



# ARNOLDIA

*The Arnold Arboretum*

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Front cover: Female cones amidst the whorled foliage of *Pseudolarix amabilis*.  
Photograph by G. Koller.

# Sargent's Weeping Hemlock Reconsidered

by PETER DEL TREDICI

The Sargent weeping hemlock (*Tsuga canadensis* f. *pendula*) is a tree that inspires amazement and wonder in anyone who is fortunate enough to see it. Mature specimens can be twelve to sixteen feet high and twice as broad. The pendulous foliage cascades down to the ground giving the plant a fluidity that more upright trees lack. Not only is this variety of hemlock the most beautiful of the hundreds of known hemlock forms, but it also has the most colorful history, involving many of the horticultural giants of the late nineteenth century. Tradition has it that four weeping hemlocks were found near the town of Beacon, New York around 1860 and that from these all future generations of Sargent's hemlock were propagated. Then in 1939 Mr. A. B. Stout, writing in the *Journal of the New York Botanical Garden* (Vol. 40; 153-66) announced the discovery of a fifth weeping hemlock of the Sargent type growing in the wild about nine miles east of the town of Beacon. In the same article, Stout gives a thorough discussion of the pre-1939 history of weeping hemlocks and makes the first attempt to analyze their habit of growth.

Since 1939, very little original work has been done on the weeping hemlock. This article is intended to bring the literature up to date.

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Figure 1. *The first known illustration of Tsuga canadensis f. pendula, from The Garden, October 22, 1887. The high, narrow crown clearly suggests that staking played an important role in the development of this specimen.*

#### DISCOVERY

The history of the Sargent weeping hemlock (*Tsuga canadensis f. pendula*) has always been shrouded in confusion, due partly to the lack of precise information regarding the date, location and appearance of the original wild seedlings, and partly to the numerous misstatements that seem to flow directly from one horticultural author to the next without ever being critically examined. The only way to resolve the confusion and conflicts that have arisen in the weeping hemlock literature is to go back to the original sources — the writings of the people who were directly connected with the original seedlings when they were found — to see what they had to say.

The first mention of weeping hemlocks was formerly thought to be in the October 9, 1875 edition of the British periodical *The Garden*. Unfortunately, this reference says nothing about the trees except that they existed in 1875. I have discovered another much more useful statement, also from 1875, that constitutes the first description of *Tsuga canadensis f. pendula*. It comes from Mr. Henry Winthrop Sargent (the person for whom the tree is named and who first introduced the plant into horticulture) in the supplement to the 1875 (Ninth) edition of *A Treatise on the Theory and Practice of Landscape Gardening*, by A. J. Downing. The Appendix to the Ninth Edition is fourteen pages long and contains no less than five references to the weeping hemlock, the most important of which is on page 581:

*Abies canadensis pendula*, or *Sargenti*, as sometimes called, is a very interesting and distinct variety of Hemlock. It is as pendulous as a Weeping Cherry, perfectly hardy, and admirably adapted for small places, though as yet very rare, Messrs. Parsons, of Flushing, alone having plants for sale. It is a sport of our native Hemlock, found in the Fishkill Mountains.

The most important item in this reference pertains to the location of seedlings for it shows that as early as 1875 the exact location of the original plants was not precisely known. The term "Fishkill Mountains" covers a rather broad geographical area. According to P. H. Smith, on page 174 of his *General History of Dutchess County*, published in 1877, "the Fishkill Mountains, extending along the southern border [of Dutchess County], are high, rocky and precipitous." In a map included in the book, the "Fishkill Range Mts." are shown to follow the southern boundry of Dutchess County from the east shore of the Hudson River to the Village of Hortontown. At this point, they turn away from the county line and move in a northeasterly direction up to the town of Dover Plains, where they end. They run a total distance of about thirty miles, and Mount Beacon, on the Hudson River, at 1685 feet, is their highest point. The broader geographical term "Hudson Highlands" includes the Fishkill Mountains, as well as mountains on the west bank of the Hudson, in Orange County.

The second reference to the original seedlings comes twenty-two years later from H. W. Sargent's cousin, Professor C. S. Sargent of the Arnold Arboretum, writing in Volume 10 of *Garden and Forest*:

There are a number of abnormal forms of *Tsuga canadensis* in gardens. The most distinct of them was found about forty years ago on the Fishkill Mountains, in New York, and was first cultivated and made known by Mr. H. W. Sargent. This plant, which is now usually called in gardens, Sargent's Hemlock, is a bush about three feet high with short pendant branches and branchlets, forming a remarkably dense, compact flat-topped mass of foliage. Several of these plants were originally found together and transplanted, and the largest of them which I have seen is on the Howland estate, in Matteawan, New York, and is now about twenty five feet across. This variety has been propagated by grafting the branches on the ordinary Hemlock, but in a few years, the grafted plants form an erect stem and lose the dense low habit which is the charm of the original seedlings. [pp. 490-91]

This statement is particularly important because it makes a distinction between the appearance of the original seedlings and the appearance of the subsequent grafted propagations. It is also impor-

tant because it puts the date of discovery of the seedlings at "about" 1857 (1897 minus 40 years). This figure should only be taken as a rough estimate, however, because one year later in Volume 12 of *Silva of North America* (1898) Professor Sargent states that the seedlings were found ". . . about thirty years ago . . ." a figure that puts the discovery date at "about" 1868. The best one can do with these two conflicting statements is to say that the seedlings were found some time between 1857 and 1868.<sup>1</sup>

The next reference to the original seedlings comes twenty-three years later from Sargent's colleague at the Arnold Arboretum, E. H. Wilson. Writing in *The Garden Magazine* (September 1920), Wilson was the first person to credit General Joseph Howland with the discovery of the wild seedlings and the first to mention that one of them was growing at Professor Sargent's estate in Brookline, Massachusetts.

In 1923, Murray Hornibrook in his book *Dwarf and Slow-Growing Conifers*, contributed what I would consider to be the last original reference to the Fishkill seedling:

Bean [W. J. Bean, *Trees and Shrubs Hardy in the British Isles*, 1914] separates these two varieties [the taller, upright *pendula* and the more compact *Sargentii*], but Professor Sargent informs me that the nurseryman's stock has all been produced from grafts from the four original plants found near the summit of Fishkill Mountain (near Beacon City, on the Hudson River) by General Joseph Howland about 1870. The finder grew one in his own garden at Matteawan, N.Y., gave the second to Mr. Henry Winthrop Sargent, of Fishkill; <sup>2</sup> the third to Mr. H. H. Hunnewell, of Wellesley, Mass.; and the fourth to Professor C. S. Sargent of Brookline, Mass. The second and third are dead, but the first and fourth have made very fine specimens. Grafted plants in general cultivation vary considerably, some being dwarfer and more compact than others. The best form makes a very compact hemispherical mass of pendulous branches. [pp. 185-86]

<sup>1</sup> In the 1898 *Silva* article, Sargent also says that the seedlings grow to be "two to three feet in height and twenty feet across." This is noteworthy, given the fact that in 1897 he said that the largest seedling was twenty-five feet across. This discrepancy, coupled with the discrepancy in dates, suggests that the "Silva" passage, while copyrighted 1898, was actually written before the 1897 article.

<sup>2</sup> A source of constant confusion in the literature on Sargent's weeping hemlock has to do with the use of the word Fishkill. H. W. Sargent lived in Fishkill-on-Hudson. General Howland lived in Matteawan. These two towns were side by side. In 1913, they merged to become the present town of Beacon. The present town of Fishkill is about 5 miles north of Beacon and has nothing to do with the original seedlings.

This statement of Hornibrook's was paraphrased in an article that appeared in the February 23, 1924 issue of *The Garden*. Mysteriously, the article is usually considered anonymous, but, in fact, it is clearly signed by E. H. Wilson. The fact that Sargent was alive when these two statements, by close associates appeared, makes it likely that they are reliable. However, the fact that they also contain the same obvious error (the phrase, ". . . near the summit of Fishkill Mountain . . .") must make one wary of the possibility of other mis-statements, especially when one considers that Hornibrook was giving a second-hand report forty-eight years after H. W. Sargent initially announced the discovery of the plants.

### The Fishkill Seedlings In 1980

The *Howland Hemlock*, at Beacon, New York, is in good health and looks much as it did in 1939. The normal hemlock that was shading it in 1939, is still there and has completely killed one side of it. Since 1939, the tree has put on about 2 feet in height and about 1 foot in breadth. Figure 2 shows the tree, and in Table 1, I have put together all available data on its growth.

The *H. W. Sargent* and *Hunnewell Hemlocks* are still as dead as they were when Hornibrook announced it in 1923. It is interesting to note that this first mention of their death is also the first and only mention of their existence. C. S. Sargent makes no mention of a *Tsuga canadensis* f. *pendula* in his article about H. W. Sargent's estate, Wodenethe, written for *Garden and Forest* (1897a). This is a noteworthy omission since he says specifically that:

Of the hundreds or perhaps thousands of conifers planted by Mr. Sargent during the years of his greatest activity, when he ransacked every nursery in Europe for species and abnormal forms, those which we have mentioned are now the only ones which are conspicuous for their size and healthy condition. [p. 449]

As for the Hunnewell tree, H. H. Hunnewell himself makes no specific mention of a *Tsuga canadensis* f. *pendula* in any of his various writings about his Pinetum at Wellesley (*Life, Letters and Diary of Horatio Hollis Hunnewell*, 1906). However, a "Sargenti" is shown on a map, drawn in 1895, that is included in Vol. 3. This same tree is still standing in 1980, an impressive, multi-stemmed specimen about sixteen feet tall. (fig. 3) While it is possible that this tree might be one of the original seedlings, there are no references to support this contention, and Hornibrook's 1923 statement clearly says that it is not. For lack of evidence to the contrary, then, it must be assumed that both the H. W. Sargent and the Hunnewell seedlings died prior to 1900.

The *C. S. Sargent Hemlock*, at Brookline, Massachusetts, has put on only 6 inches of height growth since 1939 but nearly 6 feet of





Figure 2. *The Howland Hemlock at Beacon, New York. The tree is about 13 feet high and 36½ feet across at its widest point. The trunk system is multi-stemmed. Photograph by A. Kelley.*

horizontal growth. The tree is quite healthy and promises to live on indefinitely. In 1962, Alfred J. Fordham gave this plant the cultivar name 'Brookline'. Table 1 gives a history of its growth, and figure 4 shows the tree as it appeared in 1900, figure 5 shows the tree as it appears in 1980, and figure 6 shows the remarkable trunk system of this tree, illustrating, from the underside, the total horizontality of the tree.

### **The 'Horton'**

In his 1939 article, Stout announced the discovery of a very old, wild-growing, weeping hemlock growing about nine miles from Beacon, New York, which he chose to call the 'Horton'. As far as I know, this first mention of the tree is also the only mention of it. When Mr. Augustus Kelley of Little Compton, Rhode Island, told me that the 'Horton' hemlock was still alive and well in 1980, I resolved immediately to go and see it for myself. It turned out to be a beautiful specimen of a tree, perched on a hillside overlooking what is now known as the Taconic State Parkway to the west and the village of Hortontown to the east. This location puts the 'Horton' squarely in the center of the "Fishkill Range Mountains" as described by Smith in 1877. The 'Horton' is completely healthy and is located on the property of Mr. Joob Veldhuis (fig. 7). Currently, Mr. Veldhuis is using the tree as a kind of storage shed, a use to which it is admirably, if ignobly, suited. The pendent branches totally conceal no less than half a cord of wood, a hundred-gallon oil tank, a ladder, a



Figure 3. *The trunk of Tsuga canadensis f. pendula, growing at the Hunnewell Pinetum, Wellesley, Mass. The tree is most likely not one of the original seedlings. Photograph by P. Del Tredici.*

wheelbarrow, numerous packages of shingles and innumerable other artifacts of country life. The tree stands 18 feet, 3 inches tall, and describes a circle on the ground 31 feet across (all measurements were taken from the downhill side of the trunk). The trunk is 24½ inches in diameter at a height of 4½ feet. The lowest branch is at 5 feet and the main branches, which make up the framework of the tree, start about 8 feet up the trunk. In this upper framework, there is considerable self-grafting, where branches have touched one another. In 1939, Stout described the trunk as quite angular, and not fully erect. Forty years of stem thickening has eliminated much of that angularity (fig. 8). Except for the increase in the size of the tree, it seems to be identical to the way it was when Stout discovered it. In Table 1, I have summarized the changes the tree has undergone.

Having seen the 'Horton', I was not satisfied with vague speculation about its age or origin, so with the help of Mr. Jack Karnig, chief forester at the Harvard Black Rock Forest at Cornwall, New York, I took a small core sample from the lowest branch of the tree (at 5 feet). While this core could not give me the total age of the tree, it gave me the age of the tree when it was 5 feet tall. Counting the annual rings under a 25× power dissecting microscope revealed that the branch at 5 feet was 119 years old. The rings were extremely small showing an average width of 0.5mm. By subtracting 119 years from 1979, I came up with 1860 as the date at which the Horton was at least 5 feet tall. Given that the Fishkill seedlings could have been



Figure 4. The C. S. Sargent Hemlock at Brookline, Mass. as it appeared in 1900. Photo by A. Rehder from the Archives of the Arnold Arboretum. Using the length of the needles for scale (currently the tree has needles that average 1.5 cm in length), the tree measured about  $3\frac{1}{2}$  feet by 9 feet.

found any time between 1857 and 1868, the date of 1860 becomes significant because it makes it likely that the 'Horton' is a wild tree and not an early propagation of the Fishkill plants. As to just how old the 'Horton' might be is hard to say. A core sample taken from a branch at 6 feet showed 115 rings, meaning that it took four years for the tree to grow one foot. Working backwards, this meant it would have taken the 'Horton' twenty years to grow 5 feet, putting the total age of the tree at 139 years. The age of the tree may be calculated in a different way, using Stout's finding that seedlings of *pendula* increased in height a bit less than 2 inches per year over a period of 23 years. Using this figure, it would have taken the 'Horton' about 30 years to reach 5 feet, putting the age of the tree at 149 years.

Regardless of whether one accepts either of these projected figures, the known age of the tree at 5 feet is sufficient to make the 'Horton' at least as old, if not older, than the Fishkill seedlings. The fact that the 'Horton' is growing "on the Fishkill Mountains" makes it possible that it might be the parent of the Fishkill seedlings found by General Howland. This seems a rather unlikely relationship, however, given their closeness in age. More likely is the suggestion that the 'Horton' is a sibling of the Fishkill seedlings, a fifth seedling, that was either not discovered or was too big to move. It is also possible that there was a time when there were many more weeping hemlocks in the area, but only the 'Horton' and the Fishkill seedlings survived.

Regardless of which hypothesis one prefers, the close geographical proximity of the 'Horton' and the Fishkill seedlings makes it likely that they are somehow related to one another.

When I visited the 'Horton' in February of 1980, the tree was covered with cones which were full of sound seed. I collected as many of these as I could, along with numerous cuttings. These seeds and cuttings are now being grown at the Arnold Arboretum for further study. It will be particularly interesting to see if the cuttings grow up to have the same erect single stem that the 'Horton' does, and if the seedlings will be weepers, as they are in the case of other specimens of *pendula* that have produced cones (Jenkins, 1935; Stout, 1939).

#### NORMAL HEMLOCK vs. "WEEPING"

##### Normal Hemlock Growth

*Tsuga canadensis* f. *pendula* is a mutant form of *Tsuga canadensis*. In order to understand the nature of the *pendula* mutation, it is crucial first to understand the nature of the normal hemlock tree. Fowells, in *Silvics of Trees of North America* (1965) summarizes the pertinent literature on the growth and development of hemlock, and Mergen, writing in the journal, *Forest Science* (1958), gives an excellent and very precise description of the growth of the terminal shoot of hemlock. I shall make further reference to Mergen's article below.

At the beginning of the growing season, the shoot tips of all branches droop down, giving the tree a graceful, feathery appearance (figure 9). As the season progresses, these drooping shoot tips slowly turn upward to become nearly erect, giving the tree an ascending rather than a drooping appearance. In New England, the terminal shoot tips of all the branches are usually horizontal or subhorizontal in July. By November, the terminals erect themselves to a nearly vertical position (figure 10). In the words of Mergen:

The straightening process was effected mostly by a bending close to the base of the current year's growth which caused the leader to turn upwards. This bending was accompanied by a stiffening of the cells. As the growing season progressed, this point of stiffening progressed up to the stem.  
[p. 102]

Associated with the erection of the leader, according to Mergen, is the formation of compression wood along the underside of the terminal. Compression wood is of general occurrence in conifers, and is readily visible to the unaided eye by virtue of its deep red color. With hemlocks, the only tool needed to see compression wood is a razor blade, which is used to make smooth cross sections of the twigs.

In pines and other straight growing conifers, small amounts of compression wood always occur on the lower side of lateral branches



*The C. S. Sargent Hemlock at Brookline, Mass., as it appeared in 1980. Figure 5 (above): The tree is 7½ feet tall and 32½ feet wide. The children shown in the picture were playing under the tree, which they called “The Fort.” Figure 6 (below): A view of the trunk system. The large, ribbon-shaped branch on the left is 14 inches by 5 inches in cross section. Photographs by P. Del Tredici.*



**Figure 7.** *The Horton Hemlock, at Hortontown, New York. The tree measures 18 feet 3 inches in height and 31 feet across. Photograph by P. Del Tredici.*

and are considered to be responsible for maintaining the branches in their horizontal position against the pull of gravity. Compression wood is found more sparingly in erect parts of the tree. It is most conspicuously formed when the leader in an erect growing conifer is destroyed and a lateral branch must change direction to replace it (Sinnott, 1952; Westing, 1965). In this instance, large amounts of additional compression wood are formed along the underside of the branch, forcing it upward.

In most conifers, compression wood functions to maintain the laterals at a specific angle. Should a tree need to change the angle at which a branch is carried, e.g., to compensate for damage, this is accomplished by increasing the amount of compression wood. In hemlock, the use of extensive amounts of compression wood to change branch angles (rather than just maintain them) is not limited to extraordinary circumstances as it is in other conifers. Instead, it is part of the normal ontogeny of the plant, functioning to erect the leader on a yearly cycle.

The growth of the hemlock tree can be summarized as follows. In the spring, as the buds break, new growth comes out plagiotropically (this is the botanical term for the horizontal position). After these terminal shoots have been growing for a month or two, second order branches start to grow out several inches below the shoot tip in the axils of newly formed needles (figure 11).<sup>3</sup> The fact that the terminal shoot is in a horizontal position when these lateral branches grow out results in a greater measure of equality between the terminal and its laterals than would be the case if the terminal were vertical (Mergen, 1958). While in the plagiotropic state, there is no absolute terminal shoot, rather there is a complex of shoots, all produced during the same season, any of which has the potential to become the new leader. In late fall and early winter, this whole shoot complex is erected to an orthotropic (vertical) position. At this point, the terminal shoot reasserts its dominance and suppresses the subtending laterals.

In young, vigorous hemlocks, raised in a nursery, the stem is usually a monopodium built up by the activity of a single terminal meristem that each year erects itself into the orthotropic position upon completion of its active growth. Only when there is some damage to the terminal shoot itself is a lateral shifted into the terminal position. In forest-grown hemlocks, this basic pattern is somewhat modified. Growth is less vigorous, and the secondary erection of the leader may take more than one year to complete. In addition, laterals become dominant not only when the terminal is damaged, but also when

<sup>3</sup>The habit of developing lateral branches without a period of dormancy is called syllepsis. The buds from which sylleptic branches grow are characterized by a lack of bud scales which over-wintered buds always possess.



Figure 8. *The trunk and branches of the Horton Hemlock. At 4½ feet, the trunk diameter is 24½ inches. Photograph by P. Del Tredici.*

the terminal loses its vigor for no apparent reason. In wild trees at the Harvard Forest, in Petersham, Massachusetts, dominance shifted from a weak, undamaged terminal to a subtending lateral on an average of once every four years (Hibbs, 1980).

This habit of growth has important implications for the hemlock tree, which can be described best by one word — flexibility. Mergen puts it this way:

If, during the growing period, the terminal growing point of hemlock trees is damaged by an insect, or by mechanical means, hardly any amount of growth is lost, but a new growing point is formed immediately without leaving a noticeable bend in the leader. If the entire leader is cut off toward the latter part of the summer, one of the side branches, which is closest to the leader, assumes dominance at once and leaves little trace of damage. As a matter of fact, it is very difficult at times to select the terminal leader during the growing season, and there appears to be a flexible, or a loose, pattern of apical dominance during the early part of the growing period. [p. 107]

In contrast, the native white pine (*Pinus strobus*) has a rigid system of apical control. One look at its crown, ravaged white pine weevil and blister rust fungus, is enough to make clear what a great advantage the “flexible” system of apical dominance can be. Indeed, the well known ability of hemlock to withstand prolonged periods of sup-





**Figure 9.** *A specimen tree of Tsuga canadensis growing at the H. H. Hunnewell Estate at Wellesley, Mass. The tree is 51 feet tall. Photograph by P. Del Tredici.*

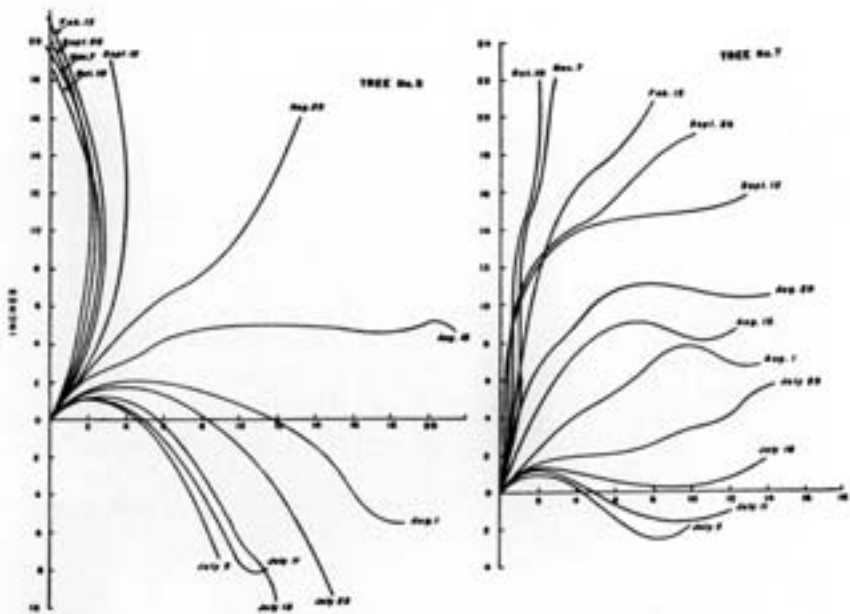


Figure 10. Graphic presentation of the course of the straightening of the leaders in two normal hemlocks. Reprinted with permission from Forest Science 4(2):103.

pression by hardwoods and pines (Fowells, 1965) is partly due to the flexibility of its growth pattern (Hibbs, 1980).

#### “Weeping” or Pendula Growth

A. B. Stout, as other authors before him, recognized two distinct forms of *Tsuga canadensis* f. *pendula*: (1) The *shrub* form, characterized by a low spreading habit and numerous stems arising near ground level, which have more of a horizontal orientation than vertical; and (2) the *standard* form, characterized by a single stem with a nearly vertical orientation. In general, plants of the standard type are more umbrella-like in their appearance and more pendulous than plants of the shrub type. Unfortunately, for those who like neat categories, there exist many specimens of *pendula* that conform neither to the shrub nor the standard type. They are intermediate between the two in terms of the angle at which their stems grow and their degree of pendulousness. In studying *pendula*-type hemlocks, it is important to recognize that there is a continuum of forms and not just two extremes. In the remainder of this section, I will address myself to those features of growth that are common to all specimens of *pendula*, saving until last the discussion of stem formation and orientation.

*Tsuga canadensis* f. *pendula* differs from the normal hemlock tree in one overwhelmingly important respect — it lacks the ability to erect a leader after the initial horizontal stage of growth is completed.

*Pendula*, therefore, is a plagiotropic plant in which growth occurs in a horizontal rather than a vertical direction. At least, this is so in theory. In reality, absolute plagiotropy is never achieved. The main branches always tend to grow at a small upward angle and the trees slowly increase in height. In the normal tree, the erection of the leader is the basic organizing principle. In *pendula*, this organizing principle is lacking.

In *pendula*, the lack of the ability to throw up a leader is the primary mutation from which the other features follow as a *natural consequence*. The plagiotropic terminals remain plagiotropic only for as long as they can resist the pull of gravity. Once they start to become pendulous, one of the laterals behind the terminal grows out during the following season, to continue growth in the plagiotropic direction. Sometimes, the lateral may overtop its own terminal and sometimes it will grow out at an angle unrelated to the terminal. In the process of overtopping the terminal, the lateral erects itself partially. Unlike the situation in the normal hemlock, however, this secondary erection never involves more than the very base of the shoot (two or three inches at the most). Without the benefit of secondary erection, the shoot tip itself succumbs to the pull of gravity and becomes pendulous, giving the plants their characteristic weeping appearance. It is interesting to compare these pendulous hemlocks with prostrate hemlocks (such as *Tsuga canadensis* 'Cole') which fail to erect any portion of their stem and consequently increase extremely slowly in height.

Once a terminal is overtopped, the main axis of growth is shifted away from it to the overtopping lateral, resulting in a stem that grows up at an angle slightly greater than the horizontal. Unlike the vertical stem of the normal tree, which is built up by utilizing the entire terminal shoot, the plagiotropic stem of *pendula* is built up by utilizing only the proximal portion of the terminal. Sometimes these plagiotropic stems go off in a fairly straight line in one direction and sometimes they grow back upon themselves and form a circle by self-grafting. It is nearly impossible to generalize about the growth of these stems, other than to say that they can grow in any direction and at any angle. Stout found considerable variation in the height of *pendula* seedlings after 23 years of growth. Among the five plants he grew, the smallest one was three feet tall, the largest about four feet. Such variation suggests that there are genetic differences in the amount of tissue that different individuals erect in the process of overtopping. Interestingly, all of the seedlings were multi-stemmed.

In hand sections of terminals of *pendula*, using a razor blade, I usually found small amounts of red-colored compression wood along the underside of the branches, but never as much as can be found in the normal hemlock tree. In general, the actively growing shoot tips of *pendula* show differing amounts of resistance to gravity as well as differing amounts of compression wood, but there seems to be no

relationship between them. The vertically flattened, ribbon-shaped stem seen in many older specimens of *pendula* (fig. 6) are a sign of eccentric radial growth, indicative of the presence of large amounts of compression wood. This extra thickening is an engineering necessity that allows the branch (which is essentially a cantilever) to carry the load that develops as a result of having to grow plagiotropically.

As a final consequence of the lack of ability to erect a leader, there is no hierarchy among the branches and hence no regulation of tree form from above. All buds are free to grow out without relation to any of the other branches. If *pendula* is allowed to grow freely, it will always describe a perfect circle of vegetation on the ground. This symmetry is not just a random occurrence, it is a reflection of the total equality and equivalence of all the plagiotropic branches.

In summary, *pendula* is plagiotropic at all stages of its life. The normal hemlock tree, on the other hand, is plagiotropic only during the period of its active growth. During the winter, it becomes orthotropic. Thus, within the same species, we have two totally opposite growth forms. Such extreme intraspecific variation is not common in trees (Hallé, 1978).<sup>4</sup>

**Stem formation.** The continuum of forms that exist from the multi-stemmed shrub forms to the single-stemmed standard forms has caused some horticulturists to speculate that there are at least two forms of *pendula*. Whether or not these forms merit separate varietal rank is dependent upon whether or not it can be established that there are genetic differences between the two types. In order to answer this question, it is necessary first to go back to the original literature on the subject. The earliest reference concerning propagation of *pendula* is from the Parsons and Son's catalogue of 1879 (Jenkins, 1933a):

*Abies canadensis pendula sargentii*, Sargent's weeping hemlock, the most graceful and delicately beautiful evergreen known. When the leader is trained to a stake, it can be carried to any reasonable height, each tier of branches drooping gracefully to the ground, like an evergreen fountain. It was first sent out from Flushing, having been received from H. W. Sargent, of Fishkill-on-Hudson.

<sup>4</sup> In the normal hemlock tree, the trunk is an orthotropic monopodium, as are all the continuously arranged lateral branches. Growth is rhythmic, as indicated by the presence of bud scales. Flowering does not interfere with this monopodial growth in so far as the male flowers are borne laterally, and the female flowers, while borne terminally, are found only on lateral branches. According to the system described by Hallé, et al. (1978), *Tsuga canadensis* (L.) Carr. would seem to belong to either Rauh's or Attim's Model. However, the fact that the terminal goes through a plagiotropic stage argues against either classification. As far as I can tell, the hemlock does not fit any of their models precisely.

Figure 11. The upright, dormant terminal shoot complex of a normal hemlock, photographed in April, 1980. The white arrow indicates the starting point of the 1979 season's growth and the black arrow indicates its end point (the total growth is 38 cm.). Note the abundant sylleptic branches. Photograph by P. Del Tredici.



So here it is plainly stated by the people who supplied all of the propagations of the original plants that they were staked to achieve a greater pendulous effect. In a statement dating from 1887 (*The Garden* 32: 363), Samuel Parsons is quoted as saying that attempts were made to graft *pendula* "upon high stocks" but he also says that he considers the results unsatisfactory. He illustrates this article with what is considered to be the first picture of a weeping hemlock (fig. 1). This early propagation clearly shows the standard form. The fact that the crown is high yet narrow suggests that staking was involved in producing this tree.

Beissner, writing with Jäger, in "Die Ziergehölze der Gärten und Parkanlagen" (1884), echoes these statements of Parsons in his description of *Tsuga canadensis* f. *pendula*:

*Tsuga canadensis* (Carr.) — *pendula*, mit hängenden Aesten, durch Aufbinden der Spitze als Stamm zu erziehen über Felsen oder Abhänge als Busch frei hängend. [p. 445]

*Tsuga canadensis* (Carr.) — *pendula*, with hanging (drooping) branches, may be trained as a stem by tying up the leader, or may be grown as a shrub hanging over slopes or rocks.

This statement is particularly important in that it comes from the man

who is the author of the name *Tsuga canadensis* f. *pendula* (Rehder, 1949).

A second factor that may contribute to the development of a single erect trunk in *pendula* was suggested by C. S. Sargent in (1897b):

This variety (*pendula*) has been propagated by grafting the branches on the ordinary Hemlock, but in a few years the grafted plants form an erect stem and lose the dense low habit which is the charm of the original seedlings. [p. 491]

This statement is of interest first, because it states that none of the original seedlings were of the standard form and second, because it suggests that the understock may be influencing the growth of the scion by making it more vigorous. A wealth of information exists which clearly shows the effects of various types of rootstocks on apple and pear tree stature and on their branching angle. It seems plausible that there should be some sort of similar root stock effect in hemlock. Given that there exist many grafted plants which do not have the standard form, it is unlikely that it is the sole cause of vertical stem formation, but that there should be some effect cannot be denied. In talking to nursery people who work with *pendula*, grafting is always accompanied by staking because the weight of the weeping foliage would break the graft union without a stake (see Jenkins, 1939). The combination of grafting and staking offer a plausible explanation of the standard form, especially when taken in conjunction with Sargent's hypothesis that the understock makes the scion more vigorous.

It is a well known fact among hemlock enthusiasts that a staked weeper (such as a *Tsuga canadensis* 'Cole') grows much faster and taller than one simply allowed to grow without interference. Why this is so, from a physiological point of view, is not clear but it shows that the artificial imposition of a leader upon a normally leaderless plant completely changes the whole habit and rate of growth of the plant. Artificially creating a leader in *pendula* eliminates one of the traits that defines it, namely, the total equality of all the branches. Mergen (1958) has shown that staking the drooping terminal in a normal hemlock changes the angle at which subtending laterals are carried, making them more like laterals and less like the potential terminals they would be if unstaked. Given the fact that staking alters the terminal-lateral relationship in the normal tree, one does not have to think very hard about the implications of staking a *pendula*.

It is possible that environmental factors, such as shade, also play a part in vertical stem development. As I see it, trees show a greater tendency to slough off lower branches under shaded conditions than they do under conditions of full sun. By eliminating the lower branches, the tree is automatically favoring height growth over horizontal growth. It is a case of stem formation by default. Human

activities, such as piling trash under the all-concealing tree, would also cause the premature loss of horizontal branches, and also favor single-stem development.

The mechanism that would cause the stem of a weeping hemlock to become vertical is not known exactly. It appears likely, however, that the large amount of compression wood that is found on the lower surface of the horizontal branches, which allows them to bear heavy loads, can have the added effect of actually pushing them into a position that is more upright than the one they had when they were formed. This process would be analogous to the way in which the upper portion of the trunk of a leaning hemlock can be brought back to the vertical position by compression wood formation (Westing, 1965, p. 449) or to the way in which lateral branches are shifted to a more vertical position following decapitation of the leader (Münch, 1938). The fact that *pendula* is a leaderless plant makes the analogy with a leaning or decapitated tree, both leaderless plants, particularly appropriate.

The only real difference between the shrub and the standard forms of *pendula* is the formation of a single erect stem. Other than this, their growth habits are identical. All available evidence indicates that a combination of horticultural and/or environmental forces are responsible for erect-stemmed specimens of *pendula*. Nevertheless, the fact that there is a small amount of secondary stem erection involved in laterals over-topping terminals, leaves room for the possibility that some of the standard forms may indeed be able to erect larger portions of their stems than shrub forms, and that they are able to combine these segments into a fully erect main stem. Experiments are now being conducted at the Arnold Arboretum in which cuttings of standard trees have been rooted to see if they develop the standard form without any horticultural treatment. I hope they will provide an answer to the question of the genetic basis of vertical stem formation in Sargent's weeping hemlock.

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Table 1. A summation of the growth of certain individuals of *Tsuga canadensis* f. *pendula*, from 1860 to the present.

Year Measured (by whom)	'Sargent' Hemlock	'Howland' Hemlock	'Horton' Hemlock	Arnold Arboretum 1514-2 <sup>a</sup>
1860			5'h <sup>b</sup>	
1897 (C. S. Sargent)		3'h 25'w		
1900	3½'h 9'w			
1913				6'h <sup>c</sup>
1924 (E. H. Wilson)	6'h 23'w			
1933 (C. F. Jenkins)	6'h 24'w	10½ h 33'w		
1939 (A. B. Stout)	7'h 27'w	11'h 35'w	16'h	10'h <sup>d</sup> 28'w
1953 (A. A. Records)				12'h 30'w
1962 (A. J. Fordham)	7'h 28'w			14'h 34'w
1980 (P. Del Tredici)	7½'h 32½'w	13'h 36½'w	18'3" h 31'h	12'9" h <sup>e</sup> 21'w

- (a) A plant grafted in 1881 from a grafted plant received from Parson's Nursery in 1880;  
 (b) Estimate based upon ring counts from a limb cored in 1980 (see text);  
 (c) Estimate based upon ring counts from a limb removed in 1980;  
 (d) Jenkins, 1939;  
 (e) The tree lost a major branch around 1970.



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## **Pseudolarix amabilis**

People are often surprised to learn that a few conifers, rather than being evergreen, lose their foliage in the winter. In fact, I am told that when the larch trees (*Larix* sp.) on the Harvard campus begin their autumn leaf drop there is a flurry of concerned telephone calls inquiring after the health of the trees and what can be done to stop the defoliation.

While the deciduous species of *Larix*, *Metasequoia* and *Taxodium* are known to many, few people know or grow the rare Chinese tree known as golden larch (*Pseudolarix amabilis*). This common name describes the fall foliage color of bright golden-yellow which begins with the first crisp frost and ends when the last needle is carried away by the autumn winds. It is difficult to describe the autumn color adequately for while the golden shade is rich in itself the color saturation is intensified on clear days when the sun, as a result of its low arc in the autumn sky, produces mellow light conditions. It is because of its suffused autumn colors that the Chinese call it either *Kin-ye-sung* "golden-leaved pine" or *chin-lo-sung*, "golden deciduous pine."

Our grove of six golden larch trees growing along either side of Bussey Brook near the Walter Street gate is worthy of attention, not only in fall. In spring, the warm days stimulate new growth. Emerging leaves are a soft yellowish-green and the small, yellow, male cones are produced in dense clusters at the ends of short, spurlike branches. During the summer, leaf color is a pale emerald green which gradually gives way to golden autumn hues. Color change in the needles



*A superb group of one young and five mature specimens of Pseudolarix grows along either side of Bussey Brook near the Walter Street gate to the Arboretum. Having trees of different genotype and provenance allows adequate pollination by wind and results in an abundant seed crop every other year. Photograph by G. Koller.*

begins at the outer tip and progresses inward briefly giving the effect of a green eye surrounded by gold.

During alternate years its large crop of female cones is extremely ornamental as the individual cones have thick cone scales which are arranged in such a manner as to resemble artichokes. In the immature state they are a pale green and as they ripen, in mid-October, they become a light tan. As the cones dry the scales loosen from the central axis so that the whole structure falls apart. Two seeds adhere to each cone scale and as the cones shatter the seeds are dispersed by the wind.

In the winter the tree presents an elegant silhouette for the trunk is straight and tapers gradually to the tip. The branches are widely spaced, thin in diameter and basically spread from the tree in a horizontal or slightly upthrust angle. Mature lower branches are clear of growth near the trunk with smaller branches and foliage presenting themselves on the outer one-third to one-half of the branch. The outermost branch tips are horizontal or slightly upturned. The upper crown is densely branched, with more upright branches, so that old trees have a flattened top which gently blends with a graceful curve into the more sparsely spaced side branches.

During the summer the foliage density is thin and as a result directly beneath the tree one can find spots of sun shining on the lawn. Grass grows directly up to the trunk and there is no evidence in any of our plants of surface or shallow rooting. Spacing to create landscape effect is often critical to the visual and spatial quality of a mature grove. Our grove of trees is planted on 30-35 foot centers which allows the plants adequate space to develop a full canopy without crowding, while enabling the outer branches of individual trees to touch, providing, in effect, a continuous ceiling. Beneath mature trees with their open canopy one could establish perennial plantings of ground covers, herbaceous plants or taller woody species such as azaleas, *Leucothoe*, *Skimmia* or low growing hollies. Landscape architects who seek plants with an open airy crown at maturity should consider using the golden larch.

Bark on the trunk and major stems of mature specimens is distinctive as it is broken into a series of irregular plates separated by deep ridges with color varying from gray brown to reddish brown. Young stems and branches are smooth and gray brown.

I have observed a great variation in growth rates for this plant. While some twenty year old plants are little more than 6-8 feet tall and have a sickly yellow green summer color, others grow robustly, and at the same age are 18-25 feet tall with emerald green foliage. Of those plants which were languishing most were growing on soil with a high lime content or on limestone seams of rock. Notes in the English literature appear to confirm that they are lime intolerant. However, this needs to be more substantially documented by controlled growth experiments.

Right: The leaves are arranged in a whorled pattern at the end of a short spurlike branch. Below: Cones are abundant every other year and are generally grouped or clustered along the upper surface of the branch. Cones ripen in the autumn of their first year. Photographs by G. Koller.





*Cones which resemble artichokes in appearance change from light green to tan as they ripen in mid-October. At full maturity the cone becomes deciduous and the whole structure shatters, scattering cone scales, with two adherent seeds, in the wind. Photographs by G. Koller.*

At the Arnold Arboretum we have access to plants of different ages from which to derive observations on growth rates. In mid-February 1980 seeds were germinated at the Dana Greenhouses. Individual seedlings were transplanted from a crowded seed pan into individual 3 inch pots and by 1 October averaged 4-7 inches tall. Eighteen-year-old plants, well established in our permanent plantings, exhibit 16-22 inches of new growth on terminal and lateral branches. An examination of several mature trees 90-120 years old produced evidence of 4-8 inches of new season growth. Growth observations of several seedling batches presently at the Arboretum is deceiving as one batch was partially eaten by rabbits and in another progressive transplanting and crowding resulted in an exaggerated lack of vigor.

In order to document sources, age, and growth rate I took the following measurements from plants existing in our permanent collections on 1 October, 1980:

1. Accession Number 3656: acquired as plants of an undetermined size from Veitch and Sons Nursery in Chelsea, England in May, 1891
  - Plant A — approximately 40 feet tall, 42 feet wide with a d.b.h. of 2 feet. New season growth was 4-8 inches long.
  - Plant B — approximately 45 feet tall, 42 feet wide with a d.b.h. of 2 feet. New season growth was 4-6 inches long.

2. Accession Number 16779: acquired as seed from H. H. Hunnewell, Wellesley, Massachusetts on January 29th, 1896.  
Plant A — approximately 40 feet tall, 45 feet wide with a d.b.h. of 1 foot 9 inches. New season growth was 4-6 inches long.  
Plant B — approximately 42 feet tall by 55 feet wide with a d.b.h. of 2 feet 4 inches. New season growth was 4-6 inches long.
3. Accession number 10764: acquired as a plant of undetermined size from W. H. Hunnewell, Wellesley, Mass. on April 22, 1921.  
Plant A — Has a notation that this plant was 30 feet tall in 1946. It is now 40 feet, tall, 42 feet wide with a d.b.h. of 1 foot 6 inches. New season growth is 4-8 inches long.
4. Accession number 404-48: grown from seeds collected from 16779 during the autumn of 1947.  
Plant A — approximately 20 feet tall, 18 feet wide with a d.b.h. of 5 inches. New season growth was 4-6 inches long.  
Plant B — 25 feet tall, 28 feet wide with a d.b.h. of 10½ inches. New season growth was 4-6 inches long.  
Plant C — Not measured since it is alive but displays little vigor, greatly reduced growth and sickly yellow-green summer foliage.
5. Accession number 534-61: grown from seeds of an unspecified arboretum tree, sown in February 1961.  
Plant A — 18 feet tall, 16 feet wide with a d.b.h. of 2½ inches on the larger of two stems. Average new growth is 16 to 22 inches long.

These growth rates are compared to a venerable old specimen which presently grows on the lawn along the driveway across from the main house at the Hunnewell Estate in Wellesley, Massachusetts. This tree is undoubtedly the parent of our trees acquired from H. H. Hunnewell in 1896. On our behalf, Walter Hunnewell traced the origin of the plant and the records indicated that it was acquired as a seedling in a 4 inch pot from Veitch Nursery in 1866. In tracing the history of this tree we believe it was first mentioned in notes prepared by H. H. Hunnewell for the March 1867 issue of the *American Journal of Horticulture* when he says he has small plants. The next reference to this plant is recorded in *Life, Letters and Diary of Horatio Hollis Hunnewell* (1906. Vol. 3, pp. 127-8) with a 1905 notation as follows: *Pseudolarix kaempferi*, 35 feet tall with a trunk 4 feet in circumference and a spread of branches of 37 feet. This tree has produced seeds for many years and many seedlings have been raised from it." The tree has been measured annually since 1921 and Mr. Walter Hunnewell reports that in 1921 it had a circumference of 5 feet 6 inches and in 1979 after 58 years this had increased to 7 feet 11 inches. In October, 1980, this tree estimated to be 115 years old is



*At 115 years, this specimen of Pseudolarix, at the Hunnewell Estate in Wellesley, Massachusetts, is one of the original and oldest of its species in North America. As of October, 1980 it was approximately 55 feet tall with a spread of 50 feet. Its circumference as of 1979 was 7 feet, 11 in. Photograph by G. Koller.*



approximately 55 feet tall with branches spreading 50 feet. The lowest branch which sweeps the ground is 3½ feet above the soil level and it spreads outward 36 feet from the trunk. This bottom branch has a diameter of 10 inches at the point where it is inserted into the trunk. Most of the branches on the driveway side of the tree were lost due to ice storm damage in 1921. As of October 1st the cones are beginning to ripen but the cone scales are still firmly attached. A quick visual examination indicates that despite a few damaged branches the tree remains sound and healthy.

In examining all of the trees reported on, I checked for signs of insects or disease. Leaves were, for the most part, intact with little to no bite or chew marks. However, the foliage of one specimen exhibited tiny, circular, randomly spaced, yellowish spots which were evident only on close examination. This may indicate a fungus infection or perhaps damage by an atmospheric pollutant.

The hardiness potential of *Pseudolarix* in both its northern and southern ranges seems to be inexactly defined. It is being grown at the Strybing Arboretum in San Francisco as listed in their 1979 guide to plants. Northern limits may not have been fully explored for it is fully hardy at the University of Illinois in Champaign-Urbana where winter temperatures drop to -20° F. Dr. Lyle Littlefield, at the University of Maine, at Orono, where average minimum winter temperatures average -20° to -25° F. reports that seedlings 6-8 inches tall survived only to the snow line. He felt that young seedlings lacked the ability to harden off properly and perhaps older and larger plants would have been more successful. At the Landscape Arboretum of the University of Minnesota, Dr. Harold Pellett has done laboratory controlled hardiness testing and has determined the lowest survival temperature of stem tissue to be -45° C. Perhaps this indicates that under cultivation, the tree has not yet found its way to the most northern limits of hardiness.

The fact that this tree still remains rare and little grown in North America may be due to the paucity of published information in horticultural books and periodicals. Perhaps a more important reason is that most trees reported in cultivation seem to have a low or erratic history of seed production. I believe that this is due to a lack of cross pollination, since many old specimens are grown as lone representatives of the genus in any geographical area. At the Arnold Arboretum the grove of *Pseudolarix* distinctly alternates in cone productivity year by year, but on good years we get an abundance of viable seeds. From our 1979 seed collection we distributed thousands of seeds and seedlings to nurserymen in addition to the autumn 1979 plant distribution to Friends of the Arnold Arboretum. Optimum germination of seeds takes place after 30-60 days of cold stratification at 40° F. Although we have attempted propagation by cuttings our experiments have never been successful. Should any readers have success with

cuttings we would appreciate information about the techniques used to produced positive results.

The literature indicates that there are several distinct selections being grown. However, a survey of the computer file of the Plant Science Data Center in Mt. Vernon, Virginia, failed to reveal any institution in North America which grows any cultivars or plants which vary from the type. In reviewing the literature, I wonder how many of those plants described separately actually exist today. In the *Manual of Cultivated Conifers* by den Ouden and Boom (1978, pp. 366-68) the cultivar 'Annseleyana' is described as dwarf and bushy, but in 1964 the type plant at Castlewellan in County Down, Ireland was described as over 100 years old and 30 meters tall. The cultivar 'Dawsonii' described as a dwarf conical shrub was raised from seed of a normal sized tree in the Hunnewell Pinetun by J. Dawson of the Arnold Arboretum in 1895. This tree no longer survives nor do we have any progeny. Perhaps it exists elsewhere. The cultivar 'Nana' is described as a artificial dwarf and from this I take it to mean that it's dwarfness was maintained by techniques similar to Bonsai. From indication of the early literature describing this tree it has long been popular as a dwarfed pot plant in China. We have plants in our collection raised from seeds collected from 'Nana' and today they are normal sized trees.

In terms of growing environment the tree grows best with an exposure of full sun but it seems to be tolerant of light shading. In the wild, seedlings normally develop in the shade of neighboring trees rather than with an exposure of full sun. As to soil conditions it seems to prefer a well drained, lime free soil.

Landscape use of this tree certainly could be more extensive. It not only makes a superb specimen tree but it is even more spectacular as a grove planting. Several people have expressed a dislike for this tree in the home landscape because it becomes too large, yet the same people plant maples, elms and lindens which grow as large or larger. It seems to me that those who would like a tree under which they can build a garden, should eagerly explore the use of this conifer. Golden larch should also be tested for its adaptability to urban growing conditions since its deciduous nature might reduce its susceptibility to salt and chemical pollutants. The fact that the needles are tiny and that the cones shatter into many segments would diminish their nuisance potential in regard to litter. And finally, the open airy canopy of a mature specimen would allow light to penetrate nearby windows while providing some shade for adjacent structures.

The correct scientific name of this plant has been a subject of dispute since it was first described. Most references list it as *Pseudolarix kaempferi*, while our taxonomists feel that it is more correctly called *Pseudolarix amabilis*, and so I have called it throughout this article. See references by Tjaden, Hara, & Brummitt, and Nicholson cited in the reference list.



*A. A. 3656-B, acquired May, 1921 from Veitch & Sons Nursery in Chelsea, England. Current d.b.h. is 2 feet and height is 45 feet. Note the plated bark, widely spaced branching pattern, and the angle at which branches are inserted into the trunk. Photograph by C. Lobig.*

If at this point I have aroused your interest in growing this golden larch you will need a source of plants or seeds. Landscaped sized plants are available from Weston Nurseries, Hopkinton, Massachusetts 01748; one year seedlings from Groundnut Hill Nursery, Inc., Logging Road, Cape Neddick, Maine, 03903; and seeds are available from F. W. Schumacher Co., South Sandwich, Massachusetts 02563.

GARY L. KOLLER

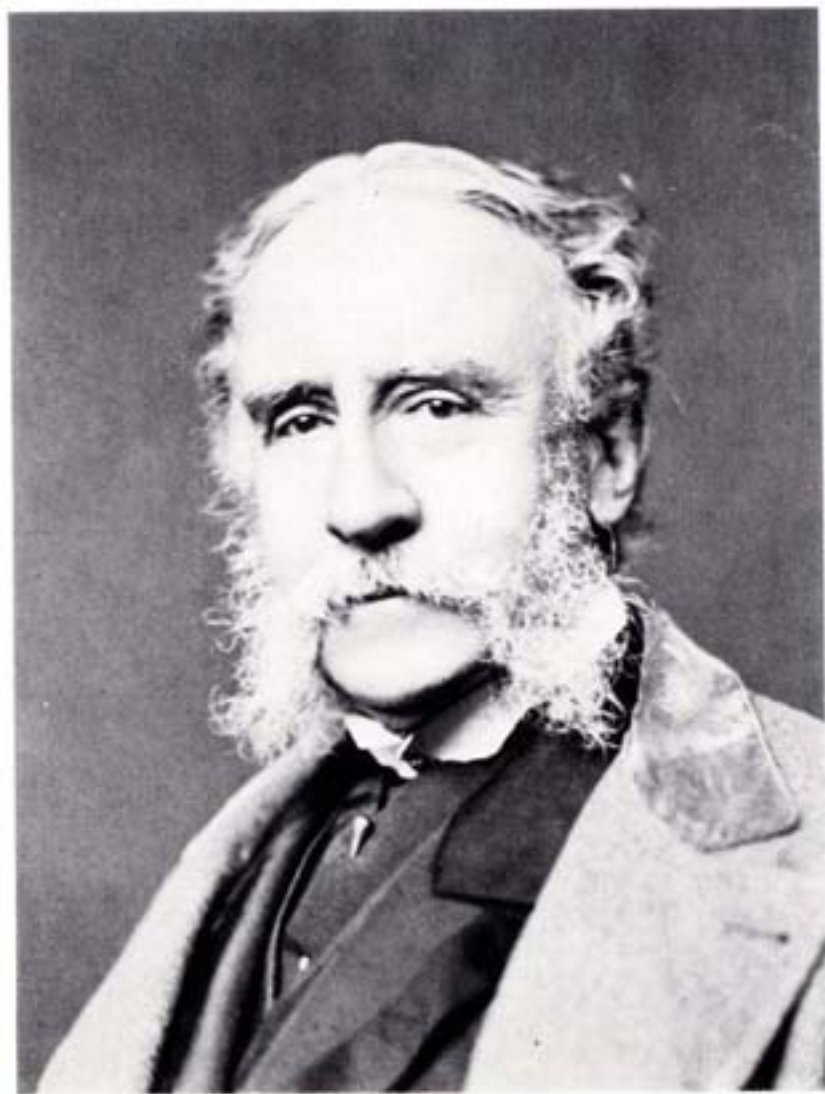
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Right: *Henry Winthrop Sargent, born in Boston 1810; died in Beacon, New York, 1882. Photograph by A. Sorrel, 1870.*

Back cover: *Tsuga canadensis f. pendula, A.1551 at the Arnold Arboretum. Photograph by J. Raer, 1945.*



*Next Issue:*  
The Director's Report



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