Culture and Propagation of Japanese Maple

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Abstract

Japanese maples have maintained a steady presence in nurseries and across the suburban landscape of America for many years now. Their fineness of texture, relatively small stature, and colorful displays are attributes that have earned them the admiration of studied horticulturalists and casual observers alike. This document attempts to compile the published accounts of several decades of observations and experiments pertaining to the general culture and propagation of Japanese maples, most specifically, information pertaining to *Acer palmatum*.

In addition to aesthetic beauty, several factors combine to make Japanese maple a valuable horticultural species. These factors are: seedling variability, wide-ranging environmental adaptability, moderate ease of asexual propagation, limited problems with pest and pathogens in both nursery and landscape settings, and consistent commercial value and appeal. Despite the popularity and overall viability of Japanese maple cultivation, specific information concerning its culture and propagation is limited.

Acknowledgements

I want to thank this part of Virginia for providing me with a feeling I hadn't felt for a long while - some place to call home. The credit hours have been earned *and just in time.* This town has become too loud, with construction on every corner, helicopters in the sky too often, kids hollering nonsense just about every night. Thanks to all the people who treated me kindly and peacefully, amidst all the noise. Especially Dr. Seiler, who kept things human in an increasingly inhuman, academic business-like environment. Take it easy - let the kids shovel the driveway.

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1. Introduction

Acer palmatum, Japanese maple, is a fine textured, small sized tree, native to the understory of forests on the islands of Japan and nearby territories. In landscape use it has survived and often flourished in a wide range of environmental conditions. Environmental adaptability and the species' inherent tendency towards variation amongst seedlings – any mass of seedlings sure to produce any number of obvious genotypic variations - have combined to make Japanese maple a nursery industry and landscape favorite (Mulloy, 1976). This paper will provide a general description of Japanese maple aesthetics, culture, and propagation. A review of decades of literature regarding these practices has been synthesized and simplified wherever possible. It is worth mentioning that the information used to compile this review has largely been derived from the published experiences of long time Japanese maple growers and collectors, more so than the published accounts of research experiments found in scientific journals.

2. Japanese Maples: Value and Appeal

Taxonomical and nomenclatural confusion have long been encountered concerning *Acer palmatum* and its range. The *Acer palmatum* complex is considered by some to be widely distributed - parts of Korea, China, and Taiwan have all been observed to possess populations of *Acer palmatum* very closely related to, if not indistinguishable from those growing on the islands of Japan (Chang, 1990). Broadly considered, Japanese maple refers to any of the 23 species of the genus *Acer* native to the islands and nearby territories of Japan. It is interesting to note that *Acer palmatum* and all its varieties are almost exclusively endemic to Japan (Vertrees, 2001), an island approximately the size of Montana. For the purposes of this paper the name Japanese maple refers specifically to *Acer palmatum* and *Acer japonicum*, and the myriad cultivars related to both species. I include *Acer japonicum*, Fullmoon maple, because it has similar cultural requirements to Japanese maple, as well as similar aesthetic appeal (Dirr, 1998).

Brief mention of the history of Japanese maple cultivation is in order. The generic Japanese word for *A. palmatum* is *Momiji*, roughly translated to mean "the baby's hand" (Mulloy, 1976). The Japanese, a culture known historically for its aesthetic and spiritual sensitivity, have selected, bred, and propagated Japanese maples since the early 1600's. By the late 1700's these selections were being distributed to horticulturalists, nurseries, and arboreta around the world. Records show that over 200 named cultivated forms of Japanese maple existed during this time period. Sadly, many disappeared during the hard times brought about by World War II. To alleviate fuel shortages Japanese maples were used as firewood. Nurseries once devoted to cultivating horticultural specialities were mandated to use their land for growing food. Consequently, much of the legacy of centuries of Japanese maple cultivation was lost or destroyed over the course of about 20 years (Vertrees, 2001).

Japanese maples were first introduced to England in 1820 (Dirr, 1998). The Arnold Arboretum of Harvard University in Boston, Massachusetts, the oldest garden and arboretum intended for public use in the United States, planted their first Japanese maple on March 1st, 1880 (Port, 2003). Today, Japanese maples are widespread throughout the suburban American landscape. Their small stature, from shrub size up to 8 meters (25 feet), is well suited for restricted lawn and garden spaces (old and prosperous individuals along the East Coast have matured to 13 -15 meters (40-50 feet) (Dirr 1998)). The typically crimson colored, palmate shaped, or sometimes finely cut ("dissected") leaves appeal to almost everyone. In addition to the attractive form of the leaves, dependable fall coloration of the leaves - the reds, oranges, and yellows, typical of majority of *Acer* species - increases popularity. Beyond these obvious attributes, more refined and subtle tastes appreciate Japanese maple's picturesque branch architecture, the spring flowers, and the decorative fall seed set. Perhaps the popularity of Japanese maple is in part due to its abundant presence in the contrived environments most frequented by people. Japanese maple is a tree that is not so massive that casual close inspection becomes impossible, or to the contrary, so minutely fine that only a trained horticulturalist with a hand lens could appreciate it. To say it another way: a beautiful plant specimen placed ubiquitously throughout the landscape will not lack the attention of admirers.

3. General Culture

> "Japanese maples are remarkably adaptable to soil and climatic conditions. In their native habitats, *Acer palmatum* and its natural varieties have adapted to a wide range of environments on the islands of Japan. In North America, these plants thrive in the soils and climates ranging from the rain-forest type of the Pacific Northwest to the very warm climate of southern California, and from upstate New York down the Atlantic seaboard to the southeastern states and through the Midwest. In Europe, they grow in the warm Mediterranean conditions of Italy, in the almost-pure peat soils of Boskoop, Netherlands, and in the varied soils in Britain."
>
> - J.D. Vertrees, *Japanese Maples*, p.47

The statement above speaks boldly regarding the range of Japanese maple. Perhaps further insight into the adaptability of Japanese maple stems from the species' native elevational range of tolerance. On the islands of Japan, Japanese maples can be found growing from approximately 100 - 1308 meters (330-4290 feet) (Vertrees, 2001). As elevation increases, harsh exposures, thin soils, and stingy moisture regimes often result. Heat tolerance may also be attributable to Japanese maple's adaptation to elevational range. Mountainous terrain depends on aspect as a key factor. Sites with southern and western aspects experience increased drought stress due to solar driven transpiration and evaporation. Japanese maples have evolved to survive in both cool, moist cove areas, and harsh, rocky, mountain exposures. Perhaps Japanese maple's surprising cultural tolerance is similar to bald cypress (*Taxodium distichum*), the swamp species of the American southeast. Bald cypress specimens have been growing successfully for 75 years in the harsh winters of Syracuse, New York (Dirr, 1998), a climate and location well beyond their native range. Perhaps the case for Japanese maples is the same: environmental adaptability of a species straining the limits of belief.

Soils

Soils *preferred* by Japanese maples are slightly acid sandy loams with low to medium organic matter content (Vertrees, 2001). Dirr (1998) recommends soils that are moist, high in organic matter, and well drained. Soil conditions to be avoided are those that are poorly drained and those that are high in pH. Japanese maples have shallow root systems and this allows them to tolerate heavier soils, or sandier, infertile soils, provided they are mulched adequately and attention is given to maintaining an even watering regime. Mulching is highly recommended to also help young plants establish themselves and buffer against dry spells and cold snaps (Vertrees, 2001).

Cold hardiness / Microclimates

Cold hardiness varies amongst the many Japanese maple cultivars. Above ground parts of many Japanese maples can tolerate winter air temperatures down to -18ºC (0°F), once established. The roots survive undamaged to around -10ºC (14°F) (Vertrees, 2001). These hardiness limits are debatable. According to well-known horticulturalist Michael Dirr, the observations of he and his colleagues place Japanese maple cold tolerance limit to about -29ºC (-20°F). His observations have placed the species generally within USDA Plant Hardiness Zones 5-8 (Dirr, 1998). Dirr (1998) explicitly mentions the popular red-leafed cultivar 'Bloodgood' as perhaps the most cold hardy of all the Japanese maple cultivars. Microclimates play key roles in making or breaking the performance of Japanese maples in marginal environments. Those microclimates known to be excessively hot and dry, or those prone to dessicating winds, or late spring frosts will cause problems. Hot and dry microclimates will cause leaf scorch and premature leaf drop, as will windier sites. Extremely cold and windy sites have been known to cause bark and cambial damage (Vertrees, 2001). Late frosts jeopardize tender leaves; Japanese maples leaf out early and sometimes an entire year's potential growth can be lost (Dirr, 1998). Cold exposure that would merely cause one year's loss of growth for the more common green and red leaf Japanese maple varieties, will often outright kill the more finely textured dissected leaf varieties (Bean, 1970). Bean (1970) suggests planting all varieties away from harsh winter northern and eastern exposures.

Container cultivation and transplanting

Japanese maples are very well adapted to container growing. This is at least in part attributable to their characteristic shallow rooting habit. From a homeowner's perspective, container grown Japanese maples provide great aesthetic enhancement of patios, porches, and confined urban / suburban environments. From a nursery owner's standpoint, suitability to container growing means great financial gain relative to a small and concentrated area of production. Compared to the other common transplanting methods, balled-in-burlap (B&B) and bare root, container growing allows for greater flexibility when transplanting. Timing relative to seasonal weather considerations and strict attention to the least stressful circumstances possible concerning transport, interim storage, and watering become less crucial to plant survival when containerized material is used. Container growing can be successful on a permanent basis – larger containers can adequately accommodate all sizes of Japanese maple cultivars, not just the dwarf cultivars (Vertrees, 2001).

Two conditions must be met to successfully grow Japanese maples in containers of any size. First, the medium in which the plants grow must be of a structure and texture that allows for good drainage and aeration. The second condition is that regular attention must be paid to the water needs of the specimen, relative to its location and the weather. Steady but not excessive watering is crucial. Minimal fertilization is required (Vertrees, 2001). Regarding soil / media fertility, a more specific recommendation came from the work of horticulturalists at Virginia Tech. Using pine bark media (*P. taeda*) of varying pH levels, it was found that a micronutrient amendment, instead of a lime amendment (a once-common treatment thought to be necessary for counteracting excessive pine bark acidity), was moderately beneficial for growth. Results of the study did, however, suggest that Japanese maple was less particular about its pH and micronutrient requirements than other common landscape species (*Acer saccharum, Cercis canadensis, Cornus florida, Cornus kousa, Koelreuteria paniculata, Magnolia x soulangiana, Nyssa sylvatica, Quercus palustris*) (Wright et. al., 1999).

The absence of a deep root system and the fact that planting stock is commonly container grown make Japanese maples relatively easy to transplant. In soils lacking moderately beneficial structure and nutrient availability, amendments with organic compost of some sort should be made. It is important that whatever sort of compost is used, *it should be well composted*. An amendment in an advanced state of decomposition will help avoid any subsequent nitrogen deficiencies in the soil (Vertrees, 2001).

Japanese maples are also suitable for bare root and ball-in-burlap transplanting. It is recommended that bare root transplants be no more than 4 years of age. As mentioned before, the use of bare root and B&B restricts transplanting flexibility, whereas containerized stock can be transplanted any time of the year. Also, the use of container stock minimizes transplant shock since transplants experience little to no root loss (Vertrees, 2001).

Another benefit associated with Japanese maple's shallow rooting habit relates to its use in close proximity to other garden and lawn plantings, or those plantings more naturalized in design. Japanese maples are not vigorous competitors for soil volume and moisture (Vertrees, 2001). Due to very similar cultural needs, typical companion shrubs include rhododendrons and azaleas.

In summary, Japanese maple has performed admirably in many different growing situations. Dirr (1998) praises this impressive cultural adaptability, as well as Japanese maple's aesthetic capacity: "Probably one of the most flexible maple species as far as landscape uses; magnificent specimen, accent plant, shrub border, grouping, bonsai; definitely lends an artistic and aristocratic touch…(p.29)" As mentioned earlier, understanding a particular planting site's microclimate and modifying cultural treatments accordingly will benefit a Japanese maple's health and vitality. It is also possible that microclimates can exist or be created to exactly suit a Japanese maple in an otherwise less than favorable environment.

4. Economic Sketch

This section will provide a cursory look at the value of Japanese maples as a nursery crop. The 1998 Census of Horticultural Specialties lists Japanese maples as 7% of the total sales of deciduous shade trees. Japanese maple sales in that year totaled $33,168,000. For comparison, the sales of Japanese maples in 1998 exceeded those for sugar maple ($18,521,000), Callery pear ($30,088,000), flowering cherries ($24,810,000), dogwood ($26,633,000), and magnolia ($21,522,000) (USDA, NASS, 1998).

The following table gives a measure of Japanese maple's retail value relative to other popular landscape species, on a single specimen scale. Prices come from the 2002 Weston Nurseries (Hopkinton, Massachusetts) retail catalog. It is interesting to note that the 'Bloodgood' cultivar is priced higher than all other Japanese maple cultivars, including dissected leaf, variegated, weeping, and dwarf varieties.

Table 4.1. Retail value comparison between *Acer palmatum* 'Bloodgood' and assorted other ornamental species

Species and height	price ($)
Acer palmatum 'Bloodgood' 3-4 ft.	240
Chionanthus virginicus (fringe tree) 3-4 ft.	90
Magnolia stellata 'Royal Star' 3-4 ft.	69
Picea pungens 'Misty Blue' 3-4 ft.	135
Acer palmatum 'Bloodgood' 5-6 ft.	330
Acer griseum (paperbark maple) 5-6 ft.	135
Acer tegmentosum 'White Tigress' 5-6ft	165
Cornus kousa hyrid 5-6 ft.	120
Malus spp. 'Donald Wyman' 5-6 ft.	135
Stewartia pseudocamellia 5-6 ft.	210
Cedrus atlantica 'Glauca' 5-6 ft.	180
Picea pungens 'Hoopsii' 5-6 ft.	225

5. Propagation

> "We emphasize that there are about as many method variations of propagating these maples as there are nurseries or propagators. Each has his own method, and most of them are quite successful."
>
> – J.D. Vertrees, *Japanese Maples*, pp. 192-193

Propagation of *Acer palmatum* is commonly done by three methods: seed, stem cuttings, and grafting. Traditionally, the nursery industry has relied on grafting techniques utilizing seedling understock in order to propagate popular and valuable ornamental varieties of Japanese maple. However, advancements in climate controlled greenhouses over the last few decades have led to improved practices and success rates for the propagation of many notable cultivars by stem cuttings. While most of the dissected leaf, variegated, weeping, and dwarf cultivars are still done by grafting, many worthy cultivars, including the well-known red-leaf variety 'Bloodgood', are now done by stem cuttings. Each propagation method has its advantages and disadvantages.

Propagation by Seed

This method of propagation is primarily used to produce massive quantities of Japanese maple grafting understock to be later grafted with the scion material of specificly desired cultivars. Japanese maple open-pollinated seedlings are the standard understock of all Japanese maple cultivars. Germination of seeds collected from *Acer palmatum* var. *atropurpureum* sources, the variety most commonly found in the landscape (these are the burgundy leaved cultivars, 'Bloodgood' for example), will yield seedlings with leaves of varying degrees of burgundy and green. Some will be entirely burgundy, others will be entirely green; most will show shades of both colors. From my own observations, I do not understand why more of these highly variable seedlings, especially those more green in color, do not find their way into the cultivated landscape. The green-leaf varieties are less particular about light requirements than are their burgundy-leaf relatives, and are often equally sensational for fall color (Vertrees, 2001).

Seeds should be collected in the fall before they dry on the tree. The color of the samaras should be at least a shade of pink, if not darker red, to indicate suitable maturation (Hutchinson, 1971). The collection of local seed is best. This decreases the likelihood of excessively dried seed coats and decreased and delayed germination rates (Hutchinson, 1971). The simplest method is to sow the seeds directly in seed beds or flats after collecting, and allow for natural winter stratification (Lamb, 1978). With this method, it is important to consider potential problems with fungi, insects, and rodents. An example of one grower's fall sowing method uses prepared beds of 50% pine bark, 12.5% sand and perlite each (all % by volume), and seeds dipped in fungicide (sometimes a rodenticide, too) covered with 6.3mm (1/4 inch) of medium and 32mm (1 ½ inches) of pine needles. Shade of 70% is provided during the growing season (Wolff, 1991). This example reinforces the notion that each individual grower will likely have their own particular specifications (some more specific than others).

More commonly, growers choose to stratify their seeds in refrigerators. Seed collected prior to being naturally dried should be dusted with fungicide and mixed with moist peat at 4.4ºC (40°F) for 3-5 months (Dirr and Heuser, 1987). Seed I obtained from a grower in Oregon was said to have been unconventionally cold / moist stratified. The unconventional treatment employed an approximate month of seed exposure to below freezing temperatures. No specifics could be obtained due to a staunch attitude regarding trade secret security. Interestingly, others have reported that freezing seed during stratification prevented germination of Japanese maple (Toth and Garret, 1989). Dry seed should be soaked in 43.3ºC (110°F) water for 2 days and then cold / moist stratified for 3 to 5 months. (Dirr and Heuser, 1987.) It should be reported that germination rates will vary with or without strict adherence to specific treatments – dry seed has been known to germinate sporadically over the course of several years. If attempting to germinate Japanese maple seeds, two bits of advice apply: sow many times the number of seedlings one wishes to grow, and do not give up after the first spring.

Grafting

This time consuming and specialized method is still the chief method used for the propagation of slow growing varieties and the dissected leaf varieties of Japanese maple. It is generally accepted that these dwarfs and dissected leaf varieties do not root in high percentages from stem cuttings and this is part of the reason why they are still done by grafting. On the other hand, Bean (1970) has observed scions that have failed as grafted plants, succeed when vegetatively propagated and grown on their "own roots". Also, nursery growers observe faster growth rates with dissected leaf varieties, dwarfs, variegated varieties, and weeping varieties when grown on standard seedling-raised Japanese maple understock. Some growers claim grafted varieties of certain dissected leaf forms and other slow growing variegated, dwarf, or weeping forms, grow in a more commercially appealing form when regular Japanese maple understock is used. These comparisons suggest that somewhere there exist specimen plants of these particular cultivars growing from root systems of their own genetically specific sort – perhaps the original seed-derived mutants, or vegetatively cut sports. Moreover, these "own-root" specimens are well observed by reliable people and comparisons made between them and their grafted counterparts are based on evidence and not just hearsay. No quantitative accounts of these "own-root" versus grafted (onto commonplace Japanese maple rootstocks) growth form comparisons were found in the literature. Most likely the word *commercially* is the key word in the phrase, and as stated previously, generic Japanese maple rootstocks add vigor to the otherwise very slow growing, yet highly valuable dwarf, variegated, weeping, and dissected-leaf varieties.

Grafting procedures vary between growers and are often specific to the climates in which the plants are being grown. In the eastern United States, Japanese maples are commonly grafted during the winter months, with 1 ½ - 2 year old, 6.3mm (1/4 inch) caliper previously transplanted and potted rootstock brought into warm greenhouses (15.5ºC; 60°F) and allowed to break dormancy. Between 1 and 2 months later new white root growth signals grafting time. Scion material of the desired traits is cut from dormant stock plants growing outside, ideally at temperatures above freezing. Side-grafts are most commonly used. Success rates range from about 60% for novices, up to 97% for experts. Sterilization and extreme sharpness of tools are stressed. Successful graft unions produce new growth in about a month. They are left in the same greenhouse until spring for a gradual acclimatization to outside growing conditions. When the grafted plants are placed outside, shading of 40% is recommended, until acclimatization, then shading is removed (Wolff, 1991). Interestingly, the above procedure is that of the same grower who prefers to grow his rootstock material under 70% shading permanently. No correlation is given. This topic, the light conditions of stock plants prior to use for propagation material, will be touched upon in the next section.

In the Pacific Northwest region of the United States, Oregon in particular, grafting of Japanese maples is done during August. This choice of timing is relevant to the scheduling of various other nursery tasks, as well as the region's characteristic long and mild fall season, favorable environmental conditions for graft unions to take. Monrovia Nursery, a large scale producer of grafted Japanese maples, employs bark-grafts. A typical bark-graft uses a small length of scion wood possessing several buds inserted in a T-shaped incision made towards the bottom portion of a 1-2 year old containerized rootstock (Harris, 2003).

In the conclusion section of his book The Grafter's Handbook, Garner (1958) includes a warning against the "misuse of grafting." He admonishes nurserymen who make a habit of grafting all specimens which exhibit the slightest degree of shyness to root (Garner, 1958). This statement hints at the nebulous realm of graft incompatibility. Incompatibilities may lead to a plant's slow, steady, mysterious decline. A grafting union may never be completely successful; a union may only be partial; a union may be successful at first, but ultimately fail; a union may lead to deficiency symptoms, nutritional disorders, degeneration of tissues, abnormalities of stored carbohydrates, premature leaf fall, etc. (Mahlstede and Haber, 1957; Dirr and Heuser, 1987). This list of potential reasons for ultimate plant failure would likely leave academics, arborists, nurserymen, and homeowners alike all standing together, dumbfounded, staring at the dead specimen in the front yard.

Propagation by Stem Cuttings

Propagation by stem cuttings is separated into 3 categories that are based on the suppleness of the stems being cut and the time of year during which the cuttings are taken. Softwood cuttings are typically taken during mid to late spring; semi-hardwood cuttings are taken sometime in the summer, after new growth has increased in firmness; and hardwood cuttings are taken during the dormant season. The majority of stem cutting propagation of Japanese maple uses softwood cuttings. Hardwood cuttings have been reportedly been successful, which I will briefly mention later. It is likely that “soft-wood” cuttings have been taken and rooted successfully that were in actuality more like semi-hardwood cuttings due to their degree of lignification. A growth extension's degree of suppleness is a subjective quality. This is said not to confuse matters, but to remind readers that no single exact timing will result in exact percentages of success and failure, given different individual trees and plants, differing environmental conditions tree to tree, year to year, etc. The success or failure of vegetative cuttings can not always be successfully rationalized or understood. The following paragraphs will synthesize optimal procedures for taking stem cuttings of Japanese maple reflecting decades of experimentation and experience – most of which has been subsequently supported by further experimentation. This information most directly applies to the relatively vigorously growing Japanese maple cultivars such as the ubiquitous burgundy leaf cultivars of confused lineage sharing the trade name ‘Bloodgood’ (Dirr, 2001). The same methods can be applied to other Japanese maple cultivars: the dissected leaf types, the dwarfs, the weeping types, and the variegated, but success rates will typically drop.

Softwood Cutting Procedure and Environment

Softwood cuttings should be taken sometime between late May and mid June, depending on geographic location, with new growth extending 15 - 20 cm (6-8 inches) ideally. The thickest, most vigorous terminal stems should be selected. The source of these cuttings should ideally be an immature, yet well-established specimen. The benefits of juvenility for ease of rooting are strongly evident with Japanese maple. Many growers cut back stock plants heavily to promote an abundance of new shoots suitable for cutting. These stock plants are often containerized and brought into greenhouses mid to late winter and forced to grow in response to the controlled temperatures and supplemental light. One grower brought containerized plants into the greenhouse for forcing with only the cold weather of autumn to satisfy his maples' chilling requirements (Carey, 1974). This technique allows for the cuttings from such stock plants to experience longer than normal growing seasons after root formation has occurred, thereby increasing carbohydrate reserves which helps with overwintering survival (Wells, 1980). The subject of overwintering and its related factors will be discussed in a later section.

As is true with all stem cutting material, cuttings should be taken in the early morning to ensure that they are turgid. Also, they must not be allowed to lose any moisture once they have been taken. The best rooting medium for placing the cuttings is a 2:1 mixture of peat and perlite. Cuttings should possess at least 2 –3 nodes. Thin tips of cuttings should be removed as well as the lower 2 leaves at the base of the cutting. Wounding has proven beneficial. This means a thin slice is to be removed 25 - 38 mm (1 – 1½ inches) in length along one side of base of the stem. The wound should remove the outer bark and expose some central woody tissue – approximately no more than 1.2 mm (1/16 inch) deep (Wells, 1980).

Standard hormone treatment is a 2% indolebutyric acid (IBA) and talc mixture with a fungicide additive, commonly available premixed from nursery suppliers. The strongest available concentration of IBA should be used. Cuttings should be dipped in hormone immediately after wounding and stuck in the rooting medium. They should be stuck about 5 cm (2 inches) deep – burying the cutting up to the top of the wound (Wells, 1980).

Once the cuttings are stuck in the medium, automated misting is very beneficial – leaf surfaces of the cuttings must be kept moist as long as it is daylight. Mist cycles can be reduced during nighttime hours, but still dry leaf surfaces will be detrimental. Daytime temperatures can reach 32ºC (90°F), as long as constant moisture is maintained on the leaves. Bottom heat at 21ºC (70°F) is also advised (Wells, 1980).

The preceding information is based on the life work of Wells (1980) and corroborated by the research and experience of Dirr (1987) and Lamb (1972). All sources neglect to mention information pertaining to the light intensity / degree of shading received by the stock plants prior to the taking of cuttings, and light requirements of the cuttings during root formation. Some degree of shading is common in most propagation houses.

A researcher in West Germany studied the effects of light and shading on *Acer palmatum* 'Atropurpureum' cuttings. The study states that "standard" shading in a propagation house creates light intensity conditions quantifiable within the range of 10 to 200 W/m^2. The study concluded that "light" or "standard" shading appeared to be helpful for rooting and subsequent growing. Uniquely, the study suggested that "moderate" shade, a level of shade slightly heavier than "standard" shade, appeared advantageous for growing the stock plants prior to cutting (Behrens, 1988). Based on previous findings, the study associated the usefulness of shading stock plants with the notion that high sugar and starch levels have been observed to decrease the rooting potential of cuttings (Lovell et al. 1972; Hansen et. al. 1978; Loach and Whalley, 1978; Loach and Gay, 1979; Grange and Loach, 1985). The study also correlated shading of stock plants to lower levels of indoleacetic acid oxidase (IAA-oxidase) activity. IAA-oxidase is an endogenous plant compound known to decrease levels of endogenous auxin, a hormone known for its role in stimulating root initiation (Fang and Butts, 1957; Naqui and Gordon, 1967).

Experiments also have been done successfully forcing shoots from dormant stem sections of Japanese maple, and then using the shoots as softwood cutting material (Henry and Preece, 1997).

Aftercare of Rooted Cuttings

Once cuttings have shown root growth, the after-care is critical for survival. Once roots reach 5 - 8 cm (2-3 inches) in length, individual cuttings should be lifted and potted. The same medium used for rooting will suffice for potting. If the cuttings were generally comprised of at least 3 nodes, it is recommended that a leaf be removed from the middle node. Potted cuttings should be put back under the mist and then gradually weaned off misting over the course of another 3 weeks (Dirr and Heuser, 1987).

"The secret of bringing many plants through the first winter as rooted cuttings is to induce new growth on the cuttings immediately after rooting" (Wells, p.118, 1980.) Japanese maple is very sensitive to additional light. Again "shaded" conditions are mentioned in addition to the supplementary light – the supplementary light is used to increase the photoperiod, not the light intensity. A 60-75 watt incandescent light bulb placed about .91 m (3 feet) above the plants will be sufficient to increase photoperiod and initiate growth. Lightbulb(s) may be left on all night, or put on timers with bulbs turning on and off every 5 minutes for a total duration of anywhere between 4 and 7 hours (Dirr and Heuser, 1987). The bottom line here is that not much energy is needed to achieve the desired effect and therefore none should be wasted.

New growth will most likely occur from the node where the single leaf was removed during potting. Leaves are a source of abscisic acid, a hormone that inhibits growth. Removal of leaves may stimulate dormant buds to grow, if growing conditions are otherwise suitable. The increased photoperiod accomplishes this (Dirr and Heuser, 1987).

Supplementary light should be discontinued in October. Assuming the cuttings are taken around the beginning of June and rooting is accomplished by July, new shoot growth occurs for a full 3 months before the photoperiod is returned to its natural length. During this period of growth, light fertilization (1/4 the suggested concentration) is recommended (Dirr and Heuser, 1987). This recommendation appears again to be based on the life work of nurseryman and Japanese maple enthusiast James S. Wells. Another study urges against fertilization, in particular nitrogen fertilization in ammonium form, at any point prior to the first winter's dormancy of the rooted cuttings (Goodman and Stimart, 1987). Based on another study done by Stimart et. al.(1985), this warning against nitrogen fertilization may most directly apply to outdoor or unheated, unprotected, growing situations that are most susceptible to the vagaries of fall weather. The researchers' understanding is that a delay in cold acclimatization is due to a lack of vegetative tissue maturity brought about by nitrogen fertilization. Furthermore, lack of growth cessation and subsequent cold acclimatization is a more important factor for overwintering survival, rather than the accumulation, or lack there of, of stored carbohydrates in the roots (Stimart et. al., 1985).

As light levels are returned to natural conditions, temperatures should also be allowed to fluctuate and fall as would occur naturally for the season. Some protection should be given to the potted plants in colder climates – air temperatures at about 0.55ºC (33ºF) throughout winter would be ideal for satisfying dormancy requirements (Wells, 1980).

After winter the plants can be transplanted to larger containers or lined out in the field. Prior to bud break, the new growth stimulated by last season's supplementary light should be cut back by half to increase plant density (if desired). The young Japanese maples can be expected to reach about 30 - 46 cm (12 – 18 inches) in size by the end of their first full growing season (Dirr and Heuser, 1987).

Propagation by Hardwood Cuttings

As mentioned previously, hardwood cuttings are those that are taken during the dormant season. For a deciduous species such as Japanese maple, this means that the cutting is merely a stick with some dormant buds that is stuck in a suitable medium. The lack of foliage allows a propagator to forget the worrisome balance between keeping leaf surfaces evenly moist while at the same time maintaining the medium at a state not too moist, and well aerated. For hardwood cuttings, bottom heat is recommended, but air temperatures can remain cool, ideally below the 15.5ºC (60ºF) range, especially at night. These environmental factors – no misting, moderate bottom heat, and little to no air heat result in a very economically efficient way to propagate. The fact that dormant cuttings are taken during the time of year when nursery activity is all but dormant too, means another kind of economy and efficiency is achieved as well: the economy and efficiency of *time.* One paper from the annals of the Combined Proceedings of the International Plant Propagator's Society stood almost alone on this subject. I include a summary of it here because I consider the notion of hardwood cuttings of Japanese maple to be of unrealized merit.

The experiment with hardwood cuttings was begun due to a surplus of grafting scion material. The greatest success has been had with *Acer palmatum* 'Atropurpureum' varieties. This is the name commonly given to Japanese maples that have red colored leaves of varying shades and retain this trait, in varying degrees, when propagated from seed. Successful rooting and survival of this variety has been between 60 – 70%. However, experiments with the dissected leaf varieties have proven more challenging, as is common for these same types when propagated by softwood cuttings. Success is often as low as 25% (Carville, 1975).

Cuttings were taken from field stock plants during the first week of January (Rhode Island). Material was between 4.8 - 9.5 mm (3/16 – 3/8 inch) thickness; possessing 2 –3 nodes. The previous season's growth is taken, ideally as thick as possible, 15 - 20 cm (6 –8 inches) long. Wounds were made, 2 on each cutting, 19 - 25 mm (3/4 - 1 inch) long. Many hormonal solutions have been tried and Jiffy Grow ™ was found to be the best. (10 second dip; 29 mL (1 oz.) Jiffy Grow™ to 87 mL (3 oz.) water; Jiffy Grow™ is a mixture of IBA .5%, NAA .5%. boron .0175%, phenylmercuric acid .01%). Medium is a 2 parts peat / 1 part perlite. Medium was slightly firmed and watered; cuttings were stuck; all was watered again then "ignored". The temperature of the medium was kept between 15.5 - 20ºC (60 – 68 ˚F). Air temperatures were kept below 20ºC (60˚F) at night; no mention of the daytime temperatures. “Excessive top heat and /or overwatering will lead to complete failure, thus my statement to the effect that the cuttings should be ignored. The medium should feel almost dry to the touch and at no time during the first 4 weeks should you be able to squeeze water from a handful of the mix (Carville, 1975, p. 40)"

Roots appear in about 4 weeks (callus in 15 days). Vegetative buds will soon be swelling after roots have been observed. It is imperative not to overwater during this time. Roots will rot very easily at this point. Newly emerging leaves need shading. A mild fungicidal solution is thought to be helpful in controlling *Botrytis* fungal infection. By mid- March the rooted cuttings can be potted, perhaps planted into fields directly in milder climates. 3.77 - 7.5 L (1 – 2 gallon) potted plants can be expected to reach 30 - 38 cm (12 – 15 inches) tall by late August (Carville, 1975).

Carville (1975) concludes by noting, “Unit cost of production is far less than that from softwood cuttings and is considerably less than that from graftage (p. 41).” Another advantage he mentions is that rooted hardwood cuttings are in “phase” with the normal spring time growing conditions and therefore no extra work nor fuss needs to be placed on the necessity of forcing growth before fall, as is the case with softwood cuttings (Carville, 1975).

I found only one other article on the subject of hardwood cuttings of Japanese maple. A researcher in Poland used *Acer palmatum* var. atropurpureum (again, this name indicates generic red leaf Japanese maple) to test various times and temperatures of storage of hardwood material prior to sticking into pots of a 1:1 peat and sand medium. It was found that cuttings obtained in November, stored in plastic bags at 13ºC (55.4 ˚F) for 3 weeks and then stored at 2ºC (35.6 ˚F) for 6 weeks worked best. The researcher suggests that the storage period improves callus and root initiation so that the timing of root growth does not lag behind the development of bud break, once the cuttings are stuck (Marcinkowski, 1988).

The following table summarizes the advantages and disadvantages of each of the 3 previously discussed propagation methods.

Table 5.1. Propagation methods and their advantages and disadvantages

Propagation method	Advantages	Disadvantages
seed	-Increases genetic variability of seedlings; increases potential resistance to pests and pathogens and likelihood of new and exciting cultivars. - simple way to produce an abundant supply of grafting understock	- germination rates can be frustrating -no control over genetic combinations of seedlings - desirable traits of parent trees will most likely be less obviously expressed - low cost/unit
grafting	-Remains the most reliable way to propagate dissected leaf, dwarf, variegated, and weeping cultivars -can increase growth rates of slow growing varieties due to more vigorous nature of understock root system -genotype of desired variety is retained - often done during winter; a slow time for nursery people	-often requires heated greenhouse space - requires skilled employees -uses considerable time and space for limited amount of end product (high cost/unit) -success percentages vary, sometimes for mysterious reasons
softwood cuttings	-Once specific timing and hormone treatments are worked out, many propagules can be simply processed -genetically controlled desirable traits of stock plant are retained -relatively unskilled labor can perform the task	-special propagation facilities are needed -has not yet been used effectively for dissected leaf, variegated, weeping, and dwarf varieties -success percentages vary -done during spring; a very busy time for nursery people - intermediate cost/unit
hardwood cuttings	-Time of cutting coincides with nursery industry slow season -Due to lack of leaves on cuttings, misting system is not needed -Cuttings after root growth and bud break are in phase with natural outdoor cycles	- again difficulties are had propagating dissected leaf, variegated, weeping, and dwarf varieties

6. Cultural Challenges

> "In general, Japanese maples have fewer pathological problems than many other genera of woody ornamentals. When grown under normal conditions and with good culture, they are remarkably free of disease and insect problems..."
>
> - J.D. Vertrees, *Japanese Maples*, p. 78

The following section is brief compilation of the problems encountered by Japanese maple growers, typically mass producers and collectors whom have been closely observing and studying Japanese maples for many years.

Fungal Diseases

Verticillium, *Fusarium*, *Botrytis*, *Pythium*, *Pseudomonas*, and Anthracnose are all fungal pathogens known to affect Japanese Maples. All degenerate plant tissue, especially vascular tissue, disrupting healthy plant functioning and typically resulting in whole or partial plant mortality. The most common occurrences of fungal disease relate to mass rearing of seedlings or asexual cuttings (Vertrees, 2001).

Verticillium is a soil borne pathogen known to plague many species of woody plants. Typical symptoms include wilting and die back of young twigs – vague symptoms that appear the same as those from leaf blight, leaf scorch, and general root disturbance. *Verticillium* is often spread by propagation tools and therefore meticulous sterilization is important. *Botrytis* and *Fusarium* are two fungal pathogens known to infect concentrated collections of seedlings causing what is called "damping off". Both pathogens also attack older plants as well. It is thought that overfertilizing field seedlings with nitrogen can lead to increased threat of *Botrytis*. Frost damage and unnatural hardening off processes in general have been known to result in damaged tissue with increased *Botrytis* susceptibility. *Pythium* and *Pseudomonas* attack and enter fresh tissue of emerging seedlings at or below ground level. Conditions most commonly leading to *Pythium* and *Pseudomonas* losses involve warm moist springs and summers, with seedlings growing in alkaline to neutral pH conditions, especially if the soil is heavy in texture or unusually rich in nitrogen. Anthracnose is a disease that overwinters on dead twigs and branches and infects newly emerging leaves in the spring. Cool wet springs are ideal for infection. Leaves suffer necrotic spots that can often coalesce and render the leaf useless. The infection may also penetrate the stem via the petiole and cause stem dieback. The specific Anthracnose known to afflict Japanese maple is *Kabatiella apocrypta*; it can be recognized by the light tan color of the afflicted leaves (Sinclair, Lyon, and Johnson, 1987). Control involves the removal and burning of dead limbs or the use of preventative fungicidal sprays twice as the leaves open in spring (Greenwood, 2000; Vertrees, 2001).

Three other fungal diseases, not mentioned above, are powdery mildew *Phyllosticta* leaf spot, and *Cristulariella* leaf spot. These pathogens are not as aggressive, nor as potentially lethal, compared to those mentioned above. Powdery mildew is a general group of fungi characterized by a grayish-white cast to the leaves due to a profusion of fungal mycelia growing on the leaf surfaces. Photosynthesis is impeded, but the spread of the fungus does not extend to internal plant tissue. Dry soil conditions combined with moist air conditions allow powdery mildews to thrive. Control involves soil irrigation during dry times – and avoidance of unnecessary moisture on the leaves (Greenwood, 2000). *Phyllosticta* leaf spot (*P.minima*) causes brown, changing to tan, small (5cm or less diameter) spots on leaves. The spots are often bordered with a reddish purple hue, and for this reason the pathogen is sometimes call *eye spot*. If infection is severe, spots will coalesce to form larger, irregularly shaped necrotic areas (Sinclair, Lyon, and Johnson, 1987). *Cristulariella* leaf spot (*C. depraedens*) causes small necrotic spots similar in size and shape to *Phyllosticta*, but slightly different in color - grayish-brown with a dark border. Cool wet weather in midsummer favors *Cristulariella* growth, causing spots to coalesce and give the leaves a "scalded" look (Sinclair, Lyon, and Johnson, 1987). Leaf spot afflictions typically do not warrant treatment. They are most often only superficial. Major defoliation can occur but natural weather fluctuations usually keep proliferation of the fungi in check (Sinclair, Lyon, and Johnson, 1987).

Relative to all the above fungal pathogens, especially in a nursery setting, control can be achieved by decreasing plant density and increasing air circulation and sunlight exposure.

(Amongst nurserymen, a wise old saying has it that free air circulation and sunshine are the two greatest and most economical fungicides.) Fungicidal soil drenches are also commonly used to help control outbreaks of those pathogens which are soil borne. Avoidance of overhead watering and removal of dead stems also help control fungal problems.

Cankers

A canker is any necrosis of trunk or stem cambial tissue. Cankers are often fungal infections or, less commonly, bacterial infections that have gained entrance via open wounds. Cankers cause abnormalities in bark or stem appearance. Infected areas may be sunken, raised, discolored, etc. Some sign of necrotic cambial tissue is apparent. Canker is a generic term: many different species of cankers infect many different species of plants – symptoms and severity of reactions vary greatly. Some cankers are entirely defeated by a plant's defenses; others may be so overwhelming that no part of the plant is left healthy and death results within just a few years.

Fungal species in the genera *Nectria* and *Phytophthora* (the latter more commonly seen as a root rot) have been observed to infect Japanese maples (Vertrees, 2001). The fungus *Colletotrichum acutatum* was identified as the pathogen causing high rates of mortality of Japanese maple asexual cuttings at a nursery in Connecticut. This is significant because *C. acutatum* had not previously been identified as a primary pathogen of woody plants in North America (Smith, 1993).

The bacterium *Pseudomonas syringae* has been associated with leaf spots, vein blackening, and tip dieback of Japanese maples. This last sign of disease is considered a canker. The spread of *P. syringae* is in part accelerated by the bacterium's production of a toxin that destroys host cell membranes. Interestingly, tip die back may result from the capacity of some strains of *P. syringae* to act as a nucleating point for the formation of cell damaging ice crystals during winter time. This trait reduces an infected plant's ability to protect against cell damage by "supercooling," a technique by which nucleating points are removed from intra to extracellular spaces thereby preventing the formation of ice crystals within cells until uncommonly cold temperatures are experienced. It is believed that tip die back of Japanese maples results from the combination of cold and *P. syringae*, while either agent alone would be virtually harmless (Sinclair, Lyon, and Johnson, 1987).

Avoidance of cankers is the recommended strategy. Proper pruning techniques and the maintenance of trees at optimal levels of health and vigor by sound cultural practices will help avoid problems.

Chlorosis

Chlorosis, a steady yellowing of a plant's leaves, indicates a nutrient deficiency often associated with a soil pH either too acidic, or more commonly, too alkaline. Macro and micro nutrients have ranges of soil pH values at which they are available for root uptake. Outside of these ranges nutrients become chemically locked up the soil and unavailable for uptake. Though Japanese maples are known to have a wide tolerance of soil pH values, chlorosis does occur occasionally. In higher pH soils an abundance of calcium restricts the availability of iron and this deficiency of iron leads to interveinal chlorosis. Attempts to remedy the lack of available iron provide only temporary benefits (Vertrees, 2001). It is most important to know the soil conditions of the planting site prior to planting the tree.

Insects / Pests

Japanese maples do not generally suffer from debilitating pest infestations. Some years may bring problems with aphids (family: Aphididae), sap sucking insects of leaves and tender shoots. Springs following mild winters are more likely to bring about heavier aphid populations. The damage is primarily aesthetic. Sooty molds develop on leaves covered with aphid "honeydew" (excrement) furthering the aesthetic damage. Aphid sprays, the kind commonly available for rose bushes, are effective for control – especially when aphid populations are first noticed (Vertrees, 2001).

Less common than aphids are spider mites (family: Tetranychidae). Mites also suck sap from leaves. Evidence of mite damage is noticeable by a yellow stippling of the leaves. Mites tend to successfully attack already weakened trees. Drought is a common example of a predisposing stress. Japanese maples growing in less hospitable sites also succumb more easily to mites (Vertrees, 2001). Other kinds of mites occasionally affecting Japanese maples are gall-forming mites and Eriophyid mites (many from the genus *Trisetacus*). Eriophyid mites are a diverse group of very small, almost microscopic mites (0.1 – 0.3 mm). It is thought that many species of this group exist that have not yet been identified and studied. Some of the symptoms caused by the various species of Eriophyid mites are as follows (Nielsen, 1998):

- Russeting, or rusty, silvering or bronzing of leaf surfaces from feeding
- Gall formation – injection by mites of plant growth regulators causing irregular tissue growth for the purpose of sheltering and feeding the mites
- Erinea – hairy patches on the surfaces or undersides of leaves and petioles; patches help mites anchor themselves
- Leaf edge rolling – a symptom of feeding and again thought to be a shelter of sorts
- Bud destruction – feeding within buds, destroying embryonic parts, often resulting in disturbed irregular subsequent growth; sometimes similar to herbicidal injury
- Other symptoms of Eriophyid mite activity: witches-brooming, retarded maturation of fruits, berries, etc.; blistering of leaves; virus-like symptoms; virus transmission; bacteria transmission

Another sap sucking pest reported to occasionally use Japanese maple as a host is Cottony Camellia Scale; also known as Cottony Taxus Scale (*Pulvinaria floccifera*). The presence of this pest becomes obvious only after the white, "cottony" egg sacs appear on the undersides of the leaves. Damage caused by Cottony Camellia Scale results in off-colored, lighter green foliage (Johnson and Lyon, 1991).

Of the chewing pests (as opposed to sucking), various Lepidoptera most affect Japanese maples. Examples include fall cankerworm (*Alsophila pometaria*), green-striped maple worm (*Dryocampa rubicunda*), and the maple-leaf cutter (*Paraclemensia acerifoliella*). Typically, the defoliation is not host specific. During years of heavy defoliator populations the majority of landscape plants are vulnerable, Japanese maples included. Only in repeatedly infested areas, or in years of very heavy defoliator populations, is insecticide application warranted (Vertrees, 2001).

Japanese beetles (*Popillia japonica*) are both a leaf and root feeding pest, and may occasionally cause partial defoliation of Japanese maples. Both immature and mature forms of Japanese beetle can damage plants. Immature and partially mature beetles (grubs) live in the soil and feed extensively on new root growth, often damaging a smaller specimen beyond recovery before the problem is diagnosed (Johnson and Lyon, 1991). A research field test study comparing Japanese beetle feeding on green vs. red leaf varieties concluded that the red leafed cultivar 'Bloodgood' was especially attractive to congregating Japanese beetles. The study found that defoliation of 'Bloodgood' could be as high as 32%, compared to an average of 10% for other common red or green leafed landscape plants (Rowe et. al., 2002).

Another root feeding pest, root weevils (*Otiorhynchus spp*.), can be a particular problem in Japanese maple nursery environments. Roots may be stripped of all bark and vascular tissue, including the cambium. Such damage is most commonly a problem with seedlings. Both those in the soil and those growing in flats or small containers are at risk Transplanting seedlings in the fall helps alleviate losses (Vertrees, 2001; Harris, 1982).

Bark beetles, usually *Scolytus* species, attack and bore into stems and small limbs of stressed trees, especially dense plantings of young stressed trees in a nursery setting. These kinds of beetles are drawn to trees in poor health because such trees emit ethylene gas that acts as a semiochemical. A semiochemical is a compound that stimulates an organism to behave in a certain way. *Scolytus* beetles are often no bigger than a grain of rice. Eggs are laid in bark crevices and the resulting larvae bore into the stem tissue and channel all around often damaging vascular tissue to the extent that infested stems can no longer sustain themselves and dieback results. The beetles also have symbiotic relationships with fungi (generally *Ophiostoma spp*.)(Showalter and Filip, 1993). The beetles introduce the fungi within the tree. The fungi feed off the tree's carbohydrates. The beetles feed on the mycelia of the fungi. *This relationship is not symbiotic for the tree.* Damage is done in summer and autumn and is often not noticed until spring when buds fail to develop. Springtime is also the time when fully grown beetles exit the trees and go elsewhere to lay more eggs. Small exit holes in the bark can be seen at this time but, of course, the damage has already been done. However, if dieback is only partial, it is a good idea to cut out and burn the dead branches to curtail the spread of internal rot from the fungus. The best control of bark beetles is avoidance. As it is mentioned several other times previously in this text, it is important to plant Japanese maples in reasonably suitable sites. Sites that are deficient in moisture should be irrigated judiciously. Afternoon shade would be helpful in hot and dry environments (Vertrees, 2001).

Leaf Scorch

Physiological leaf scorch is a water relations problem, not to be confused with bacterial leaf scorch, the xylem restricting wilt pathogen. Leaf scorch is the necrosis of leaf tips and margins, spreading inward between the veins. The condition occurs when plant roots are unable to take up enough water to balance their transpirational losses. Prolonged periods of water deficiency cause stem dieback. Factors contributing to leaf scorch include heavy winds, salty winds, and poor soil conditions, such as heavy texture and poor permeability, or sandy texture and low moisture retention. These conditions cause high levels of transpiration and evaporation via the leaves, a problem compounded by low levels of available water at the roots. Excessive alkalinity or nitrogen in the soil, as well as late spring frosts cause similar leaf and stem conditions. Overhead irrigation during hot, sunny weather (during the hottest part of the day) will cause leaves to be scorched, especially on the red, dissected leaf Japanese maple types. The damage caused by leaf scorch translates to a loss of vigor during the present growing season. Generous mulching of the root zone and supplemental watering during droughts help avoid leaf scorch (Vertrees, 2001). A pigment bleaching leaf scorch starting at the tips of lower leaves and spreading down the leaf and up the plant was observed by researchers at NC State. They also observed another type of leaf scorch without bleaching characterized by general and erratic leaf necrosis. Under greenhouse growing conditions, leaf water potentials of -14 bars were measured in healthy leaves of nonstressed plants, compared to -30 bars in stressed plants (Moles and Raulston,1979).

Leaf Color Fading of Red Leaf Varieties

Some Japanese maple aficionados are troubled by the fading of red leaf varieties due to the inevitable heat of summer. Leaves that were the deepest burgundy in spring tend to fade to a burgundy tinged with green, or sometimes an interesting bronze color. This occurrence is predictable with cultivars that are propagated and grown in more northerly climates and then shipped and planted somewhere in the south. A study was conducted at North Carolina State, helping further understanding about leaf color retention and temperature.

Field observations led researchers to suggest that night temperatures were more influential than day temperatures. Cooler nights typically minimize the loss of carbohydrates associated with maintenance and uncoupled respiration. This leaves more carbohydrates for growth, storage, and pigment production (Lambers, 1985). Reddish pigmentation in leaves is due to glycosidic flavanoid compounds called anthocyanins (Goodwin, 1976). Known to be common in young leaves, anthocyanin concentrations that remain steady throughout the growing season are much less common and therefore highly desirable for ornamental use. Anthocyanins tend to accumulate when sugars in leaf tissue exist at levels exceeding that which is required for immediate growth. Anthycyanin presence is dependent on the rate of carbohydrate metabolism (Goodwin, 1976). Cooler night temperatures decrease dark respiration rates and lead to higher sugar contents in leaves, increasing production and retention of anthocyanins (Levitt, 1972). With high night temperatures anthocyanin pools in leaves are gradually depleted by the demand for energy to account for high levels of respiration uncoupled with photosynthetic carbohydrate gains (Deal et. al., 1990).

Researchers concluded that Japanese maples grown and selected for propagation in areas with reliably cooler summer night temperatures – areas of more northerly latitude, areas of higher elevation, and areas with lower water vapor in the air – would be aesthetically and physiologically hindered by the higher night temperatures of areas such as the U.S. Southeast. This means that growth is also impaired by high night temperatures and associated uncoupled respiration (Deal et. al., 1990). These concepts suggest red leaf Japanese maples ought to be selected from experimental field plots growing in the Southeast, or other regions with higher night temperatures than the traditional testing grounds of Oregon, New England, the Netherlands, New Zealand, and England.

7. Summary

Japanese maples have long enjoyed a wide reputation for beauty. Several other factors combine to ensure continued cultivation of the species. Plant collectors and horticulturalists admire them for their seedling variability. Every seedling has the potential to be uniquely beautiful. Beyond the beauty, Japanese maples have proven themselves to be adaptable to a wide range of environmental conditions. *Beauty with substance* - cultural adaptability is an attribute every gardener appreciates in a plant specimen. Nursery growers have good reason to respect Japanese maples, too. Moderate ease of propagation, limited problems with pests and pathogens, and high marketability are attributes that will always make for a good relationship between plant and commercial grower.

By this point in the document it should be excusable if I draw from my own opinions and experiences. I would like to acknowledge that J.D. Vertrees' *Japanese Maples* did more for me than bear an apparently heavy citation load. The book served as a steady photographic reminder of why Japanese maples deserve special attention. Now, I too, have a unique collection of Japanese maple seedlings in my garden and I can hardly wait to see what they will look like when spring comes and they unfold their fresh leaves.

Regarding the literature, I admit to being most impressed by the tales of Japanese maple's wide-ranging environmental adaptability. I had always assumed Japanese maples were too finely structured and artistic to be tough and uncomplaining. My observations of suburban and urban specimens from Virginia north to Maine have served to bolster all that I have read about the species' environmental versatility. I've seen tip dieback and leaf scorch occasionally, but never to the extent that I felt a specimen needed to be put out of its misery.

I would like to mention another important attribute I did not find discussed anywhere in the literature: Japanese maple's strength against snow and ice loading. Blacksburg is a place where it seems winter storms refuse to deliver precipitation in one consistent form. Snow, sleet, and rain tend to fall interchangeably and cover the landscape in icy layers. Many of the older Japanese maples I see around town show no sign of having ever had their architecture harshly altered. Dr.s Seiler, Kane, and Harris, the members of my committee and reviewers of this document, together have observed many Japanese maples and agree the species appears to be strong wooded. This impressive trait deserves further attention.

My research efforts also pointed out many holes and thin spots in the body of Japanese maple research. The following are suggested topics that could use further investigation:

- greater precision regarding water and nutrient requirements of Japanese maples
- investigation of Japanese maples and urban environmental tolerance
- investigation of Japanese maples and limits of soil adaptability and tolerance
- greater understanding of tip die back of Japanese maples
- improved methods of propagation for dissected leaf and other specialty varieties

Also, field studies should be conducted in an effort to select and propagate specially adapted Japanese maple individuals for the following traits:

- drought and heat tolerance / tolerance of urban conditions
- cold hardiness

- red leaf color retention for hotter climates (diversity beyond 'Bloodgood')

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Vita

Guy Phillips was born in Poughkeepsie, New York. This is not a fact he acknowledges readily. Since then he has lived most of his days between Massachusetts and Maine. He received a Bachelor of Arts degree in History from Boston College, and then went into early retirement before he ever really began working. Many years spent enjoying this nation's diverse countryside led him to consider studying an environmental discipline. Fed up to the teeth with the media's portrayal of environmental issues he finally signed up at Virginia Tech in hopes of learning some science on which to base his own opinions. He is proud to have studied in the Forestry department. He still climbs trees for fun.