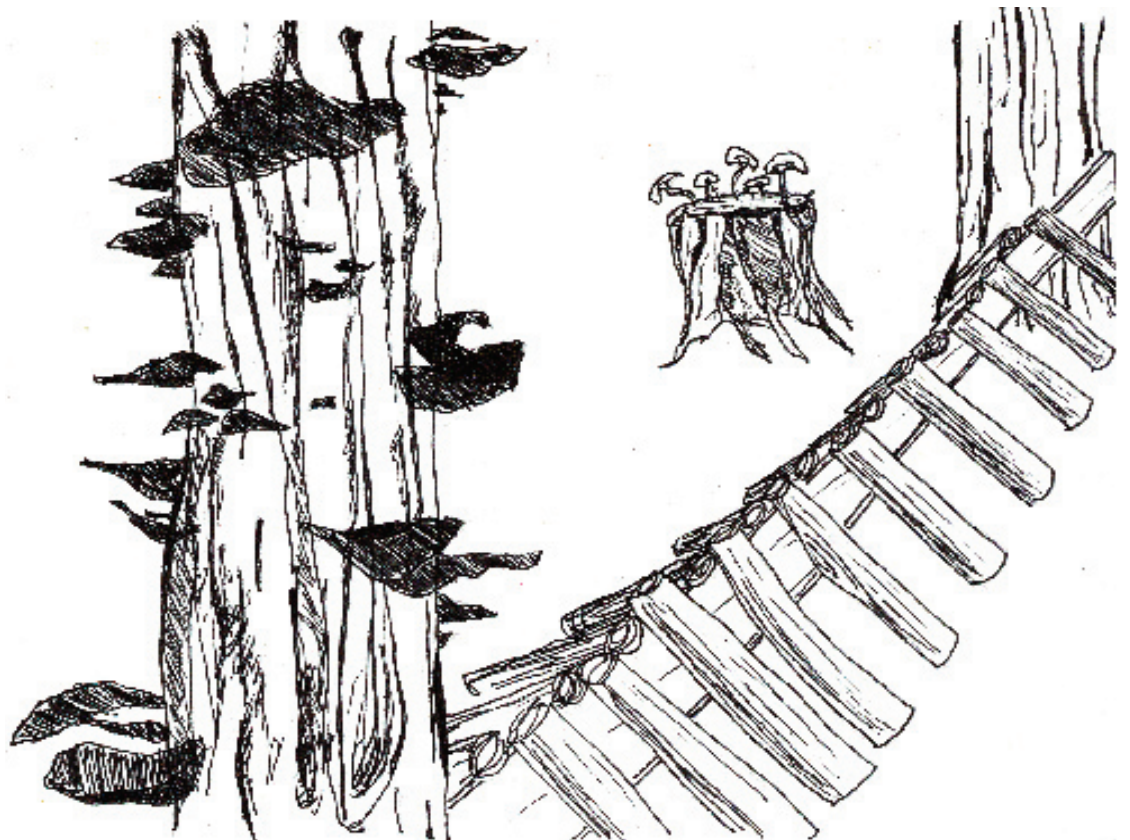


D Acres of New Hampshire
Organic Farm & Educational Homestead
Presents

**A Guide to Outdoor Mushroom Log Cultivation:
Highlighting shiitake, reishi, and tree oyster mushrooms**



Sustainable Forestry and Selecting Tree Species

Managing a woodlot requires selective thinning in order to maintain a healthy forest. Mushroom cultivation works hand-in-hand with sustainable forestry in that the felled trees are by-products of necessary cutting that allows preferred species space to thrive. To put it simply, we are not cutting down trees so that we can grow mushrooms; it is actually a fringe benefit. Inoculating felled trees with mushroom spawn is a valuable alternative to using this wood for firewood and wood crafting.

It is best to locate your logs in various sites. Site variety will ensure that you do not fell all of your logs in an area overrun with competitor fungi. In this manner you may be insuring a greater degree of success. It is much less labor intensive if you find a location close to where you have cut down the trees you will be using for your mushroom log cultivation.

Trees should be cut in late winter or early spring when the sapwood is rich in sugars. Once felled, the logs should not be in contact with the ground. This prevents contamination by bacteria and other fungi. Storage can be achieved by stacking the logs to be used in cultivation on top of other fresh logs or gravel. It is best to inoculate in the late winter or early spring. February and March, if you can get an early start, is ideal. You definitely want to introduce the mushroom spawn to the logs within two months of felling the trees in order to optimize the internal moisture content of the logs and decrease the chances of contamination. Once the trees are cut into 40-inch lengths, they should be inoculated as soon as possible, optimally within three weeks, as waiting will allow competitor fungi to contaminate the logs as well. A diameter of 3-6 inches is suggested for ease in handling. If possible, it is preferable to keep the logs in shade during the pre-inoculation period.

The mushroom species we have chosen to cultivate all grow on hardwood trees, though there are also a few species that proliferate on softwoods. It is important to use the tree species available to you, as a by-product of managing your woodlot. If possible however, it is preferable to use trees with a thick outer bark and a higher ratio of sapwood to heartwood. Denser trees will take longer to decompose, thereby continuing to produce mushrooms for a longer period of time. Oak is often suggested for use in log cultivation. However, because it is a preferred species at D Acres we use primarily beech and red maple instead. Other possible species are poplar, cottonwood, ash, and basswood. Birch and alder can also be used, however the bark of these trees is easily damaged.

Species Selection and Site Location

Here at D Acres, we are experimenting with the natural culture approach to mushroom cultivation. We are attempting to create an environment where the selected species will naturally thrive, requiring a minimum of maintenance aside from occasional watering. When designing a mushroom habitat it is important to consider site location, topography, sun exposure, and the trees species available.

By locating your mushrooms in a watershed area, you can reduce the time needed to water, provided there is sufficient rainfall. A gentle slope enables the water runoff to provide moisture without overloading the area. An ideal situation includes bordering plants or shrubs. This creates a mutually beneficial relationship with the plants; plants providing the necessary shade and the mushrooms providing nutrients and increased moisture retention. North facing slopes that allow for sufficient shade and moisture are optimal choices. Protection from the wind is also an important consideration, as wind will contribute to loss of moisture. It is also favorable to attempt to recreate the habitat where the mushroom is generally found growing. These attempts to make the mushrooms “at home” in their selected environment will aid in producing the proper growth parameters. Also, certain mushroom species have relationships with certain tree species that we don’t fully understand; therefore one should attempt to accommodate this when determining the proper site. Finally, it is important to keep in mind how you can make the task of watering your logs as easy as possible. If you have a stream, pond, or other water source on your property you may want to situate your mushroom site close by. It is useful to have a large container or barrel filled with fresh water for deep soakings if a natural water source is not a possibility.

Identification and Contamination

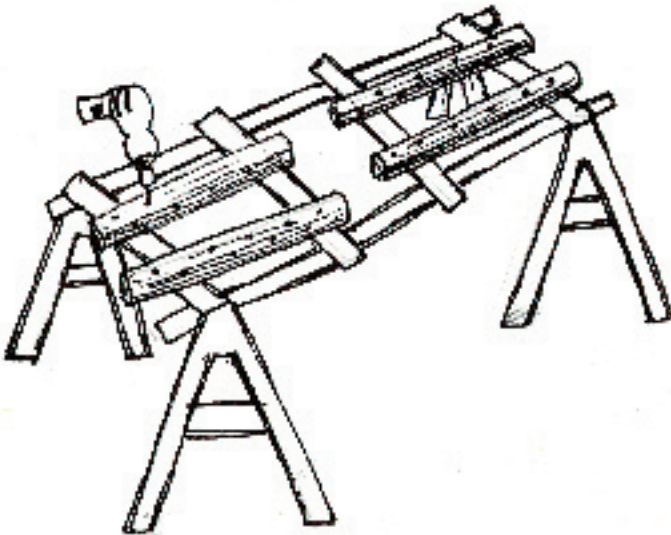
It is important to be able to identify the mushroom you are cultivating, as other mushroom species may contaminate your logs. The forest abounds with fungi and you may find many other mushrooms growing in the immediate vicinity that could either take over the logs or co-exist with the species you are cultivating. If possible, clear the area of debris harboring other species and try not to set up your operation where there is an obvious population of another mushroom. A mushroom identification guide is recommended to prevent the ingestion of toxic species, as well as to enlighten you about other edible fungi you may come across. (Extreme caution is recommended when collecting mushrooms in the wild. It is best to attend a mushroom walk conducted by a knowledgeable mycologist before eating something you think you have identified. There are many look-a-likes and a mistake can be fatal!)

Log Cultivation

Unless you are able to inoculate immediately after felling, it is important to soak the logs to ensure proper internal moisture content. Using clean, fresh water, submerge the logs for 24 hours a few days before you plan to inoculate, allowing for a day or two for the bark to dry.

There are two options when buying spawn (the material impregnated with the mycelium). Plug spawn is often easier for beginning mushroom cultivators because it only requires a mallet for inoculation. These hardwood plugs carry the mycelium in the outer grooves and can be easily tapped into a hole drilled to a depth of 1 inch with a 5/16-inch drill bit.

Sawdust spawn requires the use of an inoculation tool. This tool is used by jabbing the end into the sawdust spawn to pick up a slug of spawn. The tool is then placed over the hole, and lightly packs in the spawn. Sawdust spawn requires $\frac{3}{4}$ inch deep holes, drilled with a 7/16 inch bit. If you plan on inoculating over 125 logs, an inoculation tool is a more cost effective option than the plug spawn. Because inoculation tools can be pricey, we bought some copper pipe, a bolt to fit snugly inside the pipe, and a spring and made our own at a fraction of the cost.



Drilling the 40-inch logs in a pattern that begins 2 inches from the end of the log, with holes spaced 6 inches apart, ending 2 inches before the other end, works well. The next row is then started 2-3 inches from the initial row, depending on the diameter of the log, and drilled in a diamond pattern off-setting the holes. The drill bits should be sterilized with alcohol between logs to prevent spreading contamination that may have occurred in some of the logs. It is helpful to create a storyboard, or guide, to help you with this spacing during the drilling process.

After the holes are plugged, the logs are then sealed with cheese wax at each inoculation site for optimal moisture retention and to prevent contamination by insects and other fungi. The wax melts at 145 degrees Fahrenheit and should not be allowed to get too hot. Take note when

the wax has started to cool, as maintaining the proper temperature ensures the wax is sufficiently bonded to the log. Some growers do not suggest sealing the ends because it is more difficult for the log to absorb moisture in future soakings and does not allow for excess water to drain off properly. However, sealed ends may retain enough moisture to allow you to dead stack the logs in ricks for 3 months before the first necessary soaking. Feel free to experiment with sealing or not sealing the ends to see which method you prefer.

A production line set up using saw horses and connecting planks is great when you have a team together for log cultivation. This work station will enable you to station the drillers at one end, who can then pass the

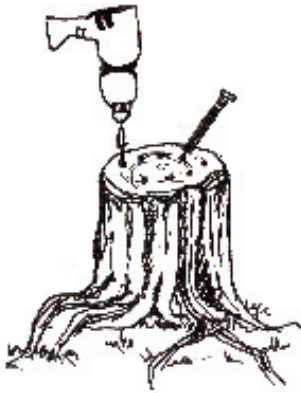
logs onto people equipped with the spawn and inoculation tools. The inoculated logs can then reach the end of the assembly line for site waxing. It is also helpful if you do have a large work posse to have people passing the logs to the drillers, as well as others who can tag and stack the finished logs.

Experimentation and Documentation

Expert mycologists suggest experimenting with various methods to discover what works for you, in your climate, using available materials. There are a variety of methods of inoculation and stacking, as well as small differences in the way people go about specific parts of the process. In order to find out what works best with as little input as far as labor and materials, experiment with different methods.

Tagging your logs with the appropriate tree species, strain, and date is also an important part of the process. You may find a particular tree species more favorable to log cultivation. Site variety may also teach you that your logs produce better in one location over another. I suggest keeping extensive records of when you cut your trees and logs, as well as any details about inoculation and watering cycles. Any observations are important to document, as they will only benefit your future cultivation strategies.

Stump Cultivation and Other Inoculation Techniques



Stumps are an excellent growing medium because their roots are still intact and able to take care of their own moisture needs. It is important that stumps are located in a shady environment, such as a ravine or small valley. The presence of mosses, lichen, and ferns are a good indicator that the site will be beneficial to mushroom growth. However, avoiding sites already occupied by other fungi is important to reduce contamination and maximize moisture content. It is best to inoculate stumps in late winter or early spring before the wild mushrooms start popping up. Some have found an increased success rate by girdling the stump with a chainsaw. This shallow cut around the base of the stump may aid in reducing contamination by wild species.

There are several techniques of stump cultivation. The tops of stumps can be drilled and plugged in the same manner described for log cultivation, being sure to seal the inoculation sites with cheese wax. Another method involves cutting wedges out of the sides of the stump, applying the sawdust spawn to the now exposed surface, then fastening the wedge back onto the inoculated site with a few nails. I would also recommend sealing the cracks with wax.



Alternatively, it is also possible to cut the stump into sections and apply a ring of spawn around the edges, and then fasten the sections back on top of the stump in layers. This is very similar to a method used for indoor cultivation in which 6-inch diameter discs are inoculated and sandwiched together with tack nails. The discs are then stored in a large plastic bag to retain moisture and humidity.

These methods can all be applied to log cultivation as well. The ends of logs can be inoculated with sawdust spawn and covered with aluminum foil or a sock, or a cross-section can be inoculated and nailed back together.

It is also possible to buy biodegradable chainsaw oil, infused with spores, in order to inoculate stumps as you cut. The result is more mushrooms with less effort and the rate of decomposition is greatly increased. You simply dilute the spore oil with other biodegradable lubricants before use.

Maintenance

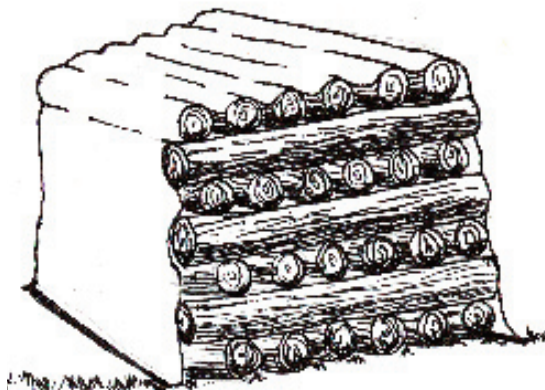
Some cultivators prefer to do deep, rather than frequent soakings, meaning they allow the logs to soak for 24 hours once every week or two, or when necessary. Others recommend watering with a sprinkler twice a day. We feel that the deep soakings are more effective and a better use of water. Most growers suggest 45-60% internal log moisture content, allowing the bark to dry between soaking. Oftentimes a spring or fall rain will stimulate the fruit body (the scientific term for mushroom) to develop. Some research suggests allowing this development to occur naturally for the first fruiting. Commercial operations often employ a method referred to as forced fruiting that simulates fall and spring conditions. Forced fruiting speeds up the process and cycles logs through a watering schedule to produce mushrooms all year round. Forced fruiting will encourage faster fruit body development and decomposition of the substrate material (or growing medium). Therefore, the logs will produce more over a shorter span of time. The natural culture philosophy favors allowing nature to run its course. The advantage to growing outdoors is that the logs will benefit from natural weather conditions. While the logs may take longer initially to produce, they will continue their production for many years. We are taking all methods into consideration and attempting to manage our cultivation operation with a minimum of maintenance.

We have set up a watering schedule for the various sites in order to experiment with the amount of input necessary for successful cultivation in terms of labor and time geared toward watering. Different sets of logs will receive a deep soaking treatment ranging in frequency from one week to one month. Others that are sealed on the ends with wax and crib stacked will not be soaked again for a few months after inoculation. It is important to consider rainfall and other location specific needs that may arise and adjust accordingly. Also, in early spring, before the deciduous hardwoods start to leaf out, some locations may receive more sun than when the canopy develops into the spring and summer. Be flexible. Ultimately, we are looking to discover how much input is necessary for success in order to assess the possibilities of expanding our cultivation operation.

If you are concerned about the internal log moisture content, there are expensive probes that you can purchase or you can do a simple test, in which you take a sample from one of the smaller diameter logs. Saw off a one-inch thick disc (the ends will be drier than the rest of the log, so you want to get an internal sample) and record the weight. After it has dried out, weigh it again. The percentage of moisture in the log will be the difference between these weights divided by the wet weight. (Hint: A microwave will speed up this drying process.)

Shiitake Mushrooms (*Lentinula edodes*)

Evergreens provide the ideal shade for shiitake log cultivation. Shiitakes grow naturally on Asian oaks and beeches. For cultivation purposes they will also grow on other hard woods including oak, sweetgum, poplar, cottonwood, eucalyptus, alder, ironwood, beech, birch, willow, and many other non-aromatic broadleaf trees. At D Acres, we are primarily using red maple and beech. Poplar, ash, and rock maples may also be good choices. Keep in mind that denser trees will often produce for up to six, even ten years, while trees that decompose more rapidly will last for about three years.



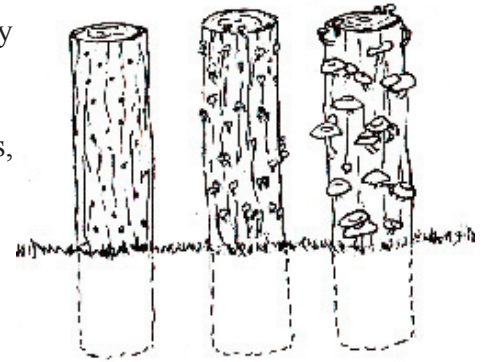
Shiitakes should be harvested when the margins of the caps are still 80% inrolled for optimum quality, though this practice will reduce the subsequent yield. Shiitake gills bruise easily. Outdoor-grown shiitakes often have brown spots due to insects; therefore it is important to watch for bacteria in damaged areas. Remember to cut mushrooms flush with the log to keep bacterial growth from occurring on remaining stems.

Paul Stamets, the mushroom guru of the Northwest, suggests

waxing the inoculation sites and the ends of the shiitake logs, or billets, and crib-stacking them in ricks. The logs are then covered with a tarp. It is important that the bark is dry before crib stacking and that the logs do not get exposed to the rain during this period as mold may be encouraged to form. After 6-12 months (though other growers say to wait only three months), the logs are soaked and lined up, lean-to fashion. Logs that are not producing shiitakes within a year are removed. The Mushroom People at The Farm in Tennessee suggest initially stacking lean-to style and watering everyday during dry spells. They suggest crib stacking during the resting stage of the logs if you are attempting to force fruit for daily harvests. When considering this information, it is important to think about the climatic differences when determining the course of action that is appropriate in the Northeast. Chances are internal log moisture in New England falls somewhere in between the content of logs in Washington and that in Tennessee. It may be a safer bet to soak within three months or less in order to be sure the mycelium does not dry out and die. Another option is to deep soak every one to two weeks.

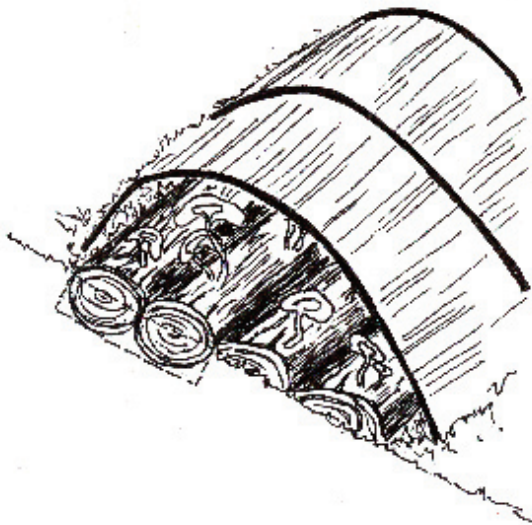
The Tree Oyster Mushroom (*Pleurotus ostreatus*)

Oyster mushrooms are the easiest and least expensive to grow. They are thought to have the potential to revitalize the economies of rural areas and developing countries. The Tree Oyster generally pops up in lowland, hardwood forests in the spring and fall mainly on cottonwoods, oaks, alders, maples, aspens, ash, beech, birch, elm, willows, and poplars. They enjoy broadleaf shade with spots of light. These mushrooms should be harvested young, in clusters, when the surface of the mushroom is slightly dry. Tree Oysters are quick to spoil and produce abundant spores after this optimal time, to which many report an allergic reaction. For cultivation some growers suggest burying a quarter of the log standing vertically in sandy soil to aid in retaining moisture. *Pleurotus ostreatus* will continue to grow through the winter.



Reishi Mushrooms (*Ganoderma lucidum*)

Ganoderma lucidum grow on oaks and other hardwoods, however, there are two other very similar species in this family, the *Ganoderma tsugae*, that one may find growing on hemlocks, or the *Ganoderma oregonense*, which is found on a variety of conifers. In the Northeast, *Ganoderma lucidum* is most common to maple groves, though it is less frequently found in temperate climates. The reishi is purportedly a little more difficult to grow than the oyster or shiitake mushrooms. In China and Japan, reishi logs are shallowly buried, horizontally in a shady, naturally moist location. In this case, only the tops of the logs are drilled and inoculated. By covering a patch with hoop-frames, plastic, and a shade cloth, you can ensure proper shade and less evaporation. These logs will take 6 months to 2 years to produce the first flush of mushrooms, however, they will continue to produce for 4 to 5 years. It is also possible to inoculate smaller logs and place them in nursery pots, which are filled with pasteurized sawdust and topped with soil. Large cultivators fill greenhouses with these pots, though I think they would also make nice houseplants. The logs should be watered fairly frequently to keep them sufficiently moist.



References and Supplies

Mushroom Cultivation and Supplies:

Paul Stamets' *Growing Gourmet and Medicinal Mushrooms* is an excellent resource. He also offers growing kits, spawn, equipment, and other mushroom products through Fungi Perfecti.

The Mushroom People in Tennessee have a catalog with a variety of spawn offered at reasonable prices. They have a phone line open to questions and a staff with many helpful suggestions.

Mary Ellen Kozak & Joe Krawczyk. *Growing Shiitake Mushrooms in a Continental Climate*

J.S. Chilton and Paul Stamets. *The Mushroom Cultivator*

Perter Oei. *Mushroom Cultivation*

Bob Harris. *Growing Wild Mushrooms*

Field Guides:

David Arora. *Mushrooms Demystified*

David Arora. *All That the Rain Promises and More...*

Gary Lincoff. *The Audobon Field Guide to North American Mushrooms*

George Barron. *Mushrooms of Northeast North America: Midwest to New England*

Alan E. Bessette, Arleen R. Bessette, and David W. Fisher. *Mushrooms of Northeastern North America*

Medicinal Mushrooms:

Christopher Hobbs. *Medicinal Mushrooms*

Kenneth Jones. *Shiitake, the Healing Mushroom*

Terry Willard, M.D. *Reishi Mushroom*

Ken Jones. *Reishi: Ancient Herb*