

1. PROJECT TITLE: Biological control of garlic mustard with the crown-boring weevil, *Ceutorhynchus scrobicollis*: Developing and implementing strategies for rearing and mass release

**BIOLOGICAL CONTROL OF INVASIVE PLANT TECHNICAL WORKING GROUP
CONTACT:**

Michelle S. Frank
Entomologist
Pesticide Use Management and Invasive Plants
USDA Forest Service
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2. PRINCIPAL INVESTIGATOR:

Roger L. Becker Professor	<u>Affiliation (Office or Dept.)</u> Dept. of Agronomy and Plant Genetics, Univ. of Minnesota 411 Borlaug Hall 1991 Buford Circle St. Paul, MN 55108	<u>Phone, E-mail</u> 612-625-5753 becke003@umn.edu fax: 612-624-3288
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CO-INVESTIGATORS:

David W. Ragsdale Head, Dept. of Entomology	Dept. of Entomology University of Minnesota	612-624-6771 ragds001@umn.edu
Elizabeth J. Katovich Senior Scientist	Dept. of Agronomy and Plant Genetics, Univ. of Minnesota	612-625-5230 katov002@umn.edu

3. COOPERATORS:

Luke C. Skinner Supervisor Invasive Species Program	<u>Affiliation (Office or Dept.)</u> Minnesota Dept. of Natural Resources luke.skinner@dnr.state.mn.us	<u>Phone</u> 651-259-5140
Laura Van Riper Terrestrial Invasive Species Coordinator	Minnesota Dept. of Natural Resources Laura.Vanriper@state.mn.us	651-259-5050

4. AMOUNT REQUESTED: \$73,059

5. PROJECT GOALS AND SUPPORTING OBJECTIVES:

The goal of this project is to control and manage the invasive weed, garlic mustard (*Alliaria petiolata*) through implementation of a biological control program with the crown-boring weevil, *C. scrobicollis*.

Objective 1: Develop methods for field mass-rearing and release of *C. scrobicollis*.

Objective 2: Develop protocols for land managers to self-rear *C. scrobicollis* from starter populations, collect, and then field-release the insects.

Objective 3: Develop a field use manual to describe how to propagate garlic mustard and rear *C. scrobicollis* for field release.

6. PROJECT JUSTIFICATION/URGENCY: Garlic mustard is an entrenched, invasive plant and is native to Europe. It poses a threat to native herbaceous and woody plants in the forest understory (Blossey et al. 2001, Cavers et al. 1979). Garlic mustard has spread to 37 states, has the potential for a wider distribution (Welk et al. 2002) and was rated as the top invasive plant species in 20 Northeastern area states in a recent Forest Service survey.

Due to abundant seed production, garlic mustard is able to rapidly colonize mesic forests to produce dense stands (Meekins and McCarthy 2002) and is more competitive than other woody understory species (Meekins and McCarthy 1999). Garlic mustard produces phytotoxins (Vaughn and Berhow 1999) that are exuded from root tissue and can directly inhibit growth of native hardwoods such as red maple, sugar maple and white ash, or disrupt the mutual associations between native tree seedlings and mycorrhizal fungi that are critical for tree growth and survival (Roberts and Anderson 2001, Stinson et al. 2006, Wolfe et al. 2008).

Use of biocontrol agents to control garlic mustard would provide long-term control and management of this invasive biennial weed. Extensive host specificity testing on a potential biocontrol agent, the stem and crown-boring weevil, *C. scrobicollis*, has been completed at CABI Bioscience in Switzerland and at the University of Minnesota (Gerber et al. 2009). Results of these tests indicate that *C. scrobicollis* is a highly specific herbivore.

At the University of Minnesota, our Level 2 High Security Containment Facility is currently the only location in the country where work on *C. scrobicollis* is being conducted. At our facility, we have been rearing and conducting host specificity testing with *C. scrobicollis* for the past five years. After completion of a series of vigorous host range tests, we have applied to the Technical Advisory Group (TAG) for Biocontrol of Weeds for approval for field release of *C. scrobicollis* and are now testing some additional native mustards at reviewers' request.

In Europe, *C. scrobicollis* adult oviposition begins in the fall and continues until spring. Larvae develop in the roots and crowns of garlic mustard throughout the winter. Attacked garlic mustard crowns typically have multiple larval instars present. Larvae pupate in the soil and

adults emerge over an extended period in the late spring (Gerber et al. 2001). We anticipate similar behavior in North America.

When disturbed, adult *C. scrobicollis* drop to the soil and are found in the leaf litter near the base of the garlic mustard crown. For this reason, collecting adults can be labor intensive. Rearing adults on potted caged plants may be an effective method to contain and collect the weevils from soil litter. Therefore, we will compare rearing *C. scrobicollis* using caged potted plants versus large field cages. Results of our rearing studies will be incorporated into protocols for natural resource managers to self-rear and release *C. scrobicollis*.

Development of a field use manual, similar to “*Biology and Biological Control of Mile-a-Minute Weed*” (Hough-Goldstein et al. 2008) would be a useful document for natural resource managers who were interested in implementing garlic mustard biocontrol. The manual would contain information on the biology of garlic mustard, seed germination and garlic mustard propagation, *C. scrobicollis* rearing, release and post-release monitoring protocols.

Once we receive TAG approval, we will use this funding to implement the garlic mustard biocontrol program. Our interdisciplinary team of entomologists, weed scientists and plant ecologists have over twenty years of experience in weed biological control development and implementation. This, in combination with fact that we are the only group in the country to currently rear *C. scrobicollis* in quarantine, renders us uniquely qualified to implement this project. There is an urgency to get this project completed since we anticipate TAG approval for field releases within the next 12 months.

7. APPROACH:

Objective 1. Our goal is to develop field mass-rearing and release methods for *C. scrobicollis*. Adults emerge over an extended period in the spring. In addition, collecting adult weevils can be very labor intensive because they hide in the soil litter at the base of garlic mustard crowns. For this reason, we will compare the following rearing and release methods:

Rearing methods: Compare:

- a. Rearing adults on individual caged potted plants.
- b. Rearing adults directly in field cages with garlic mustard rosettes.

Release methods: Compare:

- a. Collecting weevils from soil litter and releasing a known quantity into field cages.
- b. Collecting soil litter containing weevils and sprinkling known quantity of litter over garlic mustard plants in field cages.
- c. Rearing adults on potted plants, then placing pots directly into field.

All treatments will be replicated. Percentage of attacked garlic mustard plants will be determined in each field cage. Attack rates will be determined by leaf feeding damage and on dissection of a representative number of garlic mustard crowns in caged field sites. ANOVA and mean separation techniques will be used to determine effectiveness of rearing and release methods. This experiment will be conducted a minimum of two years. Results will be

incorporated into our garlic mustard biocontrol field manual, presented at professional meetings and published in a peer-reviewed journal, such as *Biological Control*

Objective 2: Develop protocols for land managers to self-rear *C. scrobicollis* from starter populations, collect, and then field-release the insects. Based on our results from Objective 1, we will develop protocols for land managers to self rear *C. scrobicollis* from starter populations, collect, and then field-release the insects. To reach this objective, we will determine:

- a. Optimum number of weevils for starter population
- b. Optimum time of release, spring vs. fall
- c. Optimal weevil collection and release methods

Objective 3. Develop a garlic mustard biocontrol field-use manual to distribute to natural resource managers. The manual will include protocols for propagating garlic mustard, rearing, releasing and post-release monitoring protocols. This manual will target natural resource managers throughout the United States and Canada who want to manage garlic mustard using biological control. The product will be transferred through publication of the manual or will be placed on an appropriate website. Objective will be completed after obtaining results from Objectives 1 and 2.

8. EXPECTED PRODUCTS AND OUTCOMES:

Objective 1:

Standard of Success: Develop mass rearing and release protocols for *C. scrobicollis*.

Implementation of Products/methods: Implement *C. scrobicollis* rearing and release protocols by natural resource managers.

Expected Outcomes: Develop successful *C. scrobicollis* rearing and release protocols to implement the garlic mustard biocontrol program.

Objective 2:

Standard of Success: Develop protocols for natural resource managers to self-rear and release *C. scrobicollis*.

Implementation of Products/methods: Implement *C. scrobicollis* rearing and release protocols by natural resource managers.

Expected Outcomes: Rearing and release of *C. scrobicollis* by natural resource managers.

Objective 3:

Standard of Success: Develop a garlic mustard biocontrol field-use manual containing garlic mustard propagation and *C. scrobicollis* rearing and release protocols.

Implementation of Products/methods: Use of field manual by natural resource managers to rear and release garlic mustard biocontrol insects

Expected Outcomes: *C. scrobicollis* rearing and release by natural resource land managers.

Vita for Roger Becker

Title: Extension Agronomist - Weed Scientist
Department: Agronomy and Plant Genetics
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411 Borlaug Hall
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St. Paul, MN 55108
Telephone: (612) 625-5753 **E mail:** becke003@umn.edu
Appointment: Extension 75% / Research 25%

Specific Areas of Responsibility: Weed management strategies in annual and perennial systems in disturbed and undisturbed habitats. Current projects include management of purple loosestrife in wetlands; garlic mustard and buckthorn in woodlands; and Canada thistle in native prairies, pastures and right-of-ways. Also prairie establishment, weed management in forages and in processing vegetables, and the environmental impacts of herbicide and non-herbicide weed management systems.

Education:

<u>Degree</u>	<u>Major</u>	<u>College/University</u>	<u>Years</u>
B.S.	Agronomy	Iowa State University	1972 - 1976
M.S.	Botany-Plant Physiology	Iowa State University	1976 - 1978
Ph.D.	Agronomy-Crop Production and Physiology	Iowa State University	1978 - 1982

Professional Positions:

<u>Employer</u>	<u>Dates</u>	<u>Position</u>
Iowa State University	1978-1982	Extension Associate
Monsanto Company	1982-1985	Product Development Representative
Monsanto Company	1985-1987	Product Development Associate
University of Minnesota	1987-1993	Assistant Professor
University of Minnesota	1993-1999	Associate Professor
University of Minnesota	1999- present	Professor

Recent Referred Publications:

- Katovich E.J.S., R.L. Becker, D.W. Ragsdale, and L.C. Skinner. 2008. Growth and Phenology of Three Lythraceae Species in Relation to Feeding by *Galerucella californiensis* and *Galerucella pusilla*: Predicting Ecological Host Range from Laboratory Host Range Testing. *Inv. Plant Sci Management*. 1(2):207-215.
- Sheaffer C.C., Undersander, D.J., and R.L. Becker. 2007. Comparing Roundup Ready and Conventional Systems of Alfalfa Establishment. © 2007 Plant Management Network. Published 24 July 24, 2007. 7 p. <http://www.plantmanagementnetwork.org/sub/fg/research/2007/alfalfa/>
- Bollman, J.D., C.M. Boerboom, R.L. Becker, and V.A. Fritz. 2008. Efficacy and tolerance to HPPD-inhibiting herbicides in sweet corn. *Weed Technol*. 22:666-674.
- Van Riper, L.C., R.L. Becker, L.C. Skinner. 2010. Population biology of garlic mustard (*Alliaria petiolata*) in Minnesota hardwood forests. *Inv. Plt. Sci Mgt*. 3:48-59.

Curriculum Vita
DAVID W. RAGSDALE

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Education:

Louisiana State University, Baton Rouge, Ph.D. (1980) Entomology
Louisiana State University, Baton Rouge, M.S. (1977) Entomology
Point Loma College, San Diego, B.A. (1974) Biology.

Employment:

Head, Department of Entomology, 2009 - present
Assistant to Full Professor, University of Minnesota, 1981-
present

Honors:

FAME Award, Faculty Award for Mentorship in Entomology, Entomology Graduate Student
Organization, Frenata, 2009
Entomological Foundation, IPM Team Award sponsored by Dow AgroSciences for work by the
Soybean Aphid IPM Team, 2009
USDA National Award of Excellence in Research, S-1039 Regional Project, 2009
Carol Mortensen Invasive Species Management Award, Minnesota Invasive Species Council,
2008
Certificate of Appreciation, Minnesota Soybean Research & Promotion Council, Research and
Tech Transfer, 2002

Summary of Grant Activity - 1981-present: \$13,912,004 includes 48 national competitive
grants (federal); 19 State funded projects (agencies); 49 commodity check-off funds (potato
and soybean); 13 Industry contract and grant-in-aid, and 14 U of MN competitive grants
(RARF). **Last 5 years Total:** \$4,645,687

Selected Publications: 82 Total refereed publication, 66 journal articles + 16 contributed book chapters,
141 Other communications: 11 electronic publications, 24 popular, extension, or trade publications,
48 published abstracts or proceedings, and 58 misc. non-refereed publications

Ragsdale, D. W., G. E. Heimpel, D.A. Landis, J. Brodeur, N. Desneux. 2011. Ecology and Management
of the soybean aphid in North America. Annual Review of Entomology (in press)
Yoder, M. V., L.C. Skinner, and D.W. Ragsdale. 2008. Common buckthorn, *Rhamnus cathartica* L.:
Available feeding niches and the importance of controlling this invasive woody perennial in North
America. Proc. International Biological Control of Weeds Symposium. pp. 232-237.
Ragsdale, D. W., B. P. McCornack, R. C. Venette, B. D. Potter, I. V. MacRae, E. W. Hodgson, M. E.
O'Neal, K. D. Johnson, R. J. O'Neil, C. D. Difonzo, T. E. Hunt, P. Glogoza, and E. M.
Cullen. 2007. Economic threshold for soybean aphid (Homoptera: Aphididae). J. Econ. Entomol.
100(4): 1258-1267.

Elizabeth J. Katovich

Elizabeth J. Stamm Katovich
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University of Minnesota
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Telephone: (612) 625-5230

Education:

1981	Purdue University, West Lafayette, IN B.S. in Plant Protection
1984	University of Arkansas, Fayetteville, AR M.S. in Agronomy
1988	University of Minnesota, St. Paul, MN Ph.D. in Agronomy/Weed Science

Employment:

1998-present	Senior Scientist. Department of Agronomy and Plant Genetics, University of Minnesota.
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Relevant Publications:

- Strefeler, M. S., E. Darmo, R. L. Becker and E. J. Katovich. 1996a. Isozyme characterization of genetic diversity in Minnesota Populations of *L. salicaria*, *Lythrum salicaria* (Lythraceae). *Amer. J. of Bot.* 83:265-273.
- Strefeler, M. S., E. Darmo, R. L. Becker and E. J. Katovich. 1996b. Isozyme variations in cultivars of *L. salicaria* (*Lythrum* sp.). *Breeding and Germplasm Resources. Hort. Sci.* 31:279-282.
- Katovich, E.J.S., R. L. Becker, C. C. Sheaffer, and J. L. Halgerson. 1998. Seasonal fluctuations of carbohydrate levels in roots and crowns of purple loosestrife (*Lythrum salicaria*). *Weed Sci.* 46:540-544.
- Katovich, E. J. S., A. J. Milles, D. W. Ragsdale and R. L. Becker. 1999. Feeding and oviposition preference of *Galerucella* spp. in *Lythrum*. X International Symp. Biol Control of Weeds. p. 99.
- Katovich, E. J. S., R. L. Becker and D. W. Ragsdale. 1999. Effect of *Galerucella* spp. on survival of purple loosestrife (*Lythrum salicaria*) roots and crowns. *Weed Sci.* 47:360-365.
- Katovich, E.J.S., D. W. Ragsdale, L. C. Skinner, and R. L. Becker. 2001. Effect of *Galerucella* spp. feeding on seed production in purple loosestrife. *Weed Sci.* 49:190-194.
- Katovich, E. J. S., R. L. Becker and J. L. Byron. 2003. Winter survival of late emerging purple loosestrife (*Lythrum salicaria*). *Weed Sci.* 51:563-568.
- Katovich, E.J. S., R. L. Becker, D. W. Ragsdale and L. C. Skinner. 2008. Growth and phenology of three Lythraceae species in relation to feeding by *Galerucella californiensis* and *Galerucella pusilla*: predicting ecological host range from laboratory host range testing. *Invasive Plant Sci. and Management.* 1:207-215.
- Gerber, E., Cortat, C., Hinz, H.L., Blossey, B., Katovich, E., Skinner, L., 2009. Biology and host specificity of *Ceutorhynchus scrobicollis* (Curculionidae; Coleoptera), a root-crown mining weevil proposed as biological control agent against *Alliaria petiolata* in North America. *Biocontrol Science and Technology*, 19 (2), 117-138.

BUDGET REQUEST:

	Item	Requested Funding	Other-Source Funding	Source Cost Sharing
FY 2011				
Administration	Salary	\$ 23357.0	\$ 8307.0	Salary for PI (8%)
	Overhead	\$ 8201.0	\$ 696.0	Benefits for PI
	Travel	\$ 500.0		
Procurements	Services	\$ 800.0		
	Space rental	\$ 1000.0		
	Supplies	\$ 800.0		
Year Totals		\$34658.0	\$ 9003.0	
FY 2012				
Administration	Salary	\$23357.0	\$ 8307.0	Salary for PI (10%)
	Overhead	\$ 8201.0	\$ 696.0	Benefits for PI
	Travel	\$ 500.0		
Procurements	Services	\$ 800.0		
	Space rental	\$ 1000.0		
	Supplies	\$ 800.0		
Year Totals		\$34658.0	\$ 9003.0	
FY 2013				
Administration	Salary	\$ 2732.0	\$ 8307.0	Salary for PI (10%)
	Overhead	\$ 1011.0	\$ 696.0	Benefits for PI
	Travel	0		
Procurements	Contracting	0		
	Equipment	0		
	Supplies	0		
Year Totals		\$ 3743.0	\$ 9003.0	
Total		\$ 73059.0	\$ 27010.0	

BUDGET REQUEST EXPLANATION: Annual budgets includes salary costs for a 0.40 FTE scientist and one part-time summer student worker to design rearing and release methodologies to implement the biocontrol of garlic mustard. Fringe benefits are included in overhead costs (37% of \$21,857 and 7.57% of \$1,500) Year 1 and 2 and 37% of \$2,732 for Year 3. Travel requested will cover the costs for the PI's to travel to release sites, collect insects or attend a professional meeting. Supplies requested will cover supplies required to develop rearing and release methodologies. General operating services include weekend watering services. Short term rents and leases include renting field space on the University of Minnesota campus for field work. This grant will be administered as a Cooperative Agreement with the US Forest Service with a 75/25 matching requirement.

Cost Share: Matching funding is in the form of unrecoverable indirect costs at a rate of 25% in the form of salary and fringe benefit costs for Roger Becker, Principal Investigator, @ 8% effort. for a total of \$27,010.

(Please see attached letter).

Time Table:**Year 1**

September 2011: Establish rearing experiments in field

Winter 2011-2012: Draft garlic mustard field biocontrol manual

May, 2012: Collect emerging weevils in potted plants and screen cages, collect data

Release weevils into field cages for release experiments

Year 2

September 2012: Collect data on number of attacked plants in field cages.

Repeat rearing experiments

Winter 2012-2013: Continue to write biocontrol manual

May 2013: Collect emerging adults in potted plants and screen cages, collect data

Summer 2013: Use results to develop protocols for *C. scrobicollis* self-rearing and release for natural resource managers

Year 3

Continue to develop rearing and release protocols

Complete field guide

LITERATURE CITED

- Blossey B., V. Nuzzo, H. Hinz and E. Gerber. 2001. Developing biological control of *Alliaria petiolata* (M. Bieb.) Cavara and Grande (garlic mustard). *Natural Areas J.* 21:357-367.
- Cavers, P. B., M. I. Heagy and R. F. Kokron. 1979. The biology of Canadian weeds. 35. *Alliaria petiolata* (M. Bieb.) Cavara and Grande. *Can. J. Plant Science.* 59:217-229.
- Gerber, E., H. L. Hinz, N. Guazzone, J. McKenny, S. Michler and M. Zuefle. 2001. Biological control of garlic mustard, *Alliaria petiolata*. CABI Bioscience. Switzerland Centre. Annual Report.
- Gerber, E., Cortat, C., Hinz, H.L., Blossey, B., Katovich, E., Skinner, L., 2009. Biology and host specificity of *Ceutorhynchus scrobicollis* (Curculionidae; Coleoptera), a root-crown mining weevil proposed as biological control agent against *Alliaria petiolata* in North America. *Biocontrol Science and Technology*, 19 (2), 117-138.
- Hough-Goldstein, J. E. Lake, R. Reardon and Y. Wu. 2008. Biology and biological control of mile-a-minute weed. Forest Health Tech. Enterprise Team. FHTET-2008-10. 65 pages.
- Meekins, J. F. and B. C. McCarthy. 2002. Effect of population density on the demography of an invasive plant, *Alliaria petiolata*, (*Brassicaceae*) population in a Southeastern Ohio forest. *American Midland Naturalist.* 147:256-278.
- Meekins, J. F. and B. C. McCarthy. 1999. Competitive ability of *Alliaria petiolata* (garlic mustard, *Brassicaceae*), an invasive, nonindigenous forest herb. *International J. Plant Science.* 160:743-752.
- Plants.usda.gov. Plants database. Accessed 3/24/2010.
- Roberts, K. J. and R. C. Anderson. 2001. Effect of garlic mustard [*Alliaria petiolata* (Bieb. Cavara Grande)] extracts on plants and arbuscular mycorrhizal (AM) fungi. *American Midland Naturalist.* 146:146-152.
- Stinson, K. A., S. A. Campbell, J. R. Powell, B. E. Wolfe, R. M. Callaway, G. C. Thelen, S. G. Hallett, D. Prati, and J. N. Klironomos. 2006. Invasive plant suppresses the growth of native tree seedlings by disrupting belowground mutualisms.
- Vaughn, S. F. and M. A. Berhow. 1999. Allelochemicals isolated from tissues of the invasive weed garlic mustard (*Alliaria petiolata*). *J. Chemical Ecology.* 25:2495-2504.
- Welk, E. K. Schubert and M. H. Hoffmann. 2002. Present and potential distribution of invasive garlic mustard (*Alliaria petiolata*) in North American. *Diversity and Distributions.* 8:219-233
- Wolfe, B. E., V. L. Rogers, K. A. Stinson, and A. Pringle. 2008. The invasive plant *Alliaria petiolata* (garlic mustard) inhibits ectomycorrhizal fungi in its introduced range. *J. Ecol.* 96:777-783.

To Whom It May Concern:

Regarding overlapping funds, our current garlic mustard biological control efforts are funded on USFS Cooperative funding passed through the MnDNR. Based on the funding limits for this grant, we are asking for partial support of research Scientist positions over the three year period allowed, giving us the flexibility to begin funding from this grant should we be successful, when the current USFS Cooperative funding runs out. This is anticipated to occur Oct. 1, 2010. If we are awarded this grant, we will not encumber any of that funding until the current USFS funding is fully encumbered and spent.

As for the required matching funds, this USFS grant does not allow indirect costs. The University of Minnesota is forgoing the Indirect Cost, which typically runs from 28 to 51%. The University of Minnesota will allow the nonpayment of Indirect Costs if used to fulfill the 25% cash or in-kind match requirement of this grant.

Dr. Roger Becker, PI
Professor, Weed Scientist
University of Minnesota
Department of Agronomy and Plant Genetics

March 31, 2010

TO WHOM IT MAY CONCERN

I am writing to confirm that the Department of Agronomy and Plant Genetics will provide a total of \$27,010 in cost sharing over three years in support of the USDA Forest Service proposal “Biological control of garlic mustard with crown-boring weevil, *Ceutorhynchus scrobicollis*, Developing and implementing strategies for rearing and mass release.” The cost sharing account is 1802-11028-21367-AES0013064.

Roger Becker, PI @ 8% effort – salary	\$24,922
Fringe @8.38%	2,088
<hr/>	
Total contribution	\$27,010

Please do not hesitate to call me at 612-625-1937 if you have questions.

Sincerely,

Nancy J. Ehlke, Ph.D.
Professor and Head