The First and Final Flowering of Muriel’s Bamboo

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Regular readers of Arnoldia can appreciate the many satisfactions that come from working at the Arnold Arboretum, with its endless opportunities for studying plants. Even after twenty years of daily contact, there’s always something new and exciting. Some days it is the first flowers on a recently planted specimen; on others, it is stumbling, sometimes quite literally, across an amazing old plant never before noticed. The highlight of the 1998 season was definitely the discovery of flowers on Muriel’s bamboo, Fargesia murielae, which appeared at the Arnold Arboretum for the first—and last—time.

The Flowering

Fargesia murielae is native to the mountains of central China, where it grows at elevations between two and three thousand meters. The species is one of the principal foods of the giant panda bear and arguably one of the most ornamental of the hardy species of bamboo. Its graceful, arching stems reach two to three meters in height and add a measure of exotic elegance to any garden. As a clump-forming species it expands slowly, in stark contrast to bamboos that spread by long, underground stems—the “running bamboos”—which are often the bane of unwary gardeners. Experienced bamboo growers are universal in their praise of Fargesia murielae, not only for the above-mentioned traits, but also because Muriel’s bamboo is among the hardiest of the entire family, growing well in USDA zone 5 and, with protection, into zone 4.

For all of its attractiveness, however, the most interesting feature of Muriel’s bamboo is its monocarpic life cycle—it flowers once in its life and then dies. Gardeners are used to seeing sunflowers germinate, grow, and die in a single season, and foxgloves die after two years, but the idea of a plant flowering after eighty to one hundred years and then dying seems more than a little strange. And strange indeed it is, being found only among the “woody” monocots, such as the well-known century plant (Agave sp.),
a few genera of palms (most notably in the genus Corypha), and an Andean bromeliad of tree-sized proportions (Puya raymondii), which tend to come into flower when they reach a critical size.\(^1\)

Monocarpic bamboos are unique even among this unusual group because they do not flower according to their size, but according to a predetermined maturation cycle, the length of which appears to be genetically fixed for each species.\(^2\)

The eighty-to-one-hundred-year flowering cycle of Muriel's bamboo, while certainly not the longest on record, is among the most widely known and well documented. Indeed, it was the widespread flowering and subsequent death of the umbrella bamboo in China in 1971, along with that of several closely related species, that created worldwide concern about the survival of the giant panda. The panda population in central China, it was found, had become overly dependent on the high-elevation species of Fargesia after bamboo species growing at lower elevations were eliminated by land clearance for agriculture.\(^3\)

Even more remarkable than their long flowering cycle, many bamboos are also synchronous in their flowering behavior. This term refers to the tendency of most or all of the individuals of a given species to come into flower at more or less the same time. This unusual behavior has led some authors to postulate that flowering in these bamboos is controlled not by climatic factors but by some sort of internal clock. In reality, however, the synchronicity is less precise than generally believed, particularly when plants in their native habitat are compared with same-aged cohorts in cultivation that have been repeatedly propagated by division.\(^4\) It may be propagation by subdivision that affects cultivated bamboos, but in any case their flowering cycle occurs as much as twenty years later.

While many authors have speculated on the possible evolutionary and ecological significance of the monocarpic habit in bamboos, nothing has been proved. One theory, proposed by Daniel Janzen,\(^5\) is that the long delay in flowering is a strategy for preventing a buildup of predators that would feed on the highly nutritious seeds if they were produced on a predictable schedule. However, this idea does not explain why the flowering intervals of many bamboos greatly exceed the lifespans of most animals that would feed on their seeds. More likely, the real reason is inextricably embedded in a complex matrix of physiological, ecological, and evolutionary factors.

**The Introduction**

The history of the plant's introduction into cultivation in the West, like that of so many other plants, is cloaked in mystery and confusion. It was first collected by the Arnold Arboretum's most famous plant collector, E. H. Wilson, who assigned it number 1462. The Arboretum has most of Wilson's field books in its archives, and those for his first Arboretum expedition, from February 1907 through April 1909, contains the following entry: "1462. Bamboo, 12 ft., stems golden, thickets, 7000–9000 ft, Fang. Plants, _—_._—_."\(^6\) Unfortunately, the last three words of the passage are unintelligible, but one important piece of information is unequivocal: living plants, along with the usual herbarium specimens, were part of this collection.

With the help of Alfred Rehder, Wilson reworked his field notes and published them in *Plantae Wilsonianae*,\(^7\) a work in three volumes that appeared in sequence in 1913, 1916, and 1917. The reference to the umbrella bamboo occurs on page 64 of volume II:

*Arundinaria* sp. Western Hupeh: Fang Hsien, uplands, alt. 2000–3000 m., April 17, 1907 [No. 1462, 2–4 m. tall, stems golden]. Without flowers. This plant is in cultivation. It forms on the mountains of north-western Hupeh dense thickets and with its clear golden slender stems is one of the most beautiful of Chinese Bamboos. A picture will be found under No. 0111 of the collection of my photographs. E.H.W."\(^8\)

The photograph that Wilson referred to is found in a bound volume entitled "Arnold Arboretum Second Expedition to China: 1910–1911."
Photographs by E. H. Wilson." Photograph #0111 clearly shows a clump-forming bamboo growing below a group of fir trees (*Abies fargesii*). According to the notes on the accompanying label, the photograph was taken on June 19, 1910, and the plant, Wilson’s #1462, is seen growing “behind Fang Hsien” at an altitude of 8,000 feet. Wilson’s diary for this day includes the following entry:

The rain had ceased when we woke at 5 am & though dark mist obscured everything from a hundred yards above & around us I prophesied a fine day. It remained fine for about two hours & then commenced to rain steadily. It increased as the day advanced & we had a fine soake. All were soon drenched to the skin & everything became sodden. We hurried on as fast as possible & reached the head of the pass at 10 am . . . Much of the Bamboo has been burned and cut away from the path which is considerable improved since our last visit . . . This bamboo is the handsomest I know with its bright golden yellow culms some 10–15 ft high shrubs and with arching plume. It must be very hardy for the climate here is very rigorous. Patches of original forest remain here and there & especially near water-course silver fir & many Birch with willows and Rhod. are practically the sole constituents.

The final reference to bamboo #1462 in the Arboretum archives comes from an undated notebook in Wilson’s own handwriting entitled: "Numerical list of seeds [no. 1–1474, 4000–4462], collected on his Arnold Arboretum expeditions to eastern Asia, 1907–09, 1910, which were planted in the arboretum nurseries." Under #1462, a single bamboo plant is listed as being located in the “Greenhouse & Frames” area of the nurseries. Unfortunately, the Arboretum’s permanent records of plants growing on the grounds do not contain any mention of #1462, strongly suggesting that the plant was never cultivated out-of-doors.

*Fargesia murielae* photographed by E H Wilson in its native habitat, Fang Hsien, China, at 8,000 feet. The plants are ten to fifteen feet high with yellow culms *Abies fargesii* stand in the background. Below is Wilson’s field book entry for collection #1462.
The first scientific description of Wilson's #1462 did not appear until 1920, in an article in Kew Bulletin of Miscellaneous Information, under the name Arundinaria murielae Gamble. In the notes following J. S. Gamble's Latin description, W. J. Bean, Kew horticulturist, noted that, "By Mr. Wilson's special wish the species is dedicated to his daughter, Muriel Wilson." Bean went on to detail the plant's history:

This Bamboo was presented to Kew from the Arnold Arboretum in the autumn of 1913. A single plant came in a pot, and this was divided up into about half a dozen pieces, which were repotted and grown for a few months in a greenhouse. They were then planted out in the collection of Bamboos near the Rhododendron Dell where they have grown luxuriantly and promise to be as ornamental as any hardy species. They are at present (October 1920) about 8 ft. high forming dense masses of culms, the outer ones of which arch outwards towards the top and give the plants a very graceful appearance... On the whole A. murielae is a distinct and most attractive addition to hardy bamboos.

At the Royal Botanic Garden, Kew, the only record of Wilson's #1462 is in the accession books, which noted its arrival on December 12, 1913.

Wilson's only other reference to #1462 is in A Naturalist in Western China, published in London in 1913 and New York in 1914. On page 49 he describes the vegetation behind Fang Xian by paraphrasing his journal entry of June 19, 1910:

The summit is of hard limestone with rare outcroppings of red sandstone. Stunted windswept Silver Fir and various kinds of Currant extend to the summit. Rhododendron and a dwarf Juniper (J. squamata) are also common. The descent was through woods of Birch and Bamboo to an open, grassy, scrub-clad, sloping moorland, through which a considerable torrent flows. The Bamboo, so common hereabouts, is very beautiful, forming clumps 3 to 10 feet through. The culms are 5 to 12 feet tall, golden yellow, with dark, feathery foliage; the young culms have broad sheathing bracts protecting the branchlets. Taken all in all, this is the handomest Bamboo I have seen.

The footnote at the bottom of the page reads: "In 1910 I successfully introduced it into cultivation." In the revised edition of the book, published in 1929 under a new title, China, Mother of Gardens, Wilson makes clear that the nameless bamboo mentioned in the 1913 edition was collection #1462 by removing the footnote and adding the following to the end of the above-quoted paragraph: "In 1910, I successfully introduced it into cultivation. It has been named Arundinaria Murielae in compliment to my daughter."11

From all this information, it appears that only one plant of Wilson's #1462, collected on May 17, 1907, survived the long journey from Fang Xian in China to the Arnold Arboretum, where it was observed growing in the greenhouse in 1910. In December 1913, without ever being cultivated out-of-doors here, the plant was sent to Kew Gardens where it was divided—it must have been quite large—and planted out in the bamboo collection. Although Fargesia murielae was widely distributed throughout Europe during the first part of the century, the Arnold Arboretum did not get another plant until 1960, when the U.S. National Arboretum in Washington, D.C., sent one (under the name Sinarundinaria murielae) that had been imported in 1959 from the Royal Moerheim Nurseries in Dedemsvaart, Holland.12

Flowers at Last

The first flowers of Fargesia murielae in the West appeared in Denmark in 1975.13 While these plants were clearly representative of the species, it is not certain that they were part of Wilson's #1462 clone. The plants were said to be smaller than Wilson's, and they came into bloom several years earlier than plants known to be divisions of #1462.

While the origin of the Danish plants will never be determined with certainty, the fact remains that in 1998 the flowering of known clones of Wilson's Fargesia murielae appears to be virtually complete, more than ninety years after it was collected from the wild. Some of the plants of #1462 have produced seed, but it is important to remember that they are the result of self-pollination, and as such they are likely to suffer from the deleterious effects of inbreeding depression. Only by re-collecting the species in central China—from seedlings that germinated following the widespread flowering that
**History of *Fargesia murielae* in the West**

1892: The French missionary P. Farges collects a herbarium specimen of an unknown flowering bamboo in Szechuan Province, China. In 1893, the French taxonomist A. Franchet assigns it to a new genus, *Fargesia*, with the specific name *spathacea*. 14

17 May 1907: On his first expedition to China for the Arnold Arboretum, E. H. Wilson collects plants and three sterile herbarium specimens of an unknown bamboo at Fang Xian, Hubei, under collection #1462.

[1910]: Wilson makes note of a single plant from his collection #1462 growing in the “greenhouses and frames” area of the Arnold Arboretum.

10 June 1910: On his second Arboretum expedition to China, Wilson revisits Fang Xian and photographs #1462, labelling the photograph #0111.

12 December 1913: One plant of Wilson’s #1462 is received by Kew Gardens from the Arnold Arboretum. The plant is divided into six pieces that are planted out in the bamboo area.

1916: Wilson labels #1462 as *Arundinaria* sp. in volume II of *Plantae Wilsonianae*, but lists the wrong collection date.

1920: Wilson’s #1462 is given the name *Arundinaria murielae* by J. S. Gamble.

1935: T. Nakai of Japan reclassifies *Arundinaria murielae* as *Sinarundinaria murielae*.

23 December 1959: U.S. National Arboretum botanist F. Meyer arranges for the importation of plants of *Sinarundinaria murielae* (PI #262266) from the Royal Moerheim Nurseries, Dedemsvaart, Holland. The plants are probably divisions of Wilson’s #1462. One of them is received by the Arnold Arboretum on 8 November 1960, under accession #1239-60.

1975: Plants of *Sinarundinaria murielae* in Denmark, possibly divisions of Wilson’s #1462, come into flower.

1979: Based on the flowering specimens of the Danish plants, T. Soderstrom proposes the name *Thamnocalamus spathaceus*, for the umbrella bamboo. Based on the same specimens, other botanists argue that the species should be classified as either *Fargesia murielae* (Gamble) or *F. spathacea* (Franchet).

1988: At Kew Gardens, the original plants of Wilson’s #1462 come into flower for the first time.

1995: C. Stapleton makes the case for preserving the name *Fargesia murielae*, but proposes correcting the spelling of the specific to *murielae*. 15

May 1998: Arnold Arboretum plants of *Fargesia murielae*, received from the U.S. National Arboretum in 1960, come into flower for the first time.
The flowers of Fargesia murielae are inconspicuous occurred there during the 1970s—can we hope to obtain material comparable in quality to the original Wilson #1462.

The story of the introduction of Muriel’s bamboo is typical of the interplay between meticulousness and confusion that often surrounds the introduction of a new plant. That we can follow the Fargesia story as well as we can bears witness to the care and effort that the Arnold Arboretum in general, and Wilson in particular, put into the process of collection and documentation. The story illustrates another point as well: the importance of sharing plants among botanical gardens. Kew Gardens, and especially its horticulturist W. J. Bean, deserve credit for propagating and eventually distributing the plant throughout Europe. Distributing rare plants is an act both of generosity and of self-preservation: if you have two plants and give one away, you can get it back when you lose the one you kept. Such losses happen frequently, but the tradition of sharing plants provides an important safety net that greatly increases the chances of successful introduction. Given the rate at which the forests of the world are disappearing, failure to thoroughly document collections—and to share them—can represent the loss of a resource that can never be recaptured.

Endnotes


4 Renvoize, op cit.


7 C. S. Sargent, ed., *Plantae Wilsonianae* II (Arnold Arboretum, 1916), 64.

8 Wilson’s diary entry for April 17, 1907, makes no mention of any bamboo, but when I checked the herbarium specimens that document #1462, I found all of them dated “17/5/07” in Wilson’s handwriting. In the absence of any journal for the month of May 1907, this discrepancy in dates was resolved by checking Wilson’s other herbarium specimens collected at Fang Xian According to former Arboretum director R. A. Howard, in his 1980 article “E. H. Wilson as Botanist” (part I, *Arnoldia* 40[3]: 102–138; part II, 40[4]: 154–193), the Fang Xian material all had collection dates in May 1907. This clearly suggests that the date of April 17 published in *Plantae Wilsonianae* is an error, and that May 17, 1907, noted on the specimen, was the actual date for the collection of *Fargesia murielae*

9 E. H. Wilson, AA Manuscript #39611: Numerical list of seeds [no. 1–1474, 4000–4462], collected on his Arnold Arboretum expeditions to eastern Asia, 1907–08, 1910, which were planted in the arboretum nurseries [undated, probably 1910–1911].

10 J. S. Gamble, in Anon, *Decades Kewenses: Plantarum novarum in Herbario Horti Regii*
Fargesia munelae at Kew Gardens, lifeless at the conclusion of its flowering in 1997

Perhaps Wilson used 1910 as the date for "successfully" introducing *Fargesia munelae* because it was then that he inventoried his collections for those that were actually alive "in the arboretum nurseries." An alternative, and rather unlikely, interpretation is that Wilson recollected the bamboo in 1910 and simply recycled #1462 from the 1907 expedition. Of course, one can not discount the possibility that Wilson just made a mistake in giving 1910 as the date for the introduction of *F munelae*

At the National Arboretum the plant was given inventory number 262266; at the Arnold Arboretum, it became accession number 1239–60


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Nature Study Moves into the Twenty-First Century

Candace L. Julyan

The veining of the leaves and the construction of the stalks . . . are as interesting to me as the construction of a locomotive is to an engineer. When you get to know the plants, you feel as though you ought to have a garden where you can take care of real plants and study them.

Plants move, though many people do not know it. It is true that they do not move with a jerk, but they move very slowly. When the corn gets beaten down by a heavy rain or hail storm, it gradually works itself up again, although it never gets perfectly straight as before. When we move, we bend our joints. That is the way also with the corn. It bends at the nodes.

—Reports from fourth-grade students at the Francis Parker School, Chicago, 1915.

In many respects these reports could be more readily attributed to students today than to those at the beginning of this century. The study of plants is now considered a routine part of the elementary curriculum, and reports are a standard form of communication between teacher and student. However, classroom practice that encourages students’ observations of nature, considered laudable today, was much more controversial at the beginning of the century. At the Arnold Arboretum, education for children has been shaped by our strong belief that the most powerful learning happens out in the landscape, a belief that was articulated at the turn of the century by participants in the “nature-study movement.” The fourth-graders quoted above, students at a school founded on the principles of this movement, had studied plants by observing corn growing in their schoolyard, rather than by reading about it in a textbook. A closer
look at the tenets of nature-study serves to identify the roots of our beliefs and to illuminate new ways to approach the study of nature.

The nature-study movement, which peaked between 1890 to 1920, was part of a progressive education philosophy that proposed a child-centered approach to learning by encouraging engagement and play in contrast to more traditional, text-driven practices. Nature-study educators (who used the hyphen to signify that their nature study included a pedagogical approach) proposed that learning about the natural world was as important as studies of reading, writing, arithmetic, and grammar. The key precepts of the nature-study movement can be summarized briefly:

- The objects of study can be ordinary, seasonal phenomena.
- Direct observation is central to learning; drawing can be a useful, complementary tool.
- The teacher guides the students’ exploration; fostering discussions is considered more critical than memorization.
- Truly significant learning about nature takes place outdoors, “in nature.”
- Education should instill a love of nature in the child.2

Much of the impetus for this movement came from a concern that the rigid approach to teaching was not resulting in significant learning by students. Samuel Jackson, an important spokesman for the movement, summarized the dissatisfaction of many with traditional book-centered study:

Instead of providing the child with proper conditions which cause him to grow out of the old into the new, usually, the teacher merely smites him with a definition. The child is finally belabored into saying, “The earth is round like a globe or a ball,” and the matter is dropped; but most of his geography forever conforms to his picture of the old flat earth of his childhood.3

Such misgivings were certainly not new. Over two centuries earlier, the Moravian monk John Amos Comenius (1592–1670) wrote a critique of the approach to children's education at that time:

Hitherto the schools have done nothing with the view of developing children, like young trees, from the growing impulse of their own roots, but only with that of hanging them over with twigs broken off elsewhere. They teach youth to adorn themselves with others' feathers, like the crow in Aesop's Fables. They do not show them things as they are, but tell them what one and another, and a third and a tenth, had thought and written about them, so that it is considered a mark of great wisdom for a man to know a great many opinions which contradict each other.4

Comenius developed his ideas in the first illustrated children's book, *Orbis Pictus*, published in 1658 and focused on topics familiar to young people. The book's small woodcut graphics are accompanied by short texts that deal with a wide range of topics drawn from both nature and ethics—from clouds, trees, and animals, to honesty, respect, and love.
Another writer influential in the development of the nature-study movement was Jean Jacques Rousseau (1712–1778). Many of his ideas were incorporated into the movement's philosophy: the principles of science are discovered by the child, not learned as facts; learning should begin with observation of common phenomena; the order of learning should be determined by the learner's interests and experiences, not by the organization of science; and the objective should be enthusiasm for the discipline and methods of science, rather than a body of memorized facts.  

As the nature-study movement gathered momentum in the late nineteenth century, its leaders built upon these ideas to create an approach to education with careful study of the outdoor environment as its centerpiece. While a growing number of teachers found these ideas exciting and in line with their own thinking, many others were baffled by the idea of teaching without books and using natural objects and phenomena to help children understand the world around them. Ultimately the movement lost strength as educators turned away from the ideas of progressive education in favor of more traditional approaches.

**The Relevance of Nature-Study Today**

While the philosophy of the nature-study movement could be found in small pockets of schools throughout this century, the ideas gained favor again in the 1960s and 1970s with the growth of environmental education and of science education that focused on experience and, more recently, in the 1980s and 1990s, with a renewed focus on science education. The notion of a compatibility between science and nature-study was not prevalent at the turn of the century. Although exceptions existed, such as Louis Agassiz, a nineteenth-century scientist whose credo was "Study nature, not books," generally, nature-study educators and professors of science held significantly different ideas, as suggested in these passages written by Anna Comstock in 1911:

> For a long time botanical science, in the popular mind, consisted chiefly of pulling flowers to pieces and finding their Latin names by the use of the analytical key. All the careful descriptions of the habits of plants in the classic books were viewed solely as conducive to accuracy in placing the proper label on herbarium specimens. Long after the study of botany in the universities had become biological rather than purely systematic, the old regime held sway in our secondary schools; and perhaps some of us today know of high schools still working in the first ray that pierced primeval darkness. . . .

> To-day nature-study and science, while they may deal with the same objects, view them from opposite standpoints. . . . The child, through nature-study, learns to know the life history of the violet growing in his own dooryard, and the fascinating story of the robin nesting in the cornice of his own porch.

Comstock explained that nature-study "does not start out with the classification given in books, but in the end it builds up a classification in the child's mind which is based on fundamental knowledge; it is a classification like that evolved by the first naturalists, it is built on careful personal observations of both form and life."

She would, no doubt, be surprised to learn how the teaching of science has shifted in the intervening years. In 1994, the National Academy of Science convened a large group of scientists and educators to consider how and what children should learn about science and the environment. The conclusions of this group, published in 1996 as the *National Science Education Standards* (NSES), suggest certain "big ideas" to be addressed at each grade level and propose an approach to teaching that in many ways resembles the one endorsed by the nature-study authors at the turn of the century:

Learning science is something students do, not something that is done to them. In learning science, students describe objects and events, ask questions, acquire knowledge, construct explanations of natural phenomena, test those explanations in many different ways, and communicate their ideas to others.

The Arboretum's work with children employs a combination of the nature-study philosophy and scientific practice. Begun in 1984, the Arboretum's Field Studies Experiences are designed for small groups of elementary stu-
dents who come to the Arboretum to observe closely and make sense of what they see. In the fall, students look for seeds and determine their mode of travel; in the spring, they discover the stages of transformation from flower to fruit. In both of these activities, careful observation is supplemented by conversations with the guides, who help students make sense of what they see. This program is based on a belief that children learn best through experiences in the landscape, guided by attentive adults.

A decade later, we explored ways to add data collection to these observation-based activities. In 1995, with funding from the National Science Foundation (NSF), the Arboretum began the development of a program that could serve as a model for partnerships between elementary schools and institutions involved in science. While based on many of the principles of nature-study, this new project, called Seasonal Investigations, also includes an emphasis on keeping systematic records of observations and sharing those data with others using a computer web site.

A Design for Nature Study in the Twenty-First Century

Before I investigated a twig in winter, I just thought that the leaves fell off a tree and gradually grew back. But boy, did I learn a lot about trees from just one little twig!

Maybe I should tell you about some things I learned. . . . I learned the names of the different parts of a twig, like the Terminal Bud, which is the bud at the tip, and the Lateral Buds, the little buds on the sides. I, myself, liked the names our class made up better. Like the name I gave to the Terminal Bud, Kiss-End Tail (an off-spring from the expression “Kiss and Tell”).

Another thing I learned from my twig is that the different colors along the twig signal yearly growth. We also determined the yearly growth for 1995–96 by looking at the first ring from the top. Then we measured from that ring to the very tip of the twig. Get this, my twig grows one centimeter less each year! So next year, if my twig only grew one centimeter since 1995, my twig will probably stop growing. Or maybe it will start a whole new growth. I think that the reason my twig’s health has been declining is because of the harsh winters we’ve been having. Well it’ll sure be a big surprise [this spring]!
color and fall from the tree. In the winter investigation, students learn to "read" a twig and use their new knowledge to determine which was the best recent growing year for the schoolyard trees. The spring investigation revisits the features examined in the winter to learn whether and how those features change in the spring and to determine when the flowers are "open for business."

The student report quoted above was written as part of the winter twig investigation. The twigs, initially viewed by students as a bag of sticks, constitute the major focus of the class investigation. Each twig soon becomes a treasured resource. Students begin by making careful drawings and identifying features of the twig, later naming the features. These names are often revealing. For example, one student named the annual growth-ring marks "growing up lines." Many students preferred their own names to those of scientists, but they were fluent in both.

The Role of the Web Site
Now in our final year of NSF funding, we are designing a web site for Seasonal Investigations that we believe will support both the classroom and outdoor work and allow a greater number of teachers to take part in the project. While the program can be (and sometimes is) completed successfully using only the classroom and schoolyard, the on-line environment provides an important support for the four activities central to the project—observation, data collection, communication, and publication—with a web site feature dedicated to each of these activities.

The Spotlight feature changes weekly throughout each seasonal investigation; the topic of each entry is chosen to encourage closer observation. In the fall investigation, students were invited to consider patterns of leaf change, to view other students' drawings of patterns they found, and to share their observations about leaf patterns with others. Another Spotlight entry asked them to consider how bark accommodates the expansion of a tree's girth. Three possibilities—fissures, plates, and peels—were illustrated with photos; students were
asked to look at their school-yard trees and report their findings.

The Tree Talk feature facilitates communication among classes, from initial letters of introduction to later conversations about questions or findings. Contributions to most of these “conversations” can be made and viewed at any time; in addition, there is an option for a live, scheduled chat with either Arboretum staff or other classrooms.

The Activities feature provides the structure for sharing data among classes. Students are asked to provide specific data about their schoolyard trees, changing or adding to the data as the study progresses. The combined data provide opportunities for discussion in the classroom or with other students.

The Publication feature is intended to elicit a creative activity at the end of each investigation, perhaps a report or drawing, that brings together the ideas, surprises, and discoveries from the investigation.

The first three years of the project were spent perfecting the model and developing a set of investigations that could be completed in the schoolyard, with supporting visits to the Arboretum. During this, the last year of the project, the focus is on perfecting the web site to ensure that the program will continue after NSF funding ends.

Even before the project’s completion, the framework of Seasonal Investigations has been adopted as a model by other institutions engaged in science education. Descanso Gardens in Los Angeles is replicating the entire program as a pilot project with the Los Angeles Unified School District. The Garden’s director, Richard Schulhof, had first-hand experience with the project as a member of the Arboretum staff at the time it began, and is enthusiastic about using the program as a new approach to science teaching for his own staff as well as for the Los Angeles teachers. In addition, the Massachusetts Audubon Society is using the Seasonal Investigations framework to develop both teacher institutes and investigations of vernal pools in three locations across Massachusetts.

**Future Directions**

Many of the ideas of the nature-study movement are alive and in practice in today’s programs at the Arboretum, but new issues
are also being raised. What role can the web play, not as an end in itself but as a springboard to investigations outdoors? How might it provide an avenue for sharing our educational ideas, many of which have century-old roots, with interested educators around the globe?

In many ways, the words of Anna Comstock have as much relevance at the end of this century as they did at the beginning:

When the child has become acquainted with the conditions and necessities of plant life, how different will the world seem to him! Every glance at forest or field will tell him a new story. Every square foot of sod will be revealed to him as a battlefield in which he himself may count the victories in the struggle for existence, and he will walk henceforth in a world of miracle and of beauty,—the miracle of adjustment to circumstances, and the beauty of obedience to law." 

The young author who wrote about her twig is one of a growing number of students whose science experiences have been shaped, either directly or indirectly, through a connection with the Arboretum and its staff. As we enter the twenty-first century, we continue to seek opportunities for sharing our ideas about the compatibility of nature, science, and technology with teachers and students eager to learn about trees and plants. Our hope is that ideas about children’s education, developed and nurtured at the Arboretum, can grow into viable "seeds" locally and around the country.

Endnotes

1 From the Francis Parker School Year Book, vol IV, June 1915 (Archives of Gutman Library, Harvard University).


3 Quoted in Jackman, op. cit., pp. 9-10.


6 Quoted in G. F. Atkinson, First Studies of Plant Life (Boston: Ginn & Co., 1901), p. iii.

7 Comstock, op. cit., p. 5.


9 Atkinson, op. cit., p. v

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