



WISE HARVEST OF WILD MUSHROOMS: guidelines linking policy and practice



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WHY HAVE THESE HARVEST GUIDELINES BEEN WRITTEN?

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This handbook synthesizes lessons from international and national research so that forestry policy can be guided by practical examples to achieve ecologically sustainable harvest of wild fungi. Internationally, many countries harvest and trade in wild mushrooms (1). Domestic demand is also met from wild collection as well as cultivation. As a result, harvests of mushroom generate significant income for many people. China is a good example. In the alpine grasslands of the Tibetan plateau, 70-90% of rural household income is earned through caterpillar fungus trade (2). In South-west China this has become even more important since the logging ban in 1998. In the Zhongdian (Shangri-la) area of Yunnan, for example, up to 80% of annual household income used to come from logging. Today, 50-80% of household income in many villages comes from harvest and sale of matsutake. As a result, villagers have opened small businesses and built beautiful houses (3). No longer a “hidden economy”, the trade in useful mushrooms has come to the attention of conservation NGO’s, forestry officials and policy makers (4).

WHO WOULD FIND THESE GUIDELINES USEFUL?

These guidelines can be used by commercial mushroom harvesters, traders, forestry staff and conservation NGO’s and to support forestry policy decision making processes. In common with other parts of the world, not all “sustainable harvest practices” are based on good science. This handbook takes the available evidence into account and sets out guidelines that we hope will not only be useful, but will hopefully avoid some misconceptions rather than create new ones.

TEXT BOX 1: WHAT WORKS IN ONE PLACE MAY BE WRONG FOR ANOTHER

Sometimes advice given through good intentions can have unfortunate results when all the local facts aren’t known. In Japan, pine trees are the major host for matsutake. Following advice from Japanese scientists, for example, Chinese forest managers wanting to improve matsutake production cut out oak trees to create pure pine forests. Only later did foresters learn that in China, oak trees are also a major host for matsutake – so what was good practice in Japan, was not appropriate or good for matsutake production in forests in China. The fact that oak trees are important hosts for matsutake is part of local ecological knowledge held by many local harvesters in south-west China. With hindsight, ethnobotanical insights that drew on this local knowledge would have been - and still are - essential for wise resource management.

DIFFERENT LIFESTYLES OF FUNGI

Mushrooms are the fruits of certain fungi. Understanding the different lifestyles of the fungi that produce mushrooms is essential to managing them – and the forests they live in. Mushrooms can be divided into four main groups according to how they live:

- decay fungi that live on decaying material (technically called “saprotrophes”);
- fungi that have a close relationship with live plants (technically called “symbiotic” or “ecotomycorrhizal” mushrooms);
- parasitic mushrooms, such as the caterpillar fungus;
- some special cases, such as termite mushrooms.

For wise management, the differing needs of these mushrooms need to be taken into account. Each of these will be discussed in the next section.



照片

Decay mushrooms grow from dead material, often from dead trees. This way of living can duplicated through cultivation. Intensive cultivated production needs lots of dead wood. This needs to be taken into account in resource management of forests or plantations for these wood needs. We discuss this a later section of this handbook.

SYMBIOTIC MUSHROOMS

These are mushrooms require mutually beneficially relationships with living trees such as oaks and pines. Some can grow with many tree species while others are quite specific. Ganbajun, for instance, grows only with young pines and *Kettelaria*.



Many of these species are commercially harvested in Guizhou, Sichuan and Yunnan and are very important sources of income to hundreds of thousands of harvesters, are widely traded in China and internationally and are enjoyed by millions of people as a prized food.



The complexity of the caterpillar fungus lifecycle makes its management particularly challenging.

UNUSUAL CASES



Termite mushrooms (*Termitomyces*) are cultivated by termites. *Zhuling* (*Polyporus umbellatus*) can be cultivated on oak logs with the help of another mushroom, *Armillaria*. *Tremella* is also cultivated with help from another fungus.

HABITAT TYPES

Linking habitat quality and
mushroom harvests



WHICH HABITATS ARE FAVOURED FOR MUSHROOMS?

Worldwide, over 2000 mushroom species are harvested in habitats from deserts to tropical forests. South-west China is very rich in mushrooms, the highest diversity harvested from mid-altitude forests and the most valuable from high mountains pastures (caterpillar fungus) and high altitude forests (matsutake).

MID-ALTITUDE FORESTS (Broad-leaf and Pine forests)

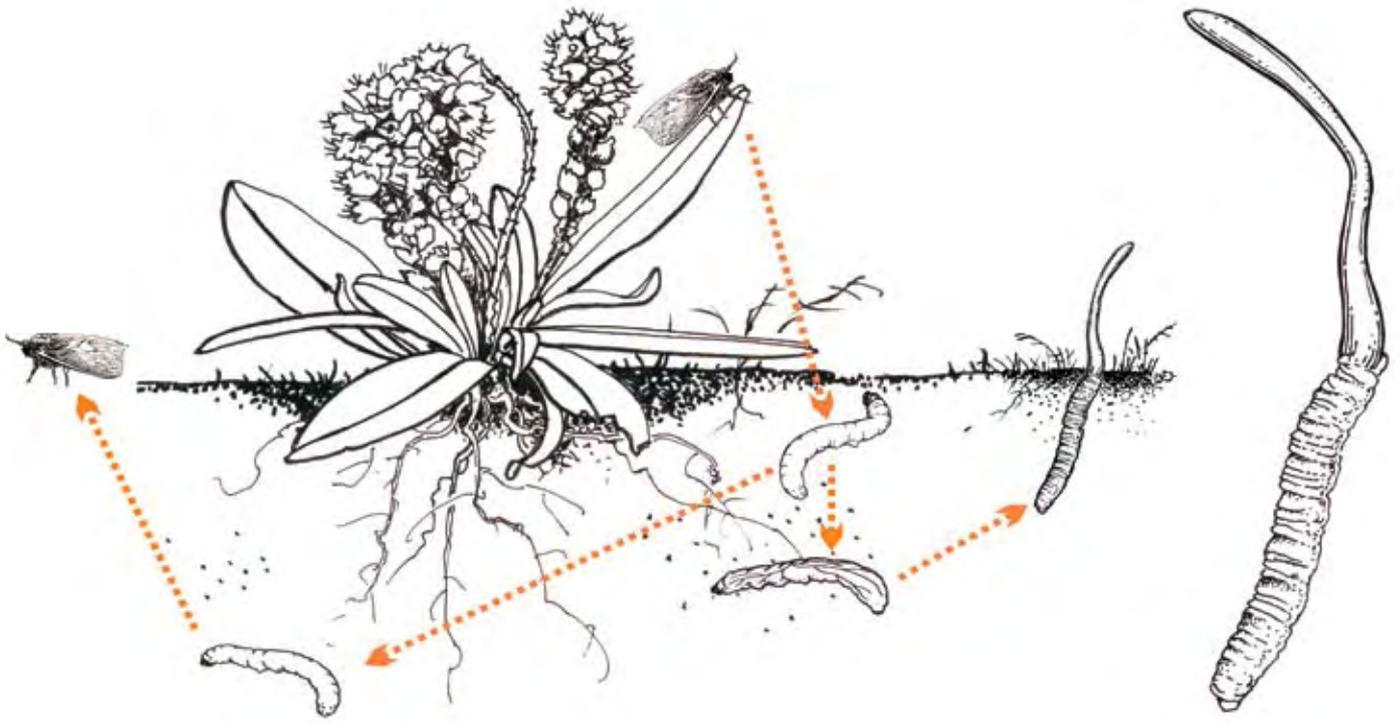


In these forests, harvesters tend to collect a range of species, rather than specialise on single, highly valued mushrooms species, as happens in high mountain forests. Due to their diversity of commercially harvested edible mushrooms, these are the most important forests for commercial mushroom harvesters. Characteristic species are mid-altitude *Boletus* species (both porcini and blue porcini), matsutake, *Russula virescens*, *Lactarius deliciosus*, *Lactarius hatsudake* and *Scleroderma*, which characteristically grows in pine forests. Even forests that look degraded have a lot of *Boletus obscureumbrinus* and *Boletus bruneissimus* (black cats-eye fungus). Many mid-altitude mushrooms are suited to young-growth forests. Other commercially harvested examples are *Laccaria* and *Scleroderma*. Forests producing porcini, *Termitomyces eurrrhizus* and *Termitomyces bulborrhizus* and the highly valued *Thelephora ganbajun* are generally regrowth that is 10 to 30 years old. Porcini are often more common in edge habitats (footpaths, roads), where the roots are actively growing. Total protection of forests, will result in lower abundance of these mushroom species.

MOUNTAINS (alpine grasslands, coniferous forests, oak forests)

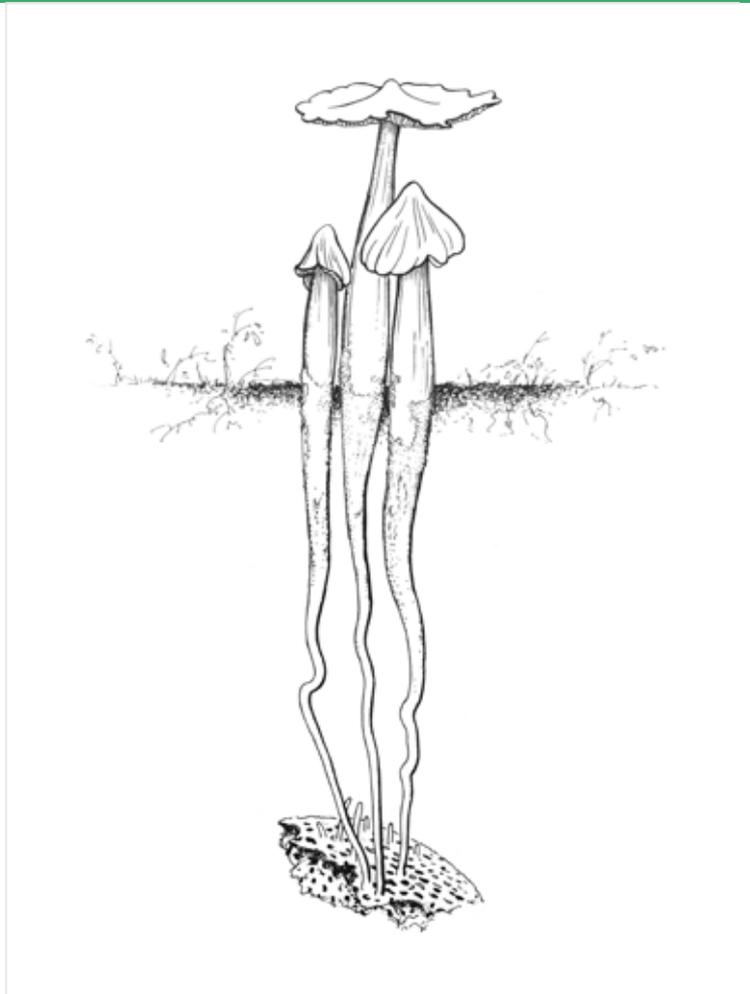


Harvesters in mountain areas can specialise on high value species. Caterpillar fungi are collected in mountain pastures and matsutake are collected from oak and pine forests, mainly for the export trade to Japan. Mountain forests are also a source of delicious edible mushrooms such as *Cantharellus* and *Lactarius*. Important tree hosts for these symbiotic fungi are birches, oaks and conifers (such as *Abies* and *Pinus*).



Hepialid moth caterpillars, spend most of their lives underground, feeding on plant roots. Some ingest spores from the entomophagous fungus, *Cordyceps sinensis*, becoming the host of the fungus and eventually dying just below ground level, where they are collected in spring.

TERMITE MUSHROOM LIFE CYCLES ARE CLOSELY LINKED TO THE LIVES OF TERMITES



Termitomyces mushrooms have a symbiotic relationship with termites, growing from termite mounds.



WHAT IS WISE USE?

“Wise” or sustainable harvests are practices that do not result in a decline in the quantity or quality of mushroom production in a given area over time.

Maintaining forest cover and managed multiple-use (rather than clear-felling, for example) is wise when one thinks that in many cases, local communities have long-term links to the landscapes where these harvests occur. Income earning options in these areas are also often limited. Maintaining the quality of different habitats across the landscape brings other benefits as well, including water quality, other health benefits and social or cultural values. While old growth forests are favoured by some mushrooms, such as *Rozites emodiensis* and some *Lactarius* and *Russula* species, many types of commercially valuable mushrooms thrive in younger secondary forests or even degraded landscapes.

DECLINING HARVESTS CAN HAVE MANY CAUSES

Yields of wild mushrooms may fluctuate wildly from year to year. Harvesters are often blamed for declining mushroom yields. Declines may occur for many reasons, however. Forest habitats are dynamic changing with age and stage after disturbance. Mushroom numbers and diversity also change as trees age, shade levels increase, understorey plants build up and trees are selectively thinned (#p.285, Egli & Ayer, 2007). Activities such as the removal of deadwood or increased foot traffic may favour some species and inhibit others.

Productivity of two of the most valuable species, porcini and matsutake has been shown to peak and then decline according the age and condition of the forests. Studies of porcini in Spain have shown that bolete production typically peaks when in pine and oak forests are 40 years old (#327, Diaz-Balteiro & Martinez, 2003). Matsutake in pine forests in Japan typically peak when the trees are 40-50 years old (#285, 3 refs). What is needed is to determine the same situation for different forest types in south-west China.

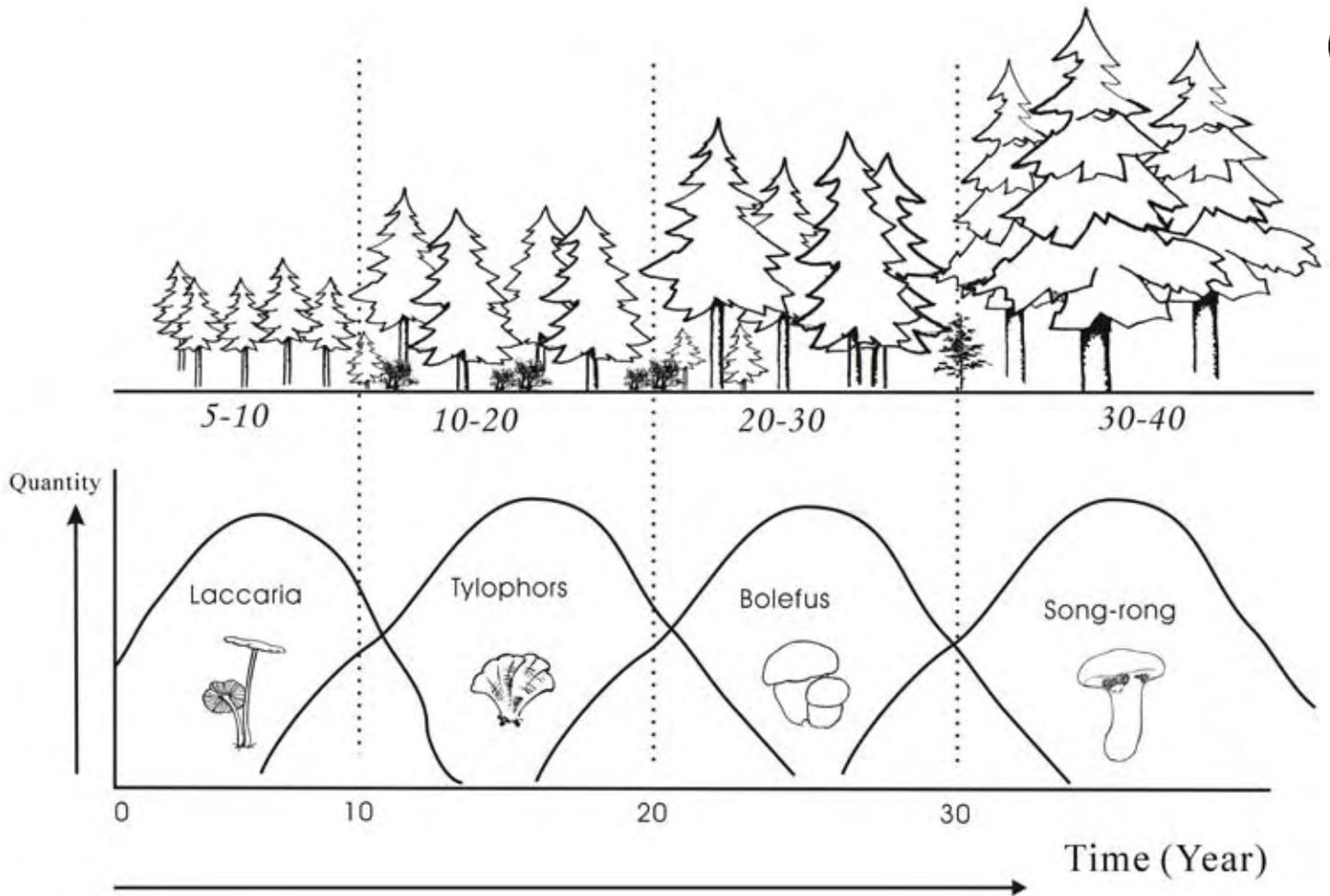
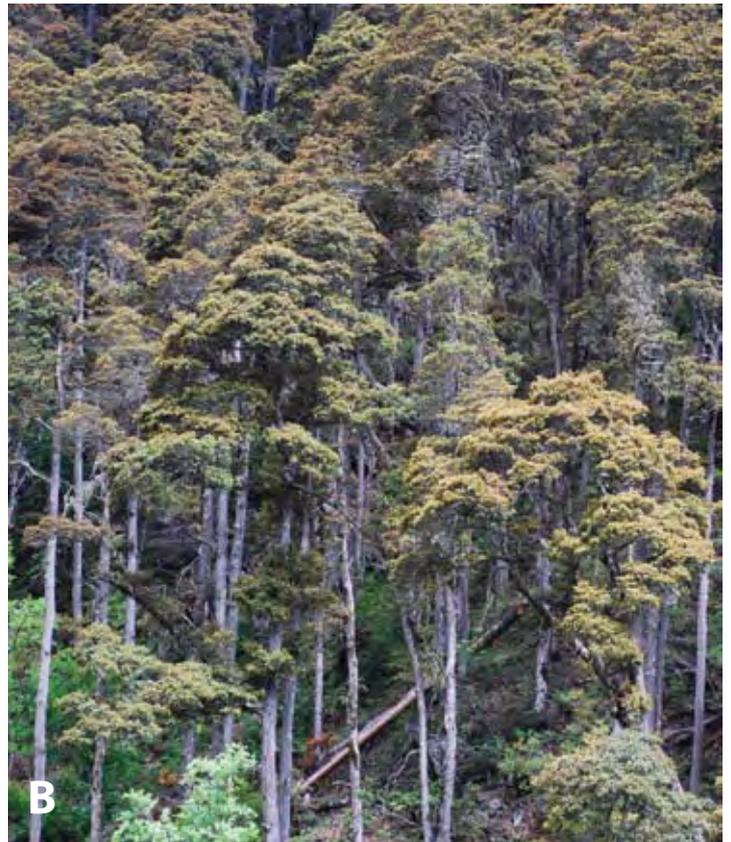
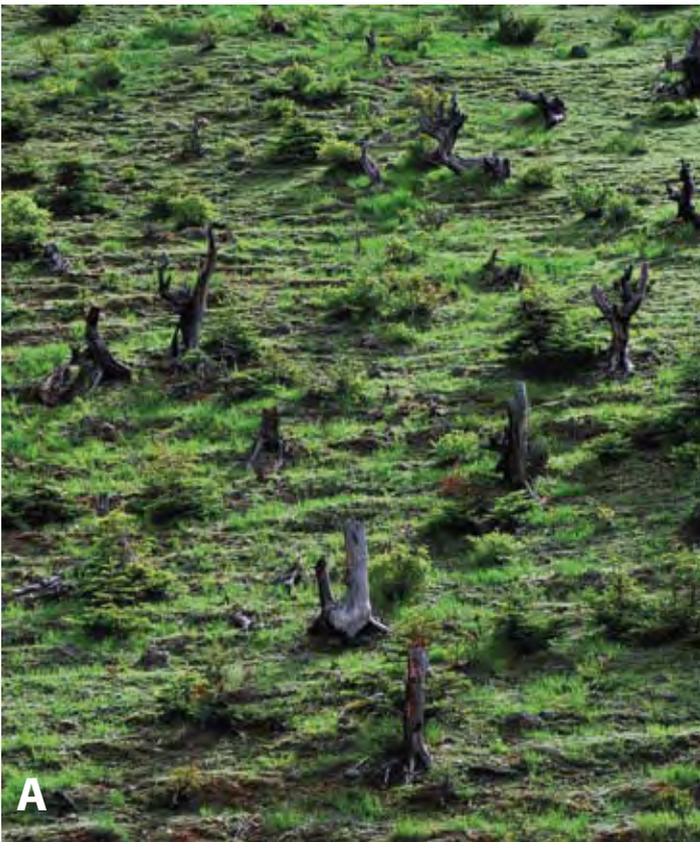


Diagram showing the links between forest succesional stages and population trends for popular edible mushrooms in China.

Forest management and restoration requires a long-term strategic plan by State authorities. A good example is pine plantation development in Korea in the 1950's, resulting in high matsutake production 30-40 years later.

THE FORESTRY BUREAU SHOULD SELECT TREE SPECIES SUCH AS INDIGENOUS OAKS AND PINES FOR RESTORATION OF LANDSCAPES THAT WERE CLEAR FELLED



Large forest areas were clear-felled in the past (A) offer an opportunity for well planned restoration and replanting (B). This would make a big contribution to future production of economically valuable mushrooms.

SELECTING MUSHROOM-FRIENDLY TREES FOR USE IN THE “GRAIN FOR GREEN” PROGRAMME WOULD DIVERSIFY PEOPLE’S LIVELIHOOD OPPORTUNITIES IN THE FUTURE

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Selecting appropriate tree species in the current slope-land conversion programme could increase mushroom yields on a large scale, with an additional link to tree tenure rights in farmed areas.

DEVELOP A FORESTRY ACTION PLAN FOR CONTROLLING INVASIVE INTRODUCED “FIRE-WEEDS”



A further factor in south-west China is the impact of invasive plants such as *Eupatorium adenophorum* (A & B, above). This South American weed, invasive in China’s pine forests, not only affects the forest understorey, but also reduces production of commercially valuable mushrooms like *Thelephora ganbajun* (C above)

Aromatic weedy species like *Eupatorium* can have a chemical effect on the soil, suppressing growth of neighbouring plants and fungi. They also form dense stands that burn easily in the dry season, creating very hot fires. These hot fires can wipe out indigenous trees and shrubs growing nearby. This is likely to also have changes on the life-cycles of mushrooms in these forests.

A young woman with dark hair, wearing a black hooded jacket over a pink shirt and a beaded necklace, stands in a forest. She is holding a large, woven wicker basket filled with various types of mushrooms. The background consists of green trees and foliage.

WISE HARVEST METHODS

FIVE STEPS TO WISE HARVEST: DEALING WITH THE SMALLER SCALE

The most important steps for wise mushroom harvest have been covered in the previous sections. These are firstly, to understand and act upon forest management, invasive species and strategically planned restoration at a landscape level. Secondly, to have forest tenure systems in place that give local communities an incentive to harvest widely. Different mushrooms react differently to different forest management and harvest regimes. Scientific data are important for informed decisions for wise harvest.

1. KNOW YOUR MUSHROOMS: A crucial first step to managing any species is at least know what you are dealing. With so many new species in south-west China, we may only know the mushroom genus - but at least this gives insights into the life-cycle requirements or preferences of the mushrooms being harvested.

TEXT BOX 2: KNOW YOUR MUSHROOMS

Accurate identification of mushrooms is not only important from a scientific point of view, but also has practical applications. A good example is the need to distinguish between poisonous fungi and edible fungi. In cases of deaths caused by eating fungi in China, most resulted from toxic *Amanita* species. If correct identification are done, then many fatalities would be avoided. This comes with experience and careful observation. To identify fungal specimens, microscopic observation and recording are important. Good fungal specimens are vital to this process.

2. AVOID DESTRUCTIVE DIGGING: Try to minimize disruption to the soil. Large-scale digging for truffles is not sustainable. Even raking for matsutake may decrease production.



Chinese truffles (*Tuber* species)



TEXT BOX 3: MOVING AWAY FROM DESTRUCTIVE HARVEST OF CHINESE TRUFFLES

Truffles are the most expensive edible mushrooms in the world. In Europe, where they are the most expensive food available, they are prized for their intense aroma, which only develops when they are fully ripe. In Europe, trained dogs are used to locate ripe truffles, which grow underground. This is a selective and non-destructive method as it allows the younger truffles to develop undisturbed. In China, where there is not along tradition of truffle use, Chinese truffles are being marketed as a food or in medicinal alcohol, but not for their aroma. As unripe truffles are used, there is no incentive to selective harvest ripe Chinese truffles. People find these truffles by digging the soil, which can be destructive. The result is that many of the truffles found are not ripe, not aromatic and not valuable, selling in Europe for a very low price. Destructive digging is also not sustainable. There is an opportunity to get much higher prices for Chinese truffles abroad and to encourage selective, sustainable harvest by training dogs. Trained dogs are already used by customs authorities in China and could just as easily be trained to find truffles. With the growing demand for ripe, high quality truffles in Japan and steady demand in Europe and North America, this strategy is well worth considering in China. Developing value-added medicinal alcohols based on young, unripe Chinese truffles is likely to further the problem of destructive, unselective harvest. In terms of value-added trade, we consider export of ripe truffles and the development of aromatic domestic products (such as truffle oils) be a better and more sustainable strategy.

3. AVOID EXCESSIVE SOIL COMPACTION: It is difficult to generalise about soil compaction, apart from extreme cases. On one hand, pressing and compacting the soil mat may negatively affect the growth of mycorrhizae and mycelia, for example due to trampling by livestock when they shelter in mountain forests. In Switzerland, a study (of *Cantharellus lutescens* (which also grows in Yunnan)) found that trampling of this mushrooms mossy habitat depressed production in that year. Long-term effects need to be studied, many mushroom species thrive at the edges of forest paths.

4. MAKE TENURE ARRANGEMENTS THAT GIVE HARVESTERS INCENTIVES FOR WISE USE.

When there is strict private tenure over mushroom harvest areas, then there are incentives to leave little mushrooms to grow larger. However, this does not work unless there is enforced agreement or unless secure tenure or agreement amongst villagers. If tenure is weak (in “open access” situations, then it’s a case of “*if I don’t take them now, someone else will*”...and the thinking of “*a little money is better than none*”. The continued harvest of very small matsutake and small porcini are a good example of why practical tenure arrangements are needed. Then harvesters can get good prices by leaving small porcini to grow larger.



Wild harvested *Boletus* (porcini) species for sale in a local marketplace, showing the small size that are sometimes collected

5. MAKE HARVEST RECOMMENDATIONS ON THE BASIS OF GOOD SCIENCE, NOT HEAR-SAY.

Common suggestions to harvesters in many parts of the world have limited scientific backing. The assumption that it is best to leave 20% of mushrooms behind is a good example (Text Box 4).

TEXT BOX 4: IS IT BAD TO PICK THEM ALL?

Spore dispersal has been shown to be important for a future crop of mushrooms. Most mushrooms produce millions and millions of spores, however. A 30-year scientific study from Switzerland showed no difference in production in areas where all the mushrooms were picked and where no mushrooms were picked areas. This contrasts with a Swiss trade recommendation that up to 20% of a mushroom population should not be picked, to allow for spore dispersal. The validity of this recommendation has not been verified by scientific studies and it runs counter to the Swiss 30-year study. In addition, asking harvesters to give up 10-20% of their income is optimistic. The possible role of harvesters in spore dispersal been studied. We do know, however, that mushrooms growing close to the ground are inefficient at spreading their spores, with more than 90% of spores being shed beneath the mushroom. It has not been shown whether it is better to leave spore-producing mushrooms in place as opposed to move them around. Even if the need to leave a certain number of mushrooms was verified, this is only likely to be followed under strict tenure.

Another example is the suggestion that harvesters must “pick mushrooms carefully or cut them off”. The idea behind this is to avoid disturbing the mycelium. For most ectomycorrhizal mushrooms, there are few mycelia connecting to the stipe base. With matsutake, the mycelium forms around the fruiting body. In most cases, if you pick the mushroom, what is picked is the above ground part, so there is little impact. With matsutake the Japanese market for matsutake from China require whole mushrooms and won't accept those that have been cut off at the base. One experimental exception being investigated in Yunnan is cutting of *ganbajun* (Text Box 5).



Rotational cutting trials by Dr He Jun (ICRAF) have had promising results for sustainably increasing harvesters income.

TEXT BOX 5: A NEW WAY OF MANAGING GANBAJUN FOR MULTIPLE HARVESTS?

In south-west China, most wild mushroom species are plucked whole from the ground. When this is done, care should be taken not to dig unnecessarily. With certain slow growing mushrooms, however, there is the possibility of getting multiple-crops by cutting them and leaving the base in the ground so it will regrow. Recent harvesting trials by the World Agroforestry Centre (ICRAF) in which local mushroom pickers participated showed this to be a promising strategy for increasing the yield of *ganbajun* (*Thelephora ganbajun*).

A final common, but scientifically unfounded mushroom harvest regulation in other parts of the world is that people are told to leave old mushrooms to spread their spores. Whether this makes a difference is questionable. As Text Box 4 describes, a 30-year Swiss study (5) found no difference with harvested and unharvested areas. In addition, many mushrooms grow close to the ground – and most spores are dumped under the individual mushroom.



A. Spore diagrams show how many millions of spores are produced. **B.** Short mushrooms close to the ground, like this *Lactarius deliciosus* generally have short distance spore dispersal. **C.** When mushrooms are tall, like this *Termitomyces*, the spores are blown by wind or washed further away by rainfall.

LAND & RESOURCE TENURE: incentives for management



MUSHROOM TENURE

Historically, the mushrooms were used as a subsistence food or condiment and were rarely sold as an income. Instead, they were considered 'insignificant' in terms of their importance for both forest management and livelihoods. As a result, their management was historically not governed by any formal regulations and mushrooms were considered to be common property resources.

Since the international and domestic market for mushroom has grown, their value has increased greatly, leading frequently to conflicts at the community level. Therefore, strong demand for regulation of mushroom management has developed at the community-level, involving higher levels of government authority when communities have been unable to resolve issues arising (6).

As mushrooms are generally considered as attached products of forest, forest policy arrangements – especially forest tenure – are important in shaping the context of mushroom management. In China, during the early 1980's forest tenure reform, known as *liangshang huafen* and *linye sanding*, the forests are divided into different tenure categories. There now are three main categories of forest tenure in China: State-owned forest (*guoyou lin*), Collective forests (*jiti lin*) and freehold forests (*ziliu shan*), which are allocated to individual households (17). Interestingly in many cases, valuable mushrooms (such as *matsutake*) have become one of the key factors influencing how the forest privatization might proceed in the future.

TEXT BOX 6: COMPETITIVE OR COLLABORATIVE MANAGEMENT?

Matsutake are the most valuable mushrooms in people's livelihoods in NW Yunnan, but in many cases, are an open access resource. As a result, matsutake use faces many problems including resource conflict and competition that result in poor harvest methods. Collaborative harvesting and benefit sharing is promoted as an ultimate objective for sustainable use and management. Different community-based management models were testing through research in NW Yunnan and documented in a DVD/video. In June 2008, this DVD was shown at a workshop on the feasibility of establishing collaborative harvesting methods and moving away from open access in Zhongdian (Shangri-La) County. Three cases from Sanchun, Lizui and Wujie were shown to illustrate different patterns of resource use from competition to collaboration and benefit sharing. All workshop participants in Jidi were very interested in the video showed and realized the advantage of the collaborated and contracted management approaches. However, when it comes to the best solution of local community, no one thought that the approaches from Lizui and Wujie were feasible to Jidi. The main reasons given for this were: a lack of strong local institution and system to protect and manage such a big open access ("no wall") area from outsiders or unmanaged harvest; the need to balance the proposed "participatory" management approach outlined in the DVD with existing benefits to households.

TENURE AND MUSHROOM USE PATTERNS IN CHINA

Tenure differences provide different incentives for harvesting behavior and site management activities. Taking the example of *matsutake* mushroom in Yunnan Province of China, management can be categorized into three major patterns:

PATTERN 1: Open access with loose regulation enforcement: The characteristics of this type are: (i) Open resource access and (ii) Regulations existing but loosely enforced or implemented. Open access operates at three possible levels:

- (a) open access within the community or communities with agreement but excluding outsiders;
- (b) allowing outsiders to access under certain conditions (generally leasing of user rights), and
- (c) fully open access to anybody. The implementation of matsutake management regulations depends heavily on market, local institutions and their capacity.

PATTERN 2: Open access with strong regulation: Well functioning local institutions and markets combine to enable strong enforcement of regulations.

PATTERN 3: Private access

This is only possible under the condition that the resources right is allocated to each individual household. In practice, this does not necessarily mean that the forest land ownership is personally owned. In many cases of Yunnan Province, the collectively owned forest is delineated into small blocks and user rights are allocated to individual households by the collective. In practice, the 'collective' usually is the local village government., which manages the forest according to regulations set by the local forestry bureau with the guidance of national forestry planning regulations.

MATSUTAKE AND MUSHROOM MANAGEMENT

One of the best known cases of mushroom management and tenure in China is matsutake, due to the high value of this mushroom trade. A recent study of matsutake management in Yunnan, for example, has shown how a multi-tiered set of different groups and institutions has emerged to form a strategy that is probably more effective than a single comprehensive policy governing all non-timber forest products (NTFPs) (17). As the Nick Menzies and Li Chun point out in their study of matsutake management (17):



A household in the Qinling mountains (Shaanxi) with and freehold forest (ziliu shan) on the nearby hill, collective forest (jiti lin) in the background and State-owned forest (guoyou lin) in the distance.

"...The management of forests and forest resources by village communities has a long recorded history in China. Recorded or not, these village rules and regulations, known as xianggui minyue (literally, 'village rules and popular compacts'), have played and continue to play a vital role in village life and in the local management of natural resources.....Practice has created a de facto policy framework based on a hierarchy of responsibilities. This has had the advantage that each level of the hierarchy, from the central government to the village, is responsible for what it is best equipped to do, even if each level may have a different perspective on the need for regulation".

In this way, lessons from the past link with modern challenges, allowing for adaptive development of practical mushroom management systems.



GETTING GOOD VALUE: quality, handling & processing



Due to their high water content, high enzyme activity and the presence of micro-flora, mushrooms are highly perishable. Processing fresh mushrooms after harvest for long-term use is often challenging. This is usually done by drying, freeze-drying, freezing, or canning. In rural areas, drying is the most common method for preserving mushrooms. Advances in freezing technology indicate a growing trend toward the production of convenience foods which are “ready to cook” or “ready to eat” (9).



Wild edible mushrooms sold on a large scale in China: grading, processing, product traceability and good packaging have enabled producers to reach large-scale commercial markets.

With a shift from wild harvest to mushroom cultivation, it is also possible to reach diverse markets and to add value through grading, processing and value-adding. Three types of upgrading have been successful:

- (1) **Functional upgrading**, where new marketing and good quality packaging are achieved, as shown in the above photograph;
- (2) **Process upgrading**: where the transforming production process has been re-organized or improved processing technology introduced;
- (3) **Product upgrading**, where fungi are developed into diverse and more sophisticated product lines, with higher values per unit volume. The beautifully packaged dried and powdered black wood-ear fungus (*Auricularia*) products in the photograph below.



Good presentation makes a big difference: design quality of a black wood-ear fungus product.

MUSHROOM CULTIVATION



The best global lessons for mushroom production are from China, which is the world's largest exporter and consumer of mushrooms. This has been achieved over the past 50 years through cooperation between the government, mycologists and 15 million local farmers. As a result, in 2002, China exported 6,648 tonnes of dried *Lentinula edodes* or 80% of the world trade volume, which was worth US\$41.48 million. Dried *Auricularia auricula* quantities were even higher—7,767 tonnes, worth US\$25.07 million. On the surface, mushroom production from cultivation to meet commercial demand for mushrooms seems simple. Tenure issues are usually clear. Harvest pressure is taken off wild stocks in multiple-use forests and intensive production of species like *Auricularia* (wood-ear mushrooms), shiitake (*Lentinula edodes*) and oyster mushroom (*Pleurotus ostreatus*) is economically viable and efficient. Greater efficiency through cultivation can bring significant economic benefits to many rural farmers, such as *Lentinula edodes* producers in Shaanxi. To sustain quality mushroom production, however, attention needs to be given to site location and environmental management.



A. Shiitake mushroom production at a village level in Shaanxi has increased income to local farmers. B. Detail of production.

Because mushrooms can concentrate metal ions from the surrounding environment, including toxic heavy metals. Fungus cultivation therefore needs to be established away from industrial areas. Even in unpolluted or mildly polluted areas, species of *Agaricus*, *Macrolepiota*, *Lepista* and *Calocybe* all can accumulate high levels of cadmium and mercury (7). In heavily polluted sites, such as near to metal smelters, the concentrations of cadmium, lead and mercury increase considerably (8). For these reasons, mushroom cultivation needs to be sited wisely. Product traceability and food quality systems also need to be established.

Cultivation does not necessarily mean and end to the need for management plans for forested landscapes. In China, wood ear mushroom production now takes place on a massive scale, using *qing gang* (*Quercus*) stems harvested from natural forests. *Zhuling* cultivation also uses *Quercus* logs. With more cultivation in China, over-harvest of large poplar trees (*Populus rotundifolia* var. *bonatii*) is also a concern. To be sustained this requires forest management plans for oak forests or a shift to other substrates for intensive mushroom production or the cultivation of relatively fast growing trees as an alternative to wild harvested poplar or oak.



A. Cultivated *zhuling* (*Polyporus umbellatus*). B. Harvested *zhuling* from a buried log. C. Logs used to cultivate *zhuling*.

LOOKING FORWARD: integrated approaches to mushroom management in cultural landscapes



LOOKING FORWARD: LANDSCAPES & INTEGRATED APPROACHES

Landscapes are dynamic and changing. For mushroom harvest to be successful in the future, three “goods” are needed (1) Good habitat; (2) Good information and (3) Goodwill. Many questions of harvest are yet to be studied. For this reason, the observations and experiences of harvesters, scientists and forest managers are all valuable. Without goodwill and respect between these different interest groups, wise mushroom management is not possible. It is our hope that these guidelines are a small step towards promoting these three factors.

At a global level, despite the estimated 1.5 million species of fungi that form a very significant part of the world's biodiversity (9), even macro-fungi have generally stayed “below the radar screen” of the 1992 Convention on Biological Diversity (CBD), despite their ecological importance and multiple values. Encouragingly, recent steps have been taken to developing national and regional strategies for macro-fungi, following a similar approach for “Important Fungus Area’s (IFA’s)” to the CBD’s Global Strategy for Plant Conservation (GSPC). Following the GSPC “model” is a good idea. The first step in this process was taken by in the United Kingdom (13) and since then at a regional scale within Europe (12). Regional and national associations of mycologists have an important part to play in this process. Examples of regional networks are the:

- European Council for the Conservation of Fungi (ECCF) (www.wsl.ch/eccf/publications-en.ehtml);
- African Mycological Association (www.africanmycology.org);
- Asian Mycology Committee (www.fungaldiversity.org);
- Australasian Mycological Society (<http://australasianmycology.com>)
- Asociación Latinoamericana de Micología (<http://almic.org>) in Latin America
- Mycological Society of America (MSA) (www.msafungi.org).

There are three main threats to macro-fungi: (1) habitat fragmentation; (2) a decline in areas with old-growth forests and (3) reduced dead wood availability. Examples of other threats are a decline of old semi-natural and unfertilized grasslands due to increased addition of chemical fertilizers, reforestation or lack of grazing.



Loss of old-growth forest habitat, clear-felling and decline in deadwood availability all impact fungal diversity.

Although awareness of the diversity and importance of fungi has increased, basic mycological knowledge is limited, particularly in the tropics where fungal diversity is probably highest. While in Asia, China and Japan are the most active in terms of mycological research (10), in Europe only six countries (Finland, Poland, Russia, Spain, Sweden and Turkey) have more than ten professional mycologists working with macro fungi (11).



The knowledge of local mushroom harvesters can be very useful for a better understanding of fungus ecology.

With so few professional mycologists available, it can be extremely useful to form partnerships with knowledgeable local people. Methods for ethnomycological research have recently been described (15).

“MycoAction Plans” that link from a global level, through regional plans to a national level and then locally, with actions grouped according to the key themes such as of collaboration, education and conservation have been proposed (10). These interlinked levels make sense because the CBD is implemented through national governments that are signatories to the Convention. Priority setting is critical where funding is increasingly scarce and problems are urgent, with the suggestion that there should be:

- agreement on a list of priority fungal groups to be surveyed in rapid assessments of sites;
- development of a list of criteria that can be used to assess and evaluate the sites of greatest importance for fungal conservation;
- to compile a list of specialists willing and able to undertake identifications of fungi, indicating which identifications will be done free of charge and which require payment, making the list available at least on-line via the International Mycology Association (IMA) home page (www.ima-mycology.org);
- developing complementary accessions policies through discussions between four to six of the major world service culture collections.

At the other end of the scale from global and national strategies for mushroom management and conservation is the involvement of local institutions and local people, such as mushroom pickers. Learning from local experience and local circumstances is an important part of tailoring broader strategies so that they can be implemented in practice.

Bringing together this hierarchy of different institutional levels to achieve the three “goods” (good habitat; good information and goodwill) will achieve the fourth “good” we all want....a good future for fungi.

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