



# **Ecological Roles of Soil Fungi: Management Implications**

**Raini Rippy**

**Deborah S. Page-Dumroese, Ned B. Klopfenstein,  
Mee-Sook Kim, Paul J. Zambino, and Marty F. Jurgensen**

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- All fungi are heterotrophs
  - obtain energy from organisms than can photosynthesize
- Some fungi are saprophytes
  - obtain energy from dead organisms
- Some fungi are biotrophs and/or symbionts
  - obtain energy from a living host
  - mycorrhizae, lichens, pathogens

**Fungi comprise 60-90% of microbial biomass in forest soils**



# Primary Functions of Fungi

- Decomposition of organic matter
- Carbon cycling
- Movement of water and nutrients
- Protection against some root pathogens



# Groups of soil fungi

- Saprophytes
- Pathogens
- Mycorrhizae
- Antagonistic fungi
- Endophytes
- Lichens





# Ecological Roles: Root Disease

- Important part of succession
- Openings provide food and shelter for wildlife
- Openings provide light and space for regeneration
- Contribute to nutrient recycling and soil formation





## **Root rot fungi can alter the structure of a forest**



**Seral and more root rot-resistant species replace climax and less tolerant species, creating a mosaic pattern in the forest and maintaining diversity of both the trees and soil organisms**



# Ecological Roles: Saprophytes

- Dominant recyclers of carbon and organic nutrients in forest debris
- Important in litter decomposition, nutrient cycling, and energy flow
- Create decay products (white, brown, cubical, and stringy)
- Capture and retain nutrients that might be leached from root zone



# Brown rots

- Soils with high contents of brown rot residues have increased water-holding capacity
- Can remain as humus in the soil for 300 years
- Soil layers with brown rot residues are major sites of ectomycorrhizal root development
- Make up to 30% of the soil volume in the upper foot of coniferous forest soils
- Brown cubical rots are also sites of nitrogen fixation





# Ecological Roles: Mycorrhizae

- Increase plant nutrient supply
- May aid in seedling establishment
- Important food and habitat for invertebrates and vertebrates
- Contribute to carbon storage in soil by altering the quality of soil organic matter



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# Ecological Roles: Antagonists

- Antagonistic fungi can be used to control pathogens, insects, nematodes through one of the following mechanisms:
  - Antibiosis
    - metabolic product of antagonist fungus inhibits or destroys another organism
  - Competition
    - antagonist fungus directly competes for another organism's resources (e.g. space, nutrients, oxygen, etc.)
  - Mycoparasitism
    - antagonist fungus invades another organism



# Ecological Roles: Lichens

- Lichen metabolites contribute to biogeochemical weathering of rock and soil formation
- Nitrogen fixation
- Food and nesting material for other organisms
- Release important nutrients (N, K, P, S) when they decompose
- Used as indicators of atmospheric pollution



# Ecological Roles: Endophytes

- Endophytes colonize living plant tissue without causing any immediate, negative effects
- May help with storage and distribution of nutrients and carbohydrates around the plant
- Produce beneficial secondary metabolites/chemical compounds
  - antibiotic/antimicrobial activity



# Fungi and Soil Formation

- Bind and aggregate particles
- Increase water retention in soils, thus increasing chemical weathering processes
- Release mineral nutrients in rock and organic matter for use by other organisms
- Some microfungi and lichens are components of biological soil crusts

# Nutrient Cycling

- In organic soils, the nutrient pool is largely derived from the mineralization of plant litter by microbial activity
- Fungi are the dominant decomposers in aerobic environments
- Basidiomycetes (white and brown rots) are the most important forest floor dwelling fungi in recycling carbon stored in wood
  - Fungi causing brown rot can be the major agents of carbon and mineral nutrient release from wood in coniferous forests





# Social Value of Fungi

- Wild edible mushroom harvest
- Sources of medicines and natural dyes
- Culture and folklore



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# Industrial Applications of Forest Fungi

- Biological control
  - Root diseases and wood decay
- Biodegradation
  - Resin acids
  - Wood preservatives
- Biopulping
- Bioremediation





# Management Implications

Timber harvesting, grazing, fire, and application of fertilizers, herbicides, and pesticides can result in:

- reduction in soil organic matter levels
- changes in soil temperature and moisture
- changes in soil pH

which can negatively effect distribution and diversity of soil fungi

# Organisms Regulate Ecosystems

- Seral species are more tolerant of endemic insects and pathogens than climax species
- Activities of these endemic organisms tend to “rogue” climax species and stressed trees
  - encouraging domination by seral species intermixed with “best adapted” individuals representing climax species



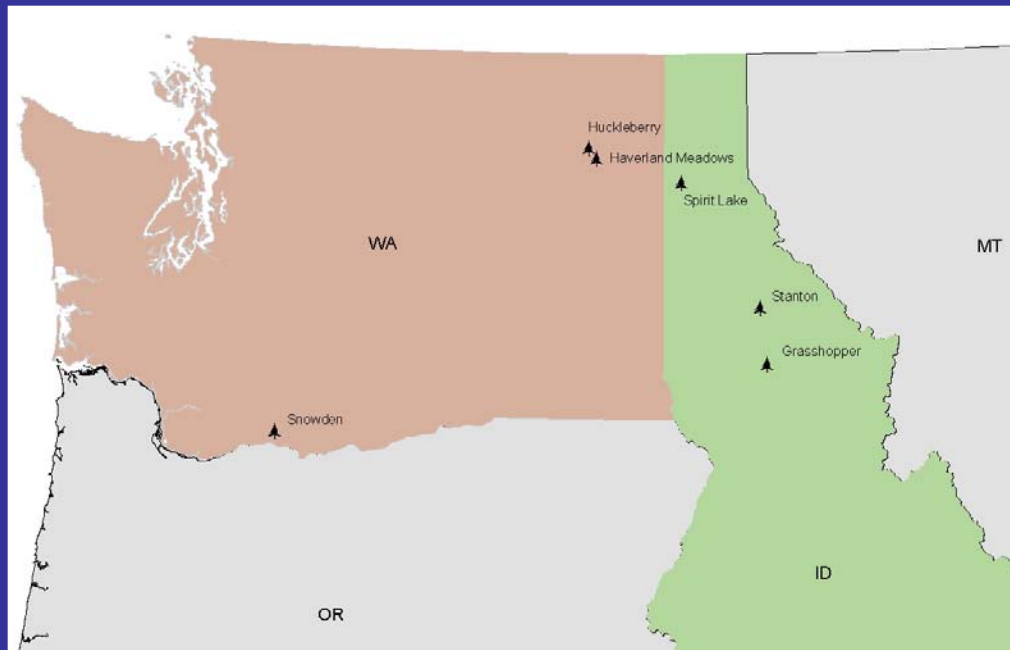
# Wood Stake Decomposition Study Update





# IFTNC Forest Health Sites

<u>Installation</u>	<u>Parent Material</u>	<u>Habitat Type</u>
• 336 Spirit Lake	Glacial till	THPL/PAMY
• 338 Snowden	Basalt	ABGR/ACCI
• 341 Grasshopper	Granite	THPL/ASCA
• 354 Huckleberry	Metasedimentary	ABGR/CLUN
• 355 Stanton	Metasedimentary	THPL/ASCA
• 362 Haverland	Granite	ABGR/PAMY

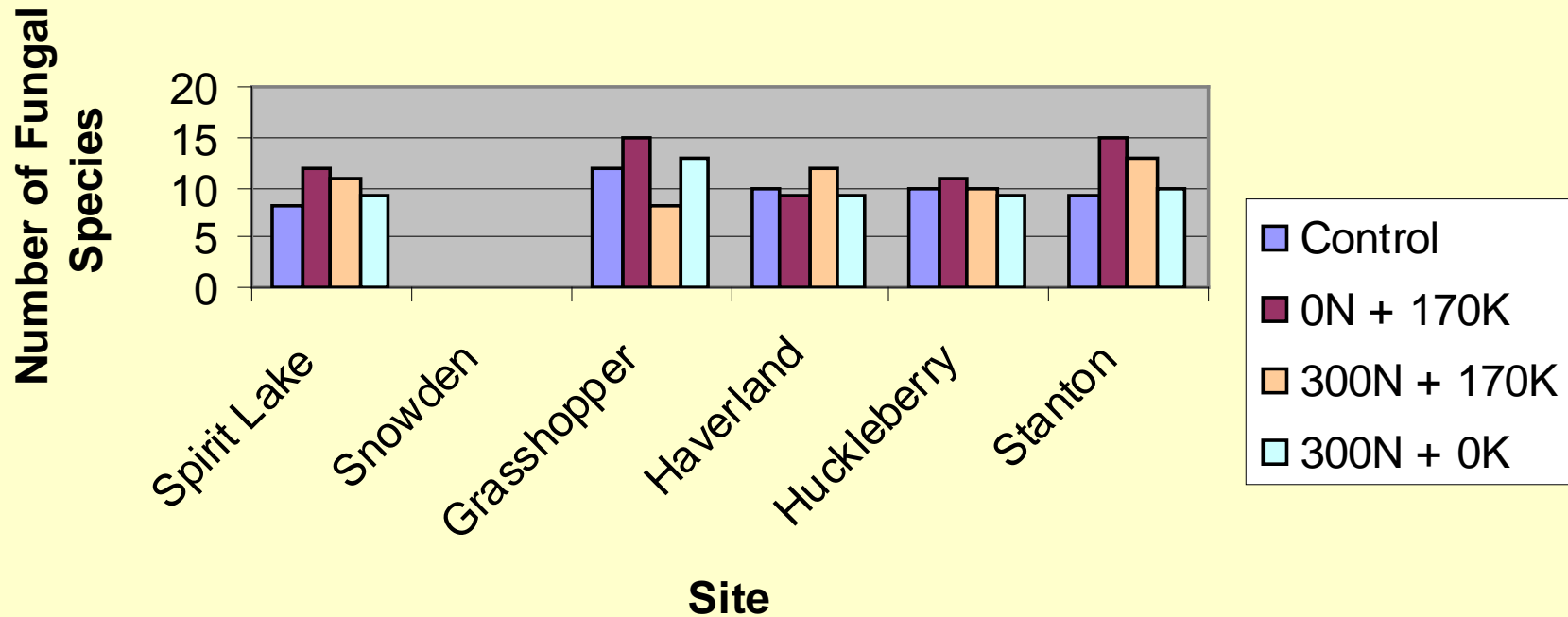


# Preliminary Results

- Fungal isolations from stakes are completed
- Total number of stakes sampled = 3090
- Total number of isolates identified to date = 1329
- Total number of fungal isolates to still be identified ~ 250
- No collections were made from Snowden in spring 2004 – site was harvested
- Soil samples will be collected from five sites this spring



## Distribution of Fungal Species on Both Insertion and Interface Stakes From Spring 2004 Stake Extractions



# Tools Available for Managers

- Species and population structure of fungi can be identified using molecular tools
- Molecular genetic techniques and GIS are helping to detect and predict diseases, such as root diseases
- Ability to identify forest fungi will help studies determine effects of management on these fungi

# Summary

- Soil fungi form chemical and physical components, such as aggregates, involved in maintenance of structure and fertility in forest soils
- Important functions of soil fungi include nutrient cycling, nitrogen fixation, protecting trees against soil pathogens, contributing to soil structure, and improving soil moisture holding capacity
- Soil organisms are vital to ecosystem sustainability



# Conclusion

- Specific habitat needs of most fungal species are poorly understood
- Therefore, it is difficult to develop management objectives that address both timber production and maintenance of soil fungal communities
- Further research is needed to examine effects of forest management on soil fungal communities and subsequent soil quality/health

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# References

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