Shiitake field trials grant received

The cultivation of shiitake mushrooms has a chance to blossom in the Pacific Northwest and the Midwest thanks to a grant from the Northwest Area Foundation based in St. Paul, Minnesota. The $87,000 grant will enable the Forest Resource Center to assist rural residents with information on how to grow and market shiitake mushrooms. Unlike conventional cash crops such as corn and soybeans, once the logs are colonized with appropriate strains of shiitake, they can be forced to fruit year-round indoors. Year-round production would allow growers to contract for volume sales and receive better prices.

Under the grant, the Forest Resource Center will complete field trials to determine which strains of shiitake grow the fastest, have the highest yield, and are the most marketable. Indoor fruiting trials, to be completed in the controlled environment chamber at the Center, will focus on the temperature, light, humidity, and air flow conditions needed to optimize year-round mushroom production. A major portion of the grant will involve financial analysis and market research that will examine all the aspects necessary to profitably raise and sell shiitake mushrooms. More information will follow.

Shiitake cultivation review

Shiitake mushrooms (Lentinus edodes) offer woodlot owners a new means to utilize low-grade trees and tops. These mealy-tasting mushrooms have been harvested from the wild for centuries in Asia. In the 1940's the Japanese developed a method of cultivation. Today, shiitake is grown in China, Japan, and Korea. It is Japan's leading agricultural export, with retail sales totaling over $1 billion per year.

The reason shiitake production is so compatible with woodlot management is that short logs can be cut from trees removed for woodlot improvement thinnings, wildlife habitat cuttings, and residues from timber harvests. It also serves as a short-term payback for long-term management.

Logs for shiitake production should be cut when the trees are dormant, as stored nutrient levels are highest at this time of the year. Avoid damaging the bark. The bark insulates the logs from rapid changes in temperature, stimulates fruiting, and helps maintain the water content in the log. Logs cut from leafless trees have better bark retention.

Shiitake will grow on several species of hardwood trees. Oak is preferred because it has a high sugar and lignin content, and the ray cells help transport the shiitake mycelium. Other species successfully used are maple, chestnut, hornbeam, alder, hickory, birch, and others. It appears however, that the harder the wood the better. For "soft" hardwoods, such as aspen, double the inoculation rate. Ideal diameters of shiitake logs should be between three and eight inches. Traditionally, shiitake logs are cut into lengths of one meter (about three

SEE REVIEW, PAGE TWO
Log moisture content determination

Table 1 - Moisture Content Formulas

\[
\%MC(F) = \frac{\text{fresh weight} - \text{dry weight}}{\text{fresh weight}} \times 100.
\]
Example: \(100\ g - 75\ g \times 100 = 25\%\)

\[
\%MC(D) = \frac{\text{fresh weight} - \text{dry weight}}{\text{dry weight}} \times 100.
\]
Example: \(100\ g - 75\ g \times 100 = 33\%\)

Calculated oven dry weights

\[
\text{CODW(F)} = \log \text{fresh wgt.} - \frac{\%MC(F) \times \log \text{fresh wgt}}{100}
\]
Example: 10 lb log fresh wgt - \(\frac{25 \times 10}{100} = 7.5\ lbs.\)

\[
\text{CODW(D)} = \log \text{fresh wgt} \times 100 - \frac{\%MC(D)}{100 + \%MC(D)}
\]
Example: \(10\ lbs \times 100 = 7.5\ lbs.\)

Conversion Formula - Fresh to Dry

\[
\left( \frac{1}{1 - \frac{\%MC(D)}{100}} \right) - 1 \times 100 = \%MC(D)
\]
Example: \(\left( \frac{1}{1 - \frac{25}{100}} \right) - 1 \times 100 = 25\%MC(D)\)

FROM REVIEW, PAGE ONE foot). Cut logs no shorter than two feet or drying will be a problem, and no longer than four feet for ease of handling. Fall inoculation is currently being evaluated. Normally, inoculation should be done before farmers get out in their fields in the early spring.

Inoculation is done by drilling a series of holes in the logs and inserting shiitake spawn plugs or sawdust spawn. Shiitake mycelium runs well with the wood grain but poorly across the grain. Therefore, starting four to six inches from the end of the log drill a series of holes two inches apart around the circumference of the log. The series of holes should be spaced eight to ten inches apart down the length of the log. Spawn plugs are hardwood dowels inoculated with shiitake mycelium. They measure 5/16" in diameter and 3/4" in length and cost between $15 - $40 per 1,000 depending on the quantity ordered. Sawdust spawn can be used in place of spawn plugs and works best on larger diameter logs because it allows a grower to inject more of the spawn into a log. It requires special handling and tools for inoculation. A 2 1/2 lb. bag contains approximately 3 1/2 quarts of spawn and will cost between $10 - $25 per bag. For your first attempts at growing shiitake, it is best to try several strains from at least two suppliers. This is because the different strains of shiitake perform differently under different conditions. This will enable you to fine out which strains grow best in your locality. Remember too that the quality of your crop can be no better than the spawn used. Use viable spawn which is free of weed fungi and bacteria. Spawn should be moist, white and fuzzy in appearance. Keep weed fungi and bacteria out by not damaging or opening the spawn containers until use. Keep the spawn from direct sunlight and extremes of temperature.

Monitoring the moisture content of your shiitake logs is a key to any successful operation. Electric moisture meters are accurate only on green logs in the early stages of development. Growers must either continually cut moisture sample wafers from logs or establish sample logs with calculated oven dry weights. These logs can be used at any time for moisture content determination. This article will review the process to establish these sample logs.

First, growers should be aware that moisture content (MC) can be determined by two different methods. The first method, called the Fresh Weight basis uses the formula \%MC(F) [see table 1]. This is the method used by Gary Leatham and many others in their literature. The second method is called the Dry Weight basis and uses the formula \%MC(D) [see table 1]. This method is used primarily by the forest products industry. Note: fresh weight is the weight of the wafer at the time it is cut. Dry weight is the weight of the same wafer once it reaches a constant weight after a drying period and is also known as the oven dry weight.

Process: Pick average logs from each log diameter class, i.e., 4", 6", 8", etc. at random. Cut off 6" from one end of the log. Next cut a 1" wafer off the log. Weigh the log and the 1" wafer and record the weight of each. Place all the 1" wafers in an oven maintained at 215-220 degrees Fahrenheit. After 24 hours, begin weighing the samples every 3 to 4 hours until a constant weight is reached. Determine the \%MC of the wafer by whichever method you are in agreement with.

The Calculated Oven Dry Weights, or CODW, of the sample logs is determined by using either the fresh or dry weight formula once again [see table 1]. You must be consistent. Do not switch between fresh and dry formulas. Use the appropriate formula to calculate each log's oven dry weight. At the Forest Resource Center, all sample logs have a 3" bright orange band painted around the circumference of the logs at each end for easy identification. A tag bearing both its number and calculated oven dry weight is attached to each log. This information is also recorded in another location.

Log Moisture Content: At any time, a grower can weigh the sample logs to determine the current "fresh weight" and then use the appropriate moisture content formula [\%MC(F) or \%MC(D)] and the log's calculated oven dry weight to figure the log's present moisture content. The ideal moisture content of your shiitake logs should be maintained between 35% and 45% MC(F). Special thanks to Harlan Taylor, a local grower, for his input in writing this article.
Don't allow the spawn to freeze. Insert the plugs or sawdust spawn flush with the log surface. An extra 1/4" between plug spawn and the bottom of the hole is left for an air pocket. This air pocket allows the shiitake mycelium to fluff up and colonize a larger area faster. Once the spawn is inserted, seal the holes with melted wax to keep moisture in and weed fungi out. Some growers wax any exposed wood and log ends. Use a soft, pliable wax.

An inoculation crew of at least four persons works best. One to drill holes, two to inject the spawn, and one to wax the logs. As a general rule, it takes a full man-day to inoculate 60-100 logs. Be sure to label each log with the date inoculated and the strain used. This will enable you to determine which strains work best and how long it takes to fruit. Accurate records are very important.

Inoculated logs should now be moved to a "laying yard" to incubate. Ideal incubation conditions are a temperature of 60 – 80 degrees F with a relative humidity of 80 – 85%. The inside of the logs should be moist but the log surface should be dry. Be ever mindful of your microenvironment. In dry environments keep the stacks low, in moist environments stack higher or restack in a different pattern to promote better ventilation. Covering the logs with burlap, straw mats, or some other porous material can be used to shade the logs. This also favors moisture retention while at the same time allowing good ventilation and wettimg from rainfall.

The logs should be protected from drying winds in the winter. Snow cover is ideal because it provides wind protection and moisture. Pine stands make ideal laying yards. They provide good wind protection and contain fewer weed fungi.

Incubation is the most critical phase of shiitake cultivation. The fungus will only produce mushrooms after the logs are well colonized. Incubation usually takes 1 1/2 years to 2 years. Once this stage is reached a fuzzy, white fungal growth may appear at the cut ends of the logs. At this time, conditions need to be changed to favor fruiting. The logs are now moved to a "raising yard". The raising yard and the laying yard can be one in the same.

Fruiting requires moisture, air movement, and shade. Optimum fruiting conditions are cool nights followed by warm days. Temperatures should average between 46 and 72 degrees F. with 85% humidity. To promote these conditions and to make harvesting easier, uncover the logs and stack them upright under shade. Leave a space the width of a log between each log. Every two to four months turn each log end to end to ensure even moisture distribution.

Logs can be forced to fruit by soaking the logs in water for 24-72 hours depending on the temperature difference between the water and air temperature. Keep the logs at a cool temperature until pinheads (mushrooms) appear, then put them in a humid area. A blue or green surface mold may contaminate logs. These molds damage mushroom cultivation by preventing mushroom growth at the surface. To prevent the spread of surface molds and other competitive fungi, scrap any log producing other mushroom species or that has more than 20% of the log surface contaminated. Also scrap any logs which have lost their bark. Dispose of contaminated logs by burying them in a separate location or burning them.

Once mushroom formation has started it takes shiitake two to seven days to mature to a harvestable stage. Pick the mushrooms just before the cap expands completely. Snap them off cleanly at the log surface. Shiitake does resist bruising but take care to minimize damage. Damaged mushrooms spoil easily and have less consumer appeal. Inoculated logs normally produce twice a year for three to five years. A cord of wood can produce about 100 pounds of mushrooms per year. Current retail prices vary, ranging from $4 to $12 per pound. Shiitake can be marketed fresh, frozen, or dried.

Adapted from Michigan Forest Management Bulletin No. 5-14.
Shiitake cultivation update

by Robert Osaki

During the past season, I have visited numerous shiitake operations, and have found that many of the U.S. shiitake growers should be updated on current cultivation techniques. Most shiitake farmers are using logs that have been cured for a month or more before inoculating. It was believed best to cure the logs down to the spawn’s preferred moisture content and then inoculate. Also, it was thought that the antibodies of the tree were still alive and would kill off the shiitake fungus. Conversely, if inoculated immediately after the tree has been cut, the log starts dying from the points of inoculation. The faster running strains should keep up with the rate of the death of the tree. This can be compared to getting a cut on the arm; the infection would start and grow from the point of the cut, not from your leg.

Inoculation should be as shown in Drawing 1. The illustration shows how the mycelium runs more rapidly with the grain vs across the grain. Growers should consult with their spawn suppliers to determine the ideal intensity of inoculation for each strain used. For example, in a one month period, our Rapid Run Strains, under ideal conditions, will grow about two cm. in length and about one mm. in width. Most other sawdust strains will grow about 50% as fast and plugs about 25% as fast.

Waxing vs styro plugs is another thing that I often see many shiitake growers evaluating. Styro plugs place the spawn further away from the cambium layer, which contains the most nutrients. The cambium layer is just under the bark. Consequently, the spawn has further to travel before it can reach the cambium and longer to colonization and fruiting.

Regarding waxing, it seems that everyone is using wax melted over a double boiler, thinking that the lower temperatures will not kill the surface spawn. Paraffin wax melts at around 60 degree C. and spawn dies in the 40 degree C. range. Does that tell you anything!? Also wax applied at lower temperatures causes a heavy build up of wax, often with pin holes allowing contaminants in. The heavy build up also falls off easily when the logs are handled.

Wax should be melted directly over the flame of a gas burner or electric hotplate, preferably a gas or propane burner, as gas can be turned off immediately in case of a flare up of flames. Wax should be left on the flame till a white vapor appears at around 150-200 degrees C., or just prior to the wax “popping” or flaming. Of course you always want to keep a fire extinguisher handy! If the wax does “pop”, to extinguish it you must cool the wax. First, cut the heat source, and using a chunk or chunks of wax that you have previously left by the burner, drop the chunks of wax into the wax can. The effect is the same as ice into a pot of boiling water. Using a brush to apply the hot wax cools the wax too much and often melts the bristles. It is very messy and does not do a sufficient job. Wax droppers have been developed for this application and are the perfect tool for this job. They are similar to a turkey baster but are made especially for shiitake log waxing. This method of using hot wax, along with a wax dropper applies a very thin even layer of wax to the log. The moisture in the spawn prevents the hot wax from penetrating very deep and the point of inoculation is sterilized by the hot wax.

Growers should also pay attention to the location and layout of their laying yaros. The laying of the logs should be on a south facing slope or flat land, with the heads of the logs facing north. Logs should be stacked on an angle that allows maximum sun ray coverage. This provides maximum heat to the logs for a faster spawn run in the cooler months.

Conversely, in the warmer months, after the temperatures reach above 20 degrees C. or 68 degrees F., it is necessary to provide some type of shade either natural or artificial using shade cloth or other materials. Inner log temperature can be calculated using the following formula: AIR TEMPERATURE (degrees C.) + ALPHA = INNER LOG TEMPERATURE (in C.). Alpha is 20, 15, 10, 5 or 0, depending on the conditions of the sun, 20 being full sun, and 0 being rain and overcast. Consequently, with 20 degree C. air temperature + Alpha of 20 with a full sun and clear skies = 40 degrees C. as the inner log temperature, which would cause thermal death to the spawn within the logs.

Robert Osaki spent from 1975 to 1983 in Japan, six of those years working within the agricultural industry, where he has obtained much of his background knowledge about shiitake cultivation. He now resides in Portland, Oregon and owns and operates Four Seasons Distributors. Mr. Osaki’s strains are all obtained from Japan. He also provides an extensive line of tools for mushroom production. (See ad - SHIITAKE CLASSIFIEDS)

ELIX CORPORATION

Featured spawn supplier
Elix Corporation

Elix Corporation was formed in 1982 for the purpose of growing shiitake and other 'wild' mushrooms. We purchased and leased 80 acres in central Virginia, where the climate is similar to shiitake growing areas in southern Japan and Korea. Central Virginia also offers an abundant source of oak, a good labor supply, and through the Charlottesville airport, ready access to major markets.

Our original belief was that Chinese-Americans would purchase all the fresh shiitake we could supply, since for years they had to rely strictly on imported dried product. We were therefore surprised, somewhat unpleasantly, to discover that these people had through the years come to prefer the stronger taste and rubbery texture of dried mushrooms over fresh. However, we soon found eager customers among chefs of fine Italian and French restaurants, and soon (through quality retailer/wholesalers such as Balducci’s in New York) equal interest among chefs of upscale American restaurants. In the next two years our increased production enables us to develop potential markets in a large number of urban centers in the United States and Canada.

In 1984 and 1985, the supermarket chains began to open up to shiitake, in spite of the steep retail price, and now with powerful marketing companies entering the picture, shiitake and other exotics are firmly established in some area
chain stores. Americans like mushrooms. All Elix and others have done is offered them a mushroom superior to *Amanita bisporus* in taste, texture and nutrition. Perhaps the next step is to produce hard evidence of the medical benefits of shiitake and sell extracts to pharmaceutical companies!

Because of our optimism regarding market development, we decided early on to encourage others in Virginia to grow shiitake. We offered our fast-growing EL and S-1 (Golden Oak) strains for sale and included instructions for inoculation and growing. We also invited potential growers to visit our farm to get a feel for actual production. Our thinking was that the more people growing shiitake means more people eating shiitake; and that means a larger market for Elix and other commercial producers to expand into. During the last three years our spawn sales have grown proportionately to our sale of fresh shiitake.

We believe the potential for shiitake production and consumption in this country is virtually unlimited, particularly since the supply of small oak trees and other suitable low grade hardwoods is far greater in this country than in major producing countries such as Japan and Korea. At the same time, drastically expanded production will require substantial reduction in wholesale prices, but with increased efficiency and technological advances, this should not entail seriously reduced profits for commercial growers. It will also be desirable for growers to find an outlet for under grade product—in canned soups or frozen food items, for example. There are, in other words, steps that must be taken in product development as well as market development for shiitake to reach its full potential in this country.

At Elix we have, to be sure, a predominately commercial interest in shiitake. But we also feel a sense of excitement and pride in helping introduce America to a food which is delicious, healthy, and certainly destined to be a permanent part of our national cuisine. (See ad—SHIITAKE CLASSIFIEDS)

Establishing an oak plantation
by Tom Hovey

Shiitake production is highly compatible with oak plantation management because many short logs from thinnings can be used for inoculation. Logs 2 to 8 inches in diameter and 3 to 4 feet long are needed for shiitake production. The potential short term payback of shiitake growing can make long term management of the plantation more attractive. Although shiitake will grow on several species of hardwood, oak is preferred because of its high sugar and lignin content and the ray cells provide a quicker path for shiitake mycelium.

This article will deal with the establishment of an oak plantation on open land such as an abandoned agricultural field. The steps in preparing an oak plantation are: 1) Selecting an appropriate site, 2) Preparing the site, 3) Controlling weeds over time, 4) Using appropriate planting stock, 5) Handling and planting the stock properly, and 6) Maintaining the plantation. Most hardwood plantations are more difficult to establish than conifer plantations. Successful establishment demands intensive labor, close attention to detail, and the ability to provide follow-up care for several years after planting. Before starting, be aware that establishing an oak plantation requires money, labor, and commitment. Failure to carry out the necessary work will likely result in the loss of time and money already spent.

**SELECTING THE APPROPRIATE SITE** First, a site must be chosen for the oak plantation that will allow the trees to live and to respond to management. The closer you can match optimum requirements of the species to the actual site of planting, the greater your chances of success will be. Important features in site selection include: Topography (aspect, slope position, slope steepness), Climate (annual rainfall, wind, temperature ranges), and Soil (surface soil depth, depth to matting, depth to impermeable layer, stone content, texture, structure, drainage, parent material).

Below are brief guides to requirements for the most likely oaks to be planted in this region.

**NORTHERN RED OAK** (*Quercus rubra*) Optimum growth occurs in deep, fertile, moist but well drained sandy loams or loams. Do not plant in excessively dry or poorly drained soil.

**BLACK OAK** (*Quercus velutina*) Optimum growth occurs on lower slopes and coves in unglaciated regions. In the northern extent of its distribution (southern Minnesota and Wisconsin) black oak is only found on ridgetops and the bottom two thirds of the warmer south and west facing slopes.

**BURR OAK** (*Quercus macrocarpa*) Burr oak
grows on dry, exposed sandy plains and on loamy slopes of south and west exposures. It is found also on heavier soils that are well drained. On uplands the occurrence of burr oak appears to be closely linked with, but not limited to calcareous soils. This species is tolerant to a wide range of soil and moisture conditions.

**WHITE OAK (Quercus alba)**: This species develops best on deep, well drained loamy soils. Growth is good on all except the driest, shallow soils. Do not plant on extremely dry, shallow soil ridges, poorly drained flats, wet bottom lands, or calcareous soils.

**PREPARING THE SITE** Apply glyphosate (ex: Roundup) in the fall before planting (while the vegetation is still green) over the entire area or spray in strips at least 6 feet wide at the rate of 3 quarts per acre. One week after spraying plow and disc or roto-till the sprayed area. On sites where mechanical site preparation is not possible or desirable (such as slopes where erosion might be a problem) spray the glyphosate in strips at least 6 feet wide or in circular spots at least 5 feet wide. This will also be an application in the fall before planting. The mechanical disturbance of the weed cover has the added advantage of depriving rabbits and mice of shelter and food, making your plantation a hostile environment for these pests.

There are no shortcuts in the measurement of correct dosages or the actual herbicide application. Applied properly herbicides can be very effective; applied improperly, herbicides can do more harm than good, both to the crop trees and the environment. If proper application (dose measuring, equipment calibration, etc.) cannot be guaranteed, herbicides should not be used. So far fertilization hasn’t proven to improve height growth or survival rates in seedlings. Fertilization is expensive and encourages weed growth. Any potential money for fertilizers would be better spent on site preparation and weed control.

**CONTROLLING WEEDS OVER TIME** Shortly after planting spray 2 to 4 pounds active ingredient per acre of simazine (ex: Princess) over the total area, strips or spots prepared for planting. See simazine label information to match the rate per acre dosage to your soil type. In the fall of the first and second year or spring of the second or third year after planting apply simazine again over the same areas. Continue spraying after the third year if necessary until the oak seedlings have outgrown the weed competition.

**USING APPROPRIATE PLANTING STOCK** Large 1x1, 2x0, or 1x1 nursery stock should be used. Any trees with less than a 3/8 inch diameter (1 inch above the root collar) should be culled and the remaining trees should average at least 1/2 inch in diameter. Larger stock generally increases your chances of success and is more resilient and resistant to rabbit damage.

Since transplants may be hard to obtain, 2 or 3 seedlings undercut at a 5 to 6 inch depth in the first year just after full leaf expansion of the first flush of growth may be a less expensive substitute. Transplants should be root pruned at 5 to 6 inches below the root collar before transplanting in the spring of the second growing season.

The large stock needed may only be available if you order at least 2 years before planting. Average (1/2 inch) and minimum (3/8 inch) basal diameters should be specified when ordering. It may be desirable to contract for planting stock to ensure that all specifications are met. Seed sources should be as local as possible. Trees of a northern origin will have a shorter growing season and those from south of the planting site will leaf out too early, exposing the new growth to injuring frosts. It is especially important that the stock from south of the planting site be avoided. The nursery should be able to tell you where the seed source is located.

**PROPER HANDLING AND PLANTING** Mortality and poor growth of oak seedlings in the first year after planting is often the result of poor handling between the nursery and the planting site. Bundles of trees must be protected from the sun and wind until they are safely planted. Tree roots are often packaged in moist peat moss. As soon as the shipment arrives open the package and check the condition of the seedlings. If the roots are dry at this or any other time don’t waste your time planting them.

Improved field plantings may result as lifting, packing and cold storage techniques are improved in nurseries. Ectomycorrhizal inoculation in nursery soils has already been shown to produce stock that grows faster and recovers from water stress faster than non-inoculated stock. In the future this and other improvements may become more available in commercial planting stock. Your nursery can root prune (8 inches below the root collar) while packing, but the tops should be clipped within 2 weeks of planting. The stem should have numerous buds (none swollen or flushed at the time of planting), be straight, and have relatively short branches on the previous year’s growth. Long branches should be pruned (8 inches above the root collar) as well as multiple leading shoots. Long, thin, whip-like stems grow slowly. Multiple stem seedlings should be culled.

Seedlings should be planted as soon as site conditions permit in the spring and as soon as the stock arrives at the planting site. If delay is unavoidable the seedlings should be kept in a cool place with the roots moist. Heel in seedlings in a shaded, well drained location, that cannot be planted or put in cold storage for over a week. This is done by digging a trench deep enough to hold the roots, placing the individual bundles of trees in the trench, and covering the roots with soil. The roots must never be allowed to dry out. Before and during planting take every precaution to keep the roots from drying out. Unopened bundles should be kept shaded and as cool as possible.

Planting on well prepared, larger sites can most easily be accomplished with a planting machine. Not all planting machines are suitable for planting hardwoods though. Planters that hit the terminal bud as they pass over the seedlings, cause seedlings to lean, or plant the seedlings in the bottom of a furrow should not be used or should be modified.

On steep slopes, very wet soils, or in other locations where a planting machine cannot operate efficiently or if no suitable machine is available, shovel planting has its place. The best manual
The method of planting is the wedge method where a wedge of soil is removed, the roots are inserted into the hole, and the wedge is replaced. The slit method in which the roots are placed in the slit made by pushing the shovel or planting bar (at least 8 inches long) back and forth can also be used. Care should be taken to eliminate air pockets at the bottom when closing the slit.

Before you plant or order your seedlings, spacing must be determined. Spacing involves a compromise between the growth requirements of the species, the purpose of planting, and the economic resources, time and equipment available for tending the plantation. Trees grown at wide spacings generally grow faster in diameter, while those grown at closer spacings will generally have better form. Closer spacings will also provide more logs for shiitake inoculation at the precommercial thinnings, higher seedling costs, quicker canopy closure (which means fewer years of weed control), and more selection for final crop trees.

A spacing of 10 feet between rows and 5 feet within rows is convenient. This spacing requires 870 seedlings per acre and allows for passage of a medium sized tractor that can be used for plantation maintenance. This spacing also allows for relatively quick shading of competing vegetation, possible mortality and stems of poor form, and at least one precommercial thinning. You can figure out the number of trees you need for different spacings by dividing the number of square feet per acre (43,560 sq. ft.) by the number of square feet required for each tree in your spacing scheme. Example for a 5 ft. x 10 ft. spacing: 5 x 10 = 50 sq. ft. per tree; 43,560 sq. ft./acre divided by 50 sq. ft. per tree = 871 trees needed per acre.

MAINTAINING THE PLANTATION With the planting operation a success you must now begin protecting and improving your investment. For the 5 years after planting you should annually prune one side of forked leaders or individual branches to improve stem form. Thereafter, remove the lowest branches every 3 to 5 years, but always leave a crown 2/3 to 1/2 the total tree height.

In the early years controlling weeds, and monitoring the seedlings for rodent, rabbit, and deer damage will be necessary. A newly planted field can be a delicious meal for deer and rabbits that browse the tops and mice that girdle the stems. Elimination of the weed cover is considered the best protection against mice and rabbits. Well secured fencing is the most effective protection against deer. Keep in mind when checking your planting for browse damage that growing season browse is much more damaging than dormant season browsing and is therefore more important to control. Other types of animal controls are hunting, spraying with repellants, placing wire screens around individual seedlings, placing tree guards around stems for girdling problems, poisoning with treated grain for rodents, and using silvicultural techniques such as not planting next to conifer stands which are home for rabbits. Check with your local game warden for valuable advice about animal problems and their solutions specific to the area where you plant.

Other things to look for when visiting your plantation are insect, disease, and weather related damage. Catching the problems early could mean the success or failure of the plantation.

Your oak plantation needs the best care it can get. Don’t forget that help is available. Contact an Extension Forester or State Forester for more information. They may help you directly or supply you with a list of Consulting Foresters or Private Industry Foresters who can provide a number of management services. The years of experience behind a professional forester can be most valuable in helping you manage your oak plantation.

Much of the information in this article is from "A Guide to Hardwood Planting on Abandoned Farmland in Southern Ontario" which is a booklet by F.M. von Althen, and "Planting Northern Red Oak in the Missouri Ozarks: A Prescription" an article in the Northern Journal of Applied Forestry by Paul S. Johnson and others.

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## Calendar

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<td>2/09/87</td>
<td>MN Extension Service</td>
<td>Rod Elmstrand</td>
<td>(612) 257-2982</td>
</tr>
<tr>
<td>Cambridge, MN</td>
<td>2/09/87</td>
<td>MN Extension Service</td>
<td>Rod Elmstrand</td>
<td>(612) 674-4417</td>
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<tr>
<td>Lanesboro, MN</td>
<td>2/28/87</td>
<td>FRC &amp; MN Ext Service</td>
<td>Resource Ctr</td>
<td>(507) 467-2437</td>
</tr>
</tbody>
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### What is the Southeastern Minnesota Forest Resource Center?

The Southeastern Minnesota Forest Resource Center's objective is to improve the management of our hardwood resources on private lands. The clientele for whom the Center is designed includes landowners, university students, local community education, secondary and elementary education programs, professional foresters and forest scientists. Working in cooperation with Minnesota's Extension Service and Department of Natural Resources, the Forest Resource Center is utilizing an existing facility that is located in the midst of 900 acres of forest land near Lanesboro, Minnesota.

The Forest Resource Center offers many services for people of all ages including quality educational programs, demonstration areas which depict woodland management techniques, a shiitake mushroom demonstration and provides a resident forester, who is available 7 days a week when forestry advice is needed. Please call in advance to arrange an appointment.

Private financial support for the educational and other activities of the Forest Resource Center will ensure their continued success. You are invited to become a contributor to this important work by sending your tax deductible check to the Forest Resource Center, Rt. 2, Box 156A, Lanesboro, MN 55949.

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