Data Submitted (UTC 11): 3/30/2024 5:36:27 PM
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Title:
Comments: Dear Planning Team

For about 50 years now, scientists around the world have agreed that there is an entire kingdom of life that is neither plant nor animal nor bacteria. These organisms are essential to providing every essential ecosystem service mentioned in the forest planning documents, from water purification and soil erosion to nutrient transport and carbon sequestration. Why is the northern boreal conifer forest such a significant carbon sink? From where do conifers obtain the equivalent of 1300 pounds of nitrate per acre? What is the reason for post management regeneration failures?

Over 51% of the living biomass in a forest is found underground. Trees receive most of their water and all their mineral needs from this biomass source, and no conifer sapling can survive long without its mycorrhizal partner. I have just managed to talk about fungal processes and ecosystem functions without using the word "fungus", something most USFS planning documents have managed to do for the 50 years since global recognition of fungi was established among the scientific community.

It is because of this failure to acknowledge fungi and recognize the importance of their roles in forest health that discussions about ecosystem management fail. You can't fix the car if you ignore the motor.

Around the world there is a movement by mycologists to remedy this problem. Guliana Furci of the Fungi Foundation has seen legislation approved that includes the fungi kingdom into with existing provisions and protections for flora and fauna and environmental impact assessments in Chile, and efforts are well underway in Colombia and Scandinavian countries to enact similar legal provisions and protections that recognize the importance and vulnerability of fungi and the subsequent need to address the needs of these organisms. Nations worldwide have long recognized the importance of non timber forest products(NTFP) such as edible mushrooms and traditional medicines, especially for vulnerable rural communities.

The United Nations FAO tracks the importance of forest products to local economies around the world and their role in food security, rural poverty, and child welfare. Their website below lists hundreds of examples of these nonwood forest products and their impact on rural development.

Yet due to outside influences, forest management here has been focused on cutting trees to the exclusion of developing more immediate and lucrative forest products and local value-added cottage industries. The USFS Young Stand Study (Pilz et.al 1999) indicates that nontimber forest products have significant economic and ecological benefits that increase over the lifetime of the tree. Schlosser and Blatner estimated in a 1992 study that matsutake mushroom harvest income surpassed the value of the wood produced by hemlock tree hosts after 20 years of harvest, in habitat similar to that found on the Lolo.

Despite the importance of fungi, they are unmentioned in the previous Lolo forest planning process. There are historical reasons for this omission. Until 1972 Fungi were grouped with Kingdom Plantae, and legal documents made no distinction; legally fungi were plants. Then the International Botanical Congress, the body that decides taxonomy and systematics officially declared Fungi to be a separate biological entity from plants based on a better understanding of their biology. Unfortunately, the legal system has failed to keep up with this important scientific development, and to this day fungi remain legally invisible and as such lack such necessary protections as the law assures recognized entities.

We propose that Fungi be included in all assessments, declarations and statements and in all decision making processes while considering timber and nontimber resource decisions, proposed developments, mining etc.

Under 219.3 Role of Science in planning "the responsible official shall use the best available scientific information to inform the planning process required by this subpart." Using a pre 1972 taxonomic classification ignores the 50 years of scientific knowledge we have gained regarding fungi and the key role they play in forest health. This does not constitute "best available scientific information" that has occurred in our lifetime.

In section 219.6 Assessment, a)1. "Identify and consider relevant existing information:" We would like to include species lists of fungi dating from 30+ years of commercial and noncommercial harvest, since the real value of these mushrooms has not been considered in forest management decisions. A species list from Western

Montana Mycological Association events in 1997 and 1998, and a baseline species list compiled by the Pacific Northwest Key Council in 1999 lists some 1700 species in this study area, are cited below as examples of existing available information.

a)2. We seek "opportunities.. To provide information for the assessment" to the process officers

In section 219.6 (b) Content of the Assessment for plan development or revision, we see that 12 of the 15 assessment points are measurably impacted by the legally invisible fungi.

Assessment of terrestrial ecosystems, aquatic ecosystems, and watersheds is hampered by the fact that few if any have had their fungal elements identified. Fungi play a key role in removing cations from water, store and transport water during drought, and are a predominant food source for invertebrates and small mammals. A list of 20 proposed fungal species of local special concern is included in the appendix, and 70 species of special concern can be found in PNW-GTR-572, Castellano et.al. cited in the bibliography.

The Pacific northwest Key Council 1999 baseline lists 1700 species from this region, including mycorrhizal species associated with mineral transport for conifers, species key to trees drought survival, essential wildlife food, each with unique characteristics and environmental requirements.

Air, soil, water resources and quality: fungal spores nucleate precipitation formation, which has a critical impact on the timing and volume of precipitation events. Fungal hyphae maintain and control virtually all the available moisture in forests during drought, and are key to recovering moisture from condensation and transporting moisture from BCR. (Chris Maser, et. al)

System drivers. Fungi are key to propagation of invasive plants, preventing soil erosion, and wildland fire recovery; over a quarter of all Ascomycete species reproduce only after a forest fire, and fungi supply essential water and minerals to the recovering forest. (Pilz 2007)

Brown Cuboidal Rot (BCR),a breakdown product of trees and fungi, is the primary reservoir of available soil moisture in our Rocky Mountain forest ecosystems. All seedling survival depends on the presence of BCR. Survival of fungal hyphae depends on factors such as soil compaction, organic matter availability, and soil temperatures, which are in turn dependent upon aspect, shade and ground cover.

Carbon sequestration and nutrient cycling are ecosystem-wide meta processes that are directly related to forest health and trees' ability to adapt to climate changes. The ability of the fungus to carry out these vital ecosystem services has evolved over millennia and depends upon a continuous supply of food. That food source, unsurprisingly, is ultimately the trees themselves. "Roughly half the energy captured by photosynthesis is used for the life processes of the tree, and over half of what remains in leaves and roots are consumed by insects,fungi, and the animals dependent on it (and almost a third of what remains is below ground). Most of the massive productivity of forests is not in stem wood." (Wittbecker 1997)

Coarse woody debris (CWD) is a critical component of our montane forest soils. It "contains very significant stores of carbon and energy and is the foundation of an important forest food web. This large material usually decays more slowly and therefore provides a more steady input of energy and nutrients and longer lasting structures. For example, approximately half the time that a mature Douglas fir is in an ecosystem, it is as dead wood." (Stevens, 1997)

Besides its current status as a star in long term carbon storage, CWD adds carbon to the soil, which increases its relative fertility significantly, provides a site for conifers to regenerate, and is a significant and key retainer of moisture, as well as physically slowing erosion and concentrating mineral nutrients.

Studies by Maser et.al showed that CWD retained 250% its weight in moisture even during summer, providing significant amounts of moisture to trees during this critical period. When CWD is absent, seedling survival plummets. Requiring CWD to be left on-site post harvest is essential for the survival of the mycelium that waters the trees. (Stevens 1997)

Dry forests tend to be nitrogen limited.(Harvey et.al 1987) the most efficient nitrogen fixers are on the root nodes of alder, but the free-living soil bacteria, often farmed by fungi, are the most common source.

Assisted by their mycorrhizal partners, the fungi are very effective at sourcing nitrogen, potassium, and phosphorus from decaying wood. The result is a soil organic layer poor in nutrients that constitutes the planet's most important carbon sink. (Smithsonian 2013)

CWD is a nutrient source for decades as it plays host to nitrogen fixing bacteria and fast growing and fast decaying fungi that elevate levels of available N, P, and K at levels far higher than the wood itself. (Harmon et.al

1994)
Attracted by the shelter CWD offers, many invertebrates key to the survival of the food chain harbor here. As most are flightless, they are slow to reestablish after a fire. CWD is also home to budworm foraging ants, found on roughly a third of downed wood samples. (Torgersen and Bull, 1995)
It is key to remember that fungi, like animals, can starve to death. A mycorrhizal network is sustained by the natural attrition of needles, branches, and windthrow, and if this food supply is interrupted, the fungus must turn elsewhere. Insuring a continuous food supply for the mycorrhizal fungi must be considered in all timber harvest proposals, as this directly impacts the ability of the forest to regenerate. (Stevens,1997)
Biochar is another overlooked element of our soil carbon content that is important for tree growth and nutrient storage. Valuable for industrial applications and key to regeneration after a fire, thousands of tons of potential biochar are currently being wasted by bottom-lighting slash piles. While top-lighting burn piles still oxidizes 90% of the wood mass, charcoal produced by low oxygen pyrolysis maintains the cellular structure of the wood, and the reduced carbon is an excellent electron acceptor that acts as a mineral reservoir and persists for decades. This simple change in forestry practice is now being adopted in eastern Washington state. (G. Flora, 2023; pers. comm.)
Biochar is also recognized for being a primary component of terra preta, the famous black soil of the Amazon that has enhanced soil fertility by orders of magnitude for centuries. Naturally occurring biochar and BCR constitute the organic material in our montane soils, and provide the primary platform for nutrient (cation) exchange. An extensive literature can be read by searching the term "terra preta"
Fungi play a pivotal role in forest ecology. As nutrient recyclers, decomposers, and symbionts, they provide trees with 85% of the water and 100% of the minerals they need. As carbon sinks, fungi sequester over a third the carbon in a forest below and in the soil. As ecosystem services, fungal hyphae play an irreplaceable role as water filters and reservoirs. Mushrooms serve as a primary protein source for dozens of mammal and hundreds of insect species, boosting biodiversity and maintaining ecosystem integrity. Indeed, fungi are one of the key sources of essential amino acids that humans cannot make themselves.
4) Carbon stocks: Fungi constitute the majority of soil carbon in northern boreal forests (Smithsonian, 2013) and fungal tissue contains roughly 700 times as much nitrogen by weight as plant tissues, due to the nitrogen containing chitin molecules that make up the fungal cell wall.
Management objectives need to include minimal provisions for the survival of mycorrhizal fungi, which support tree growth, by allowing sufficient organic matter after thinning, including coarse woody debris (CWD) and top lighting rather than bottom lighting slash piles in order to optimize byproduction of biochar. Minimum post harvest requirements of tonnes CWD/Ha have been instituted for BC timber sales in order to slow the loss of soil carbon. (T. Ehlers, pers. comm) Is there an analogous USFS policy to retain soil carbon?
The use of "fuels rhetoric" is prevalent across USFS documents. This oversimplified depiction of wood as fuel distorts the real role that wood plays in the forest ecology, which is more sponge than tinder. The mix of biochar and BCR that constitute the organic component of our montane soils is crucial for the survival of the forest. Researchers at the UM Fire Ecology Lab expressed to me their surprise that large volumes of BCR remained unburned on the ground even as standing trees had been burned branchless in the burn sites they surveyed. After 35 seasons visiting burn sites, I can verify that BCR is a primary component post fire recovery, and often survives even intense blazes due to its ability to hold moisture.
"Organic matter influences physical and chemical properties of soils far out of proportion to the small quantities present. It commonly accounts for at least half the cation exchange capacity of soils and is responsible perhaps more than any other single factor for the stability of soil aggregates."
The Nature and Properties of Soils Nyle Bradley

5) Fungi have only been surveyed in a few districts in R1 and R6. Rare and threatened species of fungi remain largely uncataloged throughout Montana, Idaho, and Wyoming. More surveys are needed, as unique and endemic species are being discovered and vouchered in Canada but the USFS lacks a system for recognizing, reporting, vouchering, and managing such collections. When unique and valuable species are found, nothing can be done about it. During our recent US-Canadian joint bioblitz of Glacier Waterton International Peace Parks, the only way to record the species and analyze its DNA was to send the specimens to Ottawa.

6) Nontimber Forest Products (NTFP) harvest, especially mushroom harvest, varies locally and is erratically enforced at best. A 2017 survey of mushroom hunters found multiple forms, fees, and regulations were in use, and sometimes multiple forms were used in the same jurisdiction.

The legal invisibility of fungi contributes significantly to the devaluing of this resource, which exceeds the value of the timber in several ecosystems, obvious examples being matsutake and chanterelles which grow in lodgepole/subalpine fir habitat. Other important NTFP include floral greens harvest, medicinal plants, boughs and xmas trees, and traditional harvests.

7) Recreational Mushroom picking is a benefit that over 2000 members of the Western Montana foraging community enjoy every year. Our organization the WMMA offers monthly educational activities and two weekend long camping forays every year, and is part of a growing community of foragers that now includes several social media groups and thousands of members. For more information about recreational mushroom hunting, visit montanamycology.com

8) Commercial morel harvest is an important source of income in rural and native communities. In the period since 2000, fires near Thompson Falls, Troy, in the Bitterroot, and elsewhere in northern Idaho and western Montana have produced tons of morels for markets around the eastern United States, Western Europe, and the Far East. Selling at a fraction of global retail prices, much of the morel harvest in western Montana fails to compete with regions with better transportation infrastructure, such as Oregon.(Evans, pers. comm) Despite this lack of infrastructure this important nontimber forest product is a significant source of income for many rural communities, and value-adding technologies can magnify that income. (In Cold Margins, Brownson 1995)

9) Mushroom hunting is a recreation opportunity that has limited access requirements. Many members of the Western Montana Mycological association with mobility issues are nonetheless able to participate in mushroom hunting on a regular basis. Foraging often happens within earshot of their vehicles. Roadside vegetation management has a huge impact on their experience.

10) na

11) na

12) Morel harvest brings tens of thousands of dollars into Indian Country. Illegal harvest by outside commercial harvesters has negatively impacted local benefits in the recent past. (Wright,F. pers. comm)

13) You cannot manage that which you cannot measure. The legal invisibility of fungi precludes measuring any cultural or historic uses. A brief synopsis of traditional uses of fungi by indigenous peoples is in the bibliography. A more comprehensive examination of the use of fungi in traditional medicine can be found in the Fungal Pharmacy by Robert Rogers. Fungi are a significant source for developing new pharmaceuticals and novel organic compounds. (below)

14) na

15) Special areas designation for NTFP harvest is needed. When the value of annual NTFP harvest exceeds 10% of the timber, area should be assigned a status outside the timber base, and income evaluated on a decadal basis' versus that of the timber value.

There are already cases where two valuable commercial species of edible mushroom, chanterelles and matsutake, grow in lodgepole/subalpine fir habitats that have low values for timber production. Despite the value of the mushrooms produced annually, such habitat is often the target of money losing timber management practices that have resulted in negative impacts on mushroom harvest without generating revenue or environmental benefits.

NTFP permitting and management has been an administrative and budgetary subset of the timber administrative budget, and as such has had no vehicle for expressing or challenging the economic or environmental impacts caused by timber harvesting on mushroom and berry production, nor do proposed management actions consider actions to improve or maintain NTFP productivity.

Post fire timber salvage sales have a history of disrupting morel mushroom harvest through road closures, etc. during the short one month season. I'm personally familiar with two times that logging operations were delayed to allow morel harvest, by tribal decision. (Red Eagle 2007, Seepay 2017) I have yet to encounter similar accommodations from federal agencies.

Known patches of edible mushrooms are being lost every year to authorized and unauthorized road building, logging, and other development, but there is no way to register these patches or to evaluate their importance in

the ecosystem where they occur or the value they hold and provide for local humans and wildlife.
Likewise, the value of mushrooms to wildlife is widely overlooked and underestimated. Few realize that 85% of the protein diet of flying squirrels comes from fungi (Rosentreader, et.al.) and that locally deer, elk, bear, and small mammals all consume multiple species of mushrooms. Elliot et.al, have researched reports of fungivory in the scientific literature, revealing that thousands of species of mushrooms are eaten by hundreds of species of mammals and invertebrates worldwide.
The value of the fungus in the ecosystem is not only that of the nutrient rich mushrooms but also the "ecosystem services" that it has provided continuously for the growing trees. This involves provision of most of the water and all the minerals that a conifer tree uses to live and grow. While the dollar value of the mushrooms may be taken into account, it is a mere shadow of the real value the fungus holds for the ecosystem itself. Remember that this is a network that contains miles of hyphae in a handful of soil that has taken millennia to develop.
Even more important than this legacy of ecosystem support is the cost of replacing this support. Reestablishing mycorrhizal networks artificially is unproven, limited to certain species and conditions, and proceeds slowly in drying conditions. Additionally, higher soil temperatures (caused by lack of shade or cover) result in higher rates of evaporation which stress both fungi and plants.
All this means attempts to replace existing mycorrhizae are difficult and expensive, and conservation of existing mycorrhizal networks needs to become a priority for forest managers.
Forest management needs to become at least as well educated about the role of fungi in the forest as the average secondary school student, and as a veteran secondary science teacher, I can assure you that is not the case today. Failure to incorporate language that acknowledges fungi as separate from plants, and ignores their existential requirements, is to deny 50 years of scientific advancement and ignores the expanded understanding of these organisms that an entire generation of Americans has now grown up with.

Resource about European forest guidelines (especially 5.1): http://www.eccf.eu/Guidance_Fungi.pdf

In Switzerland, although there are many IUCN red-listed fungi, they focused on 12 of them and made pamphlets to recognize them and hand out to park managers to be aware of them and prevent picking of such species: https://swissfungi.wsl.ch/en/species-promotion/fact-sheets-on-support-measures-of-twelve-endangered-species.html example pamphlet here: https://swissfungi.wsl.ch/fileadmin/user_upload/WSL/Biodiversitaet/Artenvielfalt/Pilze/SwissFungi/Artenmerkblaetter/12101.pdf

Some research articles involving forest management <> fungi:
https://www.sciencedirect.com/science/article/abs/pii/S0378112719313234
This is how there can be some joint symbiosis between timber industry and fungi:
https://link.springer.com/article/10.1007/s10342-012-0649-y
Another article on supporting leaving dead wood:
https://www.sciencedirect.com/science/article/abs/pii/S0378112713002880
Monitoring of fungi <> forest managemnet, and some examples from europe:
https://annforsci.biomedcentral.com/articles/10.1007/s13595-014-0447-4

For the assessment addition:
The pharmaceutical industry relies heavily on fungi for the development of new drugs, with estimates suggesting that up to 50% of all medicines come from natural products, many of which are derived from fungi…(with no/extinct fungi, then we might not find novel medication) https://link.springer.com/article/10.1007/s13225-011-0116-y

Although the US is not part of the CBD protocols, the malawi principles are still interesting one that is about forest management. Then, this "EUROPEAN CHARTER ON FUNGI-GATHERING AND BIODIVERSITY" (https://rm.coe.int/0900001680746764) ties the principles with mushroom foraging in ecosystems and has some guidelines in place

Interactions between fungi, forest management, and ecosystem services:

Appendix:
Species of special concern, now including fungi

All of these are endemic to Region 1. These species are largely mycorrhizal and all are dependent upon the mixed coniferous forests of the northern Rockies. They all sequester carbon, nitrogen, and water in their life processes and are a primary source of amino acids for the rest of the ecosystem.

Russula brevipes, a keystone species in forest ecosystems around the Pacific northwest and the Rocky mountains, boasts more interconnecting relationships than any other, being not only a mycorrhizal associate of most conifers but also several species of heterotrophs, including plant species of special concern, and hosts the ascomycete species Hypomyces lactifluum, which is the commercially traded lobster mushroom.
Hericium abetinus, the conifer-loving species of lions mane or bears head mushroom, is rare to infrequent throughout our regions. It's European counterpart was redlisted and collection of wild hericium in England for example is punishable by jail time! Related species are being cultivated commercially after discovery of medicinal neurogenic compounds produced by these fungi.
Geopyxis carbonicola group, a key element in every northern boreal ecosystem, the fire cup forms mycorrhizae with virtually every plant in every conifer forest, making it an integral component of the mycorrhizal web. In Alaska, I saw that the limits of the forest exactly corresponded to the boundaries of the presence of Geopyxis, which fruits after a forest fire.
Rhizopogon spp. are hypogeous truffles related to Suillus spp. that form subsurface fruiting bodies which are energy and protein rich, drought-resistant, and mycorrhizal with lodgepole, juniper, Doug fir, and Ponderosa pine. These are a key protein source for elk, squirrels, and gestating deer, Trappe et.al. reported deer scat collections during August were found to contain primarily undigested rhizopogon spores.
Lactarius deliciosa group are mycorrhizal with conifers and deciduous shrubs, and while they are food for invertebrates, these highly nutritious mushrooms are often ignored by forest mammals here. In Europe the corresponding species, which I have sampled, is much sought after for its vitamin A and C rich mushrooms. Recent studies show that agroforestry plantations of oak and related Lactarius indigo produce more protein more efficiently than conventional farming.
Cantharellus spp. aka chanterelles are a group of highly prized commercially valuable mushrooms that are mycorrhizal with fir and spuce and cannot be cultivated. Rich in proteins and vitamins, they are indigestible raw, and largely ignored by wildlife. Their presence indicates primarily undisturbed habitat, and is a good indicator of forest health. The mycelium are easily killed by soil compaction from heavy equipment.
Morchella sp are native highly prized commercial species. So called fire morels appear after a forest fire and annually attract pickers from around the continent. Individual fires have yielded morel harvests valued in the millions of dollars, much of which are sold to European and Asian markets. (Pilz et.al 2007)
Suillus spp are a keystone species complex and a primary source of amino acids in our ecosystems. These mycorrhizal species are key to the survival of all pine seedlings and form myriad relationships with other plants, fungi, and heterotrophs. Suillus mushrooms are the ubiquitous spongy slippery jacks, and are eaten by humans, ursines, ungulates, small mammals, and invertebrates.(Elliot, 2023)
Cortinarius caperata, aka Rozites, one of many dozens of members of this little studied family of mycorrhizal fungi, has shown antiviral properties. (Spatafora, et. al.) one of few Cortinarius eaten by people, but wildlife consume a wide variety and enormous volume of mushrooms in the Cortinarius family.
Ramaria spp the coral mushroom group, mycorrhizal with fir and pine, spring food for elk, a key protein source for wildlife in the spring. Needs full canopy and BCR rich forest soils, hyphae easily damaged by compaction. Some spp eaten by humans.
Hygrophorus spp, the waxy caps, are an important source of food for wildlife. they form mycorrhizae with all

conifers, as well as deciduous shrubs, and even grasses. These high energy mushrooms are important food for bears emerging from hibernation and overwintering deer and elk.
Fomitopsis pinicola, the red belt conk, is essential for soil building in our region as it creates brown cuboidal rot, (BCR) which is the primary vehicle for water retention in our western forests. A traditional medicine, the conks can also be felted into a leathery material for hats and handicrafts. Previously dismissed as common, its infrequency mirrors a decline in forest health.
Fomitopsis officinalis, aka agarikon, aka quinine conk, has been highly valued for its medicinal value since the days of the second world war, when the local government purchased conks that people shot off the sides of trees with .22s for use as anti malarial drugs. Paul Stamets recently published evidence of its efficacy against several viruses, from smallpox to influenza. It is rare and endemic to mature and overmature Doug fir, larch, and fir.
Boletus edulis group are mycorrhizal with conifers in our area and reliably produce volumes of delicious edible mushrooms. Their presence is also an indicator of a healthy forest, and often associated with
Amanita muscaria group often found in association with B. edulis, these toxic and medicinal mushrooms have a long history in many cultures. An integral part of the ecosystem, they form mycorrhizae with conifers and are food for mammals, birds, and invertebrates. Both species are indicative of forest health.
Tricholoma murrilli, aka T. magnivelare, aka matsutake, aka pine mushroom, enjoys enormous popularity in Asia, where it is widely considered a delicacy. Price surges in the past made matsutake hunting a lucrative lifestyle, now somewhat diminished by alternative sources. Still a commercially important mushroom and export, mycorrhizal with pine and fir in harsh environments.
Sparassis radicata aka cauliflower mushroom, a highly prized edible, indicative of old growth habitat, easily destroyed by habitat disturbances, increasingly rare.
Pycnoporus sp. local to the Lolo National Forest, have demonstrated superior lignase activity, producing a bright, high tensile pulp that matches or exceeds that produced by conventional chemical processes. It is now being used by pulp mills in Argentina. Information about bio pulping can be found at science direct/pycnoporus. Also used to break fever in traditional medicine, its use is reported from both Canada and the Amazon.
Truffles, including Tuber spp. are critical mycorrhizal partners and a vital component of the diets of small mammals in the Northern Rockies. Rosentreader et. al (blm biologist) reported that 85% the protein needs of flying squirrels were sourced from fungi. Some species are of commercial interest. Truffle populations are known to be impacted, and the species mix changed, by silvicultural practices. The removal of the host tree, high soil temperatures, and soil compaction will heavily impact production of truffles (p136; pnw gtr 772, april 2009)
Our organization has recorded more than 40 species of hypogeous fungi during Western Montana Mycological Association events and forays since 1992.

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submitted for the Western Montana Mycological Assn.