



Hybrid Hazelnut Handbook

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Forward

Hybrid hazelnuts have been under development in the Upper Midwest of the US since the 1930s, though progress and attention to the work has been sporadic, unofficial, and fragmented. In the late 1970s, the senior author began collecting the products of previous workers' breeding, including Carl Weschcke, Jack Gellatly, George Slate, and Cecil Farris. Following a decade of initial testing, major new plantings were made of crosses among these various lines, and a new round of intensive selection and breeding was undertaken at Badgersett Research Farm.

At this point, in the year 2002, the indications seem clear to many different individuals and agencies that the developing hybrids do indeed contain the characteristics necessary for the foundation of a genuine hazelnut industry for the region.

Besides the full commitment of Badgersett Research Corporation to this new industry, individuals, RC&Ds, and SWCDs in Minnesota, Iowa, Wisconsin, Illinois, Kansas, and Nebraska have begun making plantings of hybrid bush hazels that are intended not to demonstrate or test, but to produce nuts as a crop. The University of Minnesota has established test plantings on its field stations across the state, the National Arbor Day Foundation has planted 9 acres directly in front of its Lied Conference Center, and the US Army has thousands of plants being established at Ft. Leavenworth, Kansas. Individuals and institutions in 40 additional states, from Maine and Alaska to Texas have started small test plantings.

While the crop now has real momentum and a committed core group of growers, it is nonetheless still in what can only be described as an "embryonic" state. We do not yet have tons of annual production (though the plants for that are already in the ground), and a number of processes remain to be moved from the experimental state to the commercial.

Both fortunately and unfortunately, these new hybrid bush hazels are significantly different from the hazels currently used in world hazel production.

Fortunately, because these plants are immensely more cold hardy, more disease resistant, and because they are bushes, not the trees Oregon and Italy rely on. Big trees require perpetual pruning and cannot ever be as productive as good bushes can- in *all* crops, growers now change to bush forms (sometimes just called "dwarfs" if derived from tree forms) as quickly as breeders can provide the necessary genetics.

Handbook Format-

Where possible and appropriate in this handbook, a section will begin with a quick synopsis of the entire topic, followed by a more detailed treatment. Our hope is this will facilitate actually finding the information you are looking for...

CLAIMERS AND DISCLAIMERS

While production of this handbook has been supported by various universities and government agencies, none of them is responsible for its content, nor are they able to vouch for the veracity of the research findings herein. At the time of publication, Badgersett Research Corporation is the only existing provider of the type of hybrid bush hazelnut plants being discussed here, and is the only entity that has completed long term research on them. We hope and intend that many other people, companies, institutions, and agencies will become involved as the industry grows, and other providers of appropriate bush hazelnuts will develop in the near future. But at the moment, we're it.



Nuts from the same bush are identical twins in appearance: each different shape and color means a different bush- and a different nut, in taste, chemical make-up, etc.

Why Hybrid Hazelnuts?

Before delving into the hows of growing them, it may be well to take a moment to examine the whys.

No one associated with farming at the present time doubts that our farms, farmers, and farming systems are in trouble. Any serious analysis of farming problems would be both lengthy and eventually controversial- here we will try to stick to just a few points that are generally well accepted.

In the US, where so many farmers grow corn and/or soybeans, the profitability of those crops (for farmers) in recent years has become increasingly elusive. Production is so high, both in the US and abroad, that prices paid to farmers are painfully low, often, in fact, below the cost of production. Farmers go out of business, die early from stress, governments wrangle about subsidies, children leave the land, and in the next growing season, the drama is repeated. Companies that process crops continue, every year, to be quite profitable- cheap grain doesn't hurt them a bit.

Why do farmers plant corn and beans again and again when they continue to lose money? Primarily because they have no alternatives- they know how to grow corn and beans, own the equipment, and have no crop they could sensibly switch to. "Alternative crops" that have been offered to them have ranged from outright cons like "Jerusalem artichokes" to the merely ill-conceived, like emu ranching. Somewhere in the middle are alternatives like grain amaranth, which can be grown, but has yet to find any real market.

Mere lack of profitability is far from the only problem, however. One "carrot" dangled in front of the farmer is the development of new uses, and markets, for corn and beans- for example ethanol fuel from corn, or "bio-diesel" from soybeans. The idea being that if there are more buyers looking for the crop, maybe the price will go up. Here we run directly into a much greater problem, however, the environmental havoc wrought by both corn and beans.

This now becomes a deeply emotional discussion, where tempers and rhetoric often flare high. Farmers, in general, are unquestionably good people. They have grown up on the land, and have a deep attachment to it; most want to consider themselves good stewards. All too often, they may feel themselves backed into a corner on this subject- yes, they want to take the best care of the land that they can; but what else, really, can they do? Farming IS corn and beans; the world will starve without them; to grow them efficiently takes fertilizer, chemicals, and plows; there is no real alternative; people who think otherwise just don't understand the realities. So the argument runs.

The "people who think otherwise" point out the extensive and irreversible erosion of the soil, contamination of aquifers, loss of wildlife and habitat as more and more land is irreversibly converted to row crops. And new horrors like the "dead spot" in the Gulf of Mexico, considered by most experts (those who don't work for fertilizer companies, at least) to be clearly caused by nitrogen fertilizer escaped from the Midwest and carried off by the Mississippi. Farmers know about all this; they don't like it either. Many use "conservation tillage" designed to reduce erosion and runoff, and generally practice the safest kind of farming they can; but it still comes down to corn and beans. And the plow. The conclusion is inescapable, in fact; if we must grow corn and beans to eat, we will have soil erosion no matter what; and chemicals in the water, no matter what.

But that's just a Fact of Life, isn't it? If you're going to feed people, you must farm; if you farm, that means plowing. There is no "real world" alternative, is there? (I'm going to ignore, for the moment, the fact that ethanol and biodiesel have nothing to do with feeding the world.)

So, back to the question we started with. Why hazelnuts?

Imagine for a moment what the environmental benefits would be if we could grow our food, "food", as in corn, beans, rice, wheat, etc., without plowing.

"Perennial crops" have been a perennial fantasy, even extending to corn. When corn's wild grass relative *Zea diploperennis* was discovered a decade ago, plenty of mainstream agronomists began to fantasize, and work on, "perennial corn"- a dream which has proven very difficult to realize. Seen any perennial corn fields recently?

It is not the purpose of this manual to discuss the entire concept of "woody agriculture"; for that please go to the Badgersett Research Corporation website, badgersett.com, and seek out the several technical and theoretical papers there.

The new hybrid hazelnut crop is in fact well beyond theorizing; the purpose of this handbook is to explain to interested farmers how to get started growing them: a crop that has been designed from the very outset to address the problems listed above. Once established, no plowing or even cultivation is necessary. No water runs off the fields because infiltration rates are dramatically improved, regardless of soil type. Tiling should not be necessary in moderately wet soils. No fertilizer escapes into groundwater, because the crop has extensive permanent root systems, at work 365 days a year. No soil is lost to wind or rain; in fact this crop *builds* soil. Wildlife finds cover and food all year, instead of naked soil for 8 months, and one kind of plant for 4. In the near future, harvest will be entirely mechanized. And economically,

hazelnuts have a large, unsatisfied, existing world market; and processing potential even greater than soybeans. Literally.

Specifically, why hybrid hazelnuts?

The traditional hazelnut crop is based on orchard trees, in a system basically little changed from a thousand years ago. The hybrids now being developed are bushes; ie. far more amenable to machining, far less work to maintain, and intrinsically more productive. In addition, they are crosses among several species of hazel; made with the specific purpose of increasing useful genetic variations in the offspring, which is indeed happening at a remarkable rate. Our genetically savvy readers will understand that "species hybrids" are not at all the same thing as "hybrid" corn- these are very different processes, which unfortunately share the same name.

Not only is the basic productivity of the plants already greater than traditional hazels, but additional crop possibilities continue to appear- new flavors not found in any wild hazel, for example, and bushes that bear their nuts not in clusters of 5 or 6, but in clusters of more than 20. And bushes that have useful crops in 3 years, instead of 8.

The Badgersett hybrid hazels are also far more widely adapted, climatically, than traditional tree hazels, and incorporate disease resistance from a complex genetic base. Instead of cropping in alternate years, the selection program is finding the genetics that allows the bushes to produce good crops every year. The hybrids have, in fact, been designed and selected to address many different problems, with built-in genetic answers.

Our search for useful genetic responses has been long, over 25 years now; intensive, with many thousands of data points compiled; and broad; over 70,000 individual hybrids are now growing in Badgersett test plantings, with some 20,000 more growing in plantings belonging to universities, state and federal research stations, and private individuals.

The greatest crop breeders the world has ever known were unquestionably the pre-European invasion Native Americans. While our Old World ancestors took wild grass and made slightly bigger grass (wheat, rye, oats, barley, rice), our New World ancestors took wild grass and made corn; maize. A crop so vastly more productive than any wild grass, and so different in its fruit, the corn cob, that until just a few years ago many top scientists argued it could not possibly have been derived from the wild grass teosinte. Genetic fingerprinting proved it was; and bred by pre-Colombian Indians. They also gave us potatoes, pumpkins, squash, all beans but soy and fava, turkeys, tomatoes, and more.

They did it with villages; where not just the medicine men were interested in the crops, the entire village harvested and selected; and paid attention; and cheered the changes and improvements.

Hybrid bush hazels are at a point in their development just slightly advanced from the wild.

The genetic variation available to us in this hybrid gene pool is truly enormous; the genome is certainly larger than the entire world corn genome. Perhaps 10 times larger; perhaps, indeed, more than that.

What kind of food crops might the global village make of this friendly plant today?

And what might that mean for land that would no longer be plowed?



Dimensions

What do these plants look like? How big are they? One critical factor to understand is that at this point in the development of the crop, the basic answer is often "variable". Since we are dealing with a hybrid gene pool, the ancestors of which include both bushes and trees, that should be understandable.

However. In general, when these plants are mature they will average 6-8 feet in diameter, and 10- 12 feet in height. The plants in the above photo are growing in a double row, at a very tight spacing of 5' between rows, and 5' between plants within the rows. These bushes are about 8 years old.

Their growth habit will most often be similar to the common lilac, ie. many stems all arising from the ground. In most cases, the stems at the base of the plant may spread 2 feet across; narrower bases, down to 1 foot, and broader bases up to 3 feet are fairly common. They do NOT "sucker" from their root tips, like the infamously invasive multiflora rose; new stems only arise from the base.

The stems rarely grow more than 3 inches in diameter; most of the stems will average 1-2". When established, a new stem will commonly grow 4-6 feet tall in its first season.

Crop Basics

Detailed information and discussion on these points is provided later in the handbook; this is a quick overview.

Something to bear in mind: This handbook does provide quite a lot of detail; enough both to serve as a real guide to growing the crop, and enough to possibly seem confusing and overwhelming to those not already somewhat familiar. Don't be fooled: growing hybrid hazels is NOT more complicated than growing corn or soybeans. Not at all. It may actually be less complex. But it IS different- give it some time to sink in.

Climate

Completely tested and adapted in USDA Zones 4-6; large trial plantings in Zones 3 and 7 are reasonable; small trials in Zones 2 and 8-9.

Soils

We have not yet found any soil where they cannot thrive, from heavy clays to sands.

pH range - can thrive between 5.0 and 7.0; can be tested in soils up to 8.5

Fertilizer

They respond dramatically to fertilizer in terms both of plant growth and nut bearing.

Pollination

Hybrid bush hazels are wind pollinated and very good at it; no bees necessary.

Chemicals

No fungicides or insecticides are being used in any large plantings; there has been no economic need, in 25 years. Herbicides can be useful during the first 2 years; they require careful application. Mature hazels may kill grass beneath them quite dramatically. Bear in mind: all photos in this book are of plants that have NEVER had insecticide or fungicide spray.

Crop Genetics- Cultivars

Selected seedlings are planted; hazelnut seedlings are more predictable than other woody plants. Asexual clones are in advanced stages of development; test plantings are in place, commercial plantings of clones may begin in 2 years.

Animals

Plant damage- Bush hazels are not preferred deer food. Mature plantings need no protection from deer or rabbits. Mouse damage to plants seems to vary with locality. Pocket gophers (*Geomys*) may kill young plants if not controlled.

Crop damage- Animals leave these hazelnuts alone until they are fully ripe; then theft can be rapid. The biggest thieves of hazelnuts are mice. Next largest thieves are bluejays . Raccoons can be significant.

Insects

Leaves - Very young, newly established plants may be attacked by a variety of leaf-eaters, particularly if buried in weeds. No economic foliage damage to mature plants has been observed.

Big Bud Mite- this tiny mite is a major problem for other hazels; not for these.

Wood - A boring beetle, related to the Bronze Birch Borer, may become significant; some plants appear not to be affected; the multiple stem nature of these bushes means most plants will quickly grow a replacement stem for any one seriously affected.

Nuts - Several weevil species may attack the nuts; infestation rate varies with year, bush genetics, and perhaps pH. Control measures may become necessary.

Disease

No disease problems of any significance; "Eastern Filbert Blight", which is the major disease of concern, is kept at high levels in Badgersett plantings, to provide the best possible testing; the hybrids are resistant or highly tolerant of the disease.

Disasters

Drought

In 1988 and 1989, the region officially had "extreme drought"; mature plants bore their crops anyway, with no irrigation.

Flood

In 1992, we had several instances of hazels standing in several feet of water for weeks- the plants were not harmed, and nuts above water ripened normally.

Hail

Heavy hail can cause some damage to crop and plants, but because of the dense structure of the bush, most of the crop will survive. In 1999 a large planting in Wisconsin withstood a storm with 2" diameter hail with less than a 50% crop loss.

Wind

The bushes are highly flexible; it takes truly extreme winds, eg. over hurricane force of 75 mph, to cause any damage. Crops on the bush likewise survive all but the most drastic winds.

Harvest

This differs dramatically from other hazels. Main harvest is in late August, with earliest genetics ripe consistently in late July, in Minnesota; latest genetics ripe in October. Nuts are picked directly off the bushes, not swept or picked up off the ground as in Oregon. Present harvest is by hand; machine harvest is developing rapidly.

Post-Harvest

Nuts and husks are dried somewhat before husking; husks are removed and nuts cleaned by machine. Sound hazels are extremely resistant to spoilage, drying to sale weight may be accomplished in storage. Nuts can be handled and stored with standard grain equipment.

Longevity

The useful life of a bush is at least 50 years according to present data. Actual lifespan is apparently in the hundreds.

Markets

Midwest USA market is not well established; the crop is too new. Active growers intend to market jointly processed and developed value-added regional specialties before expanding to commodity sales. Commodity markets potentially larger than soybeans. No kidding.

Establishing New Plantings - Synopsis

Nursery stock

Plantings are made almost exclusively using "tubeling" plants; these are mini-containerized seedlings approximately 4 months old at planting. Dormant and active tubelings are available. Other kinds of stock are possible but difficult to obtain.

Ground Preparation

Both no-till and full till options exist. Normal steps: Roundup® spray to kill sod; subsoil if possible/necessary to break hardpan/plow pan; disc. The ground should be left level; if being machine planted, the planter path may need to be rolled to firm it. For planting windbreaks, etc., in places difficult to machine, planting directly into untilled, killed sod can be satisfactory if soil compaction is not excessive. Contour strips can be tilled, leaving sod between rows.

Planting

Machine planting is done with transplanters normally used for tobacco, strawberries, or vegetables. Not all such machines handle the tubelings adequately. Rates over 1,000 plants/hour are obtainable in good ground. These machines do best in well tilled, firmed soils with few rocks; do poorly in sods or unincorporated corn residue.

Hand planting can be done with a shovel, bulb planter, small auger, post-hole digger, or dibble. The most important factor in planting standard tubelings is that the roots not be crushed in the transplanting process.

Standard tubelings are planted from late May right through September, October in Zone 5 or warmer; bare-root dormant tubelings are planted like other dormant tree stock.

It is best if all transplants receive some water at the time of planting.

Survival rates over 90% are achieved with good practices; average is more than 75%.

Care After Planting

Water - for average soils, if rain does not provide 1/2" of water per week during the first month, the plants should be watered; if possible deliver the equivalent of 1" to each plant. In "normal" weather (by Midwest corn

country standards) watering should not be necessary after the first month- the roots will be settled and functioning by then. In droughty soils or regions, watering for 2 months is advisable. Watering in the second year is not necessary.

Weeds - good weed control is highly beneficial. Herbicide use has proven difficult so far. Cultivation is possible, but can become a problem in wet years. Mowing on either side of the row is effective and has several benefits. Mulches can be used, but require careful installation and maintenance; incorrectly done they can kill the hazels. Trials with landscape fabrics have generally had problems.

Fertilizer - contrary to what most of us have been taught, experimentation has consistently shown that the plants benefit greatly from immediate fertilizer availability. BRC practice is to provide a moderate fertilizer in the water supplied at planting. Inappropriate fertilization is possible, but generally: moderate to heavy fertilization rates will be entirely beneficial; no negative effects have been observed, survival is increased and growth rate improved.

Ground Covers - cover crops between rows have not been extensively researched; avoid covers that grow tall and heavy. Dutch white clover mixed with bluegrass works well. The hazels will survive and compete successfully with alfalfa.

Animal control - newly plantings may be attacked by deer and rabbits, particularly if no vegetation remains to distract them. Egg spray has been the most effective deterrent, raptor roosts are best for rabbits.

Establishing New Plantings- Details

Newly planted hazels respond very strongly to weed control, fertilizer, and reasonable water availability. The range of practices in use run from total neglect to luxuriously cared for plantings with irrigation and individual "tree shelters". All can work; there is a direct relationship to the amount and timing of care given and survival, growth, and onset of nut bearing.

One of the early breeding directions at Badgersett was to select only those plants that were capable of survival during establishment even when badly neglected. ALL initial breeding populations underwent years of calculated neglect. This, we feel, is commonly the fate of "trees"- planted with the best of intentions, they often are neglected in the press of other urgencies; trees, after all, can take care of themselves- and if they cannot stand it, the planting will be lost.

Results of that strategy are threefold: 1) These hazels' ability to survive terrible conditions is often amazing. 2) Visitors to Badgersett sometimes get the idea that the proper way to establish them is in heavy grass- which is not so. 3) The plants have been somewhat inadvertently selected to put their energy into the roots, only, when they are growing under stress. This can result in what appears to be very slow growth for several years- while what is actually going on is that the plant is accumulating root mass. Once a critical stage is reached, "when" depending on fertilizer, weed control, and growing season variation, as shown on the facing page, even the most neglected hazels will take off, start to make strong top growth, and begin to bear nuts.

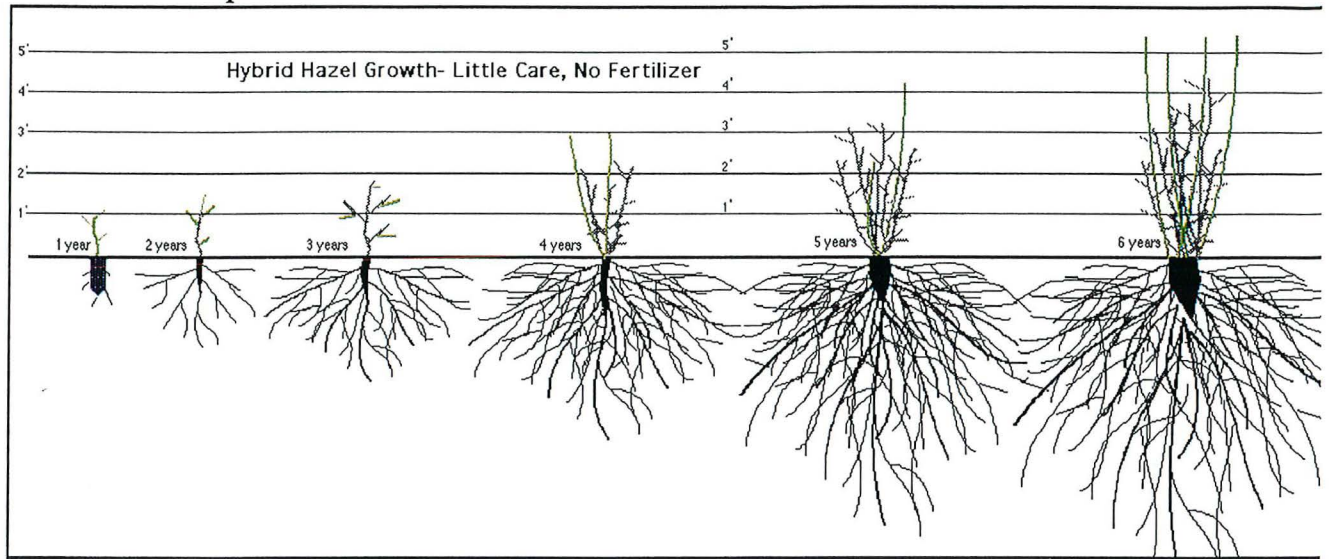


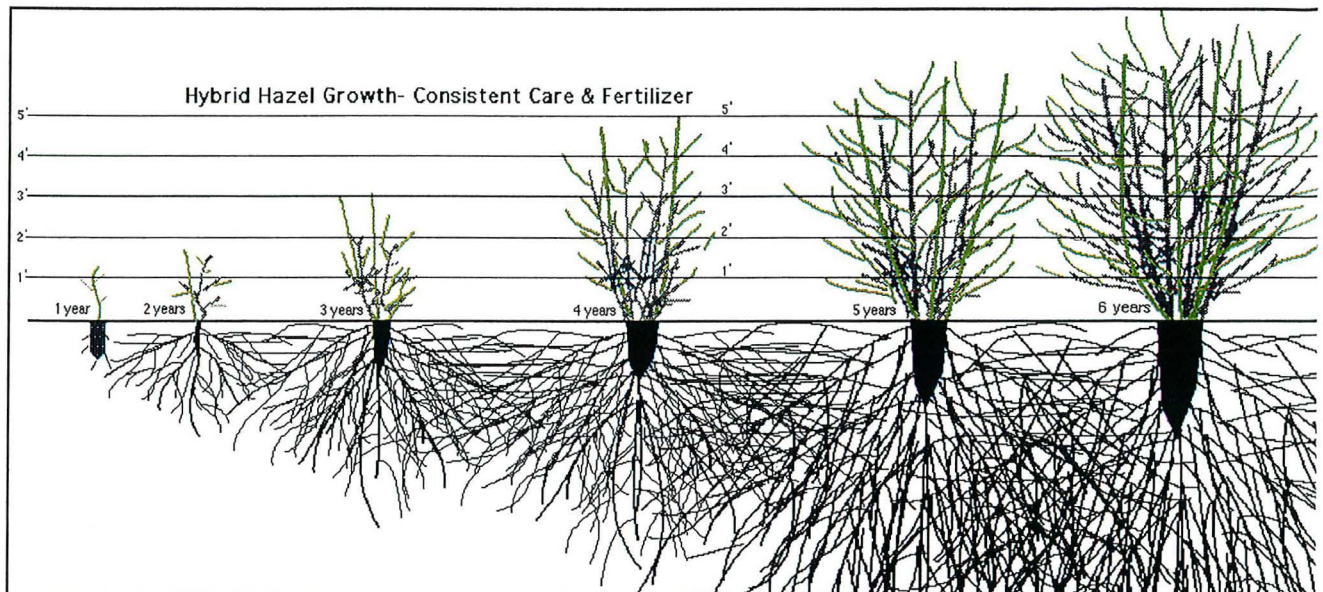
Nursery Stock Types

One of the things that sometimes confuses people getting started growing hybrid bush hazels is the nursery stock situation; at present, there is no source of standard "bare-root dormant" planting stock. This is the standard pathway for transplanting woody plants and trees in quantity at the present time; everyone is used to the process; get your ground ready as soon as the frost is out of the ground, and rush to get the little dormant sticks into the ground before they start to grow.

Several contingencies have conspired to make this standard path non-economic, at least at present. Yes, bare-root dormant hazels are available from some large nurseries, but these are either wild hazels or tree-types. The hybrid bush hazels are only available as "tubelings", young seedlings actively growing in mini-containers- the tubes.

Expected Growth- Little Care - Some Care - Good Care





Green stems indicate present year's growth. Graphics P. A. Rutter, ©

These plants are grown as tubelings because:

The nuts (seeds) are too precious to plant outdoors. A fact of life hazel growers must contend with is that hazelnuts are delicious. They are not only the subject of cravings by humans, they are dramatically more attractive to wildlife, of all sorts, than beginners can believe. Far more attractive than the crop seeds like corn or wheat that we are used to. Animals, and birds, will work 24 hours a day to get at a supply of hazelnuts, and they will succeed, in spite of all efforts to stop them. Usually, they succeed in the first 24 hours.

Wild hazel seed is cheap; nurseries can afford to have animals eat most of it; hybrid hazel seed is perforce expensive, and feeding 85% of it (a real number from years of trying) to the mice, raccoons, and woodpeckers is not economic.

Another serious economic barrier to bare-root dormant hazels is the fact that they start to leaf out with the very earliest trees. Very quickly in the spring, they are not dormant anymore; experience has shown us that most often, hazels grown in the field will be leafed out before the ground is "workable"- digging them for transplant in the spring is extremely risky. Fall digging might be possible; but it requires expensive refrigerated climate controlled storage over the winter; and our experience with experimental trials is that hazelnuts do worse than most other plants in such storage.

If this crop is going to develop, there must be many new growers, and many tons of nuts produced annually- one factor in making that happen is simply the cost of the plants; they must be as inexpensive as we can make them, so that regular folks, regular farmers, can actually afford to plant them. Grafted trees at \$20 apiece is not a route that will allow farmers to plant acres.

The tubelings are much cheaper to grow, ship, and plant than bare root dormant plants can be. (Once you have a mouse-proof greenhouse...) They are still not cheap.

Also, standard bare-root tree transplanting must be done as early as possible in the spring. We're used to that, but in fact that's an expensive proposition. Other urgent chores must be postponed; or if they are urgent enough, the tree planting must be interrupted, leading to higher tree mortality. When the season has moved from spring to summer, it is too late; they can no longer be successfully transplanted- their minimal root system cannot grow new roots fast enough to keep the top watered when it is hot, and the tree will die.

The standard tubelings are not dormant when they are planted. They have small leaf areas that have been toughened by being cut back, and a small but intact and actively growing root system. Planting requires a more gentle hand than bare-root transplanting, where we are taught to stomp the trees in, and pack the soil well around their roots. That will kill a tubeling, by smashing its root system. But it's basically identical to the gentler planting long integrated into agriculture in tobacco and tomato crops- it can be done by anyone willing to learn, and it can be done by machines.

Once used to the idea, the fact that tubelings do not have to be planted in early April, but can be planted in May, June, July, August, September... is liberating. Plantings can be planned for times when the ground is ready, the necessary labor is available, and other urgent need are not conflicting. All this means that planting can be done more cheaply.

Having made the case for standard tubelings, we must now point out that another category of planting stock has just become available; the "**bare-root dormant tubeling**". Hopefully we can avoid confusing the reader on this point.

These have only now become available as we have learned some things about hazel "dormancy". While they tend to die if kept in dark refrigeration for several months, they not only tolerate being kept in a warm greenhouse over the winter, they thrive. This is not the usual expectation. Many plants kept in continuously warm circumstances will break dormancy and start growing- a bad thing if you are wanting to transplant in early spring. The hazels, however, as part of their extreme cold-hardiness, truly require a substantial number of cold hours before they will break dormancy- kept warm, they do not get them; consequently they stay dormant, and happy, sitting in the sun in the greenhouse. In February they are pulled from their tubes and put into cold storage for a month- not a mortality problem, and giving them their cold requirement.

This kind of planting stock is now available in quantity; allowing plain old-fashioned early spring plantings. They are shipped, handled and planted just like any bare-root tree. However...

An economic drawback is that they are more expensive- since someone must care for them through the winter. In general, standard tubelings are 3-5 months old when shipped and planted into the field; bare-root dormant tubelings are 8-14 months old- it unavoidably costs more to produce them.

Cloned cultivars-

Most fruit and nut crops are based on genetically identical plants: clones, of one kind or another. Cloning of trees is an ancient practice, normally accomplished by grafting or layering. Most hazels in the Pacific NW are propagated by layering, the hybrid tree hazels being planted in Michigan are grafted. All the apples you buy at the store are from cloned trees- grafted, to produce identical fruit.

The great majority of hybrid bush hazels planted to date are not clones, but grown from seed.

Finding an economic way to clone bush hazel has been a difficult task. Grafting is both expensive and in the case of bush hazels, a waste of time rootstocks will tend to sprout and overwhelm the graft; alternative use of Turkish tree hazel rootstock would put us back in the tree business, which we do not want; bushes are more economic. Also, testing such cross species grafts is a matter of decades, to find out if such plants will actually survive over time. Rooting cuttings has been extensively investigated, in a project funded by The Agricultural Utilization Research Institute (AURI), by Dr. Harold Pellett; some success was obtained, but it was not easy, and has not encouraged further work. Layering is possible, but also is time consuming. taking years per plant, and is thus not economically very attractive, always resulting in plants that cost many dollars, where our goal is to produce planting stock that only costs pennies.

Tissue culture cloning has that potential, and BRC has been investing substantial resources into developing this process; success has been coming fast. The advantages of using tissue culture clones over seedlings for new plantings are manifold; first, the result will be a field of uniform plants with a uniform crop much easier to harvest and process; second, simple overall productivity of a clonal field should be considerably higher than from a seedling field, since only strong plants will be cloned and any seedling field will inevitably contain some weak plants, and third, the cost of producing the cloned plants is potentially much less than for any other propagation method. Since there is no nut involved, all problems with animals disappear, and the full range of automated greenhouse technology becomes available to us.

Ground Preparation

Requirements will vary greatly depending on your soil. Because these are deep-rooted woody plants, more thought needs to be given to the state of the subsoil than with row crops; subsoiling, at least below the row of plants, is a good idea. This is likely to leave the soil blocky, however, and may require more than one pass with a disc or similar implement to remove air pockets and generally smooth the soil.

For recent row crop land: 2 weeks before planting, spray Roundup® strips ~ 8' wide. (optional) Subsoil down the middle of the row, twice, in opposite directions, if the compaction seems serious. Disc twice to break up clods and firm. Immediately before planting, the row is bladed and rolled simultaneously- the blade is set to level the soil with the adjacent untilled strips, and the roller is pulled behind the blade, providing a firm smooth track for the transplanting machine.

If the site is level enough that erosion is not a significant threat the entire field may be mouldboard plowed then disked. In addition to providing an excellent planting bed, this also eliminates most rodent habitat for the first year.

For old hay ground, or heavy sod: well before planting, Roundup®, either strips or whole field depending on needs, then moldboard plow the sod. Preferably, the sods should have several months to break down before planting proceeds; the transplanting machines work badly and/or slowly in tough chunky sod. For this reason a chisel plow should not be used, since surface residue remains in the soil mix which clogs the transplanter.

For small hand plantings: by preference, strip spray or spot spray Roundup® so that an area about 3 feet in diameter is cleared of weeds. If planting in sod, sometimes less disturbance is better. Tillage brings more weed seeds to the surface to germinate. Undisturbed killed sod can act as a good mulch for as much as a year.

Planting

These plants do not need a big hole; just enough to get them into the ground. We use several tools depending on the looseness of the soil; a "bulb planter" that cuts a plug out, a "dibble" bar, that punches a hole exactly the size of the tube-pot, or a shovel. Standard tree planting "bars" or hoedad's are not good; they are designed to pack soil hard around bare roots; with tubeling plants, they crush the root ball and destroy roots.

The plants handle best if they are NOT watered just before planting; soaking-wet root balls stick to the insides of the tube and crumble easily. This causes roots to get torn, then plants spend weeks recovering instead of growing. Grasp the base of the stem just above the soil, & gently pull the root

ball straight out of the tube. Occasionally a plant may not pull easily; though it sounds strange, we may blow these out; put our mouth over the holes on the bottom and blow hard. Hold the stem as you blow, or it will shoot out! Alternatively, hold the stem just above the soil, turn the entire tube upside-down and GENTLY tap the rim of the tube on a hard surface. This should loosen the root ball enough for it to be pulled out smoothly.

If the root ball does not come out of the tube easily resist the temptation to pull just a little bit harder. This usually ends up in roots being violently ripped from the potting medium.

Once out, handle carefully; the plants are tough, but roots and new buds are tender.

Planting Depth. Plant so the root ball is slightly deeper than it was in the pot; 1/2 to 1 inch deeper is best. Covering the roots with soil is absolutely necessary to prevent drying out; any exposed potting soil will act as a wick and dry out the entire root ball. Making sure that the potting soil is completely covered is probably one of the most significant things that can be done to ensure seedling survival.

Planting deeper than 2" could hurt the plant; some of the plants may die. (nobody knows how many) If the soil you are planting into has been extensively cultivated, or "fluffed" by tilling, (most likely under dry soil conditions) be aware it will settle quite a bit, and may expose the roots of the plants unless they are set deep enough to compensate for settling; 2" may not be too deep in some cases.

WATER WELL!! right after planting. Ideally the ground around each plant should receive 1/2- 2 gallons. Don't dump water right on the plant; water around it. Try to water so the roots of the plant get wet, by absorbing water from the nearby soil. This helps to get air out of the hole, and insures good root-soil contact. Make sure the root ball is still covered with soil after watering

Weather- If you have a choice, it can help to plant as a cool, wet weather system moves in. Avoid planting in hot sun if you can; try to plant only after 2-3 PM if you can't. Preliminary research leads us to the conclusion that hazel roots may not like to be hot. It is impossible to give conclusive evidence at this time, but reports from growers in USDA zone 6 or greater, lead us to believe that hot roots are not good for hybrid hazelnut tubelings.

Remove the nut? Mice, squirrels, chipmunks, groundhogs, and other critters will still find the nut attractive on newly planted tubelings. If you are planting in an area where there is a lot of wildlife pressure, it may be best to gently pull or snip the nut off before or right after planting. The plant doesn't really need the nut for nutrition at this point, though it will certainly use it if the nut survives. In most cases if a squirrel goes after the nut on a newly

planted tubeling, it will just pull the nut off, leaving the plant unaffected. Animals are individuals, though, and sometimes plants may be pulled out of the ground- be on the lookout for this; particularly in very sandy soils, where a new plant may be easily pulled before its roots grow and anchor it. If in doubt, plant a few and watch for several days to see how they do before planting the rest.

Weed Control. Try to keep weeds at least 1 foot away from the plants in the first few years. A tractor mounted corn cultivator has worked well for many. When it is too wet to cultivate, mow between the rows. In our largest plantings, mowing is all the weed control the plants get, or need. The few weeds remaining in the row don't hurt, and in fact help, by distracting deer and rabbits from the young hazels, and providing a little wind protection.

Herbicide use is possible, but very difficult because of the high probability of damage to the seedlings; they have leaves and green bark right down to the ground. Both Roundup® and Princep® have been sprayed over the top of hazel plantings, but Princep® was found to be too difficult to control, frequently damaging the hazels. Application of Princep® prior to planting may have merit, but has not been tested. "Wick" applicators can be used to apply Roundup without danger of drift, and are recommended. They are still dangerous to your plants, however, if you hit a stem accidentally, or put herbicide on a grass stem that the wind will blow so the grass touches the seedling before the herbicide dries.

Fusillade®, and Vantage® have been used in field trials only with inconclusive success.

The primary herbicide used in the Pacific Northwest is Gramoxone®. Gramoxone® (Paraquat) is a restricted use herbicide and has not been field tested on Badgersett Bush Hybrids.

Mulches can be beneficial in dry years and for weed control, but some kinds encourage mice and steal nitrogen from the plants. Mulches that keep soil cool in summer, and warm in winter; may not be good for best growth and hardiness. "Landscape fabric", has yielded mixed results. It requires precise installation and considerable maintenance; storm winds can rip it up if not very carefully anchored. Black plastic mulch as used for growing produce has also been used with mixed results.

Traditional "tree shelters" may be simply too expensive for very large plantings. To be effective; they must be staked, weeded, tended, and lifted in fall to allow the plants to go dormant in time for winter. A company in Indiana is now producing a low-cost tube for hazels that may have promise. Several plantings report they definitely helped the seedlings get established. If you are interested in them, try a few on your site first, before investing in large numbers of tubes. 12" or 18" tubes are fine for young hazels and can be

removed after a year or two. In areas with high populations of rabbits, tree tubes may be a major benefit to survival.

Field trials in Wisconsin during a drought year showed higher survival among hazels protected with tree shelters. Increases in plant height after one year were statistically insignificant. It is not known if hazels protected with tree shelters will produce crops any earlier than those without. Likewise, it is not known whether increased survival and (hoped for) earlier nut production will offset the labor and material costs of tree shelters.

Fertilize at or soon after planting, or spray plants with a foliar fertilizer solution. Hazels can be fertilized at any time, including fall. Mature leaves should be dark green until they turn color in autumn. New leaves can be light green, or reddish. A general purpose fertilizer like 10-10-10 is fine the first year; individual soil requirements vary greatly. Be sure your fertilizer does not contain any herbicides, as "weed and feed" lawn fertilizers do. Long term fertilization needs are more complex. In general, hazels are short of nitrogen, phosphorus and potassium more often than other nutrients.

Pink or red young leaves are common, and do not indicate any nutrition imbalance, in fact we think this indicates good fertility; some young hazels normally have a red spot in the center of the leaf.

Once hazels have been growing more than a month, they will survive all sorts of disasters, from drought to being stepped on or accidentally mowed. Of course they will be hurt, but a healthy plant should sprout again from the roots: you should not have to replant.

Animals: Egg spray to discourage deer has proven effective: Liquefy 1 doz. eggs in a blender, mix into 5 gal of water and spray on the young plants until just wet. This won't wash off in rain, and is effective for 2-4 weeks. Do this the same day you plant if possible, to prevent "curiosity browsing". Don't use a heavier mix than this; several instances have been reported where raccoons pulled out newly planted tubelings after they were sprayed with heavy egg mixes; probably looking for an egg. If you have a lot of raccoons, don't spray egg at all, until 2 months after planting; use an alternative commercial deer repellent if necessary.

Red Pepper based repellants and repellants containing the ingredient "Bittrex" appear to be quite effective.

Rabbits & Mice may attack young seedlings; for hazelnuts, spiral plastic tree guards are very effective in stopping them. Put the guards on in late summer to early fall, and remove them in spring. Spiral tree guards will ensure that at least a small length of stem will be unharmed even if the top is completely snipped off by rabbits or mice. Commercial repellents such as Hinder® and Tree Guard® will help prevent this. Be on the lookout for animal damage as the seasons change. Weed control helps; rodents would

rather not feed when they are exposed to predators. The plants will survive in any case, resprout, and in a few years outgrow the critters. Once established, hazels are rarely damaged.

Most rodent and rabbit damage has appeared on small plantings especially when hazels were planted directly into sod. Once the plants reach a certain size, the damage is dramatically lessened. Hazelnuts planted into old sod create excellent rodent and rabbit habitat and are a welcome addition to the food chain. A field that has been plowed and disked for ten thousand hazelnuts provides poor rodent habitat and overwhelms the population's ability to do significant damage. The same plowed field with raptor roosts erected should have virtually no damage except on field edges.

Recommended Uses: Types of Plantings

Hybrid bush hazels are adaptable for an extraordinarily broad number of uses. The list given here is only those uses we have actually investigated- other variations may occur to new growers, and we'd be delighted to hear about them, and add them to future editions. It was an intentional part of their design that these plants should have many possible uses; far too often in the past, new crops have been developed and adopted, only for growers to find that they have very limited uses- and limited markets. Uses and types often overlap. The hope is that each grower will be able to adjust the balance of practice and use to most precisely fit their own needs. We give a range of spacings as recommended, rather than one "correct" one- depending on whether your goals are quick shelter, or ultimate ease of harvest, your choice for spacing will vary.

Conservation

A major difference between hybrid hazels and other plants normally recommended for "conservation" purposes is that it is possible to actually harvest a crop from these bushes even while they are serving their environmental function. Some thought should be given to the intended method of harvest when the planting is installed- room for people or machines to move in and out of the planting will be needed.



Windbreaks

These bushes make highly effective windbreak plantings. Their height at full maturity will average 10-12'; density of the branches and stems is easily adjusted and maintained. These hazels are very wind resistant; it takes an extreme wind to damage the foliage; a full day of 50 mph winds, with higher gusts, common here in the spring, will leave no marks on even the young leaves. Given that windbreaks are intended to take the brunt of such winds however, we recommend at least 2 rows of hazels planted close together for this purpose; that way, each plant is sheltered by its neighbors on 3 sides, and only has to take the full force of storm winds on one side.

Spacing recommended: 2 or 3 rows, 8-10 feet between rows; 3 to 5 feet between plants. Factors in adjusting your choice of space are how much you want to harvest the nuts, and how soon you want the windbreak to really function as a wind break- closer spacings will stop wind sooner.

Windbreaks for: household/farmstead- reduces heating/cooling costs
Livestock/field- protection from cold winds
livestock/buildings- capture excess nutrients

Other uses:

One: Plant more than one. Hazels don't self-pollinate.

Living Snowfence: You don't have to shovel if the snow doesn't make it to your driveway!

Riparian Buffer: Helps control non-point source pollution.

Wildlife: Hazels provide excellent wildlife cover and food.

"Alley cropping": Annual crops between hazel rows.

"Silvopasture": Grazing livestock between Hazels.

"Pick Your Own"

Maze: Great attraction for customers!

Main Crop: ... well, of course!

Details In Detail

Cold hardiness-

Forget it. These hybrids have their cold adaptations from 2 native species; at Badgersett we kept careful cold hardiness records for 10 years; then stopped. Basically, there are no data; these plants are NEVER harmed by cold. That is hard for most folks to accept- but think: our other fruit and nut crops were brought from the Old World, and are usually poorly adapted to North America; these hazels are from HERE. There are native hazels growing in Canada all along the edge of the permafrost, hundreds of miles north of the US border. And bearing nuts there. The plants at Badgersett have been through -42° F winters twice, with no effect on the crop.

Far more remarkably, they have been through a +4° F freeze IN FULL FLOWER; with no effect on the crop. That's only 4° above 0°. I'll say that again. Hard freezes have no effect on the crop. Frequently they will flower in early April, with the ground still frozen; it's their normal timing. This is hard to comprehend for people used to apples or cherries, where a slight frost of +30°F during flowering can completely destroy the crop for that year.

Hazels based on the genepool from the Pacific Northwest DO have hardiness problems; at Badgersett, which is a cold Zone 4 (USDA growth zone), they freeze to the ground in normal winters. They have an additional problem; even in mild winters, the male flowers, or catkins can be killed even though the wood is not. So even if the trees are not frozen back, there may be no crop because there is no pollen available.

Several growers have reported consistent crop success with Badgersett hazels in Zone 3; they are currently expanding their plantings.

Heat

Hot summer weather is also in their normal genetic background. There are several serious plantings of them growing in warm Zone 6 areas, with no problems reported. The National Arbor Day Foundation planting at Nebraska City seems to have responded to the extra heat (by Minnesota standards) simply by growing bigger, faster, and coming into nut production earlier.

Soils

Native hazels can be found growing on every kind of soil there is; so far, these hybrids also seem to grow everywhere, ranging from wet heavy clays to silt to gravel to muck to sand. Establishment in dry sands may need some irrigation for the first year or two; after that, deep roots should provide for normal growing needs. Root systems are deep and fibrous, extending 6-10 feet deep, and 10 feet in diameter around the plant. Our soils at Badgersett are deep loess silt loams, with some clay and sand streaks. Parent plants for the most important breeding lines came from very heavy blue glacial clay, and seemed to be thriving.

We have altered the pH of some of our experimental rows from 6.0 to 4.8 and 6.8. Results are somewhat inconclusive at the moment- the plants have thrived and borne excellent crops throughout that range. There does seem to be a correlation between very low pH, below 5.5, and higher levels of weevils in the nuts; but other effects are not clear. Native hazels, again, live in all situations, including alkaline soils up to pH 8.5. Haven't tried that.

Animals

Plant damage- Bush hazels are not preferred deer food. Mature plantings need no protection from deer or rabbits. New plantings will benefit from attention to rabbit control, and sometimes deer. New shoots are particularly susceptible. Mouse damage to plants seems to vary with locality. Even if they are browsed, the plants will grow back. Pocket gophers (*Geomys*) may kill some young plants if not controlled; there appears to be a strong preference for European hazel genes in what they eat.

Crop damage- Animals leave hazelnuts alone until they are fully ripe; then theft can be rapid. There are ways of coping, chief among them timely harvest. The biggest thieves of hazelnuts are white-footed, or deer, mice (*Peromyscus*). Next largest thieves are bluejays. Woodpeckers and raccoons can be significant. Deer may eat nuts from some bushes, and not others; bears are known to be major feeders on wild hazels. The nuts are very good food...

Insects

Crop research on hybrid bush hazels began at Badgersett with very little basic information on potential pests. Consequently, it was policy never to spray insecticide, regardless of damage levels, in order to learn what insects to expect, and how damaging they might prove to be.

The Present World Hazelnut Industry

There are a great many statistics that could be presented here- but in the interest of brevity and clarity, we will give just the basics. Those interested in more details will be best served by exploring on the Internet. The USDA Fruit and Tree Nuts outlook webpage (www.ers.usda.gov/Briefing/FruitandTreeNuts/) is a good place to start. Much of the information presented here has come from the USDA site or the dozens of links that it lists. The USDA site provides a good jumping-off point to other sources of information and it is searchable. Other information in this section has come from the junior author's seven years of experience as a wholesale produce broker and his contacts in the industry.

In short, the dynamics of world production and markets have not changed much in several decades. Turkey produces between 60 and 70% of the world crop; Europe consumes about 80% of world production. The USA is presently a minor producer by world standards, and grows only about 20% of what we consume, the rest being imported. At the moment, virtually all US production comes from the Willamette Valley area of Oregon, with plantings in adjacent areas of Washington, California, and British Columbia. Total acreage in the US has declined by nearly 1000 acres in the past few years.

Much of the decline is because of infection by Eastern Filbert Blight, which is fatal to most present commercial varieties. Production in the Pacific Northwest is based on pure European hazel cultivars: *Corylus avellana*, grown as trees, with nut crops mechanically swept from the orchard floor. New plantings of traditional tree-type hazels are being made in Michigan, based on hybrid cultivars created by Cecil Farris, a private grower. These plantings are small and are not in production yet. Additionally, the Michigan hybrids have not been extensively tested either for productivity or resistance to Eastern Filbert Blight. All Farris hybrids are currently being field-tested in Wisconsin and Minnesota with no positive results reported at this time.

Hazelnut production in the US fluctuates significantly, from around 6,000 to 15,000 tons per year. This dramatic difference is primarily due to the bearing characteristics of the varieties in production. Nearly all of the European Hazel cultivars in use in the US bear alternately with years of high productivity followed by years of low productivity. Per acre yields range from .5 to 1.5 tons per acre. Badgersett Hybrid Bush Hazelnuts, on the other hand, produce regular crops annually. Industry wide this will prove to be a great benefit both for farmers and markets. Crops experiencing alternating years of glut and shortage cannot develop the steady, dependable marketing infrastructure required for optimum market penetration.

Hazelnut production in Turkey is also based on cultivars of the European hazel, cultured most commonly as a large bush, and harvested

primarily by hand. There is a native species in Turkey, the Turkish tree hazel, *C. colurna*, which is a tree; but this species contributes virtually nothing to international commerce. Other significant Hazelnut producers are Italy, Spain, France, and Portugal, where the crop is grown mostly as a tree, and machine harvest is increasing. Several countries in the former USSR, and China, are working on increasing their hazel production, but do not yet contribute significantly to the international trade.

Production in Turkey and the rest of Europe also fluctuates dramatically, from genetic, weather, and political causes. Historically this has meant that hazel processors have had to deal with a volatile and uncertain supply- a situation which stifles development of new products, uses, and markets. Large, commercial users demand predictable and guaranteed annual supplies. The opportunity exists for growers of Badgersett Hybrid hazels to provide this supply.

One of the most telling statistics is per capita consumption. The average European eats about a cup of hazelnuts per week, in a wide variety of foods; in the USA, our consumption averages out to only 2 nuts per person, per year... a staggering difference. Virtually all agencies involved with hazelnut production and marketing agree that the reason so few nuts are consumed in the USA is simply that they are unavailable- there are just not enough nuts to go around.

An examination of the USDA statistics won't necessarily tell this story, however.... The national statistics show that every year, a certain percentage of US hazelnuts go unsold, even when this year's crop is half of what last year's crop was... (a natural bearing characteristic of *Corylus avelana*) What USDA figures don't show is how much of this inventory is carried forward into the next year's statistics, or the fact that at the end of one calendar year much inventory remains "unsold"... simply because it is under contract to large buyers and is not yet sold. What national statistics also cannot show are local shortages. USDA statistics show an unsold inventory of dozens of tons each year, but the fact that there are absolutely no hazelnuts available east of the Rockies fails to appear as a statistic. This was exactly the case with the hazelnut crop of 2000. The USDA showed large inventories of hazelnuts selling at modest prices. However, IF hazelnuts were available at all, wholesale prices in Minneapolis and Chicago were at near-record highs.

In the US, very few value-added products are currently produced that utilize hazelnuts as an ingredient. Those that are available are typically higher-priced gourmet items, especially chocolate candies. This reflects once again, a general lack of supply. In the US, most nationally recognized candy bars containing nuts have either almonds or peanuts in them. Both nuts are in abundant supply. (the US is the largest almond producer in the world), The same candy companies that use peanuts and almonds in the US, use

hazelnuts in Europe. These companies represent a huge untapped market. They already utilize hazelnuts where available. They have already developed the products, they have the processing and manufacturing equipment, the marketing and distribution infrastructure, and they already have shelf space at nearly every grocery store in the country. A careful look at the candy counter of your local grocery store will show you how competitive the industry is. New candy ideas are churned out constantly. You will always find the proven stand-by's but new products come and go almost weekly. With an abundant supply of Hazelnuts, the large, international candy companies will be able to create the new "standards" on American candy shelves.

Economics

The Commercial Hazelnut Development Project

In 2000, the Southwest Badger Resource Conservation and Development Council (RC&D) in cooperation with Mark Shepard (New Forest Farms) completed the first 2 years of a project titled "The Commercial Hazelnut Development Project". The Wisconsin Department of Agriculture Trade and Consumer Protection Agricultural Development and Diversification program awarded Southwest Badger RC&D a grant to complete the first two objectives of this project. The objectives were: 1) To record the establishment procedures used during the planting of the first commercial scale Hybrid Bush Hazelnut field in Wisconsin and 2) To discover the actual establishment costs of that planting. The final report of the project has served to provide farmers and agency personnel with the agronomic practices and economic data needed for successful establishment of commercial Hazelnut. Past constraints to the adoption of agroforestry practices such as Hazelnut production, result from the lack of reliable farm-level production data and proven establishment techniques. The commercial Hazelnut Development Project report and this handbook are a first attempt to address this need.

Harvest

Badgersett Hybrid bush Hazels are all currently hand-harvested approximately a week before they are ripe. They are then stored in a humid location while the nuts cure. After curing they are dried and husked. Current technology is primitive and rapidly changing. There are dozens of larger growers in the upper midwest all working on perfecting the necessary equipment.

Unlike apples or other fruit, Hazelnuts can be stripped from the bushes by hand rather rapidly since they are hard-shelled and will not bruise. A mechanical straddle harvester is the most likely device that will be harvesting bush Hazelnuts in the future. BEI Co. and Korvan Co., manufacturers of straddle-harvesters have both contributed to the development of the Hazelnut industry in the midwest and will continue to be involved as more growers plant the crop.

In Oregon, the ground beneath Hazelnut trees is kept completely bare and level at great expense. The nuts are allowed to ripen completely and fall to the ground. They are then blown into windrows and picked up using a vacuum or sweeper. This harvest method could be adapted for use with bush Hazels, however, the pest control, disease control and fertility benefits that come from growing Hazels in a semi-grassland ecosystem would disappear and additional costs would be incurred. Theft of the ripe nuts by wildlife would dramatically increase thereby lowering yields.

Coppice

In order to maintain plant vigor and to maximize nut bearing area on each plant, Badgersett Hybrid Bush Hazelnuts need to be periodically rejuvenated. The commonly used practice for this is coppicing. When the shrubs reach 10-12 feet in height and the new growth begins to slow down, the entire plant is mowed completely to the ground following the harvest. This can be done with a flail mower. On large plantings, a feller-buncher could possibly be used. Hazelnut wood is a potentially valuable biomass crop that can be sold for pulp, fuel, landscape mulch, edible mushroom substrate or other creative uses. Current "niche" uses for hazelnut coppice-wood are yurt poles, incense and bent-wood furniture. The anti-cancer drug Taxol, found in Hazelnuts themselves, may possibly be extracted from the chips as well. Leaving the chips on the ground where they fall helps to build soil organic matter, conserve nutrients and moisture and could be used as a substrate for stropharia mushroom production..

Establishment Costs

The project area at New Forest Farm in Viola, WI is comprised of three, moderate to steep slopes with all aspects to the sun. In the spring of 2000, 15 foot wide strips were mouldboard plowed over the entire project area. These strips of plowed soil were then disked in order to make a fairly smooth planting bed. The plowed strips were arranged on the hillside in alternating patterns so that the rows of Hazels would alternate from 10ft apart to 15ft apart repeated throughout the area. This row pattern would allow for vehicle access between every other row as the plants mature.

The planting of the Hybrid Bush Hazels began as soon as the plants were ready from Badgersett Research Co. In- field trials ongoing since 1997, it has been repeatedly shown that tree transplanting machinery that plants bare-root nursery stock does not work with these tubelings. Several vegetable and tobacco transplanters have been trialed at New Forest Farm over the years and the one that works the best is a D.R.Ellis transplanter. It works adequately without modification yet its performance is improved with some minor modifications to the machine. Most significantly, a deeper cutting knife.

In order to obtain as much information as possible from the Hazelnut project, several techniques were used in addition to the usual ones. The first 2000 hazels planted, were bare-root dormant tubelings. Thereafter, standard tubelings were used. They were identical to those that any customer would purchase. On one section of the planting, tree "tubes" were used with various tube diameters and heights. Black plastic mulch was tested as well

Planting at the project site occurred over the course of eight weeks in the summer of 2000 and three weeks in summer of 2001. The "other" demands of the farm (field prep, planting, haying, produce harvesting) would

not allow planting to occur all at once. Immediately prior to planting, the soil was disked one final time and rows marked with spray paint or barn lime. A planting crew was hired which consisted of two people on the transplanter and one driving the tractor. (It is possible for one person to ride the transplanter and one to drive the tractor. However, the entire operation is much more efficient and less frantic for the person on the transplanter if there are two of them.) As the tractor driver marked the rows, the transplanter crew carefully removed the Hazels from the tubes and placed them in the plant tray of the transplanter. The Transplanter tank was filled with water and fertilizer. The fertilizer used was Dramm "Liquid Fish", a fish and kelp emulsion. One half gallon of liquid fish was used per 50 gallons of water. "Iron Roots" brand myco-inoculant was added to the tank at the rate of 1tablespoon per 50 gallons of water. This introduced spores of beneficial root fungi to the seedlings as they were planted.

Once the transplanter made a pass down the row, the entire crew would get off the machinery and go back over the row to straighten plants and make sure that the root ball of the plant was completely covered with soil. Although this was a time consuming step, it was essential. Once again, if any of the tubeling's potting medium is exposed, it will act as a wick and will draw moisture from the plant's roots dehydrating and killing the plant in a matter of days.

In the beginning of the project, Hazels were planted at a density of approximately 873 plants per acre. The project area encompassed slightly over 12 acres. Since the information on optimal plant spacing does not exist, the decision was made to test different plant spacings on this project. The original between plant spacing was 6 feet. Approximately half way through the project area, plant spacing was changed to 3ft between plants. For the final 20% of the planting (planted in 2001) plant spacing was changed to 2ft between plants.

Since the early summer of 2000 was very wet, no supplemental watering was done. Since no data existed on herbicides suitable for hybrid bush hazelnuts, none were used. When weather and soil conditions were suitable, weed control was accomplished using a Farmall-C with cultivators. (Any corn, vegetable or tobacco cultivating equipment will suffice.) Weeds grew up between the plants within the row.

Once the rains stopped, two weeks went by when the temperatures soared. The muddy soil baked hard. One planting occurred during the first week of no rain and one occurred during the second week of no rain. When the third week of no rain occurred, the two "rainless" plantings were checked to see if they needed supplemental water. When checked, both plantings had set dormant buds and dropped their leaves. When regular rain resumed a week later, both plantings began growing again and by the end of summer

were indistinguishable from any of the plants that had not dropped their leaves.

It is recommended that newly planted Hybrid Bush Hazels be watered if they do not receive at least 1/2" of rain per week.

In the early summer of 2001, three final plantings were made and the first regular mowing took place. In the early years, it appears that the alleys between Hazelnut rows will need to be mowed between four and five times during a season. This allows more light to penetrate through the in-row weeds to the young Hazels and reduces root competition for nutrients and water.

Once established mowing and fertilizing will be the only maintenance done to the Hazelnut field until the bushes are coppiced.

Cost of Establishment

Table 1 is the Establishment Cost Summary for the planting of 10,478 Badgersett Hybrid Bush Hazelnuts. It describes the actual costs incurred during the Commercial Hazelnut Development Project.

Of note to the potential grower: Many farmers don't include the cost of their own time. For this project it was done so primarily to give an accurate picture of the true costs of establishment. If a farmer wishes to hire a contractor to plant Hazelnuts, this figure will need to be included. The \$25.00 per hour figure was chosen somewhat arbitrarily. It is probably safe to assume that a Hazelnut planting contractor would charge that much for his time, crew and overhead. For farmers planting their own Hazelnuts, the dollar amount "Labor/Self" can be ignored, since it is not a cash expenditure.

Likewise with mileage. \$0.31 per mile in order to pick up plants at the nursery is not an immediate cash expense. This figure is included to account for the overhead cost of using one's own personal vehicle. If plants aren't picked up at Badgersett personally, UPS or other shipping costs would be incurred for the plants to be delivered to the farm. This would have resulted in plants that had been handled several more times and additional cost of 10%. This additional shipping cost would have totaled \$3,405.35 for this project. This is considerably more than the \$1,015.56 personal mileage cost incurred. If the personal mileage cost is added to the personal labor cost of going to pick up plants in person (77hrs X \$25.00 = \$1925.00) the total cost to pick up the plants totaled only \$2,940.56. Picking up the plants in person helped to avoid an actual cash cost, saved the plants additional handling and was \$464.79 cheaper than UPS. This will, of course, vary with ones distance from Badgersett Research Co. in Canton, MN.

Most of the time involved in establishing this commercial scale Hazelnut field was concentrated in May, June and July. May was primarily field preparation while June and July were mainly planting. Once the Hazelnuts were planted, the labor involved in their upkeep decreased dramatically. Personal hours in the wintertime, (included in Labor (self) were spent walking through the Hazels observing whatever was noticeable. Strolls through the hazelnut field are so pleasant that they can hardly be called work!

Table 1

Custom Plowing	\$ 300.00
Labor (self) 268.3 hrs	\$ 6,706.25
Hired Labor 287.5 hrs	\$ 3,115.00
Travel (getting plants)	\$ 1,015.56
Tractor Fuel	\$ 544.04
Fertilizer & supplies	\$ 142.99
Other expenses	\$ 589.19
Hazelnut Plants	<u>\$34,053.50</u>
Project cost =	\$46,466.53
Establishment cost per acre=	\$3872.21

Table 2 lists the various cost categories and gives a per acre totals

Project Site = 12 Acres		
Site preparation costs	\$1,347.50	\$112.30/acre
Planting costs	\$4,725.00	\$393.75/acre
1 st Year maintenance costs	\$1,660.00	\$138.33/acre
Hired Labor cost	\$3,035.00	\$137.95/acre

Costs not included: Property tax, mortgage, insurance, interest.

Tables 3, and 4 show the potential cash-flows from a one acre Badgersett Hybrid Bush Hazelnut planting of different plant densities. They are constructed using very sparse data. Since the commercial growing of Badgersett Hybrids is so new, there is very little information to work with. The yield figures are derived from the Badgersett Research Corporation's research database, which was willingly provided for this project. Several assumptions were made for these cash-flow projections.

For one, Badgersett Hybrids are all seedlings and are all genetically unique. Therefore they will be somewhat variable in growth, shape, yields, nut size etc. Some have yielded as many as 9 lbs per plant. Most yield much

less. For this projection we chose a mature yield of 2lbs per plant which is a very conservative figure.

The terminal market price in Portland, Oregon for in-shell processing hazels when the Commercial Hazelnut Development Report was written, was \$0.88/lb. Since 1999, the price has fluctuated from a low of \$0.38/lb to a high of over a dollar. In order once again to be very conservative in our estimates, \$0.44/lb was used as a market price. This was only 50% of the market price when the original report was written , and low enough to demonstrate what would happen should prices remain within their most recent historic range.

Direct retail sales, farmstand sales or value added products can potentially make the return per acre even higher. Retail prices in 2000 ranged from \$2.00/lb to \$4.00/lb. Certified Organic Hazelnuts retailed in the January of 2001 for \$7.00/lb

Cash Flow Projection

The following tables use numbers from the Commercial Hazelnut Development Report 2001 to project potential cash flow for a one-acre Badgersett Hybrid Bush Hazelnut planting. Actual establishment costs may vary and some costs (such as harvest costs) are not known at this time. The table below assumes a post-harvest cost of \$0.10/lb

Table 3: Planting density of 873 plants per acre
Row spacing alternating from 10' to 15'

Year	Operating Cost	Income (Wholesale)	Cumulative Net Cash Flow
1	\$3,872.21	0	-\$3,872.21
2	\$138.33	0	-\$4,010.54
3	\$138.33	0	-\$4,148.87
4	\$138.33	0	-\$4,287.20
5	\$173.70	\$153.64	-\$4,307.26
6	\$225.63	\$384.12	-\$4,148.77
7	\$260.55	\$537.76	-\$3,871.56
8	\$278.01	\$614.59	-\$3,534.98
9	\$312.93	\$768.24	-\$3,079.67
10	\$312.93	\$768.24	-\$2,624.36
11	\$312.93	\$768.24	-\$2,169.05
12	\$138.33	0	-\$2,307.38
13	\$138.33	0	-\$2,445.71
14	\$225.63	\$384.12	-\$2,220.08
15	\$260.55	\$537.76	-\$1,959.53
16	\$312.93	\$768.24	-\$1,646.60
17	\$312.93	\$768.24	-\$1,333.67
18	\$312.93	\$768.24	-\$1020.74
19	\$312.93	\$768.24	-\$707.81
20	\$312.93	\$768.24	-\$394.88
21	\$312.93	\$768.24	-\$81.95
22	\$312.93	\$768.24	\$230.98
23	\$312.93	\$768.24	\$543.92
24	138.33	0	\$405.59

By averaging the wholesale per-acre income over 24 years, table 3 concludes that it is very likely that a grower can expect to gross on average \$460.94 per acre for processing grade hazels at commodity market prices. At 2000 prices, (when the above table was first generated) the same acre of Hazels would gross \$921.88 per acre. What lies hidden in these numbers is the fact that with establishment and later with coppicing, out of 24 years there are 7 years with no yields at all.

Using the actual figures reported in table 3, it can be derived that the per-plant establishment cost at New Forest Farm in 2000-2001 was approx \$4.44/ plant. Using this actual figure, we have estimated costs and yields for another plant density. This is shown in Table 4 .

Table 4: Planting density of 588 plants per acre (approx 5' between plants) Between row spacing alternating from 12' and 16'

Year	Operating Cost	Income (Wholesale)	Cumulative Net Cash Flow
1	\$2,610.72	0	-\$ 2,610.72
2	\$138.33	0	-\$2,749.05
3	\$138.33	0	-\$2,887.38
4	\$138.33	0	-\$3,025.71
5	\$161.84	\$103.48	-\$3,084.07
6	\$197.13	\$258.72	-\$3,022.48
7	\$220.65	\$362.20	-\$2,880.93
8	\$232.41	\$413.95	-\$2,699.39
9	\$255.93	\$517.44	-\$2,437.88
10	\$255.93	\$517.44	-\$2,176.37
11	\$255.93	\$517.44	-\$1,914.86
12	\$138.33	0	-\$2,053.19
13	\$138.33	0	-\$2,191.52
14	\$197.13	\$258.72	-\$2,129.93
15	\$220.65	\$362.20	-\$1,988.38
16	\$255.93	\$517.44	-\$1,726.87
17	\$255.93	\$517.44	-\$1,465.36
18	\$255.93	\$517.44	-\$1,203.85
19	\$255.93	\$517.44	-\$942.34
20	\$255.93	\$517.44	-\$680.83
21	\$255.93	\$517.44	-\$419.32
22	\$255.93	\$517.44	-\$157.81
23	\$255.93	\$517.44	\$103.70
24	\$138.33	0	-\$34.63
25	\$138.33	0	-\$172.96
26	\$197.13	\$258.72	-\$111.37
27	\$220.6	\$362.20	\$ 30.18

With a plant density of 588 plants per acre, a grower could expect to average approximately \$310.79 per acre in a 24 year period. In addition to providing a smaller annual cash-flow, this plant density would not make a return on the initial investment for 27 years, whereas at 873 plants per acre, breakeven is predicted to occur at 22 years.

Conclusion

The results of The Commercial Hazelnut Development Project demonstrate that Hazelnuts have potential as a low-input, low-maintenance crop in the upper midwest . At these prices and yields, Hazelnut is obviously not a get-rich-quick crop. It is, however, an easy to grow crop with large, dependable existing international markets.

As the above tables show there are several key points that will make Hazelnut production more profitable. One is yield. More research needs to be done to determine the optimum fertility for hazelnut production. Increase in yield of just a few ounces per plant can make a significant difference in return. Another factor is the length of time between planting and full production. It is possible that certain tree growth enhancing products (such as tube shelters, mats, mulch, growth hormones, myco inoculants, fertilizers, clones) can bring a Hazelnut field into production sooner. Research needs to be done on these products and technologies to determine their cost-effectiveness. Weed control during establishment also makes a difference in how fast a Hybrid Hazelnut bush comes into production. Weed control may also affect total yield per plant. Research on herbicides for Badgersett Hybrid Bush Hazels is ongoing. Their cost effectiveness is not known and more research needs to be done.

Probably the most significant factor in increasing the return to the grower for Hybrid Hazelnut is to maximize the amount of the crop sold at retail prices and/or at value-added prices. The relative scarcity of current Hazelnut supplies creates an ideal opportunity for the development of new products. Production and marketing of these new products can be an opportunity for rural job creation. An example of one possibility would be the manufacture of hazelnut oil. The oil sells at a high retail price (\$6.00 for 8oz) and can be used in cosmetics, skin care products, nutraceuticals, beverages (like soy milk) and can be used for making a plant-based cheese. The high protein meal left over from oil pressing can be used to make snack foods, baked goods, candies, flavorings or even feed for livestock. The nut -shells can be ground, graded and used as industrial abrasives, additives to wood glues, or burned for heat and electrical generation

In summary, hybrid bush hazelnuts are a crop that is here to stay. The industry is in its infancy and its future holds promise.

