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# **Shiitake Mushrooms**

## **Natural Resource Income Opportunities Series Special Forest Product Enterprises: An Edible Product Example**

### **INTRODUCTION**

For generations, many forest landowners have supplemented their income by gathering or cultivating special forest products (SFP) or non-timber forest products (NTFP) from forest lands. These products offer numerous new opportunities for increased income generation for forest landowners. However, without adequate planning these enterprises may have risks and may foster economic growth without assurances that forest resources are managed in a sustainable fashion.

Before exploring new business opportunities, there is an urgent need to examine the markets for these products and to integrate these products into forest stewardship plans. Native Americans traditionally used plants and plant products for food and medicine, and shared this knowledge with early settlers. These traditional forest products had become an integral part of rural economies. But for the most part, this knowledge has been ignored or forgotten.

In the 1990s, there has been a dramatic increase in demand for natural products. Processing and marketing often requires low capital investment, but can employ or give partial support to many at the local level.

### **MAJOR CATEGORIES OF SPECIAL FOREST PRODUCTS (SFP's)**

Special forest products (also known as non-timber forest products) are found in nature, but many times they are cultivated in the forest environment. SFP's are not a traditional timber product measured in board feet and sold through commercial timber buyers. Collected or cultivated in forests, these products are usually harvested on a small-scale. These products fall within five general categories: 1) edibles; 2) medicinal and dietary supplements; 3) decorative or floral products, 4) specialty wood products, and 5) native wild plants. Visit the special website on special forest products for more information on producing and marketing these types of products at: [www.sfp.forprod.vt.edu/special\\_fp.htm](http://www.sfp.forprod.vt.edu/special_fp.htm) .

## **A. Edible products**

Mushrooms, perhaps the most well known edible NTFP, are included in this general category along with many edible or food products gathered from or cultivated in the forest. These products include shiitake, oyster, morel and other mushrooms, ferns, berries or other fruits, nuts, ramps (wild onions), herbs, and spices.

## **B. Medicinal and herbal products**

These include plant-based products that are processed into medicines for the U.S. market and, perhaps more importantly, for the international markets. In the late-eighteenth century, over 130 plant species native to the United States were admitted to the U.S. Pharmacopoeia and/or the National Formulary. Most of these products are harvested in the wild in rugged or mountainous areas, and are widely traded as botanicals - many to international markets (Foster 1995). Many important products are manufactured from ginseng, saffrafras, goldenseal, mayapple, slippery elm, black cohosh, white oak bark, and scores of other species.

## **C. Decorative products**

Items collected for decorative products include pine boughs, grapevines, moss, ferns, flowers, cones, mistletoe, holly, galax leaves, and other plant products. These unique forest products may appear in floral arrangements, dried flower decorations and ornaments, or packaging.

## **D. Specialty wood products**

Specialty wood products include handicrafts, carvings and turnings, musical instruments, as well as utensils and containers. In general, specialty wood products are considered non-traditional if they are produced directly from trees, and not from lumber or timber purchased from mills or retail establishments. Often little is known about the impact these products have on forest resources because woodcrafters may purchase logs or collect trees directly from the forest and then process the material themselves. Products common in the Appalachian region include handicrafts, carvings, turnings, utensils, and containers (baskets), and special furniture pieces. Raw materials may include cypress knees, willow branches (for weaving), yellow poplar bark, or forked dogwood pieces. Most importantly, the raw materials for SFP's can be obtained and utilized from the waste products of manufacturing or forestry operations for minimal cost.

## **E. Native Wild Plants**

This is the propagation of forest and wetland plants for habitat restoration and “wild” gardening. In the coastal plain region, “no-net-loss” policies of forested wetland habitats have given birth to suppliers of propagated forest plants for mitigation projects. In addition, a growing interest in restoring native flora and wild gardening has created demand for sources of native forest plants. Consequently, some forest landowners have begun to cultivate and sell native forest plants for both the hobby and mitigation service markets.

How might forest landowners assess their existing resources for forest-based economic development? This publication focuses on one edible product example - **shiitake mushrooms**.

# Shiitake Mushroom Production & Marketing

## An Edible Product Example

### **A. Background**

Long-valued for their culinary and medicinal properties, specialty mushrooms have been enjoyed locally and in small quantities by Native American and ethnic populations, and widely used for centuries by Asian cultures. The shiitake mushroom (pronounced *she-ta-key*) is one of several marketed specialty mushrooms including oyster, enoki, wine cap, maitake, and pompom. Behind the common button and oyster mushrooms, the shiitake mushroom is the third most widely produced mushroom in the world and American production of shiitake has increased faster than any other specialty mushroom. The shiitake is a large, umbrella-shaped mushroom that is dark brown and is prized both for its culinary and medicinal properties. Proven medicinal benefits include antiviral, antifungal, and anti-tumor effects. For example, the consumption of shiitake mushrooms significantly lower blood cholesterol levels and is reported to lower high blood pressure in laboratory animals. Shiitake contains all eight essential amino acids in better proportions than soy beans, meat, milk, or eggs as well as a good blend of vitamins and minerals including vitamins A, B, B12, C, D and Niacin. In addition, shiitake mushrooms are a popular source of protein in Japan, and are a major diet staple in China, and other parts of the Pacific Rim.

### **B. Commercial viability**

Shiitake mushrooms have been commercially grown in the United States for over 20 years and are now well accepted by American gourmet markets. Shiitake may be used as a meat substitute in vegetarian dishes and is valued for its full-bodied flavor, dark color and meaty texture. In 1999, wholesale market prices for shiitake ranged from \$4 to \$8 per pound and growers generally received between \$4 to \$6 per pound for fresh, well formed mushrooms.

### **C. Management Considerations/Options**

Shiitake mushrooms offer a good example for those interested in mushroom production. They may be cultivated using wild-simulated or artificial conditions. Wild-simulated mushroom enterprises generally use white oak logs under shaded forest conditions and are best suited for the small-scale producer with an operation of 5,000 or fewer logs. High-intensity cultivation employs compressed sawdust/grain blend logs or blocks for growing medium and indoor growing environments. This method also requires a much larger capital investment including dedicated growing houses with climate control, sawdust logs (which may be pre-inoculated), and special equipment. Because of the large initial capital investments required, high-intensity mushroom cultivation incurs much greater economic risk than in wild-simulated operations.

Typical small-scale wild-simulated shiitake operations produce mushrooms on logs under forest shade conditions. Suitable growing logs are hardwood species and are four to eight inches in diameter and three to four feet long. Tree species desired include the white oak family, elm, sweetgum, yellow-poplar, hornbeam, ironwood, hard maple, blackgum, black locust, and white ash. White oak is often cited as the most desirable species. Species in the red oak family should be avoided as should pine species due to their fungicidal resins. Tree species are chosen with consideration given to moderate bark thickness as mushroom “pins” must be able to push through the bark at the onset of fruiting. The bark also serves as a barrier to other fungi. Another consideration essential to successful shiitake production is bark retention which may be accomplished by cutting trees during dormant months (e.g. October through February). Logs should be

handled gently to preserve bark and should be inoculated within two weeks after cutting to avoid infection from other fungal species.

### **Site selection**

A shady area should be selected for stacking and storing inoculated logs. This production area, also known as a growing yard, should have enough space to move logs, load small trucks, and conduct other production operations. Choose a location with at least 60 percent shade. Mixed pine/hardwood forests work well with pine trees providing shade throughout the year (before and after leaf fall), and hardwood trees contributing extra shade during the hot summer months.

### **Inoculation procedures**

Shiitake mushrooms are grown from spawn. Mushroom spawn may be purchased either in the form of dowel plugs or sawdust blocks or paste and should be ordered about a month before inoculation of logs. Different strains are better suited for different environmental conditions. Using the most appropriate strain for your area will be a large factor in the success or failure of your operation. Inoculation is perhaps the most time-consuming operation in shiitake production. The process of inoculation begins by taking harvested, cut to length logs and drilling rows of holes about 6 inches apart along the length of the log. Rows should be offset and spaced about 2 inches apart to allow maximum room for mushroom growth. Logs average 35-40 holes each. Hole depth and diameter will vary depending on whether dowel plug or sawdust spawn is used. Dowel spawn generally requires a 5/16-inch diameter hole drilled to a depth of 1-1½ inches. Sawdust spawn will require a slightly larger diameter hole and less depth. Dowel plug spawn is driven into each hole using a hammer; sawdust spawn requires a special inoculating tool. To prevent bacterial or fungal competitors from entering the log, each inoculation hole should be sealed with a thin coat of hot wax using a sponge. Cheese wax works well and remains pliable over a wide temperature range. Logs are then labeled with the inoculation date and spawn strain using a metal tag hammered into the end of the log.

### **Mushroom production**

After inoculation, logs should be stacked in the shade or covered with 60 percent shade cloth. Logs may either be stacked log cabin or lean-to style. Proper moisture content is critical for proper incubation and should be monitored regularly. Logs should never dry out, but should not be so wet as to produce mold; it is important to allow the bark to dry out between watering. Good air circulation will help to prevent molding. During the incubation period, water logs for 12 hours once or twice a month. Logs may be watered either using a sprinkler or by immersion in a livestock feed trough. Expect to water logs more frequently during hot, dry summer months.

Logs will begin to fruit between 6 to 18 months after inoculation and will continue to produce mushrooms for about three to five years depending on log diameter. Growers report the second and third years after inoculation as the most productive, double the production of that during the first and fourth years.

Fruiting is near when rings of white mycelia appear on the end of logs. At this point, logs may be stacked lean-to style to improve ease of harvesting. While mushrooms may be forced to fruit by soaking logs, better yields will result if the spawn is left to incubate slowly, allowing spring and fall rains to soak the logs. This strategy will also minimize your management and produce good spring and fall harvests, but very little production during summer and winter months. Year round production may be achieved by simulating fall and spring conditions throughout the year. However, this technique requires much more labor and management and requires the use of indoor climate controlled growing rooms. Mushrooms should be harvested when their caps are about two-thirds open, cutting the stem flush with the bark with a sharp knife.

Mushrooms may be stored in a cardboard box for up to a month at 36-41°F. Mushrooms may also be dried whole or sliced before marketing but you will receive substantially lower prices than fresh.

### **C. Risk Factors**

Producers using forest-grown cultivation techniques report many risk factors associated with growing shiitake mushrooms. These include adverse weather conditions, pest damage, securing a consistent source for viable spawn, and marketing challenges. Theft, however, is generally not reported as a problem. Moisture during the summer growing months is critical for a quality product and cooler, damper summers are favored. Extended hot, dry periods during summer months will negatively impact mushroom quality and yield and may significantly reduce price commanded at market. During extended dry periods, humidity can be controlled under forest conditions through use of irrigation, but at significant cost and assuming a clean, reliable water source in proximity to the production site.

Pests of shiitake include termites, slugs, squirrels, mice, birds, and deer. In some areas of the region, black bear may visit the production site inflicting considerable damage to logs and equipment in a short period of time.

Good, vigorous spawn is essential for successful production. Producers should deal with reputable spawn makers and purchase the strain of spawn best matched for the local climate and the desired season of fruiting. Spawn strains used for high-intensity cultivation on sawdust logs may not be well suited for the small-scale producer.

Small-scale shiitake operations are often a family affair and the time spent together is frequently cited as a motivating factor to begin and continue production. However, even the motivation of family time together will not keep the enterprise in production long if it does not realize at least a modest profit.

### **D. Marketing**

Main considerations for mushroom buyers include freshness, color, and shape. Signs of age include withering and darkness from oxidization. Shiitake mushrooms can generally be refrigerated for 4 to 5 days with little product deterioration. Local buyers and outlets for the small-scale producer include restaurants, bed and breakfasts, vacation resorts, organic retailers and markets, supermarkets, and farmers markets. Japan has also been a good customer but other export markets are growing. Buyers value consistent supply and generally place a high value on their relationships with producers. This may translate into a small premium for the reliable small-scale producer. If small producers are unable to find local buyers, wholesale buyers (who may also be larger producers) will buy dry product, but offer about ½ the price per unit of fresh mushrooms (\$2.50 versus \$4.00 to \$6.00 per pound - 1999).

In some areas, veteran growers have reported that high interest by start-up producers has saturated local markets and significantly reduced wholesale prices. In addition large-scale producers may also act to suppress the price that smaller producers receive for their mushrooms in local markets. From the period of 1990 to 1998, small-scale producers in Virginia's Alleghany Highlands region experienced a 50 percent decline in wholesale prices. This decline was due in part to many beginning small-scale producers entering and saturating local markets and competition with large-scale industrial producers. Even moderate wholesale price fluctuations will have a large impact on the success of a mushroom enterprise, especially for the small producer.

The smaller, wild-simulated producer may have a quality advantage over high-intensity cultivated mushrooms. Some buyers report that mushrooms grown on sawdust blocks are lower in quality with regard to taste, shelf life and increased cooking shrinkage. Given quality advantages, without the insurance of

quality year-round delivery, buyers will be more likely to purchase from large-scale industrial growers. Grower cooperatives and year-round producers can greatly aid in the process of helping small producers to deliver reliable, fresh supplies of mushrooms to market.

Considerable profits may be realized with the development and effective marketing of value-added shiitake products. For example, Ozark Specialty Products of Arkansas offers numerous food products including gourmet shiitake dinners, mushroom samplers, gift tins, sauces, soups, as well as fresh and dehydrated shiitake products. Prices per pound of value added product average about three times the wholesale price of unprocessed mushrooms. To help new producers, some veteran growers also offer audiotapes (approx. \$10.00), videos (approx. \$30.00), and books (ranging in price from \$5.00 to \$100.00). These experienced producers also sell production supplies such as drills, bits, plugs, spawn, inoculation tools, dehydrators, shade cloth, indoor cultivation equipment, and packaging.

## **E. Costs and Revenues**

Before you start any new non-timber forest product enterprise, it is important to gather and analyze current cost information. In addition, some initial study of potential markets should be conducted; thereby assuring that your investment will be warranted.

An enterprise budget is very simple financial tool to determine if an enterprise will be profitable or not. Very simply, an enterprise budget adds up all the cost of the operation for a year or cycle of production (in our example; four years which is the realistic life of a shiitake log). You then determine as realistically as possible the revenue you will expect to generate. By subtracting the total costs from the total revenues, you have an idea of the profitability of the operation before you start. A sample enterprise budget is provided that should act as a checklist for considering cost and sales price information. The following discusses potential costs, but you should update the figures given to give the most accurate estimate, based on the costs to you in your area.

Start-up costs for a 4,000-log operation average about \$2,000 per 1,000 logs, or \$6,000 in fixed costs if one-third of the logs are phased-in over a three-year period. Some of the start-up costs associated with shiitake production are listed below. Once you have decided to investigate establishing a mushroom operation, you should estimate current costs and availability of many of equipment and supplies locally or through the dealers listed in the sources section.

### **Cost Considerations**

- *hardwood logs* - available from firewood dealers, timber stand improvement harvesting/thinning operations. Average prices vary between \$0.50 (self cut) and \$0.75 (harvested) log (4-8" diameter, 3-4' length).
- *drill* - \$175-250; look for 5000 rpm or greater to reduce drilling (inoculation) time; high amps; bit stop (depth gauge) recommended: additional \$2.
- *drill bits* - \$6-10; bit life approximately 500 logs/bit (or 15-20,000 holes/bit)
- *food grade wax* - \$2.50/lb.; 10 lb./1,000 logs
- *sponge wax daubers* - \$0.30/dauber
- *spawn* - varies by quantity, assuming 35 holes per log at 1,000 logs:
  - sawdust type: \$600/1,000 logs
  - dowel type: \$1,000/1,000 logs
- *aluminum tags* - \$0.05/tag; or \$0, make your own from aluminum cans!
- *inoculation tool* - \$25
- *shade cloth (60%)* - \$0.37/sq.ft.

- *water trough (metal)* - \$80-\$100 (used available?)
- *refrigerator (buy a used one)* - estimated cost \$50

Variable costs of production include the following: production and harvesting labor, fuel, electricity, and packaging. Optional costs include grower's association dues, videos, and books.

### **Revenue Considerations**

Using the above figures, production costs average about \$3 per pound of fresh mushrooms. Assuming a wholesale price of \$4.50 per pound for fresh mushrooms and a 20% cull rate, a 4,000 log producer can expect a 6.5 percent return (after taxes) on their investment over a four year period. Higher prices for fresh mushrooms and value added products will significantly increase the grower's margin. Careful attention to inoculation and incubation as well as thorough marketing will greatly aid in the success of a shiitake grower's enterprise.

Based on the profitability produced by the development of the enterprise budget, you can either refigure your operation, start the enterprise, or abandon the idea. You are doing so with the best information available.

### **E. Other Types of Mushrooms**

There are many different types of mushrooms that can be cultivated and collected. Below is a short list of the more common mushrooms and few of their characteristics. More information on these mushrooms is available from the information sources and mushroom suppliers.

**AGARICUS:** There are many *Agaricus* species that are grown commercially. Most commonly grown are the "White Button" (*Agaricus. brunnescens*) and "Portobello" (*Agaricus portobello*) also known as "Italian *Agaricus*".

**ENOKI:** Also known as Enokitake mushrooms (*Flammulina velutipes*) and the winter mushroom. Today, these are seen on many grocers shelves packaged in small plastic shell packs.

**REISHI:** This mushroom (*Ganoderma lucidum*) is widely used in the orient for its' medicinal properties. Can be cultivated in nursery pots or on conifer and hardwood stumps.

**LIONS MANE:** Considered to be edible and choice by mushroom fanciers. *Hericium erinaceus* is claimed to taste like lobster. Produces cascading, icicle-like clusters that enlarge to baseball size.

**HEN OF THE WOODS:** Also known as Maitake and *Grifola frondosa (Polyporus frondosus)*. This mushroom has rapidly gained popularity and can produce enormous (up to #100) mushrooms. These prefer hardwood stumps.

**MOREL:** X

**MAITAKE:** X

**NAMEKO:** This is considered to be Japans #2 mushroom after shiitake, very edible and is considered to be very choice. Nameko (*Pholiota nameko*) is very easy to produce.

**OYSTER:** There are many species of cultivated oyster mushrooms including: *Pearl (Pleurotus ostreatus)*, *Pink (Pleurotus djamor)*, *Grey (Pleurotus pulmonarius and P. sajor-caju)*, plus several others. These are prized for their oyster-like flavor and ease of culture. Also, commonly seen on grocer shelves.

**PATTY STRAW:**

(*Volvariella violaceae*) This is one of the oldest mushrooms in cultivation and is very simple to produce in some kind of controlled temperature growing area due to their high temperature (86-95F) demand. Ideal for greenhouse production.

**SHIITAKE:** (*Lentinula Edodes*) Shiitakes have led the way for other mushrooms acceptance in local and national markets. They can be grown on straw or fresh cut hardwoods, have a very well understood culture and can be relied on for timely harvests. There are many very specific strains, some are better suited to certain regions or temperature regimen, while others are classified by either indoor or outdoor culture.

**OTHERS:** There are many other mushrooms offered for cultivation, included among these are: *Chicken of the Woods (Polyporus sulphureus)*, *King Stropharia (Stropharia rugoso-annulata)*, *Shaggy Mane (Coprinus comatus)*, and many more.

## **F. Information Sources**

- American Mushroom Institute, 907 E. Baltimore Pike, Kennette Square, PA 19348.
- Appalachian Mushroom Growers Association, Route 1, Box 30BYY, Haywood, Virginia 22722.
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- Special Forest Products Website. Supported by Virginia Tech, Blacksburg, VA. [http://www.sfp.forprod.vt.edu/special\\_fp.htm](http://www.sfp.forprod.vt.edu/special_fp.htm)
- Grow Shiitake Mushrooms. The Forest Steward – The National Arbor Day Foundation. March/April 1997. P. 4.

## **G. Suppliers**

Field & Forest Products  
N3296 Kozuzek Rd.  
Peshtigo, Wi 54157  
(715) 582-4997 Phone  
(715) 582-0181 Fax  
Books, Equipment & Supplies

Fungi Perfecti  
P.O. Box 7634  
Olympia, Wa 98507  
(206) 426-9292 Phone  
(206) 426-9377 Fax  
Books, Classes, Consulting, Equipment, And  
Supplies  
Hardscrabble Enterprises, Inc.  
RC7 Box 42  
Circleville, Wv 26804  
(301) 358-2921 Phone  
(202) 332-0232 Phone  
Books, Equipment, & Supplies

Mushroom Harvest  
P. O. Box 5727  
Athens, OH 45701  
614-448-6105 Phone

Mushroompeople  
P.O. Box 220  
Summertown, Tn 38483  
(615) 964-2200 Phone & Fax  
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Suite 145  
Silver Spring, Md 20904  
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(301) 384-5288 Fax

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702 Nw 4th St.  
Corvallis, Or 97321  
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Phone (501) 723-8441  
Fax (501) 723-4443

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Kittaning, Pa 16201  
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(412) 545-9113 Fax  
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Rt. 3 Box 186  
Bruceton Mills, Wv 26525  
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Supplies

Wonshan  
11305 Elk Run Rd.  
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(703) 788-1127 Phone  
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Books, Equipment, & Supplies

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