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Growing Shiitake Mushrooms in an Agroforestry Practice

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Cultivating Shiitake Mushrooms through Forest Farming

Cultivating shiitake mushrooms represents an opportunity to utilize healthy low-grade and small-diameter trees thinned from woodlots as well as healthy branch-wood cut from the tops of harvested saw-timber trees. When the mushrooms are collected and marketed, the result is a relatively short-term payback for long-term management of wooded areas.

The cultivation of shiitake mushrooms on solid wood requires a significant amount of shade and wind protection, but not a significant amount of acreage. Therefore it is an excellent opportunity for landowners with smaller acreages to utilize forested or shaded areas. Shiitake producers can often obtain wood for cultivation from land management agencies or private landowners. In addition to making productive use of woodlots and forested acres, logs that have been used for shiitake production, called "spent" logs, can be ground and recycled as compost *(see page 12 for Kimmons and others, 2003)* or used as a fuel and heat source for winter mushroom production *(see box page 6)*.

> "When I walk into a restaurant and see my mushrooms on the menu, it gives me huge pleasure and makes all the work worthwhile."
>
> *– Nicola McPherson, Ozark Forest Mushrooms*

Shiitake mushrooms can be grown indoors or outdoors on almost any deciduous wood that retains its bark for a number of years. When shiitake are cultivated outdoors on logs in a managed shade environment, a forest farming practice is initiated.

The practice of intentionally managing shade levels in a forest to favor the production of certain crops represents the agroforestry practice called forest farming. Properly applied, forest farming can enhance and diversify income opportunities, while at the same time improving the composition and structure of the forest for long-term stand health, quality and economic value. By developing an understanding of the interactions between the overstory trees and the understory environment, forest management activities can be used to create understory sites ideal for growing profitable shade-loving crops like shiitake mushrooms. The shade-loving plants that may be grown in the

In this forest farming practice, shiitake and other forest farming products, such as ferns and ginseng, are grown under the shade of trees.

understory of a forest are often termed non-timber forest products. However, to accomplish this, forest canopy densities must be controlled.

Getting Started: Basic Steps for Shiitake Production

1) Understanding the Shiitake Life Cycle
2) Selecting and Preparing a Shiitake Cultivation Site
3) Obtaining Substrate Logs
4) Thinning as a Tool for Shiitake Cultivation
5) Shiitake Strain Selection
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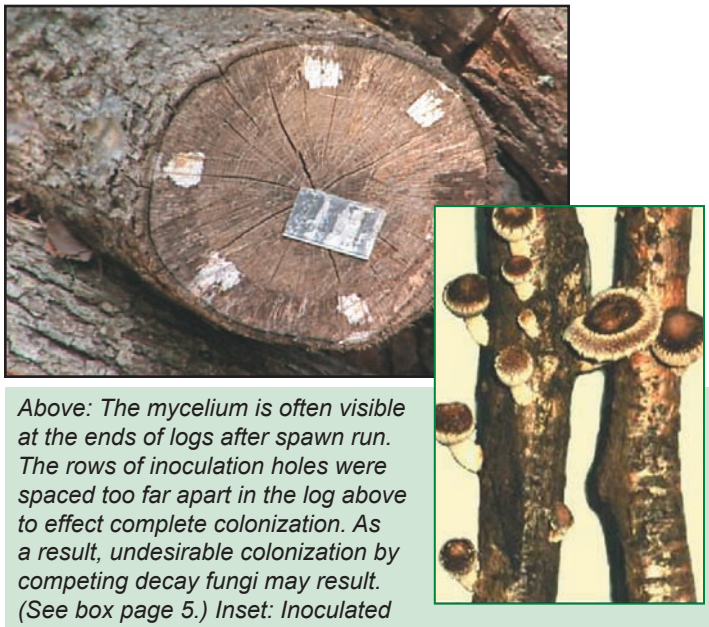
8) Fruiting the Crop
9) Harvesting
9) Pest Management
10) Shiitake: An Emerging Market

Understanding the Shiitake Life Cycle

Although specialty mushroom production in a forest farming practice is intriguing, it should not be considered "quick and easy." To establish a successful production system, a great deal of knowledge and planning is necessary. Before beginning to cultivate shiitake mushrooms, it is important to understand the shiitake life cycle and how the forest farming relationship interacts with this cycle.

Fungi do not use photosynthesis to produce their own food. Many mushroom fungi (including shiitake) obtain energy and nutrients by decomposing dead plant material. Shiitake decay the cellulose and lignin of wood. The visible part of the shiitake fungus that is harvested and consumed is the fruiting body (mushroom), connected to an unseen mycelium consisting of tiny threads growing in the log substrate. The mycelium derives nutrients by decaying inoculated logs, and a portion of these nutrients is eventually used to produce mushrooms.

Mushrooms are often called fruiting bodies because they are the site of spore production by the fungus. The mushroom stem serves to elevate the mushroom cap into the air; the cap serves to protect the developing gills; and the gills provide an extensive surface on which myriad spores are produced. Mushroom spores are sexual propagules of the fungus species, and therefore are highly variable. This is why we do not use spores as inoculum to cultivate shiitake. The mycelium and mushrooms produced from spores would likely differ from the parent strain in various important characteristics.



Above: The mycelium is often visible at the ends of logs after spawn run. The rows of inoculation holes were spaced too far apart in the log above to effect complete colonization. As a result, undesirable colonization by competing decay fungi may result. (See box page 5.) Inset: Inoculated and fully colonized logs at the fruiting stage.

Selecting and Preparing a Shiitake Cultivation Site

One of the keys to successfully growing shiitake mushrooms in the forest is to select or produce a cultivation site with an overstory canopy that provides the appropriate amount of shade.

In the initial process of selecting a shiitake cultivation site, realize that north- to east-facing slopes will help protect against sun and heat. Ravines and valleys often provide access to water as well as superior shade.

Shade levels can be adjusted by manipulating the structure and/or species composition of the forest. If there is not enough shade for the understory crop, more trees can be planted or retained to produce more shade. Wind protection and shade can also be enhanced by hanging a curtain of mesh shade fabric

Materials Checklist: Outdoor Log Cultivation of Shiitake

- Access to water for forced fruiting. (Cooler water is better.)
- A cultivation area with shade and protection from wind.
- Hardwood logs cut from healthy pole-sized trees, or from healthy branches of larger trees.
- Extremely high-speed drill (available from professional suppliers). A 10,000 RPM works very well for this purpose. If you purchase only one piece of equipment, it should be an extremely high-speed drill.
- Screw-tip drill bits with adjustable collar stops.
- Spawn and spawn-plunging tool.
- Cheese wax: For sealing sawdust or dowel spawn.
- Daubers: For applying cheese wax.
- Spawn and supplies can be purchased from professional suppliers, such as Field and Forest Products, Inc. – *see page 11.*

around the edges of the cultivation site. If there is too much shade, the stand can be thinned or individual trees can be pruned. Over time, the changes that occur in a mature or developing stand may require that both thinnings and new tree establishment be applied to maintain the required level of shade and wind protection. Evergreen species provide the most useful spring and autumn shade, but an overstory of sugar maple or oak will provide earlier and later season shade than cherry, walnut or honey locust. A good way to judge the adequacy of shade and wind protection in the cultivation area is based on mushroom condition. Under excessive shade, mushrooms produce longer stems and smaller caps. A 1- to 2-inch stem is ideal. If protection is inadequate, developing mushrooms may suffer from exposure and dehydration.

Obtaining Substrate Logs

Log-grown shiitake are better quality and can have a longer shelf life than shiitake grown on supplemented sawdust substrates (a common large-scale indoor method). Log-grown shiitake also achieve higher prices in some segments of the wholesale and retail markets, especially if they can be certified local or organic.

Shiitake logs can be obtained both from the stems of healthy young trees selected for thinning and from healthy branch-wood taken from the tops of trees felled for saw-timber. In either case, only logs with intact bark, free of heartrot, and with as much sapwood as possible, should be selected. Logs already dead or with heartrot will be infected with other decay fungi and must be avoided. If you do not have access to forested areas, purchase logs from a public land management agency or a contract logger. If you contract for logs, be sure to specify undamaged bark and appropriate diameter.

The ideal time to fell trees is mid- to late-winter, for early spring inoculation. This is especially true for sugar maple, which begins sap flow earlier than oaks. For spring inoculation, it is best to harvest trees in February for inoculation in April or early May. Felled logs should be protected from desiccation (wind and sun) to maintain an internal moisture content above 35 percent.

While it is desirable to inoculate logs for shiitake production in the very early spring, some large-scale growers need to inoculate a portion of their crop of logs during the early winter. If this is necessary, it is important not to harvest trees for substrate logs until they have achieved complete dormancy. Trees harvested before they are completely dormant will not have finished storing carbohydrate in the sapwood, and therefore will contain less energy for mycelial growth and mushroom production.

At the University of Missouri's Horticulture and Agroforestry Research Center, sugar maple and white oak have proven to be superior substrate species. Other dense hardwoods with good bark retention can also be used to produce shiitake. Pines and other conifers are not effective hosts for shiitake production.

Properly managed, smaller logs (3" to 5" diameter at the smaller end and 36" long) produce more mushrooms per unit of log weight and are consumed more quickly than larger diameter logs. This is partly because larger logs (especially oaks) tend to contain more decay-resistant heartwood. Also, the bark on larger logs begins to deteriorate before the entire wood volume can be exploited by the shiitake. Also keep in mind that larger logs are heavier, and logs need to be moved at least several times in preparation for their service as shiitake substrate.

Thinning as a Tool for Shiitake Cultivation

Keep in mind that the area to be managed as the actual mushroom production site is relatively small compared to the forest area required to produce a sustainable supply of substrate logs.

Before thinning a forest area, careful thought and planning is required. To maximize forest health, timber, wildlife and/or aesthetic values, talk to resource professionals at the Missouri Department of Conservation (http://mdc.mo.gov/), Natural Resources Conservation Service (www.nrcs.usda.gov/) or the Missouri Consulting Foresters Association (www.missouriforesters.com). Also, visit the Missouri Timber Price Trends Report online at www.mdc.mo.gov/forest/products/prices/ for tree values, to avoid unnecessarily removing a potentially high-value species. Traditionally, black walnut, white oak and red oak species have maintained some of the best timber values. Trees that are straight and that branch high in their canopy represent the highest value within a given species. Trees with forks, several knots or visible wounds will have a lower timber value. The crowns of healthy trees will have large, vigorous leaves (not stunted, pale or wilted) and few dead branches. A tree with more than 15 percent dead branches in its crown indicates the tree is likely suffering from decline.

For a detailed explanation of related forestry practices, see "Internet Resources," page 11.

Shiitake Strain Selection

Shiitake strains have been bred and selected for many characteristics and purposes. For example, shiitake strains differ in the size, texture and ornamentation of mushroom caps. Strains differ in the length of their spawn-run period *(see "Spawn Run," page 5)*, in their response to cold-water forcing *(see "Fruiting the Crop," page 6)* and in their tendency to fruit at different temperatures. Certain strains are preferred for indoor vs. outdoor cultivation. One may grow several strains to extend the fruiting season or to cover the range of growing season temperatures.

Strain integrity is maintained by storing mycelium in an inactive state at ultra-low temperatures to prevent genetic change. Samples of mycelium are brought out of frozen storage to produce vegetative spawn in pure culture as needed. High-quality spawn of known strains is well worth the price.

Ask your reputable spawn provider *(consider Field and Forest Products, Inc.; see "Internet Resources," page 11)* for guidance in selecting strains appropriate to your climate and production needs. University of Missouri Center for Agroforestry (UMCA) research has shown WR46 (a wide-temperature strain) produces best under Missouri conditions. Night Velvet (a warm-weather strain) produces especially beautiful mushrooms.

Spawn is sold in plastic bags that contain 5 to 10 pounds of colonized amended sawdust. Bags have a breathing patch of mesh fabric that permits gas exchange and prevents fungus suffocation without permitting contamination. Each block of spawn consists of brownish sawdust bound together by white mycelium, all covered with a white mycelial felt with brown patches. Mushrooms may even form inside the bag and should be discarded or eaten. Spawn should be ordered several months in advance of need, to allow for production time. The supplier should try to ship the spawn to arrive just prior to planned inoculation.

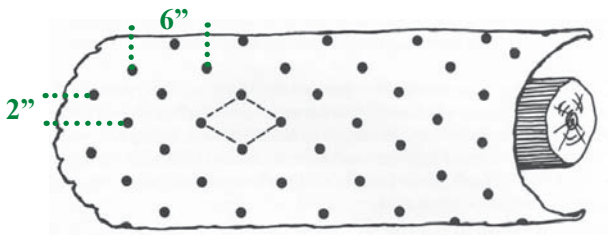
Holes are drilled in cut logs using an extremely high-speed drill.

The Inoculation Process

Logs cut from healthy trees are inoculated with shiitake spawn inserted into holes made in the substrate logs using an extremely high-speed drill. Holes should be approximately 1" deep, separated by 6" along rows 2" apart and staggered to produce a diamond pattern *(see diagram page 5)*. The inoculation process should be conducted in the shade to conserve moisture.

Spawn can be purchased in several forms: "traditional" loose sawdust spawn; styrofoam-capped "thimble" spawn; or wooden dowel spawn. Wooden dowel spawn has been recommended for late autumn

Inoculating and Sealing



Drill holes 1” deep in a diamond pattern, separated by 6” along rows 2” apart. If inoculation holes are spaced too far apart, spawn run will be incomplete and contaminating fungi will gain a foothold. (Image courtesy Mary Ellen Kozak and Joe Krawczyk, “Growing Shiitake Mushrooms in a Continental Climate.”)

Spawn should be injected immediately into pre-drilled holes in the log using a spring-loaded thumb injector. Any delay between drilling and inoculation will promote desiccation and contamination of the logs. These supplies are available from commercial mushroom suppliers, such as Field and Forest Products, Inc. (see page 11).

Hot cheese wax is applied immediately to seal inoculum into the log to prevent spawn desiccation. Note the sizzling of the wax when applied to the inoculum.

inoculation because it may be less likely to frost heave from the log during cold winter weather. Research has shown at HARC that logs inoculated with loose sawdust spawn produce best regardless of season of inoculation. Although thimble spawn produces quite well, it more expensive and is produced in non-recyclable plastic sheets. The dimensions of dowel, loose sawdust and thimble spawn differ slightly, so attention must be paid to the depth and diameter of holes drilled. Screw-tipped auger bits with adjustable collar stops work best.

Holes should be filled with spawn immediately after drilling to prevent desiccation and contamination. Dowel spawn is inserted with a hammer; loose sawdust spawn is inserted with a spring-loaded thumb pressure spawn-plunging tool; and thimble spawn is inserted with thumb pressure. When using dowel or loose sawdust spawn, be careful not to leave the dowel protruding or overfill the holes.

Dowel and loose sawdust spawn need to be covered immediately with sizzling-hot wax (cheese wax is generally preferred), using a simple daubing device. The hotter the wax, the better the seal. If the dowel is left protruding or the sawdust spawn is mounded, the wax seal will be vulnerable to damage. The styrofoam cap on the thimble spawn provides sufficient protection from desiccation and contamination.

Spawn Run

A thread-like network of mycelium grows from the spawn into the inoculated log. The period of time during which the mycelium initially colonizes the log (the “spawn run”) requires about a year.

Logs should be stacked loosely after inoculation for the spawn run (pre-production) period to allow for initial log colonization. Appropriate log orientation depends on your ability to protect the logs from wind and sun. If your region has high humidity or you are able to sprinkle your logs with water during dry weather, you can stand the logs up or crib stack them loosely. Otherwise, logs can be lain horizontal on rails elevated 4” to 6” off of the ground. Logs should never be in contact with soil, to avoid contamination.

Optimal log moisture content for shiitake spawn run is 35 to 45 percent. Moisture conservation is best achieved by protecting logs from wind and sun while maintaining enough ventilation to allow bark to dry after periodic sprinkling to simulate a soaking rain. Constantly moist bark can foster the development of molds and other competing decay fungi, resulting in premature bark loss.

Although logs inoculated between December and May will produce a few mushrooms by the following

autumn, they should not be "forced" to fruit *(see "Fruiting the Crop, next section)* until the following spring to assure good spawn run. Energy devoted to fruiting slows the spawn run process and can give competing fungi an advantage.

Inoculated oak logs have been carefully cut to size for proper stacking in a simulated forest shade environment at the Ozark Forest Mushrooms commercial shiitake operation. Selected saw-timber trees grown on the premises are cut and sold to sawmills; residual branch-wood is the main source for shiitake logs. Spent logs should be removed from the production area to avoid contamination by competing molds and decay fungi, and can be burned for heat in a year-round greenhouse. Top image: Crib stacks for holding logs during "spawn run." Logs should be well-spaced in crib stacks to prevent mold development. These logs will be relocated under a forest canopy to begin "fruiting" (inset). Then, during fruiting, these logs will be placed upright on end for more efficient mushroom picking.

Fruiting the Crop

The timing of mushroom production in nature depends on both temperature and the timing of precipitation. Once a log has "flushed" (produced a crop of mushrooms), it should be allowed to "rest" for 10 to 12 weeks to provide the mycelium time to replenish the energy required for fruiting. Thus, forcing 8 to 10 percent of one's logs to fruit every week permits constant fresh production to meet market demand. When logs are forced to fruit too frequently, fewer and smaller mushrooms are produced.

Forced fruiting involves submersion of logs in cool water for approximately 20 hours. UMCA research has demonstrated that use of 52-degree F water stimulates more fruiting than warmer water.

This practice will also result in earliest recovery of log value by stimulating both wood decay and fruiting. As a result, logs will return their optimum value more quickly than with only natural rainfall.

Wide temperature range and warm weather strains of shiitake spawn respond well to this method of forcing. Cool weather strains respond to air

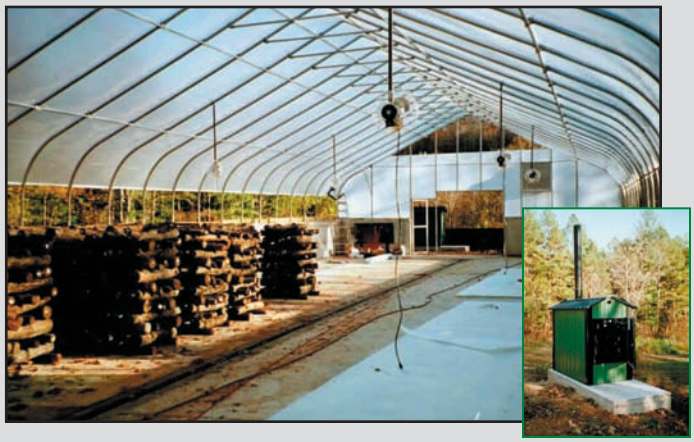
Winter Production: Creative Recycling of Spent Logs

In the right setting, shiitake can be produced indoors during the winter. Shade and light levels, ventilation and temperature must be controlled to recreate the outdoor fruiting season environment. In the late autumn, logs that have just completed their first fruiting season (logs in prime condition) are moved into the greenhouse for this purpose.

Dan Hellmuth and Nicola McPherson, proprietors of Ozark Forest Mushrooms, have built a greenhouse with a radiant heated concrete floor and are using spent shiitake logs to provide much of the fuel for heating this indoor winter cultivation facility.

"We're not actually depleting our forest resources over time," Hellmuth said. "Basically we're turning waste wood into high-value mushrooms and then using the spent logs for fuel to heat our greenhouse to continue production throughout the winter."

(At right: Ozark Forest Mushrooms' greenhouse facility. Inset: The wood-burning boiler provides hot water for the radiant slab greenhouse floor.)



Top: Shiitake logs soak overnight in a stock-watering tank equipped with a drain. Inset: At this point, developing mushrooms may be protected from both desiccation and heavy rain by covering logs during fruiting with horticultural fabric (see below).

temperature fluctuations in spring and autumn, but are unresponsive to soaking. For this reason, growers often prefer to inoculate their largest logs with cool weather strains because they do not need to be moved to a tank for soaking and can be left to fruit naturally in response to changing temperature.

When logs inoculated with wide-range or warm temperature strains begin to fruit spontaneously in the early spring, it is time to initiate a forcing routine.

Logs should begin to "pin" (initiate mushrooms), often at inoculation sites, within a few days after soaking. Once the bark surface dries after removal from soaking, the logs may be covered with a horticultural fabric to prevent both desiccation during dry weather and watersoaking during heavy rains. However, if the fabric blocks too much light, the mushrooms will develop longer stems and smaller caps. Fruiting should be complete in approximately one week.

Water is also needed for occasional thorough sprinkling during summer droughts. Logs should not be continuously watered, and the bark surface should dry out between waterings to minimize development of destructive surface molds and competing decay fungi. Log ends should be kept off the ground (or on weed barrier fabric) to prevent colonization by soil-borne decay fungi, such as *Armillaria* (the honey mushroom).

Indoor commercial shiitake production presents its own special challenges, requiring environments similar to outdoor conditions, with variable temperature, lighting, humidity and ventilation. Indoor production facilities are vulnerable to build-up of pests and mold populations if the environment is not properly maintained.

Harvesting

Mushrooms develop over a several day period, depending on temperature and moisture. Mushrooms should be harvested when their caps are 70 to 90 percent open (expanded), while the cap margin is still slightly inrolled. Agricultural shade fabric can be used during fruiting to both minimize mushroom desiccation and to protect mushrooms from absorbing too much water during rainfall. Mushroom development is much faster during warm weather than cool weather. As a result, nearly mature mushroom caps can expand beyond prime marketable condition overnight during very warm weather.

Harvest mushrooms by twisting and pulling the stem off of the log. Cutting the mushroom stem will shorten the shelf-life by causing the mushroom to dry out through the cut stem. Leaving the mushroom stem in the woods can increase insect pest problems.

Harvested mushrooms should be taken to market as quickly as possible following harvest. While shiitake have a good shelf life compared to other mushrooms, their quality begins to deteriorate slowly after harvest. Clearly, a better price will be obtained for the freshest mushrooms. The best price is obtained through retail sales to restaurants or at farmers' markets. Fresh mushrooms should be stored in well-ventilated, humid containers like paper bags or cardboard cartons.

Pest Management

Properly inoculated, shiitake are relatively pest resistant. The main considerations in pest management are to maintain proper inoculation density, prevent log desiccation and avoid log contact with the soil. Proper spacing of inoculation points, and prompt filling and sealing is essential for efficient spawn run. If inoculation sites are spaced too far apart, or if inoculation is delayed, other decay fungi will become established in the log and reduce shiitake production accordingly.

Correspondingly, as shiitake mushroom production begins to decline after several years, logs become a liability due to the build-up of contaminating fungi. Smaller logs are generally consumed more rapidly than larger. Logs that produce abundant fruiting bodies of competing fungi should be removed from the commercial production area, because fruit bodies of contaminant fungi are producing spores that increase their presence in the production area.

Above: Stereum (a contaminating wood decay fungus) fruiting on log end between rows of inoculation sites. Inset: Snail feeding on shiitake cap.

People aren't the only animals that enjoy shiitake. The key to minimizing stress in this regard is to grow enough shiitake to supply the neighborhood! Mice will leave occasional incisor marks on mushrooms they have tested for quality, but they cause little damage. Mushrooms forming close to the ground may harbor irritating numbers of fungus gnats between the gills, and slugs and snails can damage shiitake caps during prolonged humid weather. Finally, shiitake cultivation involves substantial activity in the production area, which can result in disturbance and compaction of the forest floor. Unmanaged, this disturbance can stress the trees producing the shade required for mushroom production. Thus, it is very important to establish a "traffic pattern" in the production area that minimizes compaction.

Shiitake: An Emerging Market

Markets for shiitake and other specialty gourmet mushrooms continue to show promising profit potential for Missouri forest land owners. Interest in fresh locally grown shiitake mushrooms is increasing with gourmet chefs, farmers' markets and household consumers, as information spreads about their nutritional benefits and rich, versatile taste.

Fresh shiitake mushrooms harvested from Ozark Forest Mushrooms are packed in cardboard containers for delivery to chefs and restaurants, left inset. Top and right inset: Value-added dried mushroom mixes are paired with locally grown rice for an attractive and consumer-friendly retail product.

Ozark Forest Mushrooms carves market niche

One of the Midwest's most significant demonstrations of a successful forest farming practice is Ozark Forest Mushrooms near Eminence, Mo. Dan Hellmuth and Nicola McPherson established the mushroom operation in 1990 in the midst of what was then a timber operation. Together with a small staff, they coordinate every step of the value-added process, from procuring the logs to packaging consumer-friendly, locally produced mushroom products.

A key to their success is developing an agroforestry practice compatible with their land base. Under the guidelines of the Stewardship Incentive Program, administered by the Missouri Department of Conservation, Dan and Nicola recover a renewable supply of mushroom logs from the tops of harvested saw-timber trees, while simultaneously maintaining a healthy forest. Consequently, what began 18 years ago with only 100 oak logs in production

has grown to 16,000. Only five acres of the couple's 2,500 forested acres are used for actual mushroom production. Their outdoor production site is situated under a short-leaf pine canopy, which provides year-round shade.

Ozark Forest Mushrooms gives particular emphasis to targeted marketing of their value-added boxed mixes and products. "The biggest marketing challenge for a rural area is that most of the mushrooms are a fairly high-value specialty food, and the largest market is in some of the state's bigger cities," said Hellmuth. "We are marketing products in St. Louis and need to deliver them to the city on a weekly basis."

Prices and marketing strategies

Many landowners fail at non-timber forest production by overlooking the importance of marketing research. Prior to beginning a specialty mushroom operation, investigate the possible markets in your area and know the price range you may encounter. Does the retail price compensate for the materials that will be needed? You should take the time to learn who your potential buyers are and what prices they are willing to pay. It is also helpful to learn how your local grocers place and price specialty mushrooms in the store, interview other growers and observe consumers purchasing mushrooms. Visit farmers' markets to see if they are being sold there, to whom and at what price. Contact restaurants to determine if they are interested in offering dishes prepared with fresh mushrooms. Don't forget about the market opportunities for mail order or Internet sales. Value-added products, like boxed mixes, sauces and dried mushrooms are another option.

In all markets, the relationship you establish with your buyer is critical. Be certain you have the production capacity before arranging an order. Remain in close contact with the buyer to ensure they have received the quality they were seeking.

Consumer education is also critical. Prepare a pamphlet for your buyer, telling them about the careful steps you take in production and ways to keep the mushrooms fresh in storage. McPherson gives customers a flyer telling the story of their operation, their local employees and the growing process. In an effort to reinforce the connection between customers and locally-grown foods, Ozark Forest Mushrooms has become part of a chef's collaborative to promote local farms and foods to area restaurants.

"Cross-marketing with other locally grown foods helps build name recognition and an attractive connection to the local community," McPherson said. Keep in mind that the better the quality of mushroom you produce, the higher the price you can achieve. The best prices are obtained through restaurateurs. It is not uncommon to achieve a price of $10 to $15 per pound for fresh, high-quality shiitake sold to a restaurant. The lower prices you observe at supermarkets reflect the lower-quality mushrooms that growers are unable to sell to restaurants or at farmers' markets.

Additional markets include catering companies and organic food stores. Ozark Forest Mushrooms refrigerates its mushrooms within one hour of picking to retain optimum freshness and quality, and then ships directly or delivers to customers.

"As you try to manage your market, you should work toward producing a steady supply of mushrooms. Your customers will expect that," McPherson said.

Why Shiitake?

The rich "umami" flavor and meaty texture of shiitake mushrooms is outstanding when sautéed, broiled, baked or grilled. A staple in the Asian diet for centuries, the shiitake mushroom has become the second-most consumed mushroom in the world. It is the third-most commonly consumed mushroom in the U.S., after white button and portobello mushrooms. In addition to great taste and versatility, shiitake are gaining worldwide recognition for health benefits.

Exotic mushrooms – including shiitake – have long been used for medicinal purposes in Asia. Lentinan, a natural complex carbohydrate found in shiitake, is used as a cancer treatment in Japan. In addition, the mineral selenium – shiitake are a good source – is being studied in the prevention and treatment of some types of cancer (selenium is a type of antioxidant), according to the National Cancer Institute's Web site, www.cancer.gov

Shiitake are nutritious

- *Low in calories*
- *Low in glucose (beneficial for diabetics)*
- *Low sodium content*
- *High content of potassium and phosphorous*
- *High content of trace elements, including copper and zinc*
- *Good source of fiber and high-quality protein*

Umami (oo-MA-mee): A meaty, savory, satisfying taste. Often described as the "fifth taste," after sweet, salty, sour and bitter. Discovered in Japan in the early 20th century. Foods with the umami taste have high levels of glutamate, a building block of protein. MSG (monosodium glutamate) is a processed additive that can add umami taste to food. Umami is found in wine, parmesan cheese, anchovies and soy sauce, for example, in addition to shiitake.

Recipes

Crisp Cucumber Shiitake Salad
David Owens, modified by J. Mihail

1/2 lb.	cucumbers (pref. seedless; peel only if waxed)
1/2 T.	salt
1/2	large red onion
2 C.	finely sliced shiitake
2 t.	salad oil
1/4 C.	rice wine vinegar
2 T.	honey
2 t.	sesame oil
	black pepper to taste

Wash cucumbers and slice thin. Toss with salt and allow to drain in colander for 2 hours. Slice onion as thin as possible and set aside in large mixing bowl. While cucumbers drain, heat salad oil in heavy skillet just until smoking. Brown mushrooms in hot oil, cooking just until tender and seared. Remove from pan to cool. Combine remaining ingredients with onion and mix thoroughly. Add salted cucumbers and shiitake, toss to coat with the dressing mixture. Serve (makes 4 portions). Recipe scales up well!

Shiitake Soup
Mary Ellen Kozak's Mom

1/4 lb.	mushrooms, coarsely chopped
2 C.	water
3 T.	butter
3 T.	flour
2 C.	skim milk w/ shredded lion's mane mushroom
1/4 C.	onion, chopped

Pour water over 2/3 of the mushrooms and simmer 20 minutes. Melt butter, and saute the remaining mushrooms and all the onion until lightly browned. Add flour to butter/mushroom/onion mixture, and cook 5 minutes. Add milk mixture and broth/mushroom mixture, and simmer 5 minutes. Season with salt and pepper and serve.

Mushroom, Barley and Parsley Chowder
J. Mihail

1 1/2 lb.	mushrooms
1/4 C.	olive oil
2	large onions, chopped (or 3 leeks)
1/4 C.	sweet Hungarian (or regular) paprika
1 can (14.5 oz.)	Roma tomatoes
2 qts.	regular-strength chicken or beef broth
2 C.	water
1 C.	pearl barley, rinsed
2 T.	red wine vinegar
1 C.	minced parsley
	salt and pepper

Slice mushrooms thinly. In a 6- to 8-qt. pan over high heat, combine mushrooms and olive oil. Stir often for about 15 minutes, until mushroom juices evaporate. Add onion and stir often for about 10 minutes, until limp. Stir in paprika, tomatoes (and packing juice), broth, water, barley and red wine vinegar. Over high heat, bring mixture to boil. Reduce heat to simmer, cover and cook about 30 min., until barley is tender. Stir in 3/4 of parsley, ladle into bowls; sprinkle with remaining parsley just before serving. Salt and pepper to taste.

Suggestions for cooking with shiitake

- Virtually any recipe, including those calling for button mushrooms, will be improved with shiitake (eg. soups, stews, egg dishes).
- Consider grilling or broiling large shiitake basted with a mixture of olive oil, crushed garlic and soy sauce.

Zucchini Cheese Mushroom Custard
J. Mihail

2 T.	butter or margarine
4	eggs
8 oz.	shredded Monterey jack cheese (or cream cheese)
4 oz.	shredded cheddar cheese
1/2	cup seasoned dry bread crumbs
2	cloves garlic, pressed

2 T. grated onion
4 C. coarsely shredded zucchini
1 C. grated Parmesan cheese
1 small can green chiles
finely diced shiitake

Coat bottom and sides of a shallow 2.5-quart baking dish with the butter. Beat eggs in large mixing bowl. Stir in cheeses, bread crumbs, garlic, onion, chiles and mushrooms until well blended. Fold in the zucchini. Scoop the mixture into the buttered baking dish. Smooth the top and sprinkle with Parmesan cheese. Bake uncovered in a 350 degree oven until top is well browned and center is firm (about 45 minutes). Cool 10 minutes before serving. Makes 8 to 10 servings.

Additional Resources for Shiitake Production

Internet Resources: Supplies and Information

Field & Forest Products, Inc. Growers' information, starter kits, spawn, cultivation tools and related products. www.fieldforest.net/ (800) 792-6220.

Ozark Forest Mushrooms. Commercial production of shiitake and other gourmet mushrooms. Growing process information and examples of value-added products. www.ozarkforest.com (314) 531-9935.

Royse, D.J. Cultivation of Shiitake on Natural and Synthetic Logs. Penn State University. http://pubs.cas.psu.edu/FreePubs/pdfs/ul203.pdf

The Shiitake Mushroom Center. http://www.shiitakecenter.com/index.html

"The Mushroom Growers' Newsletter" is available at www.mushroomcompany.com

Internet Resources: Forest Management

University of Missouri Forestry Extension: http://extension.missouri.edu/explore/agguides/forestry

Forest Management for Landowners, Missouri Department of Conservation: www.mdc.mo.gov/forest/library/

Optimum site conditions for North American tree species, United States Forest Service: www.na.fs.fed.us/spfo/pubs/silvics_manual/table_of_contents.htm

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Kimmons, T.E., M. Phillips, and D. Brauer. 2003. Small farm scale production of aerobic compost from hardwoods predigested by *Lentinula edodes.* Journal of Sustainable Agriculture 23: 109-123.

DVD

Agroforestry Five-Practices DVD (Forest Farming section). University of Missouri Center for Agroforestry. Available for purchase online at http://www.centerforagroforestry.org/pubs/index.asp#dvd

Associations

The North American Mycological Association: Includes an annual directory and bimonthly newsletter. www.namyco.org

The Mushroom Council: Marketing and consumer trend information. www.mushroomcouncil.org

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