

Table 1. Data sets available in climatic data base.

Temperature	Wind
Normal maximum	Average speed
Normal minimum	Average direction
Average	
Record maximum	Relative humidity
Year of occurrence	Morning R.H.
Record minimum	Afternoon R.H.
Year of occurrence	Evening R.H.
Degree days	Miscellaneous
Heating D.D.	Possible sunshine (5)
Cooling D.D.	Thunderstorm days
	Days below 0°C
Precipitation	(32°F)
Normal	Days above 32°C
Monthly maximum	(90°F)
Year of occurrence	Miscellaneous
Monthly minimum	(includes parameters
Year of occurrence	relating to yearly
	totals or seasonal
	averages)

is a weather data base. The subroutine has been developed, but has yet to be incorporated into the main body of the program. It allows access to climatic information from National Weather Service (NWS), first-order weather stations (2). These stations correspond to major cities within each state. The data is stored on a disk and includes information on temperature, winds, solar radia-

tion, heating and cooling degree days, precipitation, and various other parameters. Most of the climatic information needed to produce an environmentally sound design is included in this single source. As well as enabling the user to access and view the data during the drafting session, provisions have been made for incorporation of the wind and solar data directly into the climatic analysis phase of the design process. With the data, design decisions dependent upon climatic information can be enhanced over conventional methods currently available. Inputs from the climatic data base are made using keyboard and joystick inputs. Data sets contained in the weather data base program are listed in Table 1.

Conclusions

Certain tasks can be made easier and less expensive by the use of interactive graphics (1). Interactive graphics offers a tool for exploring alternative solutions to problems in landscape design. Different combinations may be tried quickly by utilizing the natural ability of the human eye to absorb information contained in graphic representation. This technique enables the user to spend more time and energy on the creative aspects of design.

This technology is a first step toward integrating 2 areas: landscape design and mi-

crocomputer graphics. Future ramifications of its use are difficult to anticipate due to changes in graphics hardware by computer manufactures. This project, however, may be applied presently to the needs of students in landscape design, enabling them to focus on design principles. Landscape designers and nurserymen may use it to develop designs with more variety. Researchers may use such a design process to test better use of landscape materials, aesthetic and environmental factors of designs, and methods of teaching landscape design.

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Nomenclature of the Cultivated Apple

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A historical analysis of apple nomenclature leads to the conclusion that the legitimate epithet for the cultivated apple is *Malus Xdomestica* Borkh.

The scientific nomenclature of the cultivated apple has been a constant problem for the horticulturists and botanists (12). The origins of the cultivated apple are lost in antiquity but date back 2900 years to the days of Homer (11). It was well-known to the ancient Greeks and Theophrastus (23) in the 3rd century B.C. refers to various cultivars. It was spread later throughout Europe and to Asia by the Romans (10). Since many of the apple species intercross freely, it seems likely



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that cultivated apples evolved from both interspecific and intraspecific crosses. The uncertainty of knowing the original species of the cultivated apple is reflected in the several names presently found in the literature. These include *Pyrus malus* L., *Malus pumila* Mill., *M. sylvestris* Mill., *M. domestica* Borkh., and *M. malus* Britt.

Present apple-breeding programs have incorporated genes from diverse taxonomic

backgrounds into their new introductions, as it is the case in the Purdue-Rutgers-Illinois cooperative breeding program, the rootstocks of the USSR, and the People's Republic of China selections. The purpose of this article is to unravel the sources of the different names used and to identify the best-suited nomenclature based upon past and present status of the cultivated apple.

Apple nomenclature

Linnaeus in his *Species Plantarum* in 1753 (14), joined the pear, apple, and quince to-

- a. *PYRUS* foliis serratis, pomis bafi concavis. *Hort. cliff. Malus*. 150. *Hort. up.* 170. *Fl. lux.* 402. *Mat. med.* 257. *Rev. 1624*. 200. *Mal. brit.* 361.
- Malus sylvestris*. *Banc. riv.* 433. *Dod. pomet.* 700. *Sylvestris*. *pum.* 433.
- γ. *Malus praefornata*. *Banc. riv.* 433. *praefornata*.
- δ. *Malus iativa*, fructu languenti coloris ex auctero sub-rubiliana dulci. *Tournef.* 177. 635.
- ε. *Malus curtipendula* dicta. *Banc. kiff.* 1. p. 21. *curtipendula*.
- ζ. *Poma orbiculata*. *Ruell. fimp.* *Epirica*.
- Hautast in Europa*. b

Fig. 1. Linnaeus' description of *Pyrus malus* in his 1753 edition of *Species Plantarum* (14). (Courtesy of the Library of the Univ. of Illinois.)

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The Species are ;

1. *MALUS sylvestris, acido fructu albo. Tourn.* The Crab-tree.
2. *MALUS sylvestris, foliis ex albo eleganter variegatis. Cat. Plant. Hort.* The Crab-tree with striped Leaves.
3. *MALUS sylvestris Virginiana, floribus odoratis. Cat. Plant. Hort.* Virginian Crab-tree, with sweet Flowers.
4. *MALUS fructifera, flore fauci. H. R. Par.* The Fig-apple.
5. *MALUS pumila, quæ potius frutex, quam arbor, fructu rubente & candido. C. B. P.* The Paradise-apple.
6. *MALUS sativa, foliis eleganter variegatis. Cat. Plant. Hort.* Apple-tree with striped Leaves.

Fig. 2. Philip Miller's classification of *Malus* species in the 2nd ed. of the *Gardener's Dictionary* in 1740 (15). (Courtesy of the Library of the Univ. of Illinois' Rare Book Room.)

gether under the genus *Pyrus*. He named the common apple *Pyrus Malus* and listed underneath it several botanical varieties. These include *Malus sylvestris*, β *M. paradisaca*, γ *M. prasmila*, δ *M. rubelliana*, ϵ *M. cestiana*, and ξ *M. epirotica* (Fig. 1). The last 5 forms marked by the Greek letters indicate the cultivated varieties of the common apple.

MA1.US. The Apple-tree.

The CHARACTERS are,

The empalment of the flower is of one leaf, cut into five segments. The flower consists of five leaves, which expand in form of a Rose, & whose tails are inserted into the empalment. The fruit is hollowed about the foot-stalk, is for the most part roundish, and unbelled at the top; it is fleshy, and divided into five cells or partitions, in each of which is lodged one oblong seed.

Dr. Linnaeus has joined the Pear, Apple, and Quince together, making them all of the same genus, and has reduced all the varieties of each to one species. The Apple he distinguishes by the title of *Pyrus foliis serratis*, pomis bali concavis. Hort. Cliff. i. c. Pear with serrated leaves, and the Apple hollow at the base. But where the fruit is admitted as a distinguishing character of the genus, the Apple should be separated from the Pear, this distinction being founded in nature; for these fruits will not take by budding or grafting upon each other, though it be performed with the utmost care. Indeed I have sometimes succeeded so far, as to have the bud or graft of an Apple shoot when grafted on a Pear, but they soon decayed, notwithstanding all possible care was taken of them; therefore I shall beg leave to continue the separation of the Apple from the Pear, as hath been always practised by the botanists before his time.

The SPECIES are,

1. *MALUS (Sylvestris) foliis ovatis serratis, caule arboreo. Apple with oval serrated leaves, and a tree-like stalk. Malus sylvestris, fructu valde acerbo. Tourm. Hist. R. H. 635. Wild Apple with a very sour fruit, commonly called Crab.*
2. *MALUS (Coronaria) foliis serratis angulosis. Apple with angular serrated leaves. Malus sylvestris Virginiana, floribus odoratis, Cat. Hort. Wild Crab of Virginia, with a sweet-scented flower.*
3. *MALUS (Pumila) foliis ovatis serratis, caule fruticoso. Apple with oval serrated leaves and a shrubby stalk. Malus pumila quæ potius frutex quam arbor. C. B. P. 433. Dwarf Apple, which is rather a shrub than a tree, commonly called Paradise Apple.*

Fig. 3. Miller's description of the apple in the 8th ed. of the *Gardener's Dictionary* in 1768 (16). (Courtesy of the Library of the Univ. of Illinois' Rare Book Room.)

P. Malus sylvestris, which is not preceded by a Greek letter, is considered to be the wild form of the common apple (24). Linnaeus based his description of *sylvestris* and *paradisaca* on Bauhin's *M. sylvestris* and *M. pumila*, respectively (1).

Philip Miller (15) distinguished the apple from the pear based on the fact that these 2 fruit trees cannot be propagated onto one another, and chose *Malus* as the generic name for the apple (15). Since then, the specific epithet for the cultivated apple has undergone repeated changes. Miller listed 6 species of *Malus* using polynomial descriptions (Fig. 2) in his 2nd edition of the *Gardener's Dictionary* in 1740 (15): 1) *M. sylvestris*, crab tree, 2) *M. sylvestris*, crab tree with striped leaves, 3) *M. sylvestris virginiana*, Virginia crab tree, 4) *M. fructifera*, fig-apple, 5) *M. pumila*, paradise apple, and 6) *M. sativa*, apple-tree with striped leaves. Miller discussed the apple tree in detail in the 2nd volume of this edition and listed the different varieties of apples that were propagated for "the kitchen, the dessert, or to make cyder" (15). However, he never mentioned the species to which these cultivated apples belong in either volume. In the 8th edition of the *Gardener's Dictionary* in 1768, Miller used the binomial system for classification for the first time and listed only 3 species (Fig. 3): 1) *M. sylvestris*, crab, 2) *M. coronaria*, wild crab of Virginia, and 3) *M. pumila*, paradise apple (16). All 3 species were described by Miller as best suited for use as rootstocks. *M. pumila* in particular was described as a distinct species having weak branches that was more of a shrub rather than a tree. Again, Miller made no mention of the species to which cultivated apples belong.

This omission led pomologists to make their own choices for names for the cultivated apple. Since *M. sylvestris* and *M. pumila* commonly were used in earlier botanical descriptions, both had popular support. *M. pumila* was favored by systematists, who argued that *M. sylvestris* (the tall, glabrous, woodland form) had less to do with the origin of the cultivated apple (24). Van Eseltine (24) eloquently argued that *M. pumila* Mill., which is synonymous to *P. paradisaca* L. and *M. pumila* Bauhin, is a shrub that might have been involved in the evolution of the cultivated apple but it is not equivalent to Linnaeus' *P. malus*.

In a posthumous publication of the *Gardener's and Botanist's Dictionary* by Miller in 1807 (17) (arranged and corrected by Thomas Martyn, a Professor of Botany at Cambridge), the common apple is listed as *P. malus*, underneath which is the name of the cultivated apple tree referred to as the variety β *M. sativa* (Fig. 4). This publication might have reflected the position taken by later pomologists of the 19th and 20th century who preferred using Linnaeus' *P. malus* to any other name (29).

We maintain the separation of the apple from the genus *Pyrus* for several reasons which include graft incompatibility, breeding behavior, flower odor and morphology, and phenolic constituents (5, 12). These distinc-

4. *Pyrus Malus. Common Apple Tree. Lin. spec. 686. f. 466. Reib. 301. Willd. 1017. arb. 261. mat. med. 127. hort. cliff. 189. upl. 130. fl. succ. n. 437. Hudf. angl. 210. Wither. arr. ed. 3. 462. Smith. brit. 531. engl. bot. 1. 179. Ligbif. fect. 258. Reib. cant. n. 362. Sibth. exon. n. 452. Hall. belz. n. 1097. Polisch pal. n. 478. Scop. carn. n. 599. Hoffm. germ. 173. Roth. germ. 1. 215. 2. 549. Krock. jilef. n. 761. Villars. dauph. 3. 544. Du Roi herb. 222. Blackw. 178. Pienck. ic. 394. Sorbus Malus. Crantz. austr. 93. Malus sylvestris. Mill. dict. n. 1. Baub. pin. 443. Ger. 1276. emac. 1461. Park. theat. 1503. 2. Raii bist. 1488. fyn. 452. Crab Tree or Wilding. β . Malus sativa. The cultivated Apple Tree. Baub. bist. 1. 1. Dod. pempt. 789. Raii bist. 1445. fyn. 451. Mill. illustr. Blackw. 141. Malus. Park. theat. 1503. 1. parad. 586. Ger. 1273. 1274. emac. 1459. Leaves ovate-oblong acuminate serrate smooth, umbels simple sessile:—claw of the corolla shorter than the calyx, styles smooth.*

Fig. 4. Taxonomical classification of the apple in Philip Miller's *Gardener's and Botanist's Dictionary*, arranged and corrected by Thomas Martyn in 1807 after Miller's death (17). (Courtesy of the Library of the Univ. of Illinois' Rare Book Room.)

tions are supported further by the biochemical studies of Challice and Williams (6). Thus, 2 acceptable names based on *Malus* are found in the literature: *M. communis* of Poiret in 1804 (13) (Fig. 5) and *M. malus* Britt. in 1897 (3) (Fig. 6). Both are equivalent to *P. malus* L., although the latter is ruled out according to the International Code of Botanical Nomenclature which forbids duplicate binomials (22).

M. communis would have been a satisfactory name, but in 1803, one year earlier, Borkhausen described the cultivated apple and proposed the name *M. domestica* (2) (Fig. 7). Thus, according to Article 29 of the International Code of Botanical Nomenclature (22), *M. domestica* is the first valid published name

ES PÈCES.

1. POMMIER commun. *Malus communis.*

Malus umbellis sessilibus; foliis ovato-oblongis, acuminatis, serratis, glabris; unguibus calice brevioribus, stylis glabris. Aiton. Hort. Kew. vol. 2. pag. 175. — Willden. Arb. 261. & Spec. Plant. vol. 2. pag. 1017. n.º 9. — Lam. Illustr. Gen. tab. 43 f. f.

Pyrus foliis serratis, umbellis sessilibus. Linn. Spec. Plant. vol. 1. pag. 686. — Miller. Dict. n.º 1. & Illustr. Ic. — Follich. Pal. n.º 478. — Desf. Flor. atl. vol. 1. pag. 398.

Harlk. pag. 221. — Scop. Carn. n.º 599. — Hoffm. Germ. 173. — Roth. Germ. I. 21 f. 11. 549. — Lam. Flor. franc. vol. 3. pag. 491. n.º 1089. IV. — Desf. Flor. atl. vol. 1. pag. 398.

Le pommier est un arbre d'une moyenne grandeur, dont les branches sont étalées, & les rameaux garnis de feuilles petioles, épaisses ou par bouquets, ovales, un peu aigues à leur sommet, légèrement dentées à leurs bords, un peu velues en dessous, d'un vert sombre. Ses fleurs sont très-agréables, d'un blanc mêlé de rose, & disposées en une sorte d'ombelle feuillée: elles sont remplacées par des fruits arrondis, charnus, succulents, très-acides dans l'état sauvage, mais qui varient à l'infini dans leur forme & leur saveur par la culture.

Fig. 5. Poiret's classification and description of the apple in Lamarck's *Encyclopédie Méthodique Botanique* in 1804 (13). (Courtesy of the Library of the Univ. of Illinois.)

for the cultivated apple and should supersede all names published thereafter. The "domesticated" apple, according to Borkhausen, originated from the wood apple, *M. sylvestris*, the hairy-leaved wild apple, *M. dasyphyllus*, and John's apple, *M. praecox*. Borkhausen's *sylvestris* is synonymous to that of Miller and to Linnaeus' *P. M. sylvestris*; *M. dasyphyllus* is synonymous to a sweet-fruited *M. sylvestris* described by Dillenius in 1709; and *M. praecox* is synonymous to Linnaeus' *P. M. paradisaca* and *M. pumila* of Bauhin (2).

Although earlier pomologists and systematists denied the significant role of *M. sylvestris* in the development of the cultivated apple (24), others disagree (3, 19, 20, 29).

Thus, to accept Borkhausen's theory on the origin of the cultivated apple is to admit that it is a hybrid. Rehder (20) agrees that *M. sylvestris* Mill., *M. prunifolia* Borkh., and *M. baccata* Borkh. are involved to some degree. Breeding programs in recent years have incorporated genes for disease resistance from *M. floribunda* Sieb., *M. micromalus* Mak., *M. atrosanguinea* Schneid., *M. baccata jackii* Rehd., *M. sargentii* Rehd., and others (28).

Biochemical and cytological evidence

Williams' extensive biochemical investigations (25, 26, 27) demonstrated the presence of a distinct glucoside compound which occurs only in 4 of the 25 *Malus* species listed by Rehder (25): 1) *M. floribunda* Sieb., 2) *M. zumi* Rehd., 3) *M. sargentii* Rehd., and 4) *M. sieboldii* Rehd. This compound also has been observed in all hybrids of these 4 species (25, 26).

Although the majority of the cultivated apples are functional diploids ($2n = 34$), several studies have suggested that they are complex polyploids. Darlington and Moffett

(7) concluded that the basic chromosome set of $x = 17$ is derived from the ancestral basic chromosome number of $x = 7$ which is common in Rosaceae. Sax (21) proposed the theory of amphidiploid origin of Pomoideae, where these are derived from remote ancestral types having $x = 8$ and $x = 9$ chromosomes; these are thought to correspond to the genera Prunoideae and Spiraeoideae, respectively (5). Derman (8) supported Sax's theory and stated that only a mixture of diverse characters of species of 2 or more distinct genera could account for the vast taxonomic differences in the characters of Pomoideae and those of other Rosaceae forms.

The cytological work presented above does not presently have a bearing on the generic name of the apple, since according to Articles H.8.1 and H.9.1 of the International Code of Botanical Nomenclature (22), the names of the ancestral genera have to be published validly, yet the investigations of Darlington and Moffett (7), Sax (21), and Derman (8) indicate that several species are involved in the origin of the cultivated apple. This is supported further by the extensive cytological studies conducted by Nebel in 1929 (18), where no sufficient evidence is found to place the cultivated apple under the name of any specific species. This further suggests that cultivated apples are a result of interspecific hybridization. This means that the binomial *M. domestica* Borkh. has to be corrected according to Article H.3 of the International Code of Botanical Nomenclature (22), and Articles 9.b and 15 of the supplementary International Code of Nomenclature for Cultivated Plants (9) where a multiplication sign (X) should be placed between the genus and species epithets. Article 15 (9) reads "The botanical name designating first and subsequent generations of an interspecific cross consists of the generic name followed by a Latin collective epithet, the latter immediately preceded by the multiplication sign,

X . . . The Latin collective epithet of an interspecific hybrid is not affected when the botanical name of either parent is changed for nomenclatural reasons."

Therefore, regardless of the number of species involved in the continuous hybridization, the binomial for the cultivated apples should read *Malus Xdomestica* Borkh.

459) Zahmet Äpfel, *Malus domestica*.

Dornlos, mit eiförmig-länglichen, zugespitzten, sägezähigen unten mehr oder weniger filzigem Blättern; übriges wie beim Holzäpfel.

Pyrus Malus Linn.
Malus domestica auct.
Zahmet Äpfelbaum.

Ob die mannigfaltigen Sorten von kultivierten Äpfeln, welche, in Größe, Gestalt, Farbe, Geschmack und Geruch, dergleichen in dem Wuchs der Bäume und der Zeit der Fruchtzeit, so sehr von einander abweichen, von einer oder mehreren Stammarten abstammen, darüber ist schon sehr viel gestritten worden, ohne daß man noch ein gewisses Resultat erhalten hätte. Es ist hier der Ort nicht, über diesen Gegenstand ins Detail zu gehen, nur meine eigene Meinung will ich kurzlich anführen. Ich glaube daß die drei vorhergehenden Äpfelarten, der Holzäpfel, der haarblättrige wilde Äpfel, und der Johannisäpfel, die Stammeltern sämtlicher kultivierter Äpfelarten, und zwar dieser der süßen Früchäpfel, jene beiden aber der übrigen Äpfelarten sind, und daß mannigfache Kulturkunst, dergleichen Klima, Lage und Boden nebst andern mehr oder weniger günstigen Mitwirkenden Ursachen, mancherlei Varietäten erzeugt haben, durch deren Bastardbefruchtung unter sich abermals mehrere Varietäten entstanden sind, welche zum Theil schlechter, zum Theil besser, als die Stammeltern gebildet, so wie deren noch täglich durch die Kreuzung unter unsern Augen entstehen.

5. *Malus Malus* (L.) Britton. Apple. (Fig. 1982.)

Pyrus Malus L. Sp. Pl. 479. 1753.
Malus sylvestris Mill. Gard. Dict. Ed. 8, no. 1. 1768.

A large tree with spreading branches, the trunk sometimes reaching a diameter of 3° in cultivation. Leaves petioled, broadly ovate or oval, obtuse or abruptly pointed at the apex, rounded or slightly cordate at the base 1'-3' long, dentate or nearly entire, glabrous or nearly so above, pubescent and often woolly beneath, especially when young; pedicels generally tomentose, 1'-2' long; flowers pink, or white, 1½'-3' broad; calyx tomentose; fruit depressed-globose or elongated, hollowed at the base, 1½'-3' in diameter.

In woods and thickets, frequent in southern New York, New Jersey and Pennsylvania. Our common apple, introduced from Europe and escaped from cultivation. Native also of western Asia. Wood hard, reddish brown; weight per cubic foot 50 lbs. April-May.

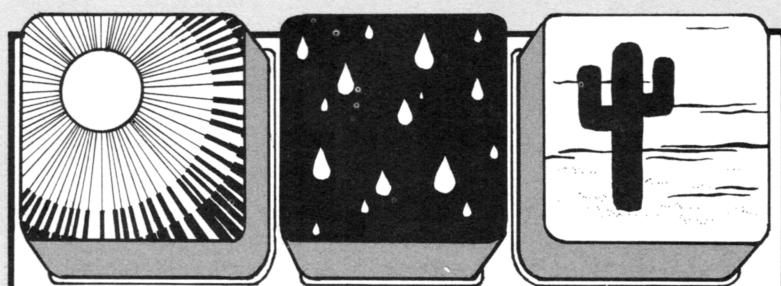


Fig. 6. Britton's nomenclature and description of the apple in 1897 in his *Illustrated Flora of the Northern U.S.* (3). (Courtesy of the Library of the Univ. of Illinois.)

Fig. 7. Borkhausen's name for the apple and its origin as printed in 1803 (2). His description of the "Domesticated Apple" may be translated "Thornless, with egg-shaped, elongated, pointed, saw-toothed leaves, which are more or less nappy underneath, otherwise like the wood apple . . . Whether the manifold varieties of cultivated apples, which differ from one another in size, shape, color, taste, and smell as well as in the growth of the tree and the time of fruit ripening, derive from one or several basic stocks, has been argued much already without providing a certain result yet. This is not the place to go into detail on this subject, but I would like to share my opinion briefly. I believe that the preceding apple varieties, the wood apple, the hairy-leaved wild apple, and John's apple are the progenitors of all cultivated apple varieties; the latter of the sweet early apples and the two former of the remaining variety of apples, and that varied arts of cultivation, likewise climate, location and soil alongside more or less favorably collaborating causes produced all sorts of varieties which by cross hybrid fertilization among themselves again produced several varieties, which in part turned out better and in part worse than their progenitors, just as under our own eyes further varieties still arise daily from seedling." (Courtesy of the Library of the Univ. of Chicago's Special Collections.)

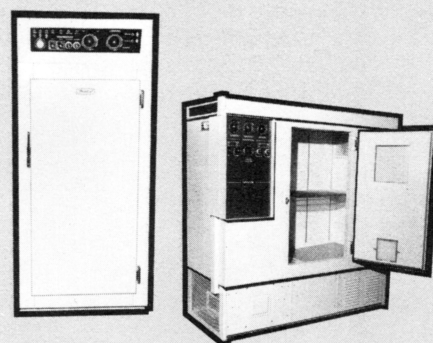
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