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Ecology and Management of Morels Harvested From the Forests of Western North America

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Cover Art

Peeling bark on the log illustrates the tendency of morels to fruit following tree death. Morels can differ widely in color and shape depending on species, genetic diversity, age, exposure to sunlight, and other environmental conditions. Original painting by Paula Fong (http://www.prfong.com)

Abstract

Pilz, David; McLain, Rebecca; Alexander, Susan; Villarreal-Ruiz, Luis; Berch, Shannon; Wurtz, Tricia L.; Parks, Catherine G.; McFarlane, Erika; Baker, Blaze; Molina, Randy; Smith, Jane E. 2007. Ecology and management of morels harvested from the forests of western North America. Gen. Tech. Rep. PNW-GTR-710. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 161 p.

Morels are prized edible mushrooms that fruit, sometimes prolifically, in many forest types throughout western North America. They are collected for personal consumption and commercially harvested as valuable special (nontimber) forest products. Large gaps remain, however, in our knowledge about their taxonomy, biology, ecology, cultivation, safety, and how to manage forests and harvesting activities to conserve morel populations and ensure sustainable crops. This publication provides forest managers, policymakers, mycologists, and mushroom harvesters with a synthesis of current knowledge regarding these issues, regional summaries of morel harvesting and management, and a comprehensive review of the literature.

Keywords: Morel mushrooms, *Morchella*, forest management, special forest products, nontimber forest products, edible fungi.

Summary

Morels are the fruiting bodies of species in the genus *Morchella*. They are prized edible mushrooms that fruit, sometimes prolifically, in many forest types throughout western North America as well as in temperate forests globally. They are commercially harvested and sold locally, nationally, and internationally. Annual commerce in morels likely ranges in value from $5 million to $10 million in western North America; thus they are one of the more valuable special forest products in the region. Large gaps remain, however, in our knowledge about morels. Their taxonomy is confusing and most North American species lack valid scientific names. Their biology, nutritional sources, life cycle, and modes of reproduction are unusual and complex. Ecologically, we do not yet fully understand how and why some morels fruit prolifically following tree death, wildfire, or other forest disturbances. Efforts to cultivate morels have only been partially successful; thus wild crops remain competitive in the marketplace. Species in genera closely related to morels are sometimes harvested or sold as food, but some of these species can be poisonous and their sale affects regulations regarding morel commerce. Morels also can accumulate toxic heavy metals under certain circumstances. As with morel biology, no comprehensive summary exists about morel harvesters and their culture; about social, economic, and environmental aspects of morel commerce; or about harvest regulations that are specific to morels. Morels fruit from Mexico to Alaska in western North America. Within this range, morel crops, forest habitats, land ownership, forest management goals, laws and regulations, and morel commerce differ by region. This publication provides forest managers, policymakers, mycologists, and mushroom harvesters with a synthesis of current knowledge regarding these issues, regional summaries of morel harvesting and management throughout western North America, a discussion of how forest management and morel crops interact, suggestions for useful research, and a comprehensive review of the literature.

Contents

Introduction

In the late 1980s and early 1990s, commercial mushroom harvesting expanded rapidly on federal lands in the Pacific Northwest. Molina and others (1993) examined the species that were being harvested and the issues involved. Three types of mushrooms constituted the bulk of harvested mushroom crops: the American matsutake or pine mushroom (*Tricholoma magnivelare*), various species of chanterelles (*Cantharellus* and related genera), and morels (*Morchella* species). This publication completes a series of three General Technical Reports (GTRs) focusing in greater detail on the ecology and management of these commercially important fungi. The first (Hosford and others 1997) discussed the American matsutake and the second (Pilz and others 2003) examined chanterelles. All of these publications were written for forest managers, policymakers, and the general public, but contain sufficient detail and references for use by mycologists (people that study fungi) and other scientists.

American matsutake are the most valuable mushrooms harvested in the Pacific Northwest but are not as abundant as chanterelles or morels. Chanterelles are the most abundant, but sell for considerably lower prices than American matsutake or morels. Morels are more valuable than chanterelles and more abundant than American matsutake; hence in combination, the total value of morel crops in the Pacific Northwest is larger than either of the others (Blatner and Alexander 1998, Schlosser and Blatner 1995).

Morels are more valuable than chanterelles and more abundant than American matsutake; hence in combination, the total value of morel crops in the Pacific Northwest is larger than either of the others.

Morels are distinct in a number of other ways. Compared to most other harvested forest fungi, they occur in a wider variety of forested ecosystems and habitats, they appear to be more genetically diverse, they differ widely in appearance, their taxonomy and distinctions among species are poorly defined and in flux, they exhibit heterogeneous and adaptive lifestyles, and their potential interactions with forest management activities are complex and numerous. Additionally, they are among the most avidly sought and highly esteemed mushrooms for culinary use and ease of preservation.

Morels are of global importance, not only because they are widely appreciated wherever they grow, but also because international commerce in morels is extensive. Cultivated morels still have not replaced wild-harvested morels in most markets. We will discuss the reasons why morels are difficult and expensive to grow. Meanwhile, harvesting morels from forests remains profitable and forest management plays an important role in maintaining such crops.

This publication focuses on morel mushrooms that grow from Mexico to Alaska and from the Rocky Mountains westward. We have chosen this geographic region for three reasons. First, morels occur in large crops and are commercially harvested in significant quantities in many places throughout western North America. Second, forest ecosystems throughout this region differ from forests east of the Rocky Mountains in their greater abundance of conifers, sparser summer precipitation, and more frequent wildfires. Lastly, several excellent books address morels of the Eastern United States, but we know of none that specifically address morels in the West.

"Managing" morels is a multifaceted issue. Biologically, it entails understanding their ecological niches, life cycles, nutrient sources, and reproductive strategies. Forest management issues include how the organism persists in ecosystems over time and how it reacts to disturbance, whether natural or produced by humans. Cultivation efforts illustrate the complexity of morel lifestyles and why they will likely remain predominantly wild-harvested for the foreseeable future. Methods that harvesters use to collect morels demonstrate the harvester's interest in sustainability. Culinary use and concerns about inherent or absorbed toxins will stimulate further debate about regulating commerce in wild mushrooms. The value of morels in national and international markets affects the demand for access to harvesting opportunities and the environmental impacts associated with harvesting. Harvester strategies and transient workers pose challenges and opportunities for local communities and forest managers. Mixed ownership of forest land and varied land management goals create a mosaic of mushroom harvesting regulations that can be confusing to harvesters and difficult for land management agencies to enforce. These considerations overlay regional differences in forest ecosystems, climate, morel productivity, available labor, and transportation networks. This complex matrix of management issues and concerns, and our lack of understanding about essential aspects thereof, provide ample opportunities for continued research. Investigations that involve collaborative participation by individuals and organizations with diverse perspectives and interests will be especially useful for resolving management controversies while supporting economic opportunities (Pilz and others 2006b). By addressing all these issues, we aim to provide readers with a comprehensive synthesis of current knowledge and a thorough compilation of pertinent sources of information.

This publication is intentionally written for readers with diverse interests and backgrounds, so the following comments about format and usage are meant to improve clarity. With the exceptions of spore size and one figure, only English units are used. Conversion factors for metric units are provided in the section immediately preceding the "Literature Cited" section. All Web sites listed in this publication were last accessed and checked for availability on 20 December 2006.

All prices cited in the literature from other countries have been converted to U.S. currency values by using historical exchange rates that existed at the time of the original publication.[1] We use mycological terminology (technical terms about fungi) throughout the document. Each term is explained at first usage and listed in a glossary immediately after the "Closing Remarks" section. Acronyms used in only one section are defined at first usage. Common acronyms found in multiple sections of the document are USFS (U.S. Department of Agriculture, Forest Service) and BLM (U.S. Department of the Interior, Bureau of Land Management). Various terms, acronyms, and definitions are used around the world for wild crafted products. "Special forest products" is used by federal land management agencies in the Pacific Northwest and the states of Oregon and Washington. "Nontimber forest products" is the most common usage in the literature and internationally. We use either according to the context.

We use both scientific and common names interchangeably and in combinations; our intent is to make the text explicit yet readable. Frequently we abbreviate "*Morchella*" to "*M.*" when referring to a species of morel by scientific name. The appendix is a table of common and corresponding scientific names for all the organisms we mention in our text. To facilitate finding names in the appendix, fungi are listed in alphabetical order by scientific name; all other organisms are listed in order by common name.

One of the biggest challenges in preparing this document was the lack of agreement on scientific and common names for Western morels. Scientific names for morels described from other continents should be used for North American morels only provisionally, if at all, until comparison of specimens proves they are identical. Preliminary studies are revealing more diversity and endemism (native to only one place, region, or continent) than many researchers expected to find. As a result, the application of scientific names to North American morels is in a state of flux. Because common (vernacular) names are not applied according to a fixed system, they vary tremendously in their usage. Table 1 provides the names that we will use in this document. It is not meant to be definitive or unchanging; it merely provides consistency to our discussion and is based on our current understanding of Western morel species.

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[1] Prices from other currencies were converted to dollars with historical data corresponding to the year of the cited report by using tables obtained from the Web site of the OANDA Corporation, http://www.oanda.com/convert/fxhistory.

Table 1—Names used in this publication for distinctive western morels occurring in western North America north of Mexico

Our usage[a]	Disturbance[b]	Morel clade[c]	Scientific names[d]	Comments
Natural black morel	None or nonfire	Black	(*M. elata*) (*M. conica*) (*M. angusticeps*)	Putative species A (Pilz and others 2004)
(Pink?)[e] burn morel	Fire	Black	(*M. conica*) (*M. angusticeps*)	Putative species B (Pilz and others 2004)
(Green?)[e] burn morel	Fire	Black	(*M. conica*) (*M. angusticeps*)	Putative species C (Pilz and others 2004)
Gray morel[f]	Fire	Unknown	("*M. atrotomentosa*"[g] as used by McKnight 1987)	Putative species D (Pilz and others 2004) Also called "fuzzy foot" or "black foot" morel
Mountain blond morel	None or nonfire	Unknown	None yet	Putative species E (Pilz and others 2004)
Yellow morel	None or nonfire	Yellow	(*M. esculenta*) (*M. crassipes*)	Likely several difficult-to-distinguish species (*M. crassipes* is an old-growth *M. esculenta*) (Kuo 2005, 2006)
Red-brown blushing morel	None or nonfire	Blushing (several subtropical species)	*Morchella rufobrunnea* (*M. deliciosa*)	In Xalapa, Mexico (Guzmán and Tapia 1998) and likely California (Kuo 2006) The similar *M. deliciosa* likely does not grow in the West
Half-free morel	None or nonfire	None of the above	*Morchella semilibera* (*Mitrophora semilibera*)	

[a] Common names for morels are so numerous, and used so inconsistently, that we make no effort to cross-reference them. We use "natural black" and "gray" morels, because these terms are common among commercial harvesters. This list is likely not inclusive of all the unique morel species that will eventually be identified in western North America. Kuo (2005) suggested there are other distinct black morels in western North America.

[b] Nonfire disturbances include insect infestations of trees, logging, tree death, floods, landslides, or any disruption or compaction of soil layers. Division of morels into fire and nonfire species reflects current understanding of how particular morels typically respond to disturbance. As species become better delineated and described, we might find that some species have more diverse habitat preferences and fruiting triggers. See "Morel Strategies" section and Kuo (2005).

[c] Two major clades, or groupings of closely-related true morels, are currently recognized in North America, "yellows" and "blacks." A third clade of subtropical blushing species (*M. rufobrunnea, M. guatemalensis,* and *M. rigidoides*) is postulated by Guzmán and Tapia (1998).

[d] Most scientific names used for morels in North American field guides were given originally to European species, and it is currently unknown which, if any, of these species actually occur in North America. *Morchella rufobrunnea* and *Morchella semilibera* are the only scientific names in our chart that most taxonomists would accept as applicable in North America. We list the other scientific names (abbreviated and in parentheses) because they are widely used in the literature, but the North American morels to which these names have been assigned might be endemic species that require original names.

[e] Co-author Carol Carter (Pilz and others 2004) suggests that burn morels in the black clade are likely two or more species. These species can be difficult to distinguish by field appearance because their shades of color intergrade. Co-author Nancy S. Weber tentatively suggests "pink" and "green" as common names for these putative burn species.

[f] The gray morel can range in color from very dark to almost blond as it matures (see fig. 2 in the "Species Descriptions" section). As with the "natural" black morel, we use a common name for this morel that is widely used among commercial mushroom harvesters. It also reflects this morel's overall color when it is young, fresh, and prime for harvesting.

[g] "*M. atrotomentosa*" is not a valid scientific name. See comments for the gray morel in the "Species Descriptions" section.

About Morels

Whence Morels

The names for morels in many Germanic languages can be traced to the early German dialect called "Old High German" (Weber 1988). *Webster's Third New International Dictionary* provides this derivation [with abbreviations spelled out]: "French morille, of Germanic origin, akin to Old High German morhila, diminutive of moraha 'carrot'" (Gove and others 1993). Regardless of its English etymology, cultures around the world have bestowed names with local meaning (table 2). These are often descriptive. For instance, the indigenous Nahua of Tlaxcala, Mexico, call morels "olonanácatl," a word derived from the Náhuatl language meaning: olotl = corncob + nanácatl = mushroom (Montoya and others 2003). Other names used by indigenous groups in Mexico include "colmenitas" (little beehives), "mazorquitas" (little tender corn ears), "elotitos" (little ears of green corn), and "pancitas" (little paunches) (Guzmán and Tapia 1998). On the other side of the world, on the Tibetan Plateau, morels are called "gugu shamu" meaning the "cuckoo mushroom," because they fruit when the cuckoo bird returns in spring.[2]

Despite the cultural and linguistic evidence that morels are used and esteemed around the world, little information exists regarding Native American uses of morels north of Mexico.

Moerman (1998) did list the Crow Tribe of southwestern Montana and northern Wyoming as using morels for soap, and Gilmore (1919) reported that the Omaha Tribe esteemed boiled morels as food. The Omaha-Ponca name for morels was Mikaiʰ.thi, which translates literally as "star sore." Even some famous early European-American explorers failed to appreciate our North American morels. "Cruzatte brought me several large morells," writes Meriwether Lewis on June 19, 1806, "which I roasted and eat without salt pepper or grease in this way I had for the first time the true taist of the morell which is truly an insippid taistless food. . ." (Ambrose 1996: 362, Nelsen 2002).

Few chefs would recommend cooking morels without plenty of butter or cream, and indeed, many people disagree with Lewis's opinion of morels. Lonik (2002) estimated that 50 million people worldwide pick morels. Morel harvesting has been described in terms like "morel madness" (Weber 1988), "fungal lust" (Boom 1995), "the sickness" (Kuo 2005), and "screams of delight" (Casey 1995). Companies

[2] Winkler, Dan. 2005. Personal communication. Conservation consultant, Eco-Montane Consulting, 9725 NE 130 Place, Kirkland, WA 98034.

Table 2—Some non-English common names for morels

Common name	Cited scientific names[a]	Country	Reference[b]
Amigasa-take	*M. conica*	Japan	Kreisel 2005, Rolfe and Rolfe 1925
Bankai yangdujum	*M. semilibera*	China	Hall and others 2003
Cagarria	*Morchella* species	Spain	Kreisel 2005
Colmena	*M. angusticeps, M. esculenta, M. conica*	Mexico	Guzmán 1977
Colmenilla	*Morchella* species	Spain	Kreisel 2005
Colmenita	*Morchella* species	Mexico	Guzmán and Tapia 1998
Cutui yangdujun	*M. crassipes*	China	Hall and others 2003
Ekte morkel	*Morchella* species	Norway	Chandra 1989
Elote	*Morchella* species, *M. esculenta, M. conica*	Mexico	Guzmán 1977
Elotito	*Morchella* species, *M. angusticeps*	Mexico	Guzmán 1977
Funguli	*Morchella* species	Ancient Rome	Rolfe and Rolfe 1925
Gaoyandujun	*M. elata*	China	Hall and others 2003
Guchhii	*Morchella* species	Himachal Pradesh, Kashmir, North India	Prasad and others 2002
Gugu shamu	*Morchella* species	Tibet	Winkler[c]
Halbfrei morchel	*M. semilibera*	Germany	Kreisel 2005
Hättmurkla	*M. semilibera*	Sweden	Korhonen 1986
Höhe morchel or Höhlmorchel	*M. elata*	Germany	Svrček 1983
Huhtasieni	*Morchella* species	Finland	Korhonen 1986
Jianyangdujun	*M. conica*	China	Hall and others 2003
Kabuteng hugis utak	*Morchella* species	Philippines	Chandra 1989
Käppchenmorchel	*M. semilibera*	Germany	Dähncke and Dähncke 1984, Kreisel 2005
Kartiohuhtasieni	*M. elata, M. conica*	Finland	Korhonen 1986
Kellohuhtasieni	*M. semilibera*	Finland	Korhonen 1986
Koestliche morchel	*M. deliciosa*	Germany	Dähncke and Dähncke 1984
Kucsmagomba	*Morchella* species	Hungary	Chandra 1989
Leimai yabgdujun	*M. costata*	China	Hall and others 2003
Mazorca	*M. angusticeps, M. esculenta, M. conica*	Mexico	Guzmán 1977
Mazorquita	*Morchella* species	Mexico	Guzmán and Tapia 1998
Merkel	*Morchella* species	Germany	Weber 1988
Mikai^{h}.thi	*Morchella* species	Omaha-Ponca Tribes, North America	Gilmore 1919

Table 2—Some non-English common names for morels (continued)

Common name	Cited scientific names[a]	Country	Reference[b]
Morchel	*Morchella* species	Germany	Kreisel 2005
Morhila	*Morchella* species	Old High German	Gove and others 1993
Morielje	*Morchella* species	Netherlands	Chandra 1989, Kreisel 2005
Morilla	*M. conica, M. esculenta*	Mexico, Spain	Guzmán 1977, Kreisel 2005, Weber 1988
Morille	*Morchella* species	France	Chandra 1989, Kreisel 2005, Weber 1988
Morille conique	*M. elata*	France	Kreisel 2005
Morille vulgaire	*M. esculenta*	France	Kreisel 2005
Morillon	*M. semilibera*	France	Kreisel 2005
Morkel	*Morchella* species	Denmark, Norway	Chandra 1989, Kreisel 2005
Murkla	*Morchella* species	Sweden	Kreisel 2005
Olonanácatl	*Morchella* species	Mexico	Montoya and others 2003
Olote	*M. conica, M. esculenta*	Mexico	Guzmán 1977
Olotito	*Morchella* species	Mexico	Montoya and others 2003
Pancita	*Morchella* species	Mexico	Guzmán and Tapia 1998
Pallohuhtasieni	*M. esculenta*	Finland	Korhonen 1986
Pique	*M. elata, intermedia,* and *conica*	Chile	Honrubia[d]
Pumpalka	*Morchella* species	Bulgaria	Chandra 1989
Rundmorkel	*M. esculenta*	Norway	Kreisel 2005
Rund toppmurkla	*M. esculenta*	Sweden	Korhonen 1986, Kreisel 2005
Sfonduli	*Morchella* species	Ancient Rome	Rolfe and Rolfe 1925
Smardz	*Morchella* species	Poland	Chandra 1989, Weber 1988
Smardz jadalny	*M. esculenta*	Poland	Chandra 1989
Smardz pólwolny	*M. semilibera*	Poland	Chandra 1989
Smardz wyniosly	*M. elata*	Poland	Chandra 1989
Smorchok	*Morchella* species, *M. esculenta*	Russia	Chandra 1989, Kreisel 2005
Smrž	*Morchella* species	Czech	Chandra 1989, Kreisel 2005, Weber 1988
Smrž obecný	*M. esculenta*	Czech	Kreisel 2005
Smrž polovolný	*M. semilibera*	Czech	Kreisel 2005
Speisemorchel	*M. esculenta*	Germany	Dähncke and Dähncke 1984, Kreisel 2005
Spissmorkel	*M. elata*	Norway	Kreisel 2005
Spitzmorchel	*M. conica*	Germany	Dähncke and Dähncke 1984

Table 2—Some non-English common names for morels (continued)

Common name	Cited scientific names[a]	Country	Reference[b]
Spongiae in humore pratorum nascentes	*Morchella* species	Ancient Rome	Chandra 1989
Spongioli	*Morchella* species	Ancient Greece or Rome	Rolfe and Rolfe 1925
Spugnola	*Morchella* species	Italy	Chandra 1989, Kreisel 2005, Weber 1988
Suéter	*Morchella* species	Mexico	Montoya and others 2003
Toppmurkla	*Morchella* species, *M. conica, M. elata*	Sweden	Kreisel 2005, Korhonen 1986
Yangdujun	*M. esculenta*	China	Hall and others 2003
Zbírciog	*Morchella* species	Romania	Chandra 1989

[a] Scientific names are those used in the cited publications.
[b] Most names listed in this table were compiled and provided by Paul Kroeger. 2005. Personal communication. President, Vancouver Mycological Society, 101 - 1001 West Broadway, Box 181, Vancouver, BC V6H 4E4 Canada.
[c] Winkler, Dan. 2005. Personal communication. Conservation consultant, Eco-Montane Consulting, 9725 NE 130 Place, Kirkland, WA 98034.
[d] Honrubia, Mario. 2005. Personal communication. Professor, Departamento de Biología Vegetal, Área de Botánica, Laboratorio de Micología-Micorrizas, Facultad de Biología, Campus de Espinardo, Universidad de Murcia, 30100 Murcia, Spain.

selling morel products have similarly descriptive names such as "Morel Mania"[3] and "Morel Heaven."[4] Such is the popularity of morels, that they are commonly a theme in cartoons (Grace 2005), and their harvest in Alaska was used as the setting for a murder mystery novel by Stabenow (1995). In table 2, the global popularity of morels is illustrated by listing various names for morels in languages and countries around the world.

Distribution

Morels grow in all countries of the Northern Hemisphere that have temperate or boreal forests (Arora 1986), that is, forests that experience a distinct cold season, especially with winter snow. They also occur in some Mediterranean or subtropical regions such as coastal California (Arora 1986, Kuo 2005), the highlands of

[3] Morel Mania is a private company specializing in morel-related items. They list twelve 2006 morel festivals in Wisconsin, Michigan, Illinois, Indiana, Kentucky, and Missouri on their Web site. http://www.morelmania.com/4Events/index.html.

[4] "Morel Heaven" is now called "Mazur's Mushrooms and More" after the founder and morel enthusiast Larry Lonik died and close friends continued the business. The Web site http://www.morelheaven.com/ lists annual festivals in Michigan.

Mexico and Guatemala (Guzmán-Dávalos and Rodríguez-Alcantar 1993, Guzmán and Tapia 1998), and the Middle East (Goldway and others 2000). Many morels in the Southern Hemisphere were likely introduced from the Northern Hemisphere, but endemic species also seem to exist. For instance, preliminary data suggest that although Australia has some introduced morel species (Barnes and Wilson 1998), it also hosts two possible endemic species.[5] This finding is not surprising given that morels in Australia and Tasmania associate with eucalypts and acacias (Faris and others 1996, Stott and others 2002), trees that are very different from those endemic to Northern Hemisphere forests. In Chile, morels growing with blue gum trees (*Eucalyptus globus*) and in Monterey pine (*Pinus radiata*) plantations in the Mediterranean climatic region were likely introduced along with those tree species,[6] but Gamundi and others (2004) also reported native morels in the southern beech (*Nothofagus*) forests of Argentina and of Chile. Both introduced and native morels are being studied. Researchers from the Universidad de Concepción in Casilla, Chile, in conjunction with the national Instituto Forestal, have begun a program of inoculating chestnut trees (*Castanea sativa*) with *Morchella conica* spores in an effort to produce mycorrhizal seedlings for out-planting.[7] In Argentina, research has begun on native morel productivity and enhancement in Chilean cedar (*Austrocedrus chilensis*) forests of the Patagonian Andes in Chubut Province.[8] Supporting commercial opportunities to harvest morels in a sustainable manner is one goal of the project. Research sites include Los Alerces National Park and nearby private lands where commercial morel harvesting can be proscribed and study sites kept secure.

Morels can be found throughout the United States if you look in the right habitats, such as the forested slopes of Hawaiian volcanoes (Hemmes and Desjardin

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[5] O'Donnell, Kerry. 2005. Personal communication. Microbiologist, Microbial Genomics and Bioprocessing Research Unit, National Center for Agricultural Utilization Research, U.S. Department of Agriculture, 1815 N University St., Peoria, IL 61604.

[6] Palfner, Götz. 2005. Personal communication. Biologist, Departamento de Ciencias Químicas, Universidad de La Frontera, Av. Francisco Salazar 01145, Casilla 54-D, Temuco IX Región, Chile.

[7] Reinoso, R.; Cjas, D.; Chung, P. [and others]. 2005. Evaluation of the mycorrhization process on plants of the species *Castanea sativa* (Fagaceae) with mycorrhizal *Tuber aestivum* and *Morchella conica* (Ascomycetes). [Unpublished abstract]. 4th international workshop on edible mycorrhizal mushrooms, 29 November–2 December 2005, Murcia, Spain. Professor, Departmento de Botánica, Facultad de Ciencias Naturales y Oceanográficas, Universidad de Concepción, Edmundo Larenas S/N, Concepción, Casilla 160-C, Chile.

[8] Barroetaveña, Carolina. 2006. Personal communication. Post-doctoral researcher, Centro de Investigación y Extensión Forestal Andino Patagónico CC. 14, Esquel (9200), Chubut, Argentina. Dr. Mario Rajchenberg is director of the project and Dra. Barroetaveña will be implementing it.

2002). They are rare, however, in hot climates such as inland southern California, the desert regions of the Southwest, the coastal plain of the Gulf of Mexico, and most of Florida. This distribution likely reflects their common association with trees and their tolerance to cold soils or "psychrotolerance" (Schmidt 1983). Morels also exhibit what has been called "broad ecological amplitude" and "environmental plasticity" (Wedin and others 2004). These terms will be further discussed in the "Biology" section.

Habitats

Disturbance—Throughout this publication we will discuss disturbances such as tree death, soil disruption, or fires as habitat factors that can stimulate morels to fruit, often in large quantities. Such triggers for fruiting appear to differ by species to some extent. For instance, we chose to distinguish "burn" from "nonburn" species of morels because frequent observations by the authors and commercial harvesters, as well as currently published information (McFarlane and others 2005, McLain and others 2005, Pilz and others 2004), suggest that some Western species only occur for a year or two after forest fires, whereas other species occur year after year in areas that have not burned. Absence of evidence to the contrary does not constitute proof of fruiting exclusively under certain conditions, however, and what we call burn or nonburn species might fruit occasionally under the reverse conditions. In resolving this issue, it will be especially important for future data to specify if the collected morel was found growing from burned soil or not, rather than simply from within a wildfire perimeter, because nonburned areas frequently remain within the boundary of a forest fire.

Even morels that we call "nonburn" species can respond with large flushes of fruiting in response to disturbances such as soil displacement, soil compaction, tree death, or other stimuli. The following sections illustrate the range of such conditions.

Arora joked that morels "usually grow outdoors."

Range of habitats—Morels have adapted to a wide range of habitats and environmental conditions. Illustrating the wide range of places and conditions where morels fruit, Arora (1986) joked that morels "usually grow outdoors." We will not list all literature reports of the places, conditions, and circumstances where morels fruit, but here are some examples and references for further reading.

- Kuo (2002) and Weber (1988) discussed morel habitats in general, describing habitats they had seen or heard about, including river bottoms and flood plains, burn sites, areas landscaped with wood chips, near old sawmills, near wood piles, and near railroad beds.

- Weber (1988) described unusual habitats such as fields, dunes, landscaped areas, garbage dumps, abandoned coal mines, old mine tailings, cellars and basements, and along railroad tracks, but cautioned against eating morels from some of these habitats.
- Lonik (2002: 31–33) listed 62 places to find morels.
- Thompson (1994) made it clear that even though morels are common in riparian (river and stream) forests, they do not appear after heavy flooding.
- Hallen and others (2001) described morels fruiting away from trees in sand dunes and open meadows.
- Huffman and Tiffany (2001) mentioned road cuts, excavations, deer trails, orchards, and sand bars of rivers.
- Ramsbottom (1953) described morels fruiting in bomb craters, trenches, and the ashes of burned buildings after World War II.
- Kaul (1975) said morels fruit in bomb craters, areas where bonfires have burned, in limed soils, and soils where ashes have been spread.
- Carpenter and others (1987) and Stamets (1993, 2000) described large numbers of morels fruiting in the aftermath of the Mount St. Helens eruption, although the mushrooms were too gritty to clean and eat.
- Obst and Brown (2000) reported that 90 percent of morels found at their boreal forest study site fruited on the better drained hummocks of soil rather than in low-lying swampy areas.
- A construction worker observed morels growing where sheetrock had been allowed to disintegrate outdoors in winter rains.[9]
- Several authors of this publication have observed morels fruiting in the footprints of previous morel hunters.
- Almost any morel hunter will tell you they find some morels where they are unexpected.

Trees—Many morels fruit in nondisturbed forests in association with live trees. Others fruit in great abundance with trees that are declining, dying, or recently dead. Thompson (1994) provided a fascinating tale of the latter situation by recounting his massive morel harvests from 1971 to 1977. As Dutch elm disease (see appendix for scientific names) spread westward across the Midwestern United States, he followed the fungal bounty reliably found around the bases of dying and recently dead elms. The association of particular morel species with either healthy or moribund trees, and sometimes both, will be discussed in greater detail in the "Biology" section. We list a few examples from the literature here.

[9] Avery, Lydia. 2006. Sheet-rocking contractor, P.O. Box 260, Alsea, OR 97324.

- Weber (1988) reported morels in Michigan as associated with oak-hickory or beech-maple forests, or under sycamore, elm, ash, cottonwood, and apple trees.
- Kuo (2005) listed morels in the Eastern United States as associated with ash, elm, and tulip trees, and often found in old apple orchards.
- Thompson (1994) found morels with senescent or dying apple trees, just-dead cottonwoods, and especially elms.
- Volk and others (1997) described morels fruiting with elm, ash, aspen, tulip poplar, and black cherry.
- Tiffany and others (1998) stated that most morels fruit near elms in Iowa and that black morels are rare and only found in upland oak forests on limestone outcroppings.
- Boom (1995) described morels in the Sierra Nevada range of California as "necrophiles of the alpine forest."
- Stamets (2000) described immense crops of morels after the 1988 Yellowstone forest fires.
- Pilz and others (2004) reported morels fruiting disproportionately in recently burned or insect-infested true fir forests in eastern Oregon.
- McFarlane and others (2005) described morels fruiting most abundantly in burned true fir/spruce forests at higher elevations in Montana.
- Keefer (2005) found morels fruiting close to subalpine fir in forest that burned the previous summer in British Columbia.
- Winder (2006) cited Canadian herbarium data (Natural Resources Canada 2005) that indicate *M. elata* grows in association with domesticated or wild members of the Rosaceae such as apple, cherry laurel, and ocean spray.

Timing

When do morels fruit? Many reports describe vegetative indicators of what Kuo (2005) called "angst relief" for impatient morel hunters. Examples of such signs are "when apple trees are in bloom" and "when oak leaves are the size of mouse ears" (Hammond 1999). Kuo (2005) provided eight examples, including when lilacs are in bloom and trilliums begin to flower. Low (1995) suggested a colorful indicator: "…when the hard, brown galls of cedar-apple rust hang their orange, gelatinous spore bodies on juniper trees." *Geopyxis carbonaria*, another postfire fungus, often fruits before burn morels, but is no guarantee morels will follow (Obst and Brown 2000). Lonik (2002) reported that in the Eastern United States, the morel season moves south to north at about 100 miles per week. Kuo (2005) provided a map that shows the progression of fruiting northward in the United States and southern Canada from the end of February to mid-June. An online progression map can be accessed through subscription to the Morel Mushroom Hunting Club at http://www.morelmushroomhunting.com/.

The bottom line is that morels fruit when winter snow has melted, the soil is beginning to warm, and the air is still humid. In any one location, the season can last from several weeks to several months depending on rainfall, humidity, topography, and the morel species. Warmth and humidity provide the conditions morels need to continue development once they start fruiting. In areas that have hilly or mountainous topography, morels will fruit first at low elevation or on south-facing slopes that warm up early, then at higher elevations and on north-facing slopes that warm up later (Low 1995). Burned soils also warm more quickly than nonburned soils because the black surface absorbs infrared radiation better. As with fruiting locations, the timing and length of morel fruiting can be unexpected. Although morels typically fruit in the spring, Sturgis (1905) reported massive quantities of morels fruiting on the 11th of September at 7,000 feet elevation in southwestern British Columbia in an aspen and spruce forest that burned the previous summer. Equally unusual, Goldway and others (2000) described morels fruiting continuously for 8 months in a nature reserve in northern Israel where they grew near a steady supply of spring water and under dense shade.

Morels fruit when winter snow has melted, the soil is beginning to warm, and the air is still humid.

Taxonomy

Kindred organisms—Both Weber (1988) and Kuo (2005) discussed, in general, the history of morel taxonomy, the frustrating inaccuracies, and the incompleteness of much of the earliest work. We will not expand upon their discussions here, other than to note two important early descriptions (Persoon 1797: 36, Fries 1822: 5) that are referenced by Weber (1988), and a French treatise on morel species by Constantin (1936).

Arora (1986), Kuo (2005, 2006), and Weber (1988) all provided general discussions of morel taxonomy. Descriptions of the genus *Morchella* can be found in Arora (1986: 785), Hanlin and Hahn (1990: 66), Jacquetant (1984), Smith and others (1981: 53), and Weber (1988: 128-129).

O'Donnell and others (1997) applied molecular methods of genetic analysis in order to better understand the evolutionary relations between *Morchella* and other closely related fungi. In many instances, such methods are modifying our understanding of how organisms are related to each other, and taxonomic discussions in older field guides often are outdated. The following classification scheme illustrates the position of *Morchella* and the related "look-alike" genera *Verpa* and *Gyromitra* in taxonomic context by using family and genus arrangements as per O'Donnell and others (1997).

Kingdom Fungi
- Phylum Ascomycota
  - Subphylum Pezizomycotina
    - Class Pezizomycetes
      - Order Pezizales
        - Family Morchellaceae
          - Genus *Morchella* (true morels)
          - Genus *Verpa* (thimble morels)
        - Family Discinaceae
          - Genus *Gyromitra* (false morels, lorchels)

Rather than rigid hierarchical categories of relationships based on observable characters, such as the outlined classification scheme above, the analogy of a "tree of life" is now often used to describe how closely organisms are related (Lutzoni and others 2004) and how long ago they had common ancestors or branching points. For instance, Birren and others (2003) and Galagan and others (2005) suggested morels diverged from related fungal lineages in the Mesozoic era about 100 to 150 million years ago. Discoveries of this nature are occurring at an increasingly rapid pace and redefining taxonomy. In an effort to keep up with the pace of discovery, collaborative Web sites are being used to compile the information. Taylor and others (1996) are coordinating the Ascomycete branch of the Tree of Life Web Project (http://tolweb.org/tree?group=Ascomycota&contgroup=Fungi) where current information can be found.

Calling morel taxonomy "problematic" is an understatement.

Morel species—Morel taxonomy above the level of species is not controversial, but when morel species are discussed, calling the field "problematic" is an understatement (Weber 1995). The Index Fungorum online database (http://www.indexfungorum.org/Names/Names.asp) lists 196 species and subspecies worldwide (CABI and others n.d.). Hallen and others (2001) estimated that more than 100 morel species have been described based on their morphological features. These are features of form (size and shape) or other characteristics (for instance, color or texture) that can be observed either macroscopically (with the naked eye) or microscopically. Examples of morel features that are often described include color of ridges, pits, and stem; configuration of the ridges; spore size and shape; attachment of the head to the stem; texture of head and stem; discoloration and bruising; stem wall thickness or layering; and changes in such features as a morel ages. The problem is that morels are extremely polymorphic (able to exhibit a wide variety of forms), and such observable features often intergrade among described or presumed species.

Such polymorphism undoubtedly has a genetic component, but environmental conditions such as moisture and sunlight also can affect the growth, development, form, size, and color of morel fruiting bodies. For instance, Jung and others (1993) asserted that the tan, gray, and large forms of the eastern yellow morel are actually all one polymorphic species in the clade of yellow morels.[10] Morels can change color in response to ultraviolet radiation (Jacobs 1982) and grow quite large if conditions of warmth and humidity are favorable. Thompson (1994), in his autobiography of a lifetime of picking morels, claimed that variations in morel appearance seemed to be consistently related to the type of trees growing where he found the morels, so perhaps such food sources also play a role in determining morphology. Royse and May (1990) also found little correspondence between variation in allozyme patterns (an enzymatic analysis of genetic variation) and morphological characters. The interplay between genetic variation, morel nutrition, and the environmental conditions influencing development of the fruiting body are likely quite complex.

In addition to morphology, fungal species can be delineated based on the ability to interbreed, long-term isolation of populations (for instance, geographic isolation), or consistent differences in the genetic makeup. Unfortunately, mating trials with morels are difficult to conduct. Getting colonies of fungi to grow together (compatible) or to exhibit inhibition zones (not compatible) is an easy, but not always definitive, laboratory procedure. To demonstrate full mating compatibility, the reproductive cycle must be completed with the production of morel fruiting bodies and spores. This process is difficult for reasons that we will discuss under the section on attempts at commercial cultivation. Similarly, just because populations have been geographically isolated for extended periods of time from other populations, does not necessarily mean they have diverged sufficiently to be considered separate species. So how can species of morels be distinguished? There is no one criterion that is ideal for all circumstances, but molecular techniques of genetic analysis are gaining broader acceptance (Taylor and others 2000).

Studies of genetic differentiation and speciation among morels have yielded some interesting results. For instance, Jung and others (1993), Bunyard and others (1994, 1995), and Wipf and others (1996a) reported more genetic variation between

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[10] Because many North American morels might not yet have valid scientific names, their use by the authors we cite must be considered the equivalent of using imprecise common names. We default in our discussion to the common names listed in table 1.

distant populations of morels within the same species than between different morel species (although these results might in some cases reflect inaccurate species delineations). Similarly, Wipf and others (1999) reported that the genetic differences between black and yellow morel clades approach the magnitude of the differences between the genera *Morchella* and *Verpa*.

Molecular methods of genetic analysis are being applied with increasing sophistication to the question of how many species of morels actually exist in North America and whether they deserve different scientific names than species previously described in Europe. The literature on this topic is technical, sometimes contradictory, often narrowly focused, and potentially compromised by the lack of valid scientific names. Unless one is a specialist and familiar with all the publications, the implications of such research can be confusing. For readers who wish to explore the progress of such studies, they are listed here in chronological order: Gessner and others (1987), Yoon and others (1990), Royse and May (1990), Jung and others (1993), O'Donnell and others (1993), Bunyard and others (1994 1995), Gessner (1995), Buscot and others (1996), Wipf and others (1996a, 1996b, 1999), and O'Donnell and others (2003). Although Gessner (1995) preceded some of the other papers, it is a review paper that can help the reader put this field of research in perspective.

We summarize some of the conclusions that have been derived from these studies. Bunyard and others (1994, 1995) asserted that there are probably only three major groups of morels (black, yellow, and half-free morels) and speculated that there were probably only a few polymorphic species based on their samples. O'Donnell and others (1993) discerned 12 distinct morel species or species complexes from 150 morel collections in North America and Europe, although this was only a conference abstract with no indication of how representative the samples were. In a second abstract, O'Donnell and others (2003) described analyzing a global collection of 600 morel specimens. Twenty-eight species were identified, and they fit into two clades (groups of similar species). Thirteen species fell into the yellow-tan-gray "esculenta" clade, and 15 into the black "elata" clade. Twenty-four of the 28 species were found on only one continent. North America appeared to be the ancestral home of *Morchella* and had the greatest diversity of morels with 13 endemic species—4 yellow and 9 black.

Kuo (2006) has summarized recent unpublished evidence about morel species on his Web site entitled The Morel Data Collection Project http://www.mushroomexpert.com/morels/mordat.html and in his book (Kuo 2005). Kuo concluded that there are likely more than a dozen North American species. He asserted that yellow morels are actually two look-alike species in the east, but that neither occurs in California; rather, the similar species growing in coastal California is the same as *M. rufobrunnea* in Mexico. He also affirms that what has been called *M. crassipes* in the Eastern United States is simply a very large form of the yellow morel. In the Western United States, results published by Pilz and others (2004) differ from recent species descriptions posted on The Morel Data Collection Project Web pages (Kuo 2006), especially concerning green and pink morels as putative burn species. Readers interested in the evolving field of morel taxonomy will have plenty of interesting new developments to contemplate in the years to come.

It is important to note, however, that simply discerning distinct species is only the first step in resolving their taxonomic status. To be recognized as a species with an acceptable scientific name, appropriate collections must be accessioned to a public herbarium and a taxonomist must publish a thorough description of the vouchered collection specimens. Naming and publishing must be in accordance with the International Code of Botanical Nomenclature (Greuter and others 2000). Ideally, a sufficient number of specimens will have documented collection information so that a tentative range for the species, as well as its typical habitat and fruiting conditions, can be described. Once a species has been validly named, then that scientific name is available for use. Most morels in North America lack scientific names that meet the standards of the International Code of Botanical Nomenclature.

Most morels in North America lack scientific names that meet the standards of the International Code of Botanical Nomenclature.

Given the preceding discussion, readers are advised to treat the names in table 1 and the following species descriptions as subject to change in the near future. This information is presented here as a synopsis of our current understanding of morels in western North America.

Species Descriptions

Publications like this often include a key before species descriptions; the reader can use such keys to determine the species of a specimen by choosing among series of alternate choices about morphological characters or habitat preferences. We have chosen not to include such a key because the taxonomy of western morels is still in flux and the identity of some of the putative species described below is tentative. The names "natural black," "green," "pink," "gray," and "mountain blond" morels derive from the 2004 publication by Pilz and others, which provides a field key to these putative species (the only species that were found on the sites in the study). Alternative common names that we list are those we have encountered in harvester vernacular and other sources of information. All such names are problematic and, as noted elsewhere, valid scientific names would be much preferable if they were available.

None of the following descriptions constitute formal, complete, or technical species descriptions. Instead, they are intended to provide readers with some relevant details concerning the appearance of the morels that we discuss. Adequate descriptions for the pink, green, and mountain blond morels will require systematic assessment of fresh and dried features of specimens that have been confirmed to be genetically distinct. It is likely that some western morel species have not yet been identified, let alone described. Readers who wish to assist with collections for such analyses should refer to pertinent publications (Mueller and others 2004, Weber and others 1997) and contact interested taxonomists regarding their preferred collecting and description procedures.

Descriptions for the natural black, pink, green, gray, and mountain blond morels are excerpted and modified from Pilz and others (2004). Descriptions for the yellow and half-free morel are adapted with minor modification from Weber (1988). Guzmán and Tapia's *The Known Morels in Mexico, a Description of a New Blushing Species,* Morchella rufobrunnea, *and New Data on* M. guatemalensis (1998) was consulted for the description of the red-brown blushing morel.

Natural black morel—also called black morel, conica, and angusticep (fig. 1).

Description—**Head:** in profile broadly rounded, conic to irregularly ellipsoid when young, often broadening especially near the stalk as it matures. **Ribs:** minutely and inconspicuously velvety when young, becoming dry and smooth with age; shades of dull grayish tan, steely gray, or dark brownish gray when young, becoming black by maturity; edges typically remain intact and sterile. **Pits:** dull grayish tan to steely gray when young, grayish tan or light brown in age. **Stalk:** ivory to light tan or washed with dusky rose when young, varying to tan or rosy tan in age; surface smooth at first, appearing grainy in age; never brown to black. **Spore size:** (23-)[11] 26–33 x 15–16 (-18) µm.[12]

Ecology—This common morel fruits on nonburned soils, litter, and duff including nonburned islands in burned areas. When found on burned soils, they apparently fruit no sooner than the second spring after an intense wildfire.

[11] Extreme values listed in parentheses.

[12] Fungal spores are often measured in micrometers (µm). A micrometer is one millionth of a meter in length or 1/25,000th of an inch. This unit of measure is also called a micron.

David Pilz

Figure 1—
Natural black morel.

Comments—The name "natural" for this black morel derives from commercial harvesters who collect them from nonburned or nondisturbed forests, hence fruiting under what they referred to as "natural" conditions. Arora (1986) diplomatically circumvents the controversy surrounding an appropriate scientific name for this species or group of species by referring to it as "the so-called '*M. elata-M. angusticeps-M. conica*' complex." It appears to be widespread, common, and is routinely harvested from nonburned forests in the Pacific Northwest. Black morels, that we believe were this species, fruited prolifically in nonburned but insect-killed, grand fir stands on the Lakeview Ranger District of the Fremont National Forest, Oregon, in 1994 (Weber and others 1996). Pilz and others (2004) reported this morel as the most abundant on their nonburned plots (both healthy and insect-killed forests) and it also fruited the second year (but not the first) following a fire on burned plots.

Pink morel—previously lumped with those referred to as angusticeps, conicas, burn, fire, or black morels

(No definitive image available)

Description—**Head:** at first elongate conic with rounded conic apex, sometimes expanding to broadly conic in age. **Ribs:** not conspicuously velvety when young, becoming dry and smooth in age; cream-colored to pale shell pink when young, typically black well before maturity; edges typically remain intact, sometimes with a fertile strip down the center. **Pits** cream-colored to dusky pink or pinkish tan when young, becoming pinkish tan to light pinkish brown at maturity. **Stalk:** white or nearly so at all ages; smooth at first becoming slightly grainy in age; never brown to black. **Spore size:** 21–24 x 13–16 µm.

Ecology—Fruiting likely restricted to burned soils the first spring or early summer after an autumn fire, but in very small quantities, if at all, thereafter.

Comments—Although genetically distinct (Pilz and others 2004) from the natural black morel, and fruiting under different ecological circumstances (burned versus nonburned forests), this species has not been differentiated in current field guides. Additional work will be necessary to describe reliable differences in appearance from the green morel, and possibly other species, that fruit in the same habitat and ecological conditions (burned soils).

Green morel—also previously lumped with those referred to as angusticeps, conicas, burn, fire, or black morels

(No definitive image available)

Description—**Head:** at first elongate-conic with rounded conic apex, sometimes expanding to broadly conic in age. **Ribs:** not conspicuously velvety when young, becoming dry and smooth in age; gray when young, becoming black well before maturity; edges typically remain intact, sometimes with a fertile strip down the center. **Pits:** dark gray to dark olive gray when young, olive gray to olive brownish gray in age. **Stalk:** white or nearly so at all ages; smooth at first becoming slightly grainy in age, never brown to black. **Spore size:** 20–24 x 13–16 µm.

Ecology—Fruiting likely restricted to burned soils the first spring or early summer after a fall fire, but in very small quantities, if at all, thereafter.

Comments—The natural black, pink, and green morels we describe all key out to *Morchella elata* complex, *M. conica*, or *M. angusticeps*, depending on the reference used. Kuo (2006) suggested that what we call pink and green morels actually are part of a complex of more than two species and that morphological differences remain inadequately described to distinguish among them without DNA analysis. From an observational perspective, commercial harvesters see more morels than scientists do, and although their methods of drawing conclusions might not be as systematic or precise, harvesters invariably recognize differences in the mushrooms they collect. For instance, one experienced harvester states:

> Some harvesters already distinguish the green species of black fire morel, calling them "pickles." They assert that compared to other black fire morels, green morels dry and re-hydrate differently, are more robust, bruise reddish or brown, and fruit later in the season when gray morels begin to appear.[13]

Gray morels—also called fuzzy foot morel, black stocking morel, or black foot morel (fig. 2).

Description—**Head:** elongate-ovoid to nearly columnar when young, expanding variously in age. **Ribs:** conspicuously velvety/hairy when young, the hairs collapsing with age; silvery gray to charcoal gray when young; gray to black at maturity where intact; edges extremely fragile, soon cracking and breaking away to expose the white to ivory underlying tissue; lacking fertile tissue. **Pits:** deep gray to nearly black when young, varying from gray to tan to dark ivory in age. **Stalk:** charcoal gray to nearly black when young, becoming pale gray to tan to ivory at

Karl Olson

Figure 2—A series of photographs illustrating color changes in a maturing gray morel. Photographs taken June 25, July 2, and July 9, 2003, at the Livengood Fire (78 miles NW of Fairbanks, AK). Note varied scales (spruce needle size) and lighting in each photograph.

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[13] Evans, Larry. 2005. Personal communication. President, Western Montana Mycological Association, P.O. Box 7306, Missoula, MT 59807.

maturity; densely velvety from projecting hyphae when young; the velvety layer stretched apart leaving tufts of brown hyphal tips on an ivory, off-white, or pale tan background in age. **Spore size:** 19–25 x 13–16 µm.

Ecology—The gray morel fruits in conifer forests and is found abundantly the first spring or summer after a wildfire and in reduced numbers the second postfire year. It is found in greatest abundance at high elevations and northern latitudes. Its fruiting season of late spring into summer (McFarlane and others 2005) follows, but overlaps, the fruiting of the pink and green burn morels.

Comments—McFarlane and others (2005) described the gray morel as being large, heavy, and durable, and as having a "double wall," a feature that refers to alternating darker and lighter layers of flesh seen when the stem is cut in cross section during harvesting. The gray morel is a good match for what McKnight (1987) called the "burn site morel" or *Morchella atrotomentosa* (Moser) Bride. Because Moser (1949) described *M. esculenta* var. *atrotomentosa* as a "*nov. var. ad*.[*sic*] *int*." or "temporary new variety," not as an unqualified new variety, it is not considered to have been published in accordance with the International Code of Botanical Nomenclature (Greuter and others 2000). Thus neither that name nor combinations based on that name are available for valid scientific use. This morel would not currently be considered a close relative of *M. esculenta* anyway. Although the common name of "gray" morel is widely used for this species in the Pacific Northwest; in eastern North America, young specimens of some yellow morels also are called "gray" morels (Weber 1988:103). Kuo (2006) called this morel the "fuzzy foot" morel to avoid using color attributions, because the color of the fruiting body changes as it matures.

Mountain blond morel—also called western blond morel (fig. 3).

Description—**Head:** columnar to narrowly obtusely conic when young, variously expanding with maturity but typically remaining relatively narrow in relation to height. **Ribs:** essentially glabrous when young, becoming dry and waxy in age; pale grayish tan when young, ivory to pale tan in age and then often with rusty ochre stains; edges typically remain intact and are sterile. **Pits:** light smoky gray when young, near straw yellow or the color of a manila folder in age. **Stalk:** ivory to cream-colored, sometimes with rust-colored or amber discolorations; smooth. **Spore size:** 23–26 (-28) x 14.3–16 (-18) µm.

Ecology—Both the mountain blond and yellow morels occur in western North America, but the mountain blond morel appears to be more commonly found in conifer forests (especially true fir, lodgepole, or ponderosa pine forests), whereas yellow morels are found more often in riparian hardwood forests that are sometimes mixed with conifers (Pilz and others 2004). Kuo (2006) called this putative species the "western blond" morel, and suggested that it also can be found among hardwoods at lower elevations and that it is primarily distinguished from the yellow morel by the morphological features described in the next paragraph.

Comments—The mountain blond morel closely resembles yellow morels (*M. esculenta* in the broad sense). In parts of Oregon, these two morels are often lumped together as "esculentas." However, a close comparison of specimens with most descriptions of *M. esculenta* from Europe or elsewhere in North America reveals differences. Unlike members of the yellow morel complex centered on *M. esculenta*, the head is relatively narrow rather than oval or rounded, especially in young specimens. Also, the primary ribs are strongly vertical and relatively straight, thus producing elongated pits rather than the rounded to somewhat irregular pits generally attributed to *M. esculenta*.

David Pilz

Figure 3—The mountain blond morel (center), compared to two natural black morels (either side). All specimens found on the Sisters Ranger District, Deschutes National Forest, in a pine forest that had been thinned the year before, but not burned.

Yellow morel—Also called esculentas, common morel, and many other common names (fig. 4).

Description— **Head:** oval to subcylindrical or slightly tapered toward the apex, but seldom strongly conic. **Ribs:** at first similar in color to pits and close together, gradually spreading as the head expands and becoming paler than the pits; usually white to creamy white, then stained rusty yellow or dingy brown; more waxy than velvety; collapsing or flaking away in old age. **Pits:** generally more round than elongate in maturity; pale dingy gray to tan when young, becoming tan, dull ochraceous, or golden tan as spores mature. **Stalk:** off-white to ivory or pale cream color; appearing covered with fine meal in youth; surface layer stretched apart in age; base often enlarged, appearing pleated or gathered. **Spore size:** 21–25 (-28) x 12–16 µm.

Ecology—This species is usually found in riparian forest of willow, cottonwood, alder, or ash, or sometimes in oak forests or fruit orchards, In the west, black morels are more abundant at high elevations than yellow morels, although their ranges overlap (Arora 1986).

Comments—Yellow morels are less common in western than in eastern North America. In western montane forests that consist solely of conifer tree species, light-colored morels might more likely be the mountain blond morel. Along coastal California, yellow morels are likely the red-brown blushing morel, *Morchella rufobrunnea*.

Pamela Kaminski, http://www.pamelasmushrooms.com/

Figure 4—Yellow morel.