Conservation Assessment for Fungi Included in Forest Service Region 6 Sensitive and BLM Oregon and Washington Special Status Species Programs

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Overview

This Conservation Assessment (CA) was prepared to address the fungi included in the Oregon and Washington Bureau of Land Management Special Status and Region 6 Forest Service Sensitive Species Programs. This assessment does not make any commitment or allocation of resources nor does it represent a management decision by the US Forest Service or Bureau of Land Management. Although the best scientific information available was used, and appropriate experts were consulted, significant new information may arise, and the assessment may need to be revised. Questions or information updates related to this document should be directed to the Interagency Special Status and Sensitive Species Conservation Planning Coordinator (FS Region 6 and BLM OR/WA) in Portland, Oregon: http://www.fs.fed.us/r6/sfpnw/issssp/contactus/ .

Species covered in this Conservation Assessment include all of those listed as Sensitive by the BLM and Forest Service in Oregon and Washington, as well as those fungi species listed as Survey and Manage, as of December 2003. Pages 1-17 provide an overview and general discussion of the fungi addressed in Appendices I and II. No species-specific information is presented in pages 1-17. Appendix I has been modified in this August 2013 update, to reflect the current list of Sensitive fungi species in Oregon and Washington, with species specific accounts removed; instead, the reader is encouraged to review individual Species Fact Sheets that have been created for each of these Sensitive species, that are located on the Interagency Special Status and Sensitive Species web site: http://www.fs.fed.us/r6/sfpnw/issssp/ . Appendix II covers Survey and Manage species that are not also listed as Sensitive. This August 2013 update focuses on including new information specific to taxonomy, morphological habit, habitat associations, etc. for these species. Each species in Appendix II has a species account, with specific information on the known range, species description, ecological relationships, management considerations, and references. Appendix III has also been updated to reflect current information and conservation gaps as identified by the Fungi Work Group.

Executive Summary

Species and Taxonomic Group

Fungi are a large, diverse group of non-photosynthetic organisms belonging to the Kingdom Fungi, which is distinct from either the Plant or Animal Kingdom. Taxonomic information including Family, Genus and Species is presented in Appendix II or in Species Fact Sheets.

Management Status

Appendix I lists those species currently listed by the agencies as Sensitive through the BLM Special Status or Forest Service Sensitive Species Programs. Appendix II covers other Survey and Manage fungi species (as of December 2003) not currently Sensitive and is provided as additional information.

Range

All of the species covered in this Conservation Assessment are known or suspected to occur within all or a portion of the Northwest Forest Plan area of Washington, Oregon, and California. In addition, some of these species are known or suspected to occur in other portions of Washington, Oregon, or California or other parts of the United States. The range and general occurrence information for each species is summarized in Appendix II and in Species Fact Sheets.

Habitat

Most of the species in this Conservation Assessment are associated to some degree with forest floor litter, down woody material, host tree or shrub species, or some combination thereof. While this association is known, details about the requirements for forest floor litter or down woody material for most fungal species are not well understood, and host specificity is not often known beyond the broad categories of conifers, hardwoods, or plant families within these categories. Down woody debris and forest floor litter are direct food sources for fungi that play a role in decomposing organic material. Host trees (or shrubs in some cases) provide necessary carbohydrates to some fungi through transference of carbohydrates from the roots of the host to the fungus via an underground network termed mycelia.

The size and scale of down woody material influence the range in size of fungal individuals. Fungal colonies can range in size from microscopic to many acres and can persist for years or decades. Fungi are typically patchily distributed, in part due to patchy distribution of substrate (e.g. living host plants, down wood).

Threats

Management activities may pose direct or indirect threats to fungal individuals or mycelial mats, depending on the timing or intensity of the activity. The types of activities that can result in threats to fungal individuals or alter habitat conditions beyond a given threshold of tolerance include activities that:

- intensively or extensively remove or consume the woody substrate, forest floor litter, or shrub hosts with which the species is associated;
- remove or destroy the fungal organism;
- remove host tree species or significantly modify the microclimate at the species' site.

Some examples of these activities (depending on scope and intensity) may include:

- Prescribed fire, broadcast burning (includes underburning);
- Piling and pile burning;
- Retardant/foam application;
- Regeneration harvest;
- Thinning**;**
- Chopping, crushing, grinding, and mowing woody debris;
- Chipping woody debris;
- Mushroom harvesting and raking.

Management Considerations

Knowledge of life processes, as well as the nature of fungal habitat requirements or preferences, remains elusive for most fungi species. Although the research data needed to describe habitat parameters or environmental conditions that might provide for fungi persistence are still lacking, the following represent key considerations in managing known fungi sites:

- Reduce or avoid hot burns over the fungal site. If burning is necessary or unavoidable, consider spring burns (or spring-like burns) to help maintain fungal diversity and reduce the potential for substrate loss and fungal root tip impacts.
- Avoid piling, chopping, crushing, grinding, mowing, and chipping within the fungal site. If actions are necessary to reduce fuel loadings within the area managed for the fungus, consider placing piles and residual fuels outside of the managed area, and retain an array of larger woody material from a variety of decay classes.
- Discourage foam/retardant application within the fungal site. If foam/retardant application is unavoidable, avoid direct application on any sporocarps, and consider leaving some larger down woody material unsprayed, to provide potential refugia/untouched habitat.
- Discourage raking within the fungal area. For raking associated with fuels reduction work, consider light raking to remove fine fuels, but to minimize disturbance to the duff layer.
- Discourage the issuance of commercial collection permits in areas managed for fungal persistence.
- For timber harvest activities, consider aggregating leave trees around the fungal site to maintain host tree to fungus continuity and to mitigate the effects of the microclimate change. This can also serve to reduce potential impacts from the activity to the substrate or fungal organism.
- Larger managed areas/leave tree retention areas should be applied for sites in regeneration cuts versus thinnings, due to the differences in the microclimate changes from the two types of cuts and isolation of host trees. Retention areas can also help maintain woody substrates associated with the fungal organism

Additional considerations for fungal habitat where species presence/absence has not been determined are also included in the text of the Conservation Assessment.

Research, Inventory and Monitoring Opportunities

Information is needed on apparent habitat preferences (habitat needs, local microclimatic conditions), species' range, relative abundance, distribution, effects of management actions, and on the extent to which existing reserve systems and Forest and Land and Resource Management Plans provide for species' persistence.

Introduction

Goal

The goal of this Conservation Assessment is to summarize existing knowledge regarding the biology and ecology of fungal species included as Sensitive in the Forest Service Region 6 Sensitive or Oregon/Washington BLM Special Status Species Programs (SSSSP), and those identified as Survey and Manage species, as of December 2003. Threats to and management considerations for these species are also discussed to aid federal management in species conservation. According to the best current information, these species are of concern because of low abundance, restricted distribution, or both. Frequently, information about their habitat preferences or needs is limited or unavailable. The extent to which these species may be affected by land management actions is often unknown.

Management of the fungi species listed in Appendix I follows Forest Service Sensitive Species (SS) policy (FSM 2670), and/or BLM Special Status Species (SSS) policy (BLM 6840 and Oregon/Washington state supplements). Under these programs fungi are distinctly different than most of the other species: they are not practical to survey for, and they grow below the soil surface making it difficult to accurately define an occupied site. The Agencies seek to manage the known sites and habitat across the landscape in such a way that SS and SSS fungi will persist across their range on federal land in Oregon, Washington, and northern California in compliance with SS and SSS policy. Forest Service SS policy requires the agency to maintain viable populations of all native and desired non-native wildlife, fish, and plant species in habitats distributed throughout their geographic range on National Forest System lands. Forest Service management "must not result in a loss of species viability or create significant trends toward federal listing" (FSM 2670.32) for any identified sensitive species. For Oregon and Washington BLM administered lands, SSS policy details the need to manage for species conservation.

Scope

The geographic scope and applicability of this assessment encompasses consideration of the known and suspected range of all included species within Washington and Oregon in their entirety, and those portions of California covered by the Northwest Forest Plan. A limited amount of new information has been generated regarding these species in the last few years, especially with respect to distribution and habitat. Recent interagency strategic surveys have provided some new information for some species. Still, significant gaps in the understanding of the basic ecology, abundance, and distribution for these species remain, and information updates may be necessary to keep this assessment current.

Threats discussed in this document are those currently known or suspected, and may change with time and additional information. Management considerations discussed in this assessment may be applied to specific sites, though some large-scale issues, such as population connectivity, and range-wide concerns are also discussed. Throughout the document, uncertainty and inference are acknowledged where appropriate, and care has been taken to limit considerations to those supported by current literature or research.

Management Status

Appendix I lists those species currently identified as Sensitive through the BLM Special Status or Forest Service Sensitive Species Programs in Oregon and/or Washington. Appendix II covers other fungi species not currently Sensitive. Except for one species in Appendix I, all of the species in both Appendices are Survey and Manage species under the Northwest Forest Plan.

Species status may change, as species are added and removed from Agency lists in response to new information. For FS Region 6 and Oregon/Washington BLM, current species lists, species-specific maps, number of sites by physiographic province, and other conservation tools are available on the Interagency Special Status Species website: www.fs.fed.us/r6/sfpnw/issssp/ .

Additional information and updated Global, State and Heritage List ranks can be found at State Heritage Programs websites.
For Oregon: http://orbic.pdx.edu/
For Washington: http://www.dnr.wa.gov/nhp/about.html

Classification and Description

Systematics and Synonymy

Fungi are a large, diverse group of non-photosynthetic organisms belonging to the Kingdom Fungi, which is distinct from either the Plant or Animal Kingdom. Taxonomic information including Family, Genus and Species is provided in Appendix II and in Species Fact Sheets.

Species Description

Descriptions for each species, and the references from which they came, are included in Appendix II or in Species Fact Sheets.

Biology and Ecology

Life History and Reproductive Biology

The living body of a fungus is composed of thread-like filaments called hyphae. Masses of hyphae are called mycelium. The mycelium is generally underground and remains undetected until or unless it develops visible reproductive structures (fruiting bodies such as mushrooms, truffles, corals, puffballs, cups), or the substrate is disturbed, exposing the usually white mycelial mats. Most fungi have a specialized niche in the environment, growing through the soil, and relying on spores to colonize new substrates. Fruiting bodies generally function to produce as many spores as possible, maximizing the chance of successful colonization. Some morphological features which fungi use to increase their

spore-bearing surface include pores, tubes, teeth, gills or branching and wrinkling of the spore-bearing surfaces.

Fungi are heterotrophic and must absorb nutrients from organic material or other host species on which they live. They are unlike most plants in this respect, which manufacture their food through photosynthesis. In general, fungi must digest before they ingest, which they do by secreting digestive enzymes, which break down the substrate, allowing for absorption of the substrate's nutrients by the fungus. The external food source (the substrate or host on which a fungus depends) determines ecological function.

Mycorrhizal Fungi

Mycorrhizal fungi form highly interdependent relationships with their living host plants, and contribute beneficially to the arrangement through plant roots. The fungus obtains carbohydrates from the host plant's photosynthate, while the host plant obtains mineral nutrients and water transferred through the fungus to the host plant's root system (for reviews see Allen 1991, O'Dell et al. 1993, and Smith and Read, 1997). About 95% of vascular plant species belong to families that are mycorrhizal (Trappe 1977, 1987), depending on mycorrhizal fungi for nutrient and water uptake. The fungal network vastly extends the plant roots, increasing the surface area and absorption capacity far beyond the roots' own physical limits.

Mycorrhizal fungi are generally split into two major groups, arbuscular mycorrhizal (AM) and ectomycorrhizal. Both types form mutually beneficial symbiotic associations with the fine root systems of plants. AM fungi grow within roots, between and within root epidermal and cortical cells, penetrating cell walls but not cell membranes. Ectomycorrhizal fungi colonize the short feeder roots, forming a mantle around them and a network of mycelium between the epidermal and outer cortical cells. Ectomycorrhizal fungi are common in many forest tree species, especially among the families of Pinaceae, Fagaceae, Betulaceae, and Salicaceae. The extent of their reach into the soil matrix is difficult to determine without genetic analysis, but genetic individual sizes may be extensive.

Saprobic fungi

Saprobes feed on dead and decaying organic material and play a vital role in decomposition and nutrient recycling. Fungi and bacteria are some of the organisms capable of decomposing dead leaves and other organic materials; insects also contribute to this critical role. Fungi provide an invaluable recycling service by extracting nitrogen and other essential nutrients from decaying materials and then releasing it for use again by plants.

Saprobic fungi can be wood saprobes, found on dead or decaying wood or humus, litter saprobes, found in leaf and twig debris or duff, or both. Unlike the mycorrhizal fungi, saprobes obtain their nutrients by the chemical decomposition of dead plant matter. Wood-decaying fungi probably do not extend beyond the available substrate (log, stump etc.), though hyphal strands or mycelial cords (rhizomorphs) may be found in some species. Litter-decaying individuals can extend over a large area, reaching through rhizomorphs or mycelial cord networks up to 150 meters in diameter (Hansen and Hamelin 1999).

Parasitic fungi

Parasitic fungi depend on a living host; some may kill their host, while others do not. Some continue to live as saprophytes after the host has died. Relatively few fungi are parasitic, but included among them are several serious fungal pests (Arora 1986). Parasites play an important role in forest ecology by culling weaker trees, creating gaps as the trees fall, softening heartwood cavities and creating wildlife habitat, thus adding to a more diverse forest. Parasitic fungi included here are obligatory parasites on other fungi (mostly on species in the family Russulaceae), and are unable to survive without the living host tissue (Alexopoulos *et al.* 1996).

Many fungi in all functional groups exhibit some degree of host specificity. The fungus grows in specific association with a particular plant family, genus or species, or fungal family or genus, and cannot exist without the host. There is a shortage of information relating to fungal host species, and the numbers and distribution needed to maintain fungal populations. Ensuring the continuity of the host increases the likelihood of persistence of the dependent species, although a general lack of data affects the extent to which effective management recommendations can be proposed for these species.

A significant problem encountered by mycologists is insufficient understanding of an organism's reproductive processes, which is essential to efforts to provide for a reasonable assurance of persistence across the landscape. Each fungal species has a separate set of environmental variables that will trigger the production of fruiting bodies. The timing of mushroom development (and thus organism detection) varies according to species, and depends on light, soil temperature, pH, and moisture, among other variables (Hunt and Trappe 1987, Luoma 1991).

Range, Distribution and Abundance

Surveys for species presence are often difficult, because fungi can be seen only when fruiting bodies are produced. Even with above-ground fruiting bodies present, their correlation with the extent and abundance of the fungal organisms underground is unknown (Straatsma and Krisai-Greilhuber 2003). Patterns of fruiting body occurrence and abundance can be influenced by several variables that are difficult to separate: (a) environmental conditions; (b) type, amount and distribution of substrate; and (c) ecological succession (Straatsma and Krisai-Greilhuber 2003). Work by Luoma (1991) and Smith et al. (2002) documented that proportions of species differ annually, as does species composition. O'Dell et al. (1996) suggest that in order to maximize detection, monthly surveys in spring and autumn over a minimum 5-year period are necessary.

All of the species covered in this Conservation Assessment are known to occur within all or a portion of the Northwest Forest Plan area of Oregon, Washington, and California. In addition, some of these species are known or suspected to occur in other portions of Washington, Oregon, or California, or other parts of the United States. The range and general occurrence information for each species is summarized in Appendix II and in Species Fact Sheets.

Population Trends

For the reasons outlined above, information on population trends for any of the species included in this document is minimal at best or completely unknown.

Habitat

Most of the species in this Conservation Assessment are associated to some degree with forest floor litter, down woody material, host tree/shrub species, or a combination thereof. While this association is known, details about the requirements for forest floor litter or down woody material for most fungal species are not well understood, and host specificity is not often known beyond the broad categories of conifers hardwoods or plant families within these categories. Down woody debris and forest floor litter are direct food sources for fungi that play a role in decomposing organic material. Host trees (or shrubs in some cases) provide necessary carbohydrates to some fungi through transference of carbohydrates from the roots of the host to the fungus via an underground network termed mycelia.

Down woody material requirements for most fungal species are not well understood. Down woody material may function to retain moisture, allowing root tips to support active ectomycorrhizae (Harvey et al. 1976, Harvey et al. 1978, Amaranthus et al. 1989, Harmon and Sexton 1995). These fallen tree "reservoirs", large limbs, and stumps can provide refugia for seedlings and mycorrhizal fungi, especially in drier forest communities. As stands mature, the availability of downed wood may be crucial for establishment of fungi as well as plant seedlings (Kropp 1982).

Down woody debris is a direct food source for wood-decaying fungi. Studies in Scandinavia and North America indicate that the presence of large down wood promotes higher diversity of wood-decay fungi species (Kruys, 1999, Crites and Dale 1998, Ohlson et al. 1997, Høiland and Bendiksen 1996, Bader et al. 1995, Wästerlund and Ingelög 1981). Høiland and Bendiksen (1996) found that rare wood-inhabiting fungal species occurred primarily on long (average length = 11 meters) and well decayed (average decay Class III) down wood. When surface area is taken into consideration, fine woody debris appears to be equally important to species diversity (Kruys and Jonsson 1999).

The presence of large, well decayed down wood in managed stands can provide habitat for both ectomycorrhizal and wood-decay fungi, as well as plant seedlings. For some fungi, spore dissemination into disturbed areas is the primary method of re-establishment. Remnant stands of late seral forest neighboring managed areas may serve as refugia (Clarkson and Mills 1994). In addition, resistant fungal propagules may remain in soils or down wood after disturbance (Baar et al. 1999). Regardless of the method of re-establishment, it may take a great deal of time before fungal species can be detected.

The size and scale of down woody material influence the range in size of fungal individuals. Fungal colonies can range in size from microscopic to many acres and can persist for years or decades (Smith et al. 1992, De la Bastide et al. 1994, Bonello 1998). Typically fungi are patchily distributed, in part due to patchy distribution of substrate (living host plants, down wood). Scattered islands of down wood throughout a management unit, including many sizes

ranging from twigs to large logs, as well as a variety of decay classes, may provide better fungal habitat than one size or decay class of down wood homogeneously covering the forest floor.

Data on quantities or coverage of down wood necessary to support a diversity of fungi in Pacific Northwest forests do not currently exist. In the dry forests of western Montana, Harvey et al. (1981) estimated that 25-37 tons of down wood per hectare are needed to support ectomycorrhizal activity necessary for forest communities developing after stand removal.

Conservation

Threats to Species

Threats and impacts to fungi may occur at several scales. At a local habitat scale, impacts or threats could include anything that affects (removes, alters) the substrate on which fungi grow. Impacts may also occur on a larger scale as a result of the cumulative effects of many smaller local impacts. Local threats combined on larger scales could alter the distribution of populations across regional landscapes, resulting in the impairment of landscape-wide species persistence. For example, the loss of several populations within one area could truncate population continuity, inhibiting the ability of a species to disperse across distances. Such disjunct distributions can often result in expanding areas of extirpation. As cumulative effects may be difficult to address, perhaps the most useful strategy is to focus on what can be managed locally, assuming that cumulative effects will thus be minimized as well.

Larger-scale, indirect effects (such as global warming or air pollution) are difficult to assess, given limited knowledge of even microhabitat requirements of most fungi. The effect of larger-scale issues on fungi populations remains unknown, and cannot be adequately addressed with the management tools discussed in this document.

Management activities may pose direct or indirect threats to fungal individuals or mycelial mats, depending on the timing or intensity of the activity. Types of activities that can result in threats to fungal individuals or alter habitat conditions beyond a given threshold of tolerance include activities that:

- intensively or extensively remove or consume the woody substrate, forest floor litter, or shrub hosts with which the species is associated;
- remove or destroy the fungal organism;
- remove host tree species or significantly modify the microclimate at the species' site.

Below are listed general characteristics of some specific federal management actions that serve as examples of actions that may potentially threaten known fungal sites.

- **Actions that intensively or extensively remove or consume the woody substrate, forest floor litter, or shrub hosts with which the species is associated, such as:**

High intensity fire/burning
High intensity fires in any season may result in significant consumption of substrate (down logs and litter) with subsequent damage to fungi caused by high heat intensity or prolonged heat residence time. These effects are not universal and will vary with fire intensity, distribution, residence time, and fungal species present. Recognition that high intensity fires may be potentially harmful to some fungi populations should lend credence to efforts to restore forest health. Luoma (2005) has hypothesized that "fire may be important to the reproductive evolution of ectomycorrhizal fungi" and their results "add further impetus to the development of management plans that seek to restore forest health from the effects of decades of fire suppression."

The pattern of litter consumption may be patchy however, because of variations in fuel moisture. Low-intensity fires may allow litter to accumulate because not all fuels are consumed. This litter accumulation is beneficial to fungal survival before the next growing season (Evers 2001).

Densely spaced pile burning
Although there is not specific research, the biology of the fungi covered in this assessment indicates that pile placement and subsequent burning very near or over known sensitive fungi sites may result in localized mortality of mycelia filaments, but the organism as a whole (the underground mycelial network) may not necessarily be consumed by pile burning, due to the potential for extensive underground mycelial networks. If piles are densely spaced, more extensive mortality to the mycelia network may occur, resulting in the loss of the fungal site.

Mastication or chipping to reduce the fuel bed
These actions can damage or destroy duff and substrate layers on which fungi depend. In addition, excessive deposition of chipped material can smother fungi and potentially alter duff and substrate chemistry.

- **Actions that remove or destroy the fungal organism, such as:**

Extensive applications of long-term fire retardant/foam
Long-term fire retardants are effectively fertilizers, composed of ammonium phosphate and ammonium sulfate salts, which act by forming a combustion barrier between the fire and the fuel. The retardant remains effective until removed by rain or erosion. (Additional technical discussions are provided in Adams and Simmons 1999). There have been a few studies focused on the unwanted vegetation changes and reduced species diversity caused by additions of nitrogen and phosphorous to plants and soils, though the degree or persistence of effect of retardant application may be dependent on vegetation type as well as intensity of application. Brief summaries of studies conducted to date are cited in Adams and Simmons (1999). Although work to date is associated with vascular plants, it could be a reasonable assumption that the ectomycorrhizal fungi associated with these plants would be similarly affected. Changes to or reductions of plant species diversity will result in corresponding changes to or reductions in ectomycorrhizal fungal species diversity.

Intensive mushroom harvesting and raking
Raking in pursuit of fruiting bodies is harmful to litter saprophyte and mycorrhizal species, because it disrupts and/or removes the duff layer on which they depend. Raking may also be used to reduce fuel loading that has built up around the base of large, old trees; material is generally reduced to ½" diameter or less (Evers 2001). Recent work by Luoma et al. (2006) suggests that removal (without replacement) of forest floor litter is strongly detrimental to matsutake production, and that effects persist for at least 9 years. Although matsutakes are not a species of concern in this assessment, their biology and ecological response to raking and duff removal could be similar to that of other ectomycorrhizal species.

- **Actions that remove host tree species or significantly modify the microclimate at the species' site, such as:**

  Thinning, regeneration, shelterwood and green tree retention prescriptions where host trees are removed and canopy cover (which aids in the retention of forest floor moisture) is reduced to around 40% or less
  These actions can either remove the host tree species (resulting in the loss of the fungal organism), or alter the microclimate past a point where the fungal organism can continue to persist. Potential microclimate changes include modifications to air temperature, humidity, wind, water retention (in duff and logs), and solar exposure.

Known Management Approaches

Studies conducted in the Gifford Pinchot (WA) and Umpqua (OR) National Forests suggest that the use of dispersed green-tree retention, in combination with aggregated retention, is beneficial when sporocarp production and fungal diversity are management goals (Luoma et al. 2004, Luoma et al. 2005). A 75% aggregated green-tree retention treatment showed the least reduction in number of fruiting species. Although sporocarp production is not a SSSS program-level management goal, it may be a useful qualitative measure for predicting site persistence. Readers of this assessment are encouraged to refer directly to Luoma et al. 2004 and 2005 to obtain specifics on actual differences in sporocarp production associated with varying green-tree retention levels for development of management prescriptions.

Although Luoma's work (with others, 2004 and 2005) is not specific to the sensitive fungal species included in this conservation assessment, recommendations from this research could be considered where promotion of ectomycorrhizal habitat is desired. This work also suggests that truffles and mushroom species respond differently to disturbance from natural events or management actions. Events that promoted forest gaps (even as small as 1 ha) resulted in significant reductions of fall fruiting ectomycorrhizal mushrooms. Truffle production in the same gaps was not similarly reduced. The effects of forest fragmentation appear to be a selection for hypogeous sporocarp production over epigeous sporocarp production. Management strategies for rare truffle and mushroom species could recognize these very different responses to forest disturbance (Luoma et al. 2005).

Studies conducted in the Blue Mountains of Oregon suggest that the effects of seasonal prescribed fire on the below- surface ectomycorrhizal fungal community may vary with site

conditions, soil composition, and annual weather conditions. Weather conditions in this study for both spring and fall prescribed burns were similar: temperatures between 16-21 C, and relative humidity between 26-40%. Wind speed was also similar, between 5-11 kmh (Smith et al. 2004). Results from this study suggested that spring burning might be a better alternative than fall underburning if an objective is to maintain high fungal diversity.

Management Considerations

Management Considerations are actions or mitigations that a deciding official can use as a means of providing for the continued persistence of the species' site. These considerations are not required and are intended as general information that field level personnel can use and apply to site-specific situations.

Identifying an area to manage*:* Occupied fungal sites are evidenced by the presence of one or more fruiting bodies. Beneath these structures lies a complex system of mycelia, associated with living plant parts, wood, or the soil, which constitute fungal individuals. The extent of a fungal individual cannot be determined by the abundance and distribution of the reproductive structures alone. In addition, fungi are often patchily distributed, so that there could be much uncertainty about how much of the immediate surrounding habitat is occupied.

The objective of managing a fungal site is typically to maintain habitat conditions so that species viability will be maintained at an appropriate scale, in accordance with agency policies. Sites should have some data associated with the location of the fruiting body that can be used (in the absence of any other information) as an approximate focal point for management purposes.

Ideally, research tailored to each of the species in Appendix I would be used to describe management areas appropriate to the average organism size and habitat needs of that species. Although the volume of information on habitat needs and organism sizes is increasing, the overall availability of data remains sparse. Recent research suggests that genetic individual sizes for selected ectomycorrhizal species vary widely from 40m (Bonello et al. 1998) to 20m, 17m, and 10 m (Dahlberg 1997, Dahlberg and Stenlid 1995), to 18m (Bergeman and Miller 2002), to 9m and 1m (Redecker et al. 2001).

General Management Considerations: Current research and conservation strategies from British Columbia (Wiensczyk et al. 2002) emphasize some approaches which may help to maintain a diverse community of fungi (in this case ectomycorrhizal) across a landscape. These strategies suggest retaining refuge plants, mature trees, and forest floor integrity during timber harvest and mechanical site preparation; avoidance of high-intensity broadcast burns; minimizing the effects of host species shifts; and managing for coarse woody debris. Incorporating species sites into harvest patch retention areas (as described in the Northwest Forest Plan Standards and Guidelines 1994, C-41) may assist in providing for some of these key habitat elements.

Specific Management Considerations: Within areas identified for fungi site management, specific considerations include:

- *For actions that intensively or extensively remove or consume the woody substrate, forest floor litter, or host shrub species that the fungal species is associated with:*
    - Reduce or avoid hot burns within the managed fungal site. If burning is necessary or unavoidable, consider spring burns (or burning under spring-like conditions) to help maintain fungal diversity and reduce the potential for substrate loss and fungal root tip impacts.
    - Avoid piling, chopping, crushing, grinding, mowing, and chipping within the managed fungal site. If actions are necessary to reduce fuel loadings within the area managed for the fungus, consider placing piles and residual fuels outside of the management area, and retaining an array of larger woody material from a variety of decay classes.

- *For actions that remove or destroy the fungal organism.*
    - Discourage foam/retardant application within the fungal site under prescribed fire conditions or whenever practicable. If foam/retardant application is unavoidable, avoid direct application on any sporocarps, and consider leaving some larger down woody material unsprayed, to provide potential refugia/untouched habitat.
    - Discourage raking within the fungal management site. For raking associated with fuels reduction work, consider light raking to remove fine fuels, but minimize disturbance to the duff layer.
    - Discourage the issuance of commercial fungi collection permits in areas managed for fungal persistence.
    - In ground-based logging systems, keep skid trail density to a minimum, and use existing trails.

- *For actions that remove host tree species or significantly modify the microclimate at the species' site.*
    - Consider aggregating leave trees around the fungal site to mitigate the effects of the microclimate change. This can also serve to reduce potential impacts from the activity to the substrate or fungal organism.
    - Larger management areas/leave tree retention areas should be applied for sites in regeneration cuts vs. thinnings due to the differences in microclimate impacts surrounding the species site. Retention areas can also help maintain woody substrates associated with the fungal organism.

Additional measures could be considered within suitable habitat where species presence or absence is unknown:

- Consider conducting spring burns (or burning under spring like conditions) to maintain high fungal diversity. Duff accumulations around large trees could be gently raked from around the tree prior to burning to reduce potential harm to the trees and to minimize impacts to ectomycorrhizal communities living underneath.
- Remnant stands of late seral forest neighboring managed areas may serve as refugia. Scattered islands of down wood throughout a management unit, including

many sizes ranging from twigs to large logs, as well as a variety of decay classes, may provide better fungal habitat than one size or decay class of down wood homogeneously covering the forest floor.

- Maintain down wood in all stages of decay across forested landscapes. Many fungal species are associated with larger down woody material in advanced stages of decay.
- Maintain larger well decayed logs during stand treatments (fuels reductions and timber harvest). In younger stands, following disturbance or harvest, the presence of large, well decayed down wood legacy can provide habitat for both ectomycorrhizal and wood-decay fungi, as well as plant seedlings. For some fungi, spore dissemination into disturbed areas is the primary method of re-establishment.

Additional tools to assist in assessing project impacts and potential mitigation can be found on the interagency (Region 6 Forest Service and Oregon/Washington BLM) Special Status and Sensitive Species website: www.fs.fed.us/r6/sfpnw/issssp/planning-tools/ .

Research, Inventory, and Monitoring Opportunities

As discussed briefly in the life history section, the knowledge of life processes, as well as the nature of fungal habitat requirements or preferences, remains elusive for most fungi species. Still lacking are the research data needed to describe habitat parameters or environmental conditions that might provide for fungi persistence. Information is needed on apparent habitat preferences (habitat needs, local microclimatic conditions), species' range, relative abundance, distribution, effects of management actions, and on the extent to which the existing reserve systems provide for species' persistence.

Sites located in project areas could be revisited after completion of the project to evaluate impacts (if any) of the project to the site. Habitat conditions and characteristics might be monitored, instead of species' presence, if a connection between a particular habitat variable (soil temperature, moisture, site humidity etc.) and species presence is known or can be established. Monitoring the effectiveness of management practices could be completed through BLM District or FS Ranger District implementation and effectiveness monitoring programs.

Information is needed on the extent to which existing land allocations and Forest and Land and Resource Management Plans provide for species' persistence. This would include a larger scale assessment, which considers a variety of treatments, a variety of management area sizes, in a variety of habitat types.

Monitoring for cryptic or ephemeral species about which so little is known is challenging. New information could lead to additional management opportunities, and a chance to adjust levels of management accordingly.

In August 2006, a small interagency team assessed priority information and conservation gaps for the Region 6 FS and BLM OR/WA Sensitive and Special Status fungal species. The

following represent the gaps that the team determined to be most pertinent to address to assist FS and BLM management of these rare fungi:

- Develop a more detailed description of habitat for each species, including general habitat (plant community) and hosts/substrates
- Determine where regional level distribution gap surveys may be needed and conduct surveys.
- What are the effects of:
    - fuel reduction treatments in different eastside forests?
    - thinning and regeneration harvest in westside forests?
    - chemical applications (herbicides for noxious weeds, foam from fires, fertilization)?

Tasks to address these gaps were developed, with efforts expected in FY07-09. For a full list of the gaps that the team developed, see Appendix III.

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