Northeastern IPM Center – IPM Partnership Grant Program 2012
Project Description

PD: Dr. Heather Darby
Lead Institution: University of Vermont Extension
Co-PD(s) and Institutions:
Project Title: "Impact of cover crops on beneficial and pest insects in hops"
Project Type: IPM Issues

Project Summary:

Public interest in sourcing local foods extends into beverages, and the demand for local and organic brewing ingredients is on the rise. Although hops are not a new crop in the Northeast, they have not been grown on a commercial scale for almost 100 years. Today, 99% of hop production takes place in the arid regions of the Pacific Northwest (PNW) on hop farms averaging 450 acres. Pest management information developed for the PNW is generally not applicable to the humid Northeast leaving growers bereft of research-based information for sustainable pest management in hops. Additionally, pest pressures seen in the Northeast are different that those normally observed in the PNW, namely potato leafhoppers (*Empoasca fabae*), Eastern comma butterfly (*Polygonia comma*), and Japanese beetles (*Popillia japonica*). It is well documented that cover crops can provide a habitat to both beneficial and harmful insects, while maintaining a ground cover that can compete with weeds, but no research has been conducted on cover crops in hops in the Northeast. The objective of this project is to work collaboratively with growers to identify beneficial and harmful insects attracted to hop plants in the Northeast and create outreach materials to help farmers adopt IPM practices. We will also work with a partner farm to evaluate the impact of cover cropping on beneficial and harmful insects in hop production. Research that improves the economic and environmental sustainability of hops production will help growers produce a high-quality product that meets the demands of local brewers.

c. Problem and Justification

The Northeast Hop Alliance, in association with Cornell University, conducted a survey in 2002 which reported that the majority of the 400 breweries sampled would be willing to pay a premium of between 5 and 10% for regional hops. Nationally, according to the Brewers Association, there are 600 new craft breweries slated to come on-line in the next year, a 25% increase (Yankee Brew News, Dec 2011/Jan. 2012 edition). These breweries will be breaking into an already highly creative market, and will be looking for something that will elevate them above their peers. Local hops and beer *terroir* are one of those ways in which a regional brewery can stand out as unique. Rosalie Wilson with funding the Vermont Agency of Agriculture, Food, and Markets and the Massachusetts Department of Agricultural Resources conducted a Feasibility and Market Research Study for the Commercial Hop Production in New England. As part of her work, she interviewed brewers from throughout New England, 94% of whom declared an interest in purchasing New England hops. Great interest has been expressed in helping brewers to meet their demands, but high quality research-based information is in short supply for the Northeast.

The demand for locally sourced hops has reached the farming community resulting in a sharp increase in Northeast hop producers from six in 2009 to thirty in 2011. These growers are small scale and produce anywhere from 0.25 to 10.0 acres of hops. Although this is not a new crop to the Northeast it has not been grown in large scale for almost 100 years. The vast majority of hop growers in the Northeast are new to farming. They have limited experience with pest

identification and control. Of the 31 respondents to the UVM Extension online hop grower survey, 75.9% are currently hand weeding their hops. Seventy percent say that Japanese beetles are their primary insect pets, followed by 35% who say that aphids are the primary pest. Ninety-four percent of respondents identified weed, insect and/or disease control strategies as an important impact on their hop operation's success. Of the respondents to the UVM Extension 2011 Annual Winter Hops Conference survey, 92% stated that disease, insects and other pests were one of the major constraints to growing hops in the Northeast, and 86% said that weed control was a major constraint. In November of 2011, a Northeast Hops IPM Working Group was formed, and the needs and priorities of hop growers were identified (led by Tim Weigle, Cornell University). A need for materials to allow for field identification of insect, weed, and diseases, including both on-line resources and pocket guides was at the forefront. To quote Brian, a hop grower from Penn Yan, NY, "Something's eating my hops, but I don't know what it is!" In addition, a need for pest management guidelines for hops in the Northeast that focus on IPM and organic materials and practices was also identified, including economic thresholds for common pests. Ian from Ferrisburgh, VT "That's a potato leafhopper? Jeez, they're all over. Are they bad? How do I get rid of them?"

In 2011, hop producers in the region have started to report serious insect pressure. Pests observed in Northeast hopyards included the two-spotted spider mite, Eastern comma butterfly (*Polygonia comma*), Japanese beetle (*Popillia japonica)*, potato leafhopper (*Empoasca fabae*), and hop aphid (*Phorodon humuli*). These insects are affecting the quality of hop cones and damaging crop yield. Potato leafhoppers (*Empoasca fabae*), commonly found in alfalfa fields in the Northeast, are voracious fans of hops. Leafhoppers are not considered a pest in commercial hopyards in the PNW. Preliminary data collected by UVM Extension suggests that there are varietal differences in leafhopper predation on hops. There is currently no economic threshold documented for potato leafhoppers in hops, and it is unknown to what extent a potato leafhopper infestation can affect yield. The habitat of the Eastern comma butterfly (*Polygonia comma*) does not extend to the PNW, but has historically been a hops pest in the Northeast, and growers report that it continues to be so today. This pest can cause significant damage to a hop plant to the point of almost completely defoliating the bine if there is no intervention. Research is needed to identify Eastern comma butterfly predators, and how to promote them in them in a hopyard, maximizing biocontrols as part of the NASULCG Research Priority for Plant and Pest Biology. Japanese beetles (*Popillia japonica*) are scourge to many crops, and have been found to have a predilection to hops in the Northeast as well. Observational reports suggest that hop bines that have been heavily infested produce stunted sidearms and limited cone development, suggesting a significant correlation between pest levels and yield. Gene from Northfield, MA says "The Japanese beetles like my hops even more than my roses!" A literature review suggests that no research has been conducted on this pest in hops. Paul, a hop grower in Shaftsbury, VT says of Japanese beetles "They eat everything in sight, but the traps don't work, and the organic sprays that we use are so expensive, and I'm not even sure how well they're working! How do I know when it's worth it to spray? Should I spray something else? The hopyard is right next to the house, I don't want to use anything toxic." NASULGC Research Priorities for Plant and Pest Biology have identified environmental protection and agriculture economic viability as a priority. Pests of the PNW can also be found here, including, but not limited to, the hop aphid (*Phorodon humuli*) and two-spotted spider mites (*Tetranychus urticae*). Two-spotted spider mites and hop aphids have many predators that can be found in the Northeast, but few growers are equipped with the tools to not only identify them, but also to weigh the predator populations against the pest population to determine whether a chemical intervention would do more harm than good. This falls under the NASULGC Research Priority for Plant and Pest Biology, looking at more environmentally

friendly crop production systems that use sustainable pest management strategies that promote environmental stewardship.

The use of environmentally friendly pest management practices such as cover cropping in hopyards has been investigated in the PNW, and suggests that incorporating flowering plants among rows of hops will attract beneficial predatory insects (James et al. 2009). Cover crops have also been shown to decrease erosion, improving soil health as well as aid in the availability of nutrients (Turner 2011, Olmstead 2006). The only sustainable biological control studies on hops have taken place in the PNW. In 2000, Washington State University began studying organic and conventional agronomic methods in hopyards. Their studies were twofold, including one pesticide free experimental hopyard where alternative methods of pest control were evaluated and a second conventional hopyard where insecticide doses and the safety level of each chemical were examined. Grasswitz and James (2009) concluded that biological pest control is sustainable for hopyards in the PNW climate, presenting an easily integrated and organic method of pest control while producing high-quality hop cones. Conventionally-grown hops do not necessarily produce high-quality cones, and often have suppressed beneficial insect populations and an increased presence of other insect pests (Turner et al. 2011). The two main problematic pests seen in the WSU hop yards include two-spotted spider mites and damson-hop aphids. The mite-eating ladybird beetle (*Coccinellidae*), minute pirate bug (Orius and Anthocoris spp.), green lacewing (*Chrysoperla rufilabris*), and predatory true bug species are ecologically able to keep mite and aphid populations in check in a cover cropped organic hopyard (James 2004; Grasswitz and James 2009). This research suggests that introducing a cover crop to Northeastern hopyards will attract beneficial insects, thereby decreasing yield and quality damage from insect predation. However, species found to be successful in the PNW do not necessarily thrive in our climate, indicating a need for the identification of successful cover cropping systems tailored for the Northeast. Of the pests currently observed in our region, potential predatory enemies include the spined soldier bug (*Podisus maculiventris*), green lacewing, and members of the stink bug (*Pentatomidae*) and ladybird beetle families. These beneficial insects can be attracted to hopyards by planting species of flowering cover crops which will continue to flower in succession throughout the season (Turner et al. 2011).

Based on our current knowledge it is possible to produce high yield and quality hops in the Northeast. This new demand has created a niche market potential for many farmers and hopefully more farmers can tap into this growing sector. A Northeast hopyard can produce between 1,000-2,000 lbs of hops/acre (Darby, 2011). A price point of $10-15/lb, identified by both brewers and growers as an acceptable price, would allow many farmers to gross between $10,000-30,000/acre (Wilson, 2010). Supporting this burgeoning industry could provide a substantial source of income to farmers, and serve as an agritourism opportunity for growers and brewers. By partnering with the farmers and brewers we will ensure that hops grown in the Northeast meets brewer expectations and quality requirements so the industry can be sustainable. Developing best management practices for pest control will help meet this goal.

Growers in the Northeast do not have the decades of experience growing hops that can be found in the PNW, and can often be found spraying broad spectrum pesticides without consideration of economic thresholds or beneficial insect populations. To avoid insect pressure and ignorance putting a quick end to this fledgling industry, research and outreach must be developed on integrated pest management specific to our region. The objective of this project is to work collaboratively with growers to identify beneficial and harmful insects attracted to hop plants in the Northeast and create outreach materials to help farmers adopt IPM practices. A "Hop Pest Guide" will be developed through the project and shared through the Northeast IPM Center, UVM Extension, and Northeast Hop Alliance (NeHA) websites. The second objective is to evaluate the impact of cover cropping on beneficial and harmful insects in hop production.

Applicability of the proposed approach to other regions

Small-scale sustainable and organic hops production is growing in popularity across the United States. UVM Extension is currently collaborating with researchers in Michigan and Washington, where significant interest in sustainable and organic hop production has been expressed by both farmers and brewers. This group is currently collaborating on a USDA OREI grant that is evaluating organic production of 20 hop varieties in each region. We also consistently field calls from small-scale growers in North Carolina, South Carolina, Tennessee, California, Colorado, Canada, New Mexico, and Wisconsin, as well as states throughout the Northeast, including, but not limited to, Maine, New Hampshire, Vermont, New York, Connecticut, Rhode Island, New Jersey, Maryland, and Pennsylvania. All findings and outreach materials from this project will be made available on the Northeast IPM Center, UVM Extension, and Northeast Hop Alliance websites.

d. Objectives and Anticipated Impacts

With a growing number of hopyards, biological control research must take place to support viable hop production and meet consumer demand for local and sustainable produced beer. The aims of this proposed effort are to

1. Work collaboratively with growers to identify beneficial and harmful insects attracted to hop plants in the Northeast, and create resource material that will enable them to easily and reliably identify pests in their hopyards and provide them with viable control options.
2. Evaluate the impact of cover cropping on beneficial and harmful insects in hop production.

Our overarching goal through this project is to help hop growers in the Northeast understand hop pests and predator pests, and to be able to implement IPM practices that are environmentally and economically sustainable. Through the research and outreach outlined in this proposal, we expect to have the following outcomes and impacts:

1. 30 of the 100 attendees that attend outreach events will document an increase in hop beneficial and harmful pest identification knowledge.
2. 15 of the 100 attendees that attend outreach events or receive outreach material will implement cover crops in their hopyard. Of these 10 will document an increase in beneficial insects.
3. 40 of the 100 attendees that attend outreach events will document that they have begun scouting to identify pests and to identify best times to apply control treatments.
4. 30 of the 100 attendees that attend outreach events will document that they improved hop quality and sales by implementing knowledge and strategies gained through this project.

e. Approach and Procedures

Dr. Heather Darby, UVM Extension Agronomist, will oversee all projects with assistance from Rosalie Madden, UVM Extension Crops and Soils Technician. The cover crop trial will take place at Borderview Farm in Alburgh, VT. The replicated research plots are on a Benson rocky silt loam. The hopyard was constructed in the spring of 2010, with a finished height of 16 feet using 20' x 6" cedar posts. After the hopyard was constructed, two vegetative hop cuttings were planted per hill on August 4th, 2010. In the proposed cover cropped area, hills of hops were planted 5 feet apart, and rows were spaced at 10 feet. Bines will be trained up two strings of coir per hill in the spring. The 18 plots available for use in the hopyard for a cover cropping trial

measure in area 20' by 35'. Within each plot there are two rows of hops consisting of 7 hills in each row. Each row is planted to either the variety 'Cascade' or 'Nugget'. Each hill represents 2 plants. Therefore in each plot there are 14 plants of 'Cascade' and 14 plants of 'Nugget'. The study will be a randomized complete block design with split plots replicated three times. The main plots will be 6 cover crop treatments. The subplots will be variety (Cascade or Nugget). The cover crop treatments will include mustard, buckwheat, mustard/buckwheat mix, native flower mix, white clover/bluegrass mix, and a no cover crop control. The cover crops will be planted between the rows of hops within a plot. The plots will be prepared with a moldboard plow, disked and finished with a spike tooth harrow. The cover crops will be seeded with a 10-foot Kvernaland drill. The mustard will be planting at 8 lbs per acre to a depth of ¼ inch in mid-April (or as soon as possible). The native spring and summer flowering perennials would be planted as a mixture at a rate of 5 lbs per acre to a depth of ½ inch. The native cover crops will be planted in late April or early May when the site is no longer in danger of spring frost. The buckwheat will be planted in early June at a rate of 25 lbs per acre to a depth of 1 inch.

Insect scouting in the cover crop trial would begin the first week of June and sampled once weekly using each ground sweeping, yellow stick traps, jarring of bines, and top, middle, and bottom detail leaf inspection. Insects collected using these techniques from both the control and cover crop plots will be identified in the University of Vermont Entomology Lab with the guidance of resident entomologists. Insects would be identified at least to family and species level when necessary. Methods of collecting insects vary based on the targeted insect. Because this would be an overall assessment of what beneficial and pest insects are present in this Vermont hopyard, a variety of techniques are proposed with the physiological characteristics and layout of the hop plants in mind. Techniques are listed below.

1. Ground sweeping would be conducted using an insect sweep net to sweep along the first 4 feet of cover crop and hop vegetation in each row. Specimens would be transferred to a plastic container filled with rubbing alcohol or placed in plastic bags and frozen.

2. The yellow sticky traps would be fastened to one hop bine in randomized locations per row among the cover crop and control treatments. Collection would occur at the sampling the following week. Tags and specimens will be transferred to labeled plastic bags and frozen.

3. The jarring method has been successful in previous hop insect sampling (James 2004). One randomly selected bine from each treatment, once per week, will be whacked using a wooden stick, dislodging insects from bine, leaves, and cones. A white tarp would be placed on the ground to surround the base and shadow of the bine. An aspirator would be used to suck up all dislodged insects with collection into a bottle of alcohol.

4. Detailed sampling will take place with the goal of sampling all levels of the canopy and to collect any additional species that might have fallen through the techniques of other methods. One leaf will be collected from each bottom, middle, and top of one randomly chosen bine per treatment, totaling the collection of 6 leaves. These leaves would be taken back to the lab and insect present would be identified using a microscope.

3. A modified leaf blower will be used for sampling insects. We will standardize the amount of time (45 seconds) spent sampling on each host plant (hop plants or cover crops)

Both hop and cover crop plant phenology will be tracked by measuring the height and maturity every two weeks. Plants will be characterized into plant phenological stages. Measurements will include date of planting, emergence, critical development stages, and date at 25, 50, 75, and 100% flower. Cover crop and weed biomass will be collected at the time of cover crop full bloom. Two quadrats of 1m x 1m will be collected per plot. The samples will be separated into cover crop and weed components. Weed species will be identified and documented. Samples will be weighed and then dried to determine biomass yields on a dry matter basis. Hops will be harvested once cones reach 20-25% dry matter. Hop bines will be cut from the yard and brought to a central picking location to be harvested. Bines will be weighed, hop cones removed, and total cone weight measured. Plants and cones will be evaluated on a 1 to 10 scale for insect damage. Hop cones will be dried to 8% moisture and a 100g subsample per plot will be sent to Alpha Analytics for quality (alpha and beta acids) determination. Mixed model analysis will be calculated using the mixed procedure of SAS (SAS Institute, 2008). All treatment factors in this experiment will be considered fixed with the exception of replicates. Mean separation among treatments involving cover crop types will be obtained using the Least Significant Difference procedure when significant F-tests ($P<0.10$) are observed.

In addition to the replicated research trial insect pest information gathered from this project will be delivered to the farming community. UVM Extension will host two field days, one at the site of the research yard in Alburgh, VT, and one at a cooperating farm in the Northeast. Through these two field days we expect to make contact with over 100 people interested in, or already growing hops. At these field days we will present information gathered on beneficial and harmful insects that can be found in the Northeast, and train growers how to properly scout their hopyards. One YouTube video will be made on how to properly scout a hopyard and posted on the UVM Extension Crops and Soils website, on the UVM Extension Crops and Soils YouTube channel (71 subscribers, over 69,500 views), posted on the UVM Extension Crops and Soils Facebook page (currently 189 "Likes"), and Tweeted through the UVM Extension Crops and Soils Twitter account (currently 51 followers). Three pest bulletins will be published over the course of the 2012 growing season and posted on the UVM Extension hops blog "What's Hoppening", and linked to on the Northeast Hop Alliance and Northeast IPM Center websites. There are currently 177 people subscribed to the UVM Extension hops blog, and the hops page on the UVM Extension Crops and Soils website has been visited over 3,000 times.

A "Hopyard Insect Guide" will be developed and distributed at the annual UVM Extension Winter Hops Conference in February 2013. The guide will include beneficial and harmful insect pest identification tools, scouting protocols, and appropriate controls methods. A web version of this guide will also be available on the UVM Extension Crops and Soils website, the Northeast Hop Alliance website, and the Northeast IPM Center website. The guide will be publicized through UVM Extension Hops Email list that currently goes out to 260 recipients as well as posted on the UVM Extension hops blog "What's Hoppening."

Project Timetable

April 2012: Collaborate with Roger Rainville of Borderview Farm to finalize research plans. Finalize research protocols including insect sampling techniques. Order project supplies, including cover crop seed, sticky traps, and other sampling tools.

April - May 2012: Cover crop seedbed will be prepped as early in the spring as possible. Early season cover crop (mustard) will be seeded in mid to late April. Twine will be hung in the yard and hops will be trained onto the twine. Cover crop/hop growth and development measurements will begin.

June 2012: The buckwheat will be seeded. Hops will be weeded in the row, and fertilizer applied. Measurement of cover crop/hop growth and development continues. Sampling for insects will begin in early June. Insect identification will begin in the entomology lab. YouTube video will be developed, and scouting bulletin posted on the "What's Hoppening" blog.

July and August 2012: Measurement of cover crop/hop growth and development continues. Biomass sampling of mustard and control plots. Sampling for insects will continue weekly through July and August. Insect identification will continue. Two scouting bulletins posted on the "What's Hoppening" blog. A field day will be hosted at Borderview Farm to highlight the cover crop project and at one other collaborating farm in the Northeast to teach pest identification and scouting protocols.

August - September 2012: Final measurements of cover crop biomass will occur prior to hop harvest in late August to early September. The final sampling of insects will occur prior to harvest. Insect identification will continue. Hops harvested and yields collected. Hop cones and plants evaluated for overall insect damage. Cone samples collected and sent for quality analysis.

October- December 2012 Insect identification is finished and all data is entered and analyzed to determine results. Begin development of hop insect guide. Preliminary data presented at the Northeast Hop Alliance Annual Meeting and Fall Conference.

January- March 2013 Disseminate project results to farmers at conferences and workshops throughout New England. Finish Hop Pest Guide and distribute through web and at meetings.

f. Evaluation Plan

Through the below mechanisms the project team will be able to quantify the impact that this project has had on improvement in yield and quality of hops in the Northeast. Workshop/conference surveys will be delivered after every event. At all events farm names and contact information will be gathered. The surveys are designed to help determine if the information is useful, if it will be implemented on farms, and if it will improve the livelihood of a farm family. These surveys will also help us determine future needs for outreach and research. Interestingly, many of the farmers that attend our yearly meetings are return clientele. They return because the meetings have provided them with information that improves their farming system. Since we have repeat clientele, we have the opportunity to monitor through surveys if our work has "ACTUALLY" helped the viability of their family farm through increased hop yield and quality as a result of implementing new tools and knowledge. Farmers that participated in the advisory IPM working group will be evaluated during and after completion of this project. This small but representative group (15 farmers) will work closely with the project team to collect impact of new IPM tools, yield and quality improvements, and markets gained through participation in the project. This data will be compiled to demonstrate effectiveness of implementing new tools and knowledge gained on IPM for hops. Lastly an online survey will be

delivered to members of the What's Hoppening" blog to document changes in pest management strategies.

g. Logic Model
See attached logic model in appendix

h. Cooperation, Institutional Units, and Key personnel Involved
Key Personnel

Dr. Heather Darby is an agronomist with University of Vermont Extension and an Associate Professor with the Department of Plant and Soil Science. Since arriving at UVM in 2003, she has worked closely with farmers around the state on her research and extension work that have focused on cropping systems that protect water quality, and in 2010 developed research and outreach focused on the development of best agronomic practices for hops growers. Dr. Darby in collaboration with Tim Weigle also hosted the IPM Hops Working Group Meeting in November, 2011 to identify producer needs. Dr. Darby will oversee all aspects of this project including the on farm trial and outreach projects.

Rosalie Madden will be primarily responsible for implementing research, collecting insect data, compiling scouting data into outreach materials, and delivery to farming community. Rosalie had worked as a Technician in Dr. Darby's program for the last 3 years. She has been the primary lead on the hop variety trial and outreach development to date.

i.References Cited
Grasswitz, T., and D. James. "Influence of Hop Yard Ground Flora on Invertebrate Pests of Hops and Their Natural Enemies." Journal of Applied Entomology 133 (2009): 210-21.

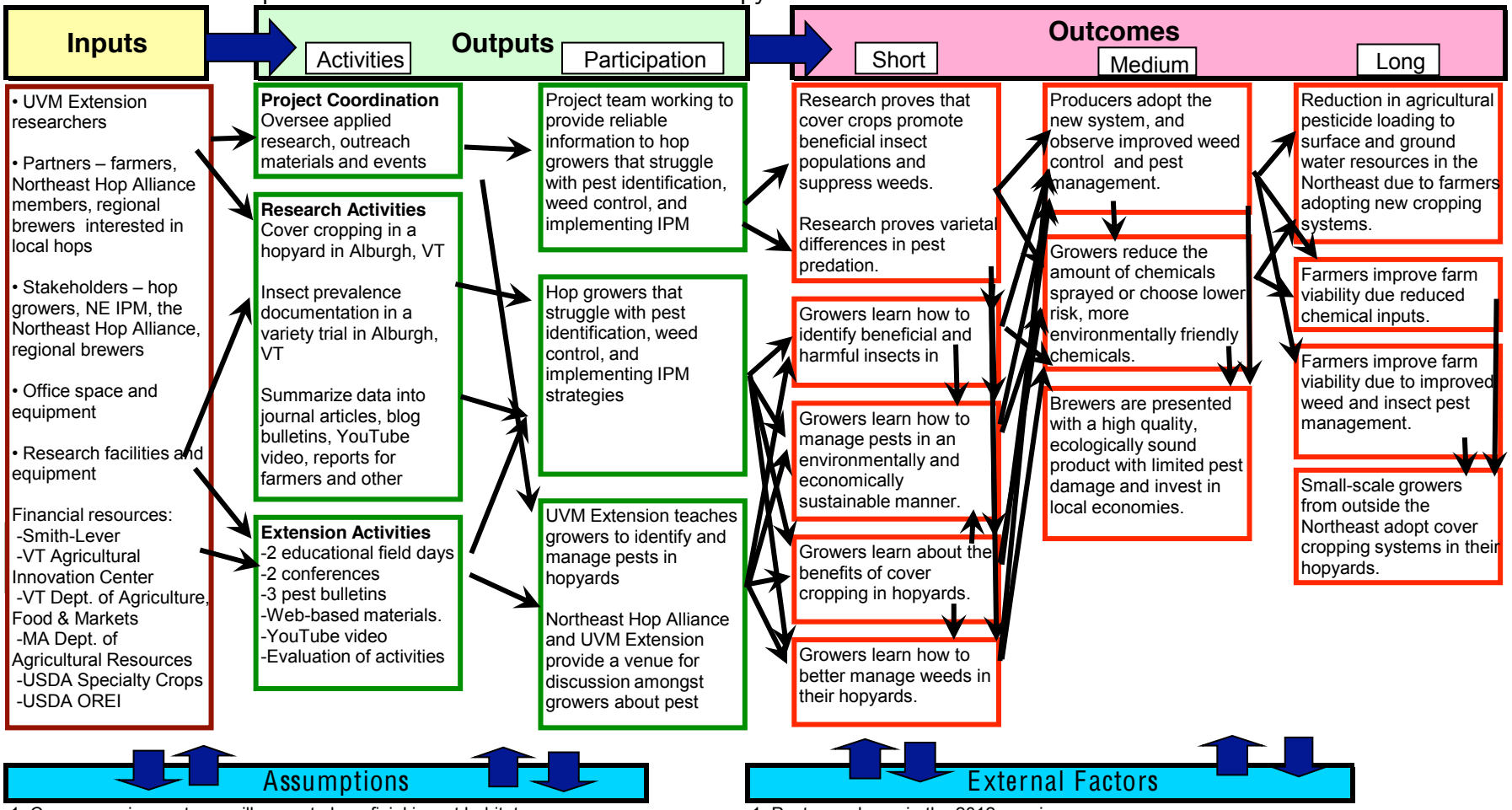
James, David. "Beneficial Arthropods in Washington Hop Yards: Screening the Impact of Pesticides on Impact and Function." Final Report for Washington State Commission for Pesticide Registration (2004): 1-28.

Olmstead, M. "Cover Crops as a Floor Management Strategy for Pacific Northwest Vineyards." Washington State University Extension 2010 Bulletin (2006 and 2010): 1-12.

Turner, Samuel, Chris Benedict, and Heather Darby. "Challenges and Opportunities for Organic Hop Production in the United States." Agronomy Journal 103.6 (2011): 1-10. Print.

Goal: The mission of the Northeastern IPM Center is to foster the development and adoption of IPM in ways that generate economic, environmental, and human health benefits. A stated priority of the Northeast IPM Center is ensure long-term cropping system sustainability by promoting more environmentally friendly crop production systems that utilize sustainable weed, insect, and pathogen management strategies that promote environmental stewardship and promote biodiversity within the agricultural landscape. This project will meet this goal by improving the understanding of beneficial and harmful insects in Northeastern hopyards and improving weed management. **Situation:** Large scale hopyard pest management information has been developed for arid climates, but is often not applicable to the humid Northeast, where the majority of hopyards are well under 5 acres. Pest pressures seen in the Northeast are different that those normally observed by hop growers in the Pacific Northwest. Growers in the Northeast are bereft of research-based information for sustainable pest management in hops. It is well documented that cover crops can provide a habitat to both beneficial and harmful insects, while maintaining a ground cover that can outcompete weeds, but little research has been conducted on cover crops in hops in the Northeast. Research that improves the economic and environmental sustainability of hops production will help the many interested growers produce a high-quality product that meets the demands of local brewers.

Influence of cover crops on beneficial and harmful insects in hopyards - LOGIC MODEL



1. Cover cropping systems will promote beneficial insect habitat.
2. Cover cropping systems will reduce weed pressure.
3. Pest prevalence is related to hop variety.
4. Cover cropping systems in hopyards will improve profitability.

1. Pest prevalence in the 2012 growing season.