Impact of Management in Northern Hardwoods on Collembola and Carabidae

Donald R. Tobi, Bruce L. Parker, Margaret Skinner & Michael Brownbridge

Entomology Research Laboratory
UVM, 661 Spear Street
Burlington, VT 05405-0105

Tel: (802) 656-5434
Fax: (802) 658-7710
Email dtobi@uvm.edu

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Sustainable Forest Management

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Ruth Farrell
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Background

Animal and plant species comprise the "biodiversity" of a habitat. Only over the last decade has the importance of biodiversity to the long-term health of a natural ecosystem, and in ecological processes such as nutrient and energy cycling, become widely recognized (Chapin et al. 1998; Schultz and Mooney 1994). The forest floor supports one of the most complex and diverse ecological communities. Decaying organic matter forms the basic food supply for many invertebrates, which are critical in the decomposition and mobilization of minerals that can then be used by trees and other plants. Soil invertebrate activity stirs up leaf litter and enhances decay processes by exposing organic matter to air. Furthermore, soil invertebrates are a direct food source for many birds, amphibians, and small mammals. If these processes are disturbed as a result of certain forestry practices, the long-term health and fertility of forest soils may be compromised, resulting in a decline in environmental quality and land productivity. This may be accompanied by loss of species and critical wildlife habitat, reduced production of forest products, and reduced levels of carbon sequestration.

Objectives

- To determine the effect of different management practices in northern hardwood forests on certain soil characteristics and on the population dynamics of the Carabidae and Collembola.

Specifically, we propose to study the effects of four forest management treatments (and build on existing insect population data) on Carabidae (ground beetles), which are generalist predators and scavengers (Bell 1990), and the Collembola (springtails), which are important in general decomposition and soil mineralization processes (Anderson et al. 1981). Carabids are commonly used as bio-indicators because they are a significant component of the invertebrate ecosystem, and highly sensitive to habitat change (Refseth 1980; Niemela et al. 1993; Rykken et al. 1997). Similarly, many collembolan species are highly site specific and are increasingly used in Europe as indicators of environmental health (Ponge et al. 1993). In addition, we will look at the relationships between these soil organisms and soil chemistry within and between the treatment units.

Relevance

Public concern over forest management practices, and how these might affect biodiversity and long term ecosystem sustainability, provide the impetus to study the impacts of management practices on forest soils, arthropod fauna and biodiversity in general. It is known that certain forestry practices have the potential to alter the characteristics of forest soils such as soil temperature, organic matter decomposition, and nutrient leaching (Mann et al. 1988; Federer et al. 1989; Pierce et al. 1993). These factors may all affect the composition and population levels of the resulting arthropod communities, influencing the ability of the upper soil horizons to reduce and decompose organic matter into plant-available nutrients and in the mineralization of soils. Damaged trees and woody-debris serve as hosts for many insects preferring declining, dead and rotting wood. Carabids are predatory in nature and populations of some species, particularly those living on the surface of the forest floor, could be altered as a result of environmental change on the forest floor. The data on species diversity and population levels of the Carabidae will strengthen the existing database generated over the last year at the Stevensville Brook site and the several years worth collected at the Proctor Research Center by James Boone. In areas where forestry practices result in an increase of woody-debris on the forest floor, populations of decomposers may increase, so collembolan populations may rise. This study will add significant insight into the potential to use both groups to monitor the impact of forestry practices on the stability, integrity, and long-term dynamics of the soil habitat. In addition, such base line data on the Collembola is essential to exploit their potential as an indicator species.

Research accomplished in 2001, 2002, and 2003

Working in conjunction with a study being undertaken by Professor William Keeton (University of Vermont) seven northern hardwood stands (treatment units), each 2 hectares in size, have been selected within the Stevensville Brook block of the Mount Mansfield State Forest, Underhill, Vermont. Stands are of similar elevation, habitat, and cover type. Treatment units are separated by a 50 m undisturbed buffer strip. In the summers of 2001 and 2002 the seven treatment units were located and delineated, sampling plots established in each one, and baseline data on Caradidae and Collembola collected for the period of July 1 through mid October 2001 and mid June through mid October in 2002 and 2003. Thousands of specimens were collected which have been sorted, pinned or put into vials, and have been identified to species. These are pre-treatment data and should be collected for at least two to three years prior to the implementation of the actual silvicultural treatments. The soils were sampled in 2001, 2002, and 2003 and the data made available (OM content, total organic nitrogen, NH_4, NO_3, Avail. P, K, Ca, and other micronutrients) for use as part of the continuance of this project or to other VMC researchers. During the winter of 2002/2003 the harvesting treatments were implemented with all work finished by March 2003.

Methods/Approach

Harvesting treatments

The following management practices will be used on the seven treatment units;

Treatment 1. Single-tree Selection: Uniform density conversion to uneven-aged diameter distribution (negative exponential "reverse J") with a q factor of 1.3. Multiple entries planned to achieve target distribution

Treatment 2. Group Selection: 1/8 acre group selection harvests to spatially aggregated uneven-aged diameter distribution

Treatment 3. Structural Complexity Enhancement – Low intensity: Variable density thinning, conversion to multi-aged structure using LAI to allocate growing space among canopy strata, crown release of dominant late-successional species, release of late-successional (primarily shade-tolerant) regeneration + scarification

Treatment 4. Structural Complexity Enhancement – High intensity: Treatment 3 + CWD enhancement (standing and downed), including pull-down of selected canopy dominants

Treatment 5. Control: No manipulation

Plot design

Within each treatment unit we have randomly delineated five 0.1 ha (~ 30m dia.) plots. A plot center was established with four transects radiating outward at 90° intervals. At 8 m on each transect a pitfall trap was located for *Carabidae* (n=4). At 11 m from plot center on each transect is a 2 m^2 plot where soil samples will be taken (n=4), and at 14 m there is another 2 m^2 plot where Collembola sampling will take place (n=4).

Soil Sampling

Soils will be sampled once each year from within the 2 m^2 soil sampling subplot. A randomly located 10 cm dia. core will be taken of the organic horizon (O) to the mineral layer. In addition, a 10 cm deep soil core will be taken from the B horizon of the mineral soil from the same spot where the O horizon sample was removed. This B horizon sample will be taken with a conventional soil corer. Samples from each of the four sample points within each plot will be pooled and processed. Samples will be ground and sieved and then analyzed for organic matter content, total organic nitrogen, ammonium, nitrate,

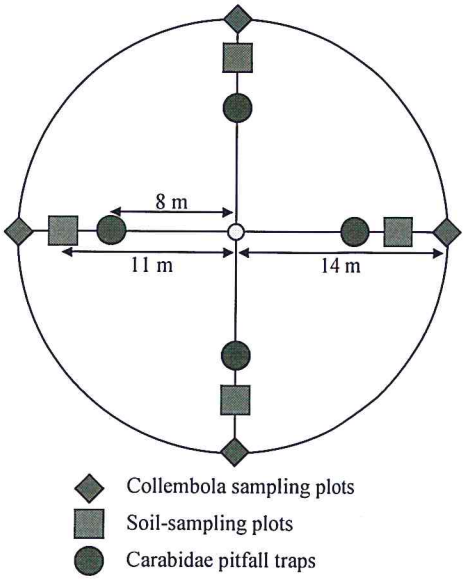
phosphorous, potassium, calcium, and other micronutrients. Analyses will be done by the University of Vermont Agricultural Testing Lab.

Carabidae Sampling

Pitfall traps for carabid sampling will be made of 59-ml plastic cups placed in 355-ml plastic cups left in the ground. Pitfall traps will be inspected and all species removed once every two weeks from June 15 through October 15. Carabids will be pinned, sorted and identified to species. Voucher specimens will be deposited at the Entomology Research Laboratory, UVM.

Collembola Sampling

From each of the four 2 m^2 collembola subplots within each main plot a soil core sample will be removed once per month using a standard bulb planter. All arthropods will be extracted into 95% EToH using Berlese funnels. Collembola will be sorted from each extraction and preserved for later enumeration and identification to family and genus level.



Nested plot design and layout details of each plot.

Statistical analyses

Descriptive statistics will include mean number and standard error of species and individuals within each stand. SAS (SAS Institute, 1996) will be used to make between-stand comparisons using ANOVA to determine if there are significant differences between the mean number of species and individuals collected from the different stands. Correlations between species abundance and soil properties will be done using SAS.

Products

We anticipate one or more peer reviewed manuscripts from this research and appropriate reports to the VMC. Posters and abstracts will be produced for applicable professional meetings.

Schedule

- Field sampling – June 15 through October 15, 2004.
- Carabidae sample sorting, pinning, identification, data entry – June 1, 2004 through June 1, 2005 (with funding from other sources).
- Collembola sample collection, extraction, and sorting – June 1, 2004 through June 1, 2005. Identification and data entry will be done with funding from other sources.
- Soil analysis and data entry – August 2004 through June 1, 2005.
- Data analysis and report writing – October 2004 – June 2005.

References

Anderson, R.V., B.C. Coleman, C.V. Cole. 1981. Effect of saprotrophic grazing on net mineralization – Role of soil fauna. Pages 201-216 in: F.E. Clark and P. Rosswall (Eds.). Terrestrial nitrogen cycles: processes, ecosystem strategies, and management impacts. Ecological Bullitens 33

Bell, R.T. 1990. Insecta: Coleoptera Carabidae Adults and Larvae. In Soil Biology Guide. D. L. Dindal. (ed.). J. Wiley & Sons NY, NY.

Chapin III, F.S., O.E. Sala, I.C. Burke, J.P. Grime, D.U. Hooper, W.K. Lauenroth, A. Lombard, H.A. Mooney, A.R. Mosier, S. Naeem, S.W. Pacala, J. Roy, W.L. Steffen, and D. Tilman. 1998. Ecosystem consequences of changing biodiversity. BioScience 48:71-78.

Federer, C.A., J.W. Hornbeck, L.M. Tritton, C. W. Martin, R.S. Pierce, C.T. Smith. 1989. Long-Term Depletion of Calcium and Other Nutrients in Eastern US Forests. Environmental Management 13:9 593-601.

Mann, L.K., D.W. Johnson, D.C. West, D.W. Cole, J.W. Hornbeck, C.W. Martin, H. Riekerk, C.T. Smith, W.T. Swank, L.M. Tritton, and D.H. VanLear. 1988. Effects of Whole-Tree and Stem-Only Clearcutting on Postharvest Hydrologic Losses, Nutrient Capital, and Regrowth. Forest Science 34:2 412-428.

Niemela, J., D. Langor, and J.R. Spence. 1993. Effects of Clear-Cut Harvesting on Boreal Ground-Beetle Assemblages (Coleoptera: Carabidae) in Western Canada. Conservation Biology 7:3 551-561.

Pierce, R.S., J.W. Hornbeck, C.W. Martin, L.M. Tritton, C.T. Smith, C.A. Federer, and H. W. Yawney. 1993. Whole-tree Clearcutting in New England: Manager's Guide to Impacts on Soils, Streams, and Regeneration. USDA For. Serv. NE For. Exp. Sta. Gen. Tech. Rep. NE-172.

Ponge, J.F., P. Arpin, G. Vannier. 1993. Collembolan response to experimental perturbations of litter supply in a temperate forest ecosystem. European Journal of Soil Biology 29:141-153.

Refseth, D. 1980. Analyses of carabid communities – potential use in biological classification for nature conservation. 17:131-141.

Rykken, J.J., D.E. Capen, and S.P. Mahabir. 1997. Ground Beetles as Indicators of Land Type Diversity in the Green Mountains of Vermont. Conservation Biology 11:2 522-530.

Schulze, E.D. and H.A. Mooney (eds.). 1994. Biodiversity and Ecosystem Function. Springer-Verlag, New York, NY. 525 pp.

Data plan

Data will be entered in Microsoft Excell by inmates of the Northwest Correctional Facility twice and then checked using a data verification program. Data will be maintained on computers at the NWCF as well as computers at the UVM Entomology Research Lab. Appropriate data and summaries will be shared with VMC and other interested researchers. Insect voucher specimens will be held at the Entomology Research Lab with excess specimens available to the VMC or others.

Management plan

Donald R. Tobi: Responsible for all aspects of field work and data collection.
Bruce L. Parker: General project oversight.
Michael Brownbridge: Collembola extraction and identification.
Margaret Skinner: Financial management.
Unassigned technical assistance: Assist with field plot set-up and data collection.

BUDGET

- Year 4 -
June 1, 2004 - June 1, 2005

Personnel.	Soil sampling	Collembola sampling/ID	Carabidae sampling/ID	Cost Share
B. L. Parker < 5%				
M. Skinner < 5%				
M. Brownbridge < 5%				
D. Tobi <5% Effort	$125	$1000		
Unassigned Tech.	$250	$1000		
Fringe benefits @ 39.5%	$148	$790		
Travel				
Supplies	$44	$143		
Soil analysis	$1500			
Collembola ID				
Indirect				$1475
Totals	**$2067**	**$2933**		**$1475**
		Grand Total Year 2		**$5000**
		Total matching		**$1475**