



## Environment and Natural Resources Trust Fund (ENRTF) M.L. 2014 Work Plan

**Date of Report:** July 11, 2019  
**Date of Next Status Update Report:** January 30, 2020  
**Date of Work Plan Approval:** July 10, 2014  
**Project Completion Date:** June 30, 2022  
**Does this submission include an amendment request?** YES

**PROJECT TITLE:** Minnesota Invasive Terrestrial Plants and Pests Center

**Project Manager:** Robert Venette  
**Organization:** Regents of the University of Minnesota  
**Mailing Address:** Minnesota Invasive Terrestrial Plants and Pests Center, 1992 Folwell Ave.  
**City/State/Zip Code:** St. Paul, Minnesota 55108  
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**Location:** Statewide

<b>Total ENRTF Project Budget:</b>	<b>ENRTF</b>	<b>\$1,460,000</b>
	<b>Appropriation:</b>	
	<b>Amount Spent:</b>	<b>\$1,199,842</b>
	<b>Balance:</b>	<b>\$260,158</b>

**Legal Citation:** M.L. 2014, Chapter 312, Article 12, Section 8

**Appropriation Language:**

\$490,000 in 2015 is from the environment and natural resources trust fund for the Invasive Terrestrial Plants and Pests Center requested under this act, including a director, graduate students, and necessary supplies. This is a onetime appropriation and is available until June 30, 2022. \$970,000 from the environment and natural resources trust fund appropriated in Laws 2011, First Special Session chapter 2, article 3, section 2, subdivision 9, paragraph (d), Reinvest in Minnesota Wetlands Reserve Acquisition and Restoration Program Partnership, is transferred to the Board of Regents of the University of Minnesota for the Invasive Terrestrial Plants and Pests Center requested under this act, including a director, graduate students, and necessary supplies and is available until June 30, 2022.

**I. PROJECT TITLE:** Minnesota Invasive Terrestrial Plants and Pests Center

**II. PROJECT STATEMENT:**

The Minnesota Invasive Terrestrial Plants and Pests Center (MITPPC) will serve a lead role in terrestrial invasive species research – coordinating initiatives on prevention of establishment; early detection and rapid response; development of new control methods and technology; integrated pest management; and minimizing non-target impacts of control. The MITPPC mission is to offer science-based solutions to pest invasions that ensure the protection of Minnesota’s healthy prairies, forests, wetlands and



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agricultural resources. The goal is to eliminate, reduce, mitigate and prevent the introduction, expansion, or damage caused by terrestrial invasive species in Minnesota.

The array of terrestrial invasive species (TIS) of high concern for Minnesota are numerous and diverse, and include invasive grasses, trees, shrubs, insects, earthworms, mammals, fungal pathogens, and other microbes. TIS impact every citizen in the State: emerald ash borer damages our forests and urban landscapes; weeds diminish the biodiversity of our prairies and wetlands; and pests and pathogens destroy fruit and grain harvests resulting in significant economic costs. The annual, combined economic impact of plant, animal, and microbial invasives in the U.S. is estimated at \$134 billion (Agricultural and Resource Economic Review, 2006). Minnesota's share of this loss is estimated at \$3 billion annually, which is typical of the 50 states.

This investment will result in a comprehensive assessment of TIS risks to Minnesota and a comprehensive, planned, multi-disciplinary approach to addressing risk. MITPPC will involve researchers from multiple disciplines, and will address invasives affecting our prairies, forests, agricultural landscapes and wetlands in urban, developing and rural contexts. The Center will identify research priorities for TIS already established in Minnesota and for those that appear likely to arrive and do harm, and develop control methods, management strategies, and policy to achieve effective outcomes. Upon the completion of an initial impact assessment, the expert panel working group will establish priorities and present requests for proposals and work-plans to conduct research to address identified priority invasive species. Proposals will be sent out for peer review to ad hoc scientific reviewers in the field of research, which will allow for rapid turnaround of proposals to expedite work to be completed. The ad hoc scientific reviewers will comment on the novelty of the research, the rigor of the proposed methods, the qualifications of the team to complete the research, and the potential impact of the research on the management of invasive, terrestrial species and will make award recommendations to the Director. These specific initiatives selected and their budgets will be provided to LCCMR for review.

The Center will prioritize and support multiple projects by research teams comprised of faculty, students, and staff from one of 10 participating departments. UMN faculty will work with both graduate students and post-doctoral associates on any given project. The scope of each research project will likely vary by species addressed. With this and additional planned funding, it is expected that over an eight-year period the Center will conduct an estimated 18-25 projects and train roughly 25 graduate students and postdocs.

The Center will be administratively located in the College of Food, Agricultural and Natural Resource Sciences (CFANS) in coordination with the College of Biological Sciences (CBS). Participating departments within CFANS include Entomology, Plant Pathology, Forest Resources, Agronomy & Plant Genetics, Horticultural Science, Applied Economics, Fisheries, Wildlife and Conservation Biology, and Bioproducts and Biosystems Engineering. Participating departments within CBS include Plant Biology and Ecology, Evolution and Behavior. Additionally, research will be possible on CFANS' eight research and outreach centers located in diverse agro-ecological areas of the State.

### III. PROJECT STATUS UPDATES:

**Project Status as of January 31, 2015:**



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As this is a new center, prior to acting on either of the activities/outcomes defined in this work plan, administrative establishment of the Minnesota Invasive Terrestrial Plants and Pests Center (MITPPC) has been essential. Thus activities to date have all related to the establishment of the Center and the hiring of a director. Administrative structure and oversight has been initiated. Financial accounts and protocols have been established. MITPPC office space on the Saint Paul Campus of the University of Minnesota in the USDA Forest Service building has been identified. A search committee was established to identify and hire a center director, and Dr. Robert Venette was hired as the inaugural MITPPC Director starting January 2, 2015. A search for an Associate Director is now underway. No ENRTF funds have been spent to-date, as the above activities are currently being paid through a General Fund appropriation, other University of Minnesota sources, and contributions from the Northern Research Station of USDA Forest Service.

### **Amendment Request (01/31/2015):**

We are requesting a change in the project manager from Brian Buhr to Robert Venette. This change also impacts contact information (i.e., mailing address, telephone number and email address). In addition we have an amendment to the other funds listed in section VI B.

### **Amendment Approved: 02/06/2015**

### **Project Status as of June 24, 2015:**

MITPPC completed a rapid prioritization to identify lines of research that would be immediately beneficial for the management of invasive terrestrial plants and pests. The details of that prioritization are summarized under updates to Activity 1. The outcome of the prioritization provided the foundation for MITPPC's first request for proposals (RFP). The RFP was issued on April 31, 2015. Eight pre-proposals were received for a total request of \$3.7 million. Additional details about the RFP, the review process, and the administration of sub-subprojects are provided under updates to Activity 2.

After a national search, Ms. Heather Koop accepted the position of Associate Director for the MITPPC. She assumed the role on May 4, 2015. This position is currently paid through a General Fund appropriation.

### **Amendment Request (06/24/2015):**

The amendment requests include a correction to the street address of the Center; the substitution of contact phone number; and the substitution of the Center's new web address. The MITPPC budgets have been modified to reflect the anticipated future line items that will be necessary to fund selected research. Since those items are not known at this time, \$1 has been inserted in those line items in order to establish budgets and sub-budgets within the University's accounting system. Once the projects have been identified and recommended for funding, the MITPPC will return to the LCCMR for review with appropriate sub-work plans and sub-work budget adjustments. The travel line item in the narrative budget has been expanded to include travel within and outside of Minnesota. Examples of possible reasons for outstate travel are provided. Actual travel will be detailed in future budget amendment requests when research projects are identified. The professional/technical/service contracts line items have been expanded to include examples of the kinds of items and services that might be purchased. One other budget adjustment corrects an earlier typographical error: the line item for "travel expenses in MN" was \$13,381 and is now \$34,378 which aligns with the approved budget spreadsheet.

### **Amendment Approved: 06/25/2015**



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### **Project Status as of December 1, 2015:**

MITPPC has identified four inaugural research sub-projects for funding. In brief, the sub-projects are 1. "Novel Diagnostic Tools for Rapid and Early Detection of Oak Wilt" (Project Manager: Dr. Abbas Abdennour), 2. "Early Detection, Forecasting, and Management of *Halyomorpha halys*" (Project Manager: Dr. William Hutchison), 3. "Climate Change and Range Expansion of Invasive Plants" (Project Manager: Dr. David Moeller), and 4. "Cover it Up! Using Plants to Control Buckthorn" (Project Manager: Dr. Peter Reich). These sub-projects were the top-rated of eight pre-proposals that were received in response to the initial request for proposals. Sub-projects were evaluated by a panel of five faculty with no direct connection to the proposed research. Details of sub-projects were clarified in full proposals which were sent for peer review by experts outside the University of Minnesota, often outside the United States, to obtain fully impartial comments. Full proposals were modified based on the comments that were received. Additional details about the sub-projects and the review process are provided in the update to revised Activity 2.

MITPPC continues to make progress on its expanded prioritization of 120 terrestrial invasive species that threaten forests, prairies, wetlands, or agriculture.

MITPPC identified 16 members for its Center Advisory Board. Members who were knowledgeable about terrestrial invasive species, their impacts within Minnesota, and the University of Minnesota were nominated by MITPPC's Director and Associate Director and appointed by CFANS Dean Brian Buhr. Ex officio members are Commissioner Tom Landwehr, Department of Natural Resources; Commissioner Dave Frederickson, Department of Agriculture; and Dean Brian Buhr, CFANS. Named representatives for ex officio members are Ann Pierce, Department of Natural Resources; Matthew Wohlman, Department of Agriculture; and Greg Cuomo, Associate Dean for Research, CFANS. Rotating members that are internal to the University of Minnesota are Vince Fritz, University of Minnesota Research and Outreach Centers; Frances Homans, Head, Department of Applied Economics; Emily Hoover, Head, Department of Horticultural Science; Gary Muehlbauer, Head, Department of Plant Biology, College of Biological Sciences; and Bob Stine, Associate Dean, College of Continuing Education. Rotating members that are external to the University of Minnesota are Nan Bailly, Alexis Bailly Vineyards; Steve Chaplin, The Nature Conservancy; Reginald De Foe, Fond du Lac Band of Lake Superior Chippewa; Shefali Mehta, Syngenta; and Bob Owens, Owens Forest Products. The Board is chaired by Bob Stine. The Center Advisory Board will provide a plan to ensure the long-term sustainability of the Center.

### **Amendment Request (12/01/2015):**

This amendment request removes funding for Activity 1, Catalyzing Research and Education: Conduct Net Impact Risk Assessment. The activity has been funded to-date by the General Fund appropriation, ML 2014, Ch. 312, Art. 12, Sec. 8. The MITPPC will continue to provide LCCMR with updates of the prioritization process as it progresses. It is anticipated that the process will be complete early in 2016. A white paper describing the process and results will be distributed for comment at that time. The funds allocated to Activity 1 (\$25,381) will be placed in reserve for future project funding.

Secondly, this amendment request specifies four sub-projects and allocates funds totaling \$1,244,801 towards them to complete research that will minimize or eliminate threats posed by terrestrial invasive species. In brief, the sub-projects are 1. "Novel Diagnostic Tools for Rapid and Early Detection of Oak



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Wilt” (Project Manager: Dr. Abbas Abdennour, \$150,000), 2. “Early Detection, Forecasting, and Management of *Halyomorpha halys*” (Project Manager: Dr. William Hutchison, \$597,795), 3. “Climate Change and Range Expansion of Invasive Plants” (Project Manager: Dr. David Moeller, \$170,006), and 4. “Cover it Up! Using Plants to Control Buckthorn” (Project Manager: Dr. Peter Reich, \$327,000). The sub-projects that were chosen are based on the rapid prioritization process that was described in the RFP. These sub-projects address the priority themes of detection and distribution of invasive terrestrial plants and pests (sub-projects 1, 2 & 3); response of invasive terrestrial invasive species to climate change (sub-projects 2 & 3); and effectiveness of management alternatives for terrestrial invasive species (sub-project 2). These projects also address priority taxa identified, including the brown marmorated stinkbug, oak wilt, and a variety of noxious weeds. The sub-projects have undergone a round of internal review and a round of external review and have been modified based on comments received. In some cases, sub-project managers were asked to make adjustments to their scope of work, to strengthen the research design, or to better articulate outcomes. Additional details about the sub-projects and the review process are provided in the revised Activity 2.

Finally, the document as a whole has been updated throughout for clarity and accuracy.

**Amendment Approved: 12/04/2015**

### **Project Status as of January 31, 2016:**

The MITPPC has focused effort on the completion of the sub-work plans and establishing child accounts for each project. The Center Advisory Board met on January 26, 2016 to review updates on the prioritization process and to continue progress with the long-term business plan.

### **Project Status as of July 31, 2016:**

The MITPPC completed the initiation activities for the four research projects currently funded under this appropriation. Each of those projects have made significant progress in the last six months. Overviews of those accomplishments are provided in status updates for Activity 2 subprojects. Detailed accomplishment reports are provided as updates to the complete subproject work plans.

Center staff and stakeholders completed a draft prioritization of terrestrial invasive species, as required under ML 2014, Ch. 312, Art. 13, Sec. 44, subd. 2. The draft, “Minnesota’s Top 124 Terrestrial Invasive Plants and Pests: Priorities for Research” has been published and distributed broadly for a 30 day public comment period. Draft priorities are subject to change. Center staff will review submitted comments, make the necessary revisions, and publish the final draft. The prioritized list will be used as the basis for the next Request for Proposals, anticipated to begin in August and close in September 2016. The white paper may be found on the MITPPC website: [z.umn.edu/mitppcpriorities](http://z.umn.edu/mitppcpriorities)

Additionally, the Center Advisory Board met April 29, 2016 and continued its work on a longer-term business and strategic plan for the Center.

### **Amendment Request: 7/31/2016:**

Each of the four sub-projects made progress in the preceding months. A later start date than initially planned necessitates minor amendments to adjust three projects’ timelines, budgets, and scopes of work. Those are described under “Activity 2 Subprojects” and in greater detail in the individual sub-project workplans.



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The solicitation process which began last summer culminated in four projects moving forward to full proposal. Those full proposals were then externally reviewed during August and September 2015. The four projects were presented to LCCMR for review in October 2015 and a formal workplan amendment was submitted to LCCMR in November 2015 and approved in early December 2015. It should be noted that each of the projects indicated an August start date.

Once the Center's workplan amendment had been approved, the UMN finance and sponsored projects administration determined that child accounts would be established for the four sub-projects; those were operational by the end of January 2016.

Hence, the time from submission of the Center's workplan (August 2015) and establishment of sub-accounts (January 2016) made the projects original timeline approximately five months out of sync. This slight delay impacted the hiring of post-docs, as UMN policy encourages the recruiting and posting of new positions only when the appropriate accounts are established. In all cases, the hiring of post-docs (and other graduate students) was essential to getting the projects operational.

The adjusted timelines remain within their originally stated end dates and are all within the availability of the appropriation

The Upper Midwest Invasive Species Conference (UMISC) will be held in LaCrosse, WI on October 17-19. There is great interest in the MITPPC and a panel presentation will be part of the conference program. Three of the four funded projects (Sub-projects 1, 2, and 4) will make presentations on their projects. This amendment request is to allow presenters to attend the UMISC and be able to use their ENRTF travel funds to do so.

### **Amendment Approved: (9/9/2016)**

### **Project Status as of January 31, 2017:**

MITPPC's first four funded projects continued to make progress. Two projects, one by Dr. Abbas and the other by Dr. Reich made readjustments to the activities in order to accomplish their objectives. Those technical changes are described in greater detail in the sub-reports.

The Upper Midwest Invasive Species Conference was held in October and the MITPPC hosted a session on the first four projects funded. Two post-doctoral associates made presentations, as well as two faculty members.

### **Amendment Request (01/30/2017)**

The University of Minnesota instituted a mandate that all post-doctoral associates' salaries are to be raised to a minimum of \$47,476 a year in order to comply with the revised regulations governing overtime pay for salaried employees under Fair Labor Standards Act. The new regulation is effective Dec. 1, 2016. <http://bit.ly/2erbdbL>

As a result, there are three MITPPC-funded projects that will need to increase their salary line items (and total project allocations) to cover this unanticipated budget increase. We are requesting to budget an



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additional \$41,921 to cover the increase. We maintain a sufficient balance in ML 2014 ENRTF to absorb the increase.

Sub-project 1: increase personnel by \$14,286 from \$133,306 to \$147,592

Sub-project 2: increase personnel by \$20,580 from \$559,595 to \$580,175

Sub-project 3: increase personnel by \$7,055 from \$159,656 to \$166,711.

Additionally, we request amendments to one sub-project. Dr. Abbas and his team have redesigned two outcomes and changed the related completion dates. The goals remain the same, as does the budget and overall project completion date.

**Amendment Approved: February 20, 2017**

### **Project Status as of July 31, 2017:**

Research teams made significant progress with research presentations, publications, as well as lab and field work. Each of the sub-projects' research has produced products that direct applied applications. Dr. Abbas' labs work in quickly identifying pathogens in the field has wide application beyond plant pathology. The Hutchison lab's work in future climatic conditions under which the serious pest brown marmorated stinkbug, too, has the applied methodology that has wide-spread application for understanding additional pest invaders. Similarly, the modeling developing under Dr. Moeller's leadership has direct benefit to understanding the viability of invading plants. Finally, Dr. Reich and his team's work on buckthorn management has been adopted by several natural resource partners.

### **Project Status as of January 31, 2018:**

MITPPC is requested two minor budget changes to three projects. MITPPC sub-project 3, Climate Change and Range Expansion of Invasive Plants requested to increase personnel costs with a decrease in travel expenses. MITPPC sub-project 4, Cover it Up! requested a slight decrease in personnel and equipment/supplies and an increase to professional services and travel. Neither amendment request impacted the timeline nor outcomes of the projects.

### **Amendment request (6/26/18)**

The MITPPC requests that \$14,000 be added to ML 2014 MITPPC sub-project 2, Early Detection, Forecasting, and Management of *Halyomorpha halys* (Brown Marmorated Stinkbug) to cover unanticipated data storage costs at Minnesota Supercomputing Institute (MSI) through the life of the research project. Processed data will continue to be stored at MSI after completion of the project and will be available for future research. This increases the professional services line item from \$10,000 to \$24,000 and increases the overall project budget from \$618,375 to \$632,375.

The MITPPC requests that sub-project 3, Climate Change and Range Expansion of Invasive Plants increase the project budget by \$32,208 for personnel (from \$172,955 to \$205,163) and increases the overall budget from \$177,055 to \$209,263. Two additional two species common tansy and wild parsnip, are MITPPC priority species and will be added to the project. Tangible outputs will be a series of maps to describe current and future variation in climatic suitability for Common Tansy and Wild Parsnip. We expect that the results of this work will improve the detection of species and the development of eradication and management plans. The project end date would be extended to June 30, 2019.



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Both of these sub-project increases will be funded from the reserve line item of the ML 2014 Chapter 312, Article 12, Section 8 appropriation, decreasing the reserve from \$173,284 to \$127,076.

### **Amendment Approved (7/3/2018)**

#### **Project Status as of July 31, 2018:**

Much progress has been made with all four sub-projects funded under this appropriation since the last reporting. Significant accomplishments include published descriptions of new techniques to (1) separate the fungus that causes oak wilt from wood chips taken from infected trees, (2) extract and purify DNA from the disease causing pathogen within 15 min directly from wood drill shavings from infected trees; (3) detect the presence of target DNA from the pathogen with nanoparticles. Also, in this period, a new app, the Midwest Stinkbug Assistant, was developed and released to assist with in-field identification of the brown marmorated stinkbug. A series of maps were generated to illustrate where the climate in Minnesota is most suitable for Palmer amaranth and other invasive plants. Multiple studies continue to show that deep shade (about 95%) kills or slows the growth of buckthorn; shade levels can be adjusted by planting native plants. Results were shared at a major outreach event with over 120 participants. Additional accomplishments and results are summarized later in this document and described in greater detail in the individual subproject work plans.

One amendment was requested for sub-project #4, which extended the timeline within the end date of the appropriation for activities 1 and 2 and made a \$200 increase in supplies and materials with a commensurate decrease in travel. This amendment has been approved by LCCMR.

### **Amendment request (12/21/18)**

We request amendments to this overall work plan to reflect previously approved amendments to subproject work plans that were made since the last progress report. Here we simply summarize the date the request was made, the nature of the amendment(s), and the official date of approval by LCCMR staff. Amendments are also reflected in the M.L. 2014 Project Budget – Overall Budget of Minnesota Invasive Terrestrial Plants and Pests Center. Modifications to that document are given the current date as some projects were amended more than once between February 1, 2018 and July 31, 2018. No amendments are requested beyond what has previously been approved by LCCMR staff. In total, modifications resulted in a reduction of the Budget Reserve from \$173,284 to \$17,076. Additional details about the amendments may be found in subproject reports.

Activity 2 Subproject 1 Novel Diagnostic Tools for Rapid and Early Detection of Oak Wilt (Abbas, project manager). First amendment request (4/27/2018)- The personnel line item is reduced by \$2,590 and the equipment/supply line item is increased by \$1,527, and the travel line item was increased by \$1,063. First amendment approved (5/21/2018). Second amendment request (9/24/2018)- \$110,000 is taken from the Budget Reserve and added to this research project for additional personnel time (new total after both amendments: \$236,938), technical contracts (new total: \$2,000), supplies (new total after both amendments: \$31,081) and travel (new total after both amendments: \$4,267). The timeline is extended to accommodate completion of a hand-held luminometer as described under this sub-project's Activity 3. Second amendment approved (10/4/2018).



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Activity 2 Subproject 2 Early Detection, Forecasting, and Management of Brown Marmorated Stinkbug (Hutchison, project manager). First amendment request (6/26/2018)- \$14,000 is taken from the Budget Reserve and added to the Professional/Technical Services/Contracts line item to cover unanticipated data storage costs associated with this subproject's activity 3. The change increases the line item to a revised total of \$24,000. Funds will be paid to the Minnesota Supercomputing Institute. First amendment approved (7/3/2018). Second Amendment request (11/3/2018)- Adjustments are made within the sub-project budget to address slightly greater need for supplies (insect traps) and slightly less funding needed for computers than originally estimated. The changes simply affect allocations within the equipment/tools/supplies line item as reflected in the subproject budget. Changes do not affect the total allocation to this subproject or the Budget Reserve. Activities and outcomes for the subproject are unaffected. Second Amendment Approved (11/16/2018).

Activity 2 Subproject 3 Climate Change and Range Expansion of Invasive Plants (Moeller, project manager). Amendment request (6/7/2018)- \$32,208 is taken from the Budget Reserve to provide additional personnel time to develop climate suitability maps for two additional, priority weed species, common tansy and wild parsnip (new total: \$205,163). The project deadline is extended to June 30, 2019. Amendment approved (7/3/2018).

Activity 2 Subproject 4 Cover It Up! (Reich, project manager). Amendment Request (9/11/18)- Two changes are made to the subproject work plan timeline. The first is a short timeline extension for the subproject's Activity 1. This change is within the project completion deadline. The second is an extension to the timeline for completing manuscripts for the subproject's Activity 2, from 31 December 2018 to 30 June 2019, to enable the research team to fully include critical data collected in October 2018 after two full years of experimental treatments. A modest increase is made to the supply and materials budget of \$200, (from \$14,994 to \$15,194) with a commensurate decrease in the travel line item (\$10,500 to \$10,300.) The changes do not affect the total allocation to this subproject or the Budget Reserve. Amendment Approved (9/19/2018).

### **Amendment Approved 1/23/2019**

#### **Project Status as of January 31, 2019:**

All four sub-projects continue to make excellent progress towards achieving stated outcomes. Notable accomplishments include: 1) confirmation that a new trap design provides earlier and more sensitive detection of brown marmorated stink bug than previous trapping systems; 2) completion of the first detailed assessment of the average suitability of Minnesota's weather for Palmer amaranth, with a clear north-south gradient revealed, and projected increase in suitability statewide in the mid-term; and 3) demonstration of the benefit of deep shade to buckthorn control. Additional accomplishments and results are summarized later in this document and described in greater detail in the individual subproject work plans.

#### **Amendment request (4/24/19)**

We are requesting three amendments under this appropriation. The first amendment is for MITPPC Subproject #2. This request increases professional services by \$522 from \$13,000 to \$13,522 and decreases



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travel \$522 from \$15,200 to \$14,678. The changes do not affect the total allocation to this subproject or the Budget Reserve. An additional request is made to change the end date of Sub-project #2 from August 31, 2019 to May 30, 2020. The new end date provides the research team with time to conduct more thorough assessments of the effects of cold temperatures on mortality of adult brown marmorated stink bugs than originally planned. A more complete model will result, and will provide a better forecast of the influence of milder winter weather, or the impact of a polar vortex, on this invasive pest. The original outcomes, timeline, and budget are not affected by this request. An additional outcome has been added to Activity 2.

The second amendment is for MITPPC Sub-project #4. This request decreases professional services by \$8,750 from \$ 14,750 to \$6,000 and increases supplies by \$346 from \$15,194 to \$15,540 and personnel by \$8,404 from \$286,756 to \$295,160. The changes do not affect the total allocation to this subproject or the Budget Reserve. This request is because a budgeted second application of herbicide to conclude the project is no longer necessary and more assistance is needed than originally estimated from postdoctoral associates to complete advanced statistical analyses of the data collected through November 2018 for Activity 2. They will also refine manuscripts for Activities 1 and 3 in response to internal review feedback and complete manuscripts for Activity 2, to move project findings to publication. The team also requests a six month no-cost extension to December 30, 2019.

Lastly, pursuant to conversations with LCCMR staff, we are requesting revisions to the current and future reporting procedures to make the process as simple as possible and emphasize achievements of MITPPC-related projects while allowing LCCMR to ensure that the expenditures and outcomes described in the work plan for appropriations funded by the environment and natural resources trust fund are met. Specifically, this document will become the primary vehicle to describe research plans and report significant accomplishments of all sub-projects funded under this appropriation. Here will be found a brief overview of relevant MITPPC-related activities and a table with the current status of each sub-project. Each sub-project will be described with outcomes and activities with corresponding completion dates with enough detail to adequately convey what work is being conducted, why, and the projected impact. A budget for each sub-project will be attached to the overall work plan, however budgets for sub-projects will not report on sub-activities. Separate sub-project work plans will not be required. MITPPC will maintain copies of research addenda for each sub-project and make them available to LCCMR staff upon request. Dissemination activity will be reported with each sub-project; and overall MITPPC dissemination will be reported in the overall dissemination section of the work plan. MITPPC and LCCMR staff tested these reporting procedures for one year (2018) with appropriation M.L. 2016, Chp. 186, Sec. 2, Subd. 06a. Both parties agreed that the new procedures were more efficient (approximately 85% reduction in administrative effort) and conveyed all necessary information.

### **Amendment Approved 4/29/2019**

#### **Project Status as of July 11, 2019:**

All four sub-projects continue to make excellent progress. Sub-project #1 unexpectedly discovered that the new, nanoparticle-based technology to diagnose the oak wilt pathogen can also diagnose the pathogen that causes burr oak blight. This surprising outcome is not being tested further at the moment, but demonstrates the great potential of this technology to identify a number of cryptic pathogens. Sub-project #2 has confirmed that dual-lures with panel traps are easier, cheaper, and more



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effective to detect brown marmorated stink bug than previous methods. Results have been incorporated into statewide and national recommendations for improved detection and monitoring of this important insect. (The Minnesota Department of Agriculture has already adopted these recommendations.) Sub-project #3 is complete. Maps describing where the climate of MN is most suitable for Palmer amaranth have undergone peer review and have been published. Maps for another nine invasive weed species have been prepared. Sub-project #4 is preparing a number of publications to describe the sensitivity of buckthorn to shading and the role of native plants in managing woody invasives.

The Center's prioritization process is designed to be flexible enough to add new species as additional threats are identified. An assessment of jumping worms (*Amyntas* spp) was completed in January 2019. Analysis through MITPPC's analytical hierarchy process revealed that these species ranked as the #4 invasive invertebrate (i.e., insects and earthworms) threat to the state. This species was eligible for research funding in the Center's 2019 call for proposals. Biological summaries for 10 new species have been prepared for prioritization.

MITPPC co-hosted the "Palmer Summit" with the Minnesota Department of Agriculture in January 2019 to describe the status of Palmer amaranth in Minnesota and the Upper Midwest and to discuss regulatory and outreach goals and options. Presentations and summaries have been shared via MITPPC's website and YouTube channels.

### **Amendment request (7/11/19)**

We request an amendment to sub-project #2 to extend the end date for Activity 3, outcome 4 from December 30, 2018 to May 30, 2019. The postdoc who was working on this project was unexpectedly called away for three months and unable to work on the project. No salary was charged to the project during this time, but this period was too short to find other qualified staff to complete the work. The end date aligns with other project outcomes. No funding adjustments are requested.

**Project Status as of January 31, 2020:**

**Project Status as of July 31, 2020:**

**Overall Project Outcomes and Results:**

### **IV. PROJECT ACTIVITIES AND OUTCOMES:**

**ACTIVITY 1:** Catalyzing Research & Education: Conduct Net Impact Risk Assessment

**Description:** A key foundational principle of the MITPPC will be to develop its research activities and portfolio based on net impact assessment of various invasive species and expected outcomes of intervention strategies. This approach will include consideration of pressing need, opportunity and practicality, which will allow for strategic management of the research portfolio. The Center will establish a 12-member expert panel to create risk assessment frameworks and conduct net impact assessments that will prioritize investments in research to address existing invasive species as well as rapidly spreading invasive species that have not yet but are highly likely to enter the State. The panel will meet annually (years 1-3) to assess progress and re-prioritize as necessary.



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We will create the panel using national level scientists with demonstrated research expertise (advanced degrees in related field, publications in related discipline, affiliation with recognized research centers in related disciplines). The twelve members will include eight Minnesota experts (faculty at University of Minnesota, or Minnesota government or non-governmental organizations with credentials as above) and four external experts (similar credentials as internal but from out of state). The goal is to provide input from broader national experiences with similar challenges. The external experts will receive an honorarium of \$1,000 per meeting as well as travel expenses such as lodging, transportation and meals. The \$1,000 includes not only the two days of on-site meetings, but also it is expected that external experts will spend significant time reviewing literature and other information regarding Minnesota’s invasive species challenges. Internal experts will receive travel related and meal expenses to the extent the sessions are held off their home site and are likely to include lodging and meals.

**Summary Budget Information for Activity 1:**

**ENRTF Budget:     \$ 0**  
**Amount Spent:     \$ 0**  
**Balance:            \$ 0**

**Activity Completion Date:**

Outcome	Completion Date	Budget
<i>Establish a panel of internal and external experts to provide input on strategic direction and research priorities</i>	Sept 15, 2015	\$0
<i>Convene expert panel to create framework and then to conduct initial assessment to establish highest priority species</i>	Oct 15, 2015	\$0
<i>Convene expert panel annually (years 2-3) to assess net impacts of invasive species and control responses.</i>	Oct 15, 2017	\$0

**Activity Status as of January 31, 2015:**

Nothing to report.

**Activity Status as of June 24, 2015:** By using funds from the 2014 General Fund appropriation, the MITPPC conducted a rapid prioritization in the spring of 2015 to identify immediate research needs among state agencies with primary responsibility for the management of terrestrial invasive plants and pests on public and private lands. Initial priority plants are species on the eradicate list, the control list, or the restricted noxious weed list as designated under Minnesota’s noxious weed law, and initial priority pests were the brown marmorated stink bug (*Halyomorpha halys*) and oak wilt (caused by the fungal pathogen *Ceratocystis fagacearum*). Initial priority themes for research are:

- invasive species detection and distribution;
- invasive species response to climate change; and
- new approaches to management of invasive species.

These priorities were identified through a consultative process with eight representatives from the Minnesota Board of Water and Soil Resources, Minnesota Department of Agriculture, Minnesota Department of Natural Resources, and Minnesota Department of Transportation. Each agency had generated a list of several dozen potential research themes and topics. From these lists each agency



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self-selected their top four research-priorities. MITPPC advised that a research topic should be considered a priority if it (i) would help the agency achieve its mission more effectively, (ii) would be of benefit to another agency (iii) could be supported by the agency financially or through in-kind contributions, and (iv) could be completed with the capacity at the University of Minnesota. Agency priorities were vetted during a joint meeting on March 26, 2015. The initial prioritization was complete by April 15, 2015. The prioritization provided the basis for MITPPC's first request for proposals. More details about those proposals are provided under updates to Activity 2.

A more expansive research prioritization was initiated in May 2015 to systematically evaluate threats posed by a wider array of terrestrial invasive plants, pathogens, and insects/arthropods than could be completed during the rapid prioritization. The more expansive prioritization will be used to allocate the remaining research funds from the M.L. 2014 ENRTF appropriation and the M.L. 2015 ENRTF appropriation. Twelve panelists were identified, six from the faculty at the University of Minnesota and six program managers with advanced degrees from partner agencies (Minnesota Departments of Natural Resources and Agriculture). In total, these panelists will identify 120 significant invasive plants, pathogens, or insects/arthropods that threaten Minnesota's agriculture, forests, wetlands, or prairies. An Analytical Hierarchy Process (AHP) will be used to rank these threats. AHP is a form of multi-criteria decision analysis that makes the process of selecting the highest priority threats consistent and transparent. AHP has been used by many agencies and organizations to facilitate complex decision making. In brief, the twelve member panel will engage in a facilitated discussion about criteria by which terrestrial invasive plants and pests should be considered a high threat (e.g., spread rate, reproductive rate, and impact potential) and the relative importance of each criterion. Each of the criteria will be applied to the 120 plants, pathogens, and insects/arthropods through reviews of the literature and consultations with relevant experts. National experts will be consulted to identify the greatest research needs for these priority taxa.

**Activity Status as of December 1, 2015:** Activity 1 will no longer be funded under this appropriation. This activity has been funded to-date by the General Fund appropriation, ML 2014, Ch. 312, Art. 12, Sec. 8, and it will continue to be so until completion. The MITPPC will continue to provide LCCMR with updates on this Activity and its outcomes as it progresses. It is anticipated that the process will be complete early in 2016.

Our 12-person, pest prioritization panel met on September 8, 2015 to use the analytical hierarchy process to identify terrestrial invasive species that are most likely to invade Minnesota, cause the greatest harm if they invaded the state, and be managed more effectively through additional research. Upon further discussion, the panel encouraged comparisons among species based on their unmanaged biological threat. The panel identified nineteen criteria to measure "unmanaged biological threat." As part of the analytical hierarchy process, the relative importance of each criterion was determined by a questionnaire submitted to all panelists. The questionnaire presented pairwise comparisons of the criteria. Each panelist was asked to determine whether the paired criteria were equally important (given a value of 1), and if not, which criterion was more important on a scale of 2 (slightly more important) to 9 (extremely more important). Responses from the panel were analyzed with Comparison Core software, and results presented to the panelists. The results reflect differences in the relative importance of each criterion to determine unmanaged biological threat (for example, the panel generally felt that potential impacts were more important than the likelihood that a species would invade the state when assessing



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threat). A team of six graduate students was then hired to assemble published information about the 120 species and provide summaries of that information with respect to the 19 criteria. Those summaries will then be used in the analytical hierarchy process to compare and rank all 120 species. A white paper that describes the process and outcomes will be prepared and distributed for public comment. The final species rankings will be used to set research priorities for the Center.

### **Activity Status as of January 31, 2016:**

Graduate students provided summaries of relevant literature for each of the 120 species.

### **Activity Status as of July 31, 2016:**

The prioritization process has been completed and is out for a 30 day public comment period, closing July 29, 2016. The MITPPC will issue the final version of the white paper subsequent to review and revision provided by those critiquing the paper. This document will be used as the basis for setting research funding in the 2016 Request for Proposals. The prioritization of Minnesota's top 124 terrestrial invasive species may be found here:

[z.umn.edu/mitppcpriorities](http://z.umn.edu/mitppcpriorities)

### **Activity Status as of January 31, 2017:**

The prioritization process is complete with the publication of the document, "Minnesota's Top 124 Terrestrial Invasive Plants and Pests: Priorities for Research." This document was the basis for the August 2017 Request for Proposals. The prioritization of taxa will be reviewed and updated on an annual process. The document may be accessed here: [www.mitppc.umn.edu](http://www.mitppc.umn.edu)

### **Activity Status as of July 31, 2017:**

No activity under this activity.

### **Activity Status as of January 31, 2018:**

The MITPPC began revisiting the prioritization process during the last six months. Two graduate students were hired to conduct literature reviews on 60 species added to the list. The additions to the list resulted from an open request to scientists, land managers, and others interested in terrestrial invasive research. We anticipate completing this work by the next reporting period. Any revisions to the current list of species' ranking will be used for next year's RFP.

### **Activity Status as of July 31, 2018:**

Graduate students continue to review literature of additional invasive plants to consider in the prioritization. The students note significant complications with finding relevant literature. Summarizing available literature is progressing more slowly than anticipated.

### **Activity Status as of January 31, 2019:**

Graduate students completed draft assessments for 21 additional invasive species that have been proposed for prioritization by MITPPC. MITPPC has contacted a postdoctoral research associate with extensive experience in invasive species research to review and revise these documents. In addition, she will complete new assessments for an additional set of invasive species proposed for prioritization. In this past activity period, MITPPC also received a formal review of the literature on jumping worms, *Amyntas* spp., a growing threat to the state. The review was provided by the MN Department of



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Natural Resources and the University of Minnesota. The review addressed each of the criteria considered by MITPPC in its prioritization process. This information was incorporated into the Analytical Hierarchy Process (AHP), an objective means to set priorities. (The capacity to readily incorporate new information into AHP is a benefit of this approach.) *Amyntas* spp. received a score of 86.97 (out of 100), which placed it at #4 on the list of the most threatening insects and other invertebrate animals to the state. The high ranking of this species will make it an appropriate focus of study among research proposals solicited this coming April.

### **Activity Status as of July 11, 2019:**

Work was begun to update the prioritization process in June 2019. Dr. Amy Morey, post-doctoral associate, will undertake the research. Dr. Morey will conduct literature reviews for an additional 46 species of pathogens, plants, and pests that have been suggested by a broad array of citizens and stakeholders over the last 18 months. Some of those species to be examined are currently present and/or established in the state and others are relatively new. Ten draft assessments have been prepared. This update to the prioritization will be complete before the issuing of MITPPC's next Request for Proposals. The updating of the prioritization process is being funded by M.L. 2015, Chp. 76, Sec. 2, Subd. 6a.

### **Activity Status as of January 31, 2020:**

### **Activity Status as of July 31, 2020:**

### **Final Report Summary:**

### **ACTIVITY 2: Launch research on high priority, established terrestrial invasive species and rapid response for the prevention of establishment of new threats.**

**Description:** Upon the completion of an initial impact assessment, the expert panel working group will establish priorities and present requests for proposals and work-plans to conduct research to address identified priority invasive species. Proposals will be sent out for peer review to ad hoc scientific reviewers in the field of research, which will allow for rapid turnaround of proposals to expedite work to be completed.

The Center will initiate and/or accelerate coordinated, applied research according to the prioritized list of pest and plant species that threaten Minnesota's prairies, urban and rural forests, wetlands, and agricultural resources. Depending on the net impacts associated with each species, research may include new control methods including bio-control and technology, development of integrated pest management tools that minimize non-target impacts of control, early detection of and/or rapid response to new threats, and establishment prevention. The Center infrastructure is vital to improving Minnesota's capacity and response time to preventing and limiting introduction of new terrestrial invasive species. All research projects will include an analysis of any consequences related to the management of prioritized species to the State's non-target flora, fauna or our soils, water and climate.

Workforce development and training experts in invasive species management is also critical. A core component of each project will be funding of graduate students and postdoctoral associates to work with existing faculty. Since University faculty are expected to acquire grants that cover their research salary, existing faculty are accounted for in the budget at 25% time in their role as the project





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Research projects funded by MITPPC will be treated administratively as sub-projects under this work plan. As research sub-projects are identified for funding, new sub-project work plans and budgets will be submitted to LCCMR by the new investigators for review and approval. Regular activity updates and budget updates will be provided by sub-project leaders directly to LCCMR and to MITPPC. This overarching work plan and budget will be updated accordingly to include general progress of the Center and a synopsis of activities completed by each sub-project. The budget updates for this overall work plan will provide summaries of expenditures (by budget line item) for each sub-project. Details on expenditures will be found in sub-project reports.

### **Activity Status as of December 1, 2015:**

Four projects were recommended for funding. These selected proposals are to be considered sub-projects with respect to this work plan. A detailed overview of the sub-projects is provided below and each sub-project has its own work plan. Sufficient funding remains in reserve to support at least one additional project. The remainder of this activity update describes how these projects were reviewed and revised prior to final selection.

MITPPC received comments on the eight pre-proposals from a panel of five University of Minnesota faculty members with research expertise on invasive species and no connection to the proposals.

Reviewers rated proposals on ten criteria:

1. **FUNDING PRIORITIES:** Responds to research priorities for the MITPPC outlined in the RFP;
2. **MULTIPLE BENEFITS:** Delivers multiple benefits to Minnesota's environment and natural resources;
3. **OUTCOMES:** Identifies clear objectives likely to result in measurable, demonstrated, and meaningful outcomes that have clear relevance to invasive terrestrial species management in Minnesota;
4. **KNOWLEDGE BASE:** Contributes to the knowledge base or disseminates information that will benefit other efforts;
5. **EXTENT OF IMPACTS:** Results in broad, long-term impacts of statewide or regional significance;
6. **INNOVATION:** Employs or demonstrates innovative approaches to more effectively and efficiently solve specific environment and natural resources issues;
7. **SCIENTIFIC/TECHNICAL BASIS:** Reflects current scientific and technical knowledge, standards, and best practices;
8. **URGENCY:** Addresses an issue for which immediate future action is necessary and essential to avoid undesirable consequences;
9. **CAPACITY AND READINESS:** Demonstrates capacity and readiness for efforts to be managed and completed in a timely, accountable, and effective manner; and
10. **LEVERAGE:** Leverages collaborative partnerships and additional efforts, resources, and non-state funds. For each criterion, reviewers rated the proposal from 5 (best possible) to 1. Proposals were then ranked by score totals. Top-rated projects were selected relative to constraints from the self-imposed funding cap which limited the first round of funding to \$1.2 million to allow a reserve for research on a potential emerging issue.

Four teams were invited to submit full proposals. Revisions to proposals and budgets were requested based on initial reviewers' comments received. Full proposals were received on July 17, 2015. We then sent the proposals for review by subject matter experts outside Minnesota, often outside the United States, to obtain fully impartial comments. External reviewers were asked to comment on the novelty of the research, the rigor of the proposed methods, the qualifications of the team to complete the



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research, and the potential impact of the research on the management of terrestrial invasive species. Final comments on all proposals were received in September 2015. Project teams were asked to modify proposals and address external reviewers' comments.

Revised proposals were received in October 2015 and were recommended for funding. A detailed overview of the sub-projects is provided below. These selected proposals are to be considered sub-projects with respect to this work plan. Detailed sub-project work plans and budgets will be submitted to LCCMR for review and approval. The details about each sub-project work plan will be included as attachments to this document. Regular activity updates and budget updates will be provided by sub-project leaders and MITPPC to LCCMR. This overarching work plan and budget will be updated accordingly to include general progress of the Center and a synopsis of activities completed by each sub-project. The budget updates for this overall work plan will provide summaries of expenditures (by budget line item) for each sub-project. Detailed sub-project reports and associated budget updates will be prepared by investigators in cooperation with the MITPPC Director and Associate Director. MITPPC will provide LCCMR with updates to this overall work plan and each sub-project as a single packet.

Questions have been posed by LCCMR staff regarding the relationship between two recommended projects and former LCCMR appropriations for similar lines of research. The first question is about "Early Detection, Forecasting, and Management of *Halyomorpha halys*." This project differs from previously funded BMSB projects by greatly expanding the monitoring effort by engaging staff from the Minnesota Integrated Pest Management (IPM) program and the Minnesota Independent Crop Consultants. The project will use several monitoring devices, such as pheromone traps and the Minnesota black-light trap network. The project will also utilize direct observations by crop consultants and on-farm observations by growers. Additionally, all observations will be facilitated by the new BMSB App. This new app will include the top 10 stinkbugs in Minnesota and will facilitate rapid data entry and checking to the google-based EDD maps.

The second question is about "Cover it Up! Using Plants to Control Buckthorn." The primary goal of the 2010 ENRTF appropriation, "Healthy Forests to Resist Invasion" was to identify forest characteristics that would be effective deterrents to invasive plants. The research demonstrated that "preventive environmental care" was a line of research worth further exploration. The studies showed that buckthorn was most prevalent in sites with little leaf litter, where there was an abundance of seed, and in which native plant diversity was low. The currently proposed research picks up this finding to determine whether post-removal plantings of native seed and plants to create an abundance of dense cover will help with longer-term and cost-effective buckthorn control.

Note that the balance of funds from Activity 1 will be held in the reserve line item for future allocation to one or more additional sub-projects.

### **Activity Status as of January 31, 2016:**

Sub-workplans have been approved by LCCMR. Work is currently underway with finance and Sponsored Project Administration to establish child accounts. LCCMR approval dates for each sub-project are provided in the sub-project updates.

### **Activity Status as of July 31, 2016:**



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Work on the four sub-projects began in early 2016. Initial activities focused on the hiring of post docs and students. All sub-projects have initiated research. Overviews of those accomplishments are provided below in status updates to Activity 2 subprojects. Detailed descriptions are provided in status updates to the sub-project work plans.

In May 2016, LCCMR staff contacted MITPPC for its thoughts on several proposed terrestrial invasive species proposals before the commission. MITPPC submitted those comments addressing only the research components of those proposals. The terrestrial invasive species prioritization was not yet completed at the time of ENRTF FY 18 proposal deadline nor at the time of Dr. Venette's comments on those proposals. A potential conflict of interest was declared by Center director Rob Venette, who is a co-PI on three of the proposals that were before the commission. The MITPPC did not have a proposal under consideration in the ML 2017 ENRTF recommendations, but given the ENRTF funding history of the MITPPC, we are cognizant of the potential for conflict of interest to arise when a Center staff is a co-PI on a project under funding consideration by the Commission.

### **Activity Status as of *January 31, 2017:***

The four funded projects continue to make significant progress on their projects. Overviews of those accomplishments are provided below in status updates to Activity 2 subprojects. Detailed descriptions are provided in status updates to the sub-project work plans.

### **Activity Status as of *July 31, 2017:***

The four research projects made significant gains over the preceding six months. Overviews of those accomplishments are provided below in status updates to Activity 2 subprojects. Detailed descriptions are provided in status updates to the sub-project work plans.

### **Activity Status as of *January 31, 2018:***

The four research projects made significant gains over the preceding six months. Overviews of those accomplishments are provided below in status updates to Activity 2 subprojects. Detailed descriptions are provided in status updates to the sub-project work plans.

### **Activity Status as of *July 31, 2018:***

All four sub-projects continue to make significant progress as described below in the summaries of sub-project activities.

### **Activity Status as of *January 31, 2019:***

Details on each sub-project can be found in the summaries below.

### **Activity Status as of *July 11, 2019:***

Significant progress has been made by each of the four sub-projects under this appropriation. Sub-project 3 has completed its work and is preparing for the final report. Sub-projects 2 and 4 have completed many of their outcomes and are in the process of analyzing and synthesizing their work for publication and dissemination. Details on each project may be found in the summaries that follow.

### **Activity Status as of *January 31, 2020:***

### **Activity Status as of *July 31, 2020:***



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#### ACTIVITY 2 SUB-PROJECTS

**SUB-PROJECT 1:** Novel Diagnostic Tools for Rapid and Early Detection of Oak Wilt

**Project Manager:** Dr. Abdenour Abbas

**Description:** This project will develop new assay technologies for rapid and early detection of the invasive fungus *Ceratocystis fagacearum*, causal organism of oak wilt.

**Sub-project work plan approval date:** January 12, 2016

**Sub-project budget:** \$274,286

<b>Outcome – Activity 1: Selection and Identification of DNA aptamers for <i>Ceratocystis fagacearum</i> (oak wilt)</b>	<b>Completion date</b>
Development of a chemiluminescence assay for DNA detection	3/30/2016
Proof-of-concept of the new detection technology with <i>Ceratocystis fagacearum</i>	12/30/2016
<b>Activity 2: Application of the new assay for the detection of oak wilt</b>	<b>Completion date</b>
Demonstration of the detection of oak wilt on real samples using the new assay	5/30/2017
Characterization of the analytical parameters of the new assay	7/15/2017
<b>Activity 3: Development of a rapid cell and DNA extraction methods from wood chips and shavings</b>	<b>Completion date</b>
Demonstration of rapid separation of fungal cells from wood chips	12/31/2019
Demonstration of rapid extraction of DNA from fungal cells	12/31/2019

#### **Sub-Project Status as of January 31, 2016:**

The sub-work plan was approved by LCCMR on January 12, 2016. Efforts are now underway to establish a child account and to begin the research.

#### **Sub-Project Status as of July 31, 2016:**

A postdoctoral research associate (Dr. Renu Singh) was hired to work on the identification of new aptamers for *Ceratocystis fagacearum*. The identification of the aptamers is still in progress and will likely need two more months from the completion date indicated in the work plan (July 30, 2016.) However, the project does not need extension as other objectives have already been reached. This includes the development of new rapid method for the immobilization of the fungus on solid surfaces. This step is important for the detection of new DNA aptamers for the fungus of interest.

Principal investigators, Renu Singh and Abenour Abbas prepared a manuscript for publication related to the project, “Facile and rapid immobilization of microorganisms.” The team will present on research at the Upper Midwest Invasive Species Conference in October 2016.

Additional funds were leveraged for this project from a UMN grant-in-aid program (\$45,552) and from the Minnesota Turf and Grounds Foundation (\$10,000)



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**Sub-Project Status as of January 31, 2017:** This project is fine-tuning its focus on the detection of fungal DNA rather than fungal cells that require aptamers or antibodies. This change does not impact the outcomes nor the timeline for the project.

**Sub-Project Status as of July 31, 2017:**

Two of the four outcomes have been completed in this project: the development of microbial separation method from wood chips and the development of the rapid detection system. Both elements are the topics of two peer-reviewed academic publications (in progress.)

**Activity Status as of January 31, 2018:**

The project aims at developing a field-testing platform for rapid detection of oak wilt caused by the fungus *C.fagacearum*. Over the last year, we have developed a technology for fungi and fungal DNA extraction from wood chips and another technology for rapid DNA detection using chemiluminescence. We are currently working on combining these two technologies to develop a portable DNA extraction and detection platform, to enable field detection of oak wilt within one hour using a hand-held luminometer.

**Activity Status as of July 31, 2018:**

The MITPPC project “*Novel Diagnostic Tools for Rapid and Early Detection of Oak Wilt*” started in June 2016, with the purpose of developing a new technology for rapid and field detection of *Ceratocystis fagacearum*, the causal agent of Oak wilt. Early diagnosis of infected trees will help stop the spread of the disease and minimize the inherent cost for municipalities, counties, private property owners and the State. While conventional methods for oak wilt detection are costly, time-consuming or labor-intensive, the most commonly used immunoassays are not commercially available for oak wilt fungus, because of a lack of specific antibodies.

Within two years of research, we have developed and successfully tested 3 technologies: (1) a rapid method to separate *Ceratocystis fagacearum* fungal cells from wood chips obtained from infected trees, (2) a technology that enables the extraction and purification of *Ceratocystis fagacearum* DNA within 15 min directly from wood drill shavings of infected trees, and (3) a bioassay technology that enables DNA identification in less than 30 min using a hand-held reader. The three technologies offer a cheaper and faster alternative than commercially available tools, while offering equivalent or better performance. With some additional work, two of the developed technologies can be combined to offer a portable DNA extraction and identification platform for field detection of oak wilt.

**Activity Status as of January 30, 2019:**

The major accomplishments of this project relative to project objectives include:

Demonstrate the reproducibility of a new method of to extract fungal DNA from wood chips from wilted red oak and other species (bur and white oak): We have demonstrated that new DNA extraction method is reproducible and works well with red, bur and white oak. Our hypothesis is that the problems previously encountered with DNA-detection of the oak wilt pathogen in white and bur lie mostly with the spotty distribution, therefore sampling errors, not with the substances in the wood or any potential inhibitors. We believe that if we can find good positive samples of white and bur oak this coming summer with confirmed cultures, the techniques should work for them, too. Maybe bur and white should have more sampling locations and clearly streaking wood before use.



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Demonstrate the sensitivity and specificity of a new DNA detection method using chemiluminescence: Over the last two months, we synthesized new nanoparticles functionalized with newly designed DNA probes to improve the specificity of the assay to detect DNA from the oak wilt pathogen. We have also demonstrated that the new assay can differentiate between target and non-target DNA. However, the specificity of the assay still needs improvement. We have moved from detecting synthesized DNA targets to working directly on the detection of DNA extracted from pure cultures of the oak wilt pathogen. The first results obtained are encouraging and we expect the completion of this activity by the end of February. A demonstration of the new assay to detect DNA from the oak wilt pathogen extracted from wood chips is planned for March 2019.

Overall, there is a delay of one month due to a change in project personnel but the results obtained over the last two months are highly encouraging, and we expect to reach the project objectives without time or budget extension.

### Activity Status as of July 31, 2019:

In phase I and II of this project, we developed a novel nanoparticles enhanced chemiluminescence (NEC) assay for the fungal pathogen that causes oak wilt, *Ceratocystis fagacearum* (*C. fag*). The major accomplishments in Phase II include the confirmation of previous results and optimization of various assay parameters, including luminol concentration, nanoparticles size (3-5 nanometers) and redesign of DNA probes. We will be conducting field testing of *Ceratocystis fagacearum* (*C. fag*) this summer. We unexpectedly discovered that under slightly different test conditions (pH) the technology can also detect the presence of *Tubakia iowensis*, the causal agent of bur oak blight. at a limit of detection of 200 femtomolar (very low concentration.) The results suggest that we can detect both *C. fag* and *T. iowensis* using a single probe by simple buffer assignment.

### Sub-project status, January 31, 2020:

#### Final report summary:

**SUB-PROJECT 2:** Early Detection, Forecasting, and Management of *Halyomorpha halys* (Brown Marmorated Stinkbug)

**Project Manager:** Dr. William Hutchison

**Description:** A multi-stakeholder, comprehensive approach for early detection and forecasting, via phenology and climate change models, to improve the timing of management strategies for the Brown Marmorated Stinkbug

**Sub-project budget:** \$632,375

**Sub-project work plan approval date:** January 12, 2016

Outcome – Activity 1: Early Detection, distribution (EDD) and mapping of BMSB distributions	Completion date
Develop, field test EDD system for MN, including modified BMSB App and website	12/31/16
Trap procurement; establish “dual-lure” pheromone & light trap network in MN	12/31/19
Collate the EDD data and maps for independent validation of models for MN (see	12/31/2019



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<b>Outcome – Activity 1: Early Detection, distribution (EDD) and mapping of BMSB distributions</b>	<b>Completion date</b>
Activity 2 for this sub-project)	
<b>Outcome – Activity 2: Develop and validate biological parameters for BMSB response to temperature for improved pest management via predictive models</b>	<b>Completion date</b>
Complete BMSB developmental time studies (lab, screen house), fecundity studies	12/31/2018
Develop, assess alternative degree-day phenology models for forecasting	12/31/2018
Complete comprehensive overwintering & summer phenology models; interface with Activity 3 of this sub-project	8/31/2019
Prepare detailed forecasts and maps of brown marmorated stink bug overwintering potential across Minnesota	5/30/2020
<b>Outcome - Activity 3: Understand the role of climate change on BMSB population dynamics using degree-day and cold-stress models, and assess short-term and long-term impacts</b>	<b>Completion date</b>
Use the Weather Research and Forecasting (WRF) model to dynamically downscale climate output from the first set of three global climate change models determined to perform well within the region containing Minnesota for the historical period (1970-1999) and from 2005-2100 for two emission scenarios.	12/31/16
Statistically downscale CMIP5 climate output from 10 CMIP5 models, determined to perform well over both the eastern and middle US. Compare climate analogs between eastern US and MN. Provide data to support Activity 2 of this sub-project, to predict suitability of environment for BMSB.	12/31/2017
Use the Weather Research and Forecasting (WRF) model to dynamically downscale climate output from the second set of three global climate change models determined to perform well within the region containing Minnesota for the historical period (1970-1999) and from 2005-2100 for two emission scenarios.	12/31/2017
Use Weather Research and Forecasting (WRF) model to dynamically downscale climate output from the third set of four global climate change models determined to perform well within the region containing Minnesota for the historical period (1970-1999) and from 2005-2100 for two emission controls.	<del>12/31/2018</del> 5/30/2020

**Sub-Project Status as of January 31, 2016:**

The sub-workplan was approved by LCCMR on January 12, 2016. Efforts are now underway to establish a child account and to begin the research.

**Sub-Project Status as of July 31, 2016:**

Good progress has been made with Activity 1, the mobile app to document BMSB sightings to the EDD map system. The project team finds that additional photography of similar common stinkbugs native to Minnesota is needed. A launch date of fall 2016 is anticipated. A post-doctoral associate, Dr. Byju Govindan, was hired in May 2016, to work on Activity 2. Minor changes to the timeline to accommodate the late start are being requested and to gather additional data. The dynamical and statistical downscaling (Activity 3) is making progress; the second post-doctoral associate is hoping to be on-board in early fall 2016. Work at the Minnesota Supercomputing Institute commenced with one historical and



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future model complete. Finally, Activity 3 has fine-tuned the description of the outcomes and added an additional outcome to better describe this aspect of the project.

### **Sub-Project Status as of *January 31, 2017:***

This project is making projects under each activity area. The BMSB identification and detection mobile application is near completion and the overwintering and fluctuating temperature studies include both current and future climate scenarios.

### **Sub-Project Status as of *July 31, 2017:***

Excellent progress was made in all of the activities. Researchers are continued with their analysis of the first year data and conducted additional experiments, relevant to activities one and two. Additionally, the third activity saw progress in the development of the climate models to better understand the future conditions under which BMSB might expand.

### **Sub-Project Status as of *January 31, 2018:***

The Brown Marmorated Stink Bug (BMSB), *Halyomorpha halys*, is recent invasive species in the U.S. that is native to Asia. BMSB was first detected in the U.S. in the mid-1990s, but was not found in Minnesota until 2010. As with many stink bug species, BMSB has a wide host range, attacking >250 plant species, including many fruit, vegetable and field crops of economic value. The bug is also a severe nuisance pest, as it often invades homes, commercial buildings and other structures during autumn in search of overwintering sites. Given the previous experience of entomologists in the U.S., the primary crops at risk in Minnesota include corn, soybean, sweet corn, tomato, wine grapes, strawberry, and raspberry. Where BMSB has become established, significant increases in economic losses and pesticide use have greatly disrupted crop production. The focus of our project includes three broad objectives: a) development of new monitoring tools for early, consistent detection of BMSB in Minnesota (via new traps and a new app, the “Midwest Stinkbug Assistant”) to help farmers, crop consultants and homeowners correctly identify BMSB; b) conduct new studies of BMSB population dynamics and develop forecasting models, to understand how and where this pest is invading and colonizing the state; e.g., to determine the number of generations per year relative to the onset of winter; and c) to compare validated forecasting models of BMSB to current and future climate conditions. Advancements in each of these areas will contribute to improved management programs while minimizing unnecessary insecticide use.

### **Sub-Project Status as of *July 31, 2018:***

During the past 6-month period, substantial progress continued overall, and primarily for Activities 1-2. For Activity 1, use of the new Dual-lure system for BMSB, continued to provide early spring trap catches of adults – this year by mid-April, which has been predicted by the early Degree-day models (Rutgers; Ann Nielsen et al). These results have also been confirmed with our MDA collaborators (i.e., Angie Ambourn) in Minnesota. The dual lure and sticky trap system is also working well, and was verified by another multi-state, national USDA project that one of us (Hutchison) is collaborating with. Another significant outcome for this activity was the completion of Version 1.0 for the BMSB App. This was completed, following a new collaboration with Purdue University, initiated in 2017; the app was



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publically released in April, 2018, with several media outlets providing additional marketing help with numerous popular press articles (including MN Soy Newsletter, AG-WEB, etc.).

Activity 2 was again led by Post-doctoral Assoc. Byju Govindan, and substantial progress was made in analyzing data from all population, life table studies for egg-adult developmental time, survival and fecundity (egg-lay). Our analysis, with 2 years of data, suggests that BMSB (using the MN-acclimated strain) has the ability to complete a partial the 2<sup>nd</sup> generation (F2) faster than the 1<sup>st</sup> (F1) in terms of degree-days (DD >14.2C; also known as the “heat units” necessary for insects to complete development. The average DD requirement, using the previously published threshold of 14.2C (Nielsen et al. 2008), indicated DDs necessary for development from egg-adult averaged 544.2 for the 1<sup>st</sup> generation (very similar to Nielsen et al), but only 411.4 for the 2<sup>nd</sup> generation. We also checked for the possibility of a statistical artifact in how DDs are calculated, but using the sine-wave model, this was not an issue. Also, one of our lab studies is supportive of this; when BMSB were held at 27C (constant), egg-adult development was faster for the MN-acclimated BMSB vs. published results from PA (Nielsen et al.), i.e., with the MN bugs requiring 80 fewer DDs to complete development (could be 5-12 days under field conditions). However, the “down-side” of this partial generation, is that only about 12 to 18% of the late (5<sup>th</sup>) instar nymphs were able to molt to the adult stage, and thus have the ability to overwinter (only adults can overwinter successfully). This is due to the gradual cooling from Sept 15 to Oct 15, where fewer degree-days (or heat units per day) are available to the insects to reach maturity. There are interesting trade-offs for this species as it continues to adapt to this northern “edge” of its known range. We are still analyzing the volumes of data to better understand this, and indeed this will be one of the questions we can ask with the more detailed simulation model of BMSB dynamics. Byju has made very good progress in completing a BMSB model, and this will soon be coupled with the climate change models from Dr. Snyder’s group (Activity 3), in 2018-2019.

Regarding Activity 3, less productivity was achieved, due to delays in moving the large climate data bases to a new server. These issues will be resolved during the next 6 month period this fall, 2018. Finally, the team participated in several outreach activities with farmers and crop consultants.

### **Sub-Project Status as of January 31, 2019:**

During the past 6-months, excellent progress continued with all three activities. For Activity 1, the new Dual-lure/panel trap system for BMSB provided much earlier dates of first catch (May 14<sup>th</sup>) than the pyramid trap in previous years (usually mid-June). These results were pooled with data from 18 other states for a journal publication. In brief, we observed a major increased in the total numbers of BMSB’s captured in 2018 – from 307 BMSB in 2017 to 1,637 in 2018; BMSB has now been detected in 19 counties. The results have also been confirmed with our Minn. Dept. of Agric. collaborators (i.e., Angie Ambourn). In addition to our trapping data, the new Midwest Stinkbug App (see Star Tribune web link) was downloaded by ~588 users as of Nov. 2018.

Activity 2 was again led by Post-doctoral Assoc. Byju Govindan, and progress continued with analyzing data from all screen-house (“tents” for ambient temperature exposure), and lab-based developmental time studies for egg-adult development, and fecundity (egg-lay). Our analysis suggests that the MN-acclimated BMSB strain has the ability to *complete a partial the 2<sup>nd</sup> generation* (F2) faster than the 1<sup>st</sup> (F1) in terms of degree-days (DDs, also known as “heat units” necessary for insects to complete development). At least one trade-off has been identified in these studies, which is useful in understanding the ongoing adaptation of BMSB under MN conditions. First, the additional heat (DDs)



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that can occur in MN summers, can lead to faster developmental times of the summer generation. Secondly, however, warmer temperatures (e.g., >86F), will result in reduced egg-lay by surviving females by ~25%. Taken together, the proportion of eggs laid by summer females, results in about 1.9-15.5% reaching the adult stage in autumn –those that can successfully overwinter. The results have profound implications in altering the BMSB population dynamics on crops in a changing climate. This work has led to the development of new DD forecasting model for 2019 that will be released in the spring of 2019, via several Extension IPM web sites, including VegEdge and FruitEdge, for commercial growers. The process-oriented, detailed population modeling work is underway, and scheduled for completion in 2019.

Activity 3 outcomes, led by Drs. Snyder and Twine, are now complete except for Outcome 2, the statistical downscaling of climate model data. This includes dynamically downscaling 9 climate models for four time periods – a historical period, and near, mid, and late century projections for two emission scenarios. Although we initially had a delay with data processing via the Supercomputer Institute (UMN), the issues have been resolved. Data has all been processed and the modeling group is currently working with the BMSB modeling group to transfer data to them for their simulations. We have begun work on the statistical downscaling efforts (Outcome 2) that are being run over North America at 25-km resolution.

Outreach: Although fewer outreach activities were conducted during the past 6 months, these were substantial, with the Star Tribune article in August 2018, and a new BMSB Pest Profile, significantly revised and updated for farmers, including translations in *Hmong*, *Spanish* and *Somali*.

### **Sub-Project Status as of July 11, 2019:**

Activity 1: all objectives are now complete, including continued additions of the new BMSB infested counties to EDDMaps system; use of the Midwest Stink Bug Assistant app and trap design comparisons completed. Activity 2: all data collection is complete for objectives 1 and 2; data continue to be analysed; 3 manuscripts are in progress, with the first paper to be submitted by end of June. For objective 3, the detailed simulation model is on track for completion during the summer, with simulations compared to global climate change scenarios to begin summer with Dr. Snyder and team. Activity 3: some progress has been made with both dynamical and statistical downscaling of the high-resolution climate and global climate change data sets for Minnesota and the Midwest region, and new climate data will be available this summer to couple with the BMSB simulation model to assess long-term impacts by BMSB. This activity suffered a small setback when the postdoc on the project was called away unexpectedly for three months. Qualified replacement staff could not be identified in this short time. The postdoc has returned and progress on the project has resumed.

### **Final report summary:**

**SUB-PROJECT 3:** Climate Change and Range Expansion of Invasive Plants

**Sub-project manager:** Dr. David Moeller

**Description:** The project will develop and validate predictive distribution models of high priority invasive species under current and future climates. This work will improve detection and establish priorities for eradication and management.

**Sub-project work plan approval date:** January 12, 2016

**Sub-project budget:** \$209,263



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<b>Outcome - Activity 1: Predicting invasion under current climate</b>	<b>Completion date</b>
Maps predicting current distribution of 11 invasive plant species	6/30/2019
Maps predicting potential distribution of 11 invasive plant species	6/30/2019
Detailed documentation of plant communities associated with 3 invasive species	8/31/2017
Maps predicting potential distribution that incorporates the biotic environment for 3 invasive species	8/31/2017
<b>Outcome - Activity 2: Predicting invasion under future climate change using regional climate projections</b>	<b>Completion date</b>
Determination of historical rates of range expansion in relation to climate change from 1970-present	11/30/2017
Maps predicting potential distributions under climate change (2041-2080) for 9 invasive plant species	12/31/2017
Maps predicting potential distributions under climate change using downscaled MN-specific climate predictions	6/30/2018
<b>Outcome - Activity 3: Testing and refining species distribution models using targeted field surveys</b>	<b>Completion date</b>
Detection of new populations of 3 invasive plant species in the current geographic area of occupancy	4/30/2017
Recommendations for future surveys beyond the current range of those species	6/30/2019

### **Sub-Project Status as of January 31, 2016:**

The sub-workplan was approved by LCCMR on January 12, 2016. Efforts are now underway to establish a child account and to begin the research.

### **Sub-Project Status as of July 31, 2016:**

Since funding began in February 2016, a team of researchers including one postdoctoral associate, Ryan Briscoe Runquist, two UMN undergraduate researchers – one from CFANS and one from CBS and a part-time technician, who has expertise in plant collections management have been hired. This team has undertaken the large task of accumulating and processing records of the locations of nine invasive plant species throughout Minnesota, North America, and across the Earth. Thus far, significant strides have been made by developing a computational pipeline by which records are acquired, filtering for data quality, and vetting locality records for future analyses. This process will not only provide essential information for the species distribution models, but will also provide a centralized database for future research and monitoring in Minnesota. In the process of identifying data sources, close interface the Minnesota Department of Natural Resources and the Minnesota Department of Agriculture staffs was critical. Thus far, locality records have been acquired and curated for three invasive plant species: *Celastrus orbiculatus* (Oriental Bittersweet), *Cynanchum louiseae* (Black Swallow-wort), and *Humulus japonicus* (Japanese Hops). Maps that show the distribution of the locality points for each species (14,395 for *C. orbiculatus*, 2,582 for *C. louiseae*, 1,518 for *H. japonicus*) are given in the update to the associated sub-project workplan. Work was initiated on an additional three species using the newly developed pipeline.



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Presentations and Outreach in which our work was discussed

MITPPC Advisory Board Meeting

Meeting with MN DNR (Laura Van Riper and Andy Holdsworth)

Meeting with MN DA (Monika Chandler)

Meeting with an expert on species distribution modeling (Vincent Eckhart)

Presentation to Governor Dayton's staff during a review of funding requests from UMN (including renovation of Moeller and Tiffin laboratory) where research in our labs was described

Presentation to Minnesota Legislators and their staff during a review of funding requests from UMN (including renovation of Moeller and Tiffin laboratory) where research in our labs was described

### **Sub-Project Status as of January 31, 2017:**

The project team's main activities refined the computational pipeline for acquiring records, filtering the data quality, and vetting locality records for future analysis. Data was gathered for all invasive plant species being studied. Additionally, plant community surveys were conducted to assist with the distribution models.

### **Sub-Project Status as of July 31, 2017:**

Project researchers made significant progress on the building the current climate model for the nine species being studied. The species distribution models (SDMs) will be critical to understanding the areas of greatest possible distribution of these invasive plants. The research team will focus its future efforts on SDMs for future climate conditions.

### **Sub-Project Status as of January 31, 2018:**

Invasive plant species are a significant and growing threat to agriculture, the economy, and natural spaces. How we manage these species already has and will continue to have important ecological and economic repercussions, such as the increased use of pesticides and the loss of biodiversity and native habitats. In our project, we are interested in understanding how environmental factors may influence species that are problematic and invasive in the continental United States to expand their ranges into Minnesota. We are building correlative species distribution models using machine-learning techniques for species that are potential invasion threats. The species being investigated include: Palmer Amaranth, Dalmatian Toadflax, Black Swallowwort, Narrowleaf bittercress, Common Teasel, Oriental Bittersweet, Japanese Hops, and Brown Knapweed. To build these models we are using multiple sources of climatological and other sources of environmental data and then using the models to predict the potential suitability of Minnesota habitats for invasion under current climatological conditions and under different future climatological scenarios. In preliminary models of all species, we have found that although there is some small variability among species, areas in Southern Minnesota and some in Central Minnesota are at greatest risk of invasion under current climate conditions and that this result is robust to the use of different climatic datasets and model building techniques. We have also found that predictions of habitat suitability under future climate projections increase for much of Minnesota and more areas of the state are at greater risk of invasion.

### **Sub-Project Status as of June 30, 2018**

During the past six months, work was conducted by the core team, including the PIs (Moeller and Tiffin) and a post-doctoral researcher, Ryan Briscoe Runquist (Ph. D., U. California Davis). Our main activity during this period has been to complete model generation and projection for current and future



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distributions of the eight species within the scope of work (Grecian Foxglove was excluded due to the paucity of records). For all species, we explored the variation in model building techniques; we incorporated information about species spread and spatial autocorrelation; we also generated markdown documents with code to regenerate the models and projections or for use in future analyses of other species. Using our models, we have projected current and future distributions for all eight species. For future climates, we downloaded and processed data for 2050 and 2070 for 5 GCMs (CCSM4, GFDL-ESM2G, IPSL-CMSA-LR, MIROC-ESM, and MRI-CGCM3) that performed well for North America when assessed by CMIP5. We have also generated joint species distribution models for three species in MN using the detailed DNR releve data. During this period, we finished a manuscript on Palmer Amaranth and submitted it for peer review to *Biological Invasions* and are awaiting a decision. We have also begun to prepare a manuscript that included the other SDMs and JSDMs with current plans to submit to *Diversity and Distributions*. We have also begun to prepare guidelines on how to interpret findings for projections into MN. Two additional species were added to this research and work began to gather initial data necessary to build the SDMs.

### **Sub-Project Status as of January 31, 2019:**

In the past six months, the core team, including the PIs (Moeller and Tiffin) and a post-doctoral researcher, Ryan Briscoe Runquist (Ph. D., U. California Davis) and a new graduate student in the UMN Plant and Microbial Biology Graduate program, Thomas Lake, have continued to prepare products for presentation and have met the project outcomes for the past six months. The team's first publication has been accepted for publication in the open-access journal, *Scientific Reports*. The paper is titled "Species distribution models throughout the invasion history of Palmer amaranth predict regions at risk of future invasion and reveal challenges with modeling rapidly shifting geographic ranges". This publication is peer-reviewed and will be freely available for the scientific and management communities. Dr. Briscoe Runquist also presented the results of this paper at the UMISC meeting in MN this past October. Additionally, we are preparing two additional manuscripts for publication in academic journals and preparing a document with Minnesota-specific species distribution projections for use by management professionals. The academic publications will include the current and future projections for all of the species in the scope of work and investigations of methodological considerations for predicting invasion risk. The management document, which is currently in preliminary draft form and being revised, will be made available through the MITPPC and will present assessments of potential invasion risk for areas of Minnesota under current and future climate conditions.

### **Sub-Project Status as of July 11, 2019:**

Over the last six months, the project team has completed all of the goals and objectives as laid forth in our original proposal, "Climate change and range expansion of invasive plants", as well as the aims of the amendment to our proposal starting in July 2018. We have successfully produced invasive species models for the ten species for which we were able to attain reliable data and projected the models into current and future climates in Minnesota. We have produced a PDF document that presents our model projections and interpretation of potential habitat suitability for all of the species. This document can be used by the MITPPC and other agencies and stakeholders within Minnesota and the Upper Midwest when trying to assess climate related risk for the species of interest. Our first publication from the project, "Species distribution models throughout the invasion history of Palmer amaranth predict regions at risk of future invasion and reveal challenges with modeling rapidly shifting geographic ranges", was published in the open access journal, *Scientific Reports*. This work was also presented as a



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poster at the Palmer Amaranth conference held in January 2019 by the MITPPC. We are currently preparing two additional manuscripts for submission by late summer/early fall on the SDMs for the remaining nine species. The project has not met any major obstacles over the past six months.

**Final report summary:** The final report will be submitted by August 15, 2019 per LCCMR instructions.

### **SUB-PROJECT 4:** Cover it Up! Using Plants to Control Buckthorn

**Project manager:** Dr. Peter Reich

**Description:** Management tools will be developed to limit buckthorn re-colonization following its removal, by identifying cost-effective methods of establishing dense cover of preferred plant species that will suppress buckthorn regeneration.

**Sub-project work plan approval date:** January 20, 2016

**Sub-project budget:** \$327,000

<b>Outcome - Activity 1: Pairing non-mechanical buckthorn removal with post-removal seeding and planting to suppress buckthorn recovery</b>	<b>Completion date</b>
Census performance of buckthorn, planted species, and native volunteers	8/31/2016
2. Statistical analyses and publication-ready manuscripts completed	2/1/2019
<b>Outcome - Activity 2: Pairing mechanical buckthorn removal with post-removal treatments</b>	<b>Completion date</b>
Identify and establish sites and plots	11/30/2016
Plant seeds and juveniles in all plots	7/31/2017
Census performance of buckthorn, planted species, and native volunteers	6/30/2018
Statistical analyses and publication-ready manuscripts completed	12/31/2019
<b>Outcome - Activity 3: Testing buckthorn response to dense plantings of juvenile trees</b>	<b>Completion date</b>
Plant seeds and seedlings in all plots	6/30/2017
Census performance of buckthorn, planted species, and native volunteers	7/31/2018
Statistical analyses and publication-ready manuscripts completed	8/31/2018

### **Sub-Project Status as of January 31, 2016:**

The sub-workplan was provisionally approved by LCCMR on January 20, 2016. Additional details are being provided to LCCMR about the use of funds for Equipment/Tools/ Supplies. Efforts are now underway to establish a child account.

### **Sub-Project Status as of July 31, 2016:**

Two post-doctoral associates were hired in May 2016, Drs. Peter Wragg and Michael Schuster, and have begun the experimental research, including data analysis and publication writing. Given the late hiring date, activity timelines will need adjusting and outcomes reordered and a minor change in the budget, shifting funds from personnel to travel. Additionally, after careful survey of research plots, changes were made to the seeding and planting activities and timing at a few of the sites. Principle investigators believe that these small changes greatly improve the rigor of the research findings.

### **Sub-Project Status as of January 31, 2017:**



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The research team surveyed established buckthorn sites, planted species, and volunteers in two experimental plots. The team also identified sites for experimental plots and planted buckthorn seedlings at one site in northern Minnesota.

### **Sub-Project Status as of July 31, 2017:**

All project objectives are progressing according to schedule. Statistical analyses for Activity 1 are ongoing. Field activities for Activity 2 with summer 2017 completion dates have been completed and measurements pertaining to Activity 2 have commenced. A new cohort of seeds were planted at the IDENT experiment for Activity 3 and measurements of last year's seedlings and resource availability are ongoing.

### **Sub-Project Status as of January 31, 2018:**

Common buckthorn is an invasive shrub or small tree that displaces native plants, degrades wildlife habitat, and inhibits human use of forests. In Minnesota alone, millions of dollars are spent each year to remove buckthorn and restore affected areas. However, many efforts to remove buckthorn only yield temporary relief because removing buckthorn creates an ecological vacuum that is often more easily filled by buckthorn than by native species. Cover It Up aims to develop strategies that increase the abundance and diversity of native plants and enhance forests' ability to prevent buckthorn from coming back after it has been removed. In partnership with over a dozen public, private, and non-profit organizations, we are testing the ability of diverse mixtures of native species to suppress buckthorn in areas where buckthorn has been removed. At each of six experimental sites around Minneapolis/Saint Paul, we seeded large plots with a mixture of 35 grass and wildflower species in February 2017. Since then, we have been monitoring the performance of buckthorn and native species both with and without follow-up herbicide treatment of buckthorn. Additionally, we are monitoring the performance of buckthorn in smaller plots planted with either a mixture of four shrub species, a Maple-Fir mixture, sedges, or ferns. This work, combined with our monitoring of buckthorn in existing forest experiments, has already characterized how deep shade can slow buckthorn growth, and will provide further insights into the effectiveness of using native plants to suppress buckthorn in the coming years.

### **Sub-Project Status as of July 31, 2018:**

All project objectives are progressing according to schedule. Soil analyses for Activities 1 and 2 were completed in spring 2018. Work is proceeding on statistical analyses and a manuscript for Activity 1. Field activities for Activity 2 (maintaining experiments and measuring effects of planting and planting plus herbicide treatments on buckthorn regeneration) are ongoing. One manuscript based on Activity 1 and two manuscripts based on Activity 2 are in progress. For Activity 3, measurements of buckthorn growth in varying light levels are ongoing; statistical analyses are at an advanced stage and a manuscript is in preparation. Two students were hired to assist with measurements May-August 2018.

### **Sub-Project Status as of January 31, 2019:**

All project objectives are progressing according to schedule; we have requested a six month no-cost extension until December 30, 2019 to complete analysis and writing about this research project. A manuscript detailing the conclusions of Activity 1, led by Wragg, is undergoing internal review. Extensive field work associated with Activity 2 concluded in November 2018 and three manuscripts detailing the findings of that activity are in preparation (one led by Wragg and two led by Schuster). Measurements of buckthorn performance in Activity 3 concluded in October 2018 and a manuscript detailing the findings



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of that activity, led by Schuster, is undergoing internal review. A paper evaluating the existing research on revegetation efforts like those being tested by Cover It Up, led by Schuster, was published in the *Journal of Applied Ecology*. The research team made presentations to over 500 people throughout the past six months.

### **Sub-Project Status as of July 11, 2019:**

All field and lab work has been completed according to schedule. A manuscript detailing the conclusion of Activity 1, led by Wragg, is ready for submission. Four manuscripts arising from Activity 2 are in various stages of preparation: a manuscript led by an undergraduate intern (Anfang) is ready for submission and another led by Wragg is nearing completion. Two additional manuscripts based on data collected during Activity 2 (herbicide efficacy and phenology) are planned for the near future to be led by Schuster. A manuscript detailing findings from Activity 3 led by Schuster is ready for submission. The research team attended the Gathering Partners Conference in May 2019 and is preparing experimental sites for continued and expanded experimental work as part of a new MITPPC-funded grant (ML 2016, Chp. 186, Sec. 2, Subd. 06a.)

### **Final report summary:**

### **V. DISSEMINATION:**

**Description:** Findings will be shared with agencies and citizen groups so that public information and decision making is based on the best available science. Updates on progress and research results will be disseminated through University of Minnesota, College of Food, Agricultural, and Natural Resource Sciences, and College of Biological Sciences via websites, social media, and publications. Media releases will also be used when warranted. Additionally, findings will be presented at local and national conferences and via peer-reviewed publication and student theses.

### **Status as of January 31, 2015:**

Nothing to report.

**Status as of June 24, 2015:** A website and a Google group have been established for the MITPPC. Both may be accessed at [www.mitppc.umn.edu](http://www.mitppc.umn.edu). The website is intended to provide updates about planned and achieved progress of the Center, to announce RFPs and awards of grants, and to publicize research results. The website will assist a general educational function by publicizing pertinent media releases concerning terrestrial invasive species. The website will also provide process transparency for participants and stakeholders interested in these issues. The Google groups are intended to facilitate communications with our Center Faculty Group and other stakeholders external to the University.

### **Status as of December 1, 2015**

Presentations delivered about the Minnesota Invasive Terrestrial Plants and Pests Center:  
University of Minnesota, College of Food, Agricultural, and Natural Resources Sciences. Graduate and Research Policy Review Committee. St. Paul, MN. Feb 27, 2015.  
Minnesota State Legislature. Senate Hearings. St. Paul, MN. March 26, 2015.  
University of Minnesota, Department of Plant Pathology. St. Paul, MN. March 27, 2015.  
Minnesota Invasive Species Advisory Council. Shoreview, MN. April 22, 2015  
University of Minnesota, College of Food, Agricultural, and Natural Resources Sciences, Faculty Consultative Committee. St. Paul, MN. April 30, 2015.



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University of Minnesota, College of Food, Agricultural, and Natural Resources Sciences.  
College Assembly. St. Paul, MN. May 12, 2015.

University of Minnesota, Research and Outreach Center. Grand Rapids, MN. June 16, 2015.

Terrestrial/Aquatic Invasive Species Extension Staff Development. Minnesota Extension Service. Chaska, MN. August 12, 2015.

Center Advisory Board, Minnesota Invasive Terrestrial Plants and Pests Center. St. Paul, MN. September 21, 2015.

Minnesota Invasive Species Advisory Council. Shoreview, MN. Oct 21, 2015.

Minnesota Department of Agriculture, Plant Protection Division. St. Paul, MN. October 23, 2015.

### **Status as of January 31, 2016:**

Presentations delivered about the Minnesota Invasive Terrestrial Plants and Pests Center:

Minnesota Forest Resources Partnership, Brainerd, MN. December 17, 2015

Research Review 2016, Cloquet Forestry Research and Outreach Center, Cloquet, MN. January 12, 2016

DNR Roundtable. Brooklyn Center, MN. January 15, 2016

### **Status as of July 31, 2016:**

During this reporting period, the MITPPC redesigned its website ([mitppc.umn.edu](http://mitppc.umn.edu)) and established a Twitter (@umnmitppc) to its social media complement. The center also added Google analytics to better understand its website audience.

Presentations delivered about the Minnesota Invasive Terrestrial Plants and Pests Center:

Lessard-Sams Outdoor Heritage Council. February 11, 2016

The Nature Conservancy. March 4, 2016

MNDNR Wildlife section leaders. March 7, 2016

Great River Greening. March 14, 2016

Pheasants Forever. March 16, 2016

CFANS Research Fair. March 23, 2016

Shakopee Mdewankanton. April 5, 2016

Friends of the Mississippi River. April 5, 2016

MN House of Representatives, Environment and Natural Resources Policy and Finance committee. April 20, 2016

Dr. Sally Rockey, Director, USDA's Foundation for Future Agricultural Research. April 25, 2016

Radio interview with WTIP (Grand Marais, MN); July 18, 2016. Archived at <http://www.wtip.org/node/31>

Minnesota Landscape Association. July 26, 2016

Minnesota Invasive Species Advisory Council. July 27, 2016.

### **Status as of January 31, 2017:**

Presentations delivered about the MITPPC include:

Upper Midwest Invasive Species Conference, October 17-19, 2016

Soybean aphid and prairie butterfly symposium, November 15, 2016

LCCMR presentation, November 15, 2016

Soybean Growers Association, November 18, 2016

UMN Research and Outreach Center faculty retreat, November 22, 2016



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### **Status as of July 31, 2017:**

Presentations delivered about the MITPPC and terrestrial invasive species include:  
Minnesota House of Representatives Agriculture Finance Committee, February 23, 2017  
United States Forest Service presentation, March 1, 2017  
Emerald Ash Borer Workshop, May 23, 2017  
Legislative Citizen Committee on Natural Resources, June 7, 2017  
Minnesota Soybean Growers and Promotion Council meeting, July 25, 2017  
Emerald Ash Borer Researchers conference, July 25, 2017

### **Status as of January 31, 2018:**

Presentations delivered about the MITPPC and terrestrial invasive species include:  
UMN North Central Research station, August 24, 2017  
Legislative Citizen Committee on Natural Resources, October 17, 2017  
Rebecca Swenson agricultural communications class, October 30, 2017  
Buckthorn symposium, November 14, 2017  
Women in Agriculture, November 17, 2017

### **Status as of July 31, 2018:**

Presentations delivered about the MITPPC and terrestrial invasive species include:

Venette, R.C.; and Aukema, B.H. 2018. The future of forest pests. St. Croix Forestry Association. Sandstone, MN. February 28, 2018. (Invited co-presentation).

Venette, R.C. 2018. Terrestrial invasive species: moving forward together. ESPM 2021 – Environmental Sciences: integrated problem solving. University of Minnesota. St. Paul, MN. March 29, 2018. (Invited guest lecture).

Venette, R.C. 2018. Terrestrial invasive species. National Advanced Silviculture Program. St. Paul, MN. April 12, 2018. (Invited online lecture).

Venette, R.C.; Palik, B.; Handler, S.; Montgomery, R.; Schneider, I.; and Snyder, S. 2018. Terrestrial invasive species. Minnesota Forest Resources Council – Research Advisory Committee. St. Paul, MN. May 10, 2018. (Invited presentation).

Venette, R.C.; Reich, P.B.; Schuster, M.; and Kee, D. 2018. Cover It Up! Using plants to control buckthorn. Legislative-Citizen Commission on Minnesota Resources. St. Paul, MN. June 5, 2018. (Invited co-presentation).

### **Status as of January 31, 2019:**

Dissemination directly by MITPPC:  
Presentations



## Environment and Natural Resources Trust Fund (ENRTF) M.L. 2014 Work Plan

Cira, T.; Hutchison, W.D.; Pezzini, D.; Koch, R.L.; and Venette, R.C. 2018. Midwest stink bug assistant. University of Minnesota-Extension, Invasive Species Community of Practice. West Central Research and Outreach Center, Morris, MN. September 18, 2018.

Venette, R.C.; and Koop, H. 2018. Priority invasive pests for Minnesota's forests and strategic research investments. 2018 Joint Meeting of the Upper Midwest Invasive Conference and the North American Invasive Species Management Association. Rochester, MN. October 15, 2018.

Venette, R.C.; Christianson, L.; and Abrahamson, M. 2018. Polar plunge for emerald ash borer: is there a place that is too cold. 2018 Joint meeting of the Entomological Society of America, the Entomological Society of Canada, and the Entomological Society of British Columbia. Vancouver, BC. November 13, 2018. (ENRTF funding was not used to pay for this trip.)

Venette, R.C. 2018. MITPPC & weeds: ongoing and upcoming research. Noxious Weed Advisory Committee to the Minnesota Department of Agriculture. Arden Hills, MN. December 19, 2018.

Relaunch of MITPPC's website on January 15. Visit <https://mitppc.umn.edu>.

Development of brochure "Minnesota Invasive Terrestrial Plants and Pests Center: Spotlight on Soybeans." Distribution of 200 copies (100 requested by Minnesota Soybean Research and Promotion Council).

Sub-project #1:

No activity for sub-project 1.

Sub-project #2:

Presentations

Govindan, B.N.; Hutchison, W.D.; Koch, R.; Twine, T.; Snyder, P.; and Abrahamson, M. 2018. Life-table studies and modeling time-temperature relationships in cold-induced mortality of the brown marmorated stink bug (*Halyomorpha halys*). 2018 Joint Meeting of the Upper Midwest Invasive Conference and the North American Invasive Species Management Association. Rochester, MN. October 17, 2018.

Public relations

"Keep an eye out for the brown marmorated stink bug, and yes, there's an app for that" – Minneapolis, Star Tribune article, Aug. 18, 2018.

<http://www.startribune.com/keep-an-eye-out-for-the-brown-marmorated-stink-bug-and-yes-there-s-an-app-for-that/491132461/>



## Environment and Natural Resources Trust Fund (ENRTF) M.L. 2014 Work Plan

Wold-Burkness, S. & W.D. Hutchison. 2018. Brown Marmorated Stink Bug—Pest Profile (updated, Dec. 2018) <https://www.fruitedge.umn.edu/bmsbpp>

Hutchison, W.D. & S. Wold-Burkness. 2018. Brown Marmorated Stink Bug—Pest Profile (updated, Dec. 2018) <https://www.fruitedge.umn.edu/bmsbpp> (Also translated to: Hmong, Spanish, Somali)

Sub-project #3:  
Publications:

Briscoe Runquist RD, Lake T, Tiffin P, Moeller DA. 2018. Species distribution models throughout the invasion history of Palmer amaranth predict regions at risk of future invasion and reveal challenges with modeling rapidly shifting geographic ranges, *Scientific Reports, in-press*

Manuscript *in-prep* to include current and future projections for: Black Swallowwort, Common Teasel, Brown Knapweed, Dalmatian Toadflax, Common Tansy, and Wild Parsnip. This effort is being led by Thomas Lake with support from Dr. Briscoe Runquist and Dr. Moeller.

Manuscript *in-prep* to include current and future projections and JSDMs for: Oriental Bittersweet, Japanese Hops, and Narrowleaf Bittercress. This effort is led by Dr. Briscoe Runquist.

Presentations:

Species Distribution Models of Multiple Stages of Invasion in Palmer amaranth (*Amaranthus palmeri*), *UMISC presentation, R. Briscoe Runquist*

Conversation with Kelsey Wenner, IS coordinator of the Fond du Lac Band of Lake Superior Chippewa, December 2018

Sub-project #4:

Publication:

Schuster, M.J., Wragg, P.D. & Reich, P.B. (2018) Using revegetation to suppress invasive plants in grasslands and forests. *Journal of Applied Ecology*, 55, 2362-2373.

Presentations:

Upper Midwest Invasive Species Conference (October 2018). Oral presentations by Schuster and Wragg (approx. 100 attendees each) and one poster presentation by research technician Anfang.

Saint Croix River Research Rendezvous (October 2018). Oral presentation by Wragg (approx. 100 attendees) and poster presentation by Anfang.

Metropolitan State University Natural Sciences Department seminar (October 2018). Oral presentation by Wragg (approx. 30 attendees).

Hamline University Intro to Biology (September 2018). Oral presentation by Schuster (approx. 60 attendees).

CitSciMN symposium (November 2018). Discussions with Schuster (approx. 30 interactions).

Marine Community Library (November 2018). Oral presentation by Reich (approx. 160 attendees).



## Environment and Natural Resources Trust Fund (ENRTF) M.L. 2014 Work Plan

Status as of July 11, 2019:

Dissemination directly by MITPPC:  
Presentations:

Roundtable discussion with Rep. Betty McCollum, January 18, 2019. University of Minnesota, St. Paul, MN.

Roundtable discussion with Sen. Tina Smith, January 22, 2019. University of Minnesota, Minneapolis, MN.

Venette, R.C. 2019. Cold enough for you, EAB?!? Webinar sponsored by the Minnesota Department of Agriculture. March 4, 2019. St. Paul, MN.

Venette, R.C., H. Koop, & A.C. Morey. Clarity, consistency, and concern: communication in support of an invasive species research center. Invited presentation in symposium "Niche Specialization: Communicating Science to Targeted Audiences". 74<sup>th</sup> North Central Branch meeting of the Entomological Society of America. Cincinnati, OH. March 19, 2019. [presented by A.C. Morey; travel not funded by ENRTF].

Venette, R.C. 2019. MITPPC: Research progress on invasive species. Quarterly meeting of the Minnesota Invasive Species Advisory Council. April 11, 2019. Shoreview, MN.

Roundtable discussion with Rep. Betty McCollum and national US Geological Service Director James Reilly. April 15, 2019. University of Minnesota, St. Paul, MN.

Venette, R.C. 2019. Terrestrial Invasive Species: Impacts on Water. Clean Water Council, June 17, 2019. St. Paul, MN.

Venette, R.C. 2019. A center for research on terrestrial invasive species. Genetic biocontrol of invasive species working group meeting. June 25, 2019. St. Paul, MN.

Venette, R.C. & H. Koop. 2019. Minnesota Invasive Terrestrial Plants and Pests Center (MITPPC): Phase 5. Legislative Citizen Commission on Minnesota Resources. June 26, 2019. St. Paul, MN.

Sub-project #1:  
No activity during this reporting period.

Sub-project #2:  
Publications:

June, 2019: (Activity 1), As part of our research to evaluate improved traps and lures for BMSB monitoring (led by Eric Burkness), we leveraged the results of other states, resulting in the following multi-state publication, submitted for review:



## Environment and Natural Resources Trust Fund (ENRTF) M.L. 2014 Work Plan

Acebes-Doria, A.L., A.M. Agnello, B.R. Blaauw, G. D. Buntin, D.G. Alston, E.H. Beers, J.C. Bergh, T.E. Cottrell, R. Bessin, S. Chen, K.M. Daane, S.Fleischer, C. Guédot, L.J. Gut, G.C. Hamilton, R.Hilton, K.A. Hoelmer, E.C. Burkness, W.D. Hutchison, et al. Season-long monitoring of the Brown Marmorated Stink Bug, *Halyomorpha halys* Stål (Hemiptera: Pentatomidae), throughout the United States using commercially available traps and lures. *Journal of Economic Entomology*. (submitted, 6-4-19).

### Presentations:

Upper Midwest Fruit & Vegetable Growers Meeting, MN Fruit & Veg. Growers Annual Meeting (January 2019.) MN Extension IPM Team, with Hutchison graduate students, hosted an IPM Trade Show exhibit to display live BMSB adults/nymphs to farmers and agric. crop consultants; over 2 days, ~60 growers at exhibit.

First BMSB Degree-day (heat accumulation) forecast model released for farmer, crop consultant use, as early-warning system for stink bug adult emergence from overwintering, and subsequent start of egg-lay in spring (May 2019.) The DD model is one of a suite of insect model forecasts now available at the UMN VegEdge web page: <https://www.vegedge.umn.edu/bmsbdd>

### Sub-project #3.

#### Publications:

Briscoe Runquist, R.D., T. Lake, P. Tiffin, and D.A. Moeller. 2019. Species distribution models throughout the invasion history of Palmer amaranth predict regions at risk of future invasion and reveal challenges with modeling rapidly shifting geographic ranges. *Scientific Reports* 9: 2426  
Manuscript *in-prep* to include current and future projections for: Black Swallowwort, Common Teasel, Brown Knapweed, Dalmatian Toadflax, Common Tansy, and Wild Parsnip. This effort is being led by Thomas Lake with support from Dr. Briscoe Runquist and Dr. Moeller.

Manuscript *in-prep* to include current and future projections and JSDMs for: Oriental Bittersweet, Japanese Hops, and Narrowleaf Bittercress. This effort is led by Dr. Briscoe Runquist.

### Sub-project #4:

#### Presentations:

MITPPC Advisory Board Meeting, February 4, 2019. Presented key research findings to the advisory board.

The Cover It Up team attended the Gathering Partners Conference in May 17-19, 2019 and presented findings from the project to approximately 30 citizen scientists and practitioners.

**Status as of January 31, 2020:**

**Status as of July 31, 2020:**

**Final Report Summary:**

## VI. PROJECT BUDGET SUMMARY:

### A. Preliminary ENRTF Budget Overview:

\*This section represents an overview of the preliminary budget at the start of the project. It will be reconciled with actual expenditures at the time of the final report. See the Sub-Project Budget document for an up-to-date project budget, including any changes resulting from amendments.



## Environment and Natural Resources Trust Fund (ENRTF) M.L. 2014 Work Plan

<b>Budget Category</b>	<b>\$ Amount</b>	<b>Explanation</b>
Personnel:	\$ 949,619	one research faculty PI: \$27,300 (66% salary, 33.8% benefits); 25% FTE for 3 years one research faculty PI: \$27,300 (66% salary, 33.8% benefits); 25% FTE for 4 years one graduate research assistant: \$22,000 (56% salary 35% tuition 9% benefits); 50% FTE for 3 years one graduate research assistant: \$22,000 (56% salary 35% tuition 9% benefits); 50% FTE for 4 years one postdoctoral associate: \$45,900 (79% salary, 21.4% benefits); 100% FTE for 3 years one postdoctoral associate: \$45,900 (79% salary, 21.4% benefits); 100% FTE for 4 years (More detail to be provided as specific research projects are proposed.)
Professional/Technical/Service Contracts:	\$ 12,000	Expert panel member honoraria- approx.4 people x \$500 x 2 days (years 1, 2, and 3); engineering services, lab sample analysis. More detail to be provided as specific research projects are proposed (if applicable)
Equipment/Tools/Supplies:	\$ 464,000	Consumable lab materials, specimens and other expenses directly related to research (More detail to be provided as specific research projects are proposed)
Capital Expenditures over \$5,000:	\$ 1	More detail to be provided as specific research projects are proposed (if applicable).
Printing	\$ 1	More detail to be provided as specific research projects are proposed (if applicable)
Travel Expenses:	\$34,378	Expert panel travel - approx.12 people x \$200 x 2 days (years 1, 2 and 3) Travel directly related to research Travel to advanced technical training outside MN, or travel to professional conferences outside MN to report project results. More detail to be provided for all travel as specific research projects are proposed.
Other:	\$ 1	More detail to be provided as specific research projects are proposed (if applicable). Potential examples include fees to publish project results in open access journals.
<b>TOTAL ENRTF BUDGET:</b>	<b>\$ 1,460,000</b>	



## **Environment and Natural Resources Trust Fund (ENRTF) M.L. 2014 Work Plan**

**Explanation of Use of Classified Staff:** N/A

**Explanation of Capital Expenditures Greater Than \$5,000:** More detail to be provided as specific research projects are proposed (if applicable)

**Number of Full-time Equivalents (FTE) Directly Funded with this ENRTF Appropriation:** 14

**Number of Full-time Equivalents (FTE) Estimated to Be Funded through Contracts with this ENRTF Appropriation:** none



## Environment and Natural Resources Trust Fund (ENRTF) M.L. 2014 Work Plan

**Other Funds:**

Source of Funds	\$ Amount Proposed	\$ Amount Spent	Use of Other Funds
<b>Non-state</b>			
<b>State</b>			
General Fund Appropriation MN Legislature 2014: Chapter 312, HF 3172, Article 12, Section 8	\$3,400,000	<del>\$97,747</del> <u>\$208,911</u>	Funds will be used to support the hire of a Center Director and administrative support for the 8-year project period, and to support additional research projects and will include personnel costs (faculty, graduate students, postdoctoral associates), equipment, materials and supplies necessary for research. Each project is estimated at \$100-200K/year for 3-5 years.
M.L. 2015, Ch. 76, Art. 1, Sec. 6a	\$5,000,000	\$0	Funds will be used to support additional research projects and will include personnel costs (faculty, graduate students, postdoctoral associates), equipment, materials and supplies related directly to research. Each project is estimated at \$100-200K/year for 3-5 years.
M.L. 2016, Ch. 186, Sec. 2, Subd. 2a	\$3,750,000	\$0	Funds will be used to support additional research projects and will include personnel costs (faculty, graduate students, postdoctoral associates), equipment, materials and supplies related directly to research. Each project is estimated at \$100-200K/year for 3-5 years.
Institute on the Environment	\$2,840	\$2840	Funds will be used to convene a panel to discuss the relationship between soybean aphids, an invasive species, soybean production, and the effects of pesticides on the Dakota skipper and other insect populations.
<b>TOTAL OTHER FUNDS:</b>	<b>\$8,400,000</b>	<del>\$121,828</del> <u>\$211,751</u>	

**VII. PROJECT STRATEGY:**

**A. Project Partners:**



## Environment and Natural Resources Trust Fund (ENRTF) M.L. 2014 Work Plan

Project Partners (not receiving funds):

USDA Forest Service Northern Research Station

Minnesota Department of Agriculture

Minnesota Department of Natural Resources

Minnesota Forest Resource Council

Agencies and organizations involved in invasive species outreach programs so public information is based on the best available science.

Networks of citizen scientists could be an important part of implementing early detection programs and monitoring the effectiveness of control efforts.

This will be updated in more detail once the priorities for research are established.

### **B. Project Impact and Long-term Strategy:**

The Center's ultimate goal is to eliminate, reduce, mitigate or prevent the introduction, expansion or damage done by terrestrial invasive species in Minnesota. Metrics of success include: threat awareness, response efficiency, control effectiveness, non-target species protection, and mitigation strategies. Ancillary goals include: workforce development, citizen engagement, focused research strategies, improved response time to emerging threats, and improved coordination of efforts.

Success will depend on the ability to marshal multi-disciplinary teams in timely and prioritized ways to deliver results. While M.L. 2014 ENRTF and General Fund dollars will be used to conduct a risk assessment and launch initial research or prioritized species, funding is being sought through M.L. 2015 ENRTF to support additional multi-disciplinary research teams. With adequate funding, the Center's efforts are expected to result in numerous, effective prevention and control methods within an eight year time frame for a significant portion of the 15-20 species upon which we will focus.

**C. Spending History:** N/A

**VIII. ACQUISITION/RESTORATION LIST:** N/A

**IX. VISUAL ELEMENT:** see attached

**X. ACQUISITION/RESTORATION REQUIREMENTS WORKSHEET:** N/A

**XI. RESEARCH ADDENDUM:** Peer review will be conducted by internal U of MN process and documentation to be provided to LCCMR

### **XII. REPORTING REQUIREMENTS:**

Periodic work plan status update reports will be submitted no later than January 31 and July 31 each year (every 6 months). A final report and associated products will be submitted between June 30 and August 15, 2022.

**Environment and Natural Resources Trust Fund  
Minnesota Invasive Terrestrial Pests and Plants Center-- Sub Project List**

**Legal Citation:** ML 2014, Ch. 312, Art. 12, Sec. 8

**Project Manager:** Robert Venette

**Project Title:** Minnesota Invasive Terrestrial Plants and Pests Center

**Organization:** University of Minnesota

**College/Department/Division:** College of Food, Agriculture, and Natural Resource Sciences

**Project Budget:** \$1,460,000

**Project Length and Completion Date:** 8 years, June 30, 2022

**Current Date:** July 11, 2019



Sub Project #	Sub Project Title	Species	Project Manager	LCCMR Approval Date	Budget	Amount Spent	Balance	Status (select from dropdown menu)
reserve					\$17,076	0	\$17,076	
1	Novel diagnostic tools for rapid and early detection of oak wilt	oak wilt	Abdennour Abbas	1/12/2016	\$274,286	\$183,792	\$90,494	In Progress
2	Early detection, forecasting, and management of <i>Halyomorpha halys</i> (brown marmorated stinkbug)	brown marmorated stinkbug	William Hutchison	1/12/2016	\$632,375	\$481,207	\$151,168	In Progress
3	Climate change and range expansion of invasive plants	Multiple high-priority plants	David Moeller	1/19/2016	\$209,263	\$207,963	\$1,300	In Progress
4	Cover it up!	Glossy and common buckthorn	Peter Reich	12/4/2015	\$327,000	\$326,880	\$120	In Progress
5								
6								
7								
8								
9								
10								
11								
12								
13								
<b>Notes:</b>					<b>\$1,460,000</b>	<b>\$1,199,842</b>	<b>\$260,158</b>	

**Environment and Natural Resources Trust Fund**  
**Sub-Project Budget of Minnesota Invasive Terrestrial Plants and Pests Center (MIT**



**Sub-Project Title:** MITPPC Sub-Project [1]: Novel Diagnostic Tools for Rapid and Early Detection

**Legal Citation:** M.L. 2014, Chp.312, Sec. 8

**Sub-Project Manager:** Dr. Abdennour Abbas

**Organization:** University of Minnesota – Minnesota Invasive Terrestrial Plants and Pests Center

**Sub-Project Budget:** \$274,286

**Sub-Project Length and Completion Date:** 4 years, Dec. 31, 2019

**Project Length and Completion Date:** 8 Years, June 30, 2022

**Date of Report:** July 11, 2019

<b>ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET</b>			
<b>BUDGET ITEM</b>	<b>Budget</b>	<b>TOTAL SPENT</b>	<b>TOTAL BALANCE</b>
<b>Personnel (Wages and Benefits) - Total</b>	<b>\$ 236,938</b>	<b>\$ 163,314</b>	<b>\$ 73,624</b>
One post-doctoral associate, for 3.5 yrs (\$48,425), plus the 23% Fringe (\$11,138) = \$59,563 total per year.			
Graduate Research Assistant: \$43,645 (\$18,471 annual salary plus \$17,665 fringe and \$6,394 summer salary with \$1,125 fringe) 100% FTE for 1 yr. The student will work under Prof. Juzwick to test the developed assay on real samples, compare performance to the methods and work with the University Plant Disease Clinic for large scale testing.			
<b>Equipment/Tools/Supplies - Total</b>	<b>\$ 31,081</b>	<b>\$ 19,365</b>	<b>\$ 11,716</b>
Supplies: Chemicals, Reagents, Media and consumables–fungal cells, culture media, nucleic acids, and other related minor equipment	\$ 31,081	\$ 19,365	\$ 11,716
<b>Travel - Total</b>	<b>\$ 4,267</b>	<b>\$ 1,113</b>	<b>\$ 3,154</b>
Abbas and Juzwick will receive \$1569.50 to present findings and solicit feedback on project development at meetings with academic, public or industrial stakeholders. In each group, \$369.50 will be allocated to travels in Minnesota and \$1,200 for domestic travel outside of Minnesota			
Travel - MN: travel for project meetings between collaborators, with academic partners and with farmers			
Travel - Domestic: meetings with industrial partners and to seminars to present results of proposed research		\$ 1,113	
<b>Professional Services</b>	<b>\$ 2,000</b>		<b>\$ 2,000</b>
Fees for laboratory services, vendor TBD	\$ 2,000		\$ 2,000
<b>COLUMN TOTAL</b>	<b>\$ 274,286</b>	<b>\$ 183,792</b>	<b>\$ 90,494</b>

**Environment and Natural Resources Trust Fund**  
**Sub-Project Budget of Minnesota Invasive Terrestrial Plants and Pests Center (MITPPC)**

**Sub-Project Title:** MITPPC Sub-Project 2: Early Detection, Forecasting & Management of Halyomorpha halys

**Legal Citation:** M.L. 2014, Chp. 312, Sec. 8

**Sub-Project Manager:** William D. Hutchison

**Organization:** University of Minnesota – Minnesota Invasive Terrestrial Plants and Pests Center

**Sub-Project Budget:** \$632,375

**Sub-Project Length and Completion Date:** May 30, 2020

**Project Length and Completion Date:** 8 Years, June 30, 2022

**Date of Report:** July 11, 2019



<b>ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET</b>			
<b>BUDGET ITEM</b>	<b>BUDGET</b>	<b>TOTAL SPENT</b>	<b>TOTAL BALANCE</b>
<b>Personnel (Wages and Benefits) - Total</b>	<b>\$580,175</b>	<b>\$451,989</b>	<b>\$128,186</b>
<i>Post-doctoral Assoc. (Soil-Water-Climate UMN): Year 1=\$12,240/yr (81.7% salary, 18.3% fringe) 20% time x 1 yr; Years 2-4=\$61,200/yr (81.7% salary, 18.3% fringe) full-time x 3 yrs</i>			
<i>Post-doctoral Assoc. (Entomology): \$60,225 (81.7% salary, 18.3% fringe) x 4 yrs</i>			
<i>Dr. Robert Koch, Assistant Professor (Partial summer salary, 2 wks): \$6,140/yr (74.8% salary, 25.2% fringe) 5.5% during summer months x 4 yrs</i>			
<i>Eric Burkness, Research Fellow: \$17,381/yr (74.8% salary, 25.2% fringe) 20% time x 4yrs</i>			
<i>**The initial Underg. Line item (below) was first Re-budgeted to Temp CS, then in '17 to Labor-Represented (all expenses combined, to date)</i>			
<i>Underg. Student: \$12,337/yr (100% salary, 0% fringe) 47 wks/yr x 25 hrs/wk x \$10.50/hr x 4 yrs; however, spending for 1 summer UG still charged</i>			
<b>Professional/Technical Services and Contracts - Total</b>	<b>\$24,000</b>	<b>\$5,000</b>	<b>\$19,000</b>
<i>Dr. Michael Toews, Univ of Georgia (&amp; GA Invasive Spp. Center): \$2,500/yr x 4 yrs to provide Early Detection &amp; Distribution &amp; Mapping ("EDDMaaps"), including: "First Detector" Web site expansion to transition from Presence/Absence to Numerical trap catch, and enumerative pest density sampling in general; modification for BMSB App. &amp; maintenance for multiple OS's for Iphone, Android, etc. (Change was made to Purdue Univ; Aug 2017)</i>	\$10,000	\$5,000	\$5,000
<i>Minnesota Supercomputing Institute</i>	\$14,000	\$0	\$14,000
<b>Equipment/Tools/Supplies - Total</b>	<b>\$13,522</b>	<b>\$13,522</b>	<b>\$0</b>
<i>BMSB Traps, Pheromone Lures for pest detection, @ \$2,500/yr x 4yrs.</i>	\$11,684	\$11,684	\$0
<i>Personal Computer (2) for Data entry, mapping (\$1500 ea), Year 1</i>	\$1,838	\$1,838	\$0
<b>Travel - Total</b>	<b>\$14,678</b>	<b>\$10,696</b>	<b>\$3,982</b>
<i>Travel - MN: [In-state travel, summer-fall per year; MN BMSB Trap Network (UMN fleet vehicle; monthly lease+mileage): ~\$3800/yr x 4yrs.]</i>	\$14,678	\$10,696	\$3,982
<b>COLUMN TOTAL</b>	<b>\$632,375</b>	<b>\$481,207</b>	<b>\$151,168</b>

**Environment and Natural Resources Trust Fund**  
**Sub-Project Budget of Minnesota Invasive Terrestrial Plants and Pests Center (MITPPC)**

**Sub-Project Title:** MITPPC Sub-Project [3]: Climate Change and Range Expansion of Invasive Plants

**Legal Citation:** M.L. 2014, Chp. 312, Sec. 8

**Sub-Project Manager:** *Dr. David Moeller*

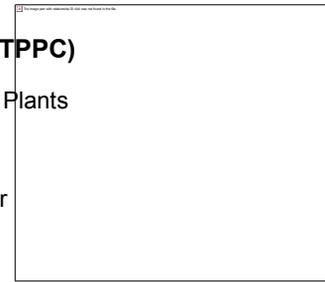
**Organization:** University of Minnesota – Minnesota Invasive Terrestrial Plants and Pests Center

**Sub-Project Budget:** \$209,263

**Sub-Project Length and Completion Date:** 2 years; June 30, 2019

**Project Length and Completion Date:** 8 Years, June 30, 2022

**Date of Report:** July 11, 2019



<b>ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET</b>			
<b>BUDGET ITEM</b>	<b>Total Budget</b>	<b>TOTAL SPENT</b>	<b>TOTAL BALANCE</b>
<b>Personnel (Wages and Benefits) - Total</b>	<b>\$205,163</b>	<b>\$204,875</b>	<b>\$288</b>
Dr. David Moeller, PI: \$22,925 (75% salary, 25% fringe) 8% for 2 yrs			
Dr. Peter Tiffin, PI: \$14,539 (75% salary, 25% fringe) 4% for 2 yrs.			
Dr. Ryan Runquist, Post-doc: -\$113,887 (82% salary, 18% fringe)80% for 2.5 yrs			
2 Undergraduate students: \$15,360 (100% salary) for 2 yrs			
<b>Equipment/Tools/Supplies - Total</b>	<b>\$3,000</b>	<b>\$2,058</b>	<b>\$942</b>
Supplies- Lab and/or Field: Supplies for field work, such as site characterization (GPS units), flagging, stakes, tape meters	\$3,000	\$2,058	\$942
<b>Travel - Total</b>	<b>\$1,100</b>	<b>\$1,030</b>	<b>\$70</b>
Travel - MN: hotel for 10 nights during field surveys (\$1,350) and motor pool for 8 weeks per summer for 2 summers (\$300/wk car rental+ fuel \$75/wk)	\$1,100	\$1,030	\$70
<b>COLUMN TOTAL</b>	<b>\$209,263</b>	<b>\$207,963</b>	<b>\$1,300</b>

**Environment and Natural Resources Trust Fund  
M.L. 2014 Project Budget**

**Project Title:** Cover it up! Using plants to control

**Legal Citation:** ML 2014, Ch. 312, Art. 12, Sec.

**Project Manager:** Peter Reich

**Organization:** University of Minnesota

**M.L. 2016 ENRTF Appropriation:** \$ 327, 000

**Project Length and Completion Date:** December 31, 2019

**Date of Report:** July 11, 2019



<b>ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET</b>	<b>Budget</b>	<b>Total Spent</b>	<b>Total Balance</b>
<b>BUDGET ITEM (original)</b>			
<b>Personnel (Wages and Benefits)</b>	<b>\$295,160</b>	<b>\$295,160</b>	<b>\$0</b>
2 U of M Post-doctoral Research Associates - 50-80% FTE appointment from May 2016 through December 2018, coordination of day to day activities, implementation of research, data analyses, publications (\$50,5000 base salary for 100 % FTE + 21.4% fringe)			
2 Interns to help with fall field work for 2 months/year, \$15/hr for approximately 170 hours each per month + 8.10% fringe; each position at 16.6 % FTE each year for 2 years			
U of M undergraduate students: 1 student to help with lab work (academic Fall semester), 5 hrs/week, 58 hours @ \$11/hour; 2.9% FTE each year for 3 years; 2 students to help with field work (3.4 months in summer), 170 hrs/month @ \$13/hour; each student 28% FTE each year for 2 years			
<b>Professional/Technical Services and Contracts</b>	<b>\$6,000</b>	<b>\$6,000</b>	<b>\$0</b>
Hire a specialist contractor to supply and apply bud inhibitor herbicide at research plots	\$6,000	\$6,000	
<b>Equipment/Tools/Supplies</b>	<b>\$15,540</b>	<b>\$15,432</b>	<b>\$108</b>
Field supplies, tools, seeds, plants, maintenance of equipment to measure light availability and soil moisture	\$15,540	\$15,432	\$140
<b>Travel expenses in Minnesota</b>	<b>\$10,300</b>	<b>\$10,288</b>	<b>\$12</b>
In-state travel to conference to present project findings at the Upper Midwest Invasive Species Conference	\$452	\$452	\$0
In-state travel to field sites, including lodging and mileage on personal vehicles	\$9,848	\$9,836	\$12
<b>COLUMN TOTAL</b>	<b>\$327,000</b>	<b>\$326,880</b>	<b>\$120</b>