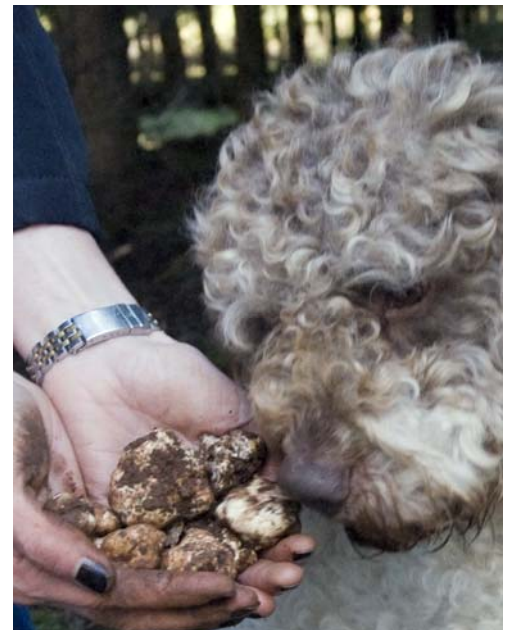


Oregon Culinary Truffles

An Emergent Industry for
Forestry, Agriculture
& Culinary Tourism



A feasibility study
by
David Pilz,
Charles Lefevre,
Leslie Scott
& James Julian



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Front cover:
Photo at left by John Valls
Photo at right by Andrea Johnson

Back cover photo by Mike McDermott

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Executive Summary

Of all the world's culinary delicacies, truffles stand out as the ultimate luxury food. With the advent of technology to control the symbiosis between truffles and the roots of their host trees, truffles have at last entered the realm of agriculture.

As with French wine grapes, Oregon has the climactic conditions required for truffle production. Given high demand, inadequate global supply and established profitability, Oregon has a unique opportunity to become a world leader in the production of this rare, highly-prized commodity.

Annual truffle commerce is expected to exceed \$6 billion within the next two decades, rivaling many other agricultural commodities traded worldwide. With adequate support, cultivated and native truffles produced in Oregon could annually exceed \$200 million in direct sales income; counting secondary economic benefits, the value of the industry could exceed \$1.5 billion. These figures rival the current value of the state's lucrative wine industry, and could be greater if Oregon pursues truffle production with similar passion and focus.

Other regions of the U.S., and other countries around the world, already recognize this economic opportunity and are formulating strategies, developing funding, and promoting their own truffle industries. Some are ahead of Oregon in one respect -- cultivation of the European truffle species. However, Oregon as a suite of competitive advantages:

- Superb native Oregon truffles that grow in private woodlands.
- Excellent climate and an abundance of suitable soils for cultivating European truffles.
- A world renown, six-decade legacy of truffle research and the greatest concentration of truffle scientists and specialists in the world.
- A local supplier of truffle-inoculated tree seedlings from that scientific community.
- The Oregon Truffle Festival, the first of its kind in the English-speaking world.
- A reputation for fine wine, gourmet dining, tourism, and foods that are produced locally, sustainably and organically.
- A wealth of innovators and entrepreneurs seeking sustainable investment opportunities.

The potential U.S. and global markets for truffles are vast and the industry is young. Given its abundant resources, Oregon could exceed production in other regions and countries by immediately and vigorously promoting the industry.

In addition to substantial direct and indirect economic benefits, a vibrant truffle industry will provide numerous other advantages. Truffles have a culinary mystique that meshes seamlessly and reciprocally with Oregon's reputation for outstanding quality of life. As a pinnacle of high cuisine, culinary truffles have the potential to improve the already strong branding of Oregon-grown specialty foods and the positive perception of the state as a whole. Truffles will promote Oregon and, in turn, Oregon's growing reputation as a culinary destination will promote its truffles.

Environmentally, truffles are not only suited to our climate and soils, but can be produced in a sustainable and ecologically friendly manner. They lend themselves to low-input and organic farming methods, and require few resources for production and distribution. One of Oregon's native truffle species grows in coastal streamside forests that enhance salmon habitat; all of them thrive in newly-planted forests that sequester the greenhouse gas CO₂.

Truffle production, possible in a variety of soils and conditions, will support rural livelihoods in agriculture and forestry, as well as employment in research and education, harvesting and processing, and restaurant and retail food businesses. Truffles, both native and cultivated, will help to connect Oregon's urban and rural communities through the food system, as they have for centuries in the cultural life and market systems of Europe (especially Italy and France).

This feasibility study starts by discussing the culinary allure of truffles; global supply, demand, and production; and the benefits Oregon will accrue from its truffle industry. It then provides detailed information on how to cultivate European truffle species and enhance the state's native truffle industry. The study concludes by detailing the steps needed to create a world-class truffle industry in Oregon. Appendices provide tables describing potential global demand and a detailed production budget for landowners contemplating establishment of their own truffle orchard.

Anticipated long-range returns on investment are higher than those of virtually any other agricultural enterprise.

As with any new agricultural crop, retaining and engaging technical expertise will greatly facilitate truffle production. Public funding, agency support and collaborative ventures will launch the industry toward success. Meanwhile, Oregon's competitive edge will be enhanced by empowering landowners, growers, harvesters and buyers with technical know-how, resources and infrastructure.

The study's authors envision a path to success. Along this path, Oregon farmers will rapidly expand European truffle orchards (*truffières*). Small woodlot owners will manage their forest for both truffles and trees. Entrepreneurs will use lower-grade truffles to extend sales of value-added truffle products throughout the year. And the tourism industry will showcase truffles as an ideal compliment to the state's wine, restaurant and outdoor adventure industries.

This feasibility study explains the opportunities that a truffle industry offers Oregon and shows how to go about developing a premier industry characterized by high-quality products, ethical business practices, environmentally responsible production, and widely accrued benefits.

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Photo by Mike McDermott

The Lure of Truffles

Culinary truffles are found in just a handful of regions around the world, and are among the world's most expensive foods. They are usually identified with France and Italy, where for centuries they have been celebrated through culinary traditions, festivals and literature, seasonally permeating the cultures of such regions as Perigord, Provence, Piedmont and Tuscany.

Truffles grow in the same soils and climates as many of the finest European wines, and when in season, are often hand carried across continents and oceans to be enjoyed with great occasion by gourmands around the world.



Oregon Black Truffles.
Photo by Charles Lefevre

While best known from Italy and France, culinary truffle species are widespread, if rare, throughout most of Europe. However, beyond Europe, culinary truffle populations are limited to the deserts of North Africa and the Middle East, the forests of the southern Himalayas, and only recently introduced to gastronomy in Oregon. Oregon is poised to join these regions of the world as the epicenter of culinary truffles in North America.

There are three primary reasons truffles enjoy a defining role in the rich and varied histories and cultures of the old world, and have endured the fads and trends in the complex world of cuisines over time.

Aroma

Mammals are particularly fond of truffles and many humans find the aroma of truffles overwhelmingly seductive. The experience of truffle has been described as intoxicating, heady, provocative, rapturous, erotic, and addictive. There are many truffle species and each produces a distinctive, complex and evolving suite of aromas. Truffles are most often associated with the fifth sense of taste "umami," or savoriness.

Where the aroma of the famous white truffle found throughout Italy and around the Adriatic Sea is often described with terms like garlic or musk, with occasional notes of honey and nutmeg among others, the Oregon black truffle is more often described with terms like tropical fruit or pineapple. Several other truffle species produce aromas described in terms like acetone, alcohol or

other solvents.

Differences among truffle species are easily recognized without a sommelier's training. However, like wine grapes, aromas produced by different truffles within a species often display nuances thought to be associated with the soils, host trees and climates where they grow.

Retail prices typically range from hundreds to over a thousand dollars per pound

Black truffles from France might ordinarily be described in earthy, musky terms, for example, but some individuals or batches collected beneath a particular tree or hillside might contain mint, fruit or alcohol overtones. Individual Oregon black truffles occasionally pass through a chocolate phase as they ripen, or another individual truffle might evoke something more like green apple, while in either case retaining the essential character of Oregon black truffle.

A truffle lexicon has naturally developed in regions of Italy and France to describe these differences. In Italy, the recognition of distinctive regions' aroma and taste differences has resulted in the development tutorials in truffle sensorial analyses. From the perspective of a developing industry these differences, this experience of terroir, create opportunities for regional distinction, specialty niches, and ultimately robust competition.

Culinary Treasures

As early as ancient Greek and Roman times truffles were lauded as gastronomic treasures and they have been prized in European cuisine through the millennia. The volatile compounds comprising their aromas are dissipated when truffles are over-heated or cooked, but fats can capture their complex aromas. Consequently they are typically prepared with rich foods such as meats, dairy products, eggs, or nearly any dish containing olive oil or butter. Only small slivers need to be shaved onto a dish to transform it from mundane to sublime. Although retail prices typically range from hundreds to over a thousand dollars per pound (depending on truffle species and quality), the most expensive truffle ever auctioned sold for close to \$100,000 per pound. The powerful sensory experience of truffles in combination with the expression of terroir in the hands of expert chefs has ensured their place in the culture and lore of every region of the world fortunate enough to be blessed with their bounty.



Oregon White Truffle.
Photo by John Higby

Mystique

The mystique of truffles derives not only from their powerful aromas and starring roles in high cuisine, but also from the mystery of their origins. While many people know of them, few have ever tasted them, and fewer still have ever seen or found one. Like other kinds of buried treasure, we are fascinated by the fact that they are rare and cryptic, but unlike gold or diamonds, truffles are ephemeral, and locating them requires pigs or trained dogs with capacities beyond our own. Their abundance one year and absence the next also remains somewhat of a mystery to this day, although Plutarch explained it this way: *"Since, during storms, flames leap from the humid vapors and dark clouds emit deafening noises, is it surprising the lightning, when it strikes the ground, gives rise to truffles, which do not resemble plants?"*

There is also something captivating about truffles themselves and the nature of their perfume. The aromas of the most famous European black and white truffles contain a pheromone that profoundly transforms the behavior of female pigs, and this compound is produced by many other mammals, including humans. It is this, perhaps, that is behind the many famous quotes and florid language used to describe them, as *"Whosoever says truffle, utters a great word, which awakens erotic and gourmand ideas both in the sex dressed in petticoats and in the bearded portion of humanity..."* (from Jean-Anthelme Brillat-Savarin, 1755-1826, ***The Physiology of Taste***, 1825). It is, perhaps, no wonder that truffles are so expensive.



**Searching for truffles at the Oregon Truffle Festival.
Photo by Andrea Johnson**

Opportunities Abound

Oregon's Advantages

Truffle Diversity

Oregon is uniquely poised to produce both European and first-rate native truffles. The ability to produce both European (Old World) and Oregon (New World) truffles represents a critical advantage for the state.

Outside of Europe, Old World truffles are exclusively cultivated in orchards. In Oregon, these orchards are currently being established on agricultural land. Our native culinary truffles are gathered from Douglas fir woodlands throughout the Willamette Valley and the valleys of the Coast Range. Although native northwest species are found from northern California to southern British Columbia, they fruit most abundantly in Oregon and are widely known as "Oregon Truffles."

Some of Oregon's climate zones and soils are suited to producing European truffles and some to native truffles. Sometimes a landowner may dedicate different parts of the same property to the production of each type of truffle.

Both cultivated and native truffles will play an integral role in Oregon's emergent truffle industry. Among the Old and New World truffle species that Oregon can produce, harvest seasons vary and overlap to allow almost a year-around harvest. Oregon has an unparalleled opportunity to attain a global reputation for culinary truffle diversity and steady supply available throughout the year.

Oregon's Image

Oregonians can be proud of our state's reputation for environmental quality, scenic vistas, careful land use, attractive communities, sustainable business practices, and entrepreneurial innovation. In recent decades, this reputation has been further enhanced by the dramatic growth of the specialty foods and fine dining industries. We are pioneering locally sourced, sustainably produced, high-quality foods that are being transformed by local chefs into notable cuisine. Add to this mix the



Chef Phillippe Boulot prepares the second course for the Oregon Truffle Festival Grand Dinner. Photo by Georgia Freedman

Both cultivated and native truffles will play an integral role in Oregon's emergent truffle industry

prominent wines, especially Pinot Noirs, now being produced in Oregon, and it is no wonder that tourism is flourishing.

Oregon's motto is "We love dreamers," but the "Brand Oregon" program makes it clear that we are doers, too. "Oregon is home to an inordinate number of people who not only dream big, but make those dreams happen." As we transform the production of truffles in Oregon from a collection of fledgling enterprises into a mature, established industry,

our truffles will add their allure to Oregon's reputation for abundance. In turn, Oregon's reputation will help to promote and market our truffles.

Oregon Truffle Festival

The dream of a culinary truffle industry for Oregon is already materializing. Since January 2006, Eugene has annually hosted the Oregon Truffle Festival, the first event of its kind in the English-speaking world. Each year, the festival features three days of cultivation seminars, truffle hunting excursions, winery tours, fine truffle dining at local restaurants, a marketplace, public lectures, and a Grand Truffle Dinner. In only its second year, 270 guests savored the Grand Truffle Dinner, a feast prepared by six James Beard award-winning or nominated Oregon chefs and embraced by the James Beard Foundation as one of their Out-of-House Events. Ensuing years have proven just as successful, attracting about two-thirds of participants from out of state, many coming to Oregon for the first time. This Festival is laying the foundation for Oregon's truffle industry by serving as a focal point for national and international attention, and creating a reputation for culinary and educational excellence.



**The Grand Truffle Dinner at the Oregon Truffle Festival.
Photo by Georgia Freedman**

Supply & Demand

What is the context of an Oregon truffle industry? Does it really have such great potential? What can be said about supply and demand in the past, present, and future? Finally, what benefits can Oregon expect from promotion of the industry?

Supply

In all but a few fortunate locales, truffles have always been a rare, expensive, and perishable luxury that few people have experienced.

Since the 1970s, scientists have developed methods to reliably cultivate some Old World truffle species in plantations. “Truffières” (the French term for truffle plantations or orchards) are being established in appropriate climates around the world. Published information about the extent of such efforts is limited. Nevertheless, enough is known about potential demand and incipient supply to assert that supply will not meet demand in any part of the world for at least two or three more decades, and probably longer.

For example, although there are about 50,000 acres of planted truffières in France, their industry originally suffered from inadvertent inoculation of seedlings with less desirable species of truffles. As a result, production of the intended black truffle still remains lower than it might have been by now. Nevertheless, 80-90% of France’s truffles are currently produced in managed truffières, and such orchards are established throughout the world.

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Spain and Italy have extensive plantations and harvest significant crops from their native oak woodlands. Italy and other countries around the Adriatic Sea produce the highly-prized white truffle, but have had virtually no success with its cultivation. Truffières are being established in Mediterranean countries such as Turkey and Israel, as well as South Africa, Chile, and China. A couple thousand acres have been planted in New Zealand and Australia, where some operations are quite large and sophisticated.

Overall, several hundred truffières have been planted outside of Europe, but most are new and either have not yet started production or have not reached their full potential. Although truffière establishment is further along in Europe than elsewhere, production there is still one-tenth or less of historic levels and truffle prices remain high. Production in the rest of the world is underway and growing, but remains insignificant to date.

There are currently about 300 acres of truffières in the United States. However, few U.S. farms have reached the 5+ years of age required to begin production, and only one has achieved significant harvests. Even by 2020, annual U.S. production is unlikely to exceed 100 tons. Thus, U.S. production could remain a small fraction of the country’s potential market for several decades or more. Existing trends toward increased culinary sophistication and use of locally produced ingredients might further increase demand as locally-produced truffles become available. Truffles can and likely will be grown in many areas of the United States, but Oregon is well positioned to be the region most associated with truffle production.

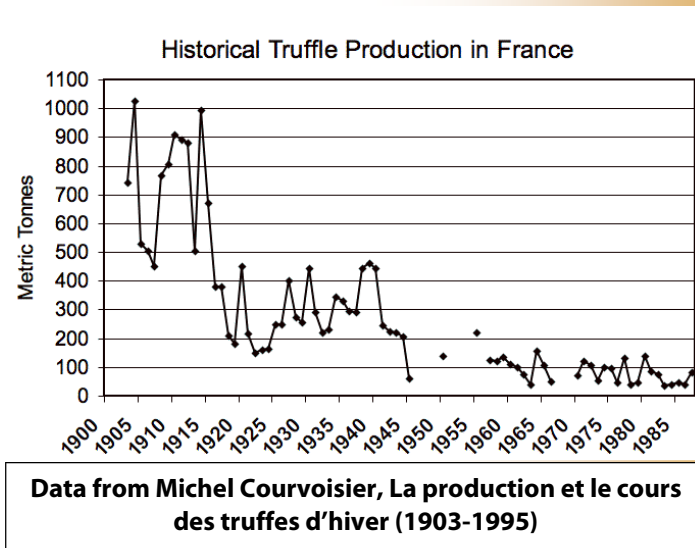
Truffles are traded globally. European black truffles harvested during the Southern Hemisphere winter are just beginning to be imported into France and the U.S during our summer off-season. However, truffles remain at peak freshness for only a few days. International shipping requires careful harvesting and rapid processing, packaging, and shipping arrangements to retain optimal quality. International trade also can be fraught with problems. For example, the U.S. currently levies a 100% tariff on truffles imported from Europe.

Demand

The concept of “demand for truffles” is elusive. It is driven by the quality of the gustatory experience, the ambience of fine dining, nuances of aroma, the complexity of their varietal character and the charm of their story.

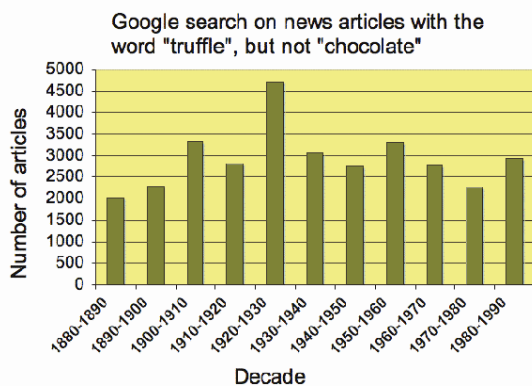
For example, during the last century, interest in truffles seemed to peak during the Roaring Twenties (as might be expected); however, even during the Great Depression and World War II, newspapers continued publishing culinary truffle stories.

Understanding supply and demand begins with a look at historical



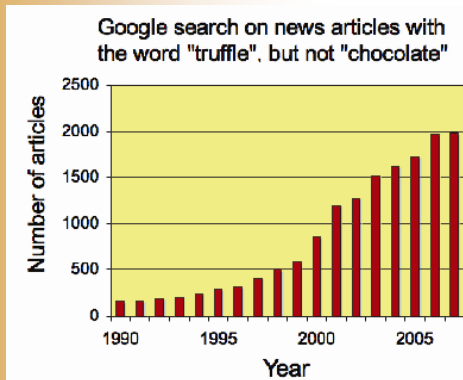
production levels in Europe.

Until the last half-century, European truffles were only harvested in natural woodlands or in oak and hazelnut groves planted by farmers to encourage naturally-occurring truffle production. Trees were not pre-inoculated in nurseries to enhance yields, and annual crop size varied with the weather. Nevertheless, production was quite high around the turn of the last century (see graph).



France and Italy have the longest traditions of truffle use in Europe. In the late 1800s, more than a thousand metric tonnes (“tonne” = “metric tonne” = 2,205 lbs) were harvested annually in France. In some villages and cities, truffles were considered quite common and widely available, even to farmers and town folk. Given France’s population at the time, this level of production represented 0.8 ounces per person per year, enough for one or two fine dishes, but not daily fare even if none of the truffles were exported.

Unfortunately, changing patterns of land use and two world wars reduced the harvest to only a hundred tonnes annually by the 1970s. Similar declines occurred elsewhere in southern Europe. By 1985, France's production was less than 50 tonnes annually (only about 0.03 ounces per capita at 1985 population levels).



Even with current scientific truffle cultivation methods, production has not risen much above a hundred tonnes annually (or 0.06 ounces per capita now). Truffle production since World War II has yet to approach potential demand, keeping prices high.

In fact, a Google search on the number of recent news articles about truffles in the English-language popular press suggests dramatically increased interest during the last two decades.

It is difficult to estimate the demand for Oregon's truffles several decades in the future, particularly since the market is dispersed throughout the world. Although truffles are quite perishable, they are so valuable and lightweight that it is practical and cost-effective to quickly and carefully ship them long distances, even overseas. To estimate the potential demand for Oregon truffles (especially cultivated ones), we must estimate potential **global** demand.

Although estimating future demand is highly uncertain, a range of predicted values can be calculated from available relevant information (see Appendix C).

We estimated potential global truffle demand (all species) for the year 2030. By that time, the Oregon native truffle industry should be more mature and production of cultivated Oregon truffles should be significant.

The greatest uncertainties in our calculations were the number of people able and willing to pay for truffles, how much are they willing to pay, and how many meals they would purchase. We know from centuries of European history that truffles are not a fad; wherever they are found, they are celebrated seasonally by everyone, from the most humble provincial harvester to the haute coutiere of Paris.

The per capita demand (consumption) values we derived from these calculations fell near (and bracketed) the current French per capita **production** value of 0.06 ounces per year. (Note: There are no data on how many are actually consumed in France). Even our most optimistic per capita **demand** level for use in global demand calculations was only 22.5% of the historic (late 1800s) French per capita **production** levels. Of course, demand and production are not the same thing, but in an economy where truffles compete globally, these factors may converge. Even historically in France, the local population might well have eaten a large fraction of the production.

A large fraction of the world’s population is too poor to buy truffles but, in spite of global economic fluctuations, the long-term trend in cumulative global economic wealth is increasing. Per capita gross world product has increased 300% in the last 50 years, and in the United States, gross domestic product has grown 250%. Although this wealth is not distributed uniformly, many people spend

Oregon’s percentage of this potentially lucrative world market depends on how aggressively the state supports its native truffle industry

large sums of disposable income on fine dining and the purchase of gourmet foods. We applied per capita demand values to the sum of (a) the total population of the wealthiest one-half of nations, plus (b) the total population of urban areas greater than 1 million in the poorer one-half of the world’s countries.

We used the current price of \$1,000/pound for *Tuber melanosporum* as a medium wholesale price for all truffles traded in 2030, and bracketed that price with \$800/pound and \$1200/pound. The lower value would reflect a downward pressure on price if supply

starts meeting demand, and the higher value would reflect inflation if supply does not approach demand. Some species of truffles cost more or less than this, but they represent a smaller share of the global market and would likely average out to this range of prices.

To calculate the area needed to produce the projected demand, we used a range of productivity expected from well-managed truffle plantations. Potential productivity is discussed in the “Yields” section of “Oregon Truffières.”

Factor	Units	Low Estimate	Medium Estimate	High Estimate	Optimistic Estimate
Per capita demand for truffles	Ounces/yr	0.02	0.04	0.09	0.18
Global demand	U.S. Tons/yr	1,250	3,125	8,438	16,875
# Acres needed	Acres	62,500	125,000	281,250	482,143
Value of global demand	\$ Billions	2	6.25	20.25	40.5

These value estimates are similar to other globally-traded commodities. For instance, the global value of all cultivated mushrooms is \$23 billion annually. (See Table 5 in Appendix B for other representative commodities).

The number of acres needed to produce this many truffles is quite reasonable. For context, see the acres shown on the soils map and chart for Oregon in the Site Selection section of “Oregon Truffières.” Although not producing well, France has planted 50,000 acres already and more truffières are being established elsewhere in the world; see the following “Supply” section.

Regardless of how these numbers are manipulated, the bottom-line result of our various calculations appears certain. The potential market for truffles, and the value of the market, measures in the billions of dollars. The percentage of this potentially lucrative world market that Oregon captures depends entirely on how aggressively the state establishes new truffières and supports its native truffle industry.

Economic Benefits

Given the estimates of potential market value in the previous sections, we anticipate that truffles could become an Oregon industry that is **directly** worth hundreds of millions of dollars annually to farmers, small woodlot owners and harvesters. For comparison, current Oregon wine sales are about \$200 million dollars per year.

Indirect or derivative economic benefits will be substantial because the truffle industry will necessarily engage diverse participants. These include agronomists, soil specialists, foresters, Extension agents, researchers, real estate agents, inoculated seedling producers, lime and fertilizer suppliers, irrigation suppliers and contractors, suppliers of farm equipment, farm laborers, accountants, marketing specialists, lawyers, and (of course) business owners and managers. Producing, marketing, and using truffles will involve harvesters, buyers, processors, value-added product producers, brokers, exporters, retailers, restaurateurs, chefs and tourism providers. All will reap substantial economic rewards from the Oregon truffle industry.

If Oregon captures a significant share of world truffle markets by 2030, the direct & secondary value of our truffle crops could equal or exceed that of Oregon's wine industry



**A recently established Oregon truffière.
Photo by Charles Lefevre**

Comparable indirect economic benefits place the complete value of the wine industry in Oregon at \$1.4 billion per year. If Oregon can capture a significant share of potential world truffle markets by 2030, we believe the direct and secondary value of our truffle crops could equal or exceed that of Oregon's wine industry.

Social and Cultural Benefits

The full value of the emergent Oregon truffle industry will be compounded not only with secondary economic returns, but also with social and cultural benefits. Truffle cultivation is inherently suited to family farms, small woodlot owners, and small- to middle-sized businesses because it requires

educated individuals paying continuous and close attention to their land, crop and business. For example, producers who use truffle-hunting dogs must pay close attention to their behavior and make a long-term commitment to their welfare. Large-scale corporate agri-businesses might invest in truffle production, but finding skilled dog handlers who are available to work seasonally will be a challenge for industrial-scale truffle production. Therefore, truffle farming will tend to persist in the domain of the small family farmer.

Harvesters, processors and purveyors of native truffles often come from rural families that have lived and worked in Oregon's countryside for generations. They care deeply about healthy forests and their inherent benefits. More than most, they are dismayed when forests are abused or converted to other uses. Given an opportunity to protect and enhance our forests, while simultaneously deriving a good income, many would enthusiastically participate in a culinary truffle industry.

Opportunities for value-added tourism also abound. Imagine a rural bed and breakfast that specializes in forays to their truffle forest with a friendly dog, followed by communal preparation of the visitor's harvest for the evening's repast. Such businesses have already been established. Similarly, it is easy to envision lodgers at a resort catching a salmon from a healthy coastal stream and harvesting native truffles on the way back through the streamside forest so they can enjoy a meal featuring both. Truffles are rarely served alone, so truffle tourism naturally showcases other foods and wines from the region.



Photo by Mike McDermott

Environmental Benefits

Both Old and New World truffles can be produced in an environmentally friendly manner. Truffle fungi grow in a symbiotic relationship with tree roots and help the trees thrive (see "Truffle basics" and "Seedling inoculation" in the next section).

The agronomic production of Old World truffles entails minimal or no soil erosion. It requires minimal foliar fertilizer use, and few soil amendments other than lime and irrigation. In addition, truffle production is pesticide-free and consumes minimal energy production, harvesting, and distribution.

Native Oregon truffles grow in young, newly-planted Douglas fir forests that sequester the greenhouse gas CO₂ from the atmosphere. Some grow in coastal streamside forests that also provide shade to salmon-bearing streams.

Old World Truffles

European Truffle Species

Although “truffle” is a commonly-used term for any fungus that fruits below ground, most culinary truffles belong to the genus *Tuber*. There are numerous European *Tuber* species, but fewer than a dozen are sought for culinary use. The “Italian” white truffle (*Tuber magnatum*) is the most valuable Old World truffle. It grows in countries near Italy, too, but has not yet been cultivated.



European black truffles
Photo by Charles Lefevre

Only three culinary European species have been successfully domesticated. Each differs in aroma, habitat and ease of cultivation. The European black truffle (*Tuber melanosporum*) is second in monetary value only to Italian whites and is relatively easy to cultivate. This species is being widely introduced into regions with appropriate climates and soils in both the northern and southern hemispheres. The other two species are the white bianchetto truffle (*Tuber borchii*) and the Burgundy truffle (*Tuber aestivum* or *uncinatum*). The bianchetto truffle is widespread throughout much of Europe and fruits in late winter and early spring. The Burgundy truffle also is widespread, but fruits in summer and autumn.

that several Old World species are available for cultivation; they are adapted to a variety of climatic and soil conditions that can be found or replicated in Oregon, and each fruits during slightly different seasons.

The story of truffle cultivation and truffle species in Europe is complex. The salient points, however, are

Culinary Use

European truffles have traditionally been paired with a wide variety of food. The most common image is that of truffles being shaved over steaming pasta at the table. Aromatic truffles are slid beneath the skin of roasted fowl; cheese stored for a day in a sealed container with a truffle becomes infused with aroma, and the truffle can still be used for other dishes. Butter mixed with grated truffles can be frozen, kept for months, and incorporated into various dishes as needed.

Soups, stews, sauces, deserts; the list is endless, but preparation need not be complicated. Dipping bread into a bowl of olive oil with shaved truffles is one of the simplest ways to enjoy the essence of their flavor.



**Creamy Dungeness Crab Salad
with Oregon black truffles.
Chef: Vitaly Paley,
Paley's Place, Portland.
Photo by Andrea Johnson**

Oregon Truffières

Truffle Basics

Truffle fungi grow symbiotically with the roots of certain trees. The tree provides the fungus with carbohydrates produced through photosynthesis; in turn, the fungus acts as an expanded fine root system for the tree, absorbing and sharing water and mineral nutrients. Trees would not grow and thrive (outside of nurseries) without such fungal partners.

Truffles are the reproductive fruiting bodies of the fungus. They grow slowly underground for months and are only fully fragrant for a week or so, as they ripen near the end of their maturation process.

To produce truffles, the fungus must be cultivated in association with its tree host. Initiating this association is a technically challenging nursery operation, and maintaining it in the field involves close attention to soil and crop management regimes. Only in the last few decades have mycologists (fungal specialists) and agronomists devised reliable methods to cultivate some of the culinary species.

Seedling inoculation

Truffle cultivation starts in nurseries where the roots of tree seedlings are inoculated with truffle spores or cultures to form "mycorrhizae" (literally myco=fungus, rhizae=roots). These are dual-organism structures on the tree's root tips where nutrients are exchanged with the truffle fungus. Ideally, all other species of fungi are excluded during inoculation so that only truffle mycorrhizae form on the seedling's roots and most of the root tips are colonized. Preventing contamination, growing vigorous seedlings, and assessing inoculation success are essential in this initial phase if orchards established with the inoculated seedlings are to succeed.

Old World truffles are adapted to European trees such as the common hazel (*Corylus avellana*), holly oak (*Quercus ilex*) and downy oak (*Quercus pubescens*), so they are inoculated onto seedlings of these species. After the tree seedling is planted in an orchard, the fungus grows from the mycorrhizal root tips



**Truffle mycorrhizae
Photo by Carlos Colinas/Chris Fischer**

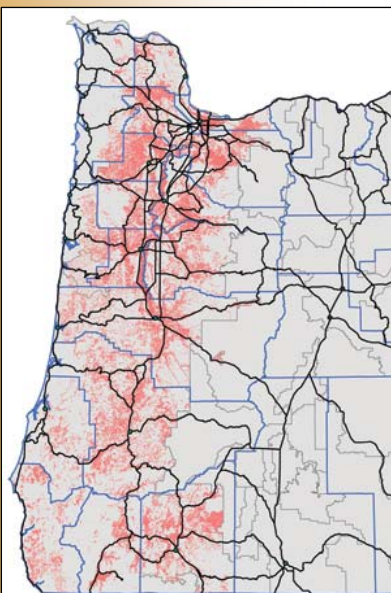
into the surrounding soil, where it must compete with local mycorrhizal fungi.

Site selection

All European truffle species require well-drained soils with high pH, but fertile agricultural soils are not necessary. For instance, in parts of Europe, truffles thrive in gravelly soils that are so marginal they will barely support cereal crops. Sites lacking trees for five or more years are best because they have fewer competing mycorrhizal fungi in their soils. The ground must be accessible to large farming equipment because western Oregon soils are naturally acidic (low pH) and large quantities of lime must be plowed into the upper soil profile to raise their pH adequately. Land ownership and zoning must allow intensively managed tree plantations (orchards). Legal and physical access to irrigation water is essential to ensure reliably large crops.

Even though ideal sites for the cultivation of Old World truffles should possess a robust combination of these attributes, millions of acres in western Oregon have appropriate soils and physiographic characters.

Soils in Western Oregon Suitable for European Truffle Cultivation



Soil map and acreage chart courtesy of Ron Raney, Soil Data Quality Specialist, Natural Resources Conservation Service, Portland, OR

Acres of soil by Western Oregon County Suitable for European truffle cultivation			
County	Truffle Acres	Total Acres	Percent of Total
Benton	125,772	434,521	29
Clatsop	12,686	558,867	2
Columbia	35,027	416,537	8
Coos	51,807	1,042,432	5
Curry	85,950	1,054,528	8
Josephine	76,973	1,048,015	7
Multnomah	53,917	297,657	18
Polk	66,398	477,056	14
Tillamook	38,895	720,147	5
Washington	88,718	465,492	19
Alsea area	8,914	177,736	5
Clackamas	140,766	648,368	22
Jackson	210,870	1,585,308	13
Lane	220,153	1,786,545	12
Lincoln	37,170	493,340	8
Linn	155,018	964,560	16
Marion	134,633	545,895	25
Douglas	284,233	2,259,471	13
Yamhill	169,182	434,400	39
Grand Totals	1,997,082	15,410,875	13

The following map and table (opposite page) show acreage that is suitable for European truffle cultivation. This acreage (1) is less than 3,000 feet in elevation, (2) has either flat terrain or faces between southeast to west, (3) slopes less than 25% (so farm equipment can operate), and (4) is well drained or somewhat excessively well drained, and (5) excludes land in the coastal fog belt.

The map shows major roads (black lines), cities (green dots), county lines (blue), soil survey lines (light grey) and soils meeting the criteria for truffle cultivation (red).

This soil map and table especially pertains to the European black truffle (*Tuber melanosporum*), which prefers warm, sunny sites where winters are mild, such as those found in the inland valleys of Western Oregon.

The other two cultivated Old World truffles, the Burgundy and bianchetto, can live on cooler sites such as north aspects, higher elevations, near the coast, or east of the Cascade Mountains. Climate change associated with global warming might become relevant to site selection for truffières intending to produce for the next half century, just as wine producers are shifting where they plant different grape varieties.

Plantation establishment & costs

Truffière establishment is similar to creating any orchard. It involves design and layout, plowing, soil amendments, fencing, installation of irrigation, and standard seedling planting methods. Oregon's acidic soils generally must be heavily limed to raise the pH to around 7.9. Liming is a common agricultural practice in Oregon and generally recognized as environmentally benign. Any concerns about heavy lime applications could be addressed with research.

The cost of establishing a truffière is comparable to that of other irrigated orchards, with two exceptions. Inoculated seedlings cost around \$20 each (although they are planted less densely than in most fruit and nut orchards) and initial lime applications exceed those for most crops.

Often, a mixture of hazelnut and oak trees is planted. Hazels start producing truffles earlier than oaks, typically within 5-7 years (versus 7-10 years for oaks). Oaks, on the other hand, maintain production longer (up to 50 years, versus 20-30 years for hazels). The ratio of hazels to oaks depends on the relative importance to the landowner of early versus prolonged production.



Attaining and maintaining ideal soil pH by liming western Oregon's acidic soils is critical to successful truffière management. Photo by Charles Lefevre

Plantation management

Truffière maintenance also is similar to many other orchard crops; weed and pest control, irrigation and pruning are the principle chores. Since these activities require relatively little time and effort, a single worker can manage 20 acres.

Periodic applications of lime are required to maintain high pH. Fertilization typically consists of supplemental micronutrients that are hard for the trees to obtain in limed soils. Weeds can be organically controlled with mowing, light tillage or weeding torches. As the truffle fungus becomes established in the soil around the trees, it hinders the growth of grass and herbaceous vegetation, creating bare zones called “brulés” or “burn” areas. The appearance of brulés indicates that the fungus is thriving. Yields (measured in pounds of truffles per acre per year) are enhanced with irrigation during dry warm summer months.

Orchard pests, such as rabbits, squirrels, pocket gophers and mice, may devour truffles and can harm or kill newly planted seedlings by eating their roots or bark. Control measures include tree guards, repellants, and use of prey animals (such as cats). In some cases, fencing might be useful for excluding big game animals or trespassers.



Newly planted seedlings with protectors.
Photo by Charles Lefevre

Hazelnuts and truffles

Truffle trees are widely spaced and pruned to allow light to reach the ground. The soil is lightly tilled for weed control, improved aeration, and ease of truffle excavation. By contrast, hazelnut orchards are encouraged to develop full canopies to maximize nut yields. Their soil is kept bare and compacted to allow harvesting equipment to vacuum up fallen nuts without excessive soil and debris. Dual production of truffles and hazelnuts might be possible if the soil is kept loose, nets or tarps are used to collect fallen nuts, and reduced nut yields are acceptable.

Income per acre for truffles is likely to far exceed that for hazelnuts (see “Income and Return on Investment,” below). Therefore, profits from co-production of truffles and hazelnuts should be compared to prospective earnings from planting oaks to prolong truffière production. Still, given the size and value of Oregon’s hazelnut industry, research on optimal co-production management regimes would prove useful.

Harvesting

Trained dogs are used to locate ripe truffles beneath the soil surface. Other animals could be employed, but medium-sized dogs have the energy and stature to cover a lot of ground. They are easily trained to hunt truffles for rewards such as play, affection or treats. During the off-season, they remain valued companions.

Truffle dogs should be selected for the ability to maintain focus on a task; some, like hunting dogs, can be easily distracted by game. In addition, truffle dogs must be able to search a wide area. Some breeds, like bloodhounds, concentrate too intensely on a small area of ground rather than also sniffing the breeze for truffle aromas. Many breeds, and mixed breeds, can be effective truffle dogs. One expensive and uncommon breed, the Lagotto Romagnolo, has been specifically bred to hunt truffles. If truffière owners obtain and train dogs a year or two in advance of anticipated production, they will be prepared for the excitement of finding the first truffles that fruit.

The harvest season varies by truffle species. The European black truffle typically matures in mid-winter. Not all truffles ripen at once, so the harvest season can extend over several months. Harvesting entails weekly or bi-weekly rounds of searching for ripe specimens. Once ripe specimens are located, they must be carefully excavated with a hand spade. Most will be less than a foot deep if the truffière has been managed to encourage root growth near the soil surface with shallow irrigation.

Yields

Yields in a mature truffière can vary widely, depending on site characteristics, seedling quality, management professionalism, and control of poaching (by animals and humans). Poorly conceived or ill-managed truffle orchards might only produce 5 pounds per acre per year (lbs/ac/yr), whereas the highest yields ever reported approached 250 lbs/ac/yr. A realistic average production is typically about 35 lbs/ac/yr.



**Truffle dog at work near Corvallis in an orchard of hazelnut trees inoculated with European black truffles.
Photo by Charles Lefevre**

Sometimes, purchased seedlings are planted on less than ideal sites by backyard “Mom and Pop” operations or hobby farmers. Although the resulting yields may be suitable for personal use, potential production from such operations can suffer from the lack of expertise, labor or capital required for intensive management. Carefully designed and intensively managed truffières that are established now will be well positioned to supply local and regional markets for decades to come.

Processing

Truffles grow in soil and must be cleaned before use. Thorough cleaning requires pruning of rotten spots or insect cavities, light brushing, brief rinsing and blotting the surface dry. Proper cleaning enhances product safety and quality, while extending shelf life.

Optimally, truffles should be sold fresh. Flash-frozen and vacuum-packed truffles retain some of their fragrance; however, truffles that have been pasteurized commonly lack aroma. Lower-grade truffles

can be effectively used in value-added products, such as purees, cheeses and pates.

Marketing

Because truffles are best when they are fully ripe and fresh, same-day sales to local or regional restaurants represent their ideal and most profitable use. Direct sales to gourmet restaurants throughout the United States also are feasible, since truffles can be shipped overnight. This ability to deliver truffles quickly represents real value for the customer, considering the shelf life of fresh truffles. North American growers can deliver their product to market days sooner than truffles imported from Europe, which represents a significant increase in value for both grower and consumer.

Truffles, like all mushrooms, also lose weight rapidly after harvest. As a truffle becomes dehydrated, its vitality and ability to produce its aroma tends to decline. A fresh truffle is naturally better, a fact that is not lost on chefs. Considering the high price per pound, the weight loss from dehydration also represents a significant loss of value, requiring higher markups on the part of importers. Ultimately, higher costs are borne by consumers for a lower quality product. All of this represents a straightforward argument justifying premium prices for locally grown truffles.

Specialty food markets that carry gourmet fresh foods are another logical choice for speedy marketing. Given customer unfamiliarity with truffles, such sales should be accompanied with educational materials that explain basic storage and use.

U.S. chefs often pay \$1000/lb or more for truffles, and retail prices can approach \$1500/lb or more in some seasons.

Truffles can also be sold retail through web sites. Small producers using this sales method can provide customers with a personal relationship by entertaining them with truffière blog stories, educating them, and assuring the source and ripeness of purchased truffles. Combined with opportunities for the customer to visit the truffière (as a bed-and-breakfast guest, for example), this marketing approach could be both profitable and extremely enjoyable. Many customers will pay far more for a gratifying experience than for a product, however fine, that lacks context.

Another option for owners of small truffières is to export their truffles through marketing cooperatives.

Prices

In Europe, harvesters earn about \$500/lb for black truffles. Prices can vary by several hundred dollars in either direction depending on quality, crop size, and availability during the course of the season. U.S. chefs often pay \$1000/lb or more for them, and retail prices can approach \$1500/lb or more in some seasons. Italian white truffles routinely command twice the price of blacks, while most other cultivated European truffles sell for somewhat less.

We anticipate no reason for Old World truffle prices to change dramatically in the near future because markets are far from saturated and demand is likely to grow in conjunction with increasing supplies.

Income and Return on Investment

Unlike wine, truffles do not require large investments in production or processing facilities. Production costs are more comparable to orchard crops. Gross income in a full production truffière, however, can be far greater. For example, if a carefully managed European black truffle plantation yields 35/lbs/acre/yr, and the truffles can be sold to brokers for \$1000/lb, gross sales receipts would equal \$35,000/acre/year. USDA 2005/2006 statistics for other Oregon crops provide a comparison: \$2,000/ac/yr for hazelnuts, \$5,000 for wine grapes, \$5,000-10,000 for various berries, and \$12,000 for blueberries. (Note, however, that production costs are higher for grapes and berries than for truffles.)

Of course, estimating return on investment (ROI) requires careful analysis of upfront costs and the length of time before truffières reach full production. Appendix C provides the details of a farm enterprise budget designed for orchard crops and modified for the inputs and management regime of a five-acre truffière that reaches production of 35 pounds per acre by its eleventh year. This analysis includes the following.

Production costs are comparable to orchard crops. Gross income in a full production truffière, however, can be far greater.

1. Discussion of 15 general assumptions.
2. Cost assumptions and calculations for machinery and its operation.
3. Input assumptions for variable, harvest and fixed costs per acre.
4. Cash flow analysis for orchard establishment.
5. Economic costs and returns analysis for orchard establishment.
6. Cumulative net economic returns and cash flows for 11 years (also shown below).
7. Annual tables of \$/acre economic costs and returns.

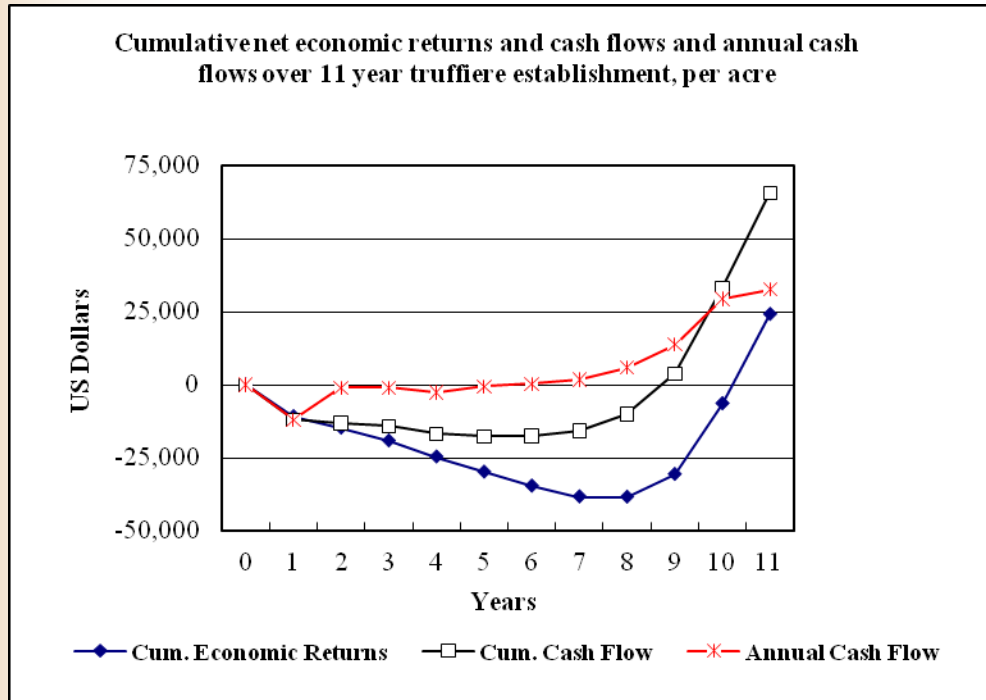
The graph (next page) shows that cash flow becomes positive in year 6, with annual income exceeding out of pocket expenses. The farmer recoups all of the cumulative cash costs in year 9, and cumulative economic returns almost break even at year 10 (assuming a 10% opportunity cost). Thereafter, both values climb rapidly into positive figures. At full production in year 11, farm revenue is approximately 8-fold greater than expenses.

Long-term return on investment for this truffière budget is dramatic. Assuming that truffle prices and operational costs both track inflation, ROI's substantially increase with orchard age.

Long Term Return on Investment for Establishing a Truffière

Year after establishment	15	20	25	30
Return on Investment	28%	36%	40%	45%

These ROI values greatly exceed the 10% opportunity cost assumed in the budget; that is, if the ROI



over time had been less than 10%, the landowner would have invested the money in another manner.

Indeed, these ROI values exceed those realized by most agricultural enterprises. Crops like hazelnuts or blueberries will start producing earlier and they often generate positive cash flows earlier, too. Yet initial investment for establishing these crops, and ongoing management costs, are so high over time that economic returns increase more slowly than those shown in the truffière example. Positive returns on investment also occur later and at lower rates. In comparison with non-agricultural investments, long term mutual funds have averaged 12% ROI and venture capitalists typically look for 20-30% ROI (albeit over much shorter time frames).

As with the huge potential global market for truffles, financial returns on investments in truffières are stunning. Critically though, the yields we assume in our examples (35 pounds/acre by year 11 and 50 lbs/acre/yr maximum) will only occur if everything is done correctly and the truffière is managed professionally and intensely.

Estimated Per Acre Returns Over Cash Costs at Varying Yields and Prices				
	----- Pounds/Acre -----			
Price/Lb	7	21	35	49
\$400	\$324	\$5,924	\$11,524	\$17,124
\$700	\$2,424	\$12,224	\$22,024	\$31,824
\$1,000	\$4,524	\$18,524	\$32,524	\$46,524
\$1,300	\$6,624	\$24,824	\$43,024	\$61,224
Estimated Per Acre Returns Over Total Economic Costs at Varying Yields and Prices.				
	----- Pounds/Acre -----			
Price/Lb	7	21	35	49
\$400	-\$1,836	\$3,764	\$9,364	\$14,964
\$700	\$264	\$10,064	\$19,864	\$29,664
\$1,000	\$2,364	\$16,364	\$30,364	\$44,364
\$1,300	\$4,464	\$22,664	\$40,864	\$59,064

LEFT: The truffle production budget is based on price and yield assumptions of \$1000 per lb. and 35 lbs. per acre per year, respectively. However, even when both these assumptions are severely challenged, the cash returns remain positive and economic returns are positive in all but the lowest price/lowest yield scenario.

Chain of Success

Success in creating highly productive truffières and earning abundant profits is contingent upon a chain of the following elements and events.

1. The current and anticipated climate of the site must be matched to the tree host and truffle species being cultivated.
2. Sites should be free of trees to minimize populations of competing mycorrhizal fungi.
3. Soils must be well drained and amended with enough (but not too much) lime.
4. Fertilization should match analyses of soil properties and focus on the dual needs of both the plant and the truffle fungus.
5. Planted seedlings must be vigorous and have almost all their roots colonized by the intended truffle species. Independent testing laboratories should confirm these seedling traits.
6. Seedling survival and growth depends on careful irrigation and vegetation control during the first year or two as they become established. Weeds and grasses should be continuously suppressed with mowing, light tillage or careful burning. Irrigation should encourage tree roots and mycorrhizae to grow near the soil surface so truffles don't fruit too deep.
7. Trees should be pruned to allow light to reach the soil surface.
8. Pests need to be controlled.
9. Enough truffle dogs must be trained so that one or more are always available during harvest season.
10. Sales outlets must be found and marketing arrangements developed.
11. Cleaning, processing, and storage facilities must be designed and built.
12. Personnel must be trained.

Since a chain is only as strong as its weakest link, all the links listed above must be equally robust to ensure high productivity and sizeable returns on investment. In addition, each link requires informed decisions, careful management and quality control.

New entrepreneurs and investors face a few transient challenges. Truffle-growing technology is not yet fully developed. Few individuals in the U.S. have direct experience managing truffières. Also, practical information is relatively limited; in particular, we lack reliable, detailed information on truffière establishment and management that is published in English and specific to Oregon.

The good news is that Oregon has one of the most qualified communities of truffle specialists outside of Europe and a dynamic agricultural Extension Service program. With adequate support, comprehensive manuals, guidelines and management technologies could be rapidly developed and disseminated, giving the state a significant competitive advantage in global truffle commerce. Meanwhile, serious growers can educate themselves by attending the truffle lectures and cultivation seminars associated with the Oregon Truffle Festival.



**Hunting truffles in a 5-year-old truffière on the day the first European black truffles were found.
Photo by Dr. Ian Hall**

Oregon's Assets for Cultivating Old World Truffles

When it comes to cultivating European truffles, Oregon has several vital assets.

Mediterranean climate

The state has a range of climate zones suited to each species of cultivated Old World truffles. Soils rarely freeze during harvest seasons (autumn to spring), and irrigation water is generally available in the dry summer months.

Suitable land

The European black truffle thrives on the same south-facing slopes suited to premier wine grapes like Pinot Noir. Truffle cuisine is a natural complement to fine wines, and vineyards may find profits and crop diversity in truffle cultivation. In addition, Old World truffles can be grown on land, and in climatic zones, that are less suited to producing premium grape varieties. Such land also can be marginal for farming as long as it is well-drained, accessible to farm equipment, and feasible to irrigate.

Learning from the experience of others

Some species of truffles (*Tuber brumale* from Europe and *Tuber indicum* from Asia) are difficult to distinguish from the European black truffle without genetic testing. Since their taste and value are inferior to European black truffles, they are not intentionally cultivated; however, they compete with other species in nurseries and truffières. Their inadvertent use for seedling inoculation can contaminate nurseries and reduce the value of subsequent truffle crops. If Oregon manages to avoid the widespread introduction of these species, freedom from contamination will remain an asset.

Negligible competition

Most truffières will be planted on agricultural soils containing few competitive fungi, especially those that grow symbiotically with hazel and oak roots. Still, competitive fungi from nearby forests could invade truffières through wind-born or animal transported spores. Native mycorrhizal fungi, however, have long been adapted to acidic soils and will probably compete poorly in high pH (alkaline) truffière soils. This will allow Old World truffles to thrive.



Sampling roots beneath a hazelnut inoculated with European black truffles. Photo by Mike McDermott

Low risk of invasiveness

Reciprocally, Old World truffles that are adapted to alkaline soils (naturally high pH) in their homelands are unlikely to be competitive or invasive in western Oregon's surrounding acidic soils.

Seedling availability

Seedlings inoculated with Old World truffles are available in Oregon. They can be obtained from New World Truffieries (<http://www.truffletree.com>), which prides itself for maintaining one of the highest quality standards in the global industry.

Infrastructure

Oregon has a well-developed agronomic infrastructure. Incorporating truffles into the mix of cultivated food products would require little novel equipment and few new facilities and transportation networks.

Priority To Do's

How Oregon can reach its full potential for producing Old World truffles

Seedling quality

Inoculated seedlings are expensive; yet establishing successful truffières requires planting vigorous seedlings colonized by the correct truffle species. Standardized, independent evaluations of quality will provide buyers with the confidence to invest in high-quality seedlings. These evaluations should



**Christine Fischer
evaluating seedling root
tips for truffle
mycorrhizae.
Photo by David Pilz**

include:

1. Genetically testing the identity of truffle inoculum and mycorrhizae
2. Evaluating the extent of root tip colonization by the intended truffle species
3. Verifying the health, size and vigor of the seedlings

Protocols for routine testing are currently being developed.

Professional management

Cultivating truffles is more complex than managing fruit or nut orchards because both trees and fungi must be given ideal growing conditions. Further, fungi are difficult to observe. Fortunately, Oregon has a cadre of truffle specialists ready to assist (see next section). Two items are especially vital to the immediate and sustained prosperity of an Old World truffle industry:

1. Detailed, readily available and inexpensive English-language publications on how to establish and manage truffières in Oregon.
2. Increased involvement of Agriculture Extension, which has extensive experience with local agronomic systems and orchard management. Extension can provide even greater assistance to new adding expertise specifically focused on truffle cultivation.

truffière managers by

Marketing

A multi-faceted approach could be used to market Oregon-produced Old World truffles. A unique brand image created for Oregon truffles could include:

- A focus on high quality standards for truffle production.
- Certification of environmentally-sensitive production methods.
- Innovative value-added products.

Public support

In European Union countries like France, Spain and Italy, the establishment and management of truffières is supported by longstanding, well-funded partnerships between government and

industry. These partnerships provide basic research, agronomic Extension Service, quality control testing facilities and financial incentives. Establishment of truffières in New Zealand and Australia were supported by favorable land use and tax laws. We discuss how Oregon's legislature and government agencies can support the growth of a state truffle industry in "Appendix A: Roadmap to Success."



**Tom the truffle dog at the Oregon Truffle Festival.
Lagotto Romagnolo's are bred for hunting truffles.
Photo by Andrea Johnson**

Oregon's New World Truffles

Discovery

Oregon has its own suite of local native truffles, some discovered by local experts.

Mycologists associated with Oregon State University in Corvallis are world renowned for their expertise in truffles and truffle-like fungi. Their legacy of research stretches back a century. Since the 1970s, they have led the world in truffle ecology and taxonomy, and have contributed to the discovery and identification of Oregon's culinary truffles. These achievements were greatly enhanced by the volunteer members of the North American Truffling Society (NATS), a scientific and educational organization. Founded in 1978 and based in Corvallis, NATS collects data on monthly truffle forays. These data have significantly broadened our understanding of the taxonomy, abundance, distribution, and ecosystem roles of fungi that fruit below ground.

Mycological societies and mycologists throughout Oregon and the Pacific Northwest also have contributed significantly to our understanding of native truffles. Awareness of the culinary value and commercial potential of several Oregon species grew as a propitious offshoot of these investigations.

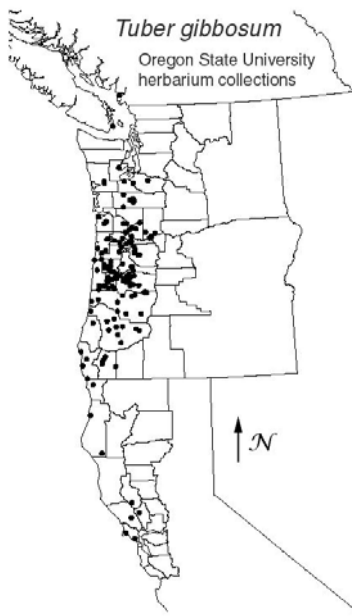


**Oregon Spring White Truffles (*Tuber gibbosum*)
with Douglas fir.
Photo by Charles Lefevre**

Concurrently since the late 1970s, commercial truffle harvesters have pioneered commerce in native culinary truffles. They have learned a great deal about the habitat and the unique harvest, handling, processing, storage and marketing characteristics of native truffles. Gathering wild mushrooms and truffles is a culturally important activity for many rural residents and, with the truffles supplied by these early entrepreneurs, Oregon's chefs are pioneering their use in local cuisines.

Oregon's Native Truffles

Oregon has at least three native culinary truffles that are highly regarded, relatively abundant and commonly harvested.



The late James Beard, a native Oregonian, once proclaimed Oregon white truffles to be as good as Italian whites. Oregon has two plentiful “white” varieties: one ripens in December through February (provisionally named *Tuber oregonense*), and one is ready to harvest in May and June (*Tuber gibbosum*). These two species are in the same genus (*Tuber*), as are all the culinary truffles of Europe.

Oregon also has a prized black truffle (*Leucangium carthusianum*). Unlike truffles in the genus *Tuber*, black truffles have a distinctively fruity fragrance that lends itself to use in desserts.

The NATS “Field Guide to North American Truffles” (listed under lead author “Trappe” in **Sources of Information**) has excellent photographs and descriptions of all three species. To learn how to recognize them, though, it’s essential to smell them. Opportunities abound at the Marketplace event during the annual Oregon Truffle Festival, where Oregon’s native truffles are displayed and sold. The NATS booth at the Marketplace is staffed by knowledgeable members and offers the Field Guide for sale.

Geographic ranges of Oregon black and Oregon white truffles based on herbarium collections at Oregon State University.

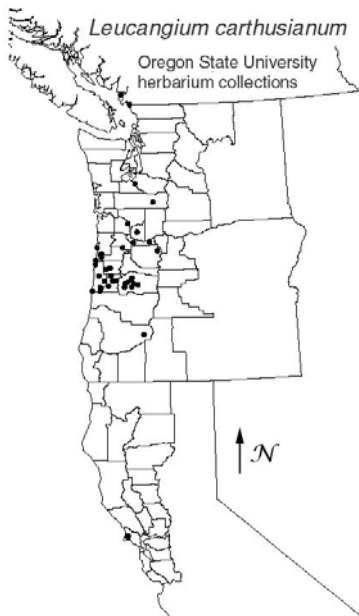
Native Truffle Forests

Habitat

All three of Oregon’s commercially-harvested truffle species grow in young Douglas fir stands at low elevations. These stands span the region from northern California to southern British Columbia, west of the Cascades Mountain Range. White truffles are found most abundantly in former pasture or agricultural land that has been planted with Douglas fir. Black truffles are widely distributed in the Coast Range and foothills of the Cascades, often in afforested plantations near streams, but also on reforested hillsides. The distribution of the three truffle species overlaps considerably, and all three species can inhabit the same stand.

White truffles tend to fruit within a few inches of the soil surface. Black truffles, however, fruit at a range of depths, from near the soil surface to over a foot below it.

Timber resource statistics for western Oregon suggest that roughly 100,000 acres of suitable forest habitat currently exists for white and black truffles. Nearly all of the land is privately owned. Given reasonable



estimates of average productivity per acre and the current small harvest of native truffles (see Economic Potential section below), we surmise that less than 2% of this acreage is being harvested.

Truffle gatherers seek highly-productive stands with easy access. The number of stands can be increased through planting and made highly productive by applying the techniques discussed in the next section.

Truffle forest management

Forest mycologists believe there is great potential for improving Oregon's native truffle yield. For instance, yields in newly-planted stands would likely be dramatically increased by inoculation techniques that could establish native truffle mycorrhizae on the roots of Douglas fir seedlings in nurseries. Although it cannot yet be done reliably, trials are under way. Additional research on this topic, in particular, has great potential for providing significant economic benefits to woodlot owners.

Surveys that correlate the abundance of native truffles with soil, forest habitat and climate variables would clarify ideal growing conditions. Strains or geographic varieties of native truffle species likely vary in their culinary characteristics and suitability for cultivation. Any surveys of native truffles should include gastronomic evaluations, genetic tests and inoculation trials for identifying strains potentially best suited to domestication.



Typical Oregon white truffle habitat: young Douglas fir planted on former pasture on the margins of the Willamette Valley.
Photo by Charles Lefevre

Stand management also could enhance the production of truffles in existing forests. For example, injecting spore slurries into the root zone of young trees might establish new truffle colonies. Irrigation during summer months likely would improve the yields of known truffle patches.

In an interesting anecdote, a Christmas tree farmer accidentally limed his trees more heavily than recommended and subsequently produced some of the largest Oregon white truffles ever found. Although Christmas tree cultivation typically involves herbicides and inorganic fertilizers (but not liming), co-production of Christmas trees might be feasible in a stand planted for truffles. Inoculated Douglas fir seedlings could be planted densely, with some harvested as Christmas trees and the rest left to develop a truffle-producing forest stand.



**Large Oregon white truffles found
in a limed Christmas tree farm.
Photo by Jim Trappe**

Finally, pruning low branches would allow greater access to truffles in young plantations, while thinning might prolong the length of time that a truffle forest remains productive. Thinning operations might be designed to produce poles or pulp, or to generate fuel from biomass.

All of these approaches are promising, but it is too early to recommend specific management practices or conduct economic analyses of investments and returns over time. Management research and resultant cost/benefit analyses will help landowners decide what investments to make and which management practices to employ. The sooner this research occurs, the sooner Oregon's native truffles will reach their full economic and gastronomic potential.

Environmental benefits

All truffles play key functional roles in forest ecosystems; they recycle nutrients, improve soil structure, nourish trees, and underpin wildlife food webs.

Forests that produce our culinary truffle species offer additional benefits. New Douglas fir plantations, established on former pastureland along coastal streams, can produce valuable black truffles while improving habitat for struggling salmon runs. Information about grants for these plantings is available from the Oregon Watershed Enhancement Board.

The planting of new forests also qualifies landowners for carbon offset payments to help reduce CO₂ in the atmosphere. Contact the Oregon Department of Forestry for information on this program.

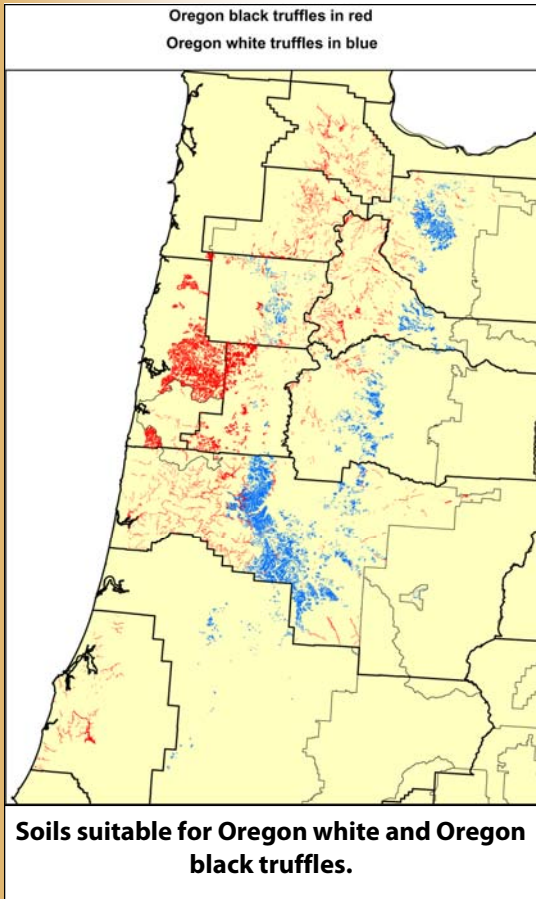
Economic Potential

Current crop size and value

Quantities and value vary widely from year to year, but the size and value of Oregon's native truffle crop is still small. Probably fewer than 5,000 pounds (2.5 tons) of all Oregon truffle varieties are collected and sold each year. At current low prices, the harvesting segment of the truffle industry in Oregon currently grosses approximately \$300,000 annually from the crop.

Potential production

The typical productivity of native culinary truffles (in pounds per acre per year) has never been systematically sampled and reported in a peer-reviewed publication. Yields of 1-3 lbs/ac/yr are reasonable for other types of edible mycorrhizal forest mushrooms (such as chanterelles) when



averaged across all the forests where they commonly occur. Values of 5-20 lbs/ac/yr have been recorded for single species of forest mushrooms in highly-productive natural habitats. Commercial harvesters, of course, prefer to gather mushrooms in such stands.

Yields of 20-40 lbs of truffles/ac/yr would not be surprising in stands planted with inoculated seedlings and actively managed. If 20 lbs/ac/yr were obtained in even 10% of appropriate habitat (10,000 acres), crop size could approach 200,000 lbs per year (100 tons), or 40-fold what it is now.

The use of trained dogs also might increase crop size by making stands with lower productivity economical to harvest; less time would be required to find widely-spaced truffle patches and mature specimens.

Prices

Field prices for Oregon white truffles range between \$20 and \$40/lb., whereas field prices for Oregon black truffles range from \$45 to \$75/lb. Purveyors who buy from harvesters and sell to restaurants typically double or triple the field prices to compensate for culls, spoilage, and weight loss during storage. These prices are based on typically poor quality, unripe truffles harvested by

raking. In contrast, truffles harvested by trained dogs have dramatically more culinary value and should, therefore, command dramatically higher prices. Given the intensity and quality of the aroma

Native Oregon Truffles: Potential 2030 U.S. Demand, Value & Acres

Factor	Units	Low estimate	Medium estimate	High estimate	Optimistic estimate
Total demand for native truffles	U.S. tons/yr	23	91	312	833
# Acres needed	Acres	9,000	18,250	31,219	55,500
Value of U.S. demand for native truffles	\$ Millions	4.5	36.5	187.3	666

produced by ripe Oregon truffles, two- to four-fold price increases would not be unreasonable.

Potential crop size and value

If crop size can be increased 40-fold and prices increased 200-400%, the economic value of the native truffle industry has the potential to expand a hundred-fold to \$30 million annually.

How do these estimates compare with potential U.S. demand for Oregon's native truffles by the year 2030? Using the same methods to estimate future demand that we used for predicting global demand for all truffles, we arrived at the numbers in the following table. (See Table 5 of Appendix B for the complete table and how the numbers were derived.) Our medium estimates of potential U.S. demand for Oregon truffles are close to the potential production discussed above.

Creating A Reputation For Quality

Oregon truffles will reach their greatest potential in the marketplace when only the best, completely mature and fully fragrant specimens are sold. Our native truffle industry will grow and prosper by ensuring fair and adequate compensation for all participants in the industry: harvesters, landowners, buyers, processors and sellers.

Certification can be a tool for verifying that truffles were harvested in an ethical, environmentally responsible and widely beneficial manner. Oregon truffles should have a reputation for quality that matches that of our state.

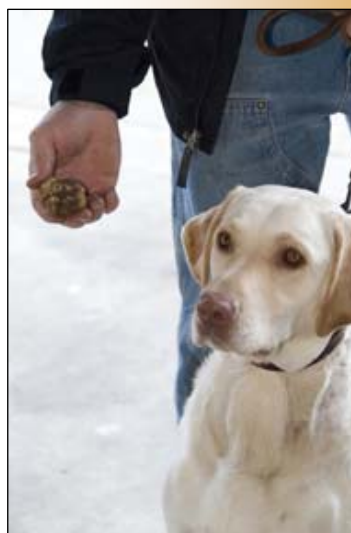
Elements of success will include the following.

Product quality

High quality, ripe Oregon truffles are as desirable as many Old World truffle species. The lower price they fetch in today's markets partly reflects previous harvest practices that temporarily tarnished their reputation and partly reveals a lack of familiarity with their uniqueness.

Until recently, few Oregonians have employed trained truffle dogs to sniff out only fully-mature, ripe truffles. Native truffles were typically gathered en masse by raking the upper layers of the forest floor.

The practice of raking for culinary truffles has a number of drawbacks, From the landowner's perspective, raking can be unsightly, and it has an unknown potential to spread root diseases on the tines of the rakes if they are not cleaned periodically. At this time, harvesters have differing opinions about whether raking alters the subsequent fruiting and productivity of white truffle patches.



Dogs intent on finding only ripe truffles will be willing partners in the quest for top quality.
Photo by Georgia Freedman

Oregon black truffles, however, fruit as far as a foot underground, Deep raking for these truffles can sever small tree roots, disrupt the truffle fungus and impair subsequent fruiting.

Truffles grow over a period of months and mature at different times. Even if the collector waits until the peak of the season, raking inevitably unearths both immature and mature truffles. Too often, harvesters sell large lots of indiscriminately raked truffles that include dirty, small and immature specimens; these are sold without cleaning or grading the truffles for damage, decay or maturity. Chefs find such truffles bland or unusable; as a result, they buy fewer truffles or pay less.

Developing methods, procedures and standards for producing and marketing only high-quality truffles will greatly enhance the reputation and value of native truffles. Using trained dogs to sniff out only the ripest truffles will help immensely by ensuring that only mature truffles will be harvested and sold.

The Oregon Truffle Festival helps educate the public about the epicurean potential of Oregon truffles, and shows industry participants how to assure that the value of truffles becomes widely recognized.

New World truffles are unique organisms that differ from their Old World counterparts in requirements for harvesting, handling, cleaning, grading, storage, preserving, shipping, retail display



As truffles mature, their interior darkens. The truffles on the right in both photos are fully mature. The truffles on the left, with white interiors, have no culinary value. Truffles with intermediate interior color can be ripened in storage, but will never be as good as those that are fully mature at harvest.
Photos by Charles Lefevre



and culinary use. If industry participants choose standards for high quality and develop mechanisms for verification, then consumers of Oregon truffles can be assured they are buying only the best and prices will rise accordingly.

Most truffle harvesters are eager to participate in developing a well informed, environmentally sensitive and world-class truffle industry that sustains the resource and their livelihoods. Better prices for high-quality truffles will provide the wherewithal for everyone to invest in developing sustainable practices that yield quality products.

Landowner involvement

Landowners must be compensated adequately if they are to perceive any benefit from managing their forests for higher truffle yields. To obtain satisfactory compensation, truffle prices must be sufficiently high for landowners to profit along with harvesters, processors and sellers.

Also, landowners must have effective means of preventing trespassers from surreptitiously collecting truffles on their property. Theft is a potential problem, as it is with any valuable natural resource subject to poaching (for example, timber or truffles in Europe). The most effective way to minimize pilfering is to collaborate with others who have a financial stake in the careful management and sustainable harvest of the resource. For instance, a landowner and harvester could make contractual arrangements to manage a stand for truffles, exclude unauthorized harvesters and share profits.

Most truffle harvesters are eager to participate in developing a well informed, environmentally sensitive and world-class truffle industry

Landowners might wish to extend their involvement by making exclusive marketing arrangements or cooperating with research projects focused on improving stand management for native truffles.

Active membership in a truffle association would open many doors to mutually beneficial endeavors. We discuss this possibility in the last section because it applies to both Old and New World truffles.

Certification

How will the chef or customer know they are buying only the best truffles produced in an ethical, environmentally sensitive and widely-beneficial manner? Not all customers will be able to ascertain the peak of potential fragrance for each species of truffle, or know how to evaluate truffles for size, lack of defects and cleanliness.

Educating consumers and chefs about the attributes of Oregon truffles is an important goal of the Oregon Truffle Festival; however, it will be a year-round, ongoing process as new customers emerge. Even if customers are able to evaluate the quality of a truffle, they have only the word of the seller

concerning how it was obtained. In many cases, this is entirely adequate. Still, as more Oregon truffles are marketed wholesale or exported, another level of assurance might become useful.

Certification could take many forms. The most helpful and germane categories could be determined by members of a truffle association. For example, “sustainably produced” might be an umbrella label that includes the use of dogs for locating only ripe truffles; training and registration of harvesters; written agreements with landowners, or standards for processing, grading and shipping. Individual producers might also pursue established certification labels such as “organic,” “salmon friendly” or “Made in Oregon.”

Gastronomic Innovations

New and Old World truffles do not directly compete. Rather, they complement each other as alternatives in the precisely crafted preparation of unique flavor combinations. The world is a richer place for having an array of appetizing truffle species with distinctive aromas and culinary applications. Oregon will be able to supply consumers with a full range of olfactory and gustatory diversity.

Many regional restaurateurs who use Old World truffles want a reliable supply of high-quality Oregon truffles, especially to enhance dishes prepared with local foods. Oregon’s finest chefs pair truffles with local salmon, tuna, crab or other sea foods; naturally produced beef, buffalo and pork; game such as elk or venison; dairy products like cream cheese, specialty cheeses and ice cream; wild forest mushroom dishes, or hazelnut sauces.

Because the unique flavors and uses of Oregon truffles remain unfamiliar to many chefs, there is ample opportunity to experiment with using high-quality native truffles in regional fare. As lessons are learned, local culinary arts programs will incorporate the use of native truffles into their educational programs.



**Chef Jack Czarnecki shaves Oregon truffles on seasonal cuisine.
Photo by Georgia Freedman**

Oregon's Assets for Production of Native Truffles

Optimal habitat

Oregon's white and black culinary truffles, although native to the Pacific Northwest, are most abundant and productive in Western Oregon.

Synergistic benefits and co-production

Native truffles grow in newly-planted Douglas fir forests that can enhance salmon habitat, sequester carbon dioxide and provide other amenities. Given appropriate management regimes, truffles can be co-produced with Christmas trees, wood products and timber.

Research legacy and expertise

Oregon's legacy of truffle research and the expertise of the state's mycologists are valuable assets for competing successfully in the realms of regional, national and international truffle commerce. The members of amateur mycological societies (such as the North American Truffling Society) also contribute time and enthusiasm. Much of this expertise has been focused on the native truffles that fruit in Oregon's forests. Further application of sound science will greatly assist the growth of the industry.

Rural stewards

Private woodlot owners and harvesters of forest products have a vested interest in maintaining productive, diverse forests. They constantly seek innovative ways to sustain the resource and conserve environmental benefits while still making a living. These stewards are intimately familiar with their woodlands, and can contribute greatly to the development of a native culinary truffle industry.



**Oregon white truffle slices layered on salmon at the Oregon Truffle Festival Grand Dinner, January 2006.
Photo by Georgia Freedman**



**In only its second year, the Oregon Truffle Festival's Grand Truffle Dinner was named a James Beard Out of House Event.
Photo by Andrea Johnson**

Priorities

How Oregon can reach its full potential for producing native truffles

Create a reputation for high quality truffles

Oregon's native truffle industry will flourish when it develops a reputation for producing and marketing only high-quality truffles. When these truffles command premium prices, their sales will generate the income needed for a well-managed industry.

Industry association

Creating this reputation will require a collective effort. In the next section, we discuss formation of a truffle association to facilitate this process. For the native truffle industry, the most important tasks will be:

- Encouraging expansion of research and Extension Service activities
- Sponsoring or supporting dog training
- Developing a certification program
- Encouraging collaborative ventures

Research and Extension

For a native truffle industry to flourish, Oregon must retain its existing professional expertise and hire additional specialists. Funds for expanded research will greatly improve the breadth and applicability of information we can provide to producers. Forestry Extension programs focused specifically on native culinary truffle production can effectively educate woodlot owners about how to profit from truffles in their woodlands. Landowners need site visits by knowledgeable individuals who can evaluate the potential of their property for truffle production.

Dogs

Trained truffle dogs will help Oregon improve the quality and reputation of its truffles and create exemplary standards for environmentally responsible harvesting practices.

Raising and training truffle dogs takes time. It requires a significant financial investment and a commitment to the long-term welfare of the animal. Professional dog trainers can help owners nurture productive, skillful, obedient and happy truffle dogs. A truffle association could provide substantial support to dog owners and trainers, accelerating improvements in truffle quality by more



**Charles Lefevre addressing members of the Small Woodlot Owner's Association.
Photo by Dirk Jacobs**

rapidly expanding the state's pool of trained truffle dogs.

Certification and standards

Producing and marketing only high-quality Oregon truffles will be a great step forward. A certification program, however, would further enhance the reputation and value of Oregon truffles. Certification could verify the truffle source, harvest practices, processing and handling methods, or quality standards.

Collaborative ventures

We have the opportunity to increase Oregon native truffle crops a hundred-fold. To achieve this potential, industry participants must work together. All participants must be able to earn adequate returns on their investments and fair compensation for their labor.

For example, landowners must maintain control over their forests and truffles if they are to invest in enhancing production. Harvesters need exclusive access to truffle patches in order to earn dependable income and realize the long-term benefits of careful harvesting. Purchasers and processors can reduce the time and effort needed to clean, sort and grade truffles if harvesters bring them fully mature ones. Researchers and Extension agents can provide technical information, outreach education and participatory research opportunities if they have sufficient funding and institutional support.

*Collaboration
reinforces the work of
each participant and
enhances the industry,
which benefits all*

The interests of all these participants are mutually compatible. Collaboration reinforces the work of each participant and enhances the industry, which benefits all.

Join the Adventure

Oregon's emergent truffle industry has reached the tipping point where a small investment in individuals, resources, organization and promotion can make an extraordinary difference in outcome.

The industry is starting with a wealth of assets at its disposal. Advantages include a legacy of research, savvy entrepreneurs, talented foresters and farmers, harvesters dedicated to resource stewardship, an ideal growing environment, environmentally-sensitive food production methods, a robust infrastructure, supportive organizations, a reputation for excellent food quality, fine dining establishments, a flourishing tourism sector, and the creative vision of its citizens.

The Oregon Truffle Festival has created a nucleus around which these inspirations and energies are coalescing to create another world-class Oregon industry. Now is the time for earnest investment to stimulate rapid growth before the competitive window of opportunity passes.



Dr. Carlos Colinas of Spain's University of Lleida addressing the Truffle Growers Forum at the Oregon Truffle Festival. Photo by Charles Lefevre

Nothing succeeds like success, and those involved in this nascent industry have the foundation and enthusiasm to succeed.

Resources

Authors

David Pilz is a consultant, writer, and forest mycologist. He earned his M.S. in Forest Ecology studying mycorrhizae. He subsequently conducted extensive research on commercially harvested forest fungi with the US Forest Service Pacific Northwest Research Station and with the Department of Forest Science at Oregon State University. Currently, he is a Natural Resource Planner with the Lassen National Forest in northern California. He may be reached at: PilzWald (Forestry Applications of Mycology), P.O. Box 727, Susanville, CA 96130. 541.753.6209. pilz@windjammercable.net, <http://home.windjammercable.net/pilzwald/>

Charles Lefevre, Ph.D. earned his doctorate in Forest Ecology by studying mycology in the Department of Forest Science at Oregon State University. He is president and owner of New World Truffieres, a producer of seedlings inoculated with various Old and New World truffle species. He may be reached at New World Truffieres, P.O. Box 5802, Eugene, OR 97405. 541.513.4176. Charles@truffletree.com or <http://www.truffletree.com/>

Leslie Scott earned her M.A. in International Studies: Community and Cultural Development. She specializes in nonprofit management and event coordination, and is an adjunct professor of Arts and Administration at the University of Oregon. She also may be reached at New World Truffieres, P.O. Box 5802, Eugene, OR 97405. 541.913.3841. Leslie@truffletree.com or <http://www.truffletree.com>.

Leslie Scott and Charles Lefevre also are co-founders and organizers of the Oregon Truffle Festival: <http://oregontrufflefestival.com>.

James Julian, Ph.D. is an agricultural economist with the Agricultural Economics Research and Extension Service of Oregon State University and works at the North Willamette Research and Extension Center in Arora, Oregon. He earned his doctorate studying horticultural trade and marketing at Purdue University in 2003. James provided the Enterprise Budget analyses for establishing an Oregon truffière. He may be contacted at NWREC, 15210 Miley Road, Aurora, OR 97002. 503-678-1264 ext 117. james.julian@oregonstate.edu.



**Authors (Left to right)
Charles Lefevre, Leslie Scott, and David Pilz
28 June 2007, Willamette Valley Vineyards
Photo by Shelby Zadlow**

Oregon Expertise

The Oregon Truffle Festival

Experience ripe Oregon truffles for yourself. Smell them, examine them and taste them. Meet the individuals who are involved in the industry. Watch truffle dog training demonstrations. Take a field trip to hunt for truffles. Attend lectures by truffle specialists. Enjoy the Grand Truffle Dinner prepared by Oregon's premier chefs. Volunteer to help or support the festival!

Oregon Truffle Festival

January 25-27, 2008

For more information, visit the web site: www.oregontrufflefestival.com

Oregon Mycological Societies

Members of Oregon's three main mycological societies have extensive familiarity with our culinary truffles and often have forays to search for them, shows that display them, speakers that talk about them, and annual potluck dinners that feature them. This is especially true of the North American Truffling Society. Voluminous information about truffles is posted on their web sites.

North American Truffling Society, Corvallis, OR: www.natruffling.org

Oregon Mycological Society, Portland, OR: www.wildmushrooms.org

Cascade Mycological Society, Eugene, OR: www.cascademyco.org

Smaller mushroom clubs in Oregon: www.mykoweb.com/na_mycos.html

Consultants

The authors of this paper and several other individuals in Oregon are available for consultation. Most of us are willing to respond to quick questions or initial inquiries free of charge, but all of us charge for consultation time, expenses and travel. Please contact us individually for information about availability and fees. We will refer you to another colleague if they are more qualified to help or can do so in a more timely manner. For more information, see Truffle Consulting Services (www.truffleconsulting.com).

Truffle Seedlings

The only supplier of truffle-inoculated seedlings in western North America is New World Truffieres (www.truffletree.com), located in Eugene, OR. It is owned and operated by Charles Lefevre, one of the authors of this paper. Some additional information about truffière establishment and management is available on the web site.

Truffle Dog Training

Trifecta Training Center (www.trifectatraining.com) is currently the only dog training school in Oregon that specifically advertises truffle dog training.

Seedling Quality Evaluation

Quantification and molecular identification of ectomycorrhizal roots or fungi used to inoculate roots (including truffles) is available at Oregon State University. Contact Dr. Daniel Luoma: 541-737-8595 or daniel.luoma@oregonstate.edu.

Mycorrhizal Root Tip Evaluation Services

MycoRoots (www.mycoroots.com) is a private Corvallis company that provides professional evaluation of mycorrhizal roots.

Sources of Information

The authors of this paper have more than 30 years of combined experience with truffles and truffle cultivation. We have summarized the best information we have, but more comprehensive and readily available information would be very useful to Oregon's emergent truffle industry. Specifically, Oregonians would greatly benefit from additional publications, educational media and web sites that:

- Pertain specifically to truffle production in Oregon and the Pacific Northwest
- Are readily available through OSU Extension Service
- Provide a thorough review and synthesis of relevant publications elsewhere
- Explain truffle biology, ecology, cultivation and management
- Address harvesting, handling, storage, shipping and culinary use
- Discuss economic, marketing, investment, regulation and labor issues
- Investigate collaborations for growing a world-class truffle industry
- Provide a resource database

Until such information becomes available, we list some of the more useful reference books and papers. The three articles are available from their lead author.

1. Hall, Ian R.; Brown, Gordon T.; Zambonelli, Alessandra. 2008. **Taming the truffle: the history, lore, and science of the ultimate mushroom.** Portland, OR: Timber Press. 282 p. \$34.95
2. Lefevre, Charles K.; Hall, Ian R. 2001. **The status of truffle cultivation: a global perspective.** Proceedings of the V International Congress on Hazelnut. Acta Hort. (ISHS) 556:513-520.
3. Lefevre, Charles K.; Pilz, David; Trappe, James M.; Molina, Randy. 2001. ***Tuber gibbosum* and *Leucangium carthusianum*: Ecology, harvesting, and marketing.** Proceedings of the Vth International Congress on the Science and Cultivation of Truffles and other Edible Hypogeous Mushrooms. Aix-en-Provence, France. March 4-6, 1999. Paris, France: Federation Française des Trufficulteurs: 4.214-4.217.

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4. Pilz, Dave; Bondi, Mike. 2005. **Oregon truffles...a culinary delight from the forest.** An Oregon Garden guide to truffles. May issue. Silverton, OR: Oregon Garden Rediscovery Forest and the Oregon Forest Resources Institute. 4 p.
 5. Renowden, Gareth. 2005. **The truffle book.** Amberley, NZ: Limestone Hills Publishing. 148 p. (Approximately \$11.50 for PDF version, \$31 for softcover and \$54 for hardcover, including shipping)
 6. Trappe, Matt; Trappe, James; Evans, Frank. 2007. **Field Guide to North American Truffles: Hunting, Identifying, and Enjoying the World's Most Prized Fungi.** Berkeley, CA: Ten Speed Press. 144 p. \$16.95

Acknowledgements

This feasibility study was made possible by a generous gift from Jim Bernau, co-founder and CEO of Willamette Valley Vineyards. The North American Truffling Society charitably agreed to provide organizational support for the project. Matt Trappe, Chris Fischer, Jim Wells, Mike Bondi, Shannon Berch, Eric Jones and Senator Floyd Prozanski reviewed the 2007 version of this paper.

In 2008, a USDA Rural Business Enterprise Grant (administered by Cascade Pacific Resource Conservation and Development) funded expanded analyses of potential global markets, an enterprise budget for a representative truffle farm, and a summary of appropriate soil types in western Oregon.

In particular, we wish to thank Karen Strohmeier, RC&D Coordinator, of Cascade Pacific Resource Conservation and Development. Her generosity of time, wealth of knowledge and invaluable guidance made this paper possible. We also thank Sarah Minier Johnson for publication design and layout.

We could not have produced this paper without our long association with valued colleagues. They include mycologists, foresters, truffle harvesters, mycology club members, truffière entrepreneurs and chefs, as well as the staff, volunteers and supporters of the Oregon Truffle Festival. Thank you!

The authors are solely responsible for the content of this paper and the opinions expressed herein.

Appendix A: Roadmap to Success

Oregon has a wealth of individuals, businesses and organizations with the desire and expertise to create a thriving culinary truffle industry. Realizing the industry's full potential will require engaging the private and public sectors, often in partnership.

In this appendix, we explore the types of support needed to build our truffle industry.

Industry Association

Many industry stakeholders support creating a truffle association to help Oregon truffles attain a reputation for quality and ensure that the industry operates in an ethical, environmentally responsible and widely beneficial manner.

The association will benefit producers of both Old and New World truffles by providing:

- A central source for information and news
- A forum for discussing issues and resolving conflicts
- Education, outreach, and marketing campaigns
- Support for, or sponsorship of, dog training programs
- Research sponsorship
- A certification program that might incorporate elements such as:
 - ◊ A common definition of "sustainable harvesting"
 - ◊ Harvest methods
 - ◊ Harvester training and licensing
 - ◊ Landowner permission
 - ◊ Quality standards (maturity, handling, processing, cleanliness, grades, storage methods or shipping protocols)
 - ◊ Production methods (organic, local, sustainable and salmon-friendly)
 - ◊ Source and brand ("Made in Oregon" or "Brand Oregon")

Farmers cultivating Old World truffles will benefit from:

- Publications on truffière establishment and management guidelines
- Cooperation with agronomic research projects that target their concerns
- Shared information and experience regarding site selection and truffière management
- A joint marketing mechanism for small truffière owners who wish to export

Small woodland owners producing native Oregon truffles will benefit from:

- More harvesters using trained dogs
- Harvester training, licensing, insurance or bonding programs
- Sponsorship of relevant research projects on their properties.
- Shared information and experiences about managing native forests for truffle production

Harvesters of native truffles will benefit from:

- An organization that represents their interests and promotes a diversity of small-scale, sustainable rural truffle businesses
- Recognition of their resource stewardship and truffle management insights
- Active engagement in developing native truffle harvest, handling, processing and marketing standards
- Sponsorship of, or participation in, truffle research that addresses issues of interest

Buyers, purveyors, processors, and brokers of truffles will benefit from:

- Common standards for product quality
- Shared information and experience regarding harvesting, handling, cleaning, storage, processing, preserving and shipping of Oregon's various truffle species.

Customers, chefs and restaurateurs will benefit from:

- The assurance of high quality truffles
- Shared information about prices, handling, storage, retail display and culinary use of New World truffle species

Potential members or collaborating organizations might include:

- Truffière owners and managers, small woodlot owners, harvesters, brokers, purveyors, chefs, restaurants, wineries, resorts or gourmet food producers
- The Oregon Farm Bureau
- Oregonians for Food and Shelter
- Oregon Small Woodlands Association
- Family Forests of Oregon
- Oregon Forest Resources Institute
- Oregon Culinary Institute
- Food Alliance
- Slow Food USA
- Ecotrust
- Sustainable Northwest
- Wine or hazelnut industry associations
- Charitable foundations that provide grants for enhancing agriculture, forestry, economic development, community welfare or environmental quality in Oregon



**Oregon winter white truffles.
Photo by Andrew Rafkind**

Oregon Legislature

The Oregon Legislature can greatly benefit the economy and people of Oregon by:

- Providing dedicated funding to university research and OSU Extension Service to enhance truffle production
- Stipulating that state agencies promote truffle production and commerce

University Research

Our universities and colleges can provide professional and institutional support for research projects.

Examples include:

- Focused research on the biology, ecology, taxonomy, and genetics of truffle fungi
- Agronomic research to ascertain optimal truffière sites and develop ideal management regimes
- Laboratory testing facilities for evaluating the quality of inoculated tree seedlings and verifying the species of truffles inoculated onto their roots
- Detailing the native range of Oregon's culinary truffle species and their preferred habitats, while investigating variation among species and strains in suitability for domestication
- Determining how best to enhance native truffle productivity with forestry trials focused on such topics as field inoculation methods, irrigation, liming and thinning
- Environmental and socio-economic research focused on developing a sustainable, equitable and widely beneficial industry
- Development of optimal harvest, handling, storage, ripening, processing, preserving, shipping and display methods



**Dr. Jim Trappe of Oregon State University identifying a truffle.
Photo by David Pilz**

Extension

- OSU Extension Service participates in applied field research and brings the latest technical information to landowners, farmers and growers.
- Agricultural Extension services focused on truffière establishment and management will be very useful because comprehensive information specific to Oregon is not yet widely and freely available.
- Oregon has the largest, most respected network of Extension foresters in the United States and is already assisting woodlot owners with managing forests for Oregon truffle production. Far more can be accomplished.
- Natural Extension collaborators include the North Willamette Research and Extension Center and the Food Innovation Center (FIC) Agricultural Experiment Station.

State Agencies

State agencies dedicated to forestry, agriculture, economics, marketing, export and tourism could facilitate the growth and prosperity of our truffle industry with their guidance, including:

- Experience with previous Oregon industries
- Sources of funding
- Information about state policies and regulations
- Analyses and projections of economic, marketing, export and tourism opportunities

Logical collaborating agencies include:

- Oregon Department of Agriculture
 - ◊ Agricultural Development and Marketing Division
 - ◊ Commodity Inspection Division
- Oregon Economic & Community Development Department
- Oregon Department of Forestry, Private Forests Program
- Oregon Department of Land Conservation and Development
- Brand Oregon



As the Oregon truffle industry grows in size and value, a semi-independent state agency such as the Oregon Wine Board would become useful. A “Truffle Board” would complement the Truffle Association of Oregon in the same manner that the Wine Board complements the Oregon Winegrower’s Association.

Appendix B:

Estimates of Potential Truffle Demand

(Tables 1-6)

All demand (equivalent to potential consumption) values were estimated for the year 2030. By that time the Oregon native truffle industry should mature and significant production of truffles cultivated in Oregon should be coming on-line. Tables 3 & 4 show global demand for all truffle species combined. Table 6 specifically shows US demand for native Oregon truffles.

Attempting to estimate the potential future demand for truffles two decades hence (by the year 2030) is fraught with uncertainty. We approached the task by creating Excel spreadsheets to calculate a range of predicted values from relevant information that was available. Notes about calculating the values follow each table.

The most salient uncertainties in our calculations are (1) how many people are able and willing to pay to eat truffles [Table 1] and, (2) how much are they willing to pay for truffles each year as a factor of how many meals they are likely to consume [Tables 2 & 3]. As there are no data on these factors, we approached demand by estimating how many people (globally) live in wealthy countries (and urban centers in poor countries) and then calculated likely per capita consumption values [Table 3].

The price of \$1,000/lb used in Tables 2 & 4 is a typical wholesale \$US price for *Tuber melanosporum* in 2008. Other truffle species sell for more or less than this figure, but *T. melanosporum* will likely constitute the majority of the market and the price for the other species will likely average out to around the same amount. We assume that global demand will continue to equal or exceed global supply in our 20 year time frame, so that there will be no downward pressure on prices. In Table 6, we assume that native Oregon truffle prices will increase, not as an effect of supply and demand, but because better harvesting practices will enhance perceptions of their culinary qualities.

Population of wealthiest ½ of nations	2,088,628,665
Population of urban areas > 1 million among poorer ½ of nations:	617,204,280
Total 2005 population to which per capita truffle demand estimates might be applied	2,705,832,946
Conservatively rounded down for “best guess” population estimate in subsequent calculations	2,500,000,000

Appendix B (cont.)

Population and relative wealth data by country were obtained from the U.S. Census Bureau, the World Bank, and the United Nations Development Programme. The most complete and complementary datasets from these organization's databases were for 2005, so these population data were used for a conservative estimate of the global 2030 populations. A combined 2005 dataset was compiled. It included population values as well as three wealth indices, namely: 1) World Bank-Per Capita Gross Domestic Product, 2) U.N. Development Programme-Human Development Index, and 3) World Bank-Individual consumption by household. For each wealth index, a percentile ranking by country was created and then these three rankings were averaged to derive a combined wealth & well-being ranking by country. This approach was useful because some countries lacked values for one or more of the indices.

For estimating future truffle demand, we used the total populations of countries that were in the upper 50% of average wealth indices, plus the populations of urban areas >1 million in population among countries in the lower 50% of average wealth indices.

Factor	Units	Modest meal	Tasty meal	Sumptuous meal
Typical weight of truffle consumed per serving	Ounce	0.2	0.4	0.6
Wholesale cost of truffles per ounce	\$/Ounce	\$62.50	\$62.50	\$62.50
Wholesale cost of truffles per meal		\$12.50	\$25.00	\$37.50

The weight (fresh or preserved) of truffles consumed per meal was derived from a web search of truffle recipes. The range was derived from 5 sources. Consumers would pay more per meal for truffles purchased in restaurant meals. Meals of native Oregon truffles would cost less. The reader can use these values to evaluate the percentage of the population [Table 3] that we postulate would eat truffles at a wholesale price of \$1,000 per pound (\$62.50 per ounce).

Appendix B (cont.)

Table 3. Estimates of Per Capita Demand for All Truffles

Factor	Units	Low Estimate	Medium Estimate	High Estimate
a. Percent of selected population eating only 1 truffle meal per year	Percent	1	2	4
b. Additional percent of population eating 2 more truffle meals per year (3 total)	Percent	0.5	1	2
c. Additional percent of population eating yet 2 more truffle meals per year (5 total)	Percent	0.25	0.5	1
d. Typical weight of truffle (fresh or preserved) consumed per meal per person	Ounces	0.2	0.4	0.6
Per capita demand	Ounces/yr	0.021	0.044	0.092

Per capita demand (consumption) per year was calculated by the formula

$$((a/100)+(2*(b/100))+(2*(c/100))*d)$$
 where the letters represent the factors in the table.

Appendix B (cont.)

Table 4. Projections for All Truffle Species in 2030: Global Demand, Acres Needed, and Value

Factor	Units	Low Estimate	Medium Estimate	High Estimate	Optimistic Estimate
Global truffle-consuming population	Billions	2	2.5	3	3
Per capita demand for truffles	Ounces/yr	0.02	0.04	0.09	0.18
Global demand	US Tons/yr	1,250	3,125	8,438	16,875
Truffière productivity	Lbs/acre/yr	40	50	60	70
# Acres needed	Acres	62,500	125,000	281,250	482,143
2030 wholesale price	\$/lb	\$800	\$1,000	\$1,200	\$1,200
Value of global demand	\$ Billions	2	6.25	20.25	40.5

The low/medium/high per capita demand values used in this table are rounded values from Table 3. They bracket the current French per capita production of truffles of 0.06 ounces per year (there are no data on how many are actually consumed in France). The doubled value of per capita demand value in the last column (0.18 ounces per year) is still only 22.5% of historic (late 1800s) French per capita production in the late 1800's. By comparison, approximate global value for other selected commodities during the last ten years are shown in Table 5.

Commodity	Value US\$
Saffron (wholesale)	350 million
Caviar (retail, before ban)	9 billion
Marijuana (producer price)	9 billion
All cultivated mushrooms (unspecified)	23 billion
Wheat (wholesale)	170 billion

These values were obtained from government sources and are all derived from the last ten years.

Appendix B (cont.)

Table 6. Native Oregon Truffles: Potential 2030 US Demand, Value, and Acres.

Factor	Units	Low Estimate	Medium Estimate	High Estimate	Optimistic Estimate
US 2030 population projections	Millions	360	365	370	370
Per capita demand for <u>all truffles</u>	Ounces/yr	0.02	0.04	0.09	0.18
US demand met by native truffles	Percent	10	20	30	40
Per capita demand for <u>native truffles</u>	Ounces/yr	0.002	0.008	0.027	0.072
Total demand for native truffles	US tons/yr	23	91	312	833
Productivity	Lbs/acre/yr	5	10	20	30
# Acres needed	Acres	9,000	18,250	31,219	55,500
Wholesale value	\$/lb (all species)	\$100	\$200	\$300	\$400
Value of US demand for native truffles	\$ Millions	4.5	36.5	187.3	666

Values for per capita demand for all truffles are rounded from those calculated in Table 3. The range of values for the fraction of US demand that might be met by native truffles is a guesstimate. For the low end of native truffle prices we use (\$100/lb) which represents an average wholesaler price for both white and black truffles (high quality) in 2008. For medium, high, and optimistic estimates, we assume that current prices will increase as the native truffle industry matures and the reputation for native truffle quality improves.

Appendix C

TRUFFIÈRE ENTERPRISE BUDGET

(Tables 1-17)

Assumptions

In this study, the authors made assumptions that provided a basis for the analysis. These assumptions include:

1. Budgets presented are representative of a 5 acre truffière in Oregon.
2. Hazelnut seedlings, inoculated with truffle spores, are planted 194 trees per acre on a 15' x 15' spacing.
3. All labor is hired at a rate of \$14.00 per hour, which includes worker's compensation, unemployment insurance, and other labor overhead expenses. All labor is treated as a cash variable expense.
4. The full production yield is 35 marketable pounds per acre. Commercial yields begin in the fifth year and full production is reached in year 12.
5. Black truffle price is \$1,000 per pound.
6. The machinery and equipment used in the budget reflect the typical machinery complement for a 5 acre truffière. A detailed breakdown of machinery values is shown in Table 1. Table 2 provides estimated machinery costs from the American Society of Agricultural Engineers. The 50-horsepower 2-wheel-drive tractor is used for harrow and flailing operations. Truffle operation will utilize 1/3 of owner's personal pick-up. Table 3 lists the estimated cost of each operation with the power unit. Gasoline and diesel costs per gallon are \$3.50 and \$4.25, respectively.
7. One dog trained to locate truffles will be purchased in year 4 for \$5,000. An untrained dog will be purchased every 3 to 4 years as needed to maintain two dogs (one trained and one being trained) beginning in year 7 for \$500. Annual care and maintenance for the dogs (food, shelter, medical, etc) is estimated at \$1,500 per year.
8. Prior to planting soil is amended with lime to approximately 7.9pH. Soil pH is monitored through annual soil tests (\$25 per 5 acres) and liming as needed.
9. Weeds are controlled with flail mower and spring-harrow. A propane torch is used around the tree base until the truffles begin to naturally suppress weed growth in the fifth year.
10. Foliar fertilizer is applied twice a year beginning in year 1.
11. The interest rate on operating funds is 8.5 percent and treated as a cash expense. One-half of the cash expenses are borrowed for a 6-month period.
12. Machinery and land are owned by the operator and assessed 8.5 and 8 percent rates of interest as opportunity costs. Land is valued at \$10,000 per acre.
13. Previous year's establishment costs are funded by the operator at a charge of 10 percent interest and are considered an opportunity cost of operator's capital.
14. The other input assumptions for variable, fixed, and harvest operation costs are listed in Table 4.
15. Price inflation for the time period of this study is ignored. Income tax consequences also are ignored for this study.

Appendix C (cont.)

Table 1. Machinery cost assumptions

Machine	Size	Market value	Hours or miles of annual Use	Expected life (yrs)	Salvage value
Tractor	2 Wheel dr 50hp, older	12,000	10	15	2,336
Flail mower	10' Unit	5,000	3	15	480
Spring tooth harrow	10' Unit	900	3	20	47
Sprayer	Tank with wand	1,500	3	15	144
Pickup*	1/2 Ton, older,	5,000	4,000	10	1,891
Truffle dog, trained	Truffle harvest dog, trained	5,000	NA	7	0
Truffle dog, untrained	Truffle harvest dog, untrained	500	NA	7	0
Irrigation dystem	Drip system, Well, Pump - per acre	3,000	NA	25	0

*Pick-up used for truffle operation is owner's personal vehicle expensed at 1/3 time

Table 2. Machinery cost calculations

Machine	Size	--- Variable Costs ---		--- Fixed Costs ---		Total Cost
		Fuel & lube	Repairs & maint.	Depr. & Interest	Insurance	
----- Costs per hour -----						
Tractor	2 Wheel dr 50hp, older	20.13	0.01	129.17	6.65	155.95
Flail mower	10' Unit	0.00	0.11	165.15	5.08	170.34
Spring tooth harrow	10' Unit	0.00	0.05	25.63	0.88	26.56
Sprayer	Tank with wand	0.00	0.08	49.54	1.52	51.14
----- Costs per mile -----						
Pickup*	1/2 Ton, older,	\$ 0.29	\$ 0.15	\$ 0.15	\$ 0.05	\$ 0.64
----- Costs per acre -----						
Truffle dog		0.00	300.00	\$ 185.36	0.00	\$ 485.36
Irrigation dystem	Drip system, well, and pump	0.00	30.00	\$ 247.50	0.00	\$ 277.50

Table 3. Estimated cost of each operation with power-unit.

Operation	Tractor	Miles per Hr	Acres per Hr	-- Machine Costs --			Total Cost per Acre
				Labor Cost per Acre	Variable Cost per Acre	Fixed Cost per Acre	
Spring tooth harrow	2WD 50hp	3.0	3.09	4.53	7.93	52.51	64.96
Flail mower	2WD 50hp	3.0	3.09	4.53	7.94	99.00	111.48
Sprayer	2WD 50hp	3.0	3.09	4.53	7.93	60.46	72.92

Appendix C (cont.)

Table 4. Input assumptions for variable, harvest and fixed costs per acre.

	<u>Year 1</u>	<u>Year 2</u>	<u>Year 3</u>	<u>Year 4</u>	<u>Year 5</u>	<u>Year 6</u>
Prices per pound	\$1,000	\$1,000	\$1,000	\$1,000	\$1,000	\$1,000
Pounds per acre	0.00	0.00	0.00	0.00	1.00	2.00
Cost of labor, per hour	\$14.00	\$14.00	\$14.00	\$14.00	\$14.00	\$14.00
Cost of food, shelter, medical per dogs	\$0.00	\$0.00	\$0.00	\$300.00	\$300.00	\$300.00
Cost of liming, custom	\$2,500.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
Cost of propane for torch	\$30.00	\$30.00	\$30.00	\$30.00	\$0.00	\$0.00
Cost of fertilizer	\$25.00	\$50.00	\$100.00	\$150.00	\$250.00	\$250.00
Cost of deer and rabbit control, tubes	\$400.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
Cost of nutrient analysis	\$5.00	\$5.00	\$5.00	\$5.00	\$5.00	\$5.00
Hours of pruning labor	0.00	3.00	5.00	8.00	10.00	13.00
Hours of weed control, propane torch	3.33	3.33	3.33	3.33	0.00	0.00
Hours of irrigation labor	12.00	12.00	12.00	12.00	12.00	12.00
Hours of harvest labor	0.00	0.00	0.00	0.00	12.00	12.00
Hours of truffle processing, per lb	0.00	0.00	0.00	0.00	0.50	0.50
Times for weed control, propane torch	3.00	3.00	3.00	3.00	0.00	0.00
Times for harrow	2.00	2.00	2.00	2.00	2.00	2.00
Times for flailing orchard	2.00	2.00	2.00	2.00	2.00	2.00
Times for foliar fertilizer	0.00	0.00	0.00	2.00	2.00	2.00
Property taxes	\$25.00	\$25.00	\$25.00	\$25.00	\$25.00	\$25.00
Land values	\$10,000	\$10,000	\$10,000	\$10,000	\$10,000	\$10,000
Tree cost	\$20.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
Gasoline price	\$3.00	\$3.00	\$3.00	\$3.00	\$3.00	\$3.00
Diesel fuel price	\$3.50	\$3.50	\$3.50	\$3.50	\$3.50	\$3.50
Operating interest rate	8.50%	8.50%	8.50%	8.50%	8.50%	8.50%
Machinery interest rate	8.50%	8.50%	8.50%	8.50%	8.50%	8.50%
Land interest rate	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%
Establishment interest rate	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%
Overhead charge	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%
% of operating capital borrowed	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%
Months to borrow operating capital	6.0	6.0	6.0	6.0	6.0	6.0
Planted trees	194	0	0	0	0	0

Appendix C (cont.)

Table 4. Input assumptions for variable, harvest and fixed costs per acre. (con't)

	Year 7	Year 8	Year 9	Year 10	Full Prod
Prices per pound	\$1,000	\$1,000	\$1,000	\$1,000	\$1,000
Pounds per acre	4.00	8.00	16.00	32.00	35.00
Cost of labor, per hour	\$14.00	\$14.00	\$14.00	\$14.00	\$14.00
Cost of food, shelter, medical per dogs	\$300.00	\$300.00	\$300.00	\$300.00	\$300.00
Cost of liming, custom	\$0.00	\$0.00	\$0.00	\$200.00	\$20.00
Cost of propane for torch	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
Cost of fertilizer	\$250.00	\$250.00	\$250.00	\$250.00	\$250.00
Cost of deer and rabbit control, tubes	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
Cost of nutrient analysis	\$5.00	\$5.00	\$5.00	\$5.00	\$5.00
Hours of pruning labor	17.00	17.00	17.00	17.00	17.00
Hours of weed control, propane torch	0.00	0.00	0.00	0.00	0.00
Hours of irrigation labor	12.00	12.00	12.00	12.00	12.00
Hours of harvest labor	12.00	12.00	12.00	12.00	12.00
Hours of truffle processing, per lb	0.50	0.50	0.50	0.50	0.50
Times for weed control, propane torch	0.00	0.00	0.00	0.00	0.00
Times for harrow	2.00	2.00	2.00	2.00	2.00
Times for flailing orchard	2.00	2.00	2.00	2.00	2.00
Times for foliar fertilizer	2.00	2.00	2.00	2.00	2.00
Property taxes	\$25.00	\$25.00	\$25.00	\$25.00	\$25.00
Land values	\$10,000	\$10,000	\$10,000	\$10,000	\$10,000
Tree cost	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
Gasoline price	\$3.00	\$3.00	\$3.00	\$3.00	\$3.00
Diesel fuel price	\$3.50	\$3.50	\$3.50	\$3.50	\$3.50
Operating interest rate	8.50%	8.50%	8.50%	8.50%	8.50%
Machinery interest rate	8.50%	8.50%	8.50%	8.50%	8.50%
Land interest rate	8.00%	8.00%	8.00%	8.00%	8.00%
Establishment interest rate	10.00%	10.00%	10.00%	10.00%	10.00%
Overhead charge	8.00%	8.00%	8.00%	8.00%	8.00%
% of operating capital borrowed	50.00%	50.00%	50.00%	50.00%	50.00%
Months to borrow operating capital	6.0	6.0	6.0	6.0	6.0
Planted trees	0	0	0	0	0

Appendix C (cont.)

Table 5. Cash flow analysis for establishing truffle production in the Pacific Northwest.

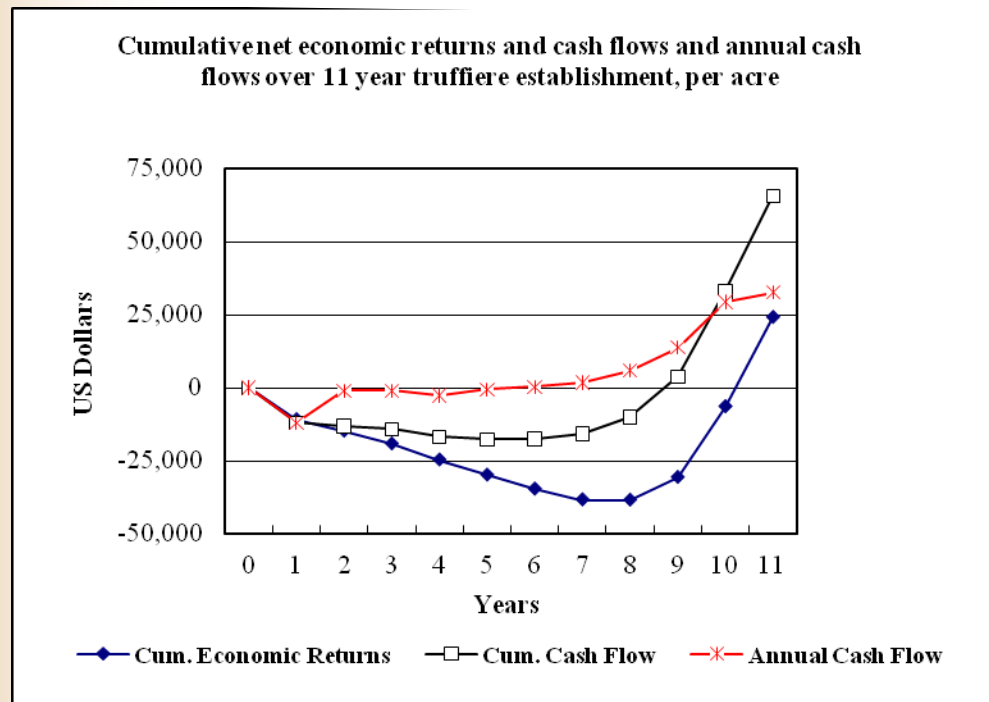
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Full Prod
Income:											
Yield (Lbs per acre)	0	0	0	0	1	2	4	8	16	32	35
Price (\$ per lb)	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00
Gross Income(\$ per acre)	0.00	0.00	0.00	0.00	1,000.00	2,000.00	4,000.00	8,000.00	16,000.00	32,000.00	35,000.00
Variable Costs:											
Field preparation	303.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Liming	2,500.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	200.00	0.00
Trees and tubes	4,280.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fertilizer	25.00	50.00	100.00	150.00	250.00	250.00	250.00	250.00	250.00	250.00	250.00
Irrigation system	3,030.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
Truffle dog	0.00	0.00	0.00	1,000.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00
Nutrient analysis	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Hired labor	528.98	367.98	395.98	447.03	335.17	377.17	433.17	433.17	433.17	433.17	433.17
Harvest	0.00	0.00	0.00	300.00	475.00	482.00	796.00	824.00	880.00	992.00	1,013.00
Machine costs	399.61	399.61	399.61	419.24	382.69	382.69	382.69	382.69	382.69	382.69	382.69
Misc. & overhead	643.75	64.21	66.45	108.10	118.23	122.15	151.75	153.99	158.47	167.43	169.11
Operating interest	184.67	18.42	19.06	31.01	33.92	35.04	43.53	44.18	45.46	48.03	48.51
Total Variable Costs	11,900.26	935.21	1,016.09	2,490.38	1,630.01	1,684.05	2,192.14	2,123.03	2,184.79	2,508.32	2,331.48
Gross Income minus VC	-11,900.26	-935.21	-1,016.09	-2,490.38	-630.01	315.95	1,807.86	5,876.97	13,815.21	29,491.68	32,668.52
Cash Fixed Costs:											
Insurance	99.29	99.29	99.29	99.29	99.29	99.29	99.29	99.29	99.29	99.29	99.29
Property taxes	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Total Cash Fixed Cost	124.29	124.29	124.29	124.29	124.29	124.29	124.29	124.29	124.29	124.29	124.29
Total Cash Cost	12,024.55	1,059.50	1,140.38	2,614.67	1,754.30	1,808.34	2,316.43	2,247.31	2,309.08	2,632.61	2,455.77
Annual Cash Flow	-12,024.55	-1,059.50	-1,140.38	-2,614.67	-754.30	191.66	1,683.57	5,752.69	13,690.92	29,367.39	32,544.23
Cumulative Cash Flow	-12,025	-13,084	-14,224	-16,839	-17,593	-17,402	-15,718	-9,965	3,725	33,093	65,637

Appendix C (cont.)

Table 6. Economic costs and returns per acre of establishing truffle production in the Pacific Northwest.

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Full Prod
Income:											
Yield (Lbs per acre)	0.00	0.00	0.00	0.00	1.00	2.00	4.00	8.00	16.00	32.00	35.00
Price (\$ per Lb)	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Gross Income(\$ per acre)	0.00	0.00	0.00	0.00	1,000	2,000	4,000	8,000	16,000	32,000	35,000
Variable Costs:											
Field preparation	303.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Liming	2,500.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	200.00	0.00
Trees and tubes	4,280.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fertilizer	25.00	50.00	100.00	150.00	250.00	250.00	250.00	250.00	250.00	250.00	250.00
Irrigation system	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
Nutrient analysis	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Hired labor	528.98	367.98	395.98	447.03	335.17	377.17	433.17	433.17	433.17	433.17	433.17
Harvest	0.00	0.00	0.00	300.00	475.00	482.00	796.00	824.00	880.00	992.00	1,013.00
Machine costs	399.61	399.61	399.61	419.24	382.69	382.69	382.69	382.69	382.69	382.69	382.69
Misc. & overhead	643.75	64.21	66.45	108.10	118.23	122.15	151.75	153.99	158.47	167.43	169.11
Operating interest	<u>184.67</u>	<u>18.42</u>	<u>19.06</u>	<u>31.01</u>	<u>33.92</u>	<u>35.04</u>	<u>43.53</u>	<u>44.18</u>	<u>45.46</u>	<u>48.03</u>	<u>48.51</u>
Total Variable Costs	8,900.26	935.21	1,016.09	1,490.38	1,630.01	1,684.05	2,092.14	2,123.03	2,184.79	2,508.32	2,331.48
Gross Income minus VC	-8,900.26	-935.21	-1,016.09	-1,490.38	-630.01	315.95	1,907.86	5,876.97	13,815.21	29,491.68	32,668.52
Fixed Costs:											
Insurance	99	99	99	99	99	99	99	99	99	99	99
Property taxes	25	25	25	25	25	25	25	25	25	25	25
Machine costs	742	742	742	742	742	742	742	742	742	742	742
Irrigation cost	248	248	248	248	248	248	248	248	248	248	248
Truffle dog costs	0	0	0	185	185	185	185	185	185	185	185
Land interest cost	800	800	800	800	800	800	800	800	800	800	800
Interest on estab. costs	0	1,079	1,467	1,896	2,464	3,002	3,499	3,886	3,916	3,154	0
Total Fixed Cost	1,914	2,993	3,381	3,996	4,563	5,101	5,598	5,986	6,015	5,254	2,100
Total Cost	10,814	3,928	4,397	5,486	6,193	6,785	7,690	8,109	8,200	7,762	4,431
Net projected returns	-10,814	-3,928	-4,397	-5,486	-5,193	-4,785	-3,690	-109	7,800	24,238	30,569
Cumulative Returns	-10,814	-14,743	-19,140	-24,626	-29,819	-34,605	-38,295	-38,403	-30,603	-6,365	24,204

Appendix C (cont.)



Appendix C (cont.)

<u>Table 7. Truffle Orchard Establishment, Year 1, \$/Acre Economic Costs and Returns</u>					
<u>VARIABLE CASH COSTS</u>	<u>Description</u>	<u>Labor</u>	<u>Machinery</u>	<u>Materials</u>	<u>Total</u>
Field preparation, custom		0.00	0.00	300.00	300.00
Mark fields	3.0 hours	42.00	0.00	3.25	45.25
Plant trees	10.0 hours	140.00	0.00	3,880.00	4,020.00
Trees tube installation	1.5 hours	21.00	0.00	400.00	421.00
Irrigation system	12.0 hours	168.00	0.00	30.00	198.00
Nutrient analysis		0.00	0.00	5.00	5.00
Lime, custom application		0.00	0.00	2,500.00	2,500.00
Weed control, propane torch	3.0 times	139.86	0.00	30.00	169.86
Spring tooth harrow	2.0 times	9.06	13.06	0.00	22.12
Mow	2.0 times	9.06	6.55	0.00	15.61
Pickup		0.00	350.00	0.00	350.00
Miscellaneous and overhead		0.00	0.00	643.75	643.75
Interest: operating capital	6.0 mons	0.00	0.00	184.67	184.67
Total VARIABLE COSTS		528.98	369.61	7,976.67	8,875.26
<u>FIXED COSTS</u>				<u>Unit</u>	<u>Total</u>
<u>CASH Costs</u>					
Machinery and equipment insurance				acre	59.32
Pickup insurance				acre	39.97
Property taxes				acre	25.00
Total CASH Costs					124.29
<u>NON-CASH Costs</u>					
Machinery and equip - deprec. & interest				acre	621.63
Irrigation - deprec & interest				acre	247.50
Pickup - depreciation & interest				acre	120.76
Land interest charge				acre	800.00
Interest on establishment costs				acre	0.00
Total NON-CASH Costs					1,789.89
Total FIXED COSTS					1,914.18
Total of All Costs Per Acre					(10,789.44)

Appendix C (cont.)

Table 8. Truffle Orchard Establishment, Year 2, \$/Acre Economic Costs and Returns					
<u>VARIABLE CASH COSTS</u>	<u>Description</u>	<u>Labor</u>	<u>Machinery</u>	<u>Materials</u>	<u>Total</u>
Tree shaping, pruning	3.0 hours	42.00	0.00	0.00	42.00
Irrigation system	12.0 hours	168.00	0.00	30.00	198.00
Nutrient analysis		0.00	0.00	5.00	5.00
Weed control, propane torch	3.0 times	139.86	0.00	30.00	169.86
Spring tooth harrow	2.0 times	9.06	13.06	0.00	22.12
Mow	2.0 times	9.06	6.55	0.00	15.61
Pickup		0.00	350.00	0.00	350.00
Miscellaneous and overhead		0.00	0.00	64.21	64.21
Interest: operating capital	6.0 mons	0.00	0.00	18.42	18.42
Total VARIABLE COSTS		367.98	369.61	147.63	885.21
<u>FIXED COSTS</u>				<u>Unit</u>	<u>Total</u>
<u>CASH Costs</u>					
Machinery and equipment insurance				acre	59.32
Pickup insurance				acre	39.97
Property taxes				acre	25.00
Total CASH Costs					124.29
<u>NON-CASH Costs</u>					
Machinery and equip - deprec. & interest				acre	621.63
Irrigation - deprec & interest				acre	247.50
Pickup - depreciation & interest				acre	120.76
Land interest charge				acre	800.00
Interest on establishment costs				acre	1,078.94
Total NON-CASH Costs					2,868.83
Total FIXED COSTS					2,993.12
Total of All Costs Per Acre					(3,878.34)

Appendix C (cont.)

Table 9. Truffle Orchard Establishment, Year 3, \$/Acre Economic Costs and Returns					
<u>VARIABLE CASH COSTS</u>	<u>Description</u>	<u>Labor</u>	<u>Machinery</u>	<u>Materials</u>	<u>Total</u>
Tree shaping, pruning	5.0 hours	70.00	0.00	0.00	70.00
Irrigation system	12.0 hours	168.00	0.00	30.00	198.00
Nutrient analysis		0.00	0.00	5.00	5.00
Weed control, propane torch	3.0 times	139.86	0.00	30.00	169.86
Spring tooth harrow	2.0 times	9.06	13.06	0.00	22.12
Mow	2.0 times	9.06	6.55	0.00	15.61
Pickup		0.00	350.00	0.00	350.00
Miscellaneous and overhead		0.00	0.00	66.45	66.45
Interest: operating capital	6.0 mons	0.00	0.00	19.06	19.06
Total VARIABLE COSTS		395.98	369.61	150.51	916.09
 <u>FIXED COSTS</u>				<u>Unit</u>	<u>Total</u>
<u>CASH Costs</u>					
Machinery and equipment insurance				acre	59.32
Pickup insurance				acre	39.97
Property taxes				acre	25.00
Total CASH Costs					124.29
 <u>NON-CASH Costs</u>					
Machinery and equip - deprec. & interest				acre	621.63
Irrigation - deprec & interest				acre	247.50
Pickup - depreciation & interest				acre	120.76
Land interest charge				acre	800.00
Interest on establishment costs				acre	1,466.78
Total NON-CASH Costs					3,256.67
Total FIXED COSTS					3,380.96
Total of All Costs Per Acre					(4,297.05)

Appendix C (cont.)

<u>VARIABLE CASH COSTS</u>	<u>Description</u>	<u>Labor</u>	<u>Machinery</u>	<u>Materials</u>	<u>Total</u>
Tree shaping, pruning	8.0 hours	112.00	0.00	0.00	112.00
Irrigation system	12.0 hours	168.00	0.00	30.00	198.00
Nutrient analysis		0.00	0.00	5.00	5.00
Weed control, propane torch	3.0 times	139.86	0.00	30.00	169.86
Spring tooth harrow	2.0 times	9.06	13.06	0.00	22.12
Foliar fertilization	2.0 times	9.06	13.08	150.00	172.14
Mow	2.0 times	9.06	13.10	0.00	22.16
Truffle dog - training & maintenance	1.0 dog	0.00	0.00	300.00	300.00
Pickup		0.00	350.00	0.00	350.00
Miscellaneous and overhead		0.00	0.00	108.10	108.10
Interest: operating capital	6.0 mons	0.00	0.00	31.01	31.01
Total VARIABLE COSTS		447.03	389.24	654.11	1,490.38
<u>FIXED COSTS</u>				<u>Unit</u>	<u>Total</u>
<u>CASH Costs</u>					
Machinery and equipment insurance				acre	59.32
Pickup insurance				acre	39.97
Property taxes				acre	25.00
Total CASH Costs					124.29
<u>NON-CASH Costs</u>					
Machinery and equip - deprec. & interest				acre	621.63
Irrigation - deprec & interest				acre	247.50
Truffle dog - deprec & interest				acre	370.71
Pickup - depreciation & interest				acre	120.76
Land interest charge				acre	800.00
Interest on establishment costs				acre	1,896.48
Total NON-CASH Costs					4,057.09
Total FIXED COSTS					4,181.38
Total of All Costs Per Acre					(5,671.76)

Appendix C (cont.)

Table 11. Truffle Orchard Establishment, Year 5, \$/Acre Economic Costs and Returns

<u>GROSS INCOME</u>						
	<u>Quantity</u>	<u>Unit</u>	<u>\$/Unit</u>	<u>Total</u>	<u>Price/Lb</u>	
Black Truffles	1	Pounds	1,000.00	1,000.00	1,000.00	
Total GROSS Income				1,000.00	1,000.00	
<u>VARIABLE CASH COSTS</u>						
	<u>Description</u>	<u>Labor</u>	<u>Machinery</u>	<u>Materials</u>	<u>Total</u>	<u>Cost/Lb</u>
Tree shaping, pruning	10.0 hours	140.00	0.00	0.00	140.00	140.00
Irrigation system	12.0 hours	168.00	0.00	30.00	198.00	198.00
Nutrient analysis		0.00	0.00	5.00	5.00	5.00
Spring tooth harrow	2.0 times	9.06	13.06	0.00	22.12	22.12
Foliar fertilization	2.0 times	9.06	13.08	250.00	272.14	272.14
Mow	2.0 times	9.06	6.55	0.00	15.61	15.61
Truffle harvesting costs						
Truffle dog - maintenance	1.0 dog	0.00	0.00	300.00	300.00	300.00
Harvest labor	12.0 hours	168.00	0.00	0.00	168.00	168.00
Clean, sort, package - cost per lb	0.5 hours	7.00	0.00	0.00	7.00	7.00
Pickup		0.00	350.00	0.00	350.00	350.00
Miscellaneous and overhead		0.00	0.00	118.23	118.23	118.23
Interest: operating capital	6.0 mons	0.00	0.00	33.92	33.92	33.92
Total VARIABLE COSTS		510.17	382.69	737.15	1,630.01	1,630.01
<u>FIXED COSTS</u>						
				<u>Unit</u>	<u>Total</u>	<u>Cost/Lb</u>
<u>CASH Costs</u>						
Machinery and equipment insurance				acre	59.32	59.32
Pickup insurance				acre	39.97	39.97
Property taxes				acre	25.00	25.00
Total CASH Costs					124.29	124.29
GROSS INCOME minus VARIABLE AND FIXED CASH COSTS					(754.30)	(754.30)
<u>NON-CASH Costs</u>						
Machinery and equip - deprec. & interest				acre	621.63	621.63
Irrigation - deprec & interest				acre	247.50	247.50
Truffle dog - deprec & interest				acre	370.71	370.71
Pickup - depreciation & interest				acre	120.76	120.76
Land interest charge				acre	800.00	800.00
Interest on establishment costs				acre	2,463.66	2,463.66
Total NON-CASH Costs					4,624.26	4,624.26
Total FIXED COSTS					4,748.55	4,748.55
Total of All Costs Per Acre					6,378.56	6,378.56
Net Projected Returns					(5,378.56)	(5,378.56)

Appendix C (cont.)

<u>GROSS INCOME</u>		<u>Quantity</u>	<u>Unit</u>	<u>\$/Unit</u>	<u>Total</u>	<u>Price/Lb</u>	
Black Truffles		2	Pounds	1,000.00	2,000.00	1,000.00	
Total GROSS Income					2,000.00	1,000.00	
<u>VARIABLE CASH COSTS</u>		<u>Description</u>	<u>Labor</u>	<u>Machinery</u>	<u>Materials</u>	<u>Total</u>	<u>Cost/Lb</u>
Tree shaping, pruning		13.0 hours	182.00	0.00	0.00	182.00	91.00
Irrigation system		12.0 hours	168.00	0.00	30.00	198.00	99.00
Nutrient analysis			0.00	0.00	5.00	5.00	2.50
Spring tooth harrow		2.0 times	9.06	13.06	0.00	22.12	11.06
Foliar fertilization		2.0 times	9.06	13.08	250.00	272.14	136.07
Mow		2.0 times	9.06	6.55	0.00	15.61	7.80
Truffle harvesting costs							
Truffle dog - maintenance		1.0 dog	0.00	0.00	300.00	300.00	150.00
Harvest labor		12.0 hours	168.00	0.00	0.00	168.00	84.00
Clean, sort, package - cost per lb		0.5 hours	14.00	0.00	0.00	14.00	7.00
Pickup			0.00	350.00	0.00	350.00	175.00
Miscellaneous and overhead			0.00	0.00	122.15	122.15	61.07
Interest: operating capital		6.0 mons	0.00	0.00	35.04	35.04	17.52
Total VARIABLE COSTS			559.17	382.69	742.19	1,684.05	842.03
<u>FIXED COSTS</u>				<u>Unit</u>	<u>Total</u>	<u>Cost/Lb</u>	
<u>CASH Costs</u>							
Machinery and equipment insurance				acre	59.32	29.66	
Pickup insurance				acre	39.97	19.98	
Property taxes				acre	25.00	12.50	
Total CASH Costs					124.29	62.14	
GROSS INCOME minus VARIABLE AND FIXED CASH COSTS					191.66	95.83	
<u>NON-CASH Costs</u>							
Machinery and equip - deprec. & interest				acre	621.63	310.82	
Irrigation - deprec & interest				acre	247.50	123.75	
Truffle dog - deprec & interest				acre	370.71	185.36	
Pickup - depreciation & interest				acre	120.76	60.38	
Land interest charge				acre	800.00	400.00	
Interest on establishment costs				acre	3,001.51	1,500.76	
Total NON-CASH Costs					5,162.12	2,581.06	
Total FIXED COSTS					5,286.41	2,643.20	
Total of All Costs Per Acre					6,970.46	3,485.23	
Net Projected Returns					(4,970.46)	(2,485.23)	

Appendix C (cont.)

Table 13. Truffle Orchard Establishment, Year 7, \$/Acre Economic Costs and Returns

<u>GROSS INCOME</u>						
	<u>Quantity</u>	<u>Unit</u>	<u>\$/Unit</u>	<u>Total</u>	<u>Price/Lb</u>	
Black Truffles	4	Pounds	1,000.00	4,000.00	1,000.00	
Total GROSS Income				4,000.00	1,000.00	
<u>VARIABLE CASH COSTS</u>						
	<u>Description</u>	<u>Labor</u>	<u>Machinery</u>	<u>Materials</u>	<u>Total</u>	<u>Cost/Lb</u>
Tree shaping, pruning	17.0 hours	238.00	0.00	0.00	238.00	59.50
Irrigation system	12.0 hours	168.00	0.00	30.00	198.00	49.50
Nutrient analysis		0.00	0.00	5.00	5.00	1.25
Spring tooth harrow	2.0 times	9.06	13.06	0.00	22.12	5.53
Foliar fertilization	2.0 times	9.06	13.08	250.00	272.14	68.03
Mow	2.0 times	9.06	6.55	0.00	15.61	3.90
Truffle harvesting costs						
Truffle dog - maintenance	2.0 dogs	0.00	0.00	600.00	600.00	150.00
Harvest labor	12.0 hours	168.00	0.00	0.00	168.00	42.00
Clean, sort, package - cost per lb	0.5 hours	28.00	0.00	0.00	28.00	7.00
Pickup		0.00	350.00	0.00	350.00	87.50
Miscellaneous and overhead		0.00	0.00	151.75	151.75	37.94
Interest: operating capital	6.0 mons	0.00	0.00	43.53	43.53	10.88
Total VARIABLE COSTS		629.17	382.69	1,080.28	2,092.14	523.04
<u>FIXED COSTS</u>				<u>Unit</u>	<u>Total</u>	<u>Cost/Lb</u>
<u>CASH Costs</u>						
Machinery and equipment insurance				acre	59.32	14.83
Pickup insurance				acre	39.97	9.99
Property taxes				acre	25.00	6.25
Total CASH Costs					124.29	31.07
GROSS INCOME minus VARIABLE AND FIXED CASH COSTS					1,783.57	445.89
<u>NON-CASH Costs</u>						
Machinery and equip - deprec. & interest				acre	621.63	155.41
Irrigation - deprec & interest				acre	247.50	61.88
Truffle dog - deprec & interest				acre	370.71	92.68
Pickup - depreciation & interest				acre	120.76	30.19
Land interest charge				acre	800.00	200.00
Interest on establishment costs				acre	3,498.56	874.64
Total NON-CASH Costs					5,659.17	1,414.79
Total FIXED COSTS					5,783.45	1,445.86
Total of All Costs Per Acre					7,875.60	1,968.90
<u>Net Projected Returns</u>					(3,875.60)	(968.90)

Appendix C (cont.)

<u>GROSS INCOME</u>		<u>Quantity</u>	<u>Unit</u>	<u>\$/Unit</u>	<u>Total</u>	<u>Price/Lb</u>	
Black Truffles		8	Pounds	1,000.00	8,000.00	1,000.00	
Total GROSS Income					8,000.00	1,000.00	
<u>VARIABLE CASH COSTS</u>		<u>Description</u>	<u>Labor</u>	<u>Machinery</u>	<u>Materials</u>	<u>Total</u>	<u>Cost/Lb</u>
Tree shaping, pruning		17.0 hours	238.00	0.00	0.00	238.00	29.75
Irrigation system		12.0 hours	168.00	0.00	30.00	198.00	24.75
Nutrient analysis			0.00	0.00	5.00	5.00	0.63
Spring tooth harrow		2.0 times	9.06	13.06	0.00	22.12	2.76
Foliar fertilization		2.0 times	9.06	13.08	250.00	272.14	34.02
Mow		2.0 times	9.06	6.55	0.00	15.61	1.95
Truffle harvesting costs							
Truffle dog - maintenance		2.0 dogs	0.00	0.00	600.00	600.00	75.00
Harvest labor		12.0 hours	168.00	0.00	0.00	168.00	21.00
Clean, sort, package - cost per lb		0.5 hours	56.00	0.00	0.00	56.00	7.00
Pickup			0.00	350.00	0.00	350.00	43.75
Miscellaneous and overhead			0.00	0.00	153.99	153.99	19.25
Interest: operating capital		6.0 mons	0.00	0.00	44.18	44.18	5.52
Total VARIABLE COSTS			657.17	382.69	1,083.16	2,123.03	265.38
<u>FIXED COSTS</u>				<u>Unit</u>	<u>Total</u>	<u>Cost/Lb</u>	
<u>CASH Costs</u>							
Machinery and equipment insurance				acre	59.32	7.42	
Pickup insurance				acre	39.97	5.00	
Property taxes				acre	25.00	3.13	
Total CASH Costs					124.29	15.54	
GROSS INCOME minus VARIABLE AND FIXED CASH COSTS					5,752.69	719.09	
<u>NON-CASH Costs</u>							
Machinery and equip - deprec. & interest				acre	621.63	77.70	
Irrigation - deprec & interest				acre	247.50	30.94	
Truffle dog - deprec & interest				acre	370.71	46.34	
Pickup - depreciation & interest				acre	120.76	15.09	
Land interest charge				acre	800.00	100.00	
Interest on establishment costs				acre	3,886.12	485.76	
Total NON-CASH Costs					6,046.72	755.84	
Total FIXED COSTS					6,171.01	771.38	
Total of All Costs Per Acre					8,294.04	1,036.75	
Net Projected Returns					(294.04)	(36.75)	

Appendix C (cont.)

<u>Table 15. Truffle Orchard Establishment, Year 9, \$/Acre Economic Costs and Returns</u>						
<u>GROSS INCOME</u>						
	<u>Quantity</u>	<u>Unit</u>	<u>\$/Unit</u>	<u>Total</u>	<u>Price/Lb</u>	
Black Truffles	16	Pounds	1,000.00	16,000.00	1,000.00	
Total GROSS Income				16,000.00	1,000.00	
<u>VARIABLE CASH COSTS</u>						
	<u>Description</u>	<u>Labor</u>	<u>Machinery</u>	<u>Materials</u>	<u>Total</u>	<u>Cost/Lb</u>
Tree shaping, pruning	17.0 hours	238.00	0.00	0.00	238.00	14.88
Irrigation system	12.0 hours	168.00	0.00	30.00	198.00	12.38
Nutrient analysis		0.00	0.00	5.00	5.00	0.31
Spring tooth harrow	2.0 times	9.06	13.06	0.00	22.12	1.38
Foliar fertilization	2.0 times	9.06	13.08	250.00	272.14	17.01
Mow	2.0 times	9.06	6.55	0.00	15.61	0.98
Truffle harvesting costs						
Truffle dog - maintenance	2.0 dogs	0.00	0.00	600.00	600.00	37.50
Harvest labor	12.0 hours	168.00	0.00	0.00	168.00	10.50
Clean, sort, package - cost per lb	0.5 hours	112.00	0.00	0.00	112.00	7.00
Pickup		0.00	350.00	0.00	350.00	21.88
Miscellaneous and overhead		0.00	0.00	158.47	158.47	9.90
Interest: operating capital	6.0 mons	0.00	0.00	45.46	45.46	2.84
Total VARIABLE COSTS		713.17	382.69	1,088.93	2,184.79	136.55
<u>FIXED COSTS</u>						
				<u>Unit</u>	<u>Total</u>	<u>Cost/Lb</u>
<u>CASH Costs</u>						
Machinery and equipment insurance				acre	59.32	3.71
Pickup insurance				acre	39.97	2.50
Property taxes				acre	25.00	1.56
Total CASH Costs					124.29	7.77
GROSS INCOME minus VARIABLE AND FIXED CASH COSTS					13,690.92	855.68
<u>NON-CASH Costs</u>						
Machinery and equip - deprec. & interest				acre	621.63	38.85
Irrigation - deprec & interest				acre	247.50	15.47
Truffle dog - deprec & interest				acre	370.71	23.17
Pickup - depreciation & interest				acre	120.76	7.55
Land interest charge				acre	800.00	50.00
Interest on establishment costs				acre	3,915.52	244.72
Total NON-CASH Costs					6,076.13	379.76
Total FIXED COSTS					6,200.42	387.53
Total of All Costs Per Acre					8,385.21	524.08
Net Projected Returns					7,614.79	475.92

Appendix C (cont.)

<u>GROSS INCOME</u>		<u>Quantity</u>	<u>Unit</u>	<u>\$/Unit</u>	<u>Total</u>	<u>Price/Lb</u>	
Black Truffles		32	Pounds	1,000.00	32,000.00	1,000.00	
Total GROSS Income					32,000.00	1,000.00	
<u>VARIABLE CASH COSTS</u>		<u>Description</u>	<u>Labor</u>	<u>Machinery</u>	<u>Materials</u>	<u>Total</u>	<u>Cost/Lb</u>
Lime, custom			0.00	0.00	\$200.00	200.00	6.25
Tree shaping, pruning		17.0 hours	238.00	0.00	0.00	238.00	7.44
Irrigation system		12.0 hours	168.00	0.00	30.00	198.00	6.19
Nutrient analysis			0.00	0.00	5.00	5.00	0.16
Spring tooth harrow		2.0 times	9.06	13.06	0.00	22.12	0.69
Foliar fertilization		2.0 times	9.06	13.08	250.00	272.14	8.50
Mow		2.0 times	9.06	6.55	0.00	15.61	0.49
Truffle harvesting costs							
Truffle dog - maintenance		2.0 dogs	0.00	0.00	600.00	600.00	18.75
Harvest labor		12.0 hours	168.00	0.00	0.00	168.00	5.25
Clean, sort, package - cost per lb		0.5 hours	224.00	0.00	0.00	224.00	7.00
Pickup			0.00	350.00	0.00	350.00	10.94
Miscellaneous and overhead			0.00	0.00	167.43	167.43	5.23
Interest: operating capital		6.0 mons	0.00	0.00	48.03	48.03	1.50
Total VARIABLE COSTS			825.17	382.69	\$1,300.46	2,508.32	78.39
<u>FIXED COSTS</u>				<u>Unit</u>	<u>Total</u>	<u>Cost/Lb</u>	
<u>CASH Costs</u>							
Machinery and equipment insurance				acre	59.32	1.85	
Pickup insurance				acre	39.97	1.25	
Property taxes				acre	25.00	0.78	
Total CASH Costs					124.29	3.88	
GROSS INCOME minus VARIABLE AND FIXED CASH COSTS					29,367.39	917.73	
<u>NON-CASH Costs</u>							
Machinery and equip - deprec. & interest				acre	621.63	19.43	
Irrigation - deprec & interest				acre	247.50	7.73	
Truffle dog - deprec & interest				acre	370.71	11.58	
Pickup - depreciation & interest				acre	120.76	3.77	
Land interest charge				acre	800.00	25.00	
Interest on establishment costs				acre	3,154.04	98.56	
Total NON-CASH Costs					5,314.65	166.08	
Total FIXED COSTS					5,438.94	169.97	
Total of All Costs Per Acre					7,947.26	248.35	
Net Projected Returns					24,052.74	751.65	

Appendix C (cont.)

Table 17. Truffle Orchard Establishment, Full Production Years, \$/Acre Economic Costs and Returns						
GROSS INCOME						
	<u>Quantity</u>	<u>Unit</u>	<u>\$/Unit</u>	<u>Total</u>	<u>Price/Lb</u>	
Black Truffles	35	Pounds	1,000.00	35,000.00	1,000.00	
Total GROSS Income				35,000.00	1,000.00	
VARIABLE CASH COSTS						
	<u>Description</u>	<u>Labor</u>	<u>Machinery</u>	<u>Materials</u>	<u>Total</u>	<u>Cost/Lb</u>
Lime, custom		0.00	0.00	\$20.00	20.00	0.57
Tree shaping, pruning	17.0 hours	238.00	0.00	0.00	238.00	6.80
Irrigation system	12.0 hours	168.00	0.00	30.00	198.00	5.66
Nutrient analysis		0.00	0.00	5.00	5.00	0.14
Spring tooth harrow	2.0 times	9.06	13.06	0.00	22.12	0.63
Foliar fertilization	2.0 times	9.06	13.08	250.00	272.14	7.78
Mow	2.0 times	9.06	6.55	0.00	15.61	0.45
Truffle harvesting costs						
Truffle dog - maintenance	2.0 dogs	0.00	0.00	600.00	600.00	17.14
Harvest labor	12.0 hours	168.00	0.00	0.00	168.00	4.80
Clean, sort, package - cost per lb	0.5 hours	245.00	0.00	0.00	245.00	7.00
Pickup		0.00	350.00	0.00	350.00	10.00
Miscellaneous and overhead		0.00	0.00	169.11	169.11	4.83
Interest: operating capital	6.0 mons	0.00	0.00	48.51	48.51	1.39
Total VARIABLE COSTS		846.17	382.69	\$1,122.62	2,351.48	67.19
FIXED COSTS						
				<u>Unit</u>	<u>Total</u>	<u>Cost/Lb</u>
CASH Costs						
Machinery and equipment insurance				acre	59.32	1.69
Pickup insurance				acre	39.97	1.14
Property taxes				acre	25.00	0.71
Total CASH Costs					124.29	3.55
GROSS INCOME minus VARIABLE AND FIXED CASH COSTS						
					32,524.23	929.26
NON-CASH Costs						
Machinery and equip - deprec. & interest				acre	621.63	17.76
Irrigation - deprec & interest				acre	247.50	7.07
Truffle dog - deprec & interest				acre	370.71	10.59
Pickup - depreciation & interest				acre	120.76	3.45
Land interest charge				acre	800.00	22.86
Total NON-CASH Costs					2,160.60	61.73
Total FIXED COSTS					2,284.89	65.28
Total of All Costs Per Acre					4,636.38	132.47
Net Projected Returns						
					30,363.62	867.53



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