**Request to Conduct Research on the Bartlett Experimental Forest**

***Our review process has two deadlines to submit proposed work – April 1 and October 1. We try to get approvals back within a month.*** Providing a complete set of information will facilitate the review process. Be as specific as possible regarding your potential sampling locations and methods.

**I.** Investigator(s) Name(s), Affiliation(s), E-mail address, and if you’ve worked at BEF: add additional lines if necessary -- \* is a required field

Name\* Affiliation\* E-mail address\* Prior BEF work\* (y/n)

Ruth Yanai SUNY-ESF rdyanai@syr.edu y

Tim Fahey Cornell tjf5@cornell.edu y

Melany Fisk Miami University fiskmc@muohio.edu y

Ed Rastetter MBL erastetter@mbl.edu y

Mariann Johnston SUNY-ESF mjohnston@esf.edu y

**ll.** Proposal Information -- you can also attach a short proposal summary with this form

Title:\* Multiple Element Limitation in Northern Hardwood Ecosystems (MELNHE)

Major hypotheses:\* We will test the patterns of resource limitation predicted by the MEL model, which predicts a greater response of aboveground productivity to N+P than N or P alone.

Funding sources (please indicate both pending or currently available sources):\* NSF LTER, NSF Ecosystems

Proposed study start date:\* 2004

Estimated duration of study:\* Ongoing. We began pre-treatment measurements in 2004, started fertilizing in 2011, and hope to keep the treatments going beyond the current funding cycle (2022).

**III**. Type of system involved/work proposed: Please address items a-c:

a. System (check all that apply):

**Terrestrial** Aquatic Watershed Atmosphere **Other: Forested System**

b. Type of work proposed:

Large-scale manipulation (e.g., compartment/watershed treatment of vegetation/site) **Small-scale manipulation (e.g., plot level treatment of vegetation/site)**

Large/small-scale non-manipulative measurements

Type of sampling proposed:

\* **Non-destructive sampling**

\* **Destructive sampling**

**\* Long-term monitoring**

\* Other

BEF Request Form 6/19/2015

c. Key words – check any descriptors that apply to your proposal:

|  |  |  |  |
| --- | --- | --- | --- |
| **Forestry** | Hydrology | Community ecology | Autecology |
| Wildlife | Remote Sensing **Population biology** | Physical ecology |
| Soils | Physics | **Biogeochemistry** | Other |
| Chemistry | Geology | **Ecosystem ecology** |  |

List the types of organisms or substances you intend to study (e.g., trees, amphibians, mammals, soils, calcium, etc): \*

 **Plant and soil**

**IV**. In which Bartlett compartments would you like to work?\* Continuing in the sites established in 2003-2005, see location information at the end of the document.

Have you discussed these sites with either Bill Leak/Mariko Yamasaki?\* Yes If so, when? Since 2003



**V**. What Bartlett ongoing research or publications are related to your proposed research?\*

The following papers report results from our work in these sites.

Djukica, I. , S. Kepfer-Rojasb, I. Kappel Schmidtb, K. Steenberg Larsenb, C. Beierb, B. Bergc, and K. Verheyene.  2018.  Early stage litter decomposition across biomes.  Science of the Total Environment 628-629: 1369-1394.  https://doi.org/10.1016/j.scitotenv.2018.01.012.

Goswami S, M.C. Fisk, M.A. Vadeboncoeur, M. Johnston, R.D. Yanai, and T.J. Fahey. 2017. Phosphorus limitation of aboveground production in northern hardwood forests. Ecology. DOI: 10.1002/ecy.2100.

Yanai, R.D., G.E. Walsh, Y. Yang, C.A. Blodgett, K. Bae, and B.B. Park. Nutrient concentrations of roots vary with diameter, depth, and site in New Hampshire northern hardwoods. Canadian Journal of Forest Research 48: 32-41. DOI: 10.1139/cjfr-2017-0223.

Yang, Y., R.D. Yanai,F.R. Fatemi, C.R. Levine, P.J. Lilly, and R.D. Briggs. 2016. Sources of variability in tissue chemistry in northern hardwood species. *Can. J. For. Res.* 46(3): 285–296. 10.1139/cjfr-2015-0302.

Kang, H., T.J. Fahey, K. Bae, M.C. Fisk, R.E. Sherman, R.D. Yanai, and C.R. See. 2016. Response of forest soil respiration to nutrient addition depends on site fertility. *Biogeochemistry* 127:113–124. DOI: 10.1007/s10533-015-0172-6.

Bae, K., T.J. Fahey, R.D. Yanai, and M.C. Fisk. 2015. Soil nitrogen availability affects belowground carbon allocation and soil respiration in northern hardwood forests of New Hampshire. *Ecosystems* 18(7):1179–1191. DOI: 10.1007/s10021-015-9892-7.

See, C.R., R.D. Yanai, M.C. Fisk, M.A. Vadeboncoeur, B.A. Quintero, and T.J. Fahey. 2015. Soil nitrogen affects phosphorus recycling: foliar resorption and plant–soil feedbacks in a northern hardwood forest. *Ecology* 96:2488–2498*.* DOI: 10.1890/15-0188.1

Falster, D.S., R.A. Duursma, M. Ishihara, D.R. Barneche, R.G. FitzJohn, A. Vårhammar, M. Aiba, M. Ando, N. Anten, J.L. Baltzer, C. Baraloto, J.J. Battles, B. Bond-Lamberty, M. van Breugel, Y. Claveau, L. Coll, M. Dannoura, S. Delagrange, J.-C. Domec, F.R. Fatemi, W. Feng, V. Gargaglione, A. Hagihara, J.S. Hall, S. Hamilton, D. Harja, T. Hiura, R. Holdaway, L. Hutley, T. Ichie, M.I. Ishihara, E.J. Jokela, A. Kantola, J.W.G. Kelly, T. Kenzo, D. King, B.D. Kloeppel, T. Kohyama, A. Komiyama, J.-P. Laclau, C.H. Lusk, D. Maguire, G. le Maire, A. Mäkelä, L Markesteijn, J. Marshall, K. McCulloh, I. Miyata, K. Mokany, S. Mori, R.W. Myster, M. Nagano, S. Naidu, Y. Nouvellon, A.P. O’Grady, K.L. O’Hara, T. Ohtsuka, N. Osada, O.O. Osunkoya, P.L. Peri, A.M. Petritan, L. Poorter, A. Portsmuth, C. Potvin, J. Ransijn, D. Reid, S.C. Ribeiro, S.D. Roberts, I. S.-R. Rodríguez, R. Rodríguez, A. Saldaña-Acosta, K. Sasa, N.G. Selaya, S.C. Sillett, F. Sterck, K. Takagi, T. Tange, H. Tanouchi, D. Tissue, T. Umehara, H. Utsugi, M.A. Vadeboncoeur, F. Valladares, P. Vanninen, J.R. Wang, E. Wenk, D. Williams, F. de Aquino Ximenes, A. Yamaba, T. Yamada, T. Yamakura, R.D. Yanai, and R.A. York. . BAAD: a Biomass And Allometry Database for woody plants. Ecology 96(5): 1445. DOI: 10.1890/14-1889.1

Wild, A.D. and R.D. Yanai. 2015. Soil nutrients affect sweetness of sugar maple sap. *For. Ecol. Manag.* 341: 30–36 DOI: 10.1016/j.foreco.2014.12.022

Fisk, M.C., T.J. Ratliff, S. Goswami, and R.D. Yanai. 2014. Synergistic soil response to nitrogen plus phosphorus fertilization in hardwood forests. *Biogeochemistry* 118(1–3): 195–204. DOI 10.1007/s10533-013-9918-1

Vadeboncoeur, M.A., S.P. Hamburg, R.D. Yanai, and J.D. Blum. 2014. Rates of sustainable forest harvest depend on rotation length and weathering of soil minerals. *For. Ecol. Manag*. 318: 194–205. DOI:10.1016/j.foreco.2014.01.012

Rastetter, E.B., R.D. Yanai, R.Q. Thomas, M.A. Vadeboncoeur, T.J. Fahey, M.C. Fisk, B.L. Kwiatkowski, and S.P. Hamburg. 2013. Recovery from disturbance requires resynchronization of ecosystem nutrient cycles. *Ecol. Appl.* 23: 621–642. DOI: 10.1890/12-0751.1

Vadeboncoeur M.A., S.P. Hamburg, J.D. Blum, M.J. Pennino, R.D. Yanai, and C.E. Johnson. 2012. The quantitative soil pit method for measuring belowground carbon and nitrogen stocks. *Soil Sci. Soc. Am. J. 76(6):2241–2255* DOI:10.2136/sssaj2012.0111

Levine, C.R., R.D. Yanai, M.A. Vadeboncouer, S.P. Hamburg, A.M. Melvin, C.L. Goodale, B.M. Rau, and D.W. Johnson. 2012. Assessing the suitability of using rotary corers for sampling cations in rocky soils. *Soil Sci. Soc. Am. J*. 76 (5): 1707–1718 DOI: 10.2136/sssaj2011.0425

Blum, J.D., S.P. Hamburg, R.D. Yanai, and M.A. Arthur. 2012. Determination of foliar Ca/Sr discrimination factors for six tree species in northern hardwood forests, New Hampshire, USA. *Plant Soil.* 356(1): 303–314 DOI: 10.1007/s11104-011-1122-2

Lucash, M.S., R.D. Yanai, Joel D. Blum, and B.B. Park. 2012. Foliar nutrient concentrations related to soil sources across a range of sites in the northeastern United States. *Soil Sci. Soc. Am. J*. 76(2): 674–683. DOI: 10.2136/sssaj2011.0160

Fatemi, F.R.**,** R.D. Yanai, S.P Hamburg, M.A. Vadeboncouer, M.A. Arthur, R.D. Briggs and C.R. Levine. 2011. Allometric equations for young northern hardwoods: the importance of age-specific equations for estimating aboveground biomass. *Can. J. For. Res.* 41(4): 881–891 DOI: 10.1139/x10-248

Wielopolski, L, R.D. Yanai, C.R. Levine, S. Mitra, and M.A Vadeboncoeur. 2010. Rapid, non-destructive carbon analysis of forest soils using neutron-induced gamma-ray spectroscopy. *For. Ecol. Manag.* 260(7): 1132–1137

Fisk, M.C., R.D. Yanai, and N. Fierer. 2010. A molecular approach to quantify root community composition in a northern hardwood forest: testing effects of root diameter and species. *Can. J. For. Res.* 40(4): 836–841

Nezat, C.A., J.D. Blum, R.D. Yanai, and B.B. Park. 2008. Mineral sources of calcium and phosphorus in soils of the northeastern USA. Soil Science Society of America Journal 72(6): 1786–1794

Yanai, R.D., M.C. Fisk, T.J. Fahey, N.L. Cleavitt, and B.B. Park. 2008. Identifying roots of northern hardwood species: patterns with diameter and depth. Canadian Journal of Forest Research 38(11): 2862-2869

Blum, J., A.A. Dasch, S.P. Hamburg, R.D.Yanai, and M.A. Arthur. 2008. Use of foliar Ca/Sr discrimination and 87Sr/86Sr ratios to determine soil Ca sources to sugar maple foliage in a northern hardwood forest. Biogeochemistry 87(3): 287-296

Vadeboncoeur, M.A., S.P. Hamburg, and R.D. Yanai. 2007. Validation and refinement of allometric equations for roots of northern hardwoods. Can. J. For. Res. 37: 1777-1783.

Park, B.B., R.D. Yanai, M.A. Vadeboncoeur, and S.P. Hamburg. 2007. Estimating root biomass in rocky soils using pits, cores and allometric equations. Soil Sci. Soc. Am. J. 71: 206-213.

Yanai, R.D., B.B. Park, and S.P. Hamburg. 2006. The vertical and horizontal distribution of roots in northern hardwood stands of varying age. Can. J. For. Res. 36: 450-459.

Yanai, R.D., J.D. Blum, S.P. Hamburg, M.A. Arthur, C.A. Nezat, and T.G. Siccama. 2005. New insights into calcium depletion in northeastern forests. J. For. 103:14-20.

Hamburg, S.P., R.D. Yanai, M.A. Arthur, J.D. Blum and T.G. Siccama. 2003. Biotic control of calcium cycling in northern hardwood forests: acid rain and aging forests. Ecosystems 6:399-406

**VI**. Proposal abstract (or a brief description of your proposed research attached to this form): \*

Theory suggests that ecosystem productivity should be co-limited by multiple nutrients, although temperate forests have long been thought to be primarily nitrogen limited. Experimental tests of nitrogen vs. phosphorus limitation in temperate forest systems are lacking, but evidence is mounting that both terrestrial and aquatic systems are most commonly co-limited by N and P. Our research combines modeling and field studies to explore processes mediating nutrient colimitation in relation to successional change in managed hardwood forest systems. The Multi-Element Limitation (MEL) model is unique in representing co-limitation from the perspective of resource optimization theory and whole-ecosystem biogeochemistry. We have extended the model to include P as well as N, carbon, light, and water, and applied it to simulate primary and secondary succession in northern hardwood forests. Using nutrient manipulations (N, P, N+P) in replicated stands of different ages, we are testing the patterns of resource limitation predicted by the model and multiple mechanisms of allocation of effort to acquire N and P. Specifically, the model predicts a greater response of aboveground productivity to N+P than N or P alone. In older stands, it predicts a greater response to N than to P addition, but in younger stands, the model suggests that the supply of N from detritus should be sufficient to create P limitation.

The overall study design involves, in addition to the stands at Bartlett, W101 and adjacent mature forest at Hubbard Brook, and a similar pair of young and old stands at Jeffers Brook.

**VII**. Proposed field methods and sampling procedures with sufficient information to determine potential disturbance and sampling impacts

A. Plots were established in 9 stands in 2004 and 2005, 3 in each of 3 age classes, as part of an earlier study on Ca cycling. There are 4 50 m x 50 m plots in each stand. They are being treated with N (as ammonium nitrate), P (as monosodium phosphate), N&P, and control. The application rates are 30 kg/ha/year for N and 10 kg/ha/yr for P. There is also a Ca treatment plot in some of the stands, in which 1150 kg Ca/ha of wollastonite (CaSiO3) was applied in 2011.

B. We will continue to monitor vegetation on the plots, including herbs as well as trees.

C. We measure soil respiration at least annually.

D. We will sample roots and soils.

E. We will collect soil samples for heterotrophic soil respiration and for differences in mycorrhizae using root tips and metabolites. She will also monitor nutrient availability using resin bags.

F. At least every five years, foliar samples will be collected from sunlit leaves of three individual of the dominant species in each plot (sampled in 2004-5, 2008-9, and 2014-6). In mature stands, we collect samples using a 12-gauge shot gun. In young stands, we use a pole pruner. We may also climb trees to collect leaf and twig samples, using safe and minimally invasive rope access methods.

G. Litter traps are deployed in 8 of the stands. We monitor litterfall mass annually, and in some years we collect fresh litter for nutrient analysis.

H. We will measure sap flow using the Granier method, following previous efforts in 2015 and 2017.

I. Mycorrhizal fungal fruiting bodies will be collected in 2018, as in 2017.

J. We will not be cutting down any trees on these BEF plots.

**VIII**. Safety-The USFS is committed to increasing safety awareness among its employees and research cooperators.

The WMNF and the Bartlett Experimental Forest occur on rugged terrain with severe weather patterns throughout the year and appropriate preparations are necessary prior to engaging in field work. Please provide us with a description of your safety guidelines for personnel working in both the field and in the lab. For example, your check in/check out procedures, job hazard analysis, relevant training, safety equipment.

Our crew leaders have a plan every day for the location of all personnel and are provided with emergency contact information.

Special considerations – If the proposed research involves potentially hazardous techniques (e.g., shotgun sampling, **tree/tower climbing**) provide specific information about the techniques and materials, including justifications for use, potential problems and concerns, and any statements on necessary precautions and safety factors that will be utilized in the process.

The operators of the guns have gone through the required safety training. When shotgun sampling occurs, we notify the local ranger district, town police, and county police on the day of collection. We also hang signs to notify researchers of our collection efforts - all protocol outlined by the Forest Service to follow.

The operators of the tree access equipment have gone through sufficient instruction and training in canopy access and aerial rescue. When tree climbing occurs we notify P.I.s and the summer crew leader and follow a check-in check-out protocol. A ground crew maintains scene safety at all times around the tree being climbed. All members of the climbing team wear helmets and carry paper copies of the tree rescue protocol outlined in the “tree rigging and access technique” document supplied below.

Some degree of NEPA assessment on the part of the researcher will be required for any of the following manipulative treatments that use contaminating materials (e.g., isotopes, introduced plants or animals, fertilizers, insecticides, and herbicides). At a minimum, a scoping letter describing the proposed experiment will be sent to all BEF abutters and WMNF for comment and a letter to the file as a categorical exclusion will be needed. A determination of the degree and extent of assessment required will be made at the time of the proposal by the Project Leader. See this link for more information: [**http://www.fs.fed.us/emc/nepa/**](http://www.fs.fed.us/emc/nepa/)

 We obtained a NEPA exclusion.

**Research Stipulations:** If you are granted permission to work at BEF: (1) any plots you establish within compartments will need to be geo-referenced with plot centers and corners identified; and a plot data file will need to be provided as soon as possible for our records; and (2) all researchers will be required to remove all field sampling material and equipment from plots and laboratory site at the conclusion of their work. All GIS data shall be in the following format:

**Projection** – NH State Plane, NAD83 Ft.  **Coordinates** – Decimal Degrees

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Site**  | **USFS Designation** | **Age in 2004** | **Elevation (m)** | **Aspect** | **GIS Coordinates** |
| **C1** | Davis Brook West Timber Sale | 12 | 570 | flat to SE | C1-1: 44.042824,-71.320720C1-2: 44.042538,-71.321201C1-3: 44.041931,-71.321822C1-4: 44.042574,-71.321958 |
| **C2** | Saco RD Cmpt 51 | 14 | 340 | NE | C2-1: 44.059038,-71.269333C2-2: 44.059480,-71.268800C2-3: 44.059813,-71.269119C2-4: 44.059526,-71.269901 |
| **C3** | Saco RD Cmpt 52 stand 17 | 19 | 590 | NNE | C3-1: 44.038185,-71.291325C3-2: 44.037742,-71.291219C3-3: 44.037665,-71.291834C3-4: 44.037222,-71.291729 |
| **C4** | Saco RD Cmpt 52 stand 8 | 26 | 410 | NE | C4-1: 44.053436,-71.268748C4-2: 44.053117,-71.268069C4-3: 44.053147,-71.267087C4-4: 44.052826,-71.266443 |
| **C5** | no stand # on map | 28 | 550 | flat to NW | C5-1: 44.039193,-71.316669C5-2: 44.039836,-71.315839C5-3: 44.040121,-71.315342C5-4: 44.040463,-71.314936 |
| **C6** | Saco RD Cmpt 51 stand 6  | 29 | 460 | NNW | C6-1: 44.040352,-71.275200C6-2: 44.039902,-71.275202C6-3: 44.040350,-71.274576C6-4: 44.039900,-71.274579 |
| **C7** | BEF cmpt 33/34 | mature | 440 | ENE | C7-1: 44.052278,-71.302577C7-2: 44.052730,-71.303198C7-3: 44.053180,-71.303195C7-4: 44.053908,-71.303122 |
| **C8** | BEF cmpt 33/29 | mature | 330 | NE | C8-1: 44.054080,-71.297186C8-2: 44.053793,-71.297666C8-3: 44.053333,-71.297457C8-4: 44.054807,-71.299769 |
| **C9** | Saco RD Cmpt 52 stand ? | mature | 440 | NE | C9-1: 44.043814,-71.278167C9-2: 44.043933,-71.278769C9-3: 44.043340,-71.279463C9-4: 44.044128,-71.279415 |

**E-mail or mail this form to:**

Mariko Yamasaki, Silviculture/Wildlife Team Leader U. S. Forest Service, Northern Research Station Forest Sciences Lab

271 Mast Road

Durham, NH 03824

Email: myamasaki@fs.fed.us

**NEPA requirements have been reviewed and approved as follows:**

This project can proceed without further assessment.

This manipulative project can proceed as a categorical exclusion after completing a scoping letter to the public and a letter to the file.

This manipulative project will require further environmental assessment work before approval.

**Approved by:**

**Project Leader**

**Date**

**Appended information specific to tree climbing**

**Tree Rigging and Access Technique**

 Study trees will be rigged only when in use by a climber. Rigging will be completely removed after each field day. Initially, a throw-weight is used to position a line in an acute angle of the tree crown. Climbing ropes are installed using nylon cord that has been positioned through the tree crown and pulled into the tree. The nylon cord is used to pull a static kernmantle climbing rope up and through a canopy branch and back to the ground.

A single rope technique (SRT) with a releasable ground anchor will be used as it provides superior protection and rescue options for tree climbers working at height. Using SRT it is less likely that a falling branch will get tangled in the single climbing rope, a situation where all safety systems are susceptible to shock-loading. The use of the SRT eliminates or reduces risk almost completely.

**Tree Rescue Protocol**

 In the event an emergency the ground safety supervisor may lower the climber to the ground from any height using the releasable ground anchor system. The ground safety supervisor will immediately call emergency medical support, The Memorial Hospital (603) 356-5461, USFS personnel Chris Costello (603) 397-7964, Mariko Yamasaki (603) 397 8079, and the Saco RD (603) 447-5448.

All ground personnel will carry an ‘Emergency Action Plan” which will include the Bartlett compartment for each research plot, printed phone numbers mentioned above, and a template for speaking with emergency response team (below).

 “My name is \_\_\_\_\_\_ and I have a \_\_\_\_\_\_(patient age) year old \_\_\_\_\_\_ (patient gender) whose chief complaint is \_\_\_\_\_\_\_\_\_\_\_\_\_. The method of injury was \_\_\_\_\_\_\_\_\_\_\_\_\_. Their level of responsiveness is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (A & O time 4, 3, 2, 1; AVPU scale).”

 “Our location is within the Bartlett Experimental Forest at latitude and longitude \_\_\_\_\_\_\_\_ (using table below). We will have a crew member available at a nearby road to flag and lead a response team to the site”.

|  |  |  |
| --- | --- | --- |
| GPS coordinates for field sites |  |  |
| SITE | LATITUDE | LONGITUDE  | Bartlett Compartiment |  |
| C1 | 44.042824 | -71.320720 | 32 |  |
| C2 | 44.059480 | -71.268800 | E-3 |  |
| C3 | 44.038185 | -71.291325 | 58 |  |
| C4 | 44.053147 | -71.267087 | E- 3 |  |
| C5 | 44.039193 | -71.316669 | 32 |  |
| C6 | 44.039902 | -71.275202 | E-5 |  |
| C7 | 44.053908 | -71.303122 | 33 |  |
| C8 | 44.053793 | -71.297666 | 33 |  |
| C9 | 44.043814 | -71.278167 | E-6 |  |

**Work Site Safety**

**What arrangements will be in place to protect those on the ground?**

All personnel will be required to wear a helmet at all times while climbers are on rope. This includes all project-related individuals located outside of the established work zone, which will be enforced by the ground safety supervisor. Prior to work, the lead safety officer and ground safety supervisor will inspect the ground surrounding the tree where failing debris or equipment could present a hazard for climbers or ground crew. This area will be referenced as the “work zone” for the project. This area will be off limits to non-essential personnel at all times, with limited access granted to essential personnel through coordination with the ground safety supervisor.

 A request to enter the work area will be initiated with the ground safety supervisor, who will then coordinate with the climbers. Specific areas to entry / exit the work zone will be established, and radio communication will be maintained so that the location of personnel inside of the work zone is known to climbers at all times. During work, it may be necessary for a climber to remove hazardous dead branches and other hanging debris lodged in the tree. These items will be jettisoned to the ground after the climber has coordinated with the ground safety supervisor to identify a clear and safe spot within the work zone to drop them in. Command calls “All clear” and response “clear” will be established prior to dropping hazards. Radio contact will be maintained at all times.