

Taxonomy and Arboretum Design

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In the second half of the nineteenth century, arboreta joined natural history museums and zoological gardens as archetypal embodiments of the Victorian fascination with the natural world.

Grouping plants by type is a familiar practice in North American gardens where small, separate collections of maples, oaks, or other genera are common features. Although it is now unusual to follow a taxonomic scheme in the layout of an entire garden, such arrangements were the vogue in nineteenth-century botanical gardens and arboreta. The plant collections in these gardens were frequently grouped into families or genera and then planted out along a winding pathway so that visitors encountered specimens in a taxonomic sequence.

Growing related plants together, in effect, organizes a collection into a living encyclopedia, allowing for comparison of the characteristics of species within a genus or genera within a family. By planting related taxa in an evolutionary progression, the more complicated sequential taxonomic arrangement reveals the ancestral affinities of modern floras. Good examples of this display theme are the "order beds" of herbaceous plants at gardens like Kew and Cambridge, which have long provided botany students with a compact synopsis of the plant kingdom arranged in taxonomic sequence.

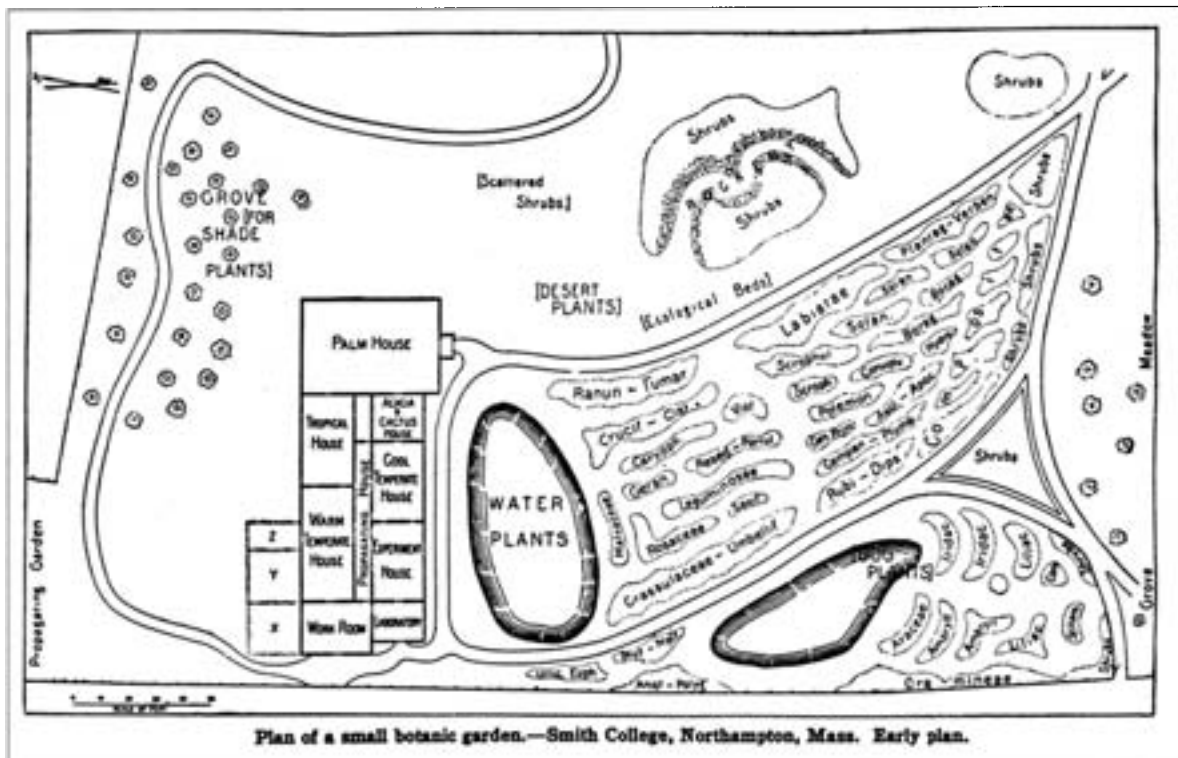
Despite the educational advantages, there are significant horticultural and management problems that result from the application of taxonomy to the layout of a garden. Because plant families tend to be ecologically heterogeneous, they require a variety of cultural condi-

tions. This is especially problematic when the concept is applied to a plant collection that strives to be all-inclusive. The arboretum projects of the Olmsted landscape architectural firms illustrate some of these problems and also exhibit how changes in plant taxonomy were expressed in the landscape.

Historical Background

The historical antecedents for arranging plant collections taxonomically include the first European botanical garden, the Orto Botanica, founded in Pisa in 1543. The plants in this garden were grouped according to their medicinal properties and, by the end of the sixteenth century, by morphological characteristics as well (Hill 1915). As the science of botany advanced during the Renaissance, the practice of storing herbarium collections in a taxonomic order developed, and this probably contributed to the practice of arranging living collections in a similar fashion.

Following the publication of Linnaeus' comprehensive plant classification system in 1753, botanical taxonomy changed radically, and taxonomic gardens quickly followed suit. William Aiton used the Linnaean system in laying out the original nine-acre botanical garden at Kew in 1760, as did the Reverend Erasmus Darwin (grandfather of Charles Darwin) when designing his private garden at Litchfield in England (Simo 1988).



This plan, which illustrates the entry on botanic gardens in Liberty Hyde Bailey's 1914 edition of the *Standard Cyclopedia of Horticulture*, reflects taxonomy's role as the standard method of organizing plant collections in botanic gardens.

In 1759, the French botanist Bernard de Jussieu became dissatisfied with the Linnaean system while laying out a taxonomic garden at Versailles. Jussieu began moving plants around in pots in an attempt to express an arrangement that reflected "genealogical" relationships. Linnaeus himself had allowed that this was the goal of botanists although he had not been able to provide more than outlines for such an arrangement. Bernard's arrangement was further developed by his nephew Antoine Laurent de Jussieu, and his classic *Genera Plantarum* fairly soon gained broad acceptance in Europe and became the basis for taxonomic arrangements in gardens.

Following Jussieu's work, three successive systems of classification have been principally employed in the layout of sequentially ordered taxonomic plant collections. In chronological

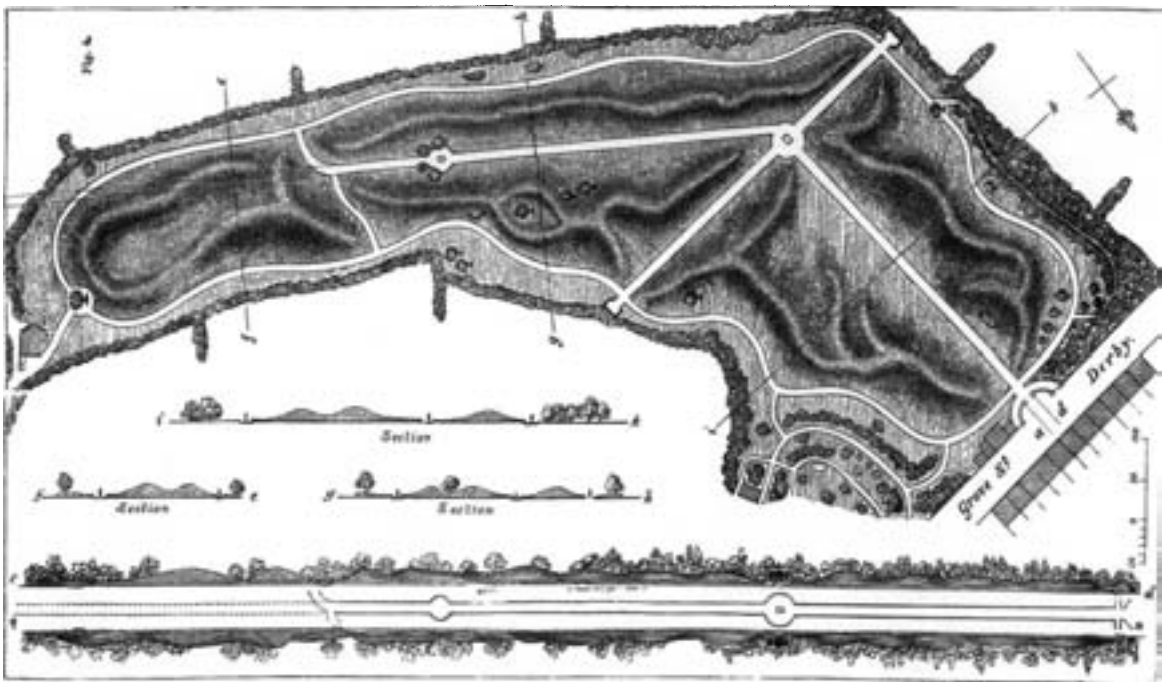
order, these were (1) the system of the Swiss botanist Augustin Pyramus de Candolle, which was based on rather different principles than that of Jussieu, although the main difference might seem to be in the plant with which the sequence of flowering plants starts—Dutchman's-pipe (*Aristolochia*) for Jussieu, and buttercups (*Ranunculus*) for Candolle; (2) the system of George Bentham and Joseph Dalton Hooker, published in England between 1862-1883, and in some ways an elaboration of the Candollean system; and (3) the post-Darwinian system of Adolph Engler and Karl Prantl, published in Germany between 1887-1915 and the first widely accepted system to be based on evolutionary progression.

In order to appreciate the progression of plant families in taxonomic gardens, it is first necessary to understand the placement of the

gymnosperms and subdivisions of the angiosperms (i.e., monocotyledons and dicotyledons) within each of these classification systems. The sequence of dicot families is especially important, for although the pre-Darwinian systems of Candolle and Bentham and Hooker began with the polypetalous (many-petaled) buttercups and magnolias, Engler and Prantl's dicot sequence commenced with the willows and birches, whose apetalous (petal-less) flowers they considered to be more primitive. Both the Candolles (Augustin as well as his son Alphonse) and Bentham and Hooker placed the gymnosperms between the monocots and dicots because they thought that gymnosperms really were very complex organisms, just like dicotyledonous trees, whereas Engler and Prantl placed them first, as the purported progenitors of the angiosperms.

The sequence of families in Jussieu's, Candolle's, and Bentham and Hooker's sys-

tems was not intended to show evolutionary progression. However, they did attempt to reflect their authors' general ideas of the progression of morphological complexity. Jussieu's arrangement, as far as can be ascertained, forms a basically linear sequence, but the Candolles and Bentham and Hooker were adamant that plant relationships did not follow a linear sequence, although the printed page forced such a sequence on them. Most plant classification systems appearing after the work of Charles Darwin and Alfred Russell Wallace have been predicated on an understanding of descent and evolution and, therefore, have tried to establish "evolutionary" relationships among plants. In the first of these phylogenetic systems, such as Engler and Prantl's, plant families were placed in a sequence beginning with the most primitive plants and ending with the most advanced. This is still the case today, although a veritable forest of evolution-



Contour plan of the Derby Arboretum, 1839. The arboretum path that winds around the periphery is concealed from the main walk at the center by thick evergreen shrubbery and six- to ten-foot berms. From J. C. Loudon's catalog, The Derby Arboretum, published in London, 1840.

ary "trees" has been produced. Each tree purports to show the complexity of the relationships between plant families that cannot be accommodated by the linear sequence of the printed book.

The Derby Arboretum

It was to the Candollean system that the English author and garden designer John Claudius Loudon looked when laying out the Derby Arboretum in England in 1839, the most influential of the taxonomically arranged British gardens. Early in his career Loudon had become intrigued by the novel marriage of science and landscape beauty that a taxonomic garden presented (Simo 1988). In 1803 he seized upon Jussieu's system as the organizing structure for a large arboretum and flower garden at Scotland's Scone Palace. In 1811 he recommended a similar "living museum" for the city of London, with plantations arranged by the Linnaean system in one area and by Jussieu's system in another. Neither the Scone Palace nor the London garden materialized as envisioned. But with the taxonomic design for Derby, Loudon brought the arboretum into a new era, where it joined the natural history museum and the zoological garden as an archetypal embodiment of the Victorian fascination with the natural world.

The Derby Arboretum was designed to be viewed in a prescribed sequence. This concept drew on the eighteenth-century English tradition of emblematic landscape gardens such as Stourhead, where statuary and classical temples, as they were revealed sequentially to the viewer, were intended to call up specific ideas and allusions, usually from classical history or poetry. At Derby, however, a new paradigm was evoked, that of science. The paths were designed to follow, in sequence, the "natural order" of the plant collections.

The main walk at Derby is on a central axis that brings visitors to a seating area in the middle of the park. The tree collection was planted along a secondary walk that takes a serpentine course around the park's perimeter, allowing visitors to enter the park, experience

the entire collection, and then leave by the same gate without retracing their steps. Loudon employed the "gardenesque" style (which he created and advocated) when planting the arboretum, displaying the trees singly with sufficient room for each specimen to develop without touching others. Such careful planning notwithstanding, the arboretum was intended to be torn up and replanted every few decades, in order to remove outsized trees and to permit the addition of new taxa (Loudon 1840).

The Derby Arboretum greatly impressed both the American landscape architect Frederick Law Olmsted, Sr., and his friend and mentor, Andrew Jackson Downing, America's first native-born professional landscape designer and most influential transmitter of contemporary English design for American use. Both men, when given the opportunity to design public parks, included taxonomic arboreta in their proposals, drawing heavily on Loudon's writings and his seminal design for the Derby Arboretum.

North American Examples

North America's first botanical gardens were planted without particular attention to taxonomic or other thematic arrangements. The continent's first proposal for a taxonomically arranged garden appears to have been made in 1839, for Nova Scotia's Halifax Public Garden, followed closely by a design by Downing for a Derby-like arboretum in Boston's Public Garden, probably in 1841 (Zaitzevsky 1982). But it was Olmsted and Calvert Vaux's inclusion of a taxonomic arboretum in their 1858 "Green-sward" plan for New York's Central Park that became the most significant early proposal, since it inaugurated eighty years of involvement in taxonomic arboretum design by the Olmsted firms.

As with the Derby Arboretum, the forty-acre Central Park Arboretum was designed to be a self-contained and sequential experience. Also like the Derby, its plan followed Candolle's system of classification. Since the Derby Arboretum had been criticized by

Downing for its "peculiarity of design," a reference to the use of "scattered single trees and shrubs" (Downing 1850), Olmsted and Vaux's planting plans for the Central Park Arboretum avoided the aesthetic shortcomings of such spotty, gardenesque planting by displaying tree species both as specimens and *en masse* (Zaitzevsky 1982).

Olmsted and Vaux not only attempted to make the taxonomic arrangement appear picturesque but also tried to place families where they would grow best. Thus they attempted to reconcile one of the major problems of taxonomic arrangements. Strict adherence to taxonomic groups and a fixed, linear sequence of families may locate plants on unsuitable sites, where they will not flourish. After all, membership in a botanical genus or family implies little or nothing about a particular species' cultural requirements or preferences in habitat. Species within the same genus may originate in such widely dissimilar habitats as bog and desert, as occurs, for instance, within the genus *Pinus*.

Given this formidable problem, Olmsted and Vaux did their best to bring each family "into a position corresponding to its natural habitats," in some locations winding the paths to achieve this. Nevertheless, in their design they were preoccupied with preserving the botanical sequence rather than concerned with the habitat preferences and performance of individual species.

Olmsted's 1858 plan for the Central Park Arboretum never came to fruition, but fifteen years later he was presented with an even greater opportunity, this time in Boston. The result was the Arnold Arboretum, North America's quintessential taxonomically arranged plant collection. The Arnold has developed out of the collaboration and foresight of a variety of institutions and individuals, among them Charles Sprague Sargent, its first director and, with Olmsted, co-designer.

Olmsted and Sargent chose Bentham and Hooker's classification as the taxonomic guide for their planting plan, which, although Bentham and Hooker's *Genera Plantarum* was

published after the appearance of Darwin's *Origin of Species* (1859), did not embrace Darwin's views. The trees were set out by genera, ordered according to Bentham and Hooker's sequence. Every species to be included was planned for in advance, which required modifications later when unanticipated species and subspecific taxa (subspecies, varieties, and formae) were acquired. As with the Candolle system, Bentham and Hooker's classification begins with the magnolias and their relatives, which were assembled at the entrance to the then one-hundred-and-thirty-acre arboretum. The rest of the collection then followed according to sequence, although this time it was to be viewed from a winding carriage road instead of a pedestrian path, a sensible innovation given the size of the property.

The design also arranged species geographically within each generic group. The plants of North America were the first to be encountered, followed by those of Europe, and finally those of Asia. This created considerable complexity in the layout. To add to this complexity, the species within each continental subgroup were placed in the sequence in which they appeared in Bentham and Hooker's book.

Because the main collection was intended to be permanent, specific places for individual specimens and groves were designated on the plan. Early studies for the distribution of plants placed related species on both sides of the road, as Olmsted had done in the Central Park Arboretum plan. But in the final Arnold plan, species groups were assembled on one side only, with the next genus appearing across the road, and so forth, in staggered fashion.

The Bentham and Hooker sequence was followed quite closely in Olmsted and Sargent's plan. Only one major genus, *Salix*, appears to have been placed out of sequence and that was due to cultural necessity. The moisture-loving willows were planted in wet ground near the arboretum entrance, far from their proper place at the end of the dicot sequence. Bentham and Hooker placed the conifers after the dicots; consequently, Olmsted deployed the dicots along winding roads so as to terminate at an



In the Bentham and Hooker sequence, conifers followed the dicotyledons. This 1991 photo by Rácz and Debreczy captures part of the Arnold Arboretum's collection at just over the century mark.

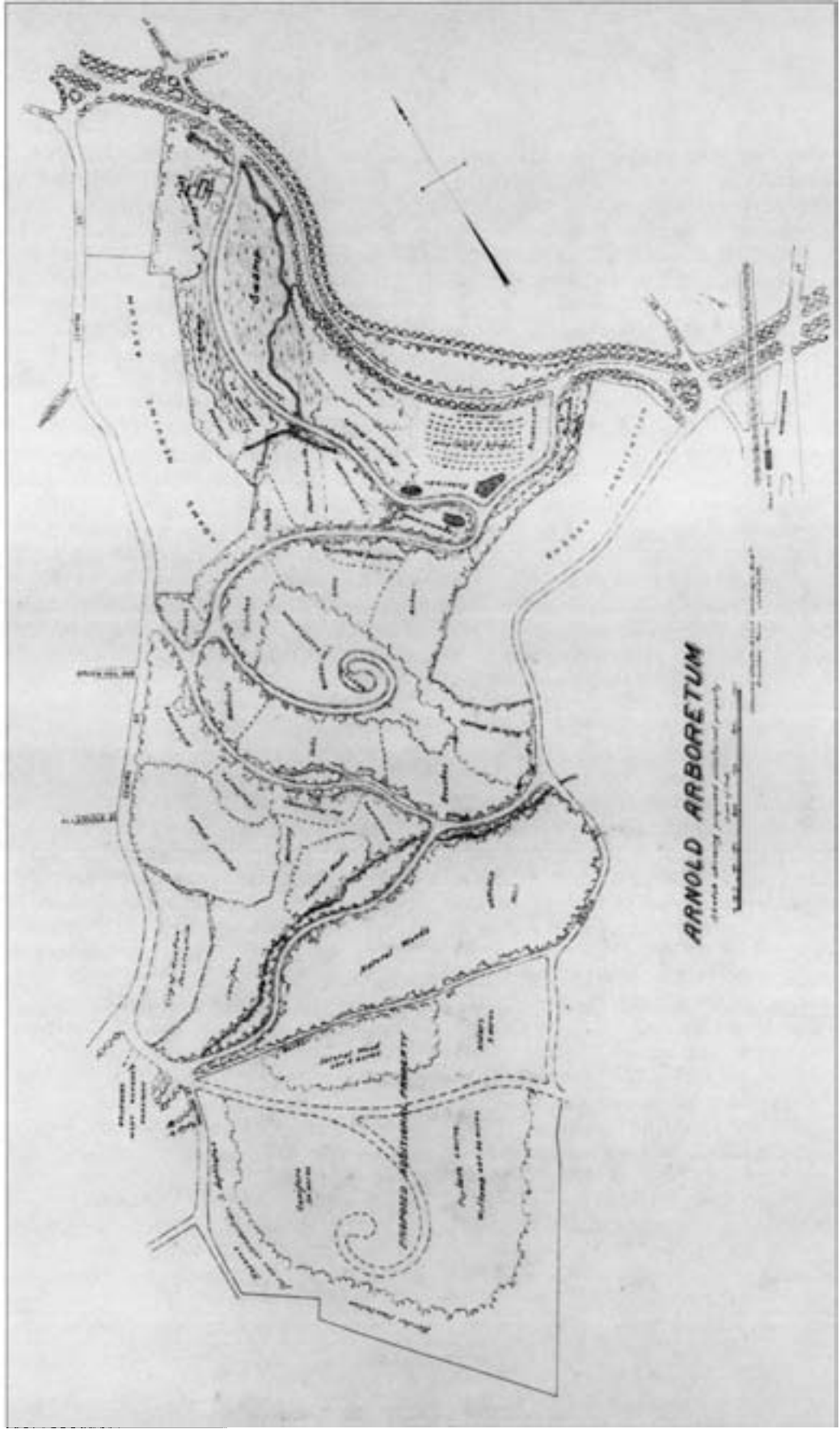
existing stand of native hemlocks. Nearby, he created a pinetum for cultivated conifers.

Unlike the plan for Central Park, where families containing mostly shrubs were interspersed in proper sequence among the tree families, Sargent arranged the shrubs at the Arnold in a separate fruticetum (from the Latin *frutex*, meaning shrub), also arranged in a progressional sequence according to Bentham and Hooker (Gamboni and Hamburg 1983).

In a few cases, strict adherence to the taxonomic scheme resulted in poor performance among various groups of plants. For instance,

the plan called for magnolias to be planted near the entrance, but some tender species have had to be sited elsewhere, where warmer microclimates prevail. Similarly, the flowering cherries had been established in one of the coldest areas in the arboretum. In subsequent years, the sequence has been modified when necessary to accommodate the cultural requirements of the plants.

The Arnold Arboretum undoubtedly had an enormous impact on the development of American gardens that followed, including the New York Botanical Garden and the Brooklyn Botanical Garden, where parts of the perma-



This 1894 plan of the Arnold Arboretum shows botanic families arrayed along the roads, with the magnolias at the Arborway entrance and the conifers near Walter Street.

ment collections were laid out taxonomically. Olmsted maintained a profound interest in the creation of arboreta throughout the remainder of his career, producing arboretum plans for the city of Rochester, New York, Stanford University, and other institutions. Olmsted's last commission, the Biltmore estate in North Carolina, included an ambitious proposal for what would have been the world's greatest collection of trees and shrubs, arranged taxonomically along a sinuous nine-mile drive. The collections policy for the Biltmore arboretum was the broadest imaginable: every woody plant from the world that might be hardy, cultivars included, was to be acquired and planted, whether it was currently in cultivation or not. (Throughout much of the Arnold Arboretum's history, its collections policy has focused on hardy *species* of woody plants, bypassing most cultivars.) Such comprehensiveness ultimately proved to be the Biltmore arboretum's undoing. Because the layout of the collection was determined by a plant classification system (in this case, Bentham and Hooker's), it was necessary to know in advance how many hardy tree and shrub species would be represented in each genus so that adequate space could be allocated in the proper sequential location. Due to an incomplete knowledge of temperate floras (especially of Asiatic regions) and widespread synonymy in the nursery trade, compilation of such a master planting list was a daunting task, as it would be today. This impasse no doubt played a part in the collapse of the arboretum project at the turn of the century.

As successors to the senior Olmsted's practice, the Olmsted Brothers firm continued a tradition of making taxonomic plans for arboreta and influenced other landscape architects to do the same. The firm was commissioned to generate plans for the Missouri Botanical Garden, the Holden Arboretum in Ohio, the original Rancho Santa Ana Botanic Garden in southern California, and the University of Pennsylvania's Morris Arboretum. Unfortunately, all of these designs either went unexecuted or no longer exist.

The Missouri Botanical Garden project is notable in that it roughly coincided with the publication of Engler and Prantl's classification system, the first system based on Darwinian ideas of evolution to achieve wide use. William Trelease, the garden's first director, decided to make use of both the Bentham and Hooker and the Engler and Prantl systems when engaging the Olmsteds to lay out two new geographic collection areas. The Bentham and Hooker was chosen for the American collection for its familiarity among botanists. A larger garden devoted to the "universal flora" followed the Engler and Prantl system because it illustrates evolutionary affinities among plants. Both gardens were to contain mere synopses of their respective floras. In this way, the designers avoided the horticultural problems that have plagued other taxonomically arranged gardens because representative species from a particular family or genus could be selected based upon their horticultural compatibility. In addition, the designers did not have to wrestle with the planning issues arising from a comprehensive collections policy, such as those that confounded the Biltmore project.

In 1936, the Olmsted Brothers produced the firm's last taxonomic arboretum plan, for the University of Washington Arboretum in Seattle. The Engler and Prantl system was exclusively applied here to a collection intended from the outset to be comprehensive in scope. Following the post-Darwinian system of Engler and Prantl, the taxonomic sequence began with *Ginkgo biloba*, the most primitive hardy gymnosperm, followed next by the conifers, the woody monocots, and finally by the dicots. The dicot sequence was initiated not by the magnolias as in Bentham and Hooker's system, but with apetalous families like the willow and birch.

Despite the aesthetic and intellectual appeal of their strikingly rendered plans on paper, the Olmsted Brothers' last arboretum design revealed a sharp decline in conceptual quality. The firm appears to have been copying aspects of the Arnold Arboretum plan merely out of



custom, without reexamining the theoretical basis for arranging plants in a taxonomic sequence. Incredibly, the critical interrelationship between the botanical sequence and the pedestrian circulation was omitted, thereby stripping the design of the educational elements that justify the use of a taxonomic sequence in the first place. Fortunately, the University of Washington Arboretum has since developed independently of the Olmsted Brothers' plan for it, with greater sensitivity given to the physical characteristics of the site and the cultural requirements of the plants.

Disadvantages

With few exceptions, North American botanical gardens founded after the 1930s have eschewed sequential taxonomic arrangements in favor of geographic, ecological, or strictly aesthetic schemes (or combinations thereof). Gardens continue to present small displays organized by evolutionary sequence, such as the Prehistoric Glen at Honolulu's Foster Botanical Garden or the Plant Families garden at the North Carolina Botanical Garden, but the comprehensive application of taxonomy to garden design is virtually forgotten today.

For purposes of comparing related plants, the approach works reasonably well with herbaceous perennials, where the plants are small and the flowers within reach—a substantial amount of diversity can be encompassed within a relatively small area. Woody plants lend themselves less successfully to a sequential taxonomic treatment. The flowers are often out of reach and the plants are spaced farther apart. This makes comparisons of floral characters difficult. However, there remains the advantage of comparison of overall form as, for instance, in the collections of maples and lindens.

A redrafted version of the Olmsted Brothers' taxonomic plan for the University of Washington Arboretum, which employed the classification system of Engler and Prantl. From the Bulletin of the University of Washington Arboretum, Volume 1, Number 1, December 1936.



A view of the Arnold Arboretum's linden (Tilia) collection in 1991. A taxonomic scheme offers the opportunity for side-by-side comparisons of overall form. Photo by Rácz and Debreczy.

New developments in taxonomy also pose problems for sequentially arranged taxonomic collections of woody plants. While a herbaceous garden can be torn out and replanted following acceptance of a new taxonomic system, such a drastic approach is impractical in a mature arboretum. Nevertheless, woody collections that follow an obsolete classification system are anachronisms, worth maintaining for their historical interest but lacking in some of the educational values that originally led to

the use of a taxonomic sequence. At the same time, it is clear that no planting sequence can do justice to natural relationships, whether as understood in 1850 or 1993. From the point of view of teaching natural relationships, some means of organizing a collection is better than none.

The most serious drawback to a taxonomic arrangement, however, deals with horticultural issues. The point has already been made that taxonomic groups above the species level

often contain plants from widely dissimilar habitats. The varying degrees of sun and shade tolerance as well as the differing nutritional and moisture requirements found among groups of related species cause problems when these plants are grown together under similar conditions. Many plants will simply die when placed in the wrong spot. Others will struggle for years in a sickly or stunted condition and consequently form poor examples of the average size, growth, or appearance of a particular species.

There are ways of avoiding some of the aforementioned problems of sequential taxonomic arrangements. Planning a synoptic collection rather than a complete one affords the opportunity of choosing plants based on ease of culture and other factors. Diversity of terrain also permits greater flexibility, as the linear sequence can be bent to site taxonomic groups in the positions best suited to the majority of their member species. Species clusters composed of the often smaller generic unit rather than of families have also tended to be more successful, since one is most likely to find a tolerable site for a smaller group of species. As at the Arnold Arboretum, curators must make exceptions to a hard-and-fast pursuit of any scheme.

Acknowledgments

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Map of Hiroshima. The star marks the hypocenter of the atomic bomb blast. Circles indicate the distances 1 kilometer, 2 kilometers, 3 kilometers from the hypocenter. Adapted from Hiroshima by Hiromi Tsuchida, Kosei Publishing Co., 1985.

- A** Eucalyptus tree (*Eucalyptus* sp.)
- B** Camphor tree (*Cinnamomum camphora*)
- C** Ginkgo tree (*Ginkgo biloba*)
- D** Pine tree (*Pinus thunbergii*)
- E** Willow tree (*Salix* sp.)