

OREGON BLACK TRUFFLES

zoe the
truffle hound

what's
in season

contact us

WHAT'S IN SEASON...

OREGON BLACK TRUFFLE

(*Leucangia carthusiana*)

A distinctive, yet complex aroma, with a hint of tropical fruit, often described as pineapple. They lend themselves well to many hearty meat-based dishes to delicate desserts.

Growing season: Late December - March.

Call for availability and pricing.

OREGON WHITE TRUFFLE:

(*Tuber oregonense*)

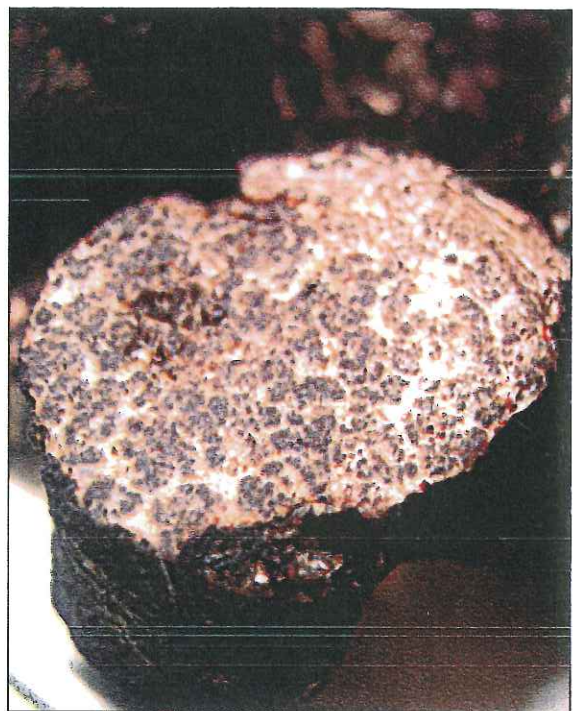
A very powerful musky garlic aroma that pairs well with many Italian dishes and cream-based recipes.

Growing season: Late December - March.

Call for availability and pricing.

Hunting truffles is literally dirty work. Most people that hunt for them do so without the aid of a dog, disrupting the truffles fragile environment. We don't buy truffles from other pickers, and we only pick what you order. We feel that a smaller footprint not only results in happier forests, but higher quality truffles for years to come.

Although black & white truffles are our specialty, we also hunt for many other types of edible mushrooms. Some of these can be effectively dried and preserved for long periods of time. See below for approximate seasons for the local fresh mushrooms available. If you'd like to inquire about dried mushrooms for sale, contact us today.



Cross section of a ripe Oregon black truffle.

WINTER

Oregon Black Truffle
(*Leucangia carthusiana*) A distinctive, yet complex aroma, with a hint of tropical fruit, often described as pineapple.

Oregon White Truffle
(*Tuber oregonense*) A very powerful musky garlic aroma.

Brown Truffle
(*Leucangium brunneum*) Availability of this rare truffle varies from year to year. Please inquire about availability.

Hedgehog Mushrooms
(*Hydnum repandum*) Taste is comparable to a Chanterelle mushroom, but with a nuttier flavor.

SPRING

Spring King
Boletus/Porcini
(*Boletus Edulis*)

Only found in the Cascade mountains in the Pacific NW!

Morels
(*Morchella*)

Fire (burn) morels: collected in year old forest fire areas.
Black Morels: found eastside of the Cascade mountains.
Esculenta (yellow) morels: found along streams and marshy areas.

Spring Oregon
White Truffles
(*Tuber gibbosum*)

Very similar to the winter variety. Though, these tend to grow much larger. Season: April through June.

SUMMER

Chanterelle

Found near conifer and Oak trees throughout the northwest.

Chicken of the Woods

Found in shelving masses or shelves on logs, stumps or trunks.

FALL

Chanterelle

Found near conifer and Oak trees throughout the northwest.

King Boletus

Often found in groups within or at the edge of forests - preferably conifers but can thrive in Oak and Birch forests.

Matsutake

Ideal habitat is sandy soil under conifers, Madrone or Manzanita.

Cauliflower Mushroom

Thrive at the base of conifers - specifically older pine trees in bad health. Also known to grow on stumps and fallen trees.



Oregon Black Truffle



King Boletus



Morel

A dark horizontal bar with a small image of a morel on the left. It contains the following text from left to right: [home](#), [zoe the truffle hound](#), [what's in season](#), [contact](#), site design by Karl Deutsch | [www.kjcreative.com](#)

OREGON BLACK TRUFFLES

zoe the
truffle hound

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in season

contact us

MEET ZOE THE TRUFFLE HOUND

We are different from most truffle hunters because we employ the use of our specially trained dog, Zoe, to seek out only the ripest of Truffles. This technique ensures that you will receive *only* the highest quality Oregon Black truffles at their peak of aroma and taste.

This method of collecting truffles causes very little disturbance to the soil and rootlets of the host tree, thus ensuring a healthy forest. We like to call this method "hound harvesting". Most truffles for sale are not collected in this manner, but rather are harvested using large rakes and disturbing huge areas of soil.



TRUFFLE HOUND FOR HIRE

We also offer on-site consultation and investigation of property owners land for the presence of Oregon black and white truffles. In conjunction with our (human) truffle expert and Zoe, we can accurately and efficiently determine if your forested land contains Black or White truffles. This valuable knowledge of your land can reap financial benefits for years to come, and the possibility of immediate compensation of the truffles found using our services. Please read important details concerning this service listed below.

HEALTHY TRUFFLE HABITAT:

Correct forest habitat is vital for productive truffle growth. Ideal forest habitat is tightly spaced Douglas fir forests, approximately 20 to 40 year old trees, with little or no undergrowth. The Cascade mountain foothills (west-side, below 2,000') and the Coast Range (east-side, below 1,000') are ideal regions for truffles. This includes the Willamette Valley. You don't need acres of forested land for this service to be of value to you. A small patch of wooded habitat could produce many pounds of truffles!

At our discretion, we may offer to buy the truffles from you at or above buyers market rate.

TRUFFLE PLANTATIONS:

For people that have an active, or hope to be active, Truffle plantation (or truffières) of European species of truffles, we are offering, for a limited time, free on-site inspection and hound -harvesting of truffles from your property.* The



only caveat is that we are allowed to take with us a small percentage of truffles found. Appointments are always discreet and completely confidential.

Truffle trees must be at least 4 years old. Percentage of yield we keep depends on the amount found (the more we find, the less we take for our services). For the first pound found, our take is 25%. Terms and conditions are subject to change without notice.

GROUP TRUFFLE HUNTS:

Experience the excitement of hunting for truffles with a dog and your friends and family at a productive truffle location. The necessary tools for harvesting truffles will be provided. Plus, you get to keep the truffles we find!

Our dogs are very efficient. Sometimes it's hard to keep up with all of her finds. This means a large group of people will all be actively hunting for truffles at the same time! They trained to sniff and 'point' to the exact location of the truffle, but lets her human counterpart harvest the truffle. The truffle season is short – typically ending around the beginning of March. Act now before all available times fill up. Call for details and reservations.




Frequently Asked Truffle Questions

What are truffles?
What is mycophagy?
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How do I find my local mycological club?


What are truffles?

Truffles are *hypogeous* (underground) versions of mushrooms. They don't form a prominent stem and their spore-bearing surfaces are enclosed. They rely on animals eating them (*mycophagy*) to distribute their spores, instead of air currents like mushrooms. Truffles resemble small potatoes, and often between the size of a marble and a golf ball (see the photo gallery). There are hundreds of different kinds of truffles, and while none are known to be poisonous, only a few of them are considered to be delicacies by humans. Truffles (and mushrooms) are only the "fruit" of the fungus (like an apple to an apple tree); the main perennial fungal body exists as a web of filamentous hyphae in the soil. All of the truffle fungi form mycorrhizae with the roots of trees, and are essential to the trees' ability to acquire nutrients. The belowground fruiting habit of truffles is thought to be an adaptation to forest fires or dry or frosty periods, in which aboveground mushrooms are more vulnerable. Oregon State University Extension has published a nice overview of truffles available here, "An Oregon Garden Guide to Truffles."

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What is mycophagy?

As most truffles never break the surface of the soil, they must rely on animals to eat them and distribute the spores in their scats. The word "mycophagy" comes from the Greek words "mykes" (fungus) + "phagein" (to eat). Some animals, like the red-backed vole, eat truffles almost exclusively. In order to be located by hungry critters, truffles have evolved strong scents that, as they mature, can be detected from a distance by a suitably sensitive nose. Depending on the species of truffle, to humans these scents can be pungent, fruity, unpleasant, or delectable.

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What is mycorrhizae?

Mycorrhizae is a *symbiotic* (mutually beneficial) association between some kinds of fungi and plants. The word "mycorrhizae" comes from the Greek words "mykes" (fungus) + "rhiza" (root). Fungal filaments (hyphae) are much more efficient at extracting water and nutrients from the soil than root hairs - it has been reported that there are as much as 100 meters of fungal hyphae in one teaspoon of healthy forest soil. The fungal hyphae not only permeate the soil, they penetrate the root cells of plants and facilitate a nutrient exchange where the host plant gets needed nutrients from the soil via the fungi, and the fungi (which cannot perform photosynthesis) get their needed sugars from the host plant. Many plants will not grow well at all unless they have mycorrhizal fungi on their roots helping them get nutrients.

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What is the role of truffles in ecosystems?

Truffles (and mushrooms) are the "fruit" of underground webs of fungi. The fungi of all truffles (and many mushrooms) are mycorrhizal. Mycorrhizae are essential in assisting trees obtain nutrients and water from the soil - without mycorrhizae we would not have forests as we know them today. Truffles are also an important part of the food chain via mycophagy. For example, flying squirrels rely on truffles for food, and spotted owls rely on squirrels for food. In turn, the fungi rely on the squirrels (and owls!) for spore distribution, the trees rely on the fungi for nutrient acquisition, the fungi rely on the trees for energy (sugars from photosynthesis), and the owls and squirrels rely on the trees for habitat.

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What are "True" vs. "False" truffles?

In Europe, the term "truffle" in the very strictest ("true") sense has historically only referred to those *hypogeous* (belowground) fungi that were gourmet edibles, primarily in the genus *Tuber*. *Tubers* are members of a larger grouping of fungi called Ascomycetes. For some folks, only *Tubers* and their close relatives are considered "true truffles" (all others being "false truffles"), and for other folks all hypogeous Ascomycetes (irrespective of culinary qualities) are called "true truffles". However, there are many, many other perfectly nice species of hypogeous fungi, both Ascomycetes and Basidiomycetes, that are not particularly prized as food outside the squirrel community. Nowadays many folks have discarded the "true truffle" and "false truffle" distinctions for a more egalitarian nomenclature, and are quite comfortable simply calling all hypogeous fungi TRUFFLES.

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What are Ascomycetes and Basidiomycetes?

Ascomycetes and Basidiomycetes are two major groups of fungi (like cats and dogs are two major groups of animals). Unlike cats and dogs, the distinction between Ascomycetes and Basidiomycetes is based on microscopic characteristics, namely the manner in which the spores are produced. In Ascomycetes, the spores are produced *inside* of sock- or sac-shaped structures called asci. In Basidiomycetes, the spores are produced on prongs on the *outside* of structures called basidia. As a general rule, Ascomycetes tend to have a brittle texture (such as *Morels*), and *hypogeous* (belowground) Ascomycetes (eg. truffles) are frequently - but not always - hollow (such as *Genea*). Basidiomycetes are fleshier in texture (all gilled mushrooms are Basidiomycetes), and the hypogeous Basidiomycetes tend to be squishy or spongy on the inside (such as *Zelleromyces*). This key may help in distinguishing "asco's" from "basid's". There are two other groups: The **Zygomycetes** form their spores individually on specialized "suspensor cells" and contain one truffle-forming ectomycorrhizal genus, *Endogone*. The **Glomeromycetes** form their spores individually or in clusters at the ends of hyphae. Only one genus in this group forms truffles, *Glomus*.

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Are any truffles poisonous?

No truffles are known to be poisonous to humans (but we don't know everything...). This non-toxicity seems sensible, considering that truffles rely on small animals (via mycophagy) to distribute their spores. That said, ALWAYS be absolutely sure of the identification of anything you are considering eating! Many poisonous *Amanita* and *Cortinarius* mushrooms start out as belowground "eggs" that can be dead-ringers for truffles at a glance. The Oregon white truffles that most folks around here are interested in eating (*Tuber gibbosum* & *T. oregonense*) are firm and brittle, will have a beige to smokey-colored marbled interior, and a pleasant earthy odor. Mushroom eggs (and many truffle species that are only appetizing to squirrels) are generally more squishy, spongy, or cartilaginous - always check every truffle you intend to eat, different species frequently intermix.

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Where are truffles found?

Truffles can potentially be found almost anywhere there are trees. Only a few families of trees (such as maples and cedars) do not associate with truffle-forming fungi. Truffles fruit throughout the fall, winter, and spring, depending on species and locality. They usually occur at the interface between the organic litter and the mineral soil, about one to six inches deep, but can emerge to the surface or be more than a foot deep. Evidence that small animals have been digging in an area recently is often a good indication that truffles may be about. For a detailed accounting of what kind of habitat a particular truffle species likes, and when it is likely to be found, see the Specific Habitats page.

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How are truffles found?

In North America, truffles are found by raking the organic litter away with a 4-tine garden rake. Find suitable habitat (most any forested area; see above) and gently peel back the litter layer (remember to replace the litter when you are done and try to leave the area as you found it). Look for things that look like little potatoes, often beige, yellowish, or reddish brown (see the photo gallery). If you find one it will be immediately apparent that it is not a dirt clod. Finding truffles takes a little luck and a lot of patience. Sometimes they just aren't there, but you never know until you look. In Europe, pigs and dogs have been used for centuries to help find truffles.

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Pigs vs. dogs?


The scents produced by truffles to encourage mycophagy sometimes attract animals that are larger than squirrels. Some truffles, including the gourmet edibles Italian perigord, French white, and Oregon white, produce a scent that mimics a male pig sex hormone. It is for this reason that *female* pigs have been used historically in Europe to help find truffles. More recently, dogs have become the preferred truffle hunting companion for several reasons, among them 1) Dogs can be trained to find, but not *eat* the truffles, and 2) Dogs are much easier to get into the back seat of a car.

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Truffle maturity and the market

In the United States, we have not advanced to the point of using trained animals to help find truffles. This is unfortunate not only from an efficiency standpoint, but also a market reputation standpoint. The reason for this is that truffles only develop the aroma that attracts animals and excites chefs when they are fully mature. Thus, pigs and dogs will only indicate where *mature* truffles are. In North America where we humans (with our lousy noses) rake indiscriminately for truffles, we frequently get as many

immature specimens as mature ones. Commercial collectors often have incentive to sell all the truffles they find, whether they are mature or not. Immature truffles have little culinary value, as they have not yet developed the pungent aromas that chefs seek. The frequent presence of immature specimens in commercially available Oregon white truffles has diminished their reputation and value on the world market compared to their European counterparts.

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Truffle dog training?

NATS offers occasional truffle dog training seminars in Corvallis, Oregon. Contact Marilyn Hinds for information. Below are some dog trainers who offer specialty courses in canine trufflehunting, in no particular order:

Pacific Truffle Dogs offers truffle dog training courses in the Portland area.

Umami Truffle Dogs offers truffle dog training courses in Veneta, west of Eugene.

NW Truffle Dogs offers truffle dog training courses in the Portland area.

Trifecta Training offers truffle dog training courses in the Eugene area.

Toil and Truffle offers truffle dog training courses in the Seattle area.

Pasqual Sricco offers truffle dog training courses in New Jersey, and sells truffle dog training videotapes.


The general principal is to start when the dog is young, and get them used to the scent of truffles by having them fetch a sock with mature truffles inside, and gradually work up to finding the hidden, then buried sock. Some folks have used a pungent cheese (like limburger) as a surrogate for mature truffles. Links to accounts of truffle dog training are below:

[Truffle dog training in Italy](#)

[A history of training poodles](#)

[Hunting truffles with dogs in France](#)

[Hunting truffles with dogs in Alba](#)

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Which truffles are the gourmet edibles?

Oregon white truffle (*Tuber oregonense* and *T. gibbosum*)

Reasonably common in the Pacific Northwest from the west side of the Cascade mountains to the coast from British Columbia to northern California. *Tuber oregonense* is generally found from October through February. Its exterior peridium is whitish when young, developing orangish-brown tints as it matures, and finally becoming orangish-brown overall. Microscopically, it has a peridium of interwoven hyphae. *Tuber gibbosum* is usually found from February through June. Its exterior peridium begins whitish and becomes pale olive-brown as it matures. Microscopically the peridium is of inflated cells. In both species, the texture is quite firm (not spongy), and the interior is white when immature becoming a marbled smokey brown as it matures. Both species seem to prefer young (15-40 year-old) Douglas-fir plantations. By February, most of the *Tuber oregonense* should be pretty mature and the *T. gibbosum* will just be getting started. Tom Volk has a nice Oregon white truffle website. You can also read more about both Oregon white and black truffles in this article.

Oregon brown truffle (*Kalapuya brunnea*)

The Oregon brown truffle was discovered by NATS members in the early 1990's and formally described in 2010. It grows in younger Douglas-fir forests in the Oregon Coast Range and western foothills of the Cascades. It has a reddish-brown exterior and a greyish mottled interior. When mature the odor can be quite garlicky.

Oregon black truffle (*Leucangium carthusianum*, formerly *Picoa carthusiana*)

Less common than Oregon white truffles, Oregon blacks are larger (golf-ball to baseball size), and are often much deeper in the soil than Oregon whites (commonly 4-10" deep). They are very dark inside and out, and have a very pungent, earthy odor when ripe. Some equate the aroma to a strange mix of pineapple, port, mushrooms, rich soil, and chocolate. Looking like irregular lumps of coal, with white-veined flesh, the Oregon black truffle has a texture of moist Parmesan and ground almonds.

French black (Perigord) truffle (*Tuber melanosporum*)

Native to the oak forests of the Perigord region of central and southwest France, it is now widely cultivated in Spain, Australia, and the United States. The black perigord is among the most valuable of truffles at up to \$1000/pound. It has a blue-black exterior when fresh, fading to brown-black with age and a pungent, earthy odor.

Italian white (Piedmont) truffle (*Tuber magnatum*)

Considered by some (mostly the French) to be second best to the French black truffles, its cost can exceed that of the perigord. It is native to the foothills and mountains of northern and central Italy and southern Yugoslavia. They grow in conjunction with oak, hazel, poplar, and beech trees. The flesh is solid, light-coloured, and very brittle; it is not unheard of for a fresh truffle to shatter if dropped on the floor. Large specimens can weigh as much as a pound, but most are the size of large walnuts. The white truffle is slightly more perishable than its darker cousins, and the flavour and aroma diminishes within a week or two after harvest. The white truffle has a distinctive pepper edge and is often eaten raw. The skin is a dirty beige when fresh, turning a darker brown with age. More information can be found at this website.

Burgundy, or Summer truffle (*Tuber aestivum*, formerly *Tuber uncinatum*)

Native to France, Italy, and Spain, the summer truffles are usually at their best in July, but can be found from May to October. They have a black exterior and off-white interior, and a relatively light scent. This truffle has been established on plantations in Sweden and New Zealand.

Tuscan truffle (*Tuber borchii*, formerly *Tuber albidum*)

Similar to the Italian white truffle in appearance, having a chestnut to muddy tan exterior and a softish interior equally divided between chocolate brown and white. The flavor can be distinctly garlicky.

Pecan (Texas) truffle (*Tuber lyonii*, formerly *Tuber texense*)

Pecan truffles (also called Texas truffles) are found from New Mexico to the gulf coast and eastern seaboard to the great lakes and eastern Canada. It is not limited to areas with pecan trees, but was named based on the habitat in which it was discovered. More information can be found at this University of Georgia website. Click here for a story about Pecan truffles from the Hilton Head Island-Bluffton Island Packet, and click here for a story about Pecan truffles from the New York Times.


Chinese truffles (*Tuber sinense*, *Tuber indicum*, and *Tuber himalayense*)

These are three distinct species found in South China, but pickers tend to lump them together as Chinese truffles. This is unfortunate since the flavor and quality vary from one species to another. First marketed in France in 1994, these truffles are now found in American restaurants at fairly reasonable prices, but their flavor and aroma do not come close to that of the French truffles, perhaps for the same reasons as Oregon white truffles (too many immature specimens). *T. indicum* is recognizable by its brown interior and very fine white veins. *T. sinense* has a dark brown interior with large ivory veins, and is said to be chewy and oily with a bitter aftertaste.

Desert truffles (*Terfezia boudieri*, *Terfezia pfeilii*, *Terfezia clavaryi*, and others)

Native to northern Africa and the Middle East, these truffles have been a staple for many nomadic tribes


for millenia. Sometimes called the Lightning Truffle, they often fruit shortly after thunderstorms wet the desert. There is an account of desert truffle culture here.

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How are truffles cooked?

Truffles are generally used raw, or very lightly cooked, because the flavor compounds are highly volatile. Truffles go very well with brie cheese (doesn't everything?). NATS has compiled a cookbook of truffle recipes, a few of which are posted on the Recipes page. Below are some links to other truffle recipe websites:

The Mycological Society of San Francisco
The Cottage Kitchen
Truffles-de-Provence, with notes about storage
The Truffle Zone
Oregon White Truffles

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Where can I buy truffles?

There are tons of websites selling truffle-related products. Here are a few, selected for no particular reason. *NATS does not endorse or guarantee any of these sites!* You might also try ebay...

Oregon Wild Edibles
Mycological Natural Products
Tartufi Unlimited
The Wine and Truffle Co.
Truffles USA
Gourmet Foodstore
Earthy Delights
Marky's Caviar
US Shops


How do I store truffles?

Truffles can be stored for several days in a paper bag (never in plastic!) in the refrigerator. They can be frozen for several months in a glass jar. They can be immersed in olive oil, and the oil will absorb the flavor, however shelf life at room temperature is limited without pasteurization. Some folks store truffles in dry white rice, but this is not recommended as the rice will tend to draw the moisture and aroma away from the truffles, diffusing and diluting the aroma. Ideally, truffles should be used as fresh as possible, unless you are in the enviable situation of having too many!

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I found a truffle. What is it?

What? You don't have your very own copy of the [NATS Field Guide to Selected North American Truffles and Truffle-like Fungi](#)? You can get one here! Alternatively, you can mail specimens to the Trufflemaster for identification. Truffles should be dried thoroughly before mailing (see below). For more information on sending truffles for identification click here. Include your email address, collection location and habitat data, and any notes about unique fresh characteristics (odor, staining reactions, etc.).

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How do I dry truffles?

Truffles should be dried before sending to the Trufflemaster for identification, but not if you intend to eat them. Fresh truffles sent through the mail often arrive as an unrecognizable furry odiferous lump - not a good thing! Ideally, truffles to be mailed for identification should be dried on a regular food dehydrator. If you don't have a dehydrator, leave them in the fridge in a loosely closed paper bag for about 3 days, this will dry them quite well (Caution: This may impart a truffle flavor all other foods in the refrigerator!). Truffles dry a lot faster if they are cut in half first. For more information on sending truffles for identification click [here](#).

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What about truffle farming?

Businesses that sell trees inoculated with truffle mycorrhiza can easily be found on the internet. Results are not guaranteed and can take years. It is a good idea to get sample trees assessed for root colonization by an independent lab (such as MycoRoots).

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How do I find my local mycological club?

Go to the excellent Club Directory on the NAMA website!

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The Hidden Life of

Truffles

Not just for gourmands, truffles play essential roles in the health of ecosystems

By James M. Trappe and Andrew W. Claridge

It's a cool November day near Bologna, Italy. We are strolling through the woods with truffle hunter Mirko Illice and his little dog, Clinto. Clinto runs back and forth among the oak trees sniffing the ground, pausing, then running again. Suddenly, he stops and begins to dig furiously with both paws. "Ah, he's found an Italian white truffle," Mirko explains. "He uses both paws only when he finds one of those." Mirko gently pulls the excited dog from the spot and pushes through the soil with his fingers. He extracts a yellowish brown lump the size of a golf ball and sniffs it. "*Benissimo*, Clinto," Mirko intones. Though not the finest example of the species, *Tuber magnatum*—which grows only in northern Italy, Serbia and Croatia—Clinto's find will fetch a nice price of about \$50 at the Saturday market.

Throughout history, truffles have appeared on the menu and in folklore. The Pharaoh Khufu served them at his royal table. Bedouins, Kalahari Bushmen and Australian Aborigines have hunted them for countless generations in deserts. The Romans savored them and thought they were produced by thunder.

Modern epicures prize truffles for their earthy aroma and flavor and are willing to pay steep prices at the market—recently more than \$3,000 per kilogram for the Italian white variety. Yet despite humanity's abiding interest in the fungi, much about their biology has remained veiled in mystery. Over the past two decades, however, genetic analyses and field observations have clarified the origins and functions of these organisms, revealing that they play key roles in many ecosystems. These findings are informing strategies for conserving some endangered species that rely on these denizens of the underworld.

A Fungus among Us

Truffles, like mushrooms, are the fruit of fungi. These fleshy organs are temporary reproductive structures that produce spores, which eventually germinate and give rise to new offspring. What sets truffles apart from mushrooms is that their spore-laden fruit forms below ground rather than above. Technically, true truffles are those fungi that belong to the Ascomycota phylum of organisms and are marketed as food. But there are trufflelike fungi or "false truffles" in the phy-

KEY CONCEPTS

- The truffles that appear on restaurant menus and on the shelves of luxury food purveyors represent only a small fraction of the world's truffle species.
- Truffles figure importantly in ecosystems, sustaining both plants and animals.
- Recognition of the ecological significance of truffles is aiding efforts to conserve threatened species that depend on them.

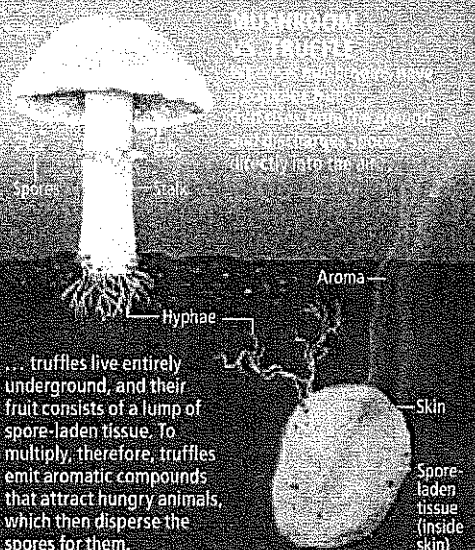
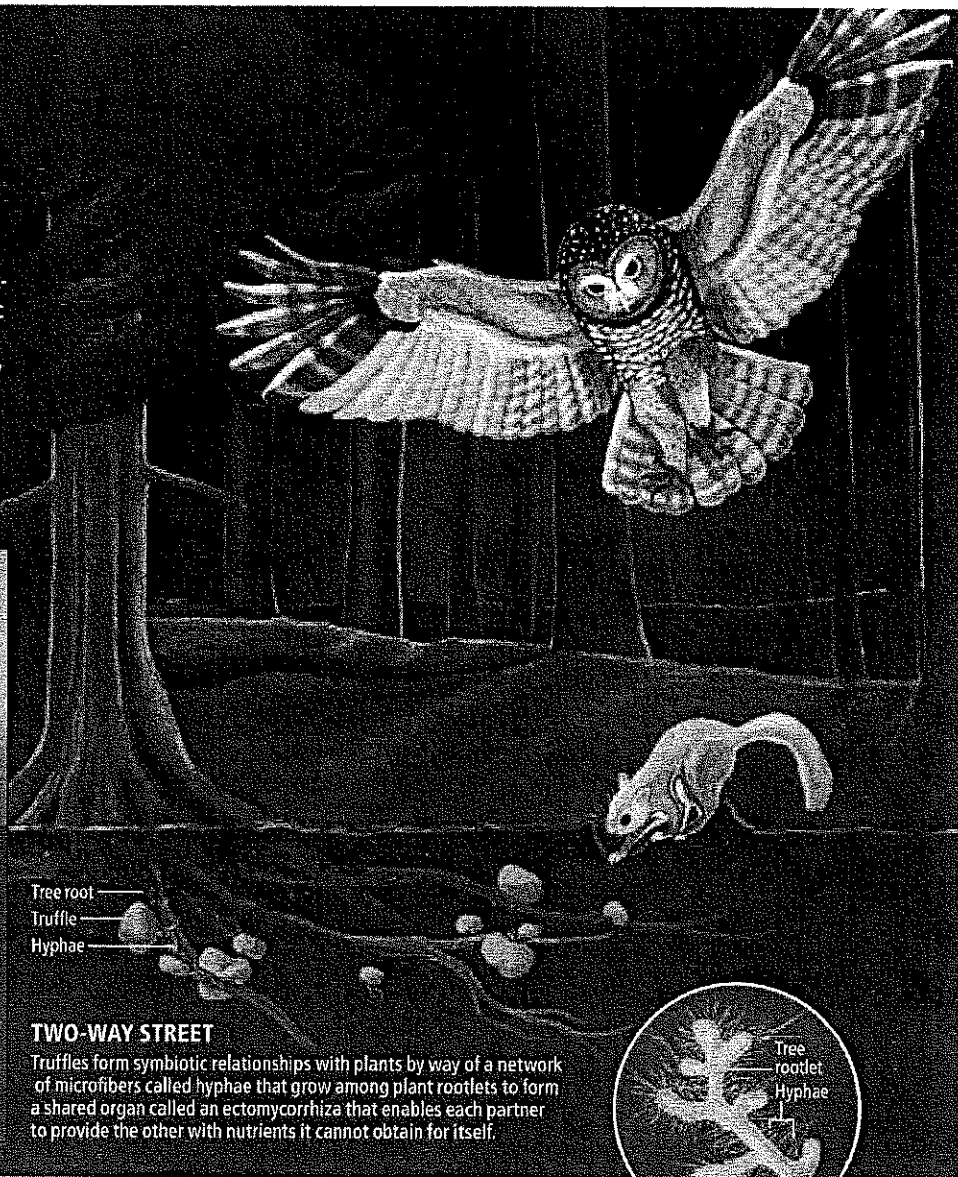
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[ECOLOGICAL SIGNIFICANCE]

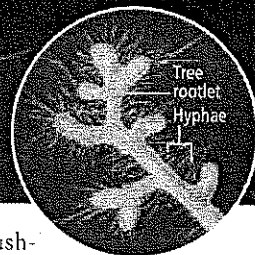
Fundamental Fungus

Truffles figure importantly in many ecosystems, benefiting both plants and animals. In the forests of the Pacific Northwest, for example, *Rhizopogon* truffles help Douglas-fir trees to obtain the water and nutrients they need. They also serve as a key source of food for the northern flying squirrel, which in turn is a favorite prey species of the endangered northern spotted owl. Protecting the owl's habitat, then, requires ensuring conditions favorable to truffles.



TWO-WAY STREET

Truffles form symbiotic relationships with plants by way of a network of microfibrils called hyphae that grow among plant rootlets to form a shared organ called an ectomycorrhiza that enables each partner to provide the other with nutrients it cannot obtain for itself.



[THE AUTHORS]

James M. Trappe is scientist emeritus at the U.S. Forest Service and a professor of forest science at Oregon State University. He has discovered more than 200 new truffle species on five continents. Jim wonders why anyone would go fishing instead of seeking new truffles. Andrew W. Claridge is a senior research scientist with the New South Wales Department of Environment, Climate Change and Water and a visiting fellow at the University of New South Wales in Australia. He has studied interrelationships among mammals and the fungi they eat for more than 20 years. His favorite hobby is fishing.



lum Basidiomycota that function like true truffles. Given these similarities, we refer to all fleshy fungi that fruit underground as truffles.

Scientific efforts to expose the secrets of truffles date to the 1800s, when German would-be truffle growers asked botanist Albert Bernhard Frank to figure out how the delicacies propagated. Frank's studies revealed that the fungi grow on and into the tiny feeder rootlets that trees use to absorb water and nutrients from the earth. On the basis of those observations, he proposed that the organisms have a symbiotic relationship in which each provides nutrients to the other. He further posited that such relationships between subterranean fungi and plants are widespread and that they shape the growth and health of many plant communities. Frank's theories contradicted conventional wisdom about truffles and other fungi—namely, that they all brought about disease and rot in plants—and drew considerable opposition from his peers. But although nearly a century would pass before scholars had definitive evidence, Frank got the story right.

All truffles and mushrooms produce networks of filaments, or hyphae, that grow between plant rootlets to form a shared absorptive organ known as a mycorrhiza. Thus joined, the fungus provides the plant with precious nutrients and water, its tiny hyphae able to reach into pockets of soil inaccessible to the plant's much larger roots. The plant, in turn, furnishes its consort with sugars and other nutrients that it generates through photosynthesis—products that the fungus needs but cannot produce on its own because it does not photosynthesize. So beneficial is this partnership that nearly all trees and other woody plants require it for survival, as do the associated fungi. Most herbaceous plants (those that do not have a permanent woody stem aboveground) form mycorrhizae too, albeit with different fungi.

Many fungal species, including all the ones that yield truffles, form a variant of the mycorrhiza called an ectomycorrhiza, in which the fungus envelops the feeder rootlets with a protective outer tissue. The diversity of these ectomycor-

LUCY READING-IKKANDA; COURTESY OF EREN CAZARES (Trappe); COURTESY OF DEBBIE CLARIDGE (Claridge)

rhizal fungi is impressive: one of us (Trappe) estimates that some 2,000 species are associated with the Douglas-fir (an evergreen used for timber and Christmas trees), and probably as many or more types partner only with Australia's eucalyptus trees. Numerous other commercially and ecologically important tree species also rely on ectomycorrhizal fungi. Most of these fungi fruit aboveground as mushrooms, but several thousand species produce truffles.

Going Under

Comparisons of the morphology and gene sequences of truffle and mushroom species indicate that most truffles have evolved from mushrooms. But given that truffles require aboveground dispersal of their spores to propagate, why would natural selection favor the evolution of species that hide underground? Consider the reproductive tactic of mushrooms. Although mushrooms exhibit a multitude of structures and colors, they all have fruiting bodies that can discharge spores directly into the air. The airborne spores may then alight nearby or far away to germinate and potentially establish a new colony in association with the roots of a compatible plant host. It is a highly effective approach.

The mushroom strategy is not foolproof, however. Most mushrooms have little defense against environmental hazards such as heat, drying winds, frost and grazing animals. Every day a few spores mature and are discharged. But if inclement weather dries or freezes a mushroom, spore production usually grinds to a halt.

Where such hazards are commonplace, new evolutionary adaptations have arisen. The most successful alternative has been for the fungus to fruit underground. Once the soil is wet enough for the subterranean fruiting body to form, it is insulated from vagaries of weather. The truffle develops with relative impunity, continuing to produce and nurture its spores even when aboveground conditions become intolerable to mushrooms. At first glance, the truffle's solution might seem facile. The form of a truffle is visibly less complex than that of a mushroom. No longer does the fungus need to expend the energy required to push its spore-bearing tissues aboveground on a stalk or develop a cap or other structure for producing and releasing the spores. The truffle is but a lump of spore-bearing tissue, usually enclosed by a protective skin.

The problem is that the truffles cannot themselves liberate their spores, trapped as they are in their underground realm. That feat demands

an alternative dispersal system. And therein lies the complexity of the truffle's scheme. Over millions of years, as truffles retreated underground, mutations eventually led to the formation of aromatic compounds attractive to animals. Each truffle species has its own array of aromatics that are largely absent in immature specimens but intensify and emerge as the spores mature.

Of the thousands of kinds of truffles that exist today, only a few dozen appeal to humans. The rest are too small or too tough, or they possess aromas that are unremarkable or downright repugnant. To other animals, however, they are irresistible, their olfactory charms wafting up from the soil. Small mammals such as mice, squirrels and rabbits in the Northern Hemisphere and rat-kangaroos, armadillos and meerkats in the Southern Hemisphere are the main truffle gourmands. But their larger counterparts—deer, bears, baboons and wallabies, among others—also seek out the undercover fungi. Mollusks are attracted to truffles, too. And insects may feed on truffles or lay eggs in them so that their larvae have a ready food source when they hatch.

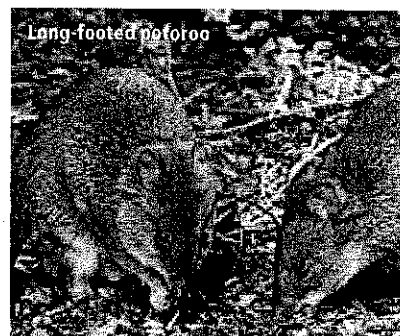
When an animal eats a truffle, most of the flesh is digested, but the spores pass through unharmed and are defecated on the ground, where they can germinate if the conditions are right. This dispersal system has advantages over the one that mushrooms employ. Feces concentrate spores, in contrast to the more diffuse scattering that occurs with aerial dissemination. In addition, feces are more likely to be deposited in the same kinds of areas where the animals forage for truffles, as opposed to the more random transport of airborne spores. This similarity of environment is beneficial because it increases the likelihood that the spores will land in a spot that has an appropriate plant species with which to establish a mycorrhiza.

Not all truffles rely on scent to attract animals, however. In New Zealand, which lacks native terrestrial mammals, some truffles have evolved rainbow hues that mimic the colors of fruits prized by the local birds. The *Paurocotylis pila* truffle, for one, emerges from the ground as it expands and lies on the forest floor, resembling the plump, red berrylike base of the seeds of *Podocarpus* trees that are a favorite bird food. (Although these colorful fungi do poke above the ground, they are nonetheless considered truffles because their spore-bearing tissues are enclosed in a skin, and they thus depend on animals to disperse their spores.)

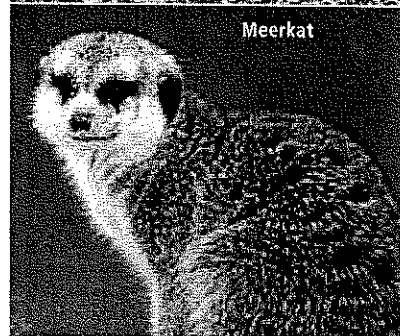
Yet another dispersal mechanism has evolved

TRUFFLE EATERS

The animals below are among the many that dine on truffles.



Long-footed potaroo



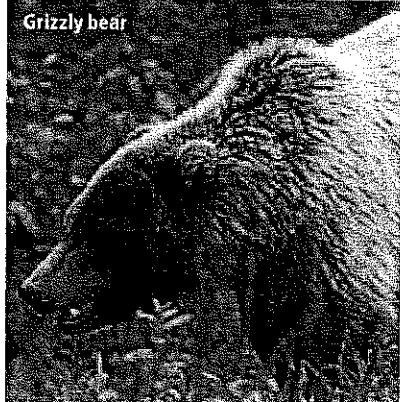
Meerkat



Great spotted kiwi



Chacma baboon



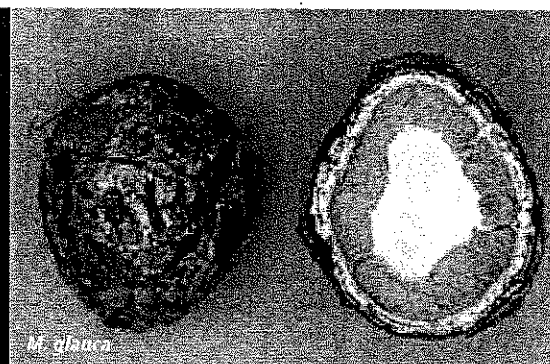
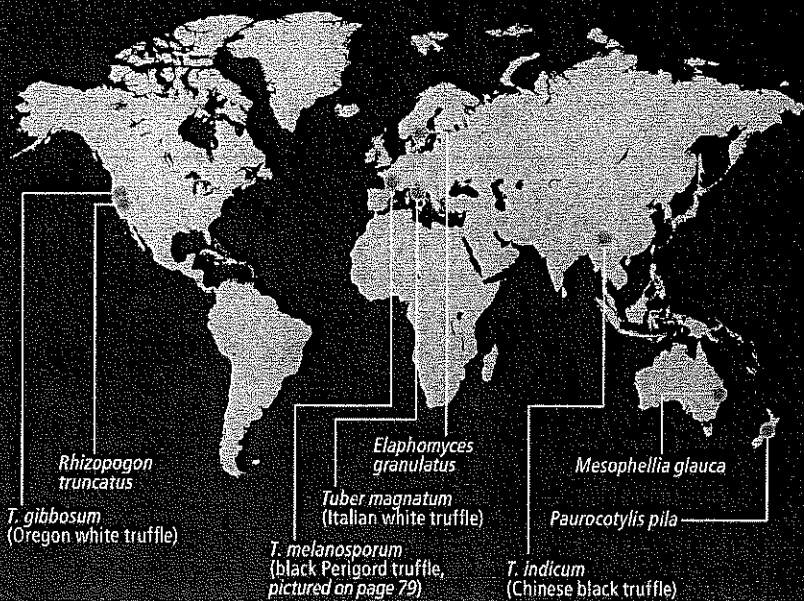
Grizzly bear

COURTESY OF BEN WRIGLEY, National Parks and Wildlife Service (long-footed potaroo); MILLARD H. SHARP, Photo Researchers, Inc. (meerkat); CHRISTOPHE COURTEAU, Nature Picture Library (kiwi); NIGEL J. DENNIS, Photo Researchers, Inc. (baboon)

[GLOBAL DIVERSITY]

Where Truffles Grow

Truffle species number in the thousands; the map shows representative locations where those mentioned in this article grow wild. The highest-known diversity of species occurs in Mediterranean Europe, western North America and Australia—regions mostly characterized by cool, rainy winters and warm, dry summers. With their subterranean lifestyle, truffles are protected from the heat, drought and frost that can occur when the fungi produce their fruit.



M. glauca



P. pila

INVADERS AND IMPOSTORS

The black Perigord truffle is under threat from an invader: the Chinese black truffle. Researchers had long been worried that the hearty and adaptable Chinese truffle could spread to the domain of the more finicky Perigord truffle and possibly outcompete it. In 2008 Claude Murat of the University of Tonno and his colleagues reported that this fear had been realized: the team detected DNA from both the Perigord truffle and the Chinese truffle in root tips and soil from an Italian truffle plantation.

Dishonest purveyors sometimes try to disguise the much more common Chinese truffle as its rarer and tastier counterpart by mixing small amounts of Perigord truffle in with the Chinese variety to give the latter the right scent. DNA analysis has been used to identify Chinese truffles masquerading as the Perigord kind

with a few groups of truffles, notably members of the ubiquitous Elaphomycetaceae family and the Mesophelliaceae family, which is endemic to Australasia. Their spores mature into a powder rather than a fleshy, spore-bearing tissue. The powder of *Elaphomyces granulatus*, for instance, is enclosed in a thick rind that is eaten by the animal, freeing the spores. Some of the Mesophelliaceae have a similar structure; others, such as *Mesophellia glauca*, possess a powdery spore mass sandwiched between a thin, hard outer rind and an edible inner core.

Even the spores of uneaten truffles can wander. After maturation, they decay into a slimy, larva-infested suspension in the soil. Invertebrates feed on this rotting tissue or move through it, picking up spores along the way. Truffle spores also travel when predators capture a small truffle-eating species: owls and hawks may carry rodents full of truffles considerable distances to their nests or roosts, where they eat the prey whole or eviscerate and discard the entrails. Either way the spores return to the soil where they may give rise to new truffles.

Together Forever

Evolution's experiments with truffles have been remarkably similar in both the Northern and

Southern Hemispheres, despite taking place long after the continents separated. The host plants in these regions are entirely different: whereas pines, beeches and oaks, for instance, partner with truffles in the north, eucalyptus and southern beeches play that role in the south. The truffle and animal species are likewise distinct between hemispheres. Yet the ecosystems and their components—the trees, truffles and animals—function in much the same way.

The greatest known diversity of truffles occurs in temperate areas of Mediterranean Europe, western North America and Australia (although most of Asia, Africa and South America remain unexplored by truffle researchers). These areas have climates with cool, rainy winters and warm, dry summers. Their fungal fruiting seasons are usually spring and autumn, when weather tends to be erratic: some years bring warm, dry spells and others deliver frost; both conditions are inimical to mushrooms. Over time, then, natural selection favored those fungi that sought refuge underground in these regions.

Exactly when the first truffles evolved is uncertain, but scientists have unearthed some clues to their origins. The oldest fossil ectomycorrhizae on record date to around 50 million years ago. And the ancestors of today's pines and other

LUCKY READING: IKKANDA (top left); COURTESY OF JAMES M. TRAPPE (M. glauca); COURTESY OF MATT TRAPPE (R. truncatus); COURTESY OF MICHAEL CASTELLANO AND JAMES M. TRAPPE (P. pila)

trees with which truffles form essential relationships arose some 85 million years ago. We can assume, then, that truffles emerged sometime between 85 million and 50 million years ago.

Given this long-standing association between truffles and plants, it is no surprise that the fungi figure importantly in the ecology of many habitats. Not only are they essential to the functioning of numerous plant species, but animals have come to rely on them for food. In the U.S. at least one creature, the Western red-backed vole, depends almost entirely on truffles for sustenance. And the northern flying squirrel, found in North America, eats mostly truffles when available in the wild. On the other side of the globe, in Australia, a marsupial known as the long-footed potoroo subsists on a diet that is about 95 percent truffles. Its fellow marsupials the other rat-kangaroos and bandicoots also bank heavily on truffles. And many other creatures the world over routinely supplement their primary food sources with these fungi.

Scientists' developing knowledge of the intimate relationship between truffles, their plant hosts and their animal carriers is guiding the efforts of cultivators and conservationists alike. In the 1980s in Oregon, Mike Castellano of the U.S. Forest Service, Mike Amaranthus of Mycorrhizal Applications and their colleagues began outfitting nursery seedlings with spores of hearty *Rhizopogon* truffle species to help the seedlings withstand drought and other stressful conditions in plantations. Going forward, cultivators could conceivably augment their returns if they substituted gourmet truffles for *Rhizopogon*. For example, Christmas tree farms in the Pacific Northwest could additionally produce the delicious Oregon white truffle, *Tuber gibbosum*. Thus far, however, attempts to inoculate trees with this truffle species have produced inconsistent results.

Meanwhile one of us (Claridge) had been using truffles to help determine the population sizes of endangered animals in southeastern Australia—a prerequisite to developing effective protection or recovery programs for these species. He soaks foam pads in olive oil infused with aromatics of the European black Perigord truffle (a favorite of humans) to attract potoroos and other truffle-loving marsupials to stations where they are photographed by motion-sensing digital cameras. This approach has enabled him to detect upward of 50 times as many of these creatures as are counted with the traditional method of cage trapping. If the success rates are this high



FAST FACTS

Black Perigord truffles contain androstenol, a sex hormone found in the saliva of male pigs. The compound is also found in the sweat glands of humans.

Truffle hunters have long used female pigs to locate the fungi underground, but increasingly they are turning to dogs for assistance because the dogs are more willing than the pigs to accept an alternative food reward for their efforts.

Most commercially available truffle oils are flavored synthetically with lab-made compounds such as 2,4-dithiapentane, one of many molecules that give Italian white truffles their distinctive aroma.

Some truffles contain compounds that have potent antituberculosis effects; others exhibit strong anti-inflammatory and antioxidant properties.

➔ MORE TO EXPLORE

Field Guide to North American Truffles: Hunting, Identifying, and Enjoying the World's Most Prized Fungi. Matt Trappe, Frank Evans and James M. Trappe. Ten Speed Press, 2007.

Taming the Truffle: The History, Lore, and Science of the Ultimate Mushroom. Ian R. Hall, Gorton T. Brown and Alessandra Zambonelli. Timber Press, 2007.

Trees, Truffles, and Beasts: How Forests Function. Chris Maser, Andrew W. Claridge and James M. Trappe. Rutgers University Press, 2008.

with imported truffle oil, which he used because it was readily available for purchase, what might the figures be once the odors of native Australian truffles are put to the test? Answering that question is a top priority for his team.

To protect these endangered marsupials and other animals that regularly eat truffles, conservationists will have to ensure the availability of their food. This provision applies not only to those animals that depend directly on truffles but also to their predators. Thus, restoring the habitat of the threatened northern spotted owl in the Pacific Northwest requires meeting the needs of the owl's primary prey, the northern flying squirrel, which eats mostly truffles.

Taming the Truffle

Although researchers have learned much about the ecology of truffles in recent decades, the science of growing them has changed little since the 1960s, when French scientists developed a greenhouse technique for adding spores of the black Perigord truffle into the potting mix of oak and hazel seedlings that are later planted in suitable sites to form truffle orchards, or *truffières*. Under ideal conditions, the *truffières* can produce a crop in four to five years.

After many failed attempts, similar *truffières* were finally established in the U.S. in the 1980s. Today the most productive truffle grower in North America is Tom Michaels of Tennessee Truffles. A former graduate student of Trappe's, Michaels produced an impressive 100 kilograms of Perigord truffles in the 2008–2009 season. To get these results, he pays careful attention to the soil, adding lime every year to keep it friable and well drained. New Zealand and Australia have succeeded in growing Perigord truffles, too.

In stark contrast to the triumphs of Perigord truffle farming, efforts to cultivate the most highly prized truffle species—the Italian white truffle that Mirko and Clinto were hunting, which has an especially intense aroma—have failed. For reasons that remain unknown, this species simply refuses to grow in the greenhouse. To that end, the sequencing of its genome, which is nearing completion, could yield clues to how to coax the king of truffles to grow on command.

Concurrently, truffles may become more prevalent even without cultivation: as the earth warms, the hotter, drier habitats that many truffles favor will spread, setting the stage for increased production and accelerated evolution. Climate change, then, may yield a benefit for some: more truffles for men and beasts. ■