United States Department of Agriculture

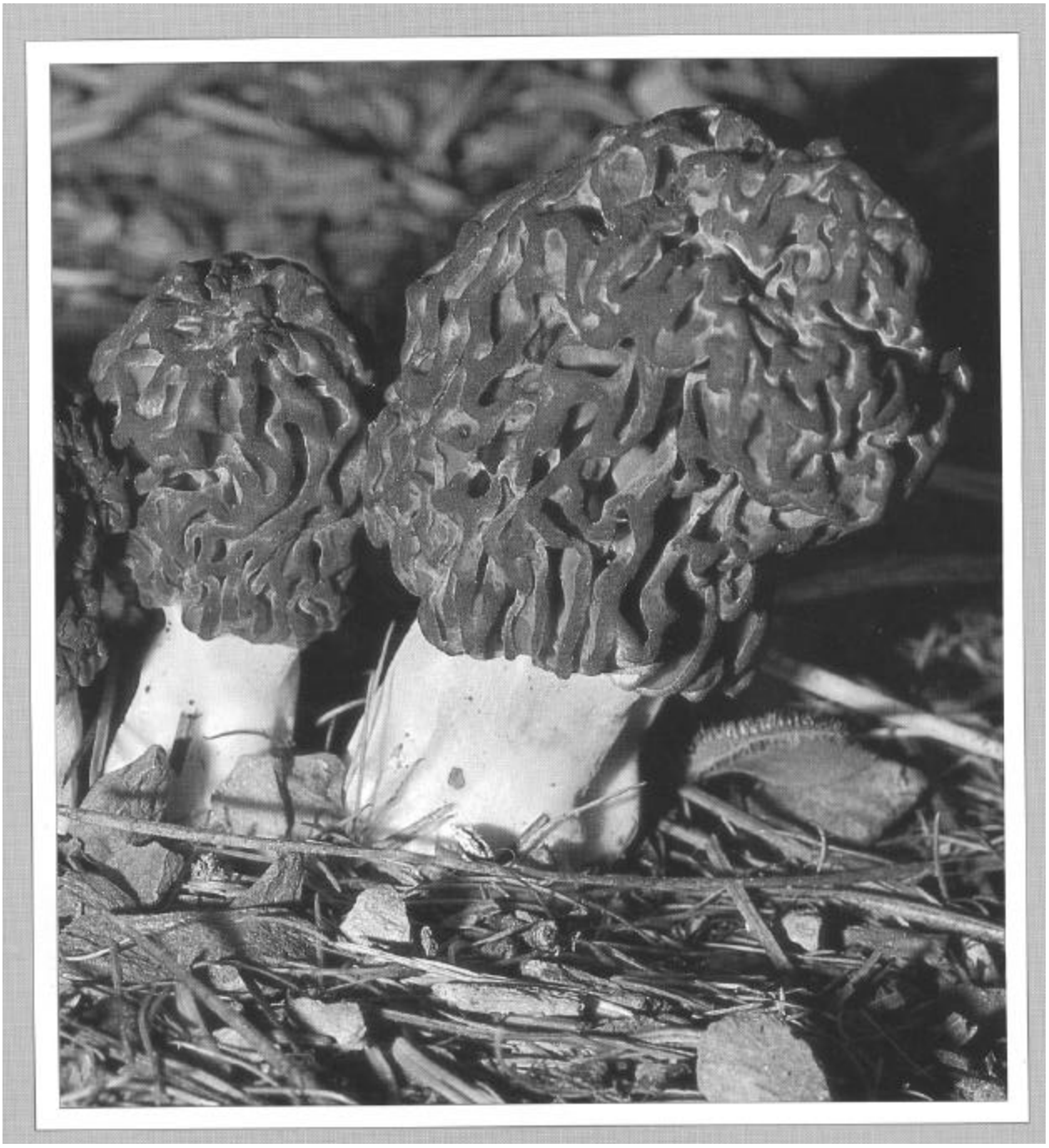
Forest Service

Pacific Northwest Research Station

General Technical Report PNW-GTR-393 January 1997

Wild Edible Mushrooms in the Blue Mountains: Resource and Issues

Catherine G. Parks and Craig L. Schmitt



Abstract

Parks, Catherine G.; Schmitt, Craig L. 1997. Wild edible mushrooms in the Blue Mountains: resource and issues. Gen. Tech. Rep. PNW-GTR-393. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 22 p.

This paper reviews the wild mushroom resource of the Blue Mountains of northeastern Oregon and southeastern Washington and summarizes issues and concerns for regulation, monitoring, and management. Existing biological information on the major available commercial mushrooms in the area, with emphasis on morels, is presented. Brief descriptions of the most commonly collected mushrooms are given, as well as the site conditions and plant communities influencing their occurrence or proliferation.

Keywords: Morels, special forest products, commercial mushroom harvest, Blue Mountains.

Disclaimer

This publication reports research and management issues involving mushroom harvesting. It neither recommends the use of mushrooms nor implies that mushroom use is without risks.

CAUTION: Mushroom consumption can pose a serious, even fatal, risk to humans. It is strongly recommended that you spend your first collecting season using field identifications guides and collecting with an expert if you intend to collect mushrooms to eat.

Authors

CATHERINE G. PARKS is a research plant pathologist, Pacific Northwest Research Station, Forestry and Range Sciences Laboratory, 1401 Gekeler Lane, La Grande, OR 97850; CRAIG L. SCHMITT is a Zone Pathologist, Blue Mountains Pest Management Zone, Wallowa-Whitman National Forest, 1401 Gekeler Lane, La Grande, OR 97850

Cover photograph: morel mushrooms. Photo taken by Paula Brooks at Hidden Campground, Hells Canyon National Recreation Area.

Contents

Introduction

In the last several years, forest managers in the Blue Mountains have observed a marked increase in the recreational and commercial pursuit of wild mushrooms. What had once been a casual recreational pastime and resource used by a few of the local population has developed into a major commercial industry for at least 2 months of the year. The commercial market has become increasingly organized and has spawned an influx of pickers and buyers into the area during the mushroom season. Aware ness of the availability of this resource also has increased the recreational pursuit of wild mushrooms. Given the high demand and limited resource, there are concerns about the increasing conflicts among commercial pickers and recreational users, and that mushroom harvesting may reduce future mushroom harvests or adversely affect other forest resources. Public land management agencies are striving to regulate mushroom harvest in a way that conforms to sustaining healthy ecosystems.

This document provides back ground information to individuals and organizations interested in the wild mushroom resource of the Blue Mountains of northeast- ern Oregon and southeastern Washington (fig. 1). It provides information for an environmental analysis, including issues and concerns for regulation, monitor- ing, and management. This paper consolidates and presents existing biological information of the major available commercial mushrooms in the area, with an emphasis on morels *(Morchella* spp.). Brief descriptions of the most commonly collected mush rooms are given, as well as the site conditions and plant commu- nities influencing their occurrence or proliferation.

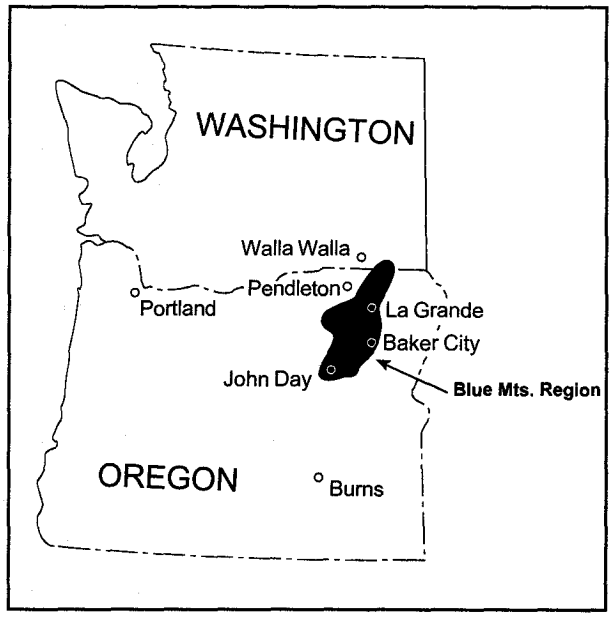


Figure 1—Region of the Blue Mountains.

Mushroom Harvest in the Blue Mountains—a Historical Perspective

The forests of the Blue Mountains produced an abundance of resources and commod- ities for Native Americans for thousands of years and for European settlers during the last 150 years. The ever-increasing population of the inland West and the continued demands on forested land have created controversy about proper forest management. The major conflict involves production and extraction of commodities versus mainte- nance of healthy and sustainable ecosystems. The current and future management direction of public lands will be to protect ecosystem health and viability while produc- ing commodities. This strategy is known as ecosystem management.'

' Ecosystem management is a system of making, imple- menting, and evaluating decisions based on the ecosystems approach, which recognizes that ecosystems and society are always changing (Bormann and others 1994).

Much of the historical commodity production on public and private forest lands has been timber, mining, and livestock grazing. Various other resources also are produced on these lands, including water, wildlife, Christmas trees, scenery, fuel wood, and mushrooms. These resources benefit the U.S. public and private land owners. Other "special products" continue to become increasingly important, especially when their production and use can be done on a sustained and ecologically sound basis.

Although documented mushroom use in the Blue Mountains is sketchy, it likely has a long history. Across North America, Native Americans used various fungus fruiting bodies (mushrooms, conks, etc.) for food, medicine, and culture (Hobbs 1995). Use differs by location and tribe. Knowledge of fungi was passed from generation to generation in chains of oral tradition. Much of the information, ancient expertise, and wisdom of these cultures has disappeared. Burke (1983) reported that the Indians of the Pacific Northwest and British Columbia were apt to be suspicious of mushrooms and considered them best used for medicine rather than food. Clark (1977), however, reported that Indians in northern California did collect morels for food. Native Americans in the Blue Mountains likely used fungi for food and medicine.

Today, mushroom gathering has become a major activity in the forests of northeastern Oregon and southeastern Washington, both as a recreational pursuit and as a major commercial enterprise. Morel mushrooms, currently account for most of the recreational and commercial harvests. Another significant species is the king bolete (*Boletus edulis*). Several other edible mushrooms in the Blue Mountains are collected by knowledgeable individuals, and a limited market exists for some of them.

At least 23 mushroom species found in the Blue Mountains have some commercial value.2 By far, most of the mushroom harvest are the morels that fruit in late spring and early summer and to a much lesser extent, the boletes. The valuable American matsutake mushroom (*Tricholoma magnivelare*), well known along the coast, on the slopes of the Cascade Range, and in Idaho, does not fruit in commercial quantities in the Blue Mountains.

Mushrooms in Western Culture

Although increasing interest in natural food products, and gourmet and ethnic cuisine, has recently contributed to wild mushroom popularity, interest and knowledge of fungi as a forest resource has been slow to develop in American culture. In the mushroom loving societies of Japan, China, northern and continental Europe, and Russia, mushrooms have long been culturally important, particularly valued for their wide ranging uses as food and medicine.

Early immigrants to the United States from Asia and Europe, brought with them their tradition of collecting forest fungi. The traditions of these immigrants have continued and are now the basis for much of the current recreational mushroom gathering. Con temporary immigrants, especially from Asia, bring with them cultures that include substantial reliance on wild mushrooms as food. Many commercial pickers are recent immigrants from Southeast Asia and Latin America. Picking mushrooms, often in family groups, generates a source of income for people who often are unable to se cure traditional mainstream employment.

2 Personal communication. 1996. Floyd Reese, owner, North West Mushroom Co. Inc. P.O. Box 2997, La Grande, OR 97850.

Although mushroom research is practically absent from American medical research, Asian medical research has extensive programs evaluating the nutritional and healing properties of mushrooms. Several antitumor agents (immunotherapeutic drugs) have been developed from mushrooms and these products have become commercially important items in Japan (Mizuno 1995, Mizuno and others 1995). Experiments have demonstrated significant anti-infection activity by select mushroom derivatives against various kinds of bacterial, viral, and parasitic infections, including Acquired Immune Deficiency Syndrome (AIDS) (Mizuno and others 1995).

Harvesting the Resource

Population growth in Blue Mountain communities and nearby population centers has resulted in steadily increasing recreational use of our woodlands. Improved access, development of campgrounds, and many recreational opportunities have contributed to use of the National Forests. Recreation often includes collecting of various forest products: fuel wood, berries, mushrooms, and other products. Recreational collecting of mushrooms is pursued predominately by local individuals. In a 5.8-percent sample of personal-use permits issued by the La Grande Ranger District, Wallowa-Whitman National Forest, in 1994, all (100 percent) had Anglo-American surnames and 90 percent designated local addresses.3

Some of the increased commercialization and development of new forest products has occurred in recent years (fig. 2). Some of this use may be due to a high proportion of seasonal labor, nontraditional careers, and live-off-the-land rural life-styles. Additionally, a reduction in the number of traditional rural jobs, such as logging and millwork, has forced families remaining in the area to find other sources of income.

In the last several years, there has been a large influx of commercial pickers into portions of the Blue Mountains during May and June to pick morels. Many commercial pickers are of Southeast Asian and Latin American descent, ethnic groups not well represented in the resident population. At the La Grande Ranger District, in 1994, commercial permits were purchased by individuals with Asian (51.3 percent), Anglo-American (44.2 percent), and Hispanic (4.5 percent) surnames. Nonlocal commercial permit holders were more common than locals; 73 percent and 27 percent, respectively (see footnote 3).

Figure 2—Fresh morel mushrooms stacked at a buying station in Prairie City, Oregon.

A Northwest-wide survey conducted in 1992 identified mushroom harvesters as Caucasian (AngloAmerican) (49 percent), Asian (37 percent), Native American (9 percent), and Hispanic (4 percent) (Schlosser and Blatner 1995).

3 Arora, David. 1994. Unpublished survey. On file with: Catherine Parks.

Commercial Harvest

In 1992, wholesale mushroom companies processed $11.8 million dollars worth of mushrooms in the eastern portions of Washington and Oregon, and Idaho. Processors paid about $9.9 million to harvesters for all mushrooms purchased in 1992. This in cluded 1.9 million pounds (861834 kilograms) of wild mushrooms (Schlosser and Blatner 1995).

Figure 3—Fresh morel mushrooms ready for weighing.

Morels are the biggest money maker among the Blue Mountain mushrooms. Nearly 1 million pounds were gathered in Oregon in 1992, most of them from the Blue Mountain region (fig. 3). Pickers earned an average of $6 per hour in 1992 (Schlosser and Blatner 1995). Forty percent of morels harvested are sold to Asian and European markets, and 42 percent are sold in the Western United States. In 1995, fresh morels sold for $5 to $6 per pound wholesale and $48 to $60 per pound retail. Until 1996, most morels were dried for packing by large-scale processing plants (fig. 4). Beginning in 1996, much of the morel harvest was sold fresh and shipped within 24 hours of harvest to the European markets (see footnote 2).

There is a substantial amount of conflicting information concerning commercial aspects of mushroom collection. Some claim that reports of pickers earning $300 to $400 per day are exaggerations. They claim also that these exaggerations may be deliberate attempts by buyers and dealers to entice people into collecting. Similarly, the amount reportedly paid is for only the highest grade specimens, whereas most of the mushrooms picked are of lower quality and command a much lower price.

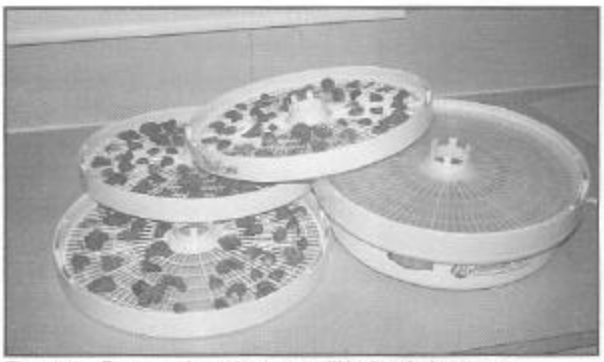


Figure 4—Dry morel mushrooms still in the drying trays.

Mushrooms are bought from pickers by individuals or agents who set up buying stations in nearby towns, communities, and occasionally, in the National Forests. Most of the freelance buyers in turn sell to established wholesalers and processors. Available records on production and processing are restricted to the established processors and shippers. This has largely been an "underground" business that deals in cash. It is likely that only a small portion of the generated income is reported.

In La Grande, OR, there is one established year-round mushroom buyer and processor. Mushrooms are mostly sold by pickers, fresh, at the end of the day. Some pickers will dry their own mushrooms and later sell them, adding value to the product. Large-scale processors partially dry and freeze their product for shipping out of the area and overseas. A small amount of the commercial harvest is marketed fresh locally in area restaurants and shipped to markets in the Northwest. Most of the market for processed mushrooms is in Europe (see footnote 2).

Regulations

Regulation of the mushroom resource has increased steadily over the last 10 years. In Washington, a task group of agencies and individuals representing State, Federal, and private lands was convened in 1985 by the Commissioner of Public Lands. An early product was a position paper on the issues involved in harvesting wild mushrooms (Acker 1986). Several workshops increased awareness of the resource and the developing industry. Washington State legislation requiring licensing and reporting of data was initially attempted in 1986 but failed to pass. A law passed in 1994 currently requires a validated specialized forest products permit (Washington Legislature 1994). The law is administered by the Washington State Department of Natural Resources and requires annual licensing of people who buy and process wild mushrooms for market. Monthly reporting is required of licensed buyers. Reports include information on species harvested, weights, location of harvest sites, dates purchased, prices paid, and name of dealer to whom the mushrooms were later sold. Dealers also are required to report to the U.S. Department of Agriculture, the quantity of mushrooms, by species, sold in-State, in the United States, and to individual foreign countries.

The 1993 Oregon Legislature passed House Bill 2130: Special Forest Products (Oregon Legislature 1993). This statute is designed to reduce illegal gathering and theft of various nontimber forest products, including mushrooms. This law requires wholesale buyers to keep a record of purchases which includes the social security number of the person from whom they bought the product, typically the gatherer. In Oregon, there are no State-wide regulations prohibiting mushroom collection; there may be individual city, county, State, or Federal parks and other lands where picking of mushrooms is prohibited or otherwise regulated.

The USDA Forest Service has used several methods to regulate harvesters and buyers in the Pacific Northwest Region. In the Blue Mountains, until 1994, there was a free-use permit available to people who collect for their own use (up to 10 days of picking per year). Until 1995, these permits were available from each Ranger District and were good throughout the Wallowa-Whitman, Umatilla, and Malheur National Forests. In 1995, regulations were changed slightly for the three Blue Mountains National Forests, and the Forests have discontinued issuing personal-use permits. Currently, recreational pickers are able to collect and possess up to 1 gallon (4.4 liters) (3 gallons [13.2 liters] in Washington) of mushrooms per day. These may not be sold.

Commercial picking permits have been required since the late 1980s for those individuals who pick on National Forest lands for sale to buyers. Recent regulations have reduced the cost of commercial permits as managers have found that most pickers will avoid buying commercial permits if the cost is high. At the Wallows-Whitman National Forest, in 1992, the cost of commercial permits was lowered to $1.00 per day. In 1996, commercial permits became available for $2.00 per day per person with a $10 minimum. A $50 annual permit also is available. It is believed that

many people pick commercially without a permit or use permits improperly. Table 1 indicates the historical issuance of commercial and free-use permits for the Wallowa-Whitman, Umatilla, and Malheur National Forests.

Areas having had large fires may produce abundant morel mushrooms and attract pickers who are willing to invest in costly permits (fig. 5). The area that burned in the Wallowa-Whitman National Forest in the 1988 Tepee Butte Fire was opened in 1989 only to people with commercial permits. Three-day permits were $10 and 30-day per-

Table 1—Mushroom harvest permits in National Forests of the Blue Mountains

National Forest	Year	No. permits sold	Permit revenue	No. free personal-use permits
Wallowa-Whitman	1989	1,803	Unknown	Not required
	1990	455	$37,900	770
	1991	14	$822	240
	1992	699	$9,066	1,100
	1993	1,502	$17,217	2,553
	1994	1,537	$21,438	2,618
	1995	2,325	$41,840	Not required
	1996	623	$15,364	Not required
Umatilla	1993	1,506	Unknown	3,276
	1994	1,746	$21,738	1,908
	1995	1,840	$29,840	Not required
	1996	808	$18,708	Not required
Malheur	1991	888[a]	$100,024	Unknown
	1992	11	$850	Unknown
	1993	98	$1,435	Unknown
	1994	137	$1,748	Unknown
	1995	165	$3,318	Not required
	1996	85	$2,190	Not required

[a] Includes 1 area contract.

Figure 5—Burn areas contain the conditions that sometimes contribute to bumper morel crops. They may also require special harvest permits.

mits were $50. Season permits were $100. In 1995, the 1994 Boundary Fire area was open only to those holding commercial permits. For some Forests, the Forest Service has auctioned picking rights to given areas in a manner similar to other forest product sales. Such was the case in 1991 when the Sheep Mountain Fire area was auctioned at the Malheur National Forest. Also in 1991 at the Malheur, commercial permits were sold for the nonwilderness portion of the Snowshoe Fire, that burned east and south of the Strawberry Wilderness. Cost was $50 for a 10-day permit and $150 for the entire season. The wilderness portion of the burn was open to personal use only.

Buyer permits have been offered for sale with few takers. These permits allow a buyer to set up a buying station on National Forest land. Only one $500 permit was sold in the Wallows-Whitman National Forest (La Grande District) in 1994.

Private Lands

Most private landowners have ignored mushroom harvesting on their lands, but many have come to realize the income potential associated with the mushroom industry. Some believe the value of mushrooms that could be produced under proper management and regulated harvest is likely to equal or exceed that of other land uses. Other land management practices may be compatible with mushroom management. Use of fire, timber harvest, and grazing may even enhance production of some mushrooms if done properly. Recently, some private landowners, including Boise Cascade, have either posted their properties to prohibit picking, or have a policy of prohibiting commercial harvests on their lands. Some private landowners likely will sell picking rights on their lands in the future. Currently, there are landowners in the area who are at tempting to develop the mushroom resource on their lands by active management and culturing (see footnote 2). Presently, most of the mushroom harvest is removed without compensation to or permission from the landowner.

Conflicts

In the last several years there have been several reports of confrontations among mushroom pickers (fig. 6). Other reports claim that conflicts among pickers have been exaggerated (Rogers 1991). When picking conditions are ideal and many people are in an area, conflicts can develop such as would occur at streamside during a heavy steelhead run. Some of these confrontations involve verbal threats, others involve display or discharge of firearms. Although this is currently a law enforcement concern, the Forest Service as an agency may be able to control picker density by limiting the number of permits that are issued for a particular area.

Figure 6—Newspaper clippings reflect the conflict over mushroom harvesting in the Blue Mountains.

Biology

General

Fungi are a broad and diversified group of organisms that range from simple yeasts and molds to specialized plant parasites such as wheat rusts and grass smuts, and those that cause various tree diseases. Fungi are not plants but belong to their own kingdom. They typically reproduce by spores and exist by deriving their food and energy from other organisms (fig. 7).

Saprophytic activity occurs where fungi derive their energy from dead material. Parasitic activity includes a similar activity on living hosts. Most plant diseases and some human diseases are the result of fungal infections. Many fungi once thought to be solely saprophytic, including some common wood decayers, are now known to actively hunt, capture, and digest various nematodes, rotifers, amoebas, copepods, and bacteria. Protein from these lower animal forms serves as a needed source of nitrogen (Baryon 1992).

Mutualists are another group of fungi that live in symbiotic association with plant hosts. Fungi in this group include mycorrhizae that are associated with the roots of trees. Mycorrhizal fungi modify the root systems of associate plants and trees by providing substantially more surface area and extensions of the small feeder roots. Consequently, these fungi provide the plant with an efficient uptake of nutrients and minerals. The plant, in turn, supports the mycorrhizal fungus that is less able to decompose complex carbohydrates than are saprophytic or parasitic fungi. Many of the choice edible mushrooms found in the West

are produced by mycorrhizal fungi. These include representatives within the class Basidiomycetes (mushrooms), which includes the genera *Cantharellus* (chanterelles), *Boletus* (Boletes), *Lactarius* (milky caps), *Tricholoma* (matsutake), *Hydnum* (tooth fungi), and *Ramaria* (coral fungi) (Molina and others 1993). Edible fungal fruiting bodies also are produced by the class Ascomycetes (cupfungi), represented by *Morchella (morels)* and the mycorrhizal *Tubercles* (truffles).

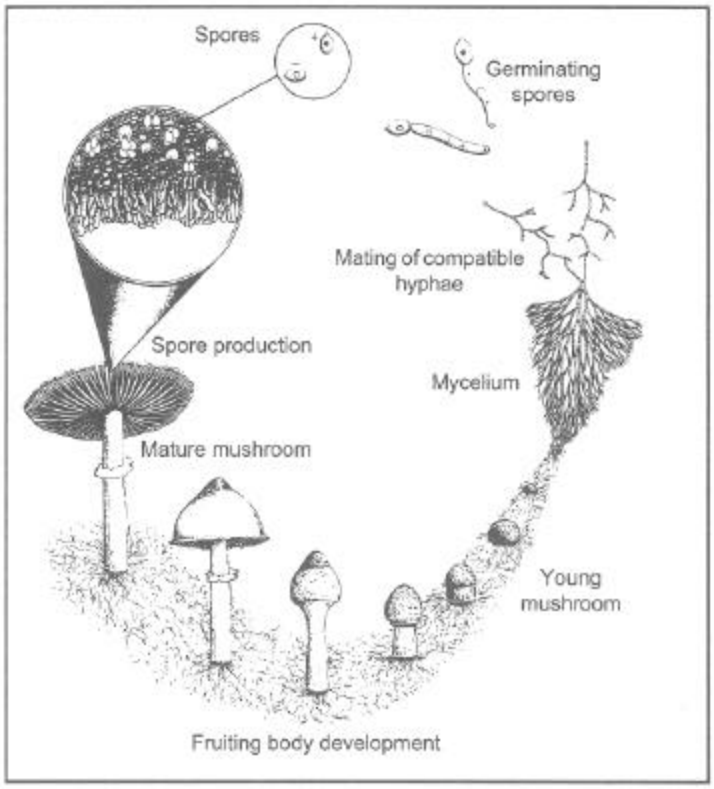


Figure 7—Life cycle of a typical mushroom (basidiomycetes). (As modified from page 64 of Stamets 1994.)

Plants can have many mycorrhizal associates; trees are believed to have more than other plant groups. Douglas-fir (*Psuedotsuga menziesii* (Mirb.) Franco) is known to have nearly 2,000 fungal species (Trappe 1977). Mycorrhizal fungi rely on the presence of their host, and will die with their host. Harvesting or fire can result in a short-term disappearance of these fungi, but they recolonize when trees again become established. Trees that are hosts to mycorrhizal fungi in the Pacific Northwest include those mainly in the families Pinaceae, Fagaceae, Betulaceae, Salicaceae, and a few Ericaceae (Molina and others 1993).

Reproduction

Specific reproductive processes are different for different species and groups of fungi. After spores are dispersed and germinate, they form haploid (monokaryote) vegetative hyphal strands (mycelium) through their adapted substrate. Sexual reproduction can occur when two compatible mating types grow together and fuse, and dikaryotic or binuculeate mycelium develops. When conditions are correct, the sexual stage is initiated and mushroom primordia develop. Primordia eventually develop into the fruiting structures where the final process of meiosis takes place and spores are again produced.

Mushrooms and cup-fungi are reproductive structures of individual fungal organisms that are primarily large networks of filamentous microscopic cells (hyphae) in soil, in wood, or on plants. Masses of hyphae (mycelium) are actually the vast bulk of the fungus. Because mycelium is either hidden or not visible to the naked eye, its importance often is overlooked relative to the apparent mushroom and cup-fungus fruiting structures. In actuality, the mycelium network functions throughout the year, whereas the mushroom or cup-fungus is produced for only a few weeks. Picking the mushroom does not alter the individual in the soil (or other substrate) but is analogous to picking fruit from a tree.

Individual mushrooms and cup-fungi produce millions to billions of spores, which serve as mechanisms for long-distance spread and maintenance of genetic diversity in the population. Usually spores are discharged and spread through the air, often for long distances, when temperature and humidity conditions are favorable. Although only a small proportion of spores germinate and colonize suitable substrates, long-distance spread is achieved, and different genetic material is continuously added to the population. Spores are produced from the hymenal surface of mature mushrooms. The hymenal surfaces are the gills or pores, usually on the underside of these fruiting bodies. On cup-fungi, such as morels, the spore-bearing surface lines the pits of the outer surface of the cap, known as the pileus. Timing of spore production differs by species of fungus. Spores are not produced in significant amounts until the mushroom is mature. For the Basidiomycetes, maturity is indicated after the cap expands, separating from the stem (stipe) and exposing the spore-bearing surface. Morels produce spores 15 to 30 days after the fruiting body is first formed; the spores line the exposed surface of the pits and grooves (Ower 1982, Weber 1995). Truffles produce spores inside the fruiting body itself. Various animals eat the mature truffle and the spores then travel through their digestive tract and are dispersed in the fecal pellets.

Mushroom fruiting differs among species. Some mushroom species are easily propagated and can be grown on farms. Some are more difficult to raise but are cultivated by hobbyists and small-scale entrepreneurs who use intensive and exacting techniques. Other species have very exacting requirements, seldom fruit, and are considered rare, although the vegetative fungus (mycelium) may be common. Most fungi usually have fairly exacting requirements of temperature and moisture for the formation of mushrooms. It is widely believed and frequently hypothesized that weather of previous months (that is, abundant moisture and accumulated degree days) will strongly influence fruiting. Most mushrooms have their specific season, usually spring or fall when moist conditions prevail. When conditions are favorable, mushroom production literally can occur overnight. Site or substrate conditions also are critical for mushroom formation. Some fungi fruit after fires or ground disturbance, others will be produced only on a few species of trees, and others may require undisturbed conditions. As sites experience constant change in vegetation as plant succession occurs, mushroom production also will change.

Morels

Morels, and some other fungi, produce sclerotia, which are dormant fungal structures that carry the fungus through periods of poor growing conditions by storing food reserves used when conditions for fruiting occur. Sclerotia require a disturbance such as high heat (fire) for activation and cause the fungus to become active, grow, and fruit. There is a clear relation between fire and subsequent abundant fruiting of morels. In some cases, abundant mushroom production is restricted to the following year; in other cases mushrooms are produced for 2 or 3 years. Fruiting is observed in burned harvest units as well as sites burned by wildfires. The relation between burn intensity levels and subsequent fruiting is currently being studied in the Blue Mountains.[4]

[4]Pilz, D.; Weber, N.; Carter, C.; Parks, C. 1995. Investigations of morel mushroom productivity, ecology, taxonomy, and population genetics following wildfires and tree mortality in Pacific Northwest forests: a study plan. On file with: Catherine Parks.

Morel collectors claim there are distinct morphological differences in mushrooms found in burned areas, in unburned areas, early or late in the season, and between years after a disturbance. These observations indicate that several species may exist in the Blue Mountains. These different morel species also may exhibit different reproductive strategies that affect their occurrence and distribution of fruiting bodies. Effort is being made to determine conditions that promote mushroom fruiting. Favorable conditions are generally well known, but predicting the precise timing and location of heavy mushroom production is more difficult.

Morels may form mycorrhiza with tree roots under certain conditions. It is possible that in nondisturbed conditions, much of the fruiting may be largely of a mycorrhizal species, whereas after fire and heavy tree mortality, fruiting may mainly be saprophytic species that are triggered by the flush of carbohydrates made available when trees die (see footnote 4).

Although the biology of some morel species is well documented under laboratory conditions, their field ecology, reproduction, taxonomy and population genetics in the wild have not been well studied. The effects of fire, fire intensity, different burn season, levels of tree mortality, and weather patterns are all believed to substantially influence the abundance of morel fruiting. Fire and tree mortality are known to make major changes in soil chemistry broadly described as nutrient flushes, pH shift, major population shifts in microorganisms, and partial sterilization (see footnote 4).

Concerns

Effect on the Mushroom Resource From Overharvesting of Mushrooms

A commonly expressed concern regarding the recent surge in commercial harvesting is the potential to deplete the resource by overharvesting. Some of this concern has resulted from European reports of recent reductions in mushroom fruiting. Cherfa (1991) reports that there has been a dramatic reduction of mushroom fruitings in recent years. Because production records exist, it has been possible to document this event. However, because edible and inedible species are both affected, overpicking has been ruled out. Forest management practices have been diminished as a cause, as the drop has been documented in various types of mature forests. Air pollution, largely the prevalence of nitrogen, sulfur, and ozone, has been shown to suppress abundance and diversity of fungi. Farming, and the application of nitrogen fertilizer, also has a negative influence on fungi in adjacent communities as hydrides and oxides of nitrogen are dispersed by wind and rain. In Europe, this is a concern beyond the production of mushrooms for eating; many of the fungi are mycorrhizal, and their demise has implications for the entire ecosystem. The relatively low level of industrial pollutants in the air of the Blue Mountains should eliminate this as an immediate concern.

Currently, we do not know the effect of picking on morel populations and long-term fruiting levels. This is a research need. A study of chanterelle mushrooms *(C. formosus)* and the effect of picking on production has shown no short-term trends in production of mushrooms associated with picking (Norvell and others 1995). Because the mushroom is simply the fruiting reproductive structure of the fungus, its removal likely has little affect on the remaining portions of the individual in the substrate (soil, wood, etc.).

There is concern over reduction in spore dispersal owing to removal of mushrooms. Spore production does not occur until after the mushroom cap expands. Commercial

buyers grade most mushrooms as higher quality if they are picked before full cap expansion. Only mature morel mushrooms have mature spores.[5] The level of maturity is often beyond that desirable for the commercial market. Although many sporophores are missed by pickers and may produce mature spores, it is unknown whether extensive harvest pressure will affect long-term reproduction.

Trappe (1989) makes a strong case for overharvesting of truffles occurring when they are located by raking the soil. Under natural conditions, primary spread of spores and rejuvenation of the species is by animals eating the truffle fruiting body and dispersing spores in feces. Raking disturbs the site and includes harvest of sporophores that are immature. Observations by Trappe indicated marked reductions in production after several years of heavy harvesting in western Oregon. The European technique of using trained dogs and pigs to hunt truffles is most apt to target the fragrant mature specimens and leave those that are immature.

As with truffles, some collectors of the pine or matsutake mushroom will use a rake to expose the lower duff layers and find the small prized buttons of this species. This mushroom is not known in the Blue Mountains, so duff scraping is not a problem here. Wherever there is mushroom harvest by raking, the concern is not only for the effect on the mushroom resource, but also for possible damage to other forest resources.

Effects of Mushroom Harvest on Other Resources

Other forest resources may be affected by many people collecting and removing mushrooms. Mushroom harvesting traffic can lead to road damage after heavy spring rains. Broken gates and similar damage may occur also.

In the Malheur National Forest, heavy concentration of pickers living in dispersed campgrounds has been reported as a potential source for some environmental effects (Volk 1991). Although traffic-related damage has been observed as a result of heavy use of dispersed camps during deer and elk hunting seasons, the total impacts associated with both hunting and mushroom picking were considered minimal (Volk 1991).

The spring morel season may closely coincide with elk calving in some cases. Disturbances associated with many people walking through these areas may result in some adverse effects on animals. Forest Service personnel in the Blue Mountains have taken an aggressive approach in creating and maintaining secure areas during elk calving. Large blocks of forested areas are closed to road vehicle travel and all-terrain vehicle offroad use.

Effect on the Mushroom Resource From Timber Harvesting

Because some prized mushrooms are mycorrhizal, there is concern that timber harvesting will decrease the availability of certain mushrooms. There is also the similar concern that removal of mycorrhizal mushrooms may affect tree growth. The population of fungi on forested sites likely will change substantially as communities go through successive stages of plant succession. Those mushrooms requiring cool, moist conditions associated with mature forests are less likely to be found on sites that have recently had a regeneration harvest. Similarly, those fungi associated with disturbed communities will occur soon after timber harvest but disappear as a regenerated stand develops on the site. Thus, mushrooms are part of the diversity of plants

[5] Personal communication. 1996. Nancy Weber, assistant professor, Forest Science Department, Oregon State University, Corvallis, OR 97331.

that change with succession. Similar changes occur with natural disturbances such as fire. Because forested communities in the Blue Mountains are closely associated with disturbance, especially fire, these changes in fungal populations should be considered a normal process.

To date, there is no indication that heavy harvesting of mycorrhizal fungi fruiting bodies has a detrimental effect on the remnant vegetative structure or the fungal-root relations in the soil.

Monitoring

Monitoring of diversity, production, and harvest of edible mushrooms was not included in the forest plans of any of the National Forests in the Blue Mountains. The importance of this resource in both value and the heavy recreational use it generates warrants more than passive management. Monitoring of the resource is needed to assure that land management practices are not affecting this ecosystem component. In some cases, there may be decisions to actively manipulate sites to promote mush room production. Molina and others (1993) recommend three types of monitoring applicable to wild edible fungi.

1. Detection monitoring is needed to provide a benchmark for future comparisons of mushroom diversity and abundance. This type of monitoring should tie mushroom information to existing databases, preferably on ecology plots where various other site and vegetation data already exist. The different mushroom fruiting periods and the often short-lived duration of fruiting present a challenge. Some sites also would need to be established as controls, where harvest is restricted. Selected sites could be revisited in successive years to determine annual variation. Given enough plots, information could be extracted on site and vegetation factors that influence fruiting.

2. Evaluation monitoring should occur when detection monitoring indicates a declining population or resource. Evaluation monitoring is designed to determine the extent and cause of the effect. Evaluation monitoring also can include studies that evaluate strategies for continued mushroom production. Determining the effects of different timber harvest strategies, wildfire and prescribed fire, plant succession, and commercial mushroom harvest all are included in evaluation monitoring.

3. Research monitoring is designed to provide detailed information on forest ecosystems at intensive research sites where long-term studies are already in place.

Research Needs

There are several morel and other wild mushroom research questions that pertain to the Blue Mountains. Land managers are most interested in monitoring and research that eventually will help direct management decisions (Pilz and Molina 1996). Mushroom production differs not only from year to year because of weather conditions, but also between locations because of various site, disturbance, vegetation, and other conditions. Treatments to enhance mushroom production likely will be incorporated in future land management strategies. Initiation of monitoring and inventory procedures are expected to help managers predict production and regulate this resource. There are several research needs associated with selecting management strategies for short- and long-term mushroom production. The most important research questions include:

1. Can productivity be predicted knowing plant community type and successional stage?
2. What are the temperature and precipitation parameters that begin and end mushroom production?
3. What are the cultural techniques that contribute to optimal mushroom production?
4. What are the negative and positive effects of land management practices, such as timber harvest, burning, and tree planting? Would any changes in management operations mitigate negative effects?
5. What is the effect of repeated heavy collection on a site to future mushroom production?
6. Are there different species or varieties of morels in an area? Are some forms mycorrhizal? Do they respond to management differently?
7. What are the proportions of different species or races of morels after fires of different intensities, and after tree mortality caused by spruce budworm and bark beetle?
8. What is the population ecology of the mush rooms in an area over time? How is genetic variability in the population related to spore spread?

Figure 8—Research areas may be restricted entirely from mushroom harvests.

Conclusions

Wild edible mushrooms from the forests of the Blue Mountains are being marketed locally, nationally, and around the world. We are just beginning to develop an appreciation for the biological and economic value of this special resource. Effective man agement of the commercial mushroom harvest requires anticipating the demand, the primary locations affected, and potential conflicts (fig. 8). Any regulations for protect ing the mushroom resource must apportion the harvest fairly. Extensive communication and cooperation among the public, industrial land owners, and governmental agencies is essential. Research and monitoring are important factors in developing strategies that will both protect and promote the Blue Mountain mushroom resource.

Acknowledgments

We thank the following people for their useful contributions and technical review of the manuscript: David Pilz, Jane Smith, Randy Molina, and Nan Vance, USDA Forest Service, Pacific Northwest Research Station; and Mike Rassbach and Diane Hildebrand, USDA Forest Service, Pacific Northwest Region. Many of the photographs were generously provided by Paula Brooks, botanist, Wallowa-Whitman National Forest and by David Pilz. Our thanks to Lynn Starr of the Blue Mountains Natural Re source Institute for assistance in editorial review and to Dancing Cranes Graphic Images, La Grande, OR, for content design and layout.

Literature Cited

Acker, R. 1986. Harvesting edible wild mushrooms in Washington: an issue paper. Misc. publ. Forest Health MQ-11. Olympia, WA: Washington State Department of Natural Resources. 44 p.

Barron, G. 1992. Jekyll-Hyde mushrooms. Natural History. March: 47-53.

Bormann, B.T.; Cunningham, P.G; Brooks, M.H. [and others]. 1994. Adaptive ecosystem management in the Pacific Northwest. Gen. Tech. Rep. PNW-GTR-341. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 22 p.

Burke, W. 1983. Puffball usages among the North American Indians. The Journal of Ethnobiology. May: 55-62

Cherfa, J. 1991. Disappearing mushrooms: another mass extinction? Science. 254(5037): 1458.

Clark, C. 1977. Edible and useful plants of California. Berkeley, CA: University of California Press. 280 p.

Hobbs, C. 1995. Medicinal mushrooms, an exploration of tradition, healing, and culture. 2d ed. Santa Cruz, CA: Botantica Press. 252 p.

Molina, R.; O'Dell, T.; Luoma, D.; Amaranthus, M. [and others]. 1993. Biology, ecology, and social aspects of wild edible mushrooms in the forests of the Pacific Northwest: a preface to managing commercial harvest. Gen. Tech. Rep. PNW GTR-309. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 42 p.

Mizuno, T. 1995. Shiitake, *Lentinus edodes:* functional properties for medicinal and food purpose. Food Reviews International. 11(1): 111-128.

Mizuno, T.; Sakai, T.; Chihara, G. 1995. Health foods and medicinal usages of mushrooms. Food Reviews International. 11(1): 69-81.

Norvell, L.; Kopecky, F.; Lindgren, J.; Roger, J. 1995. The chanterelle *(Cantharellus cibarius):* a peek at productivity. *In*: Schnepf, C., comp., ed. Dancing with the elephant: Proceedings, the business and science of special forest products-a conference and exposition; 1994 January 26-27; Hillsboro, OR. [Place of publication unknown]: University of Idaho Extension Service: 117-128. Sponsored by: Northwest Forest Products Association; Western Forestry and Conservation Association.

Oregon Legislature House Bill 2130: Special Forest Products. Passed December 1995. amending ORS 164.813.

Ower, R. 1982. Notes on the development of the morel ascocarp: *Morchella esculenta.* Mycological. 74:142-144.

Pilz, D.; Molina, R., eds. 1996. Managing forest ecosystems to conserve fungus diversity and sustain wild mushroom harvests. Gen. Tech. Rep. PNW-GTR-371. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 104 p.

Rogers, M. 1991. The mushroom wars: Who's overharvesting? Who's brawling in the woods? Mushroom, the Journal. 31:9(2): 5-7.

Schlosser, W.; Blatner, K. 1995. The wild edible mushroom industry of Washington, Oregon, and Idaho: a 1992 survey. Journal of Forestry. 93: 31-36.

Stamets, P. 1994. Growing gourmet and medicinal mushrooms. Berkeley, CA: Ten Speed Press. 64 p.

Trappe, J. 1977. Selection of fungi for ectomycorrhizal inoculation in nurseries. Annual Review of Phytopathology. 15: 203-222

Trappe, J. 1989. Are commercial takers killing our truffles? Mushroom, the Journal. 23:7(2): 10-11.

Volk, T. 1991. Commercial picking in eastern Oregon. Mushroom: The Journal of Wild Mushrooming. 34:10(1): 19.

Washington Legislature. 1994. Engrossed Senate Bill 5011. Effective Date: July 23, 1995.

Weber, N.S. 1995. A morel hunter's companion. Lansing, MI: Two Peninsula Press. 209 p.

Appendix

Mushrooms Commercially Important in the Blue Mountains

Morchella species including:
Morchella escuienta
M. deliciosa
M. crassipes
M. angusticeps
M. elata
M. conica
Common names: Morel, white morel, black morel, naturals, gray morel, cone shaped morel

Morels, *Morchella elata*, Wallowa County, Oregon.

Edibility: Choice (with caution). Some individuals have an adverse reaction to morels, especially when they are eaten while consuming alcohol. First-time eaters need to try a small amount to test for adverse reactions. Never eat morels raw.

Description: The most abundant and commercially valuable mushrooms in the Blue Mountains. These cup-fungi are members of the Ascomycetes. They are saprophytes and grow in soil. Although generally not considered mycorrhizal, they typically are found in forested sites in this area. The fruiting body is likened to a pine cone on a stem. Both the body and stem are hollow. The body is a unique honeycombed system of pits and ridges. Coloration differs from very light to dark brown. Several closely related species, strains, and varieties seem to exist. Some species fruit early in the season, others later. Black morels and cone shaped morels are usually associated with burned areas and are slightly different from fruiting bodies found in adjacent nonburned sites.

Habitat: Morels fruit in the spring usually starting in warmer, lower elevations on ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) sites. Fruiting continues in mixed conifer sites and later on higher elevation true fir sites as the season progresses. Almost all harvesting occurs in May and June. Burned conifer stands often have spectacular fruiting the spring after the fire. Fruiting often declines in subsequent years, although in a few cases, abundant fruiting on burned sites may continue through a second or third year. Riparian communities and those sites having had past ground disturbance are often prolific perennial producers of mushrooms. The mushroom appears most commonly a day or two after a rain on exposed sites. Cool wet and riparian sites are more apt to fruit when the temperature is optimum, rather than after rain. Morels quickly deteriorate and are subject to maggot infestation after 2 or 3 days.

Uses: This popular mushroom is a favorite of both commercial and recreational pickers. It can be partially dried and frozen or completely dried and stored in airtight containers. Drying the mushroom is believed to concentrate the flavor as well as help preserve quantities for future use. Use of home food dryers adjusted to a moderate temperature is a popular way to preserve morels.

Boletus edulis

Common name: King bolete

Edibility: Choice

King Bolete, *Boletus edulis*, Mount Adams, Washington.

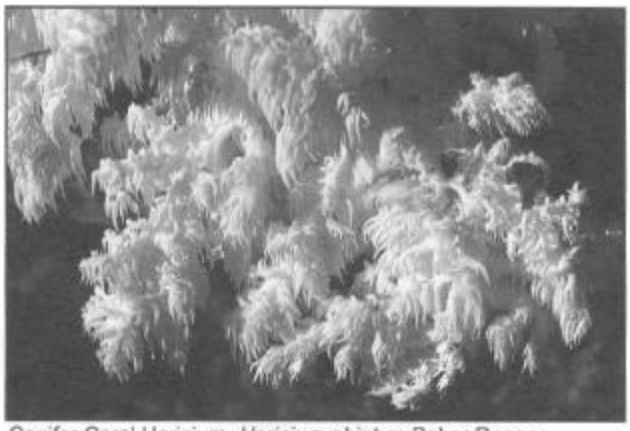
Description: This large, easily identified mushroom has a thick bulbous stalk, especially at the base, and a whitish spongy-pored (not gilled) hymenium undersurface. The surface of the cap is brown to reddish with a netlike pattern of raised veins. Because of the unique pored undersurface, boletes are easily identified, but other nonedible boletes also occur in this area. Boletes with red-pored hymenium or that bruise to blue are species other then B. edulis, and should be avoided. At the current time, boletes are a distant second to morels in popularity and contribute only slightly to the commercial harvest in this area.

Habitat: Boletes are mycorrhizal with conifers in the Blue Mountains. Fruiting is from the soil and may be single mushrooms but more often in groups. Fruiting is apt to be during the fall at lower elevations, although some spring fruiting of the mushroom may occur. At higher elevations, late spring and summer fruitings are common.

Uses: This is a prized edible and often is exported to Europe. There is substantial contract collecting by professional pickers.

Hericium species

Common names: Conifer coral hericium; goats beard, lion's mane hericium; old man's beard, comb hericium, coral tooth


Paula Brooks

Conifer Coral Hericium, *Hericium abietus*, Baker Ranger District. Washington Gulch area.

Edibility: Good

Description: The fruiting body is white to yellow-white and branched. As their name suggests, they have a form similar to branched forms of coral. They fruit on dead wood of conifers and hardwoods, mainly in the fall. They often appear perennially on the same log or tree. All of the Hericium species are edible.

Habitat: Although occasionally found in larch/Douglas-fir/ponderosa pine communities, this fungus is most common in the Engelmann spruce/grand fir and subalpine fir type. These are typically higher elevation, cool, wet sites.

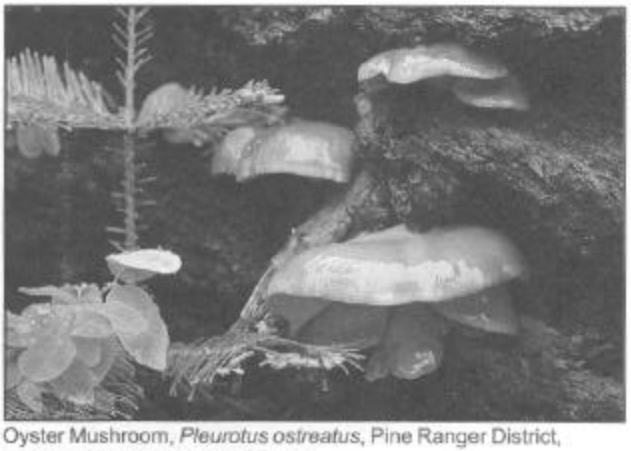
Uses: Mainly local consumption by a few collectors. Some collecting by professional pickers.

Pleurotus ostreatus

Common name: Oyster mushroom

Edibility: Choice; flavor suggests oysters to some.

Description: This shelf-like mushroom grows directly from woody material. A symmetrical cap and stem may be produced when the mushroom grows from the top of logs.



Oyster Mushroom, *Pleurotus ostreatus*, Pine Ranger District, Wallowa-Whitman National Forest.

Habitat: They are not as common in the Blue Mountains as in western Oregon. In the Blue Mountains, most fruiting is from hardwoods, especially cottonwoods (probably also aspen) in the relatively restricted communities where these species occur. Mushrooms fruit in both summer and fall.

Uses: Mainly local consumption by a few collectors. Some collecting by professional

Coprinus com atus

Common names: Shaggy mane, ink cap

Edibility: Choice

Description: This mushroom fruits in disturbed sites and is common along sides of gravel roads.

Habitat: Common in the Blue Mountains, mushrooms fruit in early summer and fall.

Uses: Mainly local consumption by a few collectors. Some collecting by professional pickers. Note: This species does not keep well when fresh because it matures and decays rapidly. It is also difficult to preserve by drying.

Shaggy mane, *Coprinus comatus*, Hurricane Creek, Eagle Cap Wilderness, Wallowa-Whitman National Forest.

Commercial Mushrooms of the Blue Mountains (see footnote 2)

Common name	Scientific name
White king bolete	*Boletus barrowsii*
King bolete	*Boletus edulis*
Giant puff ball	*Calvatia booniana*
Yellow chanterelle	*Cantharellus cibarius*
White chanterelle	*Cantharellus subalbidus*
Blewit	*Clitocybe nuda*
Shaggy mane	*Coprinus comatus*
Horn of plenty (black trumpet)	*Craterellus cornucopioides*
Medicinal varnished conks	*Ganoderma* spp.
Snow bank false morel	*Gyromitra gigas*
Conifer coral hericium	*Hericium abietis*
Hedgehogs	*Hydnum repandum*
Waxy cap	*Hygrophorus subalpinus*
Candy caps	*Lactarius fragilis*
Shaggy parasol	*Lepiota rachodes*
Fairy ring	*Marasmius oreades*
Morels	*Morchella* spp.
Oyster	*Pleurotus ostreatus*
Coral, pink	*Ramaria botrytis*
Coral, yellow	*Ramaria rasilispora*
Coral, white	*Ramariopsis kunzei*
Hawk wings	*Sarcodon imbricatum*
Cauliflower mushroom	*Sparassis crispa*

Parks, Catherine G.; Schmitt, Craig L. 1997. Wild edible mushrooms in the Blue Mountains: resource and issues. Gen. Tech. Rep. PNW-GTR-393. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 22 p.

This paper reviews the wild mushroom resource of the Blue Mountains of northeastern Oregon and southeastern Washington and summarizes issues and concerns for regulation, monitoring, and management. Existing biological information on the major available commercial mushrooms in the area, with emphasis on morels, is presented. Brief descriptions of the most commonly collected mushrooms are given, as well as the site conditions and plant communities influencing their occurrence or proliferation.

Keywords: Morels, special forest products, commercial mushroom harvest, Blue Mountains.

Pacific Northwest Research Station
333 S.W. First Avenue
P.O. Box 3890
Portland, Oregon 97208-3890