United States Department of Agriculture

BIOLOGICAL CONTROL OF INVASIVE NATIVE AND NON-NATIVE PLANTS
NEW PROJECT PROPOSAL

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Project Information
* The Submission (FY) refers to the current Fiscal Year.

	Program	Admin Region	Submission (FY)*	Additional Project ID	Report Type New Proposal (NP)
Project Number:	**BCIP**	**R1**	**19**	5	**NP**

Project Title: Combining Large-scale Ecological, Genetic, and Insect Agent Data to Improve Leafy Spurge Management through Biocontrol

Principle Investigator: Natalie M. West and John F. Gaskin

Proposed Budget Summary (this table is auto-generated from Budget Information sections)

Year 1 BCIP Total	Year 2 BCIP Total	Year 3 BCIP Total	Total BCIP Funds	Total Funds (All)
$ 26,521	$ 21,450	$ 21,010	$ 68,981	$ 168,390

Subject Description

Target Invasive Plant:

Non-Native Invasive

Common and Scientific Names:

Leafy Spurge (Euphorbia esula L.)

Biological Control Agent(s):

Aphthona spp. (5 different agents),
Oberea erythrocephala,
Hyles euphorbiae, Lobesia euphorbiana,
Spurgia capitigena & S. esulae

BCIP Priorities Addressed (check all that apply)

- ☐ Developing improved rearing, host range testing, distribution and post-release monitoring techniques for a biological control agent.
- ☑ Development and/or implementation of technologies for monitoring/assessing plant trends and quantitative assessment of biological control impacts.
- ☐ Integrated weed management with a biological control component that is part of a methods technology development approach to determine efficacy and is not considered an operational treatment.
- ☑ Development of biological control strategies through funding of pilot projects.

Define the project being developed (e.g., what is the technology, goals and objectives, and who will maintain the tool if maintenance is necessary?) (250 words):

Technologies: Building on work started by TEAM Leafy Spurge and implemented by land managers in the 1990s, we propose to refine and articulate clear, large-scale, and science-based recommendations to improve the current biological control of the leafy spurge invasion in North America (Euphorbia spp.) with existing APHIS permitted biological control agents.

Goal: Successful and improved biological control of leafy spurge in the many habitats and regions where biocontrol management is not currently effective.

Objectives:
1) Characterize the current status (relative abundance and density) of leafy spurge infestations at historical biocontrol release sites.
2) Quantify the variance in biocontrol agent communities and abundance across historical release sites.
3) Identify the taxonomic and genetic structure variation within the spurge invasion.
4) Evaluate potential correlations between habitat conditions, taxonomy, genetic structure, and agent presence.
5) Use the above science-based information to develop effective recommendations for biocontrol agent release, redistribution/ augmentation and future biocontrol agent development.

Provide background, justification, and urgency (e.g., describe the management problem, impacts of the invasive plant, supportive research) (250 words):

Leafy spurge remains a top concern for stakeholders despite decades of management (see attached State Coordinator letters). Although biological control is considered the most cost effective means of long-term spurge control (Hyder et al. 2008), we have limited understanding of what drives variation in agent success. Biocontrol establishment and impacts have been associated with multiple factors (e.g., Jonsen et al. 2001, Nowierski et al. 2002, Joshi and Olson 2009), but these assumed limitations are under-evaluated, particularly beyond small local scales, and seldom disentangle the influence of individual agents. Aphthona species are intensively studied; other agents have not been as widely distributed, though they persist in the landscape (i.e., Oberea erythrocephala, Anderson et al. 2015) and their contributions to spurge biocontrol remain unclear. Plant taxonomy and genetics may also prove important. When agents were developed, we lacked genetic information and taxonomic clarity, and current agents were likely collected on Euphorbia species or biotypes that do not represent the North American invasion (Berry et al. 2018). Earlier studies (Lym 1996, Lym and Carlson 2002) found variation in agent success on spurge genotypes from different locations, but tested only a small number of plants. We need to rigorously evaluate how different spurge taxa and genotypes are distributed and correlate with agent efficacy across a gradient of potentially limiting habitat factors. This large-scale analysis of habitat and genetic limitations, when correlated with the presence of agent communities, will provide powerful information for improved use and future development of biological control agents.

Methods/Approach (750 words):

We will quantify variation in agent presence, spurge infestation (patch size, density and frequency), and patch genetic structure across a broad spatial area in North Dakota, Montana, and Idaho. We will select a range of previous biological control release sites that vary across habitat conditions identified in previous studies: 1) sandy soils; 2) increased soil moisture; and 3) shade (canopy openness). Replicating conditions within states will allow us to gauge variation at scales similar to previous studies. Replicating across states will ensure we have sampled a large gradient that should reduce the influence of site-specific variation.
Site selection. Because Aphthona species are by far the most distributed agents, we will use that agent complex for initial site selection. We will identify accessible Aphthona sites that had more than one agent released from release records, and choose sites in each state to cover a replicated gradient of soil type and texture, soil moisture, and overhead canopy cover. Because short-term reductions in infestation immediately after releases may not reflect long-term vegetation changes, we will limit surveys to releases at least five years old. We will visit candidate sites in Year 1 to select an appropriate combination of conditions and persisting infestations, and sample plant genetic structure. In Years 2-3, we will sample a subset of 20 sites per state (N = 60) for agents and patch variability.

Year 1: Evaluating candidate sites and gathering genetic data.
At each candidate site, the size and distribution of local patches will be assessed using our DJI Matrice 100 quadcopter drone with a high-resolution visual lens. We will designate a "focal patch", a spurge infestation area with at least one side of 10 m length and least two stems/m2, in the vicinity of the original release(s) (Figure 1). We will take 5 soil samples within each focal patch to analyze soil nutrients and texture. Each plot will be assessed with the SIMP protocol (Weed et al. 2017), and swept to verify agent presence. Ten individual plants per focal patch will be collected along the SIMP transect for genetic analysis using DNA sequence and Amplified Fragment Length Polymorphism (i.e., Gaskin et al. 2009). Additionally, these plants will be assessed for agent presence in the root zone. Sites where spurge was extirpated, is at low density, or where no agents are present, will be excluded from further consideration. Analysis: We will use structural equation modeling and Classification and Regression Trees to identify factors associated with patch variability and composition of persisting agent populations.

Years 2 and 3: Sampling agent communities and patch variability
We will select our 20 sites per state to maximize a range of the soil and canopy conditions of interest (see above). Each focal patch will be re-assessed with SIMP in five parallel transects a minimum of 2 m apart, between mid-June and July each year. Insects will be collected into a 2-gallon Ziploc bag and frozen in a field cooler to be sorted later at ARS Sidney. We will count the number of sweeps required to sample the patch, as distribution of spurge should vary within the focal patch, and abundances will be quantified on a per-sweep basis. Variation in spurge cover (patch size) and biomass (patch quality) among sites will be assessed by drone flights over the focal patch (ground-truthed with the SIMP data), and extended across a 0.5-km radius area surrounding the focal patch as the center point. This additional sampling will allow us to incorporate how greater abundance of spurge in the local landscape may affect patterns of agent abundance within patches. Analysis: We will evaluate habitat conditions or genetic structure (Year 1 data) associated with infestations and the presence of biocontrol agent assemblages or genotypic variation using stepwise discriminant analysis, partial least squares regression, and glm-based permutation analysis.

Caveats: Specific release and management records are unlikely to be available for all sites, and all sites will have variable use histories; e.g., biological control is often combined with chemical or grazing management. Sampling a large number of sites will decrease the influence of individual differences on the overall correlational trends being evaluated. Further, the objective of this study is to examine the variation in large-scale habitat associations, not the local scale mechanisms driving such associations. After Year 1, we will assess whether data are too noisy to detect trends; if this is the case, we will add additional sites. We may also have to exclude appropriate sites where airspace restrictions forbid drone flights.

Describe stakeholder involvement in development of the proposal and application of the new technology (e.g., how involved are managers in the project?) (150 words):

The Montana Biological Weed Control Coordination Project will work with student groups to do SIMP assessments and sweeps in western Montana. A similar arrangement may be established with local tribal colleges in northeastern Montana and northwestern North Dakota through a cooperative relationship ARS is developing. The USDOI BLM and USDA APHIS are partnering with us in sampling and providing release and site information. State, federal, and tribal managers will aid in identifying and accessing sites, providing site histories, and enabling technology transfer.

Describe technology assistance/transfer, outreach, and the expected impacts to forest health/forest management (e.g., how will the technology be shared and how will it change current management?) (150 words):

Leafy spurge remains one of the most troublesome weeds identified by our stakeholders, despite a large established biocontrol program in the Great Plains. This study will allow us to better understand the degree to which biocontrol reduces the size of weed infestations, the best agents for particular habitats, ecological limits on biocontrol success, and will be key to informing the re-deployment of current agents and the development of additional agents to improve the biological control program. Additionally, the network of state, federal, and tribal cooperators developed for this proposal will be a platform for disseminating knowledge and implementing future improvements (aiding in impact and technology transfer).

Products/Publications/Technology transfer (e.g., provide timeline of expected project accomplishments) (150 words):

1. Quantitative assessment of leafy spurge genetics, prevalence and agent abundance at a regional scale (Year 1: publication).
2. Evaluation of the association between agent prevalence, severity of infestations, patch genetic structure, and habitat conditions (Year 2 and 3: publication).
3. Method for augmenting SIMP assessments with patch extent data from drone (aerial data combined with validation data from Years 2 and 3: technical report)
4. White paper summary of best management recommendations (general distribution publication: project conclusion)

Please see above (Methods and Approach) for timeline.

Citations:

Anderson JM, Willden SA, Wright DL, Evans EW. 2015. Long term outcomes of population suppression of leafy spurge by insects in the mountain foothills of northern Utah. American Midland Naturalist 174:1-13.

Berry PE, Riina R, Peirson JA, et al. 2018. 24. Euphorbia. Flora of North America, volume 12. www.eFloras.org.

Gaskin JF, Wheeler GS, Purcell MF, Taylor GS. 2009. Molecular evidence of hybridization in Florida's sheoak (Casuarina spp.) invasion. Molecular Ecology 18:3216–3226.

Hyder A, Leung B, Miao Z. 2008. Integrating data, biology, and decision models for invasive species management: application to Leafy Spurge (Euphorbia esula). Ecology and Society 13(2):12

Jonsen ID, Bourchier RS, Roland J. 2001. The influence of matrix habitat on Aphthona flea beetle immigration to leafy spurge patches. Oecologia 127:287-294.

Joshi A and Olson DL. 2009. Revisiting leafy spurge biocontrol: a case study. Rangelands 31(2):31-35.

Lym RG, Nissen SJ, Rowe ML, Lee DJ, Masters RA. 1996. Leafy spurge (Euphorbia esula) genotype affects gall midge (Spurgia esulae) establishment. Weed Science 44 (3):629-633.

Lym RG and Carlson RB. 2002. Effect of leafy spurge (Euphorbia esula) genotype on feeding damage and reproduction of Aphthona spp.: implications for biological weed control. Biological Control 23:127-133.

Nowierski RM, Zeng Z, Schroeder D, Gassmann A, FitzGerald BC, Cristofaro M. 2002. Habitat associations of Euphorbia and Aphthona species from Europe: development of predictive models for natural enemy release with ordination analysis. Biological Control 23:1-17.

Weed AS, Milan J, Schwarzlaender M. 2017. Analyses of nine years of citizen-based biological control monitoring of Dalmatian toadflax, Linaria dalmatica (Plantaginaceae) in Idaho, USA. BioControl 1-12.

Year 1 Budget Information (for a summary of total project costs, see page 1)

Fiscal Year (FY): 2019

Budget Type	Budget	Requested BCIP Funding	Non-Federal Match**	Leveraged Funds***	Match Source	Leveraged Source
ADMINISTRATION	Salary	$ 2,800		$ 31,021		USDA-ARS
	Travel for Data Collection	$ 7,500				
	Travel to Meetings*					
	Travel for Other					
PROCUREMENT	Contracting	$ 7,110				
	Equipment	$ 1,200				
	Supplies	$ 5,500				
INDIRECT	Overhead	$ 2,411				
	Other					
	SUBTOTAL	$ 26,521	$ 0	$ 31,021		

Overhead Rate % (Describe in Notes): 10

Year 1 Total: $ 57,542

Year 1 Notes (2000 characters):

ARS Overhead Rate is 10% for Administration
Please see budget details in attached spreadsheet
Leveraged Funds are salary + benefits from ARS-Sidney (2 SYs + 2 Technicians)

* Funds allocated for "Travel to Meetings" in year 1 will only be approved for proposals requesting a single year of funding.
** Non-Federal Matching (cost sharing) funds are raised from outside sources to increase the level of support provided by the Federal Government. This includes both cash and in-kind contributions.
*** Leveraged Funds are raised from outside sources to increase the level of support provided by the Federal Government (including cash and in-kind contributions) beyond the non-Federal matching requirements.

Year 2 Budget Information (for a summary of total project costs, see page 1)

Fiscal Year (FY): 2020

Budget Type	Budget	Requested BCIP Funding	Non-Federal Match	Leveraged Funds	Match Source	Leveraged Source
ADMINISTRATION	Salary	$ 2,800	$ 5,000	$ 34,222	MTBCWP	USDA-ARS, BLM
	Travel for Data Collection	$ 7,500				
	Travel to Meetings					
	Travel for Other					
PROCUREMENT	Contracting	$ 5,000				
	Equipment	$ 1,200				
	Supplies	$ 3,000				
INDIRECT	Overhead	$ 1,950				
	Other					
	SUBTOTAL	$ 21,450	$ 5,000	$ 34,222		

Overhead Rate %: 10

Year 2 Total: $ 60,672

Year 2 Notes (2000 characters):

ARS Overhead Rate is 10% for Administration
Please see budget details in attached spreadsheet
Leveraged Funds are salary + benefits from ARS-Sidney and Idaho BLM (ARS: 2 SYs + 2 Technicians; BLM 1 Scientist: Milan)
Non-Federal Match is: Montana Biological Weed Control Coordination Project (Maggio)

Year 3 Budget Information (for a summary of total project costs, see page 1)

Fiscal Year (FY): 2021

Budget Type	Budget	Requested BCIP Funding	Non-Federal Match	Leveraged Funds	Match Source	Leveraged Source
ADMINISTRATION	Salary	$ 2,800	$ 5,000	$ 24,166	MTBWP	USDA-ARS-BLM
	Travel for Data Collection	$ 7,500				
	Travel to Meetings					
	Travel for Other					
PROCUREMENT	Contracting	$ 5,000				
	Equipment	$ 1,200				
	Supplies	$ 2,600				
INDIRECT	Overhead	$ 1,910				
	Other					
	SUBTOTAL	$ 21,010	$ 5,000	$ 24,166		

Overhead Rate %: 10

Year 3 Total: $ 50,176

Year 3 Notes (2000 characters):

ARS Overhead Rate is 10% for Administration
Please see budget details in attached spreadsheet
Leveraged Funds are salary + benefits from ARS-Sidney and Idaho BLM (ARS: 2 SYs + 2 Technicians; BLM 1 Scientist: Milan)
Non-Federal Match is: Montana Biological Weed Control Coordination Project (Maggio)

Project Contacts (The Funding Coordinator is the individual who manages project funds. A single funding coordinator must be selected.)

FHP/BCIP Regional/Station/Area Contact

Name: Carol Randall Title: Entomologist

Institution: USDA-USFS Phone: (208) 783-2107

Email: crandall@fs.fed.us

Technical Monitor:

Principal Investigators

Name: Natalie M. West Title: Research Ecologist

Institution: USDA-ARS Pest Management Research Unit Phone: (406) 433-9440

Email: Natalie.West@ars.usda.gov Time commitment: 4080 hours

Project Role: Project Lead, Habitat and community analysis Funding Coordinator: ☑

Name: John F. Gaskin Title: Research Botanist

Institution: USDA-ARS Pest Management Research Unit Phone: (406) 433-2020

Email: John.Gaskin@ars.usda.gov Time commitment: 2400 hours

Project Role: Lead for Genetics Section Funding Coordinator: ☐

Name: Title:

Institution: Phone:

Email: Time commitment:

Project Role: Funding Coordinator: ☐

Cooperators

Name: Joseph Milan Title: Biological Control Specialist

Institution: BLM/ISDA Phone: (208) 384-3487

Email: jmilan@glm.gov Time commitment: 160 hours

Project Role: Coordinator for Idaho data collection Funding Coordinator: ☐

Name: Melissa Maggio Title: Program Coordinator

Institution: Montana Biological Weed Control Coordination Project Phone: (406) 258-4223

Email: mmaggio@missoulaeduplace.org Time commitment: 160 hours

Project Role: W Montana data collection, Technology Transfer Funding Coordinator: ☐

Name: Jeff Printz Title: Rangeland Management Specialist

Institution: USDA-NRCS - Bismarck, ND Phone:

Email: jeff.printz.nd@gmail.com Time commitment: 40 hours

Project Role: North Dakota data collection, Technology Transfer Funding Coordinator: ☐

List additional documents being sent in support of the project. (e.g., curriculum vitae, letters from stakeholders, spreadsheets, etc.) (not more than one page):

1. Additional Cooperators ("West_Gaskin Additional Cooperators.pdf")
2. Budget Spreadsheets (Matching & Requested) ("West_Gaskin Costs.xlsx")
3. Curriculum vitae - West & Gaskin ("West_Gaskin CV.pdf")
4. Figure 1 (referenced in Methods and Approach in narrative) ("West_Gaskin Figure 1.pdf")
5. State Coordinator letters of support ("West_Gaskin Weed coordinator letters.pdf")

Keywords (50 words):

Leafy Spurge, Euphorbia esula, biological control, Aphthona, plant invasions, genetics, habitat suitability