NCR-SARE Farmer Rancher Grant Program

Final Report Form

Please fill out this form and return it to the North Central Region-Sustainable Agriculture Research and Education (NCR-SARE) Program office by March 1, 2010. Your NCR-SARE Farmer Rancher Grant project is scheduled to end on December 31, 2009 and the final report is due within 60 days of that date, which is March 1, 2010. The report may be prepared on a computer or handwritten (please write or print clearly). Electronic reports are preferred, if that is convenient for you. The final payment of your grant will be awarded when a final report and final budget are received and approved. **We must receive the final report by March 1, 2010 to insure your final payment.**

I. PROJECT IDENTIFICATION

- Name: Janell K. Baran
- Address: 6000 Porter Road, Newark OH 43055
- Phone: 740-345-4689
- Project Title: Field study of a technique for combining low-cost, herbicide-free control of woody invasives, in particular *Ailanthus altissima*, with production of edible mushrooms.
- Project Number: FNC07-670-07
- Project Duration: March 24, 2008 – December 31, 2010
- Date of Report: March 1, 2011

II. PROJECT BACKGROUND

1. Briefly describe your operation (i.e. how many acres, what crops, types of cropping systems, type of livestock or dairy production, grazing systems, family operation, etc.)

Our farming operation is really 2 separate farms. We own a 130-acre tree farm (known as Blue Owl Hollow) in NE Licking Co. which has been enrolled in the American Tree Farm system since 2005. Consisting of mature native hardwoods and conifers, it is managed primarily for biodiversity conservation and non-timber forest products, e.g., culinary mushrooms on logs, native herbs, crafting materials, black walnuts & hickories, bramble berries, etc., for personal consumption and for sale locally. I also own a portable sawmill, which we use to process lumber from storm-damaged or selectively thinned timber primarily for farm use.

In 2002, we purchased an additional 3 acres nearby with several historically significant buildings, including rural store buildings, house and barn, all dating from the 1850s-1870s. I have established an herb farm on that acreage (doing business as Blue Owl Garden Emporium), growing fresh and dried culinary herbs, heirloom fruits and vegetables, and edible flowers for sale at local farmers' markets. After the store buildings are restored to their 19th c. appearance, I will make this location my principle point of sale for my own products as well as the goods of other local farmers.

I am the primary farm operator for both properties, having left a lucrative, but stressful, career as a web developer in 2005 to take up farming full-time. We use only organic methods, but are not certified as such. Philosophically, I am committed to an economically viable and environmentally sustainable local agricultural economy.

2. Before receiving this grant, did you carry out any sustainable practices? If so, briefly describe what they were and how long you used these practices.

I have used organic gardening practices for at least 25 years in our personal food production. When we bought the tree farm in 1998, we naturally applied similar methods to forest management. It was my refusal to follow

the suggested conventional treatment for invasive trees (primarily applications of glyphosate, triclopyr, and/or imazapur herbicides) that led to the development of the technique described in my grant proposal. Conservation and biodiversity are 2 primary objectives stated in our forest managment plan (original 1999, revised & updated 2008). In line with those objectives, we use primarily mechanical means to control invasive tree and plant species, plant suitable native species (trees, shrubs, forbs, and grasses) as replacements yearly, provide and/or preserve wildlife and pollinator habitat wherever possible, address erosion or storm damage issues as they arise, and generally monitor the overall health of the forest ecosystem.

Likewise, on the herb farm operation (established in 2002), no petroleum-based herbicides or pesticides are used and a parallel commitment to biodiversity and conservation is observed. Buffer strips of trees, shrubs, and forbs are maintained along property boundaries and roads. Soil amendments consist of natural mineral supplements or compost. I use locally-sourced natural mulches (compost, straw and other grasses, wood fiber products) to retain moisture and reduce weed pressure. The slopes on this property are quite steep and series of raised beds, meadow strips, and grassed access trails are used to minimize erosion. Mechanical control is used for invasive woody species; a combination of repeated cutting and yearly bushhogging of open areas has dramatically reduced the populations of Ailanthus, honeysuckle, multiflora rose, privet, and eleagnus.

III. PROJECT DESCRIPTION AND RESULTS

This is the core of the report. Consider what questions your neighbors or other farmers or ranchers would ask about what you did with this grant. Describe how you planned and conducted your research or education project to meet your goals and discuss the results.

GOALS

List your project goal(s) as identified in your grant proposal.

1) Investigate an alternative treatment for controlling the spread of the invasive tree species *Ailanthus altissima* (common name Ailanthus or Tree of Heaven) which:

a) is straightforward and inexpensive,
b) is environmentally benign with minimal impact on surrounding vegetation, soil, and water,
c) can be administered by a single person quickly and effectively and
d) enhances the economic potential of our forest farm.

2) Investigate the suitability for producing a culinary mushroom cash crop on the Ailanthus trees which are being treated, as a means to address 1. d. above.

PROCESS

Describe the steps involved in carrying out the project and the logic behind the choices you made. Please be specific so that other farmers and ranchers can determine what would apply to their operation and gain from your experience.

Step 1: Identify the areas with the worst Ailanthus infestions for use in the study.
One particular management area on our tree farm had ~200 trees of suitable size and characteristics in reasonably close proximity; I was able to lay out a reasonable number of plots with enough trees in each to provide for controls, baseline treatments, and the mushroom inoculation treatments (8 plots, labeled A-H, each with 25 trees), see Appendix A: Test Plot Map. 25 trees in each plot allows 5 trees for controls (no treatment or inoculation), 5 trees for baseline treatment (no mushroom inoculation), and the remaining 15 trees could be split into 3 groups, each treated and then inoculated with a different edible mushroom. 200 trees overall is a large enough number to be statistically valid and overcome any slight variations in aspect, slope, elevation, soil composition, etc. It turns out that the plot characteristics were all very similar.

For my forestry mapping applications I use:
Garmin GPSmap 60Csx hand-held GPS

MacGPS Pro (Mac OS X) for GPS data manipulation
Adobe Photoshop Elements for graphical representations/creating multiple map layers


Marking GPS coordinates

Each tree was recorded by GPS and its coordinates mapped in MacGPS Pro. Additionally, trees in the plots were painted with a symbol unique to each plot, making it much easier to identify them (and the plot boundaries) from a distance.

Many of these same considerations would apply for future production areas, if we choose to pursue this further. 25-tree plots seemed to be a good, manageable size for each stage of the process: treatment, inoculation, monitoring, and harvesting. Of course, as the treatment program advances, and the overall Ailanthus infestion diminishes, it will become harder and harder to lay out plots in such convenient ways. This may ultimately diminish the economic feasibility by making it too time-consuming to check on few trees widely scattered.

Step 2: Choose suitable culinary mushrooms species that:
a) are native to Ohio,
b) naturally grow on trees or logs, and
c) are easily identifiable and appealing to my market.

With the assistance of George Vaughan and the other folks at Mushroom Harvest in Athens, OH, I was able to acquire Ohio-collected strains of *Pleurotus ostreatus* (oyster mushroom) and *Laetiporus sulphureus* (sulphur-shelf or chicken-of-the-woods). Mushroom Harvest had 2 distinct strains of *Pleurotus ostreatus*, a brown and a white, in their culture library. These 2 oysters and the sulphur-shelf comprised my 3 different mushroom treatments. Both are common edible mushrooms and have few poisonous look-alikes; both can be cultivated on logs. *Pleurotus sp.* are particularly fond of soft hardwoods, such as poplar, tulip tree, etc. Ailanthus has certain similarities to poplar, so any *Pleurotus* strain seemed a good bet. The sulphur shelf was a less likely candidate, but was the next best match from the few culinary strains available. Given our managment objectives for the tree farm, it was a high priority to use only native species and local genotypes for use/introduction into our woodlot. The other edible mushrooms to meet our stated criteria were *Grifola frondosa* (maitake) and *Hericium erinaceus* (lion's mane).


Laetiporus sulphureus


Pleurotus ostreatus 'OH White'


Pleurotus ostreatus 'OH Brown'

One of the things I used my grant funds to do was acquire the resources and equipment to grow my own mushroom spawn. This has given me the flexibility to select and propagate other appropriate native culinary mushroom strains for further experimentation and development. Although for the sake of consistency, I used only the 3 strains sourced from Mushroom Harvest for the duration of the study, I was able to grow up about a third of the spawn used in the study myself. The rest was purchased from Mushroom Harvest.

This also speaks to the economic viability of the project: acquiring and maintaining my own mushroom strains and producing my own spawn is a huge cost savings over commercial spawn. The cost savings are huge for sawdust spawn (my costs are ~$3.70/5 lbs. compared to $34.75-$23.50 incl. S&H for commercial). However, plug spawn was clearly the better logistical choice for this project and the cost savings of producing my own were still very good ($19.66/1000 plugs vs. $62.25- $58.45 incl. S&H).

Step 3: Plan an appropriate treatment, inoculation, and monitoring schedule.
Most of my tree farm work is performed November - April, while the trees are dormant and undergrowth has died back. Moving through the woods with equipment while the ground is frozen also minimizes adverse impacts to soil structure and plant life. Although I have not tested it explicitly (a project for a future date), my understanding of tree biology has led me to think that treating the Ailanthus as early in the dormant season as possible is more likely to cause the most damage and lead to a quicker demise. Unfortunately, the opposite is the case for mushroom inoculations, which are best done in early spring when daytime temperatures start to be above freezing. The two may be working at cross-purposes. One way to test the timing issue was to schedule different plots for treatment/inoculation at different times.

Treatment and inoculation were scheduled during the winter months, broken down into the following 4 periods:
Period 1: Plots A & B treated Dec. 2008, inoculated Jan. 2009
Period 2: Plots C & D treated Jan. 2009, inoculated Feb. 2009
Period 3: Plots E & F treated Feb. 2009, inoculated Mar. 2009
Period 4: Plots G & H treated Mar. 2009, inoculated Apr. 2009

This is a slight modification of the original proposal, based on both adjustments necessitated by access to appropriate equipment and supplies (custom plug spawn requires a minimum of 5 weeks to produce) and on expert advice from mushroom professionals. When cultivating mushrooms on logs, one generally waits anywhere from a week to several weeks between cutting a log and inoculating it with mushroom spawn, thereby allowing any anti-fungals produced by the tree to dissipate. Trees with intact root systems may take even longer to lose their ability to fend off fungal invaders. I decided wait a full month between treatment and inoculation.

Step 4: Collect initial data on all trees and set starting conditions.
An insight provided by one of my collaborators was the need to randomize the treatments throughout the test plots to avoid bias towards larger (healthier) or against smaller trees. Ordered by size within each plot, each tree was assigned a unique tree ID or T number, T001-T200, plot by plot. For example, Plot A contained T001-T025, Plot B T026-T050, etc. I then used an on-line random number generator to generate 8 different sequences of 25 numbers between 1-25, one for each test plot. These random numbers (plus the plot letter A-H) became treatment IDs to designate which treatment each tree would receive. Treatment IDs 1-5 were control trees and received no treatment or inoculation. Treatment IDs 6-10 were baseline trees and received only the control treatment. Treatment IDs 11-15 were treated and then inoculated with the first mushroom strain, *Pleurotus ostreatus 'OH white'*. Treatment IDs 16-20 were treated and inoculated with the second mushroom strain, *Pleurotus ostreatus 'OH brown'*. The remaining treatment IDs 21-25 were treated and inoculated with the third mushroom strain, *Laetiporus sulphureus*. Each test tree was labeled with an aluminum tag containing the tree ID, the plot letter, and the treatment ID. For example, a tree in Plot E inoculated with the OH brown oyster mushroom might have a tree tag reading T103 E17. See Appendix C, Map of SARE Plot A for an example.

In addition to recording the diameter at breast height (DBH) for every tree, we also collected moisture content readings and photographed each one. Mushroom cultivation on wood requires a moisture content of 30% or greater in order to maintain viable mycelium. Most moisture meters typically do not go above 30-40%, which made it challenging to find a tool to measure this requirement. I finally found a reasonably-priced one designed for both building materials and lumber which went as high as 60%, although the rated accuracy was not great. The Extech model MO210 pin-type meter gave me readings sufficiently realistic to determine whether the moisture content was dangerously low. To help compensate for the decreased accuracy at higher moisture content levels, I took 5 readings at each point and averaged them and used the average for comparison purposes over time and across plots.

Recording moisture content

Step 5: Treat the trees on schedule.
This part was very straight-forward, since I had almost a decade of practice using this technique to combat the spread of Ailanthus in our woodlot.

Here's a summary of the technique (for images, see Appendix B or http://www.blueowlgarden.com/Ailanthus_mushroom_handout.pdf):

Organic Control of Ailanthus

Timing: Late fall, winter, or early spring

Tools: Short drawknife (6")

Technique: Starting at the base of the tree, draw knife up under bark of tree, removing a strip about 18"-24" long with each pass; completely remove bark all around tree. Hint: turning the knife around so the sharp edge is up makes it easier, since the knife doesn't bite too deep. You are removing only the bark; you are not actually girdling the tree.

Follow-up: After one growing season, re-visit the treated trees. Late fall through spring is a good time, since the underbrush has died down and you can see easily. Observe regrowth and stomp down stump sprouts. Pull any small seedlings, if present. Repeat after 2nd growing season, if necessary. Be wary in windy weather -- you have deliberately weakened this tree and it will eventually fall down. Usually it loses much of its mass before this happens and doesn't cause much damage to other vegetation, but beware and be safe.

Resources: Plant Conservation Alliance, Alien Plant Working Group
http://www.nps.gov/plants/alien/

Ohio Dept. of Natural Resources, Div. of Forestry (invasive plant identification)
http://www.ohiodnr.com/default/tabid/21391/Default.aspx

Traditional Woodworker (drawknives)
http://www.traditionalwoodworker.com/

This technique works because it essentially strangles the tree over a period of time, rather than killing it quickly; I am only disrupting part of the vascular system. Note that this is different from girdling, which disrupts the entire vascular transport system. Ailanthus has a very effective regeneration ability by using nutrients stored in the root system. The tree naturally depletes its root stores as it goes through winter and leafs out in the spring. De-barking disrupts the tree's ability to replenish these nutrients and the main trunk eventually dies. Only a few weak stump/root sprouts survive and are easily broken while young. For this reason, it is necessary to revisit each tree the second winter after the initial treatment.


Newly treated Ailanthus

Winter treatment also provides the added benefit of desiccation. The cold, low humidity, and high winds pull out vital moisture from the exposed inner tissue of the tree, further damaging its regenerative ability.

This basic treatment is a part of my normal winter woodlot management activities. I travel on foot and carry only the drawknife. The key is speed; I can do a moderate size tree (~6" diameter) in under 1 minute. Then I move to the next one. I've done as many as 25 trees in an hour, travel time included, but a more sustainable rate is about 10-15/hour. Treatment times for the trees in this study were somewhat longer than under ordinary circumstances, since I recorded moisture content readings, took pictures, etc.

Weather factors to consider are temperature and wind. De-barking at temps <20°F becomes quite difficult due to frozen moisture in the bark and there are safety concerns when working in a woodlot with high winds (20+ mph).

My preferred tool for de-barking is a 6" straight drawknife or draw shave. After trying several different styles, I found the brand Columbus McKinnon Co. with wooden handles firmly bolted to a sturdy blade (~$30) was the best for the job.

Step 6: Inoculate the trees on schedule, weather permitting.
This part was new territory for me and I learned a lot along the way. Here's the basic technique (for full details, see Appendix B or http://www.blueowlgarden.com/Ailanthus_mushroom_handout.pdf):

Added Value with Culinary Mushroom Production

Timing: Any time 2-4 weeks after above treatment, when daytime temperatures are above freezing.

Tools: 36V cordless drill with 5/16" or 8.5 mm high speed bit; extra battery pack, if required (each slim-pack 36V battery does ~5 trees); hammer; aluminum tree tags, nails & pencil; appropriate plug spawn of native Ohio medicinal or culinary mushroom -- any species that naturally grow on logs will probably work. Oyster mushroom (*Pleurotus ostreatus*) is a particularly good choice.

Technique: Drill 5-6 holes 4-6" apart in vertical rows spaced 2" apart in the tree just above the treated area, at about breast height. This is the classic diamond shape inoculation pattern used in mushroom log cultivation. This pattern will yield between 50-80 holes per tree, depending on diameter. Tap plug spawn into holes, flush with bark. Label each tree with mushroom strain and date.

Follow-up: Inspect periodically, especially after rainy periods and dramatic temperature changes, for mushroom formation. Re-visit and treat stump sprouts as before. If desired, monitor moisture content -- mycelium development requires >= 30% wood moisture content. Full incubation of an entire tree may take some time, perhaps a year or two or longer. Be patient.

Resources: Field & Forest Products (mushroom supplies, high-speed bit)
http://www.fieldforest.net/

Fungi Perfecti (mushroom supplies)
http://www.fungiperfecti.com/

Mushroom Harvest (native Ohio mushroom strains, mushroom supplies)
http://www.mushroomharvest.com/

Weather was much more critical for this step. Temps had to be above freezing to do the inoculations. Temps hovering close to freezing also affected choice of tools. I attempted to drill holes in the trees for insertion of the mushroom plug spawn using a bit brace and a 9V cordless drill and finally ended up borrowing a fellow farmer's 36V Bosch cordless drill with a lithium-ion battery. That worked quite well and I purchased my own, with extra battery packs. This was an unanticipated purchase; I bought the entire 4-tool combo and have found it to be a worthwhile investment for many other farm projects. Even with that much power, a single battery pack only lasted through the inoculation of about 5 trees so I had to carry 3 battery packs in order to complete all 15 inoculations in a plot. This, combined with short daylength, restricted me to at most 2 plots per day: I could go out in the morning and inoculate for 2-2 1/2 hours until the batteries ran out, come home for lunch while the batt packs recharged, then go out and inoculate for another couple of hours in the afternoon. The rate I estimated originally for the inoculation times were based on log inoculations (4-6 logs/hour); the tree inoculations took about the same amount of time, averaging about 5 trees per hour. Without the data collection and documentation, I expect I would be able to do 6 or more per hour.

Treated & inoculated Ailanthus w/pack of tools

I found that it worked well to do 1 or at most 2 of the mushroom strains per day and then do the rest another day. This minimized the amount of weight I had to carry around with me. The inoculation tools, drill, spawn, extra batt packs, moisture meter, GPS, labels, camera, etc. added up to 25-30 lbs., which I carried in an open-top wooden pack basket for ease of access. The load were be reduced by 5-10 lbs. without the data collection paraphernalia explicit to the research and focusing on only 1 mushroom strain at a time would reduce it even further, since each spawn container starts out weighing at least 5 lbs.

Finally, it's a very good idea to inoculate a dozen or so cut logs with the same 3 strains of mushrooms used in the test plots at the same time. These were kept in the yard close to the house and monitored as controls. Not only do these logs confirm spawn viability, but they serve as indicators for fruiting cycles/seasons.

Step 7: Monitor the plots for Ailanthus control and stump sprouts.

My initial monitoring schedule was for monthly visits and data collection of moisture content readings. While the monthly site visits were visually informative, it quickly became apparent that monthly moisture content readings were unnecessary, since there was very little variation after inoculation. Unscheduled site visits after any storm events were more critical, since as time passed, the trees became progressively weaker, esp. at the inoculation point, and soon started falling over. While this in theory is to be expected and hoped for, I was uncertain how it would affect mycelium development. The broken off trees DO provide an interesting window into mycelium growth (or lack thereof).

Freshly broken stump showing mycelia growth around plugs

Stump sprouts are the primary indicator for Ailanthus regeneration capacity.

Some of the relevent Ailanthus control literature speak of "thousands" of stump sprouts after mechanical treatment without additional use of strong herbicides. We have found this not to be the case when careful attention is paid to the timing and technique described above. Although we had treated hundreds, maybe as many as a thousand (100-200 per year over 7+ years adds up) of Ailanthus trees and saplings, we had never explicitly measured the resprouting ability of the treated trees.

Obviously, the trees do their best to resprout and carry on, but the real question is this: how many have the resources to survive beyond the 1st season? This SARE grant gave us a framework in which to more rigorously assess the technique, including that question. We took note of stump sprout emergence at several points during the course of the study, paying particular note at the end of the first growing season after treatment (Winter 2009) and at the end of the second growing season after treatment (Winter 2010). The trees clearly attempted to send out sprouts, but only a few of the trees (usually females, usually large diameter) had multiple viable

Viable Ailanthus stump sprouts

stump sprouts at the end of the second growing season after treatment. A viable sprout, regardless of time of year, has good green color all the way to the tip, is upright, and stoutly attached to the base of the stump. Any sprouts growing at an steep angle, grown curled up or around, is brown and dessicated looking, or has dried brown growing tips are not viable. Because we really wanted to find out just how effective the treatment alone was in killing the tree (without the necessity of a follow-up visit), we did not stomp down the viable sprouts on trees in the study plots, letting them go another season to see whether an even higher percentage would succumb over the next year. By the end of the 2nd year after treatment, 64% of trees had no viable stump sprouts left and can be considered dead.

Non-viable Ailanthus stump sprouts

Step 8: Monitor the plots for mushroom fruiting.

This step is greatly eased by the presence of the control logs in the yard. If the weather conditions were appropriate for the logs to fruit, we made a trip to the test plots to look for fruiting there. It was our experience that the logs fruited sooner -- expected because the woody mass was less, so the mycelium completed its incubation stage more quickly -- but less prolifically than the inoculated trees when they finally did produce. Fruiting on the trees took a very long time, also as expected due to the large mass of both above ground and below ground portions of the tree.

OH brown oyster fruiting

Also, only 1 strain produced in abundant quantities: *Pleurotus ostreatus 'OH brown'*. The OH white oyster produced just a few small clusters. *Laetiporus sulphureus* produced not at all 2 years after inoculation, but showed severe contamination by other fungal species, so it is unlikely ever to do so.

Wind-thrown test tree

By the end of the study, a majority of the trees were wind-thrown or otherwise broken off and on the ground. The trees are very weak at this point, sloughing off bark, which will result in rapidly declining moisture content. The downed tops retain more moisture in contact with the ground and the inevitable leaf cover. The broken bases still have their root system in contact with the ground, so retain moisture that way.

We did find that the broken trees produced more mushrooms: in a huge fruiting of *Pleurotus ostreatus 'OH brown'* that occurred in Nov. 2010, only 17% of the trees which produced mushrooms were upright (5 out of 30). A majority of the broken trees produced fruit on both the top and the base. The overall fruiting rate was high: 75% (30 out of 40) of the trees inoculated with this strain produced in this single event.

Step 9: Marketing the mushrooms locally.

This was not difficult. We have made connections with at least 2 commercial customers for the sale of any edible mushroom in quantity: the Executive Chef at the Granville Inn in Granville, OH and The Greener Grocer in Columbus, OH. We also maintain an email mailing list of customers, many of whom are consistent mushroom buyers. On the occasions we have had large flushes of mushrooms between markets, a simple email to the mailing list sells them quickly.

Prime OH brown oyster cluster

Because of the timing of the Nov. fruiting event (Thanksgiving!) and the

unfortunate temperature drops (the mushrooms were half frozen when harvested), we decided not to market them but use them for our own use. However, we can calculate the value of the harvest: 12 lbs. of prime oyster mushrooms @ $20/lb. (retail) = $240. In subsequent conversation with the Exec Chef at the Granville Inn, he assured me that he would buy _any_ local culinary mushrooms, pretty much _any_ time (even Thanksgiving), so I should just give him a call.

PEOPLE

List the farmers, ranchers, business people, or staff from organizations who assisted with the project and explain how they were involved. List any personnel from a public agency, such as the Extension Service, Natural Resources Conservation Services, or Soil and Water Conservation Districts who assisted with this project.

Peter Kuhlman, Assoc. Professor of Chemistry, Denison University, as spouse and co-owner of the farm, provided assistance on this project bordering on the infinite while still pursuing his own career. He provided data analysis on the results, physical labor treating Ailanthus (as he had for the previous decade), bench space in his lab for growing up mushroom spawn, expert advice on sterile tissue culture techniques, photographic and note-taking services, editorial proof-reading, invaluable advice, and unflagging support.

Peter inoculating with plug spawn

Cotton Randall, ODNR Division of Forestry, was involved in the original brain-storming session about controlling Ailanthus organically which resulted in this SARE research proposal. He wrote a letter of support for the original proposal. Later, he provided encouragement, contacts, literature, and logistical support for the Blue Owl Hollow farm tour, co-sponsored by ODNR Division of Forestry.

Jim Kiracofe, Licking Co. Soil & Water Conservation District Manager, wrote a letter in support of my SARE application and has maintained an active interest in the project ever since. He is also a farmer who owns a large woodlot, so has a personal interest in controlling invasive woody species, as well as a mulit-faceted professional one. The SWCD office was a co-sponsor of, and provided publicity and logistical support for the Blue Owl Farm tour. Jim took some excellent photos and short movie clips during the farm tour which have proved valuable in our outreach activities.

Dick Doyle, Emeritus Professor of Chemistry, Denison University, is a confirmed mycophile and has an interest in any project concerning mushrooms. He provided expert advice on sterile lab techniques, donated scientific equipment to my lab efforts, contributed keen analytical insights into the mushroom cultivation process, and served as our mushroom expert at the Blue Owl Hollow farm tour, answering questions on all aspect of mushroom lore.

Rebecca Mazur, friend and aspiring farmer, has worked with me for years on various conservation and forestry projects, including mushroom production. She spent hours in the woods with me inoculating trees and collecting data. She also demonstrated mushroom log inoculation techniques at the Blue Owl Hollow farm tour.

Rebecca hammering in plug spawn

John Johnson, Licking Co. NRCS District Conservationist, has provided encouragement in all ways related to forest conservation. We have worked together through the initiation and completion of one EQIP contract, the initiation and 1st year of a CSP contract, and the recent initiation of a second EQIP contract. All of these involve control of woody invasive species, so John has followed my SARE project activities with interest as an example for other forest landowners who are enrolling in these programs.

Mike Anderson, OEFFA Education Coordinator, facilitated the scheduling, promotion, and execution of the Blue Owl Hollow farm tour in Oct. 2009, which was co-sponsored by OEFFA.

Laura Wies, OEFFA Special Projects, facilitated in so many small ways the scheduling and setup for my presentation on this SARE research at the annual OEFFA conference in Feb. 2010.

Andy Hupp, OEFFA Certification Specialist, assisted me in many ways preparing for my 2010 OEFFA talk, plus assistance with the poster display on this research at the annual OEFFA conference in Feb. 2009.

Andrew Semler, farmer and fellow market vendor, provided invaluable assistance by lending me his 36V cordless drill after my 9V cordless drill failed miserably on about the only day with temperatures above freezing in January 2009 and therefore when I HAD to get mushroom inoculations in the test plots done. He also contributed numerous hours of labor inoculating and collecting data in the test plots with me, helping clean up and prepare for the farm tour, and then demonstrating the operation of our portable sawmill during the farm tour itself.

Andrew performing sawmill demo

Warren Hauk, Assoc. Professor of Biology, Denison University, volunteered labor in the test plots, collecting data and inoculating trees.

Frank Hassebrock, Professor of Pyschology, Denison University, provided invaluable assistance in the initial setup of the study plots and for suggesting ways to make the project more statistically valid. He has also given me encouragement and enthusiastic support throughout the project, esp. at the farm tour, and at the farmer's market where he is a regular mushroom customer.

Jessica Volzke, Granville High School student, has worked with me to learn mushroom cultivation techniques, both in the lab and outdoors. She assisted in various ways on this specific project, including data collection and outreach.

Julian Roshon, home-school student and son of a neighboring farmer, has provided manual labor in support of various tree farm endeavors, freeing me up to spend more time on this research.

Joan Benjamin, NCR SARE Associate Regional Coordinator, assisted with questions, provided cheerful encouragement and helpful feedback while guiding me though the grant paperwork and reporting requirements. And allowed me to drag her through the woods for a hands-on demonstration of this technique.

George Vaughn, owner of Mushroom Harvest in Athens, OH, and his staff provided expert mycological advice and made recommendations about suitable native Ohio mushroom strains to use in this research project. Mushroom Harvest also provided much of the plug spawn and a significant chunk of the equipment and supplies I used in course of the project.

Paul Stamets, owner of Fungi Perfecti in Olympia, WA, and his staff taught the seminar course which gave me the capability to grow my own mushroom spawn and propagate mushrooms using tissue culture techniques. A former forestry professional himself, Paul has a strong interest in sustainable forest managment, and has written about "mycoforestry" techniques to improve overall ecosystem health, an area I would like to explore further. Fungi Perfecti was the source for many supplies necessary for this project.

RESULTS

What results did you achieve and how were they measured? For production projects, include yields, field analysis, and related data. How do these compare with conventional systems used previously? For education projects, include outcomes achieved and how you measured them through surveys, attendance,

or other methods (if appropriate). Were these results what you expected? If not, why? What would you do differently next time? (Use as many pages as necessary to answer the questions. You are not restricted to the space on this form.)

Goal 1: Ailanthus control

We were able to demonstrate that this organic method:
a) performed as well or better than the recommended conventional treatment using herbicides (as reported by the relevent treatment guides),
b) had lower associated costs,
c) had fewer adverse environmental impacts, and
d) was implemented in greater safety and with less effort by the farmer.

Organic vs. conventional treatment efficacy:
The die-off of sprouts in the 2nd year after treatment was quite dramatic. By the end of the first year after treatment, the vast majority of treated trees had produced stump sprouts ranging from 1 or 2 per tree to as many as 20. Only 7% of the trees had no viable stump sprouts and could be considered dead.

By the end of the second year after treatment, 64% of the treated trees had no viable stump sprouts remaining and could be considered dead. That's a mortality rate over the 2nd growing season of 57% .

For the trees that did have viable sprouts, the number of sprouts averaged only 2 per tree across all plots by the end of the second year. On looking over the data, these numbers are somewhat skewed by a small number of trees with many remaining viable sprouts, e.g., 6 or 7 sprouts, while most others had only 1. None of these numbers can be considered numerous or even many, as described in the conventional literature. All the conventional treatment literature recommends revisiting the treated trees and I concur with that recommendation for this technique as well. However, stomping down 1 or 2 stump sprouts on less than half of the treated trees is in no way strenuous or time-consuming, taking literally only seconds. A rough guesstimate for how many trees it's reasonable to stomp down in an hour is 40 trees. That would be a labor cost of about $0.50/tree.

Cost analysis:
The cost for this treatment is very low in both equipment and time. The only real tool requirements are:

drawknife ($30)
stout pair of hiking boots (useful for stomping the sprouts as well as hiking the trails)
leather gloves, optional ($15)

Labor costs are equally low, although not trivial if you have a large infestation. At $20/hour, 15 trees treated per hour, that's about $1.33 per tree in labor costs. At the same hourly rate, stomping costs $0.50 a tree, even if you must stomp every tree; as we have shown above, the mortality rate is > than 50% without follow-up. For the 160 treated trees in the study, labor costs for treatment are as follows for treatment and follow up (worst case) 1 year later:

treatment:	$1.33/tree * 160 trees = $212.80
follow-up:	$0.50/tree * 160 trees = $80.00
	total = $292.80

By comparison, conventional treatment accounts suggest the following equipment & supplies, some of which I use in other farm activities so can speak to meaningfully in terms of costs; the herbicide equipment I cannot address:

chainsaw (decent quality, $350-$450)
chaps & hard hat/face shield/ear muff combo ($60 + $40)
hatchet ($15)

leather work gloves ($15)
stout work boots (so you don't cut your toes off with the chainsaw or hatchet)
herbicide sprayer
haz-mat suit for herbicide application, full body
recommended herbicide such as triclopyr, imazapyr, glyphosate, etc. in sufficient quantities

Labor costs for conventional treatment are huge, by comparison. I have felled trees in thinning operations and it is HARD work. So is chainsaw girdling (recommended for larger numbers of trees). I can fell about 4 trees per hour safely -- with an hour on either end of the day's work for equipment prep and clean up. Also, safe chainsaw use requires the presence of 2 people, so your labor costs are automatically doubled for the felling or chainsaw girdling operation. At $20/hour for labor, felling 4 trees an hour is $5/tree *2 (for the second person) or $10/tree. 2 hours for prep and clean up is $40. Two 4-hour felling sessions are probably all that is recommended for 1 day's work, at 4 trees per hour, that's only 32 trees per day. 160 trees would require 5 10-hour days to complete treatment for this many trees, incurring prep and clean-up costs each day.

Assuming herbicide application is somewhat easier, perhaps one could do as many as 10 trees an hour, but I believe it would have the same prep and clean up time requirements minus the requirement for a second body. That would be $2/tree for the herbicide application, plus $40 prep and cleanup. 2 full 10-hour days should do it. So initial treatment costs look something like:

felling or chainsaw girdling:	$10/tree * 160 trees = $1600.00
prep & clean up:	$40/day * 5 days = $200.00
herbicide application:	$2/tree * 160 trees = $320.00
prep & clean up:	$40/day * 2 days = $80.00
follow-up	$2/tree * 80 trees = $160.00
prep & clean up:	$40/day * 1 day = $40.00
(assume 50% survival)	total = $2,400.00

I'm not an expert, but that's probably pretty close to what you would have to pay to contract someone to come out and clean up that many medium-sized Ailanthus on your property.

Environmental impacts:
I think this one is pretty clear. The technique described in this research has almost no adverse environmental impacts, but several major environmental benefits, including:

control of an invasive tree species
increased biodiversity (mycological)
improved soil quality from the fungi-speeded decomposition
improved soil moisture retention from the added decaying tree matter
improved wildlife habitat in the few remaining upright dead snags, as well as the downed wood

Conventional treatment has several major environmental negatives, including

collateral damage to non-target plant species
increased carbon emissions (chainsaw)
poorly characterized health impacts on humans and other mammals
potential for water contamination, both petroleum-based & herbicide

Labor and safety costs:
These are pretty clearly covered in the cost analysis above. This organic treatment for Ailanthus is sufficiently simple, easy, and safe that just about any reasonably fit individual can perform it, regardless of size, age or gender (if one can participate in hiking, yoga, aerobics, or pilates, one ought be be able to use this treatment). There is simply no comparison re: safety concerns to chainsaw and/or herbicide use in the conventional treatment.

The results were pretty much as expected. The only change I would make in the future is to experiment with timing, e.g., test whether spring treatment just before leaf-out shows any appreciable improvement in overall efficacy. I also wish I had gone ahead and stomped down the treated trees in half of the test plots after the 1st year, but left the other half in order to evaluate the potential for 2nd season re-sprouting. I ultimately decided against it because that would have dramatically reduced our sample size to the point where it would have been hard to filter out the noise in the data. I intend to identify and treat additional plots with slightly refined parameters to test other mushroom species, so will incorporate that into the next round.

Goal 2: Mushroom production

We demonstrated that it is possible to produce culinary mushrooms on treated Ailanthus in sufficient quantities to sell in our local market. Whether this is truly cost effective as a full-fledged production venture is somewhat questionable, given the additional labor involved. Such a committment will equire more careful analysis. However, if the following conditions exist:

1) spawn can be produced at low cost
2) there are sufficient Ailanthus to control in order to make convenient-sized plots

I believe it is very worthwhile to continue to pursue small-scale trials or plots as a supplemental income source, not a primary one.

As described previously, I figure that producing my own mushroom spawn is a significant cost savings counterbalanced with an additional 8 hours or so of labor per week during the winter months. Since we have a mushroom log production operation anyway, it is somewhat trivial to grow up an extra strain or two for Ailanthus inoculation. The real labor cost is in the on-site inoculation. Even doing 6-7 trees an hour at $20/hour is still about $3/tree for perhaps a one-time flush yielding 2-3 pints (if Ailanthus is as poor a substrate as I think it might be and only produces for 1 year). At $5/pint retail at the market, and the time needed to harvest and prep the mushrooms for market, it's not a huge return. Now if the Ailanthus support multiple fruitings, that's a different story. It remains to be seen just how economically viable this is.

Only 1 of the 3 mushroom strains produced well: *Pleurotus ostreatus 'OH brown'*. This is a prolific and attractive mushroom with a very interesting characteristic -- it fruits at the extreme ends of the season in cold, wet conditions. While this can be a disadavantage if you're not anticipating mushroom production (as our experience in Nov. 2010 showed), it can serve as a valuable extended market season product. It remains to be seen how consistent a producer this strain is over the longer term, either on Ailanthus or on logs. My suspicion is that it has great potential for the latter and I intend to incorporate it into my mushroom log production operations. Our data showed that the Ailanthus inoculated with this mushroom strain suffered more wind-throw and breakage, most likely as a result of aggressive feeding by the mycelium: 650 days after treatment, just over 40% of the trees in this group were still upright, compared to 98% of baseline treated trees. If such is the case, Ailanthus is unlikely to be fertile enough to support this strain for long, and a denser hardwood such as elm or oak would be more appropriate for long term production.

Pleurotus ostreatus 'OH white' fruited on several occasions during the first season on the control logs we kept in the yard, but did not produce prolifically or consistently in the woods (7% of inoculated trees overall, but at 40% in 1 particular plot) and has shown no recent signs of fruiting on the control logs. This may be due to the quality of the strain or to specialized environmental requirements.

Laetiporus sulphureus does not seem to be a viable candidate at all, although this is a very slow-growing species and may still surprise us with a fruiting. I think that somewhat unlikely because of the poor nutrient load in the Ailanthus and its rapid deterioriation leading to linsufficient moisture content for mycelial development. There is also signfication signs of contamination by other fungal species on these trees not present on the others, esp. carbon balls (*Daldinia sp.*) and turkey tail (*Trametes sp.*).

DISCUSSION

What did you learn from this grant? How has this affected your farm or ranch operation? Did you overcome your identified barrier, and if so, how? What are the advantages and disadvantages of implementing a project like yours? If you were asked for more information or a recommendation concerning what you examined in this project, what would you tell other farmers or ranchers?

Goal 1: Ailanthus control

Lessons learned: we now have a more clearly defined picture for Ailanthus stump sprout mortality over time. It is reassuring to know that even if no further treatment is administered, there will be an overall large net reduction in the Ailanthus population after just the initial treatment. The follow-up requirement is a concern if this technique becomes widely implemented. It is just too easy to forget to do that follow-up a year later, esp. since many forest landowners do not reside on the wooded property. This is a disadvantage for either the organic or the conventional technique.

Farming effects: I plan to continue to use this technique to control Ailanthus and any other invasive tree species, e.g., Amur cork and European buckthorn. This study allows me to more confidently recommend this treatment for others to use and to push for its more wide-spread use as an organic alternative in ODNR Division of Forestry and USDA NRCS circles.

Advantages and disadvantages: The economic, environmental, and health trade-offs have been discussed in the Results section above.

Goal 2: Mushroom production

Lessons learned: as described above, we found great variation in mushroom productivity between strains, but the basic premise seems to be sound. It is indeed possible to produce culinary mushrooms using dying Ailanthus as a substrate. Much more work needs to be done to find the most productive mushrooms for this unique circumstance.

Another lesson to take from this experience is that growing one's own mushroom spawn is a great cost-savings, but the trade-off is the need for long-term advance planning. It takes 1-2 weeks at each of 3 growth stages to produce sawdust spawn ready to inoculate into trees or logs, i.e., 2 months lead time. For late winter tree inoculations, spawn production should start in October, just after the summer market season ends, not during the slower deep winter months when I am used to start spawn for spring log inoculations.

Farming effects: I am very excited about one of the mushroom strains (OH brown oyster) and plan to incorporate it into my mushroom log production. I am also sufficiently pleased with the in situ inoculation technique to expand it to cut stump inoculation and larger storm-damaged logs.

Advantages and disadvantages: the economic potential for producing the culinary mushrooms on Ailanthus are highly constrained by the resources and knowledge of the farmer and as such may have limited value commercially except in rare circumstances. However, I would love to see more farmers experimenting with non-timber forest products, including mushroom production, so would encourage anyone with an interest in this to go ahead and try it. If the spawn is purchased commercially, the other equipment and supplies are things that any farmer is apt to already have around, with the possible exception of a 36V drill, which is pricey. That leaves only labor inputs, but these come at a relatively slow period in the farming calendar (unless you're a tree farmer, of course).

IV. PROJECT IMPACTS

Evaluate the economic, environmental and social impacts of your project by completing the attached forms. Also, if possible, provide hard economic data.

See attached document FNC07-670-07Benefits and Impact of F-R Grant Funded Project.pdf.

V. OUTREACH

What methods did you use for telling others about: 1. Your project, 2. Project events or activities, 3. Project results? How and to whom did you communicate this information? Be sure to include details on how many people attended field days or demonstrations, and how information was further disseminated by media covering any events. What plans do you have for further communicating your results? Please send us any press releases, news clippings, flyers, brochures, or publications developed during this project. Also please send us any photos or slides which might be helpful in telling your story to others.

1) Poster presentation, Feb. 2009.
I displayed a poster at the 2009 Annual OEFFA conference and spoke with perhaps a dozen people in person about my project; the poster was displayed in the main vendor/exhibit area throughout the weekend and may have been seen by any of the ~800-900 farmers and supporters of sustainable agriculture who attended the conference. See Appendix D for a PDF of the poster.

2) Farm tour, Oct. 2009.
This event was co-sponsored by OEFFA, Licking Co. Soil & Water Conservation District, and ODNR Division of Forestry. Publicity for the event was provided by OEFFA in the 2009 Ohio Sustainable Farm Tour Series publication sent to all OEFFA members and other organizations, highlighted on the OEFFA website, and in their quarterly newsletter. Licking Co. Soil & Water publicized the event in their quarterly newsletter. I also provided information and publicity about the event at my stand at the Granville Farmer's Market.

The Blue Owl Hollow farm tour was held on Sunday, Oct. 25 2009 from noon to 5 PM. Approximately 55 people attended. Forester and collaborator Cotton Randall from ODNR Division of Forestry had a poster display on invasive plant species, collaborator Dr. Dick Doyle was available to identify and discuss wild mushrooms, fellow farmer Andrew Semler demonstrated the use of our Peterson portable sawmill, friend Rebecca Mazur demonstrated cut log mushroom cultivation techniques, and we provided several additional displays on the SARE project and the production of other non-timber forest products. At least 25 people hiked up to the SARE test plots for hands-on demonstrations where about a dozen people actually tried their hand at the treatment and inoculation techniques.

3) Conference presentation, Feb. 2010.
On February 13, 2010 I presented a workshop at the 2010 OEFFA conference describing my Ailanthus control technique and associated mushroom inoculation. Approximately 50 people attended the talk. I updated the Blue Owl website with more on-line resources pertaining to the project, in particular the hand-out from the OEFFA conference, which describes in detail both the techniques for Ailanthus treatment (Step #1) and mushroom inoculation of the trees (Step #2):
http://www.blueowlgarden.com/Ailanthus_mushroom_handout.pdf

4) Student involvement, Oct. 2009-present.
In October 2009, I began working with Granville High School student Jessica Volzke. She has an interest in the laboratory culture of mushrooms. We continue to meet once per week in the Dept. of Chemistry at Denison University. In order to earn extra credit, she must do a presentation about her individual research project at school; this has not yet been scheduled. In addition to the lab sessions at Denison, Jessica came out to Blue Owl Hollow at various times in 2010 to assist me with various other aspects of mushroom production, both in the test plots and for our mushroom log production. She helped me collect moisture content and stump sprout data in the test plots, assisted me in harvesting mushroom logs, and learned mushroom log production techniques while inoculating logs with the mushroom sawdust spawn (*Pleurotus ostreatus var. columbinus*) that she grew up in the lab during Spring 2010.

5) Blue Owl Hollow website.

I maintain a separate Special Projects page on my farm website, most of it devoted to this project. All of the various materials I've developed for posters, presentations, etc. are linked on this site: http://www.blueowlgarden.com/.

6) Individual conversations.

My OEFFA conference presentations & poster have generated several phone calls from forest landowners and others interested in both the organic Ailanthus control technique and mushroom production on Ailanthus logs. I even had a call from a man working with a non-profit from inner city Detroit wanting to know if it would be a good technique for a city garden project! I have also given several plot tours to interested individuals and described my work in conversations with long-time market customers.

7) Future outreach.
There are various opportunities for further outreach. I chatted with Mike Hogan, Ohio SARE Representative at the recent OEFFA conference about finding a suitable OSU Extension research partner in order to continue my research and he suggested some possible collaborators within the system. We will continue to work on this over the coming weeks.

My CSP (Conservation Stewardship Program) contract includes an On-Farm Research practice. This should provide some interesting opportunities for both future research directions and future outreach, esp. with the involvement of OSU Extension staff.

Finally, I anticipate I will continue to give presentations on mushroom culture at future OEFFA conferences and other such venues. At this year's conferenece (2011) I presented on mushroom log production for the home gardener and did not have the time to expand into other kinds of mushroom production, but I surely intend to do so in future talks.

I'm still working on scheduling a mushroom foray here under the auspices of the Ohio Mushroom Society, in conjunction with Dr. Dick Doyle. No dates have been confirmed, but a theme for such an event has been discussed (mushrooms for color, i.e., species that can be used as natural fiber dyes).

VI. PROGRAM EVALUATION
This was the seventeenth year the North Central Region SARE Program sponsored a Farmer Rancher Grant program. As a participant, do you have any recommendations to the regional Administrative Council about this program? Is there anything you would like to see changed?

None come to mind.

VII. BUDGET SUMMARY
Complete the attached budget form and return it with your report. You will only be reimbursed for expenses incurred and items purchased for your project. Final expenses, listed by budget category, which exceed the amounts in the proposal by 10% or more, should be explained in a letter submitted with the final report.

Please submit your final report by March 1, 2010 to:

E-mail: Jbenjamin2@unl.edu

Or mail to:

North Central Region SARE Program
University of Nebraska-Lincoln

13A Activities Bldg,
1734 N 34th St, PO Box 830840
Lincoln, NE 68583-0840

If you have questions, contact Joan Benjamin, NCR-SARE Associate Regional Coordinator at: 402-472-0809 or 800-529-1342.