UNITED STATES DEPARTMENT OF AGRICULTURE
COOPERATIVE STATE RESEARCH, EDUCATION, AND EXTENSION SERVICE

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Project Director(s) (PD):

PD Carol S. Glenister Institution **IPM Laboratories, Inc.**

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PROPOSAL TYPE

For National Research Initiative Competitive Grants Program Proposals Only

[ ] Standard Research Proposal
[ ] Conference
[ ] AREA Award
  [ ] Postdoctoral
  [ ] New Investigator
  Strengthening:
  [ ] Career Enhancement
  [ ] Equipment
  [ ] Seed Grant
  [ ] Standard Strengthening

For Higher Education Program Proposals Only:

Need Area: _____

Discipline: _____

Project Title:
Guardian Plant Systems for Greenhouse Integrated Pest Management

Guardian plant, guardian plant system, indicator plant, banker plant, trap plant
Key Words: natural enemy habitat, greenhouse biological control, whitefly biological control

An innovative pest management system using eggplants as crop guardians has evolved over the last decade in Holland and Canada in peppers, tomatoes, fuchsias, and poinsettias. For whitefly control, the eggplants pull whitefly out of the crops, the growers apply natural enemies directly to the eggplants, and in some crops, the eggplants supply reproduction sites for the natural enemies. The eggplants have also assisted in determining if pesticide action thresholds have been reached by offering the grower an efficient snapshot of the natural enemy impact on pest populations within the greenhouse. Thus, the eggplants have been serving as indicator, trap and banker plants in a technique that we refer to as Guardian Plant Systems (GPS). These GPS have substantially enhanced grower confidence in biological control, reduced monitoring time, and reduced the purchases of natural enemies, thereby reducing the cost of biological control and IPM.

Four experienced pest management groups from three northeastern states -- one from a university research laboratory (VT), one from the Department of Agriculture (PA) and two from private industry (NY) – will each demonstrate one of the following three Guardian Plant/crop combinations for 2 years: eggplants in tomatoes, eggplants in poinsettias and eggplants in specialty annuals. Three of the demonstrations will occur at commercial greenhouses, 2 of which already use whitefly natural enemies in their crops (tomatoes and poinsettias). At the third commercial greenhouse, we will be testing the eggplant GPS in a crop where there is no prior history of GPS use: specialty annuals. Each cooperator will gather and compare data on whitefly and natural enemy incidence in the crop with data on whitefly and natural enemy incidence on the GPS. They will also compare costs, depending on available data, between conventional chemical treatments and biological control, or between biological control with and without GPS. Participants will share information by meeting once a year for two years for the purposes of comparing data, results and styles of observation and analysis.

All cooperators will actively share the project information with many grower groups and with the GO IPM Working Group of NE IPM as the project progresses. This project will encourage rapid innovation in Guardian Plant management by timely sharing of methods to seed rapid implementation by greenhouse growers.

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4. Project Description

a. Problem, Background and Justification

Problem

Greenhouse production in the US represents a significant high-value cropping system, which in the Northeast enables growers of vegetables and ornamentals to extend the growing season and increase profits. Greenhouses provide protection for year-round plant production, but also offer ideal conditions for pest outbreaks. By design, most greenhouses exclude pests and their natural enemies, thereby eliminating the natural checks and balances found in outdoor plantings. Even if a grower introduces beneficials into the greenhouse, many crops lack sufficient habitat to sustain the populations at levels needed for control. Therefore beneficials must be released repeatedly, which is expensive, especially when shipping costs often exceed the cost of the contents. Greenhouse growers therefore need specialized tools to cost effectively cope with the challenges of greenhouse pest management.

Greenhouse tomato production in the Northeast is a significant source of agricultural revenues. Based on data from large-scale growers, 26 million pounds of tomatoes were produced in 2001in NY and PA. Greenhouse grown tomatoes represent a high value crop, with a fluctuating wholesale value from 2001-2004 of $0.79-$1.60 per pound depending upon the season (Cook & Calvin 2005). Production among smaller greenhouses in the Northeast is unknown but definitely is important to the economics of small farms and local markets. Production of greenhouse ornamentals is a burgeoning Northeastern industry. In 2005 over 2,800 greenhouses in CT, MA, MD, NJ, NY, and PA grew bedding plants at a wholesale value of $320 million. Over 12 million poinsettias with a wholesale value of $49.5 million were produced in the same states by 437 greenhouses with >$100,000 sales in 2005 (USDA NASS 2006).

Insect pests represent a major constraint on revenues for greenhouse crop production. They impact grower profits directly by reducing crop yield and/or quality as well as requiring cash and time expenditures for control. For growers who seek to grow their crop with a minimum of pesticides, the per acre cost for natural enemies in greenhouse tomato production could approach $4,000 in 2001 (Selina & Bledsoe 2002). Large-scale greenhouse vegetable producers are major consumers of natural enemies in the US, in part because they must protect the survival of bumblebees, an essential pollinator. The number of Northeastern growers of greenhouse ornamentals who have tried or are regularly using beneficials has increased significantly based on informal surveys conducted among attendees of greenhouse IPM workshops in ME, NH and VT (M. Skinner, personal communication). This increase is a direct result of heightened awareness among growers of the effectiveness of biological controls and how to use them.

Background

Guardian Plant Systems. Techniques are being developed and tested in North America utilizing specialized plants to sustain natural enemies in greenhouses, thereby providing an on-going supply of beneficials to combat arthropod pests. Research is also underway to evaluate plants as an early indicator of pest or beneficial populations. Many terms have been used to describe this IPM approach. Results to date are promising. It appears that indeed, some plants can be used effectively to detect pests early, others are able to sustain natural enemy populations over time. However, in this project we propose assessing plants that can serve all of these functions simultaneously. By concentrating pests and natural enemies, these plants give the pest

manager a unique, concentrated view of population levels of the pest and beneficials and at the same time serves as a continuous supply of natural enemies too. For this proposal we have coined the term "Guardian Plant Systems (GPS)", which combines the multiple potential uses into one. This concept recognizes the dynamics of the model: the same plant can serve as an indicator plant and function as a trap plant drawing the pest out of the crop. Likewise, a trap plant can act as a banker plant, providing an on-going source of beneficials. For clarification purposes, these uses are briefly described below:

Banker plants: Banker plants supply prey to support natural enemy populations. The prey may be themselves plant pests, though not usually pests of the crop that is being protected. For example, the papaya whitefly does not threaten greenhouse crops, but can be used to support whitefly parasites on papaya banker plants. The grower would not apply chemicals on this plant because it is a refuge for the beneficials. However, if a pest population becomes high on a banker plant, it could serve as a trap plant, providing a site for a targeted spray.

Habitat plants: Habitat plants supply food and shelter to beneficials. The plant provides basic needs for natural enemy survival (pollen, nectar, resting and/or oviposition sites).

Indicator plants: Many pests show preferences for certain plants over others, and natural enemies may follow them there. By attracting pests and their natural enemies, indicator plants provide sites to monitor both populations simultaneously. Indicator plants can be more accurate than sticky cards because they detect both non-flying as well as flying stages of pests. If substantial parasitism or predation occurs on an indicator plant, it has become a trap plant as well.

Trap plants: Trap plants are indicator plants on which crop pests are killed. Trap plants draw pests away from the crop and provide a localized venue where biological control or chemicals can be applied. In fact the trap plant requires that some type of control be exerted so the grower does not inadvertently cause an outbreak. When biological controls are applied, the plants may become banker plants for those beneficials.

The above discussion demonstrates the complexity of the interactions between plants, pests and their natural enemies in a greenhouse ecosystem, and IPM strategies must move toward "ecologically-based" approaches that optimize these natural systems (Pickett & Bugg 1998, Colfer 2004, Gurr, Wratten & Altieri 2004). This concept is gaining momentum in the International Organization of Biological Control too, as evidenced by the new working group "Landscape management for functional biodiversity", which focuses on improving pest, disease and weed control through landscape ecology. Whereas habitat and food resources in outdoor settings have largely aimed to supply natural enemies to crops, in greenhouse crops, plants are being selected to serve as traps or indicators for the pests, as well as habitats for beneficials.

Examples of the Potential of Guardian Plants for Pest Control

Growers demonstrate a natural ability to observe pest/plant interactions and make reasoned decisions accordingly. Several growers in the region have been informally exploring the approach of guardian plants for some time. For example, Don Banyar, a PA grower observed that tomato plants drew whitefly out of his poinsettias, and used this as a tool by removing the tomato plants, and the whiteflies too. John Sirak, PA bedding plant grower used marigolds to trap thrips. He found the marigolds drew thrips away from other bedding plants, and when these infested

plants were removed, thrips were eliminated. Pierre Ramakers, Glasshouse IPM Research, NL noted that using non-crop plants to host beneficial insects was started in Europe by pepper growers who used eggplant to attract whitefly from peppers, reducing their inputs of *Encarsia formosa*. Growers found eggplant was more attractive to whitefly than peppers, thereby concentrating the pest to limited locations requiring lower parasite release rates.

Graeme Murphy, Greenhouse Floriculture IPM Specialist, Ministry of Agriculture, Ontario CA is working with Michael Short, Eco Habitat AgriServices, Ontario, CA, to test trap plants in ornamentals for whitefly. One of their growers reported excellent results using tomatos to protect fuchsia stock plants from greenhouse whitefly (Murphy, 2004). The same system was also effective in poinsettias infested with greenhouse whitefly. In 2005, Murphy and Short initiated a trial in several commercial greenhouses to test tomato and eggplant as trap plants for the whitefly in poinsettias. Tomato is more attractive than poinsettia to greenhouse whitefly but eggplant may be more attractive to silverleaf whitefly than tomato. *Encarsia* was introduced on the tomatoes for greenhouse whitefly, and *Eretmocerus mundus* for silverleaf whitefly on the eggplant. Though pest management results differed among the grower sites, all who participated felt the system had potential, resulting in expansion of the trial to 12 growers in 2006. As of November, 9 of the 12 growers in this trial had completed the season using no whitefly pesticides, two treated once with an insect growth regulator (IGR), and only one abandoned the project due to problems with sustaining the GPS. This trial points out that GPS has great potential, but further refinement is needed to ensure results over a range of commercial settings.

Don Elliott, Applied Bionomics, CA, found that eggplant is also a good host and indicator plant for *Orius*, an important thrips predator, because it produces pollen which sustains the predator when prey is absent. He recommends this system to greenhouse vegetable growers. He notes that "they attract and build-up whitefly, thrips and spider mites if not watched, but if the correct natural enemies are added preventively, I have never seen individual eggplants cause a problem." An added benefit of this system is that beneficials build up sufficiently so growers can readily see them." Eggplants are also used as trap, indicator and banker plants in commercial cucumber and pepper greenhouses in Holland at a rate of at least one eggplant per ha.

In 2005 we initiated a multi-site experiment (NY and VT) (SARE-funded), to determine if plants could be used to attract and support diverse populations of beneficials. That study used habitat pots containing of marigolds, alyssum, lantana and fennel, as well as an aphid banker plant (a susceptible pest-infested host plant) to provide a continuous source of pollen and nectar as well as a refuge where beneficials could feed, shelter and reproduce. Observations demonstrated the on-site reproduction of 3 released species of beneficials and >5 wild species of beneficials, and control of aphids and whiteflies, but not thrips. This study proved to us that the concept of habitat systems was worthwhile but needs further development.

Justification

Wherever biological controls are introduced into conventional pest management systems, pesticide use is commonly reduced by 50-95%. In addition growers select classes of pesticides that are soft on natural enemies and the environment. The GPS for whitefly control addresses two key barriers to grower use of biological control: reduction of the time needed for pest scouting and reduced costs of natural enemies.

Eggplants in these studies will serve as focal points where growers can detect whitefly and their demise by natural enemies. Conversely, if biological control is insufficient, the GPS serve as an early warning that more beneficials or a pesticide treatment is needed. The eggplant GPS will be a tool to simplify biological control for growers.

The GPS concept is just starting to be adopted in the Northeast as evidenced by the 2005-2006 NE IPM aphid banker plant projects of Van Driesche & Sanderson (2006), the 2005-2006 aphid banker plant projects of Skinner & Brownbridge (2006), and the 2005-2006 NE SARE Habitat Pot Systems by Glenister, Skinner & Nyrop (Glenister 2006). The rate of adoption by growers is likely to be high because costs and risks are minimal and benefits to growers are tangible. The concept is definitely catching on in Canada. In 2003, one eastern Canadian grower tried the western Canadian practice of using whitefly parasites and trap plants in fuschias. In 2005, 3 poinsettia growers decided to try using whitefly parasites and eggplants. In 2006, 9 more growers are participating in the trial. Other growers are using the system independently after witnessing its success. Now, on the US side, particularly for poinsettia growers who have experienced severe outbreaks of pesticide–resistant whiteflies a window of opportunity is open for keen attention and rapid adoption of new methods of whitefly control.

b. Objectives and Impacts

Objectives:

1. Evaluate use of eggplant Guardian Plant Systems (GPS) in three greenhouse crop systems: bedding plants, tomatoes and poinsettias.
2. Compare costs of GPS with those of standard parasitoid release strategies in poinsettias and tomatoes and with conventional chemical control in research poinsettias.
3. Disseminate information about GPS and trial results regionally via fact sheets, web pages and presentations at grower meetings.

Anticipated Impacts for Growers, the Environment and IPM Implementation

Safeguarding human health and the environment: This project will demonstrate the effectiveness of GPS and increase grower confidence in biological control, encouraging grower adoption and decreased pesticide use. Pesticide exposure to growers and consumers will be reduced when growers implement GPS. In eastern Canada, GPS reduced pesticide applications for whitefly to zero or 1 per poinsettia crop, compared with routine weekly sprays. A NH poinsettia grower reported cutting from 20 sprays to 1 spot spray per crop by adopting biological control. This impact could be realized region-wide with development of simple but effective tools like the GPS for using biological control.

Economic Benefits: Parasite release rates by eastern Canadian poinsettia growers using eggplant guardian plants are 0.2 to 0.3 times less than the US rate. The cost of parasites at the US rate is equal to that of pesticides (Van Driesche et al. 2002). Therefore, when parasites are used with GPS, biological control costs in poinsettia could be reduced by over half. This GPS can also offer a solution to the Q-Biotype silverleaf whitefly which is resistant to many pesticides.

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Implementation of IPM: Assessment of the eggplant GPS is needed before it can be broadly recommended to growers. Demonstrating and measuring GPS for multiple crop types in research and commercial greenhouses will foster grower interest. We expect grower adoption of GPS to be rapid because there is minimal cost or risk associated with trying them. The timing of GPS is perfect because growers need solutions for Q-biotype silverleaf whitefly and are receptive to pesticide alternatives. Efficient communication is key. Our results from the SARE-funded project on habitat pots generated much interest among growers via presentations at the Tri-State Greenhouse IPM workshops in ME, NH and VT, the New England Greenhouse Conf., the New England Vegetable and Fruit Conf., the Mid-Atlantic Fruit & Vegetable Convention, the Assoc. of Zoological Horticulturists, and the Assoc. of Educational Research Greenhouses. Articles were also published by the Ecological Landscaping Assoc., Assoc. of Zoological Horticulture, NYS Flower Industries, PA Vegetable Grower's Assoc., PA Assoc. of Sustainable Agriculture. Our results from this GPS project will be disseminated rapidly to other IPM professionals, including the GO IPM working group as well as to >1,000 growers at our own presentations (see venues above), and thousands via websites, etc. A fact sheet about GPS will be produced as a hard copy to distribute to growers and a web version will be uploaded to sites used by growers and extension personnel. This project evaluates GPS for whitefly in the Northeast, but the technique is applicable to other regions. Sustaining beneficials using GPS for can also be adapted to other crop types and pests.

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c. Approach and Procedures

1. a. Poinsettias in research greenhouses at University of Vermont:

	1	2	3	4	5	6	7
1	X	X	X	X	X	X	X
2	X	X	SR	SD	X	X	X
3	SR	X	X	X/Y	X	SR	X
4	X	X	X	SD	X	X	X
5	X	SR	X	X	SR	X	SR
6	X	X	X	SD	X	X	X
7	SD	X/Y	SD	EP	SD	X/Y	SD
8	X	X	X	SD	X	X	X
9	SR	X	X	X	X	X	X
10	X	X	X	SD	SR	SR	X
11	X	SR	SR	X/Y	X	X	SR
12	X	X	X	SD	X	X	X
13	X	X	X	X	X	X	X
14	X	X	X	SD	X	X	X
15	X	X	SR	X/Y	X	X	SR
16	SR	X	X	SD	X	X	X
17	X	SR	X	X	X	SR	X
18	X	X	X	SD	SR	X	X
19	SD	X/Y	SD	EP	SD	X/Y	SD
20	X	X	X	SD	SR	X	X
21	SR	X	X	X	X	X	SR
22	X	X	SR	SD	X	SR	X
23	X	SR	X	X/Y	X	X	X
24	X	X	X	SD	X	X	X

Figure 1. Poinsettia crop setup design, EP = eggplant; SD = Poinsettia plant sampled for dispersal from eggplant; SR = Poinsettia plant sampled for random distribution.
X = Other poinsettia plants not sampled;
Y=Yellow sticky trap.

The Univ. of VT (UVM) will test eggplant GPS in poinsettias in two research greenhouses (one managed as a conventional greenhouse [CON] and one using best management practices [BMP]). Two 28 x 50 ft greenhouses will each contain one 24 x 7-ft long bench (168 sq ft) of poinsettias, spaced 1 ft apart over the bench. Two eggplants will be placed in the crop (Fig. 1).

When trial is started, the eggplants, poinsettias and yellow sticky cards will be sampled for baseline data on the whitefly population in both houses. Parasitic wasps will be introduced weekly into the BMP house, starting the week after the first whiteflies are detected. In the CON house, no parasites will be released. In both greenhouses, eggplants and poinsettias will be sampled weekly for 20 wk to determine the number of live whitefly by species and the number of parasitized whitefly present on the poinsettia and eggplants. If no whiteflies are observed in the first 4 wk, researchers will consider introducing laboratory-reared whitefly to create an infestation. The following data will be collected and analyzed for differences between the BMP and CON greenhouses over the two study years:

- Number of whitefly (by species) on GPS and poinsettias over time at 3 distances from GPS.
- Percent parasitism on GPS and poinsettias over time at four distances from GPS.
- Cost of parasitoid releases vs standard chemical control.
- General plant health in BMP vs CON house
- Average time to detection of first whitefly in the presence and absence of GPS.

b. Poinsettias in a commercial greenhouse

IPM Laboratories, Inc. will work with a poinsettia grower, Mischler's Florist, NY to demonstrate biological control of whitefly using GPS in a commercial setting. Mischler's will purchase the whitefly parasites and provide two greenhouses full of poinsettias, (~ 4000 sq. ft). One greenhouse will be treated with four GPS and a reduced rate of whitefly parasites weekly after the first sign of whitefly. The other will serve as a control with the "conventional" rate of one whitefly parasite per square foot per week. Natural enemies will be released weekly starting at the first sign of whitefly. An IPM consultant will monitor pests and natural enemies weekly

for presence/absence of whitefly on 24 poinsettias per greenhouse and a weekly assessment of parasitism levels and whitefly presence on the GPS. The number of minutes that it takes to detect the first whitefly will be noted on the poinsettias and on the GPS. Up to 6 whitefly-infested poinsettias per house will be marked and whitefly growth stages and survival recorded weekly. If whitefly populations are not adequately controlled by natural enemies, 1-2 insect growth regulator treatments will be applied before poinsettia bracts begin to turn red (as demonstrated by Van Driesche et al. 2002). Mischler's Florist will retain final decision-making authority on whitefly control in their crop. The number of whitefly per plant will be evaluated in mid November, before the crop is sold.

c. Greenhouse tomatoes in a commercial greenhouse

Since it is not possible to deploy eggplants in February 2007 when the tomato crop is started, the PA Dept. of Agric. IPM Program will gather monthly baseline data in 2007 on whitefly and whitefly parasite incidence and distribution in a commercial tomato greenhouse. The eggplant GPS will be added to the greenhouse in 2008. GPS will be placed in the crop at a rate of one per 1000 sq. ft. Whitefly parasites will be released weekly at a rate of 1 parasite/plant/wk starting after the first whitefly is detected. In this case, once the whitefly parasites are well-established on the GPS (probably after 4 or 6 weekly parasite releases), the GPS will be allowed to maintain itself with no further parasite releases unless warranted by low parasitism rates. Weekly pest monitoring will determine whitefly and parasitism rates as well as parasite numbers on yellow sticky cards, GPs, and tomato plants. Data will include minutes to the first whitefly detection on tomatoes vs. eggplants and whitefly and parasite levels on 6 tomato plants at each of 4 distances from the eggplants. At the end of the season, we will compare the relative numbers of whitefly at each distance from the eggplant to the numbers on the eggplant itself. We will also compare the cost of parasite introduction in the presence of eggplants to the current cost of the parasite introduction rates of previous years.

d. Specialty annuals in a commercial greenhouse

IPM Laboratories will cooperate with Bakers Acres, No. Lansing, NY, to demonstrate whitefly control with GPS in a 1,000 sq. ft. special annuals production house. Bakers Acres is a perennial nursery that prides itself on its diverse and unique offering. The special annuals house will contain about 75 varieties including plants highly susceptible to whitefly (bacopa, fuchsia, sweet potato vine, Felicia). This greenhouse typically is sprayed 3 times per season for whitefly.

Two GPS will be placed in the greenhouse and 1,000 whitefly parasites/wk will be released after propagation begins. Forty percent of the parasites will be placed on the GPS or other hot spots and 60% spaced throughout the greenhouse. Plants move quickly through the house, so we will maintain this fairly high release rate for 16 wks from mid-April through July. The sampling protocol differs from the other crops above because many plant species are growing at the same time, allowing us to detect if other crop species are more attractive than the GPS. On first entering the house each week, we will do an overall encounter survey, detecting, and noting plant species that harbor whitefly and their distance from the GPS. Next we will inspect 10 plants each of 5 species for whitefly and presence of parasites, timing ourselves on first whitefly detection for each species. On the GPS, we will record time to first whitefly detection as well as the number, stage and species of whitefly per leaf and number of parasites on 2 leaves each on the upper, middle and lower leaves. We anticipate excellent whitefly control with the possible

exception of a few small hot spots that may need an IGR treatment. Bakers Acres will retain final decision-making authority on whitefly control in their crop.

Data will be used to compare whitefly levels on the GPS to the levels on the sampled crop. Success will be demonstrated if the whitefly numbers on the crop remain low and high levels of parasitism are easily detected on the GPS. Success will also be demonstrated if we detect new trap plant species and turn them into whitefly treatment sites too.

2. **Compare Costs:** Cost comparisons are described under evaluation plans.

3. **Disseminate information:** We have a three-pronged approach to share this project's information: website, hard copy via fact sheets and trade journals, and conference presentations. We will create 3 grower web pages to broadcast project progress, completion and success to their customers and other growers with links to our main description. We will prepare a web-ready fact sheet geared to growers and site it at a single site so that hits are easily documented. We will print 5000 copies of the fact sheet and share it with our audiences and the GO IPM Working Group. We will also present our results at grower conferences, and via trade journals and newsletters as described under Impacts: Implementation of IPM on page 7, including the Tri-State Greenhouse IPM workshops which are managed by Margaret Skinner, and, by invitation, to other venues, including the biannual New England Greenhouse Conference as described on p.7.

d. Evaluation Plans

1a. Trust and confidence in biological control is difficult to measure. However, we will measure adoption of GPS (with whitefly natural enemies or with pesticides) and the proportion of these growers that are using natural enemies in conjunction with GPS. In late 2005 and early 2006, we distributed a survey (attached) to more than 500 growers in audiences of greenhouse habitat presentations asking for the names of plants that each grower used as indicator, trap, banker, or habitat plants. Each function was defined on the survey page and in the presentation that the audience was attending. The level of grower comprehension and use of Guardian Plants will be documented by a final survey that will be comparable to the baseline data.

b. Reduction in pest monitoring time. For this project, scouting will be intensive and time consuming. However, GPS have the potential to reduce grower's scouting time because these plants serve as a magnet for the pest. We will record and compare the number of minutes that it takes to detect the first pests in the presence and absence of eggplants.

c. Informal survey of future plans to adopt Guardian Plants. Evidence of success in tomatoes, poinsettias and specialty annuals will support adoption by other growers, including growers of many other crops. We will assess the real interest of our grower audiences in this new technique by adding a question to our Guardian Plant survey described above in (1) by asking , "Do you plan to incorporate eggplants into your pest management system in the next one or two years?", with multiple choice answers: definitely, very likely, likely, not likely, definitely not. We will include blanks to write the crops in which the respondents plan to deploy GPS.

2. Cost comparisons. Cost comparisons will show how much GPS can reduce biological control costs and/ or how the GPS cost compares to chemical costs. The UVM group will compare the costs of the conventional to best management practices. The PA project will compare the costs of

release rates in previous years in the tomato greenhouse to new release rates. At the NY poinsettia site we will make direct comparisons between biological control costs in the presence and absence of GPS. At the specialty annual site, we will compare the cost of whitefly biological control to spray programs in past years.

3a.. Presentations. The list of presentations, numbers in the audiences and the number of surveys collected will be evidence of the coverage by our speakers.

b. Web Report. Web access to the web reports will be recorded as number of hits per page.

TIME TABLE

Obj.	Task	Date started	Date Finished	Year	By whom
1	Set up poinsettia trials, collect & analyze data	July 2007 & July 2008	Jan. 2008 & Jan. 2009	Year 1 & 2	VT & NY
	Set up tomato trials, collect & analyze data	April 2007 & Feb. 2008	July 2007 & July 2008	Year 1 & 2	PA
	Set up annuals trials, collect & analyze data	April 2007 & April 2008	Dec. 2007 & Dec. 2008	Year 1 & 2	NY
2	Compile data on costs	On-going	On-going	Year 1 & 2	All sites
2	Analyze data on costs	January 2008	March 2009		
3	Present results at Tristate IPM grower workshops	Jan. 2008 & Jan. 2009	Jan. 2008 & Jan. 2009	Year 1 & 2	VT
	Present results at NE Greenhouse Conference and other venues	Oct. 2008 & ongoing	Oct. 2009	Year 1 &2	NY
	Prepare articles for grower trade journals	Jan. 2008 & Jan. 2009	Jan. 2008 & Jan. 2009	Year 1 & 2	All cooperators
	Prepare grower project announcements for web and news organizations	April 2007	June 2007	Year 1	NY
All	Attend annual cooperators meeting	Sept. 2007 & Sept. 2008	Sept. 2007 & Sept. 2008	Year 1 & 2	All cooperators
All	Annual Report	Nov. 2007	March 2008	Year 1	NY
All	Annual and Final Report	Nov. 2008	March 2009	Year 2	NY
3	Revise grower web announcements	January 2007	March 2007	Year 1	NY
3	Prepare web summary of first year for grower sites to link to	January 2007	March 2007	Year 1	All cooperators
3	Draft final GPS fact sheet	Jan. 2008	Jan. 2009	Year 2	All cooperators
3	Place fact sheet in web format & reproduce hard copies	Jan. 2009	Feb. 2009	Year 2	NY
3	Announce & disseminate link to other sites	Feb. 2009	Mar. 2009	Year 2	NY

5. Cooperation and Institutional Units Involved

IPM Laboratories, Locke, NY: Carol Glenister, president, will serve as the Project Director for the project. She will coordinate activities among the partners, manage the greenhouse tests in New York, prepare reports for the project, and collaborate with the subcontractors to produce the fact sheet and web content, but be responsible for their production. Carol will oversee a scout to monitor the crop at Bakers Acres, and a consultant (Karen Dean Hall) to monitor Mischler's. Carol will serve as the primary contact and represent the project at meetings of the NE IPM Advisory Council.

The University of Vermont, Entomology Research Laboratory: Margaret Skinner, entomologist, will serve as the Principal Investigator for the segment of the project dealing with research in Vermont. She will also assist with development of the fact sheet and website for the GPS Concept. She will assist with disseminating results at regional grower meetings.

Bakers Acres of North Lansing, NY: Maureen Sandsted, manager, will provide the greenhouse and the plants for the NY specialty annual trials. Maureen retains final decision-making rights over Bakers Acres crops.

Karen Dean Hall Agricultural Services: She will make weekly monitoring visits to Mischler's and communicate observations to Carol.

Mischler's Florist, NY: Mark Yadon, owner/manager, will provide the greenhouses, poinsettias, and beneficial insects for the NY poinsettia trial.

The Pennsylvania Department of Agriculture IPM Program: He will collect, analyze and share data. He will compare baseline results of normal biological control in 2007 with results in 2008 after the grower adds eggplant GPS to its current beneficial insect program. He will distribute and collect survey forms among his greenhouse grower constituency at the beginning of the project and again at the end of 2008.

6. Key Personnel (resumes follow for Glenister and Skinner)

Carol Glenister is founder and president of IPM Laboratories, Inc. She has been an IPM consultant since 1981 and active in the production and promotion of beneficial insects and mites for pest management since 1985. She is committed to the support of biological control, IPM, sustainable farming and small farms. She co-owns an organic crop farm and a cow-calf livestock herd with her husband, Richard Glenister, the farm operator.

Wade Esbenshade is a Pennsylvania Department of Agriculture Greenhouse IPM Specialist and an organic farmer.

Karen Dean Hall is an IPM consultant and program director of the NYS Flower Industries. She is a former Cooperative Extension agent for greenhouse ornamentals.

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Margaret Skinner is Research Associate Professor, Plant and Soil Science, in the University of Vermont's College of Agriculture & Life Sciences. She combines entomology research with public awareness projects on many insect pests in the Northeast. Skinner coordinates IPM education in three states, serves on the National Science Advisory Committee for the Asian Longhorned beetle and is a key link between northern New England growers and the latest entomology research. She organizes the Tri-State IPM Workshops which bring a one day greenhouse IPM session to Maine, New Hampshire, and Vermont every January.

Bakers Acres, North Lansing, NY opened in 1980. As a 30-acre 10-greenhouse operation, Bakers Acres is one of the largest herb and perennial growers in Central New York. Its nursery offers a variety of trees and shrubs, and they grow more than 1000 varieties of shade and sun perennials, 250 varieties of herbs and offer more than 75 kinds of specialty annual flowers. During its busy season Bakers Acres employs about 30 people. Maureen Sandsted, owner of Bakers Acres, is involved with Tompkins Sustainable, a grassroots project that, among other things, educates the public about the importance of embracing sustainable agriculture practices such as composting and recycling. They would like to migrate their ornamentals greenhouses to include biological controls.

Mischler's Florist grows and retails ornamental plants and flowers year round in Williamsville, NY. Both Mischler's Florist (formerly owned by Dave Mischler) and Mark Yadon are long-time users of natural enemies. Mark has managed large greenhouse facilities growing cut roses, cut gerberas, poinsettias and potted ornamentals, and general bedding plants. Many years ago he was a field pest management scout in Washington State. Mark retains final decision-making rights over Mischler's crops.