STRUCTURE AND MICROBIAL BIOMASS AS AFFECTED BY DIFFERENT SOURCES OF NUTRIENTS IN SWITCHGRASS PRODUCTION

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Different sources of nutrients are used to improve crop productivity. Sources of nutrients influence soil properties and therefore affect soil microorganisms and their activities. Soil microorganisms play an important role in nutrient cycling and can indicate soil quality. A field study was conducted at Perkins, OK to evaluate soil microbial communities and activity in dual purpose and sole feedstock switchgrass managed under different sources of fertilizer. Six sources of fertilizer were evaluated in randomized complete block design with four replicates. Because switchgrass has been reported to be an obligate mycotroph under low nutrient management, we assessed the arbuscular mycorrhizal (AM) root colonization of switchgrass under our varying fertilizer management treatments. Arbuscular mycorrhizal fungal root colonization did not significantly differ between fertilizer treatments, suggesting that AM fungi did not alter its symbiotic relationship with the plant in response to the different fertilizer sources. Assessments of microbial biomass and community structure are currently being assessed.

REASSESSMENT OF THE ROLE OF *COCHLILOBOLUS SATIVUS* IN COMMON ROOT ROT OF CEREALS: AN ORGAN SPECIFIC FUNGAL COMMUNITY STUDY

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Cochliobolus sativus and *Fusarium* spp. are considered the most important causative agents of common root rot in cereals. However the evaluation of root rot severity has been historically based on rating the discolorations and lesions on sub-crown internode. *C. sativus* is often reported as the causal agent of root rot when the sub-crown inter-node is used for fungal isolation, while *Fusarium* spp. are most frequently reported as the responsible agent when roots are plated. These variations are sources of confusion when attempting to identify the principal causative agent of common root rot in cereal. In this study, we isolated fungal communities associated with the different below-ground organs of durum and spring wheat: the crown, sub-crown internode, adventitious roots, and seminal roots. The diseased plants originated from different areas of the Canadian Prairie Province Saskatchewan. We used plate culture to isolate the fungi internally colonizing the target plant tissues. Fungal identification was based on PCR. Multiresponse Permutation Procedure and Non-Metric Multidimensional Scaling were applied to compare the fungal communities associated with each organ. We found different fungal communities associated with different below-ground organs of wheat. *C. sativus* was dominant in sub-crown internode and crown tissues, which are distinguished from the plant's roots as they anatomically belong to the plant's stem. *Fusarium* spp., on the other hand, were more frequent in adventitious roots than in crown and sub-crown internode. The most frequent fungi in seminal roots were *Periconia macrospinoso*, *Gaeumannomyces graminis*, and *Microdochium bolleyi*. Our results suggest that the role of *C. sativus* in common root rot of cereals was overestimated by the use of sub-crown internode in disease severity estimation.

BUSHWHACKING THROUGH THE TANGLED BANK: EXPLORING SOIL MICROBIAL DIVERSITY AND THE CONTROLS ON MICROBIAL COMMUNITY COMPOSITION
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Over the past few years, we have been using high-throughput pyrosequencing to examine microbial diversity in hundreds of soil samples collected from across the globe. The overarching goal of this research has been to build a predictive understanding of microbial biogeography. In other words, we seek to determine what factors shape the composition of microbial communities and the relative abundances of individual microbial taxa across space. Here I describe some recent work examining the spatial variability in soil bacterial, archaeal, and fungal communities, emphasizing how these biogeographical studies can, in some cases, reveal the life history strategies of poorly-understood taxa. I will draw from cross-biome studies (including an examination of bacterial communities in Arctic tundra), a landscape-scale study, and a study of community shifts that occur with depth through soil profiles. I will use these examples to highlight the key knowledge gaps that still remain, some pitfalls commonly encountered in microbial community analyses, and strategies for conducting cross-domain explorations of microbial interactions.

USING ORGANIC AMENDMENTS AND MULCHES TO PREFERENTIALLY ENHANCE BIOLOGICAL ACTIVITY AND SUPPRESS PLANT PATHOGENS IN ROOT ZONE SOIL UNDER PERENNIAL FRUIT CROPS

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Perennial fruit crops are particularly prone to development of root disease problems that may be related to long-term declines in soil health resulting from intensive cropping and insufficient returns of organic matter to soil. We have been performing field-based research comparing various composts, manures and high C/N ratio residues as soil amendments and mulches for production of raspberry, apple and grape. This research has included assessment of (1) soil chemical properties, (2) free-living nematodes as indicators of soil food web structure, and (3) root biomass and population densities of plant-parasitic nematodes, particularly the root-lesion nematode, *Pratylenchus penetrans*. *P. penetrans* is a widespread parasite of most perennial fruit crops and it can have significant impacts on productivity of raspberry and apple when population densities are high.

We have shown that annual applications of either compost or manure at rates sufficient to meet, but not exceed, crop N requirements can improve raspberry yields and, in some cases, improve root growth and reduce populations of root-lesion nematodes relative to the conventional practice of supplying nutrients via synthetic fertilizer. We have also observed increased root biomass and reduced root-lesion nematode populations under mulches of shredded paper or alfalfa hay in both raspberry and apple cropping systems. Organic amendments and mulches consistently increase the abundance of free-living nematodes, and some organic mulches have resulted in elevated indicators of faunal diversity and soil food web structure. However, across experiments, our data do not consistently support the hypothesis that organic matter inputs increase soil food web structure and the abundance of nematode antagonists (e.g. predacious nematodes), resulting in reduced root damage by parasitic nematodes. We also cannot rule out the possibility that observed improvements in root growth and crop productivity were the direct result of beneficial changes in soil chemical properties, such as increases in available P, exchangeable Ca or pH, rather than suppression of root lesion nematodes or other root pathogens. Most composts and manures have relatively high P contents and we have observed substantial changes in soil and plant P status in compost- and manure-amended soils; additional research addressing impacts of composts and manures on mycorrhizae is warranted.

ARBUSCULAR MYCORRHIZAL FUNGI MUTUALISM STRATEGIES

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Arbuscular mycorrhizal fungi (AMF) are obligate symbionts of almost all terrestrial plants. While the AMF symbiosis is relatively well documented, the behavior of AMF as perfect mutualists has been called into question in recent years. In some cases, it has been documented that certain isolates of AMF may actually behave more parasitically than mutualistically. This project tests our hypothesis that the AMF species, *Glomus custos*, functions as an opportunistic isolate in the host plant, *Plantago lanceolata* with increasing plant diversity. Pot experiments were set up with varying degrees of plant biodiversity (pots contained *Plantago* alone, *Plantago* with one other plant species, or *Plantago* with three other plant species). Fungal fitness was determined on the amount of *G. custos* gene copies detected using quantitative PCR. The presence of *G. custos* in *Plantago* roots was confirmed with PCR and percent root colonization. We predicted that *G. custos* gene copy number would increase with increasing plant diversity, however the results proved to be opposite. Our data shows that with increasing plant diversity, *G. custos* gene copy number decreases in *Plantago* roots ($p < 0.05$). This may suggest that *G. custos* will tolerate an undesirable host, but will switch when presented with better options, implicating fungal choice over plant choice in AMF-plant symbioses.

NEON: LONG-TERM, CONTINENTAL MONITORING FOR SOIL MICROBIAL ECOLOGY AND PRELIMINARY RESULTS FROM FOUR SITES

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The National Ecological Observatory Network (NEON) is a national-scale research platform for analyzing and understanding the impacts of climate change, land-use change, and invasive species on ecology. Soil microbes (bacteria, archaea, and fungi) play key roles in many of the processes that constitute NEON's grand challenge areas. To better understand the biogeography of soil microbes, a prototype was designed to measure temporal and spatial variability in microbial community composition within and among four eco-climatic regions over an annual cycle. The prototype focused on four NEON domains that represent gradients in mean annual temperature and precipitation including Southeast (Domain 3, Florida), Great Basin (Domain 15, Utah), Taiga (Domain 19, Alaska), and Pacific Tropical (Domain 20, Hawaii).

Phylogenetic and functional gene analyses were conducted on archived soil core samples collected five times over an annual cycle from four NEON domains. Sequences and analyses of 16S and 18S rRNA genes to identify soil bacterial, archaeal and fungal diversity and community structure were generated through Roche 454 pyrosequencing using titanium protocol analyzed using the Quantitative Insights into Microbial Ecology (QIIME) pipeline. Preliminary results show that communities cluster by eco-region and there is no distinct seasonal trend. Concurrent analyses exploring functional *nifH* gene (for nitrogenase) abundance and soil biogeochemistry will help relate community composition with specific functions. We discuss considerations of

metadata collection, sample archiving, and data quality control and assurance to capture long-term spatial and temporal trends in microbial communities.

IMPACTS OF LEAFY SPURGE HERBIVORY AND DISEASE ON INTERACTIONS WITH SOIL MICROBIAL COMMUNITIES.

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Leafy spurge (*Euphorbia esula*) is an aggressive invasive species from Eurasia, which was first observed in North America in the early 19th century. It is often highly colonized by arbuscular mycorrhizal fungi (AMF) and up to 30% of all carbon (C) fixed in photosynthesis is allocated to AMF. In return for photosynthate, plants receive phosphorus and other putative services from their AMF partners. To determine if changes in belowground C allocation impact AMF colonization and community composition, we sampled roots from naturally patchy distributions of healthy, defoliated (by biocontrol beetles and grasshoppers) and diseased (as indicated by a reddish leaf color) spurge in four areas on a ranch near Missoula, MT. We assumed that carbon assimilation between these three spurge populations would likely differ. Furthermore, because AMF are estimated to be the largest contributors of carbon to other soil microbes, we measured soil CO₂ respiration among patch types to assess shifts in microbial activity. Finally, to determine if leafy spurge status could impact mycorrhizal function, we quantified the P concentration on dormant buds that would grow in the subsequent year.

AM colonization was on average 14% lower in diseased roots relative to defoliated and healthy roots, but the difference was not significant and all roots were highly colonized (63-82%). Potential shifts in AMF colonization are currently being investigated and will be presented. Soil respiration differed significantly ($p=0.001$) among patch types and was 9% lower in the defoliated plots and 21% lower in the diseased plots, suggesting a close and dynamic interaction between above and belowground processes. The P concentration and content of the dormant buds showed the same trend ($p=0.18$), with the lowest concentration in diseased spurge, intermediate in defoliated spurge, and highest in the healthy plants, which could be an indication of a lowered P delivery from AMF since soil available P did not differ among the patch types ($p=0.87$). Bud size was also positively correlated with shoot DW, which suggests that repeated herbivory and various pathogens could weaken this invasive plant directly, but also indirectly, by affecting the C availability to associated microorganisms. More replicates are needed in the coming year to confirm and strengthen trends detected in this initial study. Lipid analyses also should be employed to assess the C status of AMF, because overall colonization may not be a sensitive variable to detect possible differences.

METHANE AND METHANOGEN COMMUNITY DYNAMICS ACROSS A SUCCESSIONAL FEN PEATLAND GRADIENT

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Peat accumulating wetlands occupy 3% of the earth's land surface, yet they store approximately one third of the total global soil carbon. Despite being long-term sinks for atmospheric carbon dioxide, peatlands also act as significant sources of methane gas. Controls on the activity and diversity of methane producing archaea in peatland soils are still poorly understood. The objectives of this research were to compare and contrast rates of methane production and the underlying methanogen communities across a well studied peatland gradient over time. *In vitro* production of methane was lowest in the poor fen site over both sampling dates. Production was highest in the intermediate fen sites, and could be further stimulated with the addition of ethanol as a substrate precursor. However, the rich fen site could not be stimulated by substrate addition. There was also indirect evidence that the carbon dioxide reduction pathway was the most significant in the rich fen site. T-RFLP fingerprinting of archaeal 16s rDNA indicated that *Methanosarcinaceae* was present across all three sites, while *Methanomicrobiales* group E1 and Rice Cluster-1 communities were present only in the rich and intermediate fen sites. The degree to which each site was affected by ethanol treatments changed both spatially and temporally, indicating that substrate availability was not the only factor limiting methane production and the underlying methanogen communities across these sites.

COMMUNITY STRUCTURE OF ERICOID MYCORRHIZAS AND ROOT-ASSOCIATED FUNGI OF *VACCINIUM MEMBRANACEUM* ACROSS AN ELEVATION GRADIENT IN THE CANADIAN ROCKY MOUNTAINS.

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Abstract

The ecological plasticity of *Vaccinium membranaceum* (Ericaceae) to grow from valley bottoms to alpine habitats allowed us to test if fungal community structure varies along an elevation gradient in east central British Columbia. Using the shrub as an independent variable, and plant and soil features along the gradient to model a changing climate, communities of root-associated fungi were investigated. The colonized roots from 40 individuals were examined using culture-dependent sequencing and ARISA (automated ribosomal intergenic spacer analysis). Our results demonstrated that high elevation fungal communities, characterised by *Rhizoscyphus ericae*, differ from lower elevation communities, where *Phialocephala fortinii* was the most frequently isolated fungus. Co-occurrence analysis indicated that, overall, fungi tended to occur together more often than would be expected by chance. At the scale of the individual host plant, facilitation may play a more important role than competition in shaping fungal communities in these ecosystems.

PINELANDS PLANT COMMUNITY STUDY

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Upland forests of the New Jersey pine barrens are characterized by a pine and oak forest canopy. The herbaceous layer consists primarily of ericaceous shrub species. Scattered throughout the region grass-sedge and lichen-moss dominated patches under a pine canopy can also be found. It is generally believed these patches come about after severe disturbance. These patches can persist even in the absence of further disturbance. In this study examples of three herb layer community types: ericaceous, graminoid and lichen dominated communities, in close proximity to one another, from three different forest locations were examined. We determined whether graminoid and lichen dominated communities differ significantly from the surrounding forest herbaceous layer vegetation matrix (ericaceous dominated community). In order to characterize the sites canopy and herbaceous layer vegetation and surface cover were assessed. Soil particle size, soil carbon, respiration, microbial biomass and extractable nitrogen were also determined. Our analysis found only minor differences in forest canopy vegetation and no difference in soil particle size among forests or among communities. The results further indicate that differences in soil chemical parameters are the result of differences in the vegetation rooting architecture and decomposability. The Lichen-moss dominated communities are distinguished by bare ground, low bulk density, low nitrogen availability and a preponderance of microbial biomass in the upper 5 cm of the soil profile. The high soil bulk density in lichens is presumably a function of its smaller root biomass content, greater percent bare ground cover and lower litter inputs. The ericaceous dominated communities are distinguished by low bulk density, low nitrogen availability a large above ground biomass (AGB) and below ground biomass (BGB), with much of the BGB in the upper 5 cm of the soil profile. Despite a significantly greater overall AGB the ericaceous community leaf mass is no larger than the graminoid or lichen dominated community AGB. The graminoid dominated communities, despite having a low % herbaceous layer cover had a high root/shoot ratio and greater levels of ammonium and nitrate. Although the communities did not vary significantly in soil particle size the Pearson correlation analysis indicates that the significantly greater levels of soil carbon, ammonium and nitrate characteristic of the graminoid community are positively correlated with % silt-clay and negatively correlated with sand. Our results indicate that each of the communities examined subtly influence soil physical and chemical properties which may explain the patterns and persistence of herb layer community type dominance.

APPLICATION OF NEUTRAL LIPID FATTY ACID ANALYSIS (NLFA) TO UNDERSTAND FAUNAL DIETS IN A FOREST SOIL

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Although the importance of soil organisms in nutrient cycling is well-recognized the structure of the belowground food web and the interactions between these organisms are poorly understood.

As a consequence we do not know which of these species are “keystone” and essential for carrying out particular ecosystem processes and what the repercussions of a loss of any of these organisms may have on ecosystem function and resilience. This is largely because until recently we lacked methodologies to study them. Recently Ruess et al. in Germany analyzed neutral lipid fatty acids (NLFA) together with PLFA to determine the food sources and feeding strategies of collembola in forest soil (PLFA of food sources are incorporated into NLFA without conversion in the consumers). They were able to distinguish between collembolan herbivores, bacterivores and fungivores and predators. We evaluated the potential of this method to understand trophic interactions and to evaluate whether aggregated or dispersed retention of living trees is better for retaining soil meso-faunal diversity after forest harvest. We applied this technique to soil fauna sampled from aggregated and dispersed retention treatments from the three replicates of the STEMS (Silvicultural Treatments for Ecosystem Management in the Sayward) Experimental Project (<http://www.for.gov.bc.ca/hre/stems/index.htm>) established by the B.C. Ministry of Forests (4 months, 2 and 7 years after harvest). Samples were taken from the centre, 10 m and 30 m from the edge of the aggregated retention patches and next to, 10 m and 30 m from retention trees in the dispersed retention treatment. We extracted, enumerated and identified populations of Oribatid, Prostigmatid and Mesostigmatid mites and Collembolan. Three thousand three hundred and fifteen soil mites, belonging to 143 species were identified, 40 species were present in sufficient numbers to enable analysis of NLFA profiles to ascertain their feeding strategies. Mites and collembola incorporated dietary FAs in their NLFA fraction, thus their own lipid pattern reflected the lipid composition of the food resource. The FA biomarkers were successfully applied to determine broad ecological groups (i.e. bacterivores, fungivores, generalists) in mites and Collembola communities. The analysis also revealed that harvesting reduced the numbers of soil mites four months after harvesting, but populations of mites recovered two years after harvest in the presence of retention trees. Harvesting reduced species richness of Prostigmatid mites, though richness was restored after seven years in both aggregated and dispersed retention treatments. Harvesting also changed the abundance of different Oribatid and Megostigmatid mite species, with *Oppiella* species becoming the dominant members of the Oribatid community. This change in mite species abundance was still present seven years after harvesting. This study has been the first to attempt such a new approach to understand trophic interactions and food webs in soil using natural faunal samples from the field. Future additional combination of stable isotope analysis on the soil fauna and lipids should be a major breakthrough in understanding C fluxes in these soil food chains.

ASSESSING ABOVE- AND BELOWGROUND COMMUNITY COMPOSITION FOLLOWING THE ESTABLISHMENT OF A WARM-SEASON INVASIVE GRASS: A LOOK AT INDIVIDUAL PLANT RESPONSE AND ITS EFFECTS ON SOIL.

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Non-native graminoid species such as old world bluestems (OWB) (Yellow, Caucasian, or Kleberg bluestem) (YB, CB, KB) are invasive grasses of the central and southern Great Plains, and are aggressively expanding their range into native grasslands. If we continue with our

current policy and management practices, OWB invasion will continue far into the future, bringing with it greater losses of native prairie, displacement and/or loss of native plants and wildlife, and costly restoration efforts. With the increased spread of non-native grasses there is a need to examine how these invasions affect the mechanisms and processes influencing native ecosystems, and how we can restore these systems to their original state. Soil was collected from beneath both native and OWB grasses from NE, KS, OK, and TX for a total of 7 collection sites. By conducting a two-stage plant-soil feedback experiment we can develop the soil microbial history (conditioning) of each experimental unit (2 gallon pot) before conducting the experiment stage of our study. Upon completion of the conditioning stage pots will be replanted with 5 seedlings (to assess seedling survival) and placed into 1 of 5 plant-soil combinations: 1) same species (e.g. OWB seedling into OWB conditioned soil); 2) different species (e.g. OWB seedling into big bluestem conditioned soil); 3) sterilized soil w/same species; 4) sterilized soil w/ different species; and 5) not re-planted. After 16 weeks of growth, we will harvest and measure the aboveground biomass produced in each pot and determine if a feedback loop exists (using home vs. away net-pairwise comparisons), if the feedback loop is positive or negative, and if they are consistent across the current geographic range of these species. By measuring the soil nutrient content, root and shoot nutrient content, root colonization, microbial communities (using spore diversity and/or PLFA analysis), before each stage and upon conclusion of the study, we hope to determine the underlying mechanism allowing OWB to overtake our native prairies so affectively. Once the biological similarities or dissimilarities of these native and non- native grasses are determined; only then can we develop effective plans for restoration of our prairies.

ALTERED LIGNIN AND C:N RATIO OF PLANT RESIDUES: INFLUENCE UPON RESIDUE DECOMPOSITION, MICROBIAL BIOMASS CARBON AND MICROBIAL COMMUNITY STRUCTURE OF SOIL

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Using *Arabidopsis thaliana* as a model plant species, a study was conducted to evaluate the influence of altered lignin and C:N ratio upon plant residue decomposition and the associated changes in soil microbial biomass carbon (C) and microbial community structure. Two wild ecotype accessions: Columbia-0 and Nossen, and down-regulated mutant lines of *KNAT7*, *MYB75* and *CCR1* genes were considered for this study. Stem and root residues from physiologically mature plants were finely ground, mixed with soil (sandy loam or clay loam), and incubated at 25°C in the laboratory for 63 days. The water content of soils was adjusted to 60% water filled pore space. After incubation, the soil was analyzed for N mineralization, microbial biomass C (chloroform fumigation-direct extraction method), and microbial community structure (phospholipid fatty acid analysis (PLFA)). Chemical analysis of residues revealed higher C:N ratio in stems of all mutant lines except the *CCR1* mutant. In stem residues, the lignin concentration was greater in *KNAT7* and *MYB75*, and lower in the *CCR1* mutant than their wild ecotypes. Decomposition of plant residues was negatively correlated to C:N ratio and lignin content. Stem residue decomposition was lower in *MYB75* and higher in the *CCR1* mutant than in the corresponding wild ecotypes. Root residue decomposition was greater in the *CCR1* mutant than its wild ecotype. Results were consistent for both soil types, although the CO₂-C

flux was lower in clay loam than in sandy loam soil. N mineralization was correlated positively with C:N ratio and was higher for the fast-decomposing *CCR1* mutant residues than other residues. Microbial biomass C was greater in the soil amended with stem residues of *MYB75* and *CCR1* mutants than their wild ecotypes. Microbial community structure was different between plant residue types. Comparative to wild ecotypes, soil amended with stem residues of *CCR1* mutant showed higher Fungal:bacterial ratio, fungi, actinomycetes, gram positive and gram negative bacteria, whereas *MYB75* stem residue amended soil had lower fungal:bacterial ratio, lower fungal abundance, higher actinomycetes and higher gram negative bacteria. In conclusion, single gene mutations related to secondary cell wall biosynthesis can influence the residence time of plant C in soil, N mineralization, microbial biomass and microbial community structure.

PHYTOCHEMICALS AND SPORE GERMINATION: AT THE ROOT OF AMF HOST PREFERENCE?

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Plants have friends and foes among soil microorganisms. Plants trigger various responses in the microorganisms living around them, attracting and repelling them with a wide array of chemicals. The appropriate and timely production of these phytochemicals is a component of plant adaptation to a biological environment. We sought phytochemicals with bioactivity on arbuscular mycorrhiza (AM) fungi spore in chickpea, a crop difficult to produce. Roots of five varieties of chickpea inoculated with *Glomus intraradices* were produced and extracted, and extracts were fractionated based on solubility in methanol and further by HPLC. We found a relationship between chickpea genotype and extractible root phytochemical composition. HPLC fractions repressed the germination of AM fungi spores or had no effect, in bioassays conducted in multi-well plates with extracts from the variety CDC Anna. This repression expresses the control of the plant on the AM fungal symbiont. *Glomus etunicatum* and *Gigaspora rosea* responded differently to the HPLC fractions soluble in 25% methanol. A differential response of AM fungal species to plant phytochemicals could be involved in the so called ‘host preference’ of AM fungi.

MUTUALISM BREAKDOWN IN BREADFRUIT DOMESTICATION

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During the process of domestication, belowground communities are rarely considered. Some studies have attempted to understand the changes in root symbionts due to domestication, but, little is known about how domestication influences mycorrhizal response in domesticated crops. We hypothesized that selection for above ground traits may also result in decreased mycorrhizal response (AMF) in roots. Breadfruit (*Artocarpus* sp.) has a long domestication history with a strong geographic movement of cultivars from West to East along Micro- and Melanesian islands. Our results clearly show a decrease in arbuscular mycorrhizas along a domestication gradient from wild to recently derived cultivars. We showed that the vesicular and arbuscular colonization rate decreased significantly in more recently derived breadfruit cultivars. In addition, we showed that AMF species richness also responded along the domestication gradient. These results suggest that human-driven selection for plant cultivars can have a negative, and unintended, effect on belowground mutualists.

RESPONSE OF ECTOMYCORRHIZAL FUNGAL COMMUNITIES OF INTERIOR SPRUCE FORESTS TO LONG-TERM ANNUAL AND PERIODIC FERTILIZATION.

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Ever-present on the roots of appropriate host trees, ectomycorrhizas are pivotal in the survival and productivity of trees of interior British Columbia. Although ectomycorrhizal (ECM) fungi provide access to nutrients that would otherwise be unavailable to roots, nutrient supply can still limit above ground productivity of trees. Such nutrient constraints have led to the use of fertilization as standard practice for increasing tree yields in some parts of the world. Although much research has been completed on the short-term response of ECM communities to nitrogen enrichment, almost none has focused on responses to long term fertilization treatments aimed at maximum tree productivity. In our study, the response of ECM fungal communities of three interior spruce (*Picea glauca*) stands in interior British Columbia to 10-15 yr of fertilization was studied. The treatments included (i) unfertilized control, (ii) annual fertilization (kg/ha); 650 N, 400 phosphorus (P), 400 potassium (K) and (iii) periodic fertilization (kg/ha); 200N, 100P, 100K, 50S, 25Mg, 1.5B applied every 6 years. The study sites were located in three different biogeoclimatic zones: the moist, cold (SBSmc2), the moist cool (SBSmk1) and the wet cool (SBSwk1) variants of the Sub-Boreal Spruce zone of central interior British Columbia. Using morphological and molecular analysis the identity of the dominant ECM fungal symbiont on 40 randomly-selected root tips was determined in order to characterize the ECM fungal community. Both ECM fungal diversity and the fungal exploration types differed amongst sites, but did not appear to be affected by fertilization. By contrast, fertilization affected the species composition of the ECM fungal community. The relative abundance of *Cortinarius* spp. and frequency of *Tylospora* spp., the two most dominant genera in the community, were lower in plots exposed to annual fertilization. No effect on the ECM fungal community was observed in response to the periodic fertilization treatment. As the periodic fertilization treatment more closely reflects operational modes of fertilization in these regions, these results suggest that large-scale fertilization could be established in the central interior of British Columbia without major disturbance to this important component of the soil microbial community.

THE ANALYSIS OF SOIL MICROBIAL FOODWEBS IN RESPONSE TO DIFFERENCES IN WATER AVAILABILITY.

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Microbial communities are important for many ecosystem functions such as nutrient cycling and soil stabilization. These communities are highly diverse, composed of a variety of specie groups including many fungi, bacteria and microscopic animals. Disturbances to soil communities may result from a variety of climatic and biotic factors. Here I study the structure of soil communities from two vineyards that are subjected to a range of water potentials. This is done in order to determine the effect of water potential on these soil communities. By comparing the change in biomass of several soil organism groups, I determine the ability of water stress to cause disturbance to these communities and which individual specie communities are most vulnerable and resistant to this water-induced disturbance.

FERTILIZATION-INDUCED CHANGES IN SOIL ORGANIC MATTER CHEMISTRY AND COMPENSATORY CHANGES IN ECTOMYCORRHIZAL FUNGAL COMMUNITY STRUCTURE AND ENZYME PROFILES

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Pine beetles (*Dendroctonus ponderosae* Hopk. and *Dendroctonus brevicomis* LeConte) are expected to kill 80% of the merchantable lodgepole pine (*Pinus contorta* Dougl. var. *latifolia* Engelm.) trees in the interior of British Columbia by 2013. Broad-scale fertilization of forests is being considered to increase productivity of remaining stands and overcome medium-term shortfalls in timber supply. Before committing to such a program, it is important to establish that belowground communities and the ecosystem services they provide are not disrupted. We sampled forest floor, mineral soil and ectomycorrhizas from three replicate plots per treatment in each of three pine stands that had undergone annual or periodic (every 6 yr) fertilization for 12-15 yr as part of a maximum productivity experiment. In the periodic treatment, nutrients were added at (kg ha⁻¹): N (200), S (50), B (1.5), P (100), K (100), Mg (25). For annual fertilization, nutrients were added in the same ratios, but adjusted to maintain foliar N at 1.3%. By 2009, aboveground productivity of pine had increased by 37% (periodic) and 59% (annual). As expected, fertilization increased litter inputs and soil organic matter content. According to proximate analysis, the composition of the soil organic matter was also altered, especially under annual fertilization. The cellulose-hemicellulose fraction decreased by 6% and the lignin-humin fraction increased by 5%, as a fraction of soil organic matter. Based on morphological groupings of 40 randomly-selected ectomycorrhizal tips per plot, followed by amplification and Sanger sequencing of the complete Internal Transcribed Spacer region of the fungal rDNA, richness and

diversity of the ECM fungal community was reduced by annual fertilization. Of the dominant types of mycorrhizas, those formed by *Cortinarius* spp. and *Suillus* spp. had lower relative abundance in fertilized plots, whereas those formed by *Cenococcum* spp. or *Piloderma* spp. were not affected. Activities of extracellular enzymes involved in the decomposition of soil organic matter were measured sequentially on individual ectomycorrhizas. Activities of β -glucosidase and xylosidase, which are involved in the breakdown of cellulose and hemicellulose, as well as laccase, which is involved in the breakdown of lignin, increased proportionally with the total weights of these components per kg dry soil. We conclude that, although taxonomic diversity of the ECM fungal community was lowered by annual fertilization, the community had adjusted to the change in SOM composition such that its contribution to cycling of nutrients from the increased litter inputs continued normally. Furthermore, most of the changes were detected only after long-term annual fertilization. Because periodic fertilization is much more likely to be used on an operational basis than annual fertilization, we do not predict significant effects of the former on the ECM fungal community or its role in nutrient cycling.

EARTHWORMS, METHANOGENS AND METHANOTROPHS IN RIPARIAN SOILS

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Methane (CH₄) is a potent greenhouse gas produced by methanogens under anaerobic conditions. About 40% of global CH₄ sources stem from natural wetlands, including riparian areas. In riparian soils, earthworms may affect methanogenic activity by altering the proportion of anaerobic to aerobic microsites, by changing soil structure (i.e. aeration) and stimulating microbial activity (i.e. decomposition and N mineralization). The few studies that have investigated earthworm influence on CH₄ production produced contradictory results; some show that earthworm activity and biostructures increase methanogenesis, others show an increase in methanotrophy or no effect on CH₄ fluxes. Our objective was to study the earthworm-microbial interactions that control CH₄ consumption and production in saturated and moist soils, representing the fluctuating moisture regimes of riparian areas throughout the year. We hypothesized that in both saturated and moist soils, earthworm presence will stimulate methanotrophic activity rather than methanogenic activity, by increasing air diffusion into the soil profile. A two-way factorial laboratory experiment tested the effect of earthworms (present or absent) and soil moisture on methanogenic and methanotrophic activity. There were three earthworm treatments (earthworms and soil, earthworm-worked soil without earthworms, and control soil) at two soil moisture regimes (~50% water filled pore space –WFPS – and ~90% WFPS). A control treatment consisting of microcosms incubated with earthworms and no soil was included as well as blanks. All treatments were replicated 5 times for a total of 40 microcosms. The clay loam soil was gathered from a riparian area along the Rivière-aux-Brochets in southern Quebec, Canada. Microcosms were initially moistened to approximately 50% WFPS. Endogeic earthworms were added to each of the appropriate microcosms, and all experimental units were left uncapped and pre-incubated at 15°C for one week. Microcosms receiving the saturated treatment were brought to 90% WFPS, and then all microcosms were capped. Difluoromethane (DFM) was applied to another set of replicates at a rate of 0.05 kPa to inhibit methanotrophy. Gas samples were taken at 0 min, 30 min, 60 min, 24 hours, 48 hours and

72 hours after capping. Gas samples were transferred to pre-evacuated exetainers until analyzed by gas chromatography for CH₄ concentration. CH₄ production and consumption were calculated with the difference between CH₄ production from microcosms with DFM application and from those without DMF. The results were based on the assumptions that DFM did not impact CH₄ production and that CH₄ production was constant during the experiment. The results illustrate the effect of earthworm activity on CH₄ fluxes, which may be correlated with soil moisture. In conclusion, managing for earthworms in riparian areas may affect CH₄ fluxes from these ecosystems.

PLANT DIVERSITY IMPACTS SOIL BIOTA AND SUBTERRANEAN FOOD-WEBS

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Over the last 2 decades diversity studies have become an important focus of ecological research. Plant diversity in particular has been shown to benefit various ecosystem functions. In a long-term experiment located in Cedar Creek (MS) plant species richness was experimentally manipulated, and increasing plant species-richness was shown to enhance plant productivity, ecosystem stability and resilience. However, the effects of plant diversity on soil communities and edaphic food-webs are generally still not well known. The goal of the present study was to assess how plant diversity impacts subterranean food-webs and soil communities. We analyzed soil samples from the Cedar Creek site, and measured the abundances of a variety of soil organisms from different trophic groups (bacteria, fungi, protozoa, nematodes, springtails, and mites), and assessed root health. Preliminary analyses indicate that soil food-web properties fundamentally changed with increasing plant species richness. Plant monocultures food-webs were dominated by bacteria, protozoa, and a high abundance of plant feeding nematodes, which concurred with increased levels of root lesions. At the other end of the diversity spectrum soils of diverse plant polycultures were dominated by fungi, fungal feeding nematodes and springtails, healthier roots, and an increased abundance of arbuscular mycorrhizal fungi, putative plant mutualists. Conversely, at the highest trophic level measured predatory mites were relatively unaffected by these effects. Our results show that plant community composition has profound effects on soil biota, and suggest that soil-plant feedbacks may enhance positive plant diversity-productivity relationships.

EFFECTS OF ENERGETIC MATERIALS ON SOIL BIOLOGICAL ACTIVITY PROCESSES IN SASSAFRAS SANDY LOAM

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We assessed the effects of nitrogen-based energetic materials (EM) 2,4-dinitrotoluene (2,4-DNT), 2-amino-4,6-dinitrotoluene (2-ADNT), 4-amino-2,6-dinitrotoluene (4-ADNT), and nitroglycerin (NG) on biologically-mediated soil processes, including litter decomposition, enzymatic activity, and soil respiration in Sassafras sandy loam (SSL) soil. The studies were designed to determine toxicity benchmarks for developing Biological Activity-based Soil Screening Concentrations (BA-SSC), and for assessing ecological risks at EM-contaminated sites. SSL soil was amended and thoroughly mixed with each EM, individually and separately, to prepare nominal treatment concentrations ranging from 10 to 10,000 mg EM/kg dry soil. Litter decomposition rates were assessed for replicated clusters of Orchard grass (*Dactylis glomerata*) straw by exposing the straw to the EM-contaminated SSL for eight months, with periodic harvesting. Litter decomposition rates were inhibited by 2,4-DNT at 1274 mg/kg and by NG at 950 mg/kg by the end of the study, when compared to control treatments. The decomposition rates increased intermittently in the 2,4-DNT soil treatments 4 and 62 mg/kg after four and six months. The 20% Effect Concentration (EC₂₀) values, based on annual decay constants, were 361 mg/kg and 277 mg/kg for 2,4-DNT and NG, respectively. Decomposition rates were not statistically different ($p > 0.05$) among any 2-ADNT or 4-ADNT treatments by the end of the study. The potential nitrification (PN), dehydrogenase (DH), acid phosphatase (AP), and N-acetyl-glucosaminidase (NAG) activities in each soil treatment were quantified during the 8 to 25-hour assays. Preliminary results showed that 2,4-DNT inhibited PN (Lowest Observed Effect Concentration; LOEC = 4 mg/kg), DH (EC₂₀ = 16 mg/kg), and NAG (EC₂₀ = 122 mg/kg) activities. 2-ADNT inhibited AP, DH, and PN activities with the respective EC₂₀ values of 830, 406, and 175 mg/kg; while 4-ADNT inhibited AP, DH, and PN activities, yielding respective EC₂₀ values of 90, 28, and 113 mg/kg. The preliminary results also showed that NG inhibited DH (EC₂₀ = 34 mg/kg) and AP (LOEC = 5800 mg/kg) activities. These preliminary results suggest that biologically-mediated processes in soil can either be inhibited or stimulated when soil is contaminated with 2,4-DNT, 2-ADNT, 4-ADNT, or NG. Research investigating the effects of these same EM on basal and substrate-induced respiration (BR and SIR) is ongoing, and the SIR data will be used to estimate the soil microbial biomass carbon. Our experimental data demonstrated conclusively that the toxicity benchmarks for EM and the corresponding BA-SSC values can be reliably established for soil biological processes in compliance with stipulations and requirements developed by the U.S. Environmental Protection Agency for terrestrial plant-based or soil invertebrate-based Ecological Soils Screening Levels.

PLANT REGULATION OF SOIL ORGANIC MATTER DECOMPOSITION AND MICROBIAL ENZYME ACTIVITY

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Decomposition of soil organic matter (SOM) is one the largest fluxes of carbon (C) in the

biosphere and is perhaps the most uncertain biogeochemical link in coupled climate models. Plants are known to strongly regulate SOM dynamics from numerous experimental studies, yet, plant-driven priming of SOM decomposition has proven particularly difficult to represent in models mechanistically. Plants alter the chemical environment of the soil in several profound ways simultaneously that are difficult to disentangle. Here, we measured direct mass loss and microbial enzyme activity in buried SOM bags over two years in a tidal wetland exposed to elevated CO₂ and nitrogen (N) addition. To assess the effects of plants on SOM decomposition we measured several key plant variables, such as species composition and root productivity as well as soil parameters such as redox potential, dissolved N and C. We found that SOM decomposition rate was positively related to fine root productivity ($R=0.52$, $F_{1,18}=6.42$, $p=0.021$), an effect commonly assumed in wetlands to relate to the delivery of oxygen to rhizospheric soil. Indeed, activity of polyphenol oxidase and beta glucosidase were both positively related to soil redox potential. However, the more direct measure of decomposition, SOM mass loss, was more strongly related to N availability ($R= -0.68$, $F_{1,18}=15.784$, $p<0.001$), than soil redox status ($R=0.45$, $F_{1,18}=4.607$, $p=0.046$). In other ecosystems, N scarcity has been shown to stimulate microbial degradation of recalcitrant, N-rich substrates. The drawdown of available soil N by plant growth may represent an underrated pathway by which plants may influence SOM decomposition in wetlands.

COVER CROPPING TO ENHANCE ARBUSCULAR MYCORRHIZAL FUNGI IN DIVERSIFIED CROP ROTATIONS OF THE UPPER MIDWEST U.S. CORN BELT

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Intensive agricultural practices, such as tillage, monocropping, seasonal fallow periods, and inorganic nutrient application, have been shown to reduce arbuscular mycorrhizal fungi (AMF). Agricultural practices that reduce AMF may reduce the benefits provided to crops by AMF, such as nutrient acquisition and disease resistance, which costs producers who must pay for these services. Utilizing no-till agricultural production systems with greater crop diversity (such as wheat-corn-soybean compared to corn-soybean or continuous corn), we are evaluating the influence of different cover crops on the number of soil AMF propagules, their colonization of corn roots, and their relationship with P uptake in corn. At both a research farm and a producer's farm, we have established replicated, no-till plots with cover crops seeded after wheat harvest and then burned down prior to corn seeding the following year. As determined by the most-probable-number technique using Bahai grass as a host, soil AMF propagule numbers were increased with forage oats as a cover crop in all three site-years sampled to date. The MPN data was corroborated by analysis of the neutral lipid fatty acid mycorrhizal biomarker, C16:1cis11. Identification of specific cover crops that promote AMF for inclusion in diversified, no till cropping rotations in the upper Midwest U.S. will provide opportunity for reduced inorganic nutrient application with economic and environmental benefit.

MYCORRHIZAL LEGACIES OF PLANT INVASIONS – NOT ALWAYS A STORY OF DOOM AND GLOOM

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Millions of hectares of native grasslands have been invaded by cheatgrass (*Bromus tectorum*), leafy spurge (*Euphorbia esula*) and knapweed (*Centaurea stoebe*) in the mountainous West. Soil microorganisms – both mutualists and pathogens – could play pivotal roles in plant invasions, yet our knowledge regarding invasion driven shifts in belowground communities is rudimentary. It has been postulated that many exotic plants do not form symbioses with arbuscular mycorrhizal (AM) fungi, or have an inherently low, or evolved, mycorrhizal dependency. As such, one would expect overall AM fungal abundance to decrease with most invasions. Furthermore, if fungal and plant species richness are correlated, the reduced plant diversity often observed in heavy infestations may be indicative of impoverished fungal communities. To determine if AM fungal communities change with invasions and if they differ among invasive plants, we used 454 sequencing to identify AM fungal taxa in areas dominated by cheatgrass, knapweed, leafy spurge, or remnant native plants. Furthermore, to assess if similar patterns exist among independent invasions, we sampled invaded and native areas from six locations in and around Missoula, MT. Root colonization measures served as an indirect measure of fungal abundance.

AM colonization differed significantly among plants ($p < 0.001$) and was highest in leafy spurge (87%) and knapweed (79%), intermediate in native plants (40%) and lowest in cheatgrass roots (12%), irrespective of location. Thus, spurge and knapweed appear to be good hosts for AM fungi and may actually increase overall fungal abundances, which suggests that broad generalizations among invasive plants should be avoided. Potential shifts in AM fungal community composition (identity and structure) and their underlying reasons (spatial location, host species, soil characteristics) are currently being investigated and will be presented. Preliminary results suggest that AM fungal taxa richness does not necessarily decline with invasions. On the contrary, richness was higher in spurge and knapweed infestations relative to cheatgrass invasions and native grasslands in five of the six locations. Whether this is due to co-invasion by AM fungi with knapweed and spurge or a loss of taxa in cheatgrass invasions and native grasslands is unclear at this point. An increased knowledge regarding mycorrhizal legacies of plant invasions is crucial not only to better understand the role of AM fungi for plant invasive success, but also to evaluate restoration efforts needed for the successful re-establishment of native plant communities.

MOLECULAR CHARACTERIZATION OF SOIL BACTERIAL COMMUNITY IN A PERHUMID, LOW MOUNTAIN FOREST

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Forest disturbance often results in changes in soil properties and microbial communities. In the present study, we characterized the soil bacterial community subjected to disturbance using 16S ribosomal RNA (rRNA) gene clone libraries. The community was from a disturbed broad-

leaved, low mountain forest ecosystem at Huoshaoliao (HSL) located in northern Taiwan. This locality receives more than 4000 mm annual precipitation, one of the places with the highest precipitation in Taiwan. Based on the Shannon diversity index, Chao1 estimator, richness and rarefaction curve analysis, the bacterial community in HSL forest soils was more diverse than previously investigated ones in the natural and disturbed forest soils with colder or less humid weather conditions. Analysis of molecular variance also revealed that the bacterial community in disturbed soils significantly differed from those in natural forest soils. Most of the abundant operational taxonomic units (OTUs) in the disturbed soil community at HSL were less-abundant or absent in other soils. The disturbances influence the composition of bacterial communities in natural and disturbed forests and increase the diversity of the disturbed forest soil community. Furthermore, the warmer and humid weather conditions could also increase the community diversity in HSL soils.

COMMUNITY DISASSEMBLY AND TROPHIC CONTRACTION IN A BOREAL BRYOSPHERE COMMUNITY UNDER ENVIRONMENTAL CHANGE

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Many ecosystems are currently undergoing dramatic changes in biodiversity due to habitat loss, habitat fragmentation, and climate change. We explore the interactive effects of alterations in climate, specifically drought-stress, and habitat ‘openness’ on soil microarthropod traits and community disassembly in a large-scale field experiment of a moss-dominated forest floor system (bryosphere). The effect of drought has a significant and overwhelming effect on community-level metrics with respect to microarthropod abundance, richness and body-size distribution which lead to a trophic contraction that is mediated by the correlation between species traits and environmental drivers. Increased temperature under ambient moisture conditions increased species richness, while habitat openness mitigated biodiversity loss associated with drought. However, these effects were group-specific, and only observed within the dominant microarthropod group (i.e. Oribatida). The Earth’s changing climate is one of a multitude of anthropogenic-induced stressors on biological diversity and the integrity of ecological systems. As species disappear from an ecosystem, the possible changes in ecosystem functioning will be related to changes in the functional diversity of the species lost as well as of the remaining organisms. Understanding how soil organisms respond to other environmental change stressors in addition to climate change is a crucial step in our efforts to mitigate biodiversity loss and declining ecosystem function.

MICROBIAL DECOMPOSITION OF LEGUME CROP RESIDUES AND N RELEASE

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The rotational benefits of grain legumes include N contribution to succeeding non-legume crops. However, usually little N is released to the first sequent crop because grain legume crop residues contain little N (after most of it is removed with grain at harvest) and have a wide C/N ratio. It is not clear how much N is released in the second and third sequent crops. Using a litterbag method, we quantified N released from residues of two pea (*Pisum sativa* L.) varieties ('Camry', a semi-leafless variety, and '4010', a normal-leaved forage pea variety), faba bean (*Vicia faba* L.) grown for seed, faba bean green manure (GM) and chickling vetch (*Lathyrus sativus* L.) GM during the first and second succeeding crops. The legumes were grown in 2007, and wheat (*Triticum aestivum* L.) and canola (*Brassica napus* L.) were grown in 2008 and 2009, respectively. The N contained in these residues at harvest was in the order: faba bean (154 kg N ha⁻¹) ≥ '4010' pea and chickling vetch GM (129 and 125 kg N ha⁻¹, respectively) ≥ faba bean GM (107 kg N ha⁻¹) > 'Camry' pea (65 kg N ha⁻¹). Averaged over all sampling times, the percentage of residue N released was in the order: chickling vetch GM (74%) = faba bean GM (67%) > faba bean for seed (55%) > 'Camry' pea (42%) = '4010' pea (38%). The average amounts of N released were in the order: chickling vetch (96 kg N ha⁻¹) = faba bean for seed (83 kg N ha⁻¹) > faba bean GM (66 kg N ha⁻¹) > '4010' pea (49 kg N ha⁻¹) > 'Camry' pea (27 kg N ha⁻¹). At the last sampling time, faba bean GM residues had only 3% of their initial N remaining, chickling vetch GM 4%, '4010' pea 21%, 'Camry' pea 20%, and faba bean for seed 23%. The cumulative amounts of N that had been released by that time were 124 kg N ha⁻¹ from chickling vetch residues, 118 kg N ha⁻¹ from faba for seed, 104 kg N ha⁻¹ from '4010' pea, and 53 kg N ha⁻¹ from 'Camry' pea. The N release patterns over time were different. Green manure residues released about 80% of their N in the first two months of decomposition in 2007, i.e., before wheat was seeded in 2008. Faba bean grown for seed released about 50% of its N, and pea residues released only about 20% of their N, in the corresponding period. While green manure residues released the little remaining N slowly thereafter, the other residues released N at faster rates when wheat and canola were grown in 2008 and 2009, respectively. Therefore, synchronization between N release and N demand was better for residues of legumes grown for seed than green manure residues.

IMPACTS OF FOREST POST THINNING RESIDUES ON SOIL CHEMISTRY, FAUNA AND ROOTS: PROBLEMS OF RESIDUE REMOVAL IN FINLAND

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There is an increasing interest in removing greater amounts of forest post-harvest residues for use in power generation. As part of a study in understanding the ecological impacts of these practices in Finland, residue piles of thinning residues of contrasting mass per unit area were established in 2003 around the base of individual Scots pine trees. As part of an NSF funded undergraduate training program, we have sampled the soil under these residue piles to evaluate the effect of leaving different amounts of residue on site to supply nutrients for remaining trees.

We present preliminary data showing that residue mass has a significant effect on the populations of mesotigmatid and juvenile oribatid mites with mite density decreasing at highest residue levels. In general, nematode abundance decreased with increasing residue load, whereas the abundance of the smallest class of enchytraids (0-2mm) tended to increase with brush loading. There was no difference in pine root mass between the highest and lowest level of residue retention but the specific root length under high brush was significantly higher than under no residue, indicating a difference in root foraging strategy. There was no effect of residue retention on root mass of understory vegetation. From data modeled by allometric equations over six years, the aboveground biomass of pine trees was significantly higher for those having residue retention compared to no-residue controls. However, root biomass suggested that root mass was suppressed at the lowest and highest residue loading levels. Soil chemistry showed a significantly higher level of extractable Al in the second lowest residue level and a trend of increasing extractable Mg with increasing residue mass. These surveys were conducted between six and seven years after plot establishment and may have missed some of the earlier impacts of post harvest residue decomposition.

SOIL PHYSICAL PROPERTIES THAT AFFECT EARTHWORM DENSITY ACROSS URBANIZED LAND COVERS

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The presence of earthworms in terrestrial ecosystems is affected by soil physicochemical characteristics. In urban ecosystems, these properties are highly influenced by management of landscapes. Therefore, human activities such as urban landscape management may strongly affect earthworm distribution and abundance. Greater understanding of relationships among urban land cover management, earthworm populations and soil properties is needed to understand ecological functions and services in urbanized ecosystems. In a previous study, earthworms were sampled from four land cover types (lawns, wood mulched areas, forest remnants, low-maintenance fields) across the campus of Roger Williams University in Bristol, RI. Earthworm densities were highly variable within and among the land cover types (range in mean density of 0-45 earthworms 625cm⁻³) suggesting that local, and perhaps historical, environmental factors may affect earthworm abundances more than land cover per se. In order to address the urbanized factors that may lead to variations in earthworm density and distribution more directly, a controlled field experiment was conducted using lawn, unmowed vegetation, and organic and inorganic mulch treatments. Earthworm density was determined by hand-sorting from 25X25X25 cm soil samples. Bulk density and standing crop mass of detritus were monitored also. Overall, earthworm densities were higher in 2009 for all land cover types than in 2010. In 2009 and 2010 earthworm densities in organic mulch plots were higher than vegetated plots. Earthworm abundances in gravel soils were lowest of all the land cover types in 2010. In 2010, earthworm densities were consistently larger in unmowed vegetation plots than lawns. Additionally, the mean detritus biomass in unmowed soils was greater than in lawns across sampling dates which may have influenced worm numbers via food availability. The differences in earthworm density across diverse urban land cover types may have implications for the levels of ecosystem services and disservices created at different locations. The results of this study can

be used to provide valuable insights into how urban land cover can be managed to favorably affect earthworms and associated ecosystem services.

GROUND ARTHROPOD POPULATIONS AND DIEL ACTIVITY PATTERNS IN HETEROGENOUS LANDSCAPES OF URBAN LAND COVERS

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In our rapidly urbanizing world, the amount of highly managed urban land cover is increasing. Knowing how urban land cover patterns affect ecological variables at the aboveground-belowground interface is important for guiding sustainable landscape management practices. Ground-dwelling arthropods are important members of soil and detritus communities because of their various roles in food webs and biogeochemical cycling. In this study, we created a field experiment in Bristol, RI (USA) to investigate how urban land cover patterns affect ground arthropod populations and diel activity patterns. In particular, we sought to examine whether arthropods in lawns would be affected by the land cover around the lawn, i.e., in its landscape context. Experimental landscape plots (6m X 6m) were composed of lawn with zero (all lawn plots) or one patch (2m X 2m) of non-lawn land cover (old field vegetation, shredded wood mulch, gravel mulch) in the center of the plot. Arthropods were sampled in 2009 and 2010 with two pitfall traps placed in the lawn on either side of the central patch. On several sampling dates, traps were collected three times daily (early morning, mid-afternoon and early evening) over a three-day period to investigate whether diel activity patterns vary with landscape context. We hypothesized that the activity-abundance levels and diel activity patterns for arthropod taxonomic groups would differ among lawns with different land cover composition in their context due to differences in the habitat structural characteristics of the central patches (e.g., temperature, detritus thickness). Results suggest that landscape context does impact arthropod activity-density levels in lawn but in different ways for different taxonomic groups and at different sampling times. For example, ants were three to five times more active/dense in lawns next to non-lawn patches than in homogeneous lawn plots in June 2010, but in July 2010, ant activity-density levels did not differ among the landscapes. In contrast, isopods were more active/dense in plots with lawn and unmowed vegetation than in those with mulches in June but were more active/dense in lawns next to mulch in July. Diel activity patterns also varied with landscape composition and across days for some taxa. For example, within lawn-only plots, entomobryomorpha collembolans tended to be more active/dense at night but in plots with wood mulch and unmowed vegetation, they became most active/dense in the adjacent lawns in the late afternoon on some days. Variation across plots and days in arthropod activity-density levels may be related to relationships between their movement rates and spatiotemporal ground temperature patterns across heterogeneous landscapes; higher ground temperatures in mulches may cause them to move out of those patches and into lawns during the day. Alternatively, spatial variation in food availability may influence the distribution of arthropods and their movement patterns. Although more research is needed to better elucidate relationships among urban land cover patterns and arthropod populations, these results suggest that opportunities exist for designing urbanized landscapes in ways that increase the numbers and/or activity levels of ground

arthropods to promote beneficial ecosystem services such as predation and favorable decomposition.

VARIATION IN SOIL COLLEMBOLAN POPULATIONS AND MICROBIAL BIOMASS ON WESTERN WASHINGTON ORGANIC FARMS

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Populations of soil organisms vary between and within farms due to management practices and edaphic properties. To be valuable indicators of soil quality the range and causes of variability need to be understood. This study investigated collembolan and microbial communities from organic farms in western Washington and compared the range to values from a long term organic farming systems experiment at the Washington State University Research and Extension center in Puyallup, WA. Soil Collembola, microbial biomass, texture, infiltration, and chemical properties were evaluated at five different organic farms within a 50 km radius of WSU Puyallup by sampling two to six locations at each farm. The range in collembolan abundance at on-farm sites was consistent with that found in the long-term systems experiment (2.63-58.2 and 1.63-62.97 individuals 100g⁻¹ soil, respectively). The standard deviation for total collembolans at four of the sites (Yee, Terry's Berries, Mother Earth, and Kirsop Away) ranged from 3.13 to 12.10, while a fifth site (Kirsop Home) had much greater on-farm variation with standard deviation of 24.78. Onychiuridae, a collembolan family of interest due to its euedaphic nature, was found to be positively correlated (R=0.53) with soil nitrate levels, yet the total collembolan abundance was not significantly correlated with nitrate. Total Collembola was positively correlated with microbial biomass (R=0.54). Sand content, had a significant effect on both collembolan populations (R=0.52) and microbial biomass (R=0.75), emphasizing the importance of inherent soil properties on biological indicators.

THE ROLE OF SYMBIONT LIFE-HISTORY STRATEGY IN COMMUNITY ASSEMBLY OF ARBUSCULAR MYCORRHIZAL COMMUNITIES IN GEOTHERMAL SOILS

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Community composition of arbuscular mycorrhizal fungi (AMF) can be affected by edaphic conditions and host-plant community composition, but attributing relative importance to either driver has been difficult. Inference about the occurrence and abundance of individual fungal taxa has also been elusive owing to the difficulty of studying AMF assemblages in complex environmental situations. Here, we attempted to detect fungal assemblage patterns along strong environmental gradients compared to symbiont life-history strategy in a model study system in Yellowstone National Park (YNP) thermal soils to prioritize influences on community

composition. Specifically, we asked: (1) Does host community life-history strategy affect species composition in mycorrhizal communities; (2) does life-history outweigh edaphic influences in structuring mycorrhizal communities; and (3) given the correlation of these two influences, can effects be partitioned sufficiently to elucidate functional traits in individual fungal taxa? Our results indicated that pH was a primary driver of AFM community composition in thermal soils, and that host community life-history strategy was difficult to separate from edaphic factors, but was also associated with a shift in fungal community richness and diversity. For those AMF taxa with sufficient frequency, this study revealed distinct patterns of taxon distribution along a pH gradient.

EFFECT OF INVASIVE EARTHWORMS ON LEAF LITTER DECOMPOSITION, SOIL CHEMISTRY AND WATER DYNAMICS

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During the Wisconsinian glaciation, native earthworms in the Northeastern United States were extirpated due to the advancing ice sheets. European settlers introduced nonnative species and recently, species from Asia have established a foothold due to importation of goods. A greenhouse mesocosm study was conducted to evaluate the effect of *L. terrestris* (LT; European) and *A. agrestis* (AA; Asian) separately and together on the decomposition rate of *Acer saccharum* litter, soil/water chemistry and water dynamics. Results in this study indicated that LT increased litter decomposition rate, while AA did not. Though separately the worms do not cause a significant difference in water loss, combined treatment LTAA shows increased evaporation and decreased leachate water volume significantly. Leachate water chemistry suggests that treatments that include LT decrease Ca, P, S, Na, Si and Mg leaching losses. The differences in nutrients lost were mostly accounted for by the volume of water and not by concentration, similar to findings by others, suggesting long term soil chemistry changes. Several factors may have contributed to the differences between the effects of each species. Evaluating the effects of different earthworm species is essential to understanding the ecological changes that may occur with invasion of a new area.

PULSE AND WHEAT CROPS' INFLUENCE ON SOIL DEHYDRROGENASE ACTIVITY, SOIL NUTRIENT CONTENT AND MICROBIAL COMMUNITY

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This study provides information on the effect of pulses on the biodiversity of beneficial soil fungi (AMF and DSE) associated with the main pulse species grown in the Canadian Prairie and their influence on wheat-based cropping systems. The root-associated microbial communities

were characterized by microscopic observation of roots and soil dehydrogenase assay, which was used as an indicator of soil microbial activity. We measure plant biomass and grain yield, tissue nutrient and water contents, while soil moisture and nutrient availability were monitored.

At mid-bloom soil microbial activity was higher in wheat crops than in pulses crops. Soil microbial activity increased in the fall after harvest in chickpea stubbles. In fact, soil microbial activity increased from mid-bloom to fall in all pulses, whereas in wheat, no differences were found. DSE and AMF colonization of roots was quantified after harvest. Pulses were better colonized by AMF than wheat. Pea had the highest level of AMF root colonization. DSE colonized the root of all crops equally, but to a lower level than AMF, except in wheat roots where no difference in the level or root occupation by these two groups was found. Root density analysis show the highest root length in wheat, however the surface area and volume was the same in pea, chickpea and wheat, and lower in lentil. Soil nutrient content differs depending on the crop grown. Soil nitrogen content increases when pea and lentil were grown. Lower nitrogen was found when chickpea or wheat were grown. The different crops did not influence soil phosphorus content. A positive correlation was found between the level of root colonization by AMF and soil nitrogen content ($R=0.4423$) and a negative correlation was found between soil microbial activity in fall and the level of AMF colonization of roots. These results suggest that different crops have different patterns of colonization by native AMF species, which influences composition and activity of the microbial communities associated to their roots, and the level of nitrogen fertility of the soil, with possible impact on a subsequent crops in rotation-based systems.

EFFECTS OF SIMULATED CLIMATE CHANGE AND DEFOLIATION ON RANGELAND SOIL MICROARTHROPODS.

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Canada contains 22,000,000 ha of land dedicated to range and forage production. To mitigate potential impacts of climate change on biodiversity and sustainable production of Canada's rangelands, it is essential to gain an understanding of links between temperature, precipitation, grazing and their effects on soil chemistry and biota.

As part of a large research group we conducted a three year study at the Kinsella Research Ranch in Alberta, Canada. We tested effects of warming, increased and decreased precipitation and low- and high-intensity defoliation on carbon and nitrogen cycling, forage quality, plant assemblages, soil microbial activity and soil microarthropod assemblages. Here we report on effects of treatments on microarthropod assemblage structure.

To date, 118 arthropod taxa have been identified including 9 orders of macro-invertebrates and 4 families of Collembola. Most of the taxa are mites (Arachnida: Acari): 2 families of Endeostigmata, 15 families of Prostigmata, 18 families of Oribatida (consisting of 27 genus- or species-level taxa, including 2 families of Astigmata). The microarthropod assemblage was numerically dominated by Collembola and mites, the latter mainly consisting of Prostigmata.

The data show contrasting patterns between the first (2007) and third (2009) year of the project. Alteration of precipitation had the strongest effect on soil microarthropods. While 2007 data showed a surprising negative association of precipitation and soil microarthropod abundance,

2009 data showed the expected opposite, with drought treatments causing reduction in abundance. In addition, 2009 data also show a positive association between precipitation and taxon richness. Only prostigmatid mite abundance was not significantly affected by alteration of precipitation, and instead responded positively to increased temperature. There was also a significant effect of a temperature x defoliation interaction on prostigmatid abundance.

For this study both the commonly used Tullgren/Berlese technique, as well as a more novel kerosene flotation method, were used to extract microarthropods. In a side-project we found that our Tullgren/Berlese extractors may give an underestimate of arthropod density and richness. Kerosene flotation, although being more labour intensive, avoids this problem by passively extracting (based on the cuticular affiliation of hydrocarbons), and therefore does not rely on the motility of the organisms. Not all identifications are complete for 2009 kerosene flotation data. When this is complete, we will test whether extraction method affects our interpretation of treatment effects on microarthropod assemblage structure.

ECOLOGY OF NEMATODE SUPPRESSIVE SOILS IN MIDWEST SOYBEAN-CROPPING SYSTEMS

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Soybean cyst nematode (SCN) *Heterodera glycines* is a major pest problem in the corn-soybean production system in the United States, especially in the North Central region. Restrictions on general soil fumigants and reduced effectiveness of resistant varieties and crop rotations provide incentives for alternative methods that rely on the ecology of free-living soil flora and fauna. Recent development of nematode community indices that integrate the responses of different taxa and trophic groups to perturbation provides a powerful basis for analysis of fauna assemblages in soil. *In situ* environmental assessment systems and analysis of nematode communities is essential to understand soil ecological processes in contrasting crop sequence, tillage and biocide treatments. There is a paucity of the information regarding the nematode communities in the corn-soybean production systems in the Midwest. Moreover, dynamics of free-living nematode communities may affect the suppressiveness of soil to plant-parasitic nematodes through bacterial or fungal channels in soil food webs. Unfortunately, the relationship between nematode community attributes and antagonists of plant-parasitic nematodes is poorly documented, and we are unaware of any publication quantifying relationships between the nematode community indices and soil suppressiveness to plant-parasitic nematodes such as the SCN. This study will fill these gaps in our knowledge. A 4-year field experiment was initiated in 2009 at two locations in southern Minnesota to test the hypothesis that the level of soil suppressiveness to *Heterodera glycines* is correlated positively to the ecological succession and trophic diversity of nematode communities, increased abundance of antagonistic fungi, and bacteria themselves associated with an increased level of soil suppressiveness. The experiment is arranged in a split-plot design with main plots with or without tillage and subplots were assigned randomly to six treatment combinations of crop sequence and biocides. Biocides specific to fungi, bacteria or both were included. Crops were grown in soybean monoculture or a rotation between corn and soybean. Nematode diversity and plant feeding nematodes were higher in the no tillage system than conventional tillage but the SCN population is similar in both tillage regimes and biocide / crop rotation combinations. Given that *Helicotylenchus* is more abundant and occupies a similar niche as *Heterodera* in the

soybean rhizosphere, it appears that competition may be partly responsible for suppression of disease symptoms in SCN. Based on changes in composition of microbial-feeding nematodes caused by biocide applications, we suggest that naturally occurring disease suppression is possible by residential soil fungi. We expect that the results of this project will aid in the effort in managing the SCN and improving soybean productivity.

UNDERSTANDING PLANT-SOIL-MICROBIAL PROCESSES TO ENHANCE SOIL CARBON SEQUESTRATION IN BIOENERGY FEEDSTOCK PRODUCTION: LOW-INPUT HIGH-DIVERSITY BIOFUELS

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Switchgrass (*Panicum virgatum*) shows great promise as a native, low-input biofuel feedstock. Cultivar development has focused primarily on aboveground biomass production. Recently, it has been suggested that native prairie grasses and forbs can also provide a sustainable, low-input biofuel feedstock, while at the same time sequestering large amounts of soil C. Our research will concentrate on the belowground aspect and consider how interactions between soil microorganisms and switchgrass or other native plants species influence soil carbon dynamics and the potential for carbon sequestration. Sustainability of feedstock production practices may be improved if breeders can better identify plant traits that reduce fertilizer inputs and increase the crop's ability to sequester carbon in recalcitrant pools. Because mycorrhizal symbioses facilitate plant growth in infertile and droughty soil and also mediate soil C accrual, these plant-fungal associations need to be considered in the design of feedstock management practices. Our study will assess mycorrhizal hyphal abundance and carbon sequestration following low-input high-diversity cultivation with mixed perennial species. Other benefits of low-input high-diversity cropping include habitat for wildlife, large reductions in agricultural inputs (i.e. fertilizers, pesticides), no soil tillage, and low water demand. We will compare intra-specific diversity with three different switchgrass cultivars and inter-specific diversity with combinations of switchgrass and big bluestem (*Andropogon gerardii*) varieties as well as other native prairie species. We will establish new sub-plots within the sustainable bioenergy crop production research facility at Argonne National Laboratory in Chicago, Illinois, USA. Productivity of AM fungi will be assessed using hyphal in-growth bags and microscopic assessment will determine inter-radical colonization by AM fungi. Phospholipid fatty acid analyses (PLFA and NLFA) will be used to determine soil microbial community composition and AM fungal biomass. Soil C and N, soil aggregation, and soil organic carbon will also be assessed. Aboveground productivity and plant tissue quality (N, P) for each plant species will be assessed at end of the year harvest. Results of this study will inform plant breeders about belowground characteristics that may improve soil tilth, decrease fertilizer inputs, and increase soil carbon sequestration, all without a loss in production.

EFFECTS OF TEMPERATURE, PRECIPITATION AND DEFOLIATION ON LITTER DECOMPOSITION (MASS LOSS) IN CANADIAN GRASSLANDS

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Native grasslands typically store more carbon than tame pasture and cropland. Since this carbon is primarily belowground, it is at a lower risk of release during disturbances such as fires. Temperate grasslands are elements of change and in Canada these grasslands are dedicated to range and forage production. Information on how increased temperature and/or altered precipitation patterns will impact the sustainability and function of these systems, particularly under sustained grazing is limited. Delineating the nature of the interactions between climate and grazing may enhance the understanding of the consequences on carbon storage (soil chemistry) as well as enhancing native biodiversity and ecosystem functioning.

In this study, we conducted a multi-factorial field experiment in the Canadian prairies (Alberta, Saskatchewan, and Manitoba) from 2007 to 2009. We established plots in which we manipulated water supply (ambient, +50% water addition, -50% water removal using rain out shelters), temperature (about 3° C warming using open-top chambers) and defoliation (hand clipping). In all sites, defoliation did not have a significant main effect on shoot or root litter mass loss and only interacted with the other factors in a few cases. This suggests that extreme defoliation disturbance by itself may have minimal effect on carbon budget in the short term. On the other hand, altered temperature and water regimes had strong effects on shoot litter mass loss after 24 months of deployment. Root litter mass loss was significantly affected only by temperature and only in Saskatchewan. We conclude that altered temperature and precipitation patterns will have the most immediate effect on the function of these systems in the short-term.

FACILITATING TALLGRASS PRAIRIE RESTORATION IN POST-MINE LANDSCAPES USING MYCORRHIZAE AND CARBON AMENDMENTS

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Habitat destruction and land use change are among the anthropogenic factors impacting many ecosystems. Ontario's highly diverse tallgrass prairies are a threatened habitat-type that only remain as isolated patches. Current restoration efforts in sand pits are hampered by a lack of soil biota diversity, nutrients, and organic substrates. The goal of this research is to test the efficiency of novel and easily applicable restoration techniques to facilitate tallgrass prairie restoration efforts. I constructed a large-scale grassland field experiment (1.23 acres) to test the utility of adding waste compost, charred plant waste (biochar), and arbuscular mycorrhizal fungi [AMF] to sand pit substrate. Using a crossed factorial design, amendment application rates and plant inoculation with the AMF *Glomus intraradices* will be assessed over time. Replicate units for each treatment combination (n=5) comprise individual 10.2 m² plots. One ton (T) of biochar, 1.5T of compost, and 8,640 plants are utilized in 150 randomized plots. The treatments effects on

native plant growth, belowground AMF community diversity, and soil carbon storage will be assessed. I predict that combining the experimental factors will increase aboveground plant growth, soil microbe activity, plant resilience to harsh conditions, and carbon accumulation rates.

MYCORRHIZATION RATES OF TWO GRASSES FOLLOWING ALTERATIONS IN MOISTURE INPUTS IN SOUTHERN MIXED GRASS PRAIRIE

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Arbuscular mycorrhizal fungi (AMF) are a type of fungus that closely associate with cortical cells of plants. This relationship is typically considered to be mutualistic, in that AMF often aids plants in obtaining key nutrients such as phosphorus, water, and other soil nutrients. During times of stress, the plant may divert resources away from the AMF, eventually causing a reduction in mycorrhization rates (Entry et al. 2002). Allen et al. (1981), observed that species of blue grama (*Bouteloua gracilis*) associated with AMF had a 100% increase in transpiration rates and concluded that “mycorrhizae may substantially alter survival ability.” Short and mixed grass prairies have variable rainfall year to year. In regions such as this, water availability may be the most influential limiting factor for plant growth and nutrient uptake. Our objectives were: 1) to investigate the effects of variability of precipitation on associations between AMF and two important southern mixed grass prairie grasses, and 2) to determine whether a correlation existed between soil nutrient availability and mycorrhization rates under these circumstances. Three precipitation treatments were used; drought (1/2 ambient), ambient, and irrigated (2x ambient). Roots of two warm season grasses, little bluestem (*Schizachyrium scoparium*), and hairy grama (*Bouteloua hirsuta*) were collected in August of two growing seasons (2009-2010) and mycorrhization quantified. Ion exchange resins were used to estimate soil nutrient (PO₄, NO₃ and NH₄) yields throughout the summers of 2009 and 2010. A multivariate analysis confirmed differences in mycorrhization rates between years and differences between species between years; however, treatment was a significant factor for only one variable in the model. Nutrient availability was not significantly correlated to any estimates of mycorrhization for 2009. Trends indicate that differences in ambient moisture between years, corresponding aboveground biomass production and shading competition may be a primary factor in determining mycorrhization levels. Future research will focus on this interaction.

SOIL MICROBIAL BIOMASS AND DIVERSITY IN IRRIGATED CROP SYSTEMS

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Soil microbial biomass is the living component of soil organic matter, excluding macrofauna and plant roots, and it plays a significant role in soil quality. Irrigated cropping presents a dual challenge of producing high value crops while maintaining soil quality. An irrigated rotation

system was set up in 2000 at Vauxhall, Alberta, to study the impact of 3-year and 4-year conventional and sustainable rotations for potatoes, sugar beets, dry beans, spring wheat and timothy. Sustainable rotations included, where possible, reduced tillage, fall-seeded cover crops, and composted cattle manure. From 2002 to 2007, soil microbial biomass and bacterial diversity were measured in the wheat phase of each rotation. The 3-year sustainable rotation had greater microbial biomass and bacterial diversity than the 3-year conventional rotation. The difference between 4-year sustainable rotation and its conventional counterpart in microbial biomass and diversity was not statistically significant. Therefore, sustainable crop rotations that included reduced tillage, fall-seeded cover crops, or composted cattle manure improved biological soil quality.

TRANSFER OF INORGANIC AND ORGANIC ^{15}N TO WOODY DEBRIS VIA MYCELIAL CORDS OF THE WOOD DECAY FUNGUS *HYPHOLOMA FASCICULARE*.

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Translocation of nitrogen (N) through mycelial cords of saprotrophic fungi is thought to be the mechanism responsible for observed increase in absolute N concentration in woody debris over time. It has been suggested that this mechanism may be responsible for storage of site N in woody debris after harvest. Woody debris removal from forests is increasing globally in response to escalating demand for bioenergy products. However, the relative importance of N storage in woody debris via saprotrophic fungi remains unclear. Mycelial-mediated translocation of nutrients to woody debris has been demonstrated for phosphorus, but little work has been done with N. Thus, this research will quantify the rate of N transfer into simulated woody debris (wood blocks) by the common saprotrophic fungus *Hypholoma fasciculare*. Given the heterogeneity of available N in forest soils, four nitrogen sources, enriched in ^{15}N to enable tracing, inorganic ($^{15}\text{NH}_4^+$, $^{15}\text{NO}_3^-$), organic (^{15}N -glycine) and litter-derived ^{15}N will be supplied separately to mycelial cords growing from wood blocks in soil microcosms. An internal divider between the wood block and N source in the microcosms will ensure translocation can only be via mycelial cords. Two covariates, hyphal coverage and relative wood density, will be used to explain expected variability between experimental units. Three sampling times (d 1, 15 and 30) will be used to establish a rate of transfer for each N-form from soil into woody debris. These rates will then be used to establish an upper limit of N-transfer into wood blocks and will further be used to make inferences about the upper limit of N storage in woody debris after harvest. This research will advance our understanding of fungal N transfer and will produce further evidence to guide woody debris management in forests.

AN ECOLOGICAL APPROACH TO 454 PYROSEQUENCING: ANALYSIS OF DISTRIBUTION, CO-OCCURRENCE AND DIVERSITY OF ECTOMYCORRHIZAL FUNGI IN BRITISH COLUMBIA

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Ectomycorrhizal (ECM) fungi play a vital role in the soil ecology of British Columbia, and associate with a variety of widely-dispersed host species. In a previous greenhouse study of interior Douglas-fir seedlings, we discovered significant differences in the abundance and composition of ECM species between soil location and host provenance. This work utilised soil from five sites spanning the distribution boundary of the host. A restricted range of ECM species were found to occur on seedlings grown in any given soil in the greenhouse. Thus we undertook another experiment to examine which fungal species were actively forming ECM associations at each of the original sites.

Ecologists have often struggled both to enumerate the vast number of species that may be present in any given soil sample, and to compare communities across samples. Recent advances in high-throughput molecular analysis techniques, such as 454 pyrosequencing, now make this possible. Recent iterations of the technology allow reads of over 500bp, which is of comparable length to the traditional Sanger sequencing methods. Critically, 454 pyrosequencing allows us to obtain sequence identities of target species, while simultaneously pairing each sequence with a location tag. Thus spatially relevant ecological data can be obtained from, in some cases, millions of DNA sequences.

For our latest experiment, soil cores were extracted along five transects at each of the five 1ha study sites used previously. Soil was cleaned from all tree root material, which was collected and bulked prior to DNA extraction. PCR products were labelled with one of 25 unique tags, allowing each sequence to be associated with its transect of origin following 454 pyrosequencing. By examining DNA from only those fungi present on host root material, we document the realised fungal communities of host trees at each site, resulting in a dataset of 150,000 sequences in total.

The following questions were addressed:

1. What is the variation within sites (species presence, sequence abundance, diversity)?
2. What is the variation between sites (species presence, sequence abundance, diversity)?
3. How is the variation distributed between hosts (shared species, diversity)?

Here we present preliminary results and provide a comparison with the previous study of ECM fungal communities of Interior Douglas-fir seedlings.

EFFECT OF BUCKWHEAT (*FAGOPYRUM ESCULENTUM*) ON SOIL PHOSPHORUS AND ORGANIC ACIDS IN A FIELD EXPERIMENT

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Phosphorus (P), an essential plant element, is often increased in low-input farming systems using cover crops, including buckwheat (*Fagopyrum esculentum*). Some plants exude oxalate²⁻ for P uptake, and buckwheat exudes oxalate²⁻ in response to aluminum toxicity; therefore, oxalate²⁻ exudation may facilitate P uptake in buckwheat and increase available P for subsequent crops through incorporation of buckwheat biomass and alterations of rhizosphere chemistry. This study

seeks to develop greater understanding of the buckwheat - P relationship and improve buckwheat's use in sustainable agriculture. Field plots with added and existing P treatments and with or without buckwheat were used to examine the effect of buckwheat on available P and oxalate²⁻ concentrations in soil, analyzed by Bray P extraction and liquid chromatography-mass spectrometry, respectively. A lettuce crop was planted in post-buckwheat soil to assess the effect of buckwheat on subsequent crop growth. Soil P and lettuce biomass did not vary significantly as a function of buckwheat treatment. Consequently, results from this study do not support a relationship between buckwheat and increased P for other crops. Though oxalate²⁻ was not detected, tartrate²⁻ was identified and varied significantly between P treatments, which may have effects on rhizosphere dynamics that have not yet been elucidated.

LITTER DECOMPOSITION IN FORESTS: WHAT HAVE WE LEARNED?

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One of the many contributions which Dennis Parkinson made to the discipline of soil ecology was in improving our understanding of litter decomposition as an ecological process - the organisms which make it happen and the factors that influence their activities. Along with his students and associates, Dennis was among the pioneers measuring rates of litter decomposition in various biomes and the relative influences of climatic and litter quality factors on decay rates. We now have results from a global suite of long-term inter-site decomposition experiments and a meta-analysis of hundreds of litterbag experiments. These have indicated that litter quality has the strongest and most direct influence on decay rates, while climate affects decay rate largely by determining the nature of the plant forms present, which (through "afterlife effects") determines the decomposability of the litter. There is also evidence of important ecological thresholds for decomposition that we may have overlooked in our search for a "master" variable controlling decomposition rates. Dennis and colleagues also investigated the litter chemistry factors that influence decay rates, in particular demonstrating the utility of the "lignin":N ratio. While the "lignin" content (i.e. the amount of acid-unhydrolyzable residue remaining after proximate analysis) remains a useful measurement for predicting litter decay rates, we now recognize that much of this material is not actually lignin, and that lignin *per se* is not as recalcitrant as formerly thought. Furthermore, new techniques for investigating the nature of soil organic matter have indicated that plant tissues are not decay-resistant; it is microbial and biochemical transformations of materials into novel recalcitrant compounds rather than selective preservation of recalcitrant compounds that creates stable organic matter. Dennis and students also conducted some early studies on the contradictory effects of nitrogen addition on decomposition; a plethora of studies in the last decade has indicated that the effect depends on the nature of the litter - N addition stimulates decay of high quality litter but inhibit decay of recalcitrant material through enzyme inhibition and reactions that promote humification rather than decomposition.

One of Dennis's particular interests was of course the fungi which colonize litter in forest and the succession of fungi that occurs on litter as it decays. These fundamental ecological studies have returned to the fore in recent years with the development of molecular techniques, metabolomics and proteomics currently generating unprecedented amounts of information. It remains to be seen if this information can be harnessed to better understand the linkages between

the organisms and the decay process. Another interest of Dennis's was the multiple influences of soil fauna, through their interactions with fungi, on the decay process. Recent evidence has questioned the presumed stimulation of decay by soil fauna and highlighted our inadequate understanding of interactions among soil organisms and processes. Incorporating the activities of soil organisms and their effects on litter decomposition processes and pathways remains the greatest challenge in decomposition research.

TRACKING DENITRIFIERS THROUGH THE DRILOSPHERE WITH 454 PYROSEQUENCING AND AN ACETYLENE BLOCK ASSAY

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Denitrification is the major biological source of nitrous oxide (N₂O) emitted from soils, which contributes to global warming. There is evidence of strong associations between denitrifiers and earthworms, but no study has compared the diversity and activity of denitrifying bacteria in the drilosphere compartments simultaneously. This experiment is a comprehensive examination of the community composition and activity of denitrifying bacteria in the drilosphere of the anecic earthworm *Lumbricus terrestris* L. Mesocosms were incubated for 30 days with and without earthworms and samples taken included: gut homogenates, casts, burrow lining and bulk soil. The denitrifier community was qualified by targeting the *nosZ* gene (encodes a subunit of N₂O reductase) with 454 pyrosequencing. Concurrently, the denitrification rate of the samples was determined with an acetylene block assay and ancillary soil properties (mineral N, dissolved organic C and N, microbial biomass C and N concentrations) were also measured. Analysis of the DNA sequences illustrated that the average denitrifier diversity measured as the Shannon index (H') was 3.40 in the gut, 3.34 in bulk soil, 3.32 in burrows and 3.19 in casts. The average Chao1 richness index estimated 787 OTUs in bulk soil, 738 OTUs in the gut, 716 OTUs in burrows and 600 OTUs in casts. There were 39 representative OTUs of which 20 were unique to only one drilosphere compartment, the remaining shared sequences from more than one and/or bulk soil. The gut had the greatest number of unique OTUs suggesting that there may be an indigenous community of denitrifiers in the gut of *L. terrestris*. Several of the representative OTUs had a low level of similarity (≤ 87) to other *nosZ* sequences as estimated by BLAST. Other OTUs were associated with *Alphaproteobacteria* (genus *Bradyrhizobium*, *Rhodopseudomonas*, *Brucella* and *Sinorhizobium*), *Betaproteobacteria* (genus *Achromobacter*, *Herbaspirillum* and *Diaphorobacter*) and *Gammaproteobacteria* (genus *Pseudomonas*) and uncultured bacteria. The acetylene block assay demonstrates that the denitrification rate from gut homogenates was 0.08 $\mu\text{g N}_2\text{O-N g soil}^{-1} \text{ h}^{-1}$ and significantly lower than all other drilosphere components but not bulk soil. In contrast, the denitrification rate of intact earthworms was 2.67 $\mu\text{g N}_2\text{O-N g soil}^{-1} \text{ h}^{-1}$ and significantly ($P < 0.05$) higher than all other samples except casts. Denitrification rates in casts and burrow linings were 0.95 and 0.55 $\mu\text{g N}_2\text{O-N g soil}^{-1} \text{ h}^{-1}$, respectively, and were significantly ($P < 0.05$) greater than the rate of bulk soil, 0.12 $\mu\text{g N}_2\text{O-N g soil}^{-1} \text{ h}^{-1}$. Denitrification was significantly ($P < 0.05$) and positively correlated to all ancillary soil parameters. This suggests that the higher denitrification rate of earthworm biostructures may be related to the higher mineral N

and organic C concentration as well as the anoxic conditions within the core of the biostructures. The collective results indicate that the drilosphere may provide high quality niche space for denitrifier activity and that there may be a community of endemic denitrifiers that is associated with the gut wall of earthworms and is not isolated upon dissection and collection of the gut content.

HERBIVORY AND MICROARTHROPODS IMPACT AMERICAN BEECH (*FAGUS GRANDIFOLIA*) LEAF LITTER DECOMPOSITION

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Soil organisms and herbivores can control the cycling of carbon and nutrients through ecosystems. Soil microarthropods are known to physically break down and consume dead plant matter, thereby altering decomposition. Herbivores regulate decomposition by inducing plant production of secondary compounds which may be toxic to decomposers. We examined how arthropod leaf damage prior to leaf senescence and how microarthropod presence or absence during decomposition can regulate litter mass loss and nitrogen release. We collected herbivore-damaged and undamaged American Beech leaf litter from Ridley Creek State Park in Pennsylvania and decomposed both litter types on the forest floor under American beech trees in litterbags. Litterbags were made with either large (1 mm openings) or small (25 micron) mesh sizes to control the presence of microarthropods. This design resulted in four treatments: damaged litter with microarthropods, undamaged litter with microarthropods, damaged litter without microarthropods and undamaged litter without microarthropods. Forty litterbags were removed during each of four removal events (July, August, and December of 2010, and February of 2011). After removal we measured mass loss and nitrogen loss to assess nutrient release into the environment. Both herbivory and microarthropods were found to decrease decomposition initially (40% and 34% decreases, respectively) and then to have no effect on decomposition at later removal dates. Herbivore-induced secondary compounds may initially slow decomposition and be depleted towards the latter part of the experiment. Microarthropods may consume decomposers that colonize the litter during the early stages of decomposition, thereby slowing decomposition rates. These findings are important because arthropod herbivore and microarthropods populations are expected to grow with increasing global temperatures.

EXAMINATION OF SOIL CONTAMINANT TOXICITY TO THE MICROBIAL COMMUNITY OF BOREAL FOREST SOILS UTILIZING A SUITE OF TESTS

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The majority of currently accepted soil toxicity test methods evaluate the effects of contaminants utilizing single species test organisms such as plants, earthworms, springtails and mites.

Although these tests provide information regarding the toxicity of contaminants to higher organisms, they tell us little about the soil microbial community on which higher organisms rely. The soil microbial ecosystem is complex and therefore difficult to assess. Environment Canada (EC) is currently developing a suite of tests to examine soil contaminant toxicity to indigenous soil microbial communities in boreal forest regions. The tests in the suite were chosen to represent diverse endpoints in an effort to collect data reflective of endemic soil microbial communities within a given site, while acknowledging that soil microbial communities vary from site to site.

The test suite evaluates soil microbial biomass, activity, and community structure utilizing the following tests: fumigation-extraction, nitrification, ammonification, organic matter decomposition, substrate-induced respiration, basal respiration, bait lamina, enzyme assays, community level physiological profiling, and denaturing gradient gel electrophoresis. Test results on organic matter decomposition, enzyme assays and community level physiological profiling from freshly-collected reference and petroleum hydrocarbon contaminated boreal forest soil as well as reference toxicant studies, utilizing boric acid as the toxicant, will be presented.

PATTERNS OF SOIL RESPIRATION, MICROBIAL BIOMASS, AND BACTERIAL RESPONSES ACROSS ECOSYSTEMS UNDER N AMENDMENTS

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Ecosystems worldwide are receiving increasing amounts of reactive nitrogen (N) through anthropogenic activities. The impact of N on soil processes is especially relevant to C cycling as many studies have reported C sequestration under N amendments. Specifically, the suppression of both soil respiration and microbial biomass under N amendments has been observed repeatedly in both field and laboratory studies. Further, our previous work on experimental N gradients at Cedar Creek, MN and Kellogg Biological Station, MI demonstrated that N fertilization consistently impacts both the phylogenetic and taxonomic structure of soil bacterial community structure in a predictable manner. While recent work has helped to understand how soil processes change and how belowground communities are altered by N inputs, it is still not clear how these changes are linked or how these changes vary across ecosystems. In order to connect changes in soil processes to changes in the microbial community, we need to first determine if the changes are indeed consistent across different soil types and ecosystems. We assessed the patterns of N effects across a variety of ecosystems in two ways. First, we compiled data from over 50 studies to obtain the general effect size of N amendments in soils. Second, we performed a lab experiment, where we amended 28 soils, collected from across North America, with N (NH₄NO₃). From this year-long incubation we obtained soil respiration, microbial biomass, bacterial community and enzyme measurements. Across all soil types we consistently observed a significant decrease in both soil respiration, approximately 20%, and microbial biomass, approximately 10%. Using high-throughput pyrosequencing we identified seven bacterial groups that responded significantly to the N additions. In combination with our meta-

analysis, our laboratory incubation allowed us to identify consistent trends across a latitudinal gradient in respiration, microbial biomass and microbial community parameters.

IMPACTS OF THE INTERACTION BETWEEN VIRAL PATHOGENS AND MUTUALISTIC FUNGI ON PLANT PERFORMANCE UNDER ELEVATED CO₂

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Predicting the effect of increasing CO₂ on plants may require that we understand how such increases alter the strength and nature of multiple, co-occurring species interactions. Here we investigate the interactive effects of fungal mutualists, a viral pathogen, and phosphorus availability on plant response to increased CO₂ supply. We predicted that the interaction of arbuscular mycorrhizal fungi (AMF) infection and virus infection would result in plants better able to handle virus infection such that virus-infected plants associating with AMF should be larger than those infected plants not associating with AMF. This effect should be amplified under elevated CO₂ during which carbon supply is greatest. We also predicted increased carbon supply would increase mycorrhizal hyphal colonization. Finally, we predicted that increases in plant carbon supply would counterbalance the disruption of the carbon supply by the virus, resulting in increased biomass for those plants infected with virus and grown under elevated CO₂ compared to those plants also infected with virus but grown under ambient CO₂.

To test these hypotheses we grew two exotic invasive annual grasses, *Avena fatua* and *Bromus hordeaceus*, and factorially manipulated atmospheric CO₂ concentration, soil phosphorus, mycorrhizal association and *Barley yellow dwarf virus-PAV* infection. The interaction of mycorrhizal and viral infections did not result in increased biomass for virus infected plants. However, elevated CO₂ significantly altered AMF colonization for plants of both species grown with additional phosphorus or infected with virus. Both mycorrhizal association and phosphorus addition independently altered viral titer in plants of both species. Thus, increases in plant phosphorus either through AMF or via soil amendments contribute to increases in viral titer. Most predictions of plant responses to elevated CO₂ fail to include the impacts of both microbial mutualists and pathogens. Our research indicates that the inclusion of these microbes is important in order to fully understanding plant responses to increased CO₂ availability.

ALTERATIONS IN SOIL MICROBIAL COMMUNITIES FOLLOWING SALT CEDAR INVASION: IMPLICATIONS FOR RESTORATION

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Biological invasions have been reported to alter soil microbial communities. These alterations may result in plant-soil feedbacks, which may be an important mechanism for these species' successful invasibility. Saltcedar (*Tamarix* spp.) was introduced into the USA for stream bank stabilization, windbreaks, and landscaping. These species have subsequently escaped intentional plantings and invaded river systems throughout southwestern USA, replacing native plant species, altering wildlife habitat, flooding patterns, and fire frequency. However, previous studies assessing impacts of saltcedar focus on aboveground parameters, with little attention given to the belowground microbial communities, although soil organisms play important roles in regulating ecosystem-level processes. Understanding how soil microbial communities are affected by plant invasions may be a critical aspect of the restoration of native ecosystems. We conducted field and greenhouse studies to assess potential plant-soil feedbacks. In our field study, soil samples were collected 1) beneath saltcedar trees in highly invaded areas; 2) from areas where saltcedar trees have been mechanically and chemically removed; and 3) from adjacent non-invaded prairie dominated by native warm-season grasses. Soil was processed for nutrient (plant-available N and P and soil pH) and microbial community analyses (using phospholipid fatty acid analysis). Our results indicate soil microbial communities were altered following saltcedar invasion; invaded and removal sites were higher in fungal abundance, attributed to both AM and saprophytic fungi. Our greenhouse study assessed plant-soil feedbacks indirectly through biomass production of six native warm-season grasses planted into soil collected from the same three areas as our field study. We hypothesized plant-soil feedbacks function as an alteration in biotic communities, including arbuscular mycorrhizal (AM) fungi, and plant growth would be inhibited in soils collected from beneath saltcedar, as compared to growth in native soils. We further hypothesize that feedbacks are transitory, and therefore, plant growth would be improved when grown in soils collected from the removal sites, as compared to saltcedar invaded sites. Soils experiencing alterations in microbial communities following plant invasions may lead to greater risk of invasion by other non-native species (invasion meltdown hypothesis). Therefore, we also assessed the biomass production of four non-native warm-season grasses in soils from these same sites. We further hypothesized that both native and non-native species would produce greater biomass in soil collected from native sites, as compared to saltcedar invaded or removal sites. Plants were grown for 16 weeks, at which time biomass production was determined. Percent root colonization by AM fungi was determined microscopically. Our hypotheses were not supported by the results of our greenhouse study. Both native and non-native plant species produced greater biomass in soils collected from saltcedar or saltcedar removal sites, as compared to production in soil from native sites. However, percent AM root colonization was greater for all species in native soil, compared to soil collected from saltcedar invaded or removed sites. These results indicate further characterization of soil alterations by these invasives will be necessary to improve restoration efforts.

EFFECT OF ORGANIC SOIL AMENDMENTS AND CONTINUOUS TOMATO MONOCULTURE ON ARBUSCULAR MYCORRHIZAL COMMUNITIES

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As interest in crop management alternatives to conventional high input farming increases, understanding the impacts of organic soil amendments and crop rotations on microbial components of the agroecosystem is desirable, especially for arbuscular mycorrhizal (AM) fungi. Soil amendments are thought to be more conducive for the activity of AM fungi, depending on nutrient supply. The effects of broiler litter and urban plant debris on infectivity and community structure of AM fungi are under evaluation in an ongoing tomato (*Solanum lycopersicum*) microplot study. Tomato plants were cultivated under conventional methods for the first two years, then transitioned for three years with alternative organic treatments and crop rotation. Mycorrhizal inoculum potential (MIP) of rhizosphere soil was assayed with maize (*Zea mays L.*) to assess activity of AM fungi. Soil DNA has been collected and will be assayed for the presence of key rDNA phylotypes in an attempt to track changes in the AM community over time at different stages of management transition. Depending on the availability of P and N, AM fungal colonization is expected to be suppressed due to plant sufficiency. Since the microplots have received multiple treatments with soil amendments, host crops, and harvests per year, the plots have been highly disturbed. Hence, the prediction is that the fungal diversity or prevalence will decrease due to hyphal network disruption. Furthermore, frequent disturbance and removal of host plant may favor more aggressive and early colonizing AM fungi. Overall, the organic plots are expected to support higher AM fungal activity, depending on organic treatment, and a distinct fungal community compared to the conventional plots.

GEOMETRIC PATTERN DIFFERENCES OF COLLEMBOLA USING SCANNING ELECTRON AND ATOMIC FORCE MICROSCOPY

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The cuticular surface of Collembola express particular geometric patterns of raised minor tubercles connected by bridges in groups of 3 – 5 within a matrix of thinner cuticle. The entire cuticle becomes a tessellation. Using a combination of scanning electron microscopy and atomic force microscopy we are evaluating differences in structural arrangement and physical properties of the components of these cuticular structures. Pattern differences have been observed between different collembolan species. This poster presents some preliminary findings of a comparison study of different genera of Collembola and contrasting patterns in different regions of the same collembolan species. The process of cuticular formation is not fully understood and, in conjunction with a study examining community assemblages of soil fauna differential adaptations may be observed in the cuticle structure from the same species at different locations and within the same animal during growth. To the best of our knowledge the combined use of these two microscopic techniques to study collembolan cuticles has not been reported.

NUTRIENT BIOAVAILABILITY FOR BLACK SPRUCE ESTABLISHMENT AS INFLUENCED BY ELEVATION AND POST-FIRE DISTURBANCE

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Black spruce (*Picea mariana*) forests are widespread across boreal North America and can be considered a climax species. These systems are consistently affected by fire disturbance and climatic factors. Four studies compared black spruce establishment potentials as influenced by climate change impacts on elevation ecotones and post-fire disturbances in eastern Newfoundland and Labrador, Canada. Plant Root Simulator (PRS)TM-probes were used as a means to understand whether soil nutrient supply rates can support black spruce relocation and regeneration success. Soil bioavailable nutrients were measured along an elevation gradient from closed-crown forest, through shrub-tree-island transition zone, and into alpine tundra. In the alpine tundra soil nutrient supply rates were compared between two common black spruce seedbeds, *Cladonia stellaris* (fruticose lichen) and *Pleurozium schreberi* (feathermoss) to determine black spruce survival and recruitment potential above the current treeline. No significant differences in PRSTM-N, P and S supply rates were found along the elevation gradient. Differences in PRSTM-Ca, Mg, K, and Mn supplies were significant (P<0.001) and show lowest levels in the tundra sites. Using principal component analyses, the tundra ecotone explained 71% of the variation in soil nutrient supply rates indicating the lichen seedbeds are more nutrient-deficient compared to feathermoss seedbeds. Soil nutrient dynamics in black spruce forest following wildfire were investigated in conjunction with microsite soil mixing (MSM) as a technique for black spruce seedbed preparation in *Kalmia angustifolia* (sheep-laurel) dominated heath. Preliminary trends showed MSM had elevated PRSTM-NO₃⁻-N, S, and K supply rates but lower PRSTM-NH₄⁻-N, Ca, Mg, and Mn supply rates as compared to controls without microsite disturbance. The authors concluded that black spruce seedlings are likely not limited by soil nutrient bioavailability alone in supporting establishments along the elevation gradient and in dominated sheep-laurel heath. Assessing black spruce seedbeds for soil nutrient bioavailability is one factor to consider in managing such ecosystems.

ARBUSCULAR MYCORRHIZAL FUNGI AND VASCULAR PLANT SPECIES ABUNDANCE AND COMMUNITY STRUCTURE IN TALLGRASS PRAIRIES WITH VARYING AGRICULTURAL DISTURBANCE HISTORIES

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Tallgrass prairie is one of the most critically endangered habitats in Canada, with less than one-percent of its original extent remaining. Information on arbuscular mycorrhizal fungi (AMF) in Canadian prairie, which may be beneficial to tallgrass prairie restoration, is lacking. We investigated the communities of AMF and vascular plants at five former or extant tallgrass prairie sites on Walpole Island First Nation, Ontario: one undisturbed prairie, two naturally recovered prairies and two old fields abandoned from agriculture 20 and five years ago, respectively. The AMF were identified morphologically using spores from trap-cultured soil

samples, and the number of spores of each taxon was used as an estimate of their abundance. We performed ester-linked extraction and measured fungal lipid biomarkers to assay the biomass of AMF. Sixteen species of AMF and 111 plant taxa were identified. Species composition, richness and diversity of both AMF and plants varied among sites. Principal components analysis distinguished fungal and plant communities at tallgrass prairie sites from more recently disturbed fields. However, AMF biomass, as assessed by the concentration of the fatty acid methyl esters C16:1*cis*11 and C18:1*cis*11, was not significantly different between old fields and tallgrass prairie. Community composition of AMF was a better indicator of agricultural disturbance than AMF abundance, species richness, or biomass. Therefore, if AMF play an important role in the reestablishment of tallgrass prairie plant species, it is most likely through plant host-specificity with particular species or taxonomic groups in the AMF community.

THE EFFECTS OF MILLIPEDES (*HARPAPHE HAYDENIANA*) ON MICROBIAL DECOMPOSITION PROCESSES OF DOUGLAS-FIR (*PSEUDOTSUGA MENSIESII*) NEEDLES

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Soil fauna is known to consume most fallen litter in some forests and thus have a significant role in litter decomposition processes. Yellow spotted millipede (*Harpaphe haydeniana*) is one of the dominant species of soil macro fauna in coastal rain forests in BC. They feed on partially decomposed leaf litter, preferentially Douglas-fir (*Pseudotsuga mensiesii*) needles, and excrete more than 90 percent of their consumption. By grazing they degrade the litter both mechanically and chemically and influence the subsequent microbial decomposition. Gut passage has been thought to increase decomposition rate, but some previous studies indicated that faeces of soil animals did not increase microbial respiration. Therefore, our questions are 1) do fauna alter microbial activity and community? If yes, 2) do the differences in microbial activity and community between faeces and litter change over time? In this study, we set microcosms with 1) Douglas-fir needles, 2) millipedes faeces derived from needle consumption, and 3) a mixture of needles and faeces and incubated them for two months. Respiratory carbon dioxide was measured on days 0, 1, 2, 3, 4, 7, 14, 28 and 56 to elucidate changes in microbial activity and phospholipid fatty acids (PLFA) were analyzed on days 0, 3, 7, 14, 28 and 56 to examine succession of the microbial community. We will discuss the differences in microbial communities and activity between needles and millipede faeces to determine the effects of millipedes on litter decomposition processes.

MOISTURE EFFECTS ON MICROBIAL COMMUNITIES IN BOREAL FOREST FLOORS ARE STAND-DEPENDENT

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Landscape level factors such as overstory canopy composition can have a profound effect on the ecology of microbial communities in boreal forest floors. However, factors influencing

community composition at the microsite scale are still poorly described and understood. Here we explored moisture effects on microbial communities in forest floor derived from undisturbed trembling aspen and white spruce stands. Forest floor samples were incubated in a laboratory experiment for a period of one month under a moisture regime ranging from moist to dry (field capacity, 60% of field capacity and wilting point). As in previous studies we found that the origin of the forest floor material had a strong effect on the microbial community. Additionally, we found that the microbial communities from the white spruce forest floor were less impacted by moisture stress, and shared similar structure and function at all moisture regimes. On the other hand, the moisture treatments had a profound effect on the aspen forest floor, and resulted in structurally and functionally distinct microbial communities. This different response to moisture manipulation could be linked to the adaptation of microbial groups to the physical environment inherent to the aspen and spruce forest floors.

COVER CROP MIXTURES FOR PROMOTING ARBUSCULAR MYCORRHIZAL FUNGI IN PRODUCTION AGRICULTURE

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Arbuscular mycorrhizal fungi (AMF) associate with an estimated 80-90 percent of flowering plants and virtually every crop species that supplies food to the world. AMF play a vital role in nutrient uptake and are particularly adept at increasing phosphorus availability to plants. With the growing emphasis on sustainability, these organisms have recently attracted attention as both biocontrol agents, and as a potential substitute for phosphorus fertilizer. Recent research has demonstrated that conventional agricultural practices have caused a decline in AMF populations compared to natural ecosystems. We found that a native prairie remnant had over 200 times the number of spores than local agricultural fields had in total propagules. Field and landscape levels of inoculation with these organisms are currently prohibitively expensive, so we investigated the manipulation of cover crops as a means of increasing AMF propagules in agricultural soils, examining both quantity and diversity. Utilizing a full factorial experiment we tested oats, vetch, canola and fallow treatments. Mixed cover crops resulted in the highest percent colonization in the roots of the subsequent corn crop. Vetch as a cover crop produced the lowest subsequent colonization of corn roots, performing significantly poorer than no cover crop. The number of soil AMF propagules also responded positively to the mixture (oats-vetch-canola) of cover crops in this set of plots and to an oats-pea mixture used in a second set of replicated plots established on a producer's farm located within a differing soil-climatic regime. At another producer's farm, we are assessing numbers of AMF propagules and spores in soil samples collected from paired locations plus or minus a five-way cover crop mixture (winter wheat-clover-vetch-turnip-radish) that was seeded following spring wheat harvest. Cover crop mixtures may simultaneously reduce seasonal fallow and provide plant diversity that promote higher numbers and diversity of AMF to deliver benefits to cash crops like corn in the upper Midwest.

THE ROLE OF BIOSOLIDS IN REPLENISHING ORGANIC MATTER IN CULTIVATED SOIL

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The capacity of soil in sustaining crop production and providing ecosystem service is largely dependent on the soil organic matter (SOM). The replenishment of SOM in cultivated agricultural soils is very slow because of low input of recalcitrant litter and high rates of SOM oxidation. In this paper, we evaluated data from recent studies on biosolids C sequestration and other published work on biosolids and soil C dynamics to address the hypothesis that biosolids can effectively build-up the organic matter in the cultivated soils. Data from a long-term experiment established in western Illinois on overburden from surface mining with continuous corn cropping showed that the build-up of soil organic C (SOC) from 1973-2010 was only 0.40 Mg ha⁻¹ yr⁻¹ under chemical fertilizer. However, with the application of biosolids of 17 Mg ha⁻¹ yr⁻¹, the SOC build-up was 1.1 Mg ha⁻¹ yr⁻¹. Carbon-13 isotope analysis showed the residual biosolids C and crop residue C both account for the greater SOC build-up under biosolids application. The SOM in biosolids-amended soils is mainly in particulate form with a high stability as demonstrated by the low microbial quotient (C mineralization by each unit of microbial biomass). The humic acids extracted from biosolids-amended soils had a high alkyl to O-alkyl C ratio, indicating high humification. The faster build-up in SOM under biosolids application is attributed to the amorphous Fe and Al in biosolids, which forms associations with SOM and increase SOM stability.

SEMI-STABLE FRACTION FORMATION AND DECAY RATES AFTER 12 YEARS OF FOLIAR LITTER DECOMPOSITION IN CANADIAN FORESTS.

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Litter decay in early and midphases of decomposition have been shown to highly influenced by climate and substrate quality, however factors affecting decay during the late semi-stable phase are less well understood. The Canadian Intersite Decomposition Experiment (CIDET) was established in 1992 with the objective of providing data on the long-term rates of litter decomposition and nutrient mineralization for a range of forested ecoclimatic regions in Canada. Such data were needed to help verify models used for national C accounting, as well as aid in the development of other soil C models. CIDET examined the annual decay, over a 12-year period, of 10 standard foliar litters and 2 wood substrates at 18 forested upland and 3 wetland sites ranging from the cool temperate to subarctic regions, a nearly 20°C span in temperature. On a

subset of sites and litter types, changes in litter C chemistry over time were also determined. Over the first 6 years, C/N ratio and iron increased, NMR showed an overall decline in O-alkyl C (carbohydrates) and increase in alkyl, aromatic, phenolic, and carboxyl C. Proximate analysis showed the acid unhydrolyzable residue (AUR) increases, but true lignin did not accumulate, in contrast to the conceptual ligno-cellulose model of decomposition. Litter decay during first phase was related to initial litter quality (AUR and water soluble extract), winter precipitation, but not temperature, suggesting the importance of leaching during this phase. Decay rate “k” during the mid phase was related to temperature, initial litter quality (AUR and AUR/N), summer precipitation, but not soil N. In most cases decay had approached an asymptote before end of experiment. Although annual temperature was the best single predictor for 12-year asymptotes, summer precipitation and forest floor pH and C/N ratio were the best set of combined predictors. The changes in the decay factors during different phases may explain some of the discrepancies in the relative importance of factors eg. temperature, which affect decomposition. Initial litter quality will have little influence during the later phase as chemical properties of well decayed litter converge. Since site factors other than climate were related to the size of the semi-stable fraction, this may reflect the role site chemistry and biota on decay rates during the semi-stable phase. Even with 12 years of data, results were not sufficient to determine late phase decay rates suggesting either even longer-term studies or other experimental approaches will be needed to determine the fate and factors affecting rates of organic matter sequestration and loss.

ABIOTIC CONTROLS ON ANNUAL AND CUMULATIVE LITTER DECAY RATES OVER FOUR YEARS IN FORESTED AND HARVESTED SITES ACROSS CANADA.

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Decomposition of plant detritus and heterotrophic respiration have been demonstrated to be affected by climate, litter type and soil biota. Clearcut harvest affects site temperature and water balance and theoretically in situ measurements of soil microenvironment and models which include them should better account for variation in soil C fluxes among sites and with disturbance than just aboveground climate. Detrital C fluxes were studied at 16 sites at 7 stations of the Fluxnet Canada Research Network, including paired closed canopy and clearcut forest sites at 5 upland stations (BC, SK, ON, QC, NB). All sites were instrumented for climate and in situ measurements of soil moisture and temperature. Cumulative litter decay was measured using surface placed litterbags with one of four standard material types (aspen leaves AL, black spruce needles BS, Douglas fir needles DF, and birch wood sticks BW). Six replicate plots were located at each site, each plot contained sufficient numbers of surface litterbags of each material to allow for four annual collections. As well unconfined birch chopsticks were placed at three depths down the soil profile (surface, 5cm, 15cm) and replaced annually to examine interannual variability in early phase annual decay. After four years of cumulative decay, litter rank by

%mass remaining had $AL < BS < DF < BW$ and in most cases litters decayed more rapidly in forests than clearcuts. Within a site annual decay of surface birch sticks was similar with interannual variability less than variability down the soil profile. The effects of clearcut varied with forest site type, on wetter sites surface BW decayed faster in clearcuts than closed forest, however this was reversed in drier forest site types. At lower soil depths on drier sites, decay was more rapid in clearcuts than in the closed forest. Interannual variation in soil moisture accounted for more variability in the annual mass loss than did soil temperature, however the relationship was weak. Both temperature and moisture accounted for differences in cumulative decay rates and mass loss of surface litter among forest site type and cover, though soil microenvironment accounted for more variation than did site climate. Forest site type and cover effects were still significant even when controlled for microenvironment, suggesting other soil or biotic factors need to be accounted for in predicting litter decay.

THERMAL ACCLIMATION OF SOIL RESPIRATION DETERMINED VIA LABORATORY INCUBATIONS DEPENDS ON MICROBIAL BIOMASS AND SUBSTRATE LIMITATION
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Soil represents one of the largest pools of stored carbon on the planet and is a major contributor to terrestrial CO₂ fluxes. The relation between temperature and soil respiration is nearly exponential, so that increased temperatures lead to increased decomposition of stored carbon. Decomposition of soil organic matter adds carbon dioxide to the atmosphere, potentially resulting in a positive feedback between increasing temperature and soil respiration. Therefore, the study of the temperature dependence of soil respiration is vitally important to understanding possible changes to carbon cycling that will occur with global warming and what these changes will imply on a global and local scale. While in the short term soil respiration increases exponentially with temperature, in the longer term thermal acclimation, or a decrease in the respiration response to higher temperatures, may occur. This pattern may result from changes in substrate availability, microbial biomass, and microbial physiology or community composition. In this study we hypothesize that soils incubated at cold temperatures for a long period of time will have higher respiration rates at a given temperature than will soils incubated at warmer temperatures. Further, we hypothesized that the temperature response will be a function of substrate availability and total microbial biomass. To test these hypotheses, we performed a one-month soil incubation at three different temperatures, with two different levels of substrate availability. On the final day, we switched the soil temperature regimes, and switched the substrate regimes in a full factorial combination of initial and final conditions. In soils that did not receive dextrose addition either initially or finally, we saw no significant evidence of thermal acclimation. Soils that initially received sugar addition but were not subsequently amended had the highest thermal acclimation response. Within this treatment, initially cold incubated soils had much higher respiration rates when switched to the warm temperatures than did the warm incubated soils. We suggest that this represents an induced substrate and/or biomass limitation of soil respiration that occurs only at higher temperatures.

COARSE WOODY DEBRIS RETENTION IN SUBALPINE CLEARCUTS AFFECTS ECTOMYCORRHIZAL ROOT TIP COMMUNITY STRUCTURE WITHIN FIFTEEN YEARS OF HARVEST

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Shifts in ectomycorrhizal (ECM) fungal community composition occur after clearcut logging, resulting in the loss of some forest species. Decayed wood is a remnant of the original forest and an important habitat for particular ECM fungal species. Therefore, retention of coarse woody debris (CWD) at harvest is expected to contribute to the long-term preservation of pre-harvest community structure because, as it decays, niches for ECM fungi will be maintained. To test for a medium-term effect of CWD retention, we examined ECM spruce roots and hyphae in 1-ha CWD retention and removal plots (N=3) at a high elevation spruce forest 12 and 13 years after clearcut harvesting. Root tips were sampled from ten *Picea engelmannii* saplings in each treatment plot. The tips were grouped morphologically, and the ECM fungal symbiont identified by PCR amplification and Sanger sequencing of the entire ITS region. Three sand-filled hyphae-trapping mesh bags were buried amongst the roots of the ten saplings at each plot; these remained in place for one year. Sand from bags surrounding each sapling was pooled and subsampled for DNA extraction. The ITS1 region was amplified with primers unique to each plot, and equimolar PCR product from all saplings was pooled and submitted for GS-FLX Titanium sequencing.

A total of 5433 ECM root tips were examined, and the ITS sequences were distributed amongst 89 OTUs. Pyrosequencing of fungal hyphae generated 87,620 ITS1 sequences for analysis; this resulted in 5437 OTUs. Both datasets were clustered at 95% sequence similarity. We assigned 46 root tip OTUs and 50 hyphae OTUs to ECM taxa, and these were used for all further analyses. The most abundant taxa amongst root tips collected and named were *Thelephora terrestris*, *Alloclavaria purpurea*, *Amphinema byssoides*, and *Tylospora asterophora*. The most abundant OTUs from mesh bags were ectomycorrhizal taxa, and the most abundant of these were *Amphinema byssoides*, *Thelephora terrestris*, *Wilcoxina mikolae*, and *Tylospora asterophora*. The mycorrhizal status of *Alloclavaria purpurea* had not previously been examined. At our site, analysis of $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ signatures in sporocarps placed *A. purpurea* within the 95% confidence limits of ECM fungi from the site; however, discriminant analysis classified it as a saprotroph. Consequently, although further work is required, we believe that *A. purpurea* is mycorrhizal. The retention of CWD had no detectable effect on taxon richness, evenness or diversity of ECM fungi on root tips or in mesh bags; however, there was a detectable shift in species composition ($P = 0.049$). Although, at our sampling intensity, we could not detect effects on the abundance of individual ECM fungi, our results suggest that the retention of CWD at the time of harvest has affected ECM habitat at this site, and has resulted in altered ECM species composition, even though the logs are still hard and intact. Ongoing experiments with non-mycorrhizal bioassay seedlings planted 13 years after harvest in both the clearcuts and adjacent forest will help to determine if the community is beginning to shift back to that of the original forest.

BUD BANK DEMOGRAPHY: BUD BANK DENSITY OF WARM SEASON NATIVE GRASSES REGULATES INVASION OF EXOTIC SPECIES

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Exotic species invasions have serious consequences for native species populations, biodiversity, ecosystem processes, and physical habitat features. Thus, identifying factors that influence invasions by exotic plant species is of critical importance. Davis et al. (2000) developed a general theory arguing that fluctuations in resource availability is the key factor controlling invasibility, and that successful invasions occur only intermittently, when resource enrichment or release coincide with the availability of propagules of the exotic species. Thus, invasions will occur during “windows of opportunity” when propagules of the invader can capitalize on newly released or available limiting resources. In perennial grasslands, the belowground population of meristems plays a fundamental role in local plant population persistence, structure and dynamics; all important factors determining invasibility. We suggest that, even during episodes of new resources and adequate exotic propagule supply, a community may still be resistant to invasion if the residents possess traits that allow them to pre-empt available resources more rapidly than the exotics. Using greenhouse and field studies (Oklahoma site and Kansas site) we tested the following hypotheses: 1) Grassland invasibility is regulated by a minimum threshold in belowground bud bank (BGBB) population densities, and 2) Increases in bud bank size will lead to increases in grassland stability, thereby reducing invasibility by exotic grasses. Our greenhouse microcosms were allowed to grow for 14 weeks, at which time the mean exotic species biomass was 410.40 g, 45.21 g, 19.05 g, and 12.68 g for 0%, 33%, 66%, and 100% of natural BGBB densities, respectively. Similar results were observed in a complementary field study (OSU-Range Research Station site) where native meristem densities were reduced with applications of glyphosate. Exotic species biomass was 199.58 g, 44.43 g, 9.67 g, and 5.03 g for 0%, 33%, 66%, and 100% of natural BGBB densities, respectively. No exotic species successfully established at the Konza Prairie Biological Station site in Kansas. Our study indicates that grassland invasibility is associated with a minimum threshold in BGBB densities. In both our greenhouse and field study (OSU-RRS) we did not observe a relationship between the various densities of BGBB (33%, 66%, or 100%) and invasibility of these grassland communities. However, our lowest meristem density (0%) substantially decreased stability and increased invasibility of our grassland community. Our findings begin a critical step in obtaining a better understanding of belowground bud banks in rangeland responses to environmental change at the population, community, and ecosystem levels.

ARBUSCULAR AND ECTO MYCORRHIZAL COMMUNITIES ASSOCIATED WITH SOIL AGGREGATE SIZE CLASSES IN THE RHIZOSPHERE OF MYCORRHIZAL INOCULATED WILLOWS (*SALIX* SPP.)

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Willows are known to benefit from symbioses with both arbuscular and ecto-mycorrhizal fungi (AMF and EMF), and are commercially inoculated to enhance their growth. Another advantage of mycorrhizal inoculation can be increased soil aggregation, however little is understood about how mycorrhizal inoculation affects the formation of aggregates and whether AMF and EMF species associate with different soil aggregate size classes. A greenhouse study was established to determine the impact that mycorrhizal inoculation has on percent water stable aggregates (%WSA) and diversity of AMF and EMF in the rhizosphere. Cuttings of willows (*Salix viminalis* and *S. miyabeana*) were potted in 6 different soils collected from Southern Ontario and inoculated with a commercial mycorrhizal inoculant in 1 of 4 combinations: 1) *Glomus intraradices* (AM), 2) *Hebeloma cylindrosporium* (EM) 3) both (AM & EM) 4) un inoculated (control). After 8 months, %WSA was determined, and soil aggregates were separated by dry sieving (>4mm, 4-2mm, 2-0.5mm and <0.5mm). The diversity of AMF and EMF associated with each size class was assessed by nested polymerase chain reaction – denaturing gradient gel electrophoresis (PCR-DGGE). DGGE bands were cut, sequenced, and compared with known sequences in Genbank and a phylogenetic tree was constructed. Mycorrhizal inoculation and soil type significantly affected %WSA and the highest percent was recorded in AM > AM & EM, > EM > control. The diversity of the AMF and EMF communities was significantly affected by soil and mycorrhizal type. Our results suggest that inoculation with AMF can improve water stable aggregation of soil. Furthermore, we have shown that AMF diversity differs between aggregate size classes, whereas EMF diversity is uniform across aggregate size classes.

SOIL RESPIRATION RESPONSES TO TEMPERATURE ARE AFFECTED BY SUBSTRATE SUPPLY AND EARTHWORM ACTIVITIES

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The temperature dependence of soil respiration is of considerable ecological importance in the context of possible climate-change feed back effects. Multiple confounding factors could influence temperature sensitivity, as discussed by some studies, however, the effect of invertebrates on temperature sensitivity has never been discussed, and the experimental results of substrate supply on soil respiration are controversial. To look at if substrate supply and earthworm could influence soil respiration, we set up a field experiment in 70 and 150 year old temperate forest stands at the Smithsonian Environmental Research Center, in Edgewater, Maryland. We manipulated earthworm density, by removing and adding earthworms and substrate supply using American beech or Tulip poplar. We measured soil respiration, soil temperature and soil moisture from Nov 2008 to June 2010. Average Q_{10} and seasonal Q_{10} were both calculated based on soil respiration and soil temperature data. Q_{10} had a large seasonal variation with the annual minimum occurring in midsummer and annual maximum occurring in the winter and spring. Seasonal values of Q_{10} were negatively related to soil temperature in the two forests and positively related to soil moisture in the young forest. Q_{10} was positively related to soil moisture when soil temperature was above 13 °C while negatively related to soil moisture when temperature was below 13 °C in the old forest. Q_{10} value was higher in the treatments with beech leaf litter than with Tulip poplar, indicating that the temperature dependence of low

quality substrate is higher than high quality substrate. Q_{10} value was lower with higher earthworm density in the old forest, indicating that earthworms could change the overall temperature response by stimulating carbon decomposition and redistributing organic matter. The effects of substrate quality, earthworm activities, soil moisture and temperature on Q_{10} have important implications for predicting the response of terrestrial ecosystems to future global warming.

PYROSEQUENCING ANALYSIS OF CHICKPEA RHIZOSPHERIC BACTERIAL DIVERSITY AS INFLUENCED BY FUNGICIDE APPLICATION

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Fungicide application in field crops have unexpected non-target effects on the agro-ecosystem. Molecular methods (polymerase chain reaction with multiplex 454 GS FLX amplicon pyrosequencing) were used to test the effects of four fungicide application programs targeting *Ascochyta* leaf blight (*Ascochyta rabiei*) on the general bacterial communities associated with two chickpea cultivars. Treatments were replicated four times in split plot experimental design in the field, in 2008 and 2009. Results showed the total OTUs, Chao and ACE richness estimating index of the bacterial communities significantly changed between two experimental years ($P < 0.001$), but richness did not significantly change ($P > 0.05$) with fungicide applications or with genotypes. However, different intensities of fungicide application affected the composition of chickpea rhizosphere bacterial communities, as revealed by Venn analysis ($P < 0.001$). Besides, genotypes of chickpea cultivars also affected the composition of the bacterial communities, as revealed by Venn analysis ($P < 0.001$). Based on these results, we conclude that foliar fungicide applications and different genotypes can affect the composition of bacterial community in chickpea field, which is also affected by environmental factors.