

**V(A). Planned Program (Summary)**

**Program # 4**

**1. Name of the Planned Program**

Climate Change- low-impact alternatives for ornamental crop production

Reporting on this Program

**V(B). Program Knowledge Area(s)**

**1. Program Knowledge Areas and Percentage**

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
133	Pollution Prevention and Mitigation				10%
211	Insects, Mites, and Other Arthropods Affecting Plants				30%
212	Diseases and Nematodes Affecting Plants				30%
605	Natural Resource and Environmental Economics				30%
	<b>Total</b>				100%

**V(C). Planned Program (Inputs)**

**1. Actual amount of FTE/SYs expended this Program**

Year: 2014	Extension		Research	
	1862	1890	1862	1890
<b>Plan</b>	0.0	0.0	0.0	14.2
<b>Actual Paid</b>	0.0	0.0	0.0	12.3
<b>Actual Volunteer</b>	0.0	0.0	0.0	0.0

**2. Actual dollars expended in this Program (includes Carryover Funds from previous years)**

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	0	622698
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	0	622698
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	0	0

## V(D). Planned Program (Activity)

### 1. Brief description of the Activity

Identify new pesticide, biopesticide, and treatment methodologies for container and field-grown nursery stock to manage disease and insect problems.  
 Determine the lowest effective rates for synthetic petroleum-based pesticides and develop new reduced rate insecticide / biopesticide combinations.  
 Identify new biopesticides that can substitute for synthetic petroleum-based pesticides and reduce worker exposure risk and environmental impact.  
 Release phorid-decapitating flies in Tennessee to provide imported fire ant biological control.  
 Provide extension training and literature to producers on imported fire ant and Japanese beetle management and train students in pest management and research techniques.  
 Provide data to support new treatments in the Domestic Japanese Beetle Harmonization Plan and the Federal Imported Fire Ant Quarantine, as well as data to support new insecticide label amendments.  
 Conduct assessment of current and future energy use by greenhouse and nursery businesses.  
 Identify alternative energy sources for the greenhouse and nursery industry.  
 Hold focus group meetings with greenhouse and nursery business owners.

### 2. Brief description of the target audience

Nursery growers, extension specialists, consumers and policy makers.  
 Regulatory agencies (e.g., U.S. Environmental Protection Agency, USDA-APHIS, Tennessee Department of Agriculture).  
 Agrochemical manufacturers.

### 3. How was eXtension used?

Scientists in this program are members of the leadership in the eXtension Imported Fire Ant Community of Practice (IFA-COP) for the state of Tennessee and also regulatory and quarantine issues (<http://www.extension.org/pages/12258/imported-fire-ants-leadership#.VMptanI0y70>). Other involvement has included reviews of webpage content and contributions of content on the IFA-COP site. The State-Specific Information webpage on the eXtension IFA-COP for Tennessee (<http://www.extension.org/pages/16159/links-to-other-websites-about-fire-ants#.VMpu8HI0y72>) links to the University of Tennessee Imported Fire Ant (UT-IFA) information website. The UT-IFA website includes multiple extension publications on fire ant management prepared by the University of Tennessee and Tennessee State University entomology programs (<http://fireants.utk.edu/resources/publications.html>). Consequently, extension publications for Tennessee also are linked to the eXtension IFA-COP.

## V(E). Planned Program (Outputs)

### 1. Standard output measures

2014	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	1940	62291	701	5675

### 2. Number of Patent Applications Submitted (Standard Research Output)

**Patent Applications Submitted**

Year: 2014  
 Actual: 0

**Patents listed**

**3. Publications (Standard General Output Measure)**

**Number of Peer Reviewed Publications**

2014	Extension	Research	Total
Actual	5	7	12

**V(F). State Defined Outputs**

**Output Target**

**Output #1**

**Output Measure**

- Workshops to inform producers about alternative insect control methodologies.

Year	Actual
2014	7

**Output #2**

**Output Measure**

- Disease resistant cultivars developed.

Year	Actual
2014	0

**Output #3**

**Output Measure**

- Extension factsheets about alternative methods to control disease and insects in nursery production.

Year	Actual
2014	4

**Output #4**

**Output Measure**

- Workshops held to inform/encourage nursery producers about alternative energy use.

<b>Year</b>	<b>Actual</b>
2014	1

**Output #5**

**Output Measure**

- Extension publications to inform nursery and greenhouse growers about alternative energy options.

<b>Year</b>	<b>Actual</b>
2014	1

**V(G). State Defined Outcomes**

**V. State Defined Outcomes Table of Content**

O. No.	OUTCOME NAME
1	Producers educated on proper management of invasive pests through presentations and workshops.
2	Producers educated on proper management of invasive pests through publications and factsheets.
3	New treatments for invasive pests.
4	New treatments for invasive pests approved by quarantine regulatory agencies.
5	Confirmed establishments of new invasive pest parasites.
6	Producers are informed about new or emerging diseases.
7	Producers are informed about new biological control treatments.
8	Producers that are informed about new sources of host resistance.
9	New cultivars exhibiting disease resistance available to growers.
10	Nursery/greenhouse operators utilizing alternative energy.
11	New alternative controls for insect pests.

## **Outcome #1**

### **1. Outcome Measures**

Producers educated on proper management of invasive pests through presentations and workshops.

### **2. Associated Institution Types**

- 1890 Research

### **3a. Outcome Type:**

Change in Knowledge Outcome Measure

### **3b. Quantitative Outcome**

<b>Year</b>	<b>Actual</b>
2014	349

### **3c. Qualitative Outcome or Impact Statement**

#### **Issue (Who cares and Why)**

Invasive pest species disrupt natural ecosystems and are detrimental to agriculture because they exhibit rapid population growth that can cause greater crop damage and harm to human health and welfare. Multiple invasive pests now impact the U.S. nursery industry. Many producers must manage multiple invasive pests simultaneously with limited, ineffective, and costly treatments, which threatens economic viability and undermines integrated pest management efforts. Producer education via workshops and other training outlets is essential for providing up to date information on rapidly evolving modifications to agro-ecosystems and guidance on successful and profitable control tactics.

#### **What has been done**

Research was conducted on the control of imported fire ant, Japanese beetle, granulate ambrosia beetle, camphor shot borer, blackstem borer, and walnut twig beetle. Producers and other agricultural stakeholders were trained at workshops, field day demonstrations, and educational venues on the latest management techniques developed from field research on invasive insects.

#### **Results**

Local and regional workshops provided producers and stakeholders with research results on management of invasive nursery pests. Total number of growers/stakeholders educated at workshop and field day trainings during this reporting period was about 339 (250 producers and 89 stakeholders). In addition, the project had about 12,079 producer and 51,683 stakeholder contacts outside of workshops, respectively, pertaining to information on pest management.

### **4. Associated Knowledge Areas**

<b>KA Code</b>	<b>Knowledge Area</b>
133	Pollution Prevention and Mitigation
211	Insects, Mites, and Other Arthropods Affecting Plants

## **Outcome #2**

### **1. Outcome Measures**

Producers educated on proper management of invasive pests through publications and factsheets.

### **2. Associated Institution Types**

- 1890 Research

### **3a. Outcome Type:**

Change in Knowledge Outcome Measure

### **3b. Quantitative Outcome**

<b>Year</b>	<b>Actual</b>
2014	1031

### **3c. Qualitative Outcome or Impact Statement**

#### **Issue (Who cares and Why)**

Due to time constraints with managing and running farm operations, as well as expense, some producers are not able to physically attend educational workshops to obtain information on management of invasive insects. As a result, publications, factsheets, and internet available materials are another route to indirectly reach these producers and stakeholders with guidance, training, and the latest successful measures for effective and sustainable pest management.

#### **What has been done**

Based on results from research conducted in this program, three new extension publications were developed, one online proceeding for the Imported Fire Ant and Invasive Ant Conference posted on the eXtension Imported Fire Ant Community of Practice, and six new online reports posted on the USDA-APHIS-PPQ Gulfport-Bioloxi Station Annual Reports. Producers also received educational handouts at workshops and several presentations given at workshops were converted into handouts in response to producer requests.

#### **Results**

Producers/stakeholders received research information to facilitate their management of invasive insects in nursery settings. These producers estimated savings of \$6,812 due to knowledge gained and practices changed by the TMNP online program and an additional \$7,375 change due to increased quality from the TMNP. It is estimated this project educated 1,031 producers and 937 stakeholders with information from website posted publications, information requests, or

given at workshops.

#### 4. Associated Knowledge Areas

KA Code	Knowledge Area
133	Pollution Prevention and Mitigation
211	Insects, Mites, and Other Arthropods Affecting Plants

#### Outcome #3

##### 1. Outcome Measures

New treatments for invasive pests.

##### 2. Associated Institution Types

- 1890 Research

##### 3a. Outcome Type:

Change in Knowledge Outcome Measure

##### 3b. Quantitative Outcome

Year	Actual
2014	4

##### 3c. Qualitative Outcome or Impact Statement

###### **Issue (Who cares and Why)**

Treatment methods for cleansing nursery stock of imported fire ant, Japanese beetle, and numerous non-indigenous ambrosia beetles are expensive, hazardous, impractical or ineffective, and often require shipping delays. Imported fire ant treatment methods like the Federal drench protocol are hazardous due to producer handling exposure and early site re-entries, labor intensive, and expensive. Most treatments for these pests rely on only a few active ingredients (i.e., chlorpyrifos, imidacloprid, or permethrin), providing producers with only limited alternatives. New biopesticide treatments that are under development may have a role in reducing climate change by offering producer alternatives for synthetic petroleum based agrochemical inputs. Invasive borers also have major impacts on forest systems and landscape plantings supplied by the nursery industry, which serve as important carbon-sinks, so improved treatments for borers may indirectly reduce climate change. It is also important that new treatments that are developed are made available to producers through modifications of federal and state regulations governing these quarantine pests.

###### **What has been done**

First, research reported in the last period with a new in-field chemigation treatment for imported fire ant (IFA) and Japanese beetle (JB) larvae utilizing common grower accessible items has been repeated for a third field season. Second, biopesticides and conventional pesticides were again evaluated in combination with a pesticide synergist to lower the rates of pesticides applied as dips and to enhance the treatment efficacy against JB larvae. Third, an IFA nursery study evaluating the combination of broadcast bait treatments, targeted mound injections with bifenthrin, and a bifenthrin band application was completed during spring 2014. The completed bait-injection-band test was the final fourth testing season of this treatment. Fourth, a test to evaluate longevity of imidacloprid activity against JB larvae when applied as a banded application is being repeated for the third and final field season. Data are continuing to also be shared with decision-making regulatory agencies, including the USDA-APHIS (i.e., Anne-Marie Callcott; Entomologist and Biloxi Station Coordinator) and the U.S. Domestic JB Harmonization Plan (JBHP) Regulatory Treatment Review Committee for consideration as new treatments. A flatheaded borer multi-rate imidacloprid test examining insecticide interaction with herbicides reported in the last period is still being monitored for the second season with the planned test termination in year three.

### **Results**

As in 2013, the results of 2014 testing with in-field chemigation drenches and dip treatments combined with Exponent demonstrated that rates of many insecticides and one biopesticide could be lowered for JB control without loss of efficacy. The in-field chemigation drench has proven to be an excellent method of applying pesticide treatments. The results of the third and final field season testing of these treatments will not be available until March 2015, but we expect similar high efficacy control of larval JB. Chemigation treatments with bifenthrin are also providing long residual IFA control. The fourth and final season of bait-injection-band testing against IFA demonstrated again that it is possible to maintain field-grown nursery rows IFA free for 6 to 7 months post-treatment. It is planned to publish the results of the new bait-injection-band treatment and to recommend approval of the treatment by USDA for the Federal IFA Quarantine. It also was determined during this reporting period that longevity of imidacloprid residues was sufficient to allow a quarter rate in the second field season, without loss of treatment efficacy against JB. The quarter rate in the second season will allow growers to use less insecticide, while still providing the same level of quarantine management. The repeat evaluation of this imidacloprid longevity test will be completed in fall 2015. Lastly, the on-going flatheaded borer test at a field-grown nursery has been yielding similar results to a previous test. The unexpected results are that herbicide-treated trees actually have higher frequencies of flatheaded borer attacks at all rate levels of imidacloprid when compared to non-herbicide treated trees. These borer results will eventually be used to recommend new management strategies for commercial nursery growers.

### **4. Associated Knowledge Areas**

<b>KA Code</b>	<b>Knowledge Area</b>
133	Pollution Prevention and Mitigation
211	Insects, Mites, and Other Arthropods Affecting Plants

## **Outcome #4**

### **1. Outcome Measures**

New treatments for invasive pests approved by quarantine regulatory agencies.

### **2. Associated Institution Types**

- 1890 Research

### **3a. Outcome Type:**

Change in Action Outcome Measure

### **3b. Quantitative Outcome**

<b>Year</b>	<b>Actual</b>
2014	2

### **3c. Qualitative Outcome or Impact Statement**

#### **Issue (Who cares and Why)**

Imported fire ants (IFA) have expanded their range into multiple nursery production systems in the southern United States. Currently, only three IFA quarantine treatments are approved for fieldgrown nurseries. All treatments are expensive, rely on one active ingredient (chlorpyrifos), and the post-harvest treatments are hazardous. More options are available for Japanese beetle quarantines than IFA quarantines, but treatments are still expensive for producers due to the limited number of options.

#### **What has been done**

Imported fire ant (IFA) and Japanese beetle (JB) research data related to new quarantine options are continuing to be shared with USDA-APHIS-PPQ, the JB Regulatory Treatment Review Committee of the U.S. Domestic JB Harmonization Plan, and the Tennessee Department of Agriculture. During the last reporting period, data shared led to the approval of three new imidacloprid products as nursery band treatments for JB.

#### **Results**

Research to develop new pre-harvest band treatments enabled the U.S. Domestic JB Harmonization Plan (JBHP) Regulatory Treatment Review Committee to approve 3 new lower cost generic imidacloprid nursery treatments (Mallet 2F, Quali-Pro 2F, and Lada 2F) in JBHP reported during the last AR 2013 report. The data have subsequently been used by the JBHP Treatment Review Committee to also approve Quali-Pro 2F and Lada 2F as new commercial sod treatments in the JBHP.

#### 4. Associated Knowledge Areas

KA Code	Knowledge Area
133	Pollution Prevention and Mitigation
211	Insects, Mites, and Other Arthropods Affecting Plants

#### Outcome #5

##### 1. Outcome Measures

Confirmed establishments of new invasive pest parasites.

##### 2. Associated Institution Types

- 1890 Research

##### 3a. Outcome Type:

Change in Condition Outcome Measure

##### 3b. Quantitative Outcome

Year	Actual
2014	0

##### 3c. Qualitative Outcome or Impact Statement

###### **Issue (Who cares and Why)**

Imported fire ants (IFA) infest over 325 million acres in North America and are continuing to expand their range. IFA cause billions of dollars in damage in the United States each year. To provide region-wide sustainable suppression of IFA populations, the USDA has an on-going classical biocontrol program to establish phorid-decapitating fly parasitoids (*Pseudacteon* spp.) of IFA from South America into the United States. There are about 20 species of *Pseudacteon* flies in South America, which exhibit niche partitioning of IFA by worker size, species, activity (foraging, mating flights), and time of the day. Therefore, to effectively manage IFA with *Pseudacteon* flies, it will likely require introductions of a suite of fly species.

###### **What has been done**

During fall 2014, a total of 22,656 *Pseudacteon cultellatus* and 2,039 *Pseudacteon obtusus* were released in Davidson Co., TN. The *P. cultellatus* species has not been previously released in the state. These releases supplement the 44,118 *P. obtusus* released between 2009-2013, 8,840 *P. curvatus* Formosan biotype between 2004-2008, 18,000 *P. curvatus* Los Flores biotype between 2000-2003, 2,856 mixtures of *P. curvatus* biotypes between 2011-2012, and 10,812 *P. tricuspis* between 1999-2006 and 2011-2012. Surveys were done by placing sticky traps either on top of or 1-meter from fire ant mounds. Traps were baited with sugar baits to attract adult fire ants, which in turn attracted adult phorid flies. Four trap replicates were operated once during each

month from May to August in Davidson, Franklin, and Sequatchie Counties in Tennessee.

### Results

Only *P. curvatus* phorid fly have been recovered. Survey efforts during the summer of 2014 yielded only *P. curvatus* recoveries, including 6 in Davidson Co., 39 in Franklin Co., and 149 in Sequatchie Co. Since *P. cultellatus* releases just began during fall 2014, it is definitely too early to expect recoveries of this species. It is still possible *P. obtusus* may be recovered in the state in coming years, but it is likely *P. tricuspis* releases have been unsuccessful due to the long period of time since releases began and the absence of subsequent fly recoveries. The *P. obtusus* release in fall 2014 was performed at a site infested with red imported fire ant (RIFA), while all previous releases were done at hybrid imported fire ant (HIFA) sites. *P. obtusus* prefers RIFA over HIFA or black imported fire ant, which may improve the success rate of the 2014 release.

### 4. Associated Knowledge Areas

KA Code	Knowledge Area
133	Pollution Prevention and Mitigation
211	Insects, Mites, and Other Arthropods Affecting Plants

### Outcome #6

#### 1. Outcome Measures

Producers are informed about new or emerging diseases.

#### 2. Associated Institution Types

- 1890 Research

#### 3a. Outcome Type:

Change in Knowledge Outcome Measure

#### 3b. Quantitative Outcome

Year	Actual
2014	50

#### 3c. Qualitative Outcome or Impact Statement

##### Issue (Who cares and Why)

Nursery growers need to be informed about new and emerging diseases so that they can be prepared for the disease by taking preventive measures and minimize the potential economic impact of the disease.

##### What has been done

Workshops and presentations on new and emerging diseases.

**Results**

Presentations provided information to growers on how to recognize the new emerging diseases.

**4. Associated Knowledge Areas**

<b>KA Code</b>	<b>Knowledge Area</b>
133	Pollution Prevention and Mitigation
212	Diseases and Nematodes Affecting Plants

**Outcome #7**

**1. Outcome Measures**

Producers are informed about new biological control treatments.

**2. Associated Institution Types**

- 1890 Research

**3a. Outcome Type:**

Change in Knowledge Outcome Measure

**3b. Quantitative Outcome**

<b>Year</b>	<b>Actual</b>
2014	40

**3c. Qualitative Outcome or Impact Statement**

**Issue (Who cares and Why)**

Nursery production systems use high rates of chemical fungicides to control powdery mildew of dogwood; this is detrimental to the environment and grower income by increasing dogwood production costs. Alternatives to chemical fungicides would be desirable.

**What has been done**

Microorganisms selected for superior efficacy against powdery mildew of dogwood were evaluated for bioactivity against other fungal pathogens. Interactions between the biocontrol agents were evaluated to determine which microbes can be combined to enhance biological control.

**Results**

Results confirmed previous observations on microbial bioactivity against powdery mildew;

improved plant growth, and showed bioactivity against other pathogens. Preliminary studies showed that the biological control agents secreted some compounds that may be involved in controlling the fungal pathogens.

#### 4. Associated Knowledge Areas

KA Code	Knowledge Area
133	Pollution Prevention and Mitigation
212	Diseases and Nematodes Affecting Plants

#### Outcome #8

##### 1. Outcome Measures

Producers that are informed about new sources of host resistance.

##### 2. Associated Institution Types

- 1890 Research

##### 3a. Outcome Type:

Change in Knowledge Outcome Measure

##### 3b. Quantitative Outcome

Year	Actual
2014	50

##### 3c. Qualitative Outcome or Impact Statement

###### **Issue (Who cares and Why)**

Growers need to know about the availability of powdery mildew resistance that will grow better without requiring routine fungicide applications.

###### **What has been done**

Research focused on powdery mildew host resistance inheritance to provide information that can facilitate breeding efforts. Identification of molecular markers and morphological markers for powdery mildew resistance will facilitate marker assisted breeding. New plants that display powdery mildew resistance were also generated.

###### **Results**

Narrow sense heritability and broad sense heritability were determined. Identification of molecular markers and morphological markers for powdery mildew resistance to assist breeding efforts are in progress. New plants that displayed powdery mildew resistance need resistance confirmation.

#### 4. Associated Knowledge Areas

KA Code	Knowledge Area
133	Pollution Prevention and Mitigation
212	Diseases and Nematodes Affecting Plants

#### Outcome #9

##### 1. Outcome Measures

New cultivars exhibiting disease resistance available to growers.

##### 2. Associated Institution Types

- 1890 Research

##### 3a. Outcome Type:

Change in Knowledge Outcome Measure

##### 3b. Quantitative Outcome

Year	Actual
2014	2

##### 3c. Qualitative Outcome or Impact Statement

###### **Issue (Who cares and Why)**

Disease resistance is the best method for disease control by farmers. New generation of cultivars that are resistant to powdery mildew would be a great contribution to nursery growers in that they would not require routine fungicide applications.

###### **What has been done**

Genetic characterization of the resistance in the two cultivars.

###### **Results**

Genetic information that can be used for advanced breeding purposes has been generated.

#### 4. Associated Knowledge Areas

KA Code	Knowledge Area
133	Pollution Prevention and Mitigation
212	Diseases and Nematodes Affecting Plants

## **Outcome #10**

### **1. Outcome Measures**

Nursery/greenhouse operators utilizing alternative energy.

### **2. Associated Institution Types**

- 1890 Research

### **3a. Outcome Type:**

Change in Action Outcome Measure

### **3b. Quantitative Outcome**

<b>Year</b>	<b>Actual</b>
2014	5

### **3c. Qualitative Outcome or Impact Statement**

#### **Issue (Who cares and Why)**

Exploring alternative sources of energy is needed to identify lower cost sources. Such sources range from bioenergy operated by an individual operator to others available through institutions in the energy business. There are various stakeholders including the State Department of Agriculture who provided the latest data base of certified growers used to conduct the mail survey. There are also others such as the Nursery Research Center located in McMinnville, other public and private sector organizations and policy makers.

#### **What has been done**

This project introduced research in an important emerging area. It can promote efficient and cost effective management practices that can overcome some of the challenges faced by the nursery/greenhouse growers. It was also able to strengthen collaboration among various groups that have stake in the issue of alternative energy sources and use. The project also generated data that two graduate students-one on energy use by greenhouse and nursery growers and another on marketing of nursery and greenhouse products have been able to use for writing their theses. Knowledge about alternative sources of energy by growers is in itself an important result.

#### **Results**

Results show that in addition to the few already utilizing alternative sources of energy, majority of the respondents to our survey indicated that they will consider adopting alternative energy sources. The results are robust and have both direct and indirect benefits. The young and more educated group appear to be more willing to consider adopting alternative sources of energy. This suggests that effort by the above group should be encouraged by extension agents, researchers, government bodies such as the Tennessee Valley Authority. Results of this study can provide some input for such effort.

#### 4. Associated Knowledge Areas

KA Code	Knowledge Area
605	Natural Resource and Environmental Economics

#### Outcome #11

##### 1. Outcome Measures

New alternative controls for insect pests.

Not Reporting on this Outcome Measure

#### V(H). Planned Program (External Factors)

##### External factors which affected outcomes

- Natural Disasters (drought, weather extremes, etc.)
- Economy
- Government Regulations

##### Brief Explanation

{No Data Entered}

#### V(I). Planned Program (Evaluation Studies)

##### Evaluation Results

Research impact and relevance was measured by one-on-one interaction with nursery growers in meetings and at field research sites, tabulating the number of requests from producers for research-related information or assistance, and surveying producers at workshops and meetings for impact and content relevance. One-on-one interactions with producers and regulatory stakeholders has indicated our research objectives are addressing their critical needs and our outcomes are reducing their costs. Direct requests from producers or related stakeholders for research-related information during the 2013 to 2014 reporting period totaled 1,735, indicating a need within the nursery community of interest for our research results. A survey taken by the eight nursery growers that completed the new online Tennessee Master Nursery Program indicated an average savings of \$6,812 per grower due to knowledge gained and practices changed and an additional \$7,375 per grower in increased quality. For future evaluations, this program will continue to obtain direct feedback from producers during workshops and one-on-one interactions to determine value of programs, impact of research, and costs-benefits.

##### Key Items of Evaluation