CALIFORNIA FOREST STEWARDSHIP PROGRAM

Forestland Steward

FALL 2013

Fungi in the Forest

Inside

Forestland Steward

Forestland Steward is a joint project of the CA Dept of Forestry and Fire Protection (CAL FIRE), Placer County Resource Conservation District, UC Cooperative Extension, and USDA Forest Service to provide information on the stewardship of private forestlands in California.

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Fantastical fungi

In this issue we go underground to look at hidden places in the forest…you will be amazed at what we find.

Fungi, the subject of our explorations, have an impact on every aspect of the forest ecosystem. They are the decomposers, nutrient recyclers, pathogens, soil creators, carbon sinks, a critical part of the food web, and drivers of community structure and population dynamics. **The bottom line is: we wouldn't have forests without fungi.**

There are three main functional groups of fungi: saprotrophic (decomposers), pathogenic (parasitic), and mutualistic (mycorrhiza). All three of these play major roles in a healthy forest.

Considering their importance, we know relatively little about this group of organisms. There are estimated to be more than a million species of fungi, of which only about 5–10% have been formally described.

Fantastical!

What we do know about fungi, however, verges on the fantastical. These tiny organisms can grow to many acres in size and thousands of tons in weight (see *page 12*). Several miles of filaments (hyphae) can be present in less than a thimbleful of soil associated with vigorously growing plants.

Some types of fungi (mycorrhiza) form partnerships with plants and exchange water and nutrients for carbon. A single plant may be associated with dozens of species of fungi. Some mycorrhiza can connect many individual plants/trees, moving life-giving water and nutrients around the forest (*see page 4*).

The bottom line is: we wouldn't have forests without fungi.

The world of fungi is incredibly diverse with species in every conceivable environment. They can grow on and in rotting logs, living trees, soil, and other substrates. Ninety percent of the forest soil biomass (weight of the living things), not including roots, is fungi.

Most of us know forest fungi only from their fruiting bodies—mushrooms and truffles—whose sole purpose is reproduction (*page 9*). Mushrooms come in all colors, shapes, and sizes. They are not only important to many wildlife species for food, they can also provide economic benefits as a non-timber forest product.

The forest management implications from our understanding of fungi are an emerging area of study (*see page 8*). Protecting fungal biodiversity may be most essential when forests are stressed.

Looking down

Forest management today is increasingly complex; it has to take into account the forest as well as the trees. The forest community is made up of many interrelated parts. The rhizosphere, where the roots are located, is critical to the well-being of the whole forest.

With this issue, expect to experience a shift in the way you view your forest. You'll find yourself looking down instead of up, knowing that the belowground portion of the forest is every bit as fascinating as the aboveground portion, and just as important.

Scot Loring, Creative Commons

Dr. Robert Thomas & Dorothy B. Orr © CA Acad. of Sci.

Fantastical fungi. (left) Calvatia sculpta, the sculpted puffball, and (right) Agaricus augustus, the prince.

Very short overview of forest fungi

Photo courtesy Beatriz Moisset

What are fungi?

Fungi are neither plant nor animal (although from genetic studies they appear to be more closely related to animals!). They are classified in their own Kingdom: Fungi.

Unlike plants, fungi cannot manufacture their own food. They have no chlorophyll to photosynthesize so have to get energy from other organisms. They do this in various ways.

Some fungi are saprotrophs that live on dead or decaying matter; their role is to decompose and recycle nutrients. Some are parasites (pathogens) that live off living plants. Another important group are mutualistis, mycorrhizal fungi that form mutually beneficial connections with plants and get their energy in the form of sugars (photosynthates) from their plant hosts. A few fungi species are even carnivorous; these digest nematodes and other small creatures in the soil.

Physiology

Fungal cells are microscopic and grow by attaching in strings (hyphae), with pores that allow material to pass down the line. Hyphae join in bundles called mycellia, which grow a few inches to several feet underground. A thousand strands of hyphae may be no thicker than a human hair.

Hyphae secrete digestive enzymes that dissolve food into a liquid form that can be absorbed through the cell walls. These enzymes break down leaves, wood, and other material for food, recycling the nutrients contained in organic matter.

Most of a fungus occurs as spreading hyphae in the soil or in trees/plants. Mushrooms are the fruiting bodies of this large fungal mass, just a very small part of the whole organism.

Ecosystem services

Fungi provide priceless ecosystem services. These include:

Decomposition. Saprotrophic fungi are experts at breaking down wood, leaves, and other organic materials. Using enzymes, fungi digest these usually inedible materials into more usable forms that plants can use. Some species specialize, for example, brown rot breaks down cellulose while white rot chooses lignin (material that makes the cell walls of plants rigid and woody).

Nutrient Recycling. Trees take up nutrients and store them in their leaves, branches, and trunks. Fungi help convert these materials back into forms that can be reused by other organisms.

Soil Creation. Fungi are responsible for building soil and maintaining soil structure. They help aggregate soil particles, create pores that aerate the soil, and break down the underlying rock.

Nutrient Retention. As nutrients are bound up in the fungal hyphae, they are protected from loss by leaching. Carbon is also retained this way.

Carbon Sinks. Forests are very important for storing (sequestering) carbon. Forests, which comprise about 30% of terrestial ecosystems, store 73% of soil carbon. Mycorrhiza are critical to that storage. Mycorrhiza move carbon from plants into the soil and help keep it there. Carbon sequestered in terrestrial ecosystems is currently declining, and what is now a global carbon sink is in danger of becoming a carbon source. New economic incentives are being put in place to manage for forest carbon storage. Forest fungi management may be one aspect of carbon retention.

Food Web. Fungi are an indispensible food for many forest creatures, including snails, small mammals, and people. Even the very tiny creatures in the soil—microarthropods and others—graze on fungi as their primary food.

Mycorrhiza. The more we learn about mycorrhiza the more fascinating they become (*see page 4*).

Short Glossary

As with any new topic, you need to get up to speed with a sometimes daunting new vocabulary. Here are a few fungi-related words you might encounter.

fruiting body—spore-producing organ of a fungus, often a mushroom or toadstool.

hypha(e)—threadlike filaments that form the mycelium of a fungus.

mycelium—filamentous portion of a fungus, specifically excluding the fruiting body. The mycelium may be invisible or conspicuous.

mycorrhiza—symbiotic relationship between a fungus and the roots of a plant.

mycologist—person who studies fungi.

mycology—the study of fungi.

mycophagous—fungi-eating organism.

rhizosphere—area in the soil immediately surrounding and influenced by roots.

saprophyte—organism that lives on dead or decaying material; a decomposer.

spore—reproductive cell in fungi.

sporocarp—fungal reproductive structure, e.g., a mushroom that produces spores.

symbiosis—relationship between two different kinds of organisms that live together and depend on each other.

The wonderful world of mycorrhiza

NOTE:
The mycorrhiza is not the fungus, it is the symbiotic partnership between the mycorrhizal host plant and the mycorrhizal fungus.

-a, -ae, or -as?

A.B. Frank coined the word mycorrhiza in 1885 by combining the Greek words for fungus and root. Traditionally, "mycorrhiza" has been used for the singular form and "mycorrhizae" for the plural. However, the -ae plural is Latin, not Greek, and so, according to purists, its use is incorrect. As a result, there is a movement away from use of the -ae form toward use of "mycorrhiza" for both singular and plural (or "mycorrhizas" for the plural form). We chose the latter convention here.

—http://www.mykoweb.com/articles/Mycorrhizas_1.html

In forests, mycorrhiza (fungus + root) is king. Fungi join with plant hosts in a mutualistic relationship that benefits both organisms. In most cases this relationship is obligatory; neither partner could survive without the other.

Mycorrhiza live in the rhizosphere, the vicinity immediately surrounding plant roots. This is an area of intense biological activity.

Trees put a huge amount of energy into the rhizosphere. As much as 80% of their photosynthate (carbohydrates made through photosynthesis) goes underground to the roots and mycorrhiza.

Mycorrhiza have been around for about 500 million years, where they may have originated with the first land plants. This partnership has been extremely successful…more than 90% of all plant species form mycorrhizal relationships.

Endomycorrhiza vs. Ectomycorrhiza

There are two major types of mycorrhiza associated with California forests:

1. Endomycorrhiza, also known as Vesicular-Arbuscular (or VA) mycorrhiza, have specialized structures that penetrate inside the plant root and are invisible without a microscope. This type of mycorrhiza is common worldwide. It is found in 85–90% of all plant species, including grasses, herbaceous plants, and even redwoods and giant sequoias. There are relatively few species of this type of mycorrhiza. Only about 170 species of fungus are associated with plants from almost all plant families so they are considered generalists.
2. Ectomycorrhiza, by contrast, form a sheath around the root and live outside the plant root. They are large enough to be seen with the naked eye. While less common globally, ectomycorrhiza associate with important forest species, including the pine family (pines, firs, spruce, etc.). Ectomycorrhiza are selective in their host plants and, therefore, are considered specialists.

Benefits of mycorrhiza

Plants are producers; they can make their own food by generating energy from the sun through photosynthesis. This energy is stored in the tree or plant in the form of carbohydrates. Below the ground, however, plants are more limited. Their roots are large, slow growing, and can only absorb water and nutrients from the larger soil pores.

Photos courtesy Brendan Twieg

Two ectomycorrhiza of host plant Douglas-fir, with fungus Russula sp. (above) and Tuber sp. (below).

Fungi, on the other hand, are highly adapted for life in the soil. Their microscopic hyphae grow rapidly and can go into the very small places even fine roots can't reach. Plus, they have enzymes and acids that can break down rock and organic matter to release nutrients. With much higher surface area for absorption than plant roots, fungi are better at getting water and nutrients by a hundred fold or more.

However, fungi can't make their own food. Therefore a partnership is the perfect solution. It's win-win for both the plant and the fungus.

More benefits

In addition, mycorrhiza can protect plants from pathogens. They actually form a barrier around the root tip that excludes fungi, bacteria, and other microorganisms. Some fungi can produce plant hormones that enhance development of the host plant's fine roots, which increases the surface area and contact area between plant and fungus.

Mycorrhizal networks

Mycorrhiza form an amazing underground network that can connect plants of the same or different species. This network can grow and strengthen over time to include many of the trees and plants in the forest. New seedlings are inoculated with fungi, which allows them to tap into the network.

The mycorrhizal network can affect the dynamics of the entire forest. It moves carbon, nutrients, and water around the forest from donor to recipient depending on where it is needed. It can aid in seedling regeneration and help partially shaded trees survive by sending them water and nutrients from established trees. By balancing out resources, mycorrhiza stabilize the forest community and aid in recovery after disturbance.

Mycorrhiza are key actors in the organization and stability of forest ecosystems. They may be especially important after disturbance or when a forest is under stress. Current research is looking at how mycorrhiza contribute to forest resilience, and whether they may be beneficial in helping to adapt to a changing climate (*see page 8*).

Terry L Spivey, Terry Spivey Photography, Bugwood.org

Plants without chlorophyll, like snowplants and pine drops, cannot photosynthesize. Their food is delivered via ectomycorrhiza from tree photosynthate.

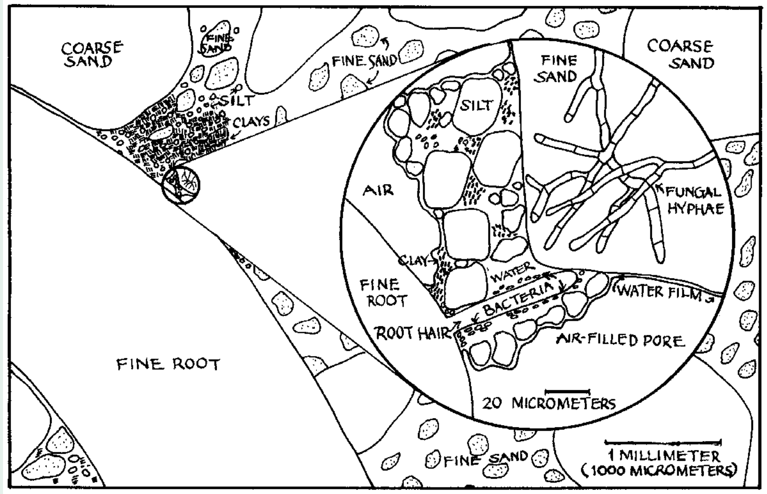

Illustration courtesy Steve Trudell

This tiny bit of soil is shown at two enlargements. The background is enlarged approximately 30 times, and the isolated portion approximately 500 times. Note the tremendous range of sizes and how the sizes of pores and the "necks" that connect them constrain the movement of water, air, and organisms. http://www.mykoweb.com/articles/Mycorrhizas_3.html

Soil is the basis of the forest. It provides the substrate and nutrients for plants to grow. Soils are complex. They contain minerals from the breakdown of the underlying rocks and varying amounts of organic matter. The spaces between the mineral and organic particles—the pores—are where water, air, and organisms reside.

Soil water from rain or snow runoff contains gases, nutrients, and other dissolved substances. This solution remains in micropores that are hard for plant roots to access. Fungal hyphae are able to go into these micropores to retrieve the nutrients and water.

Mycorrhiza build up soil structure in numerous ways. Fungal hyphae may make up to 25% of soil matter. The hyphae wrap around individual particles of soil and also secrete a glue-like material that binds soil into small aggregates. This increases the porosity and water-holding capacity of the soil, as well as helping to control erosion.

Biodiversity of form and function

The mycorrhizal community is highly diverse. For example, 2000 species of fungus are associated with Douglas-fir trees alone (*see photos page 4*). Each different combination of fungus and plant (mycorrhiza species) has a distinctive form.

It is thought that different species serve different functions in the forest community. Species dominance is known to vary through the seasons and throughout forest stages. We know little about their functional niches but, despite our limited knowledge, retaining mycorrhiza biodiversity is considered critical for forest health.

—for a superb introduction to mycorrhiza see the 5-part series by Steve Trudell beginning at http://www.mykoweb.com/articles/Mycorrhizas_1.html

Forest Hubs?

Hub trees are trees highly networked by mycorrhiza, usually the large older trees. These trees support young trees by infecting them with fungi and sending them nutrients. Studies have shown that removing hub trees can have profound negative effects throughout the forest community.

The dark side of fungi in the forest

What is a pest?

Pest is a subjective term; not all pathogens are pests. An insect or disease becomes a pest only when it causes, or contributes to, unacceptable negative impacts on defined management goals and objectives.

"The organisms involved in disease…must be understood as interacting components of the forest ecosystem.…Understanding why trees die is often not as easy as establishing a simple cause-effect relationship."

—California Oak Mortality Task Force
http://www.suddenoakdeath.org/about-sudden-oak-death/ecology-of-tree-diseases/

Some fungi can be serious forest pests. They cause numerous diseases—rusts, blights, cankers, root diseases, rots, and others—that can weaken trees or kill them outright. Weakened trees may be more susceptible to other mortality factors, such as drought, insect attack, windthrow, etc.

From a timber perspective, these diseases can be disasterous. Even trees that aren't killed can be damaged and devalued in the market, such as occurs with blue stain (*see page 7*).

Benefits of fungal pathogens

From an ecological point of view, however, this mortality can be beneficial. Fungi remove weak and diseased trees, which helps to keep the forest healthy. Gaps formed by dead trees open up the forest to allow shade-intolerant species to establish, and provide places for increased plant diversity, forage growth, and other ecological benefits that increase overall biodiversity in the forest. Living trees with heartrot can provide cavities for nesting birds and other animals that use tree cavities. Dead snags provide perches and shelter for many wildlife species.

Fungal pathogens can influence forest biodiversity and even alter the trajectory of succession by selectively killing or slowing the growth of one species, allowing another to be more competitive. They also may impact trees of a certain stage or vigor. In this way pathogens increase forest structure and heterogeneity.

A balanced system

Over millions of years pathogens and their hosts have coevolved to a state of balance where both can survive. This breaks down, however, when pests are introduced from another area. Introduced species did not evolve with the native forest community and, therefore, native plants may have little or no resistence to the pathogen.

Many of the worst fungal pests in the forest are exotic species. These include the white pine blister rust, Dutch elm disease, chestnut blight, and many others. The pathogen that causes Sudden Oak Death is an introduced species.

California Oak Mortality Task Force
Everything you want to know about Sudden Oak Death (SOD) *http://www.suddenoakdeath.org/*

SOD Guidelines for Forestry
Practical information on how to work in forests without unintentionally moving the pathogen from one area to another. *http://www.suddenoakdeath.org/wp-content/uploads/2010/08/ForestryGuidelines1.pdf*

Sudden Oak Death

Sudden Oak Death is caused by *Phytophthora ramorum*, a fungus-like pathogen known as a water mold. This disease has killed millions of tanoak and oak trees in California since it was discoverred in the mid-1990s. Many other plant species, including California bay laurel, Douglas-fir, and coast redwood, exhibit the disease by damage to twigs and leaves.

Phytophthora ramorum is a nonnative pathogen that did not originate in California, therefore, the forests here do not necessarily have natural resistance. Sudden Oak Death has been found in 14 counties in California and 1 in southern Oregon.

The ecological effects of the disease are widespread. Infected forests may experience changes in species composition and ecosystem function, increased risk of wildfire and loss of wildlife food sources.

Sandra Jensen, Cornell University, Bugwood.org

Phytophthora ramorum mycelium and fruiting bodies.

There is no cure for Sudden Oak Death, although some preventative measures can be taken (*http://anrcatalog.ucdavis.edu/pdf/8426.pdf*).

—http://www.suddenoakdeath.org/

Don Owen, CAL FIRE

Diplodia blight on Ponderosa pine.

Due to the global movement of people and timber/agricultural products, new exotic species are continually being introduced into our forests. The delicate balance between pathogen and host can also break down when the forest ecosystem changes from its natural condition. This can occur due to fire exclusion, inappropriate harvesting, planting of off-site stock, climate change, and excessive soil compaction.

Quite often diseases on forest trees are the result of a complex of factors rather than just one. One organism may weaken a tree, making it more susceptible to another type of pest.

Root diseases

Root diseases kill their host by destroying the root wood, plugging water-conducting tissues, killing the cambium, or a combination of these. Generally death occurs from a secondary cause: decayed roots allow windthrow or bark beetles attack the weakened trees.

In some cases, the inoculum can stay in the wood or soil for years or decades. Any susceptible trees that recolonize the site will be reinfected and perpetuate the disease.

Don Owen, CAL FIRE

Annosum root disease center in a stand of white fir.

Another partnership: fungi and bark beetles

Sandy Kegley, USDA Forest Service, Bugwood.org

Blue stain on Ponderosa pine caused by fungi.

Fungi are good at forming relationships. Mycorrhiza, for example, are a partnership between a plant and a fungus, lichens consist of an alga and a fungus, some ants farm fungi, and some fungi even appear to farm bacteria. So it should come as no surprise that fungi have learned to hitch rides on some species of bark beetles.

Bark beetles carry a variety of fungal species in specialized structures on their heads or adhered to their exoskeletons. The benefit of this relationship to the beetle is not understood but likely relates to nutrition.

The benefit to the fungus is clear. This clever dispersal mechanism carries the fungus to new host trees where it can become established. The impact of a fungal invasion into a bark beetle-infested tree is thought to contribute to tree death by preventing defense reactions, clogging the phloem and xylem, and aiding in beetle brood development. The degree to which the fungus impacts the tree depends on the species.

Many of the fungi associated with bark beetles are in the genus *Ophiostoma*, the blue staining fungi. These species cause a blue stain to appear in the sapwood. A cross section of the tree (*see photo above*) will reveal the presence of the fungi as a blue wedge-shaped stain running from the outer edge of the section towards the center.

The presence of the fungi does not alter the structural integrity of the wood but many mills downgrade the wood due to its appearance. However, some retailers have taken advantage of its unique aesthetic qualities and sell blue stained lumber at higher prices.

—adapted from http://www.sbcounty.gov/museum/barkbeetle/secondaryimpacts.htm

Forest management resources

Special Forest Products: Integrating Social, Economic, and Biological Considerations into Ecosystem Management *http://www.fs.fed.us/pnw/pubs/journals/pnw_1997_molina001.pdf*

The Role of Mycorrhizas in Forest Soil Stability with Climate Change. *http://www.intechopen.com/articles/show/title/the-role-of-mycorrhizas-in-forest-soil-stability-with-climate-change*

The Role of Mycorrhizal Symbioses in the Health of Giant Redwoods and Other Forest Ecosystems *http://www.fs.fed.us/psw/publications/documents/psw_gtr151/psw_gtr151_12_molina.pdf*

Forest management: Healthy forests include a healthy soil community

Over the last few decades, the focus of forest management has shifted from timber management (trees) to ecosystem management (entire forest community).

With our newfound appreciation of the vital role fungi play in the forest, can we take the next step and use this information to help design forest management practices?

First, it's important to realize that this area of research is relatively new and definitive forest management recommendations not yet available. However, despite that uncertainty, there are some fundamental facts that may help guide management decisions.

1. **Healthy soil is vital for healthy forests**. Forests are amazingly complex ecosystems and it all starts with the soil. Therefore, it is imperative to protect forest soil from unnecessary disturbance. Compaction can destroy the critically important soil pores that hold water and nutrients. Breaking up the top layer of soil can disrupt mycorrhizal networks, which are often found within the first 4" of soil. Therefore, protection of forest soil is paramount.

2. **A great diversity of fungal species live in the forest.** We don't know exactly what they do, but that doesn't mean these species don't have important roles in the forest ecosytem. Conserving the habitat for fungi includes retaining the essential components—appropriate host trees and plants, coarse woody debris like fallen logs, and healthy soil—that support fungi biodiversity.

3. **Hub trees (those trees most connected to the mycorrhizal network) play a central role in mycorrhizal communication.** Removal of these large old trees may cause repercussions throughout the forest community, endangering younger and weaker trees and impacting future regeneration.

Preparing for future forests

Since mycorrhiza help provide stability and resilience to forests, current research is looking at how this can can help prepare the way for future forests.

Trees are adapted to the sites where their seed originated. This is the reasoning behind seed zones. But when the environment changes, trees may no longer be adapted to their native sites.

The world is in a warming trend and studies suggest that there will be large climatic shifts in the next several decades, with increases in temperature from 2° to 7° C. This will stress and change forests where trees are adapted to the current temperature and moisture regimes.

A major role of mycorrhiza is to stabilize forests under environmental stress. These organisms may play a pivotal role in the success of forests to adapt to the new environments.

The following are a few forest management ideas for helping to mitigate climate change. Some are untested and may be controversial, but this can be useful for starting the discussion.

1. Conserve native forests and their associated soil fauna.
2. Use silvicultural practices that emulate natural processes.
3. Avoid management practices that lead to net losses of soil organic matter, e.g., deforestation, conversion to plantations.
5. Establish new forests before the old forest is dead so seedlings may capture nutrients from the mycorrhizal network.
6. Protect dying forests to allow remaining trees to transfer nutrients to new seedlings.
7. Use locally adapted mycorrhiza if attempting assisted tree migration.

Mushroom hunting for fun and profit

Forests provide a wealth of useful resources, some of which are commercially valuable. In economic terms mushrooms fall in the category of "nontimber forest products."

Mushrooms and truffles are the fruiting bodies of fungi. They form from the mycelium and produce spores that are released to the wind or dispersed by animals. The job of a mushroom is to reproduce.

However, wildlife and people have other ideas. Some types of wild mushrooms are highly sought after by chefs and hobbyists alike. Mushrooms have become a multimillion dollar industry.

Of course, people aren't the only mushroom hunters. There are many species of mycophagous (fungus-eating) wildlife. Some depend on mushrooms or truffles as their main source of food. For example, northern flying squirrels live on truffles, which are available year round. There is a mutual benefit to the fungus, spores pass through the animals and are dispersed in the habitat. The squirrels are eaten in turn by northern spotted owls.

Mushrooms are an unpredictable crop, appearing when conditions—especially temperature, moisture, and energy—are just right. Each species has its own requirements. Some are very restrictive while others form fruiting bodies under a broader set of conditions.

There is tremendous annual variation in production. A fungus may fruit every year or not fruit for several years. At this time we don't understand what the necessary conditions are for most species.

Studies have not found any long-term impacts to fungi health from harvesting. However, it is not yet clear whether there is an overharvesting threshhold that would cause concern.

We do know that habitat disturbance can inhibit future mushroom harvests. Edible mushrooms have been impacted by pollution, introduced pathogens, intensive timber management, soil compaction, and climate change.

Wikimedia Commons

Gerald Holmes, Bugwood.org

One mistake can be fatal!

Don't rely on descriptions or photos for mushroom identification.

When in doubt, throw it out!!

Good harvesting practices are essential. Raking into the mycelial layer can interfere with fruiting for several years, although replacement of the duff layer appears to improve recovery, especially with matzutake.

Some public lands do not allow mushroom picking; to do so can incur a large fine. Other areas, like State Parks and Forest Service lands, distinguish between recreational and commercial mushroom gathering and require a permit or carry a per-day limit on what can be picked. Check the regulations before going out to hunt mushrooms on these lands.

Harvesting wild mushrooms takes willingness to go out in cold and rainy conditions. It takes time to learn to identify edible mushrooms and their locations (and recognize the poisonous ones to avoid). Good mushroom hunters intuitively know where to expect various species. Finally, commercial harvest requires a market. Many mushroom hunters sell to dealers who have established markets.

Income Opportunities in Special Forest Products: Self-Help Suggestions for Rural Entrepreneurs. http://www.fpl.fs.fed.us/documnts/usda/agib666/aib666.pdf

Join Others

Bay Area Mycological Society
510.430.9353
http://www.bayareamushrooms.org/

Fungus Federation of Santa Cruz
http://www.fungusfed.org/

Humboldt Bay Mycological Society
http://tech.groups.yahoo.com/group/H-B-M-S/

Los Angeles Mycological Society
http://lamushrooms.org/index.html

Mycological Society of San Francisco
http://www.mssf.org/

Peninsula Mycological Circle
650-591-6616
http://penshrooms.org/

Sacramento Area Mushroomers
http://sacmush.com/

San Diego Mycological Society
760-753-0273
http://www.sdmyco.org/

Sonoma County Mycological Assoc.
http://www.somamushrooms.org/
north american mycological association

North American Mycological Association (NAMA)
PO Box 64
Christiansburg, VA 24068
(540) 230-7603
http://www.namyco.org/

Resources

More about forest fungi

Armillaria root rot fungus at the base of oak trees.

Robert L. Anderson, Forest Service, Bugwood.org

California Forest Pest Council (CFPC) educates the public and Board of Forestry about forest pests and forest health.
http://caforestpestcouncil.org

The CFPC also has a program called "**Ask a Tree Health Specialist**," which lets you upload a photo so an expert can identify the problem.
http://caforestpestcouncil.org/ask-a-tree-health-pest-specialist/

Each year the CFPC produces a report on the forest health and pest issues impacting California's forests, woodlands, and urban trees. The most recent is **California Forest Pest Conditions 2012.**
http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5435780.pdf

MykoWeb: Mushrooms, Fungi, Mycology is a comprehensive website devoted to the study of fungi and the pursuit of mushrooms. The website includes **The Fungi of California**, with photos and descriptions of 600 species found in California, plus articles, research, even recipes.
http://www.mykoweb.com/

California Forest Insect and Disease Training Manual provides information on the best Integrated Pest Management (IPM) solutions for all major forest pests in the state, including fungal diseases. IPM requires extensive knowledge of a pest's biology and ecology so there is good background material included in the manual.
http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev3_046410.pdf

California Oak Mortality Task Force website can tell you all about Sudden Oak Death, its history in California, Best Practices for homeowners and forest landowners, symptoms, treatments, research, and much more.
http://www.suddenoakdeath.org/

Technical Assistance

Many agencies are available to provide technical assistance, referrals, information, education, land management plan assistance, and advice.

California Stewardship Helpline
1-800-738-TREE; ncsaf@mcn.org

California Dept of Forestry & Fire Protection
Forest Landowner Assistance Programs
Jeff Calvert; jeff.calvert@fire.ca.gov

Forestry Assistance Specialists
Guy Anderson (Mariposa/Madera/Merced) 209-966-3622 x218
Jill Butler (Santa Rosa) 707-576-2935
Damon Denman (Siskiyou) 530-842-3516
Adam Frese (Tuolumne/E. Stanislaus) 209-532-7429 x109
Ivan Houser (Lassen) 530-257-4171
Mary Huggins (S. Lake Tahoe) 530-541-1989
Ken Kendrick (Butte) 530-872-6334
Al Klem (Plumas) 530-283-1792
Patrick McDaniel (El Dorado) 530-647-5288
Jonathan Pangburn (San Benito/Monterey) 831-333-2600
Alan Peters (San Luis Obispo) 805-543-4244
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Calendar

January 8; 11 am-1 pm
Webinar: Reforestation and Afforestation (*see article this page*)
Overview of Reforestation Process and Issues: Dr. John Helms, UC Berkeley (emeritus)
Reforestation Practices and Needs on Public Lands: Joe Sherlock, USFS Region 5

January 15; 11 am-1 pm
Webinar: Reforestation and Afforestation
Cone Surveys: Teri Griffis, CAL FIRE

January 22; 11 am-1 pm
Webinar: Reforestation and Afforestation Cone Collection Certification: Teri Griffis, CAL FIRE
Propagation of Plants other than Conifers: Rich Marovich, Solano County Water Agency

January 24–25
CA SAF Winter Meeting: One California Forestry: The Professional's Role
Location: Berkeley, CA
Contact: ncsaf@mcn.org; 800-738-TREE
Website: http://norcalsaf2014wintermeeting.eventbrite.com/

January 28–29
Board of Forestry Meeting
Location: Ventura, CA
Website: http://www.bof.fire.ca.gov

January 29; 11 am-1 pm
Webinar: Reforestation and Afforestation
Implementation Alternatives: Conifers: Karen Jones-Schimke, USFS (retired)

February 5; 11 am-1 pm
Webinar: Reforestation and Afforestation
Reforestation of Burned Areas on Federal Forest Land: Ryan Tompkins, USFS Plumas NF
Reforestation on Private Forest Land: Bob Rynearson, W.M. Beaty Associates

February 10–21
Visualizing Sudden Oak Death e-Conference
A status webinar (February 11), Google Hangout with experts (February 13), videos, photo essays…
Contact: kpalmieri@berkeley.edu
Website: http://www.suddenoakdeath.org

February 12; 11 a.m-1 pm
Webinar: Reforestation and Afforestation
Reforestation of Burned Areas at Cuyamaca Rancho State Park: Lisa Gonzales-Kramer, CA State Parks

February 19; 11 am-1 pm
Webinar: Reforestation and Afforestation Oak Woodland Restoration Alternatives: Richard Harris, NorCal SAF

February 26;11 am-1 pm
Webinar: Reforestation and Afforestation
Riparian Woodland Restoration: Rich Marovich, Solano County Water Agency

Webinar series: Reforestation and Afforestation

Thousands of acres in California are either in need of post-fire reforestation or are potential sites for forest restoration. The benefits are important both locally and globally. New carbon sequestration incentives could stimulate interest in reforestation and afforestation.

Audience: Foresters, land managers, landowners, and agency personnel

Sponsors: No. CA Society of Am. Foresters, UC Cooperative Extension and Center for Forestry, NRCS, and CALFIRE

Schedule (*See calendar for speakers/topics. All sessions from 11 am–1 pm*)
Session 1: January 8, 2014—Overview
Session 2: January 15, 2014—Cone Surveys
Session 3: January 22, 2014—Cone Collection; Plant Propagation
Session 4: January 29, 2014—Implementation Alternatives
Session 5: February 5, 2014—Reforestation on Burned Areas/Private Land
Session 6: February 12, 2014—Reforestation at Cuyamaca Rancho State Park
Session 7: February 19, 2014—Woodland Restoration Alternatives
Session 8: February 26, 2014—Riparian Woodland Restoration
Session 9: March 5, 2014—Paying for Reforestation

Registration: Registration is required though there is no fee to participate. Register at the webinar home page at *http://ucanr.edu/reforestationwebinar*

Contact: Dr. Richard Harris, SAF, rrharris2464@sbcglobal.net, or Susie Kocher, UC Coop Extension, sdkocher@ucanr.edu.

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ADDRESS SERVICE REQUESTED

The Humongous Fungus & other fungal fun facts

- The world's largest living organism, a root disease fungus of *Armillaria ostoyae*, is located in Malheur National Forest in Oregon. Known as the Humongous Fungus, it is 12,500 feet in width, covers 2,385 acres, is estimated to weigh up to 35,000 tons, and may be 8,650 years old.
- Some mushrooms are putrid smelling to attract flies and other insects to disperse their spores.
- The razor strop fungus was traditionally used as a strop for finishing the finest edges on razors, and by watchmakers to polish moving components. It is a common bracket fungus on birch trees that can last for more than a year. It is also said to have antibacterial properties.
- The average person consumes fungi products daily. The citric acid used in soft drinks, candies, artificial lemon juice, baked goods, etc. is produced by fungus fermentation using *Aspergillus niger*. The yeast fungus, *Saccharomyces cereviseae*, is used in production of beers, wines, and spirits.
- Most of the energy in streams and rivers comes from wind-blown leaves and plant debris. This debris is high in carbon but low in nitrogen (high C:N ratio). Aquatic fungi colonize these leaves and lower the C:N, making them more usable by the detritus-feeding arthropods at the base of the food chain.
- Some mycorrhizal fungi can protect the roots of plants from attack by other fungi.
- It is estimated that fungi comprise 90% of the total weight of all living things in forest soil (excluding plant roots).
- Saprophytic fungi (those that eat dead or decaying organisms) are the primary agents responsible for breaking down plants and woody debris. Eighty-five billion tons of carbon are returned annually to the atmosphere as carbon dioxide by decay of cellulose and lignified cellulose, most of this by fungi.
- More than 60 species of fungi are bioluminescent; they glow in the dark.
- Pheromones produced by fungi play an important role in sexual reproduction. Male and female fungi communicate with each other by means of these chemicals.
- Carnivorous fungi can be found in some low nitrogen environments. These fungi exhibit adaptations such as sticky knobs and nooses that help them catch nematodes and other small animals. They digest their prey to obtain food/nutrients.
- Red squirrels gather dried fungi in huge numbers and store it in trees to eat in the winter.
- Some fungi can remain dormant for centuries.
- Fungi can break down industrial waste, pesticides, and oils. This ability to clean up polluted sites is called bioremediation or, more specifically, mycoremediation.
- Lichens are a symbiotic association between an algae and a fungus, and sometimes include a bacteria too.

—*information from a variety of sources including http://www.uoguelph.ca/~gbarron/MISCELLANEOUS/facts.htm and http://www.fungi.com/blog/items/facts-about-mushrooms.html*

Photo: Joseph Berger, Bugwood.org