# EVALUATION OF TREES FOR THE CENTRAL PLAINS[1]

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Evaluations of new, different, and superior plants are meaningful to nurserymen, arborists, landscape architects and designers, and consumers. Specific problems in plant selection for the central plains vary widely because of large differences in climate, soils, and urbanization (10). Several programs have been developed to evaluate landscape ornamentals (6,7,8). Many species have been evaluated as part of the national NC-7 plant evaluation program; however, dissemination of information has lagged far behind data collection. The objective of this project was to identify and evaluate worthy landscape plants for use in Kansas and the midwest.

## Methods

Research trials have been established at sites on Kansas Agricultural Experiment Station fields in Manhattan, Hays, Colby, Tribune, Garden City, and Wichita. Each spring since 1984, five species or cultivars have been planted at each site in a randomized block design (five replications per site) at a 3.1 X 3.1 m (10 x 10 ft) spacing. Plants were selected for trial based upon their potential landscape use, availability, and likelihood of environmental tolerance. All plants were bareroot unless otherwise indicated. Selections have been limited to named or commercially available species and cultivars, but some native species have been included. Plants established in 1986 were: *Acer saccharum*, sugar maple (Caddo selection); *Acer saccharum* 'Legacy', 'Legacy' sugar maple; *Celtis laevigata* 'All Seasons', 'All Seasons' sugar hackberry; *Evodia hupehensis*, Hupeh evodia; and *Quercus imbricaria,* shingle oak.

Study personnel installed and took data from the plantings. After-planting maintenance of the plants, except fertilization and pruning, was the responsibility of cooperating personnel at each site. Beginning in the first year after planting, each plant was fertilized with 100 to 200 g (4 to 8 oz) of a low-nitrogen complete fertilizer during the spring.

Plant height and stem diameter at 30 cm (12 in) of all plantings were measured each spring. Survival, foliage and overall quality of all plantings were evaluated in late summer. Plants were evaluated for 4 years.

Relative growth of the plants, a measure of the growth performance of the plant over the duration of the study, was defined as height or stem diameter during the final measurement year divided by the height or stem diameter at planting. Relative growth data were analyzed for this and all other plantings as an ANOVA. Only plants surviving through the final measurement year were considered, and missing data were ignored.

## Results and Discussion

**Overall.** Planting sites were diverse in their soil and climatic characteristics (Table 1). For instance, summer rainfall varied from 95 cm (37 in) in Manhattan in 1986 to 17 cm (7 in) in Colby in 1989. Summer high temperatures varied from 44°C (111°F) in Hays (1988) to 38°C (100°F) in Colby, Tribune, Garden City, and Wichita in 1989. Winter lows were also site- and year-dependent, ranging from -16°C (3°F) in Manhattan, Colby, and Garden City (1986/7), to -34°C (-29°F) in Colby (1989/90). On average, Colby, Tribune, and Garden City were the driest sites with about 33 cm (13 in) rainfall per summer, while Manhattan and Wichita had 66 cm (26 in) of rain. Overall, the

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**Table 1. Average annual precipitation (cm), average summer maximum and winter minimum temperatures (C), soil. pH, and soil organic matter content (%) of the test sites. This summary of temperature and precipitation data is from March 1986 until August 1990. "Summer" includes data from March 1 until October 31; "winter" includes data from November 1 until February 28(29).**

| Year | Season | Parameter | Manhattan | Hays | Colby | Tribune | Garden City | Wichita |
|---|---|---|---|---|---|---|---|---|
| 1986 | Summer | Rainfall (mm) | 949 | 500 | 286 | 349 | 347 | 795 |
| 1987 | Summer | Rainfall (mm) | 604 | 591 | 432 | 367 | 251 | 754 |
| 1988 | Summer | Rainfall (mm) | 400 | 330 | 418 | 325 | 197 | 536 |
| 1989 | Summer | Rainfall (mm) | 673 | 426 | 166 | 358 | 495 | 752 |
| 1990 | Summer | Rainfall (mm) | 702 | 618 | 378 | 291 | 337 | 482 |
| 1986 | Summer | Max. Temp. (C) | 40.2 | 42.5 | 40.8 | 40.4 | 39.4 | 42.0 |
| 1987 | Summer | Max. Temp. (C) | 42.0 | 42.4 | 39.7 | 38.8 | 38.6 | 41.0 |
| 1988 | Summer | Max. Temp. (C) | 42.1 | 44.5 | 41.2 | 40.1 | 42.0 | 41.2 |
| 1989 | Summer | Max. Temp. (C) | 40.8 | 43.6 | 37.7 | 38.0 | 38.1 | 37.7 |
| 1990 | Summer | Max. Temp. (C) | 41.4 | 42.8 | 42.6 | 42.7 | 40.3 | 41.7 |
| 1986/7 | Winter | Min. Temp. (C) | -15.6 | -16.8 | -16.2 | -19.2 | -16.3 | -18.5 |
| 1987/8 | Winter | Min. Temp. (C) | -24.2 | -25.6 | -28.0 | -27.7 | -28.2 | -23.1 |
| 1988/9 | Winter | Min. Temp. (C) | -23.5 | -25.2 | -27.0 | -25.5 | -24.6 | -27.0 |
| 1989/90 | Winter | Min. Temp. (C) | -31.2 | -32.2 | -33.8 | -29.1 | -27.6 | -29.1 |
| | | Soil pH | 8.0 | 6.8 | 7.6 | 7.9 | 8.3 | 6.6 |
| | | Organic Matter (%) | 1.1 | 3.6 | 4.0 | 1.1 | 1.7 | 2.3 |

driest year was 1988, and the wettest was 1986. All sites had comparable average summer maximum temperatures of about 41°C (106°F), which did not vary greatly from year to year.

Similarly, minimum winter temperatures did not vary greatly from site to site and were, on average, -25°C (-13°F). However, the annual winter minimum varied greatly. The coldest winter (averaged across sites) occurred 1989/90 (-31°C, -24°F), and the mildest winter was 1986/7 (-17°C, 1°F).

Soil pH varied from 6.6 in Wichita to 8.3 in Garden City, while organic matter ranged from 4.0 % in Colby to 1.1 % in Manhattan and Tribune. A quantitative analysis of the relationship between growth and environment is presently being attempted in a separate effort (13).

The results of the 1984 and 1985 plantings have been reported elsewhere (4). We will, therefore, confine this report to a discussion of the 1986 planting.

Initial survival of the planting was quite variable, ranging from 100 to 0%, and dependent on both species and site (Table 2). All sites were amenable to 100% establishment of at least one test species, and 100% of all species survived the summer of 1986 in at least one test site. Establishment of Caddo sugar maple was acceptable (100-80% survival) at all sites. All other species established successfully (100-60%) at all sites except at the westernmost and driest (Table 1) sites of Colby, Tribune, and Garden City. No sugar hackberry survived at Colby or Tribune. Establishment of 'All Seasons' was, however, good at Manhattan, Hays, and Wichita, but they were slow to break dormancy. The site that was driest during the summer of 1986, Colby, suffered the poorest establishment of shingle oak and Hupeh evodia. 'Legacy' sugar maple was most poorly established at Tribune.

**Table 2. Survival (%) of the 1986 statewide tree planting.**

| Location | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|
| **'Legacy' Sugar Maple** | | | | | |
| Manhattan | 80 | 80 | 60 | 60 | 60 |
| Hays | 100 | 80 | 80 | 80 | 80 |
| Colby | 60 | 60 | 40 | 20 | 20 |
| Tribune | 20 | 20 | 20 | 20 | 20 |
| Garden City | 80 | 80 | 20 | 20 | 20 |
| Wichita | 80 | 80 | 60 | 60 | 60 |
| Average | 70 | 66.6 | 46.6 | 43.3 | 43.3 |
| **Caddo Sugar Maple** | | | | | |
| Manhattan | 80 | 80 | 80 | 80 | 80 |
| Hays | 100 | 100 | 100 | 100 | 100 |
| Colby | 100 | 100 | 80 | 60 | 60 |
| Tribune | 100 | 100 | 100 | 100 | 100 |
| Garden City | 100 | 100 | 100 | 100 | 100 |
| Wichita | 100 | 100 | 100 | 100 | 100 |
| Average | 96.6 | 96.6 | 93.3 | 90 | 90 |
| **'All Seasons' Sugar Hackberry** | | | | | |
| Manhattan | 80 | 80 | 80 | 80 | 80 |
| Hays | 60 | 60 | 60 | 60 | 60 |
| Colby | 0 | 0 | 0 | 0 | 0 |
| Tribune | 0 | 0 | 0 | 0 | 0 |
| Garden City | 40 | 40 | 20 | 20 | 20 |
| Wichita | 100 | 100 | 100 | 100 | 100 |
| Average | 46.6 | 46.6 | 43.3 | 43.3 | 43.3 |
| **Shingle Oak** | | | | | |
| Manhattan | 100 | 100 | 100 | 100 | 100 |
| Hays | 100 | 100 | 100 | 100 | 100 |
| Colby | 20 | 20 | 20 | 20 | 20 |
| Tribune | 60 | 60 | 60 | 60 | 60 |
| Garden City | 100 | 80 | 80 | 60 | 60 |
| Wichita | 100 | 100 | 100 | 100 | 100 |
| Average | 80 | 76.7 | 76.7 | 73.3 | 73.3 |
| **Evodia** | | | | | |
| Manhattan | 100 | 100 | 100 | 100 | 0 |
| Hays | 100 | 100 | 100 | 60 | 20 |
| Colby | 20 | 20 | 0 | 0 | 0 |
| Tribune | 40 | 40 | 40 | 40 | 40 |
| Garden City | 80 | 80 | 80 | 80 | 20 |
| Wichita | 100 | 100 | 100 | 100 | 80 |
| Average | 73.3 | 73.3 | 73.3 | 63.3 | 26.7 |

Height and stem diameter growth of the 1986 species are presented in Tables 3 and 4. Relative growth rates are presented in Tables 5 and 6. The mean annual foliage and overall quality ratings are

presented in Table 7, and statistical analysis of these subjective ratings are depicted in Table 8. Ratings were transformed to normal scores by Tukey's transformation (9) before a repeated measures analysis was performed.

**'Legacy' sugar maple**

Growth of 'Legacy' sugar maple was not spectacular at any location (Tables 3 and 4). Relative growth rates of height and stem diameter were quite varied, but did not differ significantly between sites (Tables 5 and 6). 'Legacy' is reported to be a superior selection in the South and one of the best of the newer, drought resistant cultivars (2). It also supposedly grows more rapidly than the species (11). Height growth in our study would generally be classified as slow to moderate.

The wax covering of the leaves of 'Legacy' is reportedly thicker than that of other cultivars (2), making it more resistant to leaf tatter and scorch (11). However, scorch and leaf tatter did occasionally occur on the trees at various test sites. The foliage quality of the plants in this study was generally good, but not as consistently good as that of the Caddo seedings (Tables 7 and 8). Fall color was not outstanding. Overall quality was "good", especially at the less harsh sites.

We consider 'Legacy' an acceptable selection of sugar maple for the more temperate portions of the central plains and where adequate management is available in the drier regions. Evaluation of additional sugar maple cultivars on their own roots is warranted.

**Caddo sugar maple**

Caddo sugar maple seedlings were grown from seed collected from a native Oklahoma population. This ecotype grew in dry rocky hillsides, canyons, and calcareous soil in the Oklahoma counties of Caddo, Canadian, and Comanche (3), an environment atypical of its general native range in the eastern United States. The plant established well as bareroot transplants at all locations (Table 2). The seedlings grew well at all locations, with the greatest growth at Manhattan, Colby, and Wichita (Tables 3 and 4). The growth rate was significantly greater at Manhattan and least at the more westerly sites (Tables 5 and 6). However, growth at all locations was impressive for a sugar maple.

The new foliage of Caddo was yellowish green, developing to a dull medium-green. The foliage was attractive but not as dark green as 'Legacy' or some other cultivars. Fall color was yellowish, late, and not spectacular, although individual plants have shown superior color. Scorch and leaf tatter were not tremendous problems but occurred periodically. Leaf and overall plant quality were best at Wichita, Hays, and Manhattan, but they were certainly acceptable at the other locations (Tables 7 and 8).

The seedlings tended to be generally upright-ovoid in form, possibly narrower than typical for the species. A few seedlings, however, were broader in habit than others. This presents the possibility for selections on the basis of plant form and fall color.

Overall, the selection has little to offer to compete with some of the new and outstanding cultivars in areas where sugar maple is easily and extensively grown. However, it established, grew, and generally thrived at all of the test sites. It is most worthy of consideration and a superior selection for much of Kansas and possibly throughout the Great Plains where a sugar maple is desired. Selection and sexual propagation of plants with superior form, fall color, and other aesthetic attributes should be considered seriously. At present, the plant is available only at isolated nurseries in Oklahoma.

**'All Seasons' sugar hackberry**

The growth rate of 'All Seasons' sugar hackberry has been described as aggressive (1) and was in our study after the plant became established. The cultivar grew most rapidly at Manhattan (Tables 5 and 6). Growth at the harsher locations was steady but not explosive. The cultivar did not establish well in Colby or Tribune, but this may be more reflective of the post-transplant care than of the species or cultivar.

'All Seasons' sugar hackberry has been described as a fine-textured tree with a well-balanced crown (1). Its foliage was lustrous and medium-green in summer and yellow in the fall. Foliage quality was good but declined during the summer,

**Table 3. Average plant height (m) of trees planted in 1986.**

| Location | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|
| **'Legacy' Sugar Maple** | | | | | |
| Manhattan | 1.32 | 1.29 | 1.53 | 2.44 | 3.10 |
| Hays | 1.30 | 1.16 | 1.24 | 1.33 | 1.45 |
| Colby | 1.38 | 1.40 | 1.35 | 1.43 | 1.65 |
| Tribune | 1.42 | 1.28 | 1.51 | - | 2.00 |
| Garden City | 1.38 | 1.29 | 1.26 | 1.48 | 2.00 |
| Wichita | 1.33 | 1.32 | 1.51 | 1.81 | 2.18 |
| Average | 1.35 | 1.29 | 1.40 | 1.69 | 2.06 |
| **Caddo Sugar Maple** | | | | | |
| Manhattan | 1.64 | 1.82 | 2.83 | 3.68 | 4.53 |
| Hays | 1.72 | 1.72 | 1.93 | 2.32 | 2.52 |
| Colby | 1.66 | 1.60 | 2.10 | 2.73 | 3.55 |
| Tribune | 1.68 | 1.62 | 2.72 | 2.43 | 2.74 |
| Garden City | 1.64 | 1.72 | 1.96 | 2.15 | 2.49 |
| Wichita | 1.96 | 2.00 | 2.44 | 2.96 | 3.74 |
| Average | 1.71 | 1.74 | 2.33 | 2.71 | 3.26 |
| **'All Seasons' Sugar Hackberry** | | | | | |
| Manhattan | 1.46 | 1.83 | 3.05 | 3.88 | 4.92 |
| Hays | 1.60 | 1.59 | 2.09 | 2.40 | 2.20 |
| Garden City | 1.42 | 1.11 | - | 1.93 | 2.80 |
| Wichita | 1.43 | 2.07 | 2.83 | 3.18 | 3.35 |
| Average | 1.47 | 1.65 | 2.65 | 2.84 | 3.31 |
| **Shingle Oak** | | | | | |
| Manhattan | 0.98 | 1.15 | 1.63 | 1.78 | 2.04 |
| Hays | 0.84 | 1.13 | 1.28 | 1.33 | 1.50 |
| Colby | 0.98 | 1.29 | - | 1.65 | - |
| Tribune | 0.98 | 1.11 | 1.47 | 1.30 | 1.58 |
| Garden City | 0.92 | 1.11 | 1.16 | 1.24 | 1.22 |
| Wichita | 0.89 | 1.18 | 1.64 | 2.14 | 2.62 |
| Average | 0.93 | 1.16 | 1.43 | 1.57 | 1.79 |
| **Evodia** | | | | | |
| Manhattan | 0.60 | 1.25 | 2.75 | 3.10 | 4.04 |
| Hays | 0.70 | 0.69 | 1.48 | 1.60 | 1.73 |
| Colby | 0.68 | 0.79 | 0.95 | - | - |
| Tribune | 0.68 | 0.73 | 1.70 | 2.12 | 2.80 |
| Garden City | 0.70 | 0.84 | 1.43 | 2.04 | 2.85 |
| Wichita | 0.82 | 1.14 | 1.69 | 2.01 | 2.29 |
| Average | 0.69 | 0.90 | 1.66 | 2.17 | 2.74 |

**Table 4. Average stem diameter (cm) per year of trees planted in 1986.**

| Location | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|
| **Legacy' Sugar Maple** | | | | | |
| Manhattan | 1.14 | 1.19 | 1.88 | 2.95 | 4.72 |
| Hays | 1.27 | 1.20 | 1.52 | 1.80 | 2.07 |
| Colby | 0.86 | 1.09 | 1.17 | 1.62 | 2.20 |
| Tribune | 0.94 | 1.50 | 1.49 | - | 2.86 |
| Garden City | 0.86 | 1.00 | 1.45 | 1.89 | 2.77 |
| Wichita | 1.12 | 1.31 | 1.77 | 2.66 | 3.16 |
| Average | 1.03 | 1.21 | 1.54 | 2.18 | 2.96 |
| **Caddo Sugar Maple** | | | | | |
| Manhattan | 2.23 | 2.90 | 3.73 | 5.09 | 7.45 |
| Hays | 2.42 | 2.37 | 2.67 | 2.66 | 3.21 |
| Colby | 1.94 | 2.07 | 2.63 | 3.50 | 4.73 |
| Tribune | 2.08 | 2.30 | 2.72 | 3.33 | 4.10 |
| Garden City | 2.20 | 2.44 | 2.58 | 2.87 | 3.54 |
| Wichita | 2.48 | 2.60 | 3.03 | 4.32 | 4.33 |
| Average | 2.22 | 2.44 | 2.89 | 3.62 | 4.56 |
| **'All Seasons' Sugar Hackberry** | | | | | |
| Manhattan | 1.88 | 2.43 | 5.23 | 7.78 | 10.40 |
| Hays | 1.85 | 1.76 | 2.24 | 2.58 | 2.83 |
| Garden City | 1.32 | 1.40 | - | 2.89 | 5.57 |
| Wichita | 1.58 | 2.06 | 2.80 | 3.84 | 4.09 |
| Average | 1.65 | 1.91 | 3.42 | 4.27 | 5.72 |
| **Shingle Oak** | | | | | |
| Manhattan | 1.08 | 1.41 | 2.46 | 3.07 | 3.86 |
| Hays | 1.05 | 1.30 | 1.70 | 1.98 | 2.19 |
| Colby | 1.00 | 1.30 | - | 1.61 | - |
| Tribune | 1.16 | 1.16 | 1.47 | 1.70 | 2.47 |
| Garden City | 0.84 | 1.13 | 1.28 | 1.57 | 1.71 |
| Wichita | 1.10 | 1.39 | 1.87 | 2.84 | 2.91 |
| Average | 1.03 | 1.28 | 1.75 | 2.12 | 2.62 |
| **Evodia** | | | | | |
| Manhattan | 0.84 | 2.05 | 6.29 | 9.79 | 11.32 |
| Hays | 0.70 | 0.88 | 2.00 | 2.77 | 3.19 |
| Colby | 0.60 | 1.63 | 1.40 | - | - |
| Tribune | 0.66 | 1.09 | 2.88 | 4.60 | 7.07 |
| Garden City | 0.48 | 1.29 | 2.88 | 4.78 | 7.34 |
| Wichita | 0.69 | 1.57 | 2.46 | 3.76 | 4.29 |
| Average | 0.66 | 1.25 | 2.98 | 5.14 | 6.64 |

especially at the more westerly sites (Table 7 and 8). There was no incidence of witch's broom, but a few galls were occasionally evident. The overall form of the plant was regular but somewhat open-growing. Plants at Garden City were not as fully developed as those at the other sites. It was winter hardy and not oppressed by the summer heat.

'All Seasons' sugar hackberry, a moderate-sized tree (11), should be a desirable addition in Kansas and probably throughout the Great Plains.

## Shingle oak

Shingle oak has been used as a shade and landscape tree throughout the eastern midwest. It is native from Nebraska and Arkansas eastward and reportedly tolerant of drier locations (2). Growth rate is moderate (5). The seedlings in our study were grown in polyfilm containers. They became established throughout the state, except at Colby. This failure may have been due to poor manage-

**Table 5. Mean relative height growth (m, height in 1990/ planting height) of plants established in 1986.**

| Location | Legacy Maple | Caddo Maple | All Seasons Sug. Hack. | Shingle Oak | Evodia |
|---|---|---|---|---|---|
| Manhattan | 2.30 a[z] | 2.71 a | 3.38 a | 2.04 a | 6.11 a |
| Hays | 1.18 a | 1.47 c | 1.42 b | 1.87 a | 2.88 b |
| Colby | 1.18 a | 2.08 b | - | - | - |
| Tribune | 1.43 a | 1.64 bc | - | 1.57 a | 4.33ab |
| Garden City | 1.67 a | 1.53 c | 2.80 ab | 1.36 a | 4.23ab |
| Wichita | 1.59 a | 1.70 bc | 2.35 ab | 3.82 a | 2.87 b |

[z] Mean separation by Tukey's HSD (.05). Means within columns followed by the same letter are not significantly different.

ment rather than the site or plant. Shingle oak grew at all locations, but made the greatest growth at Wichita.

The foliage and overall quality of Shingle oak were best at Wichita (Table 8). The plant also did very well at Hays. It prefers acid sites (2) but reportedly adapts to slightly alkaline soils (5). Chlorosis was a severe problem at Garden City and for two of the five seedlings at Manhattan, perhaps because of the relatively high pH at these sites (Table 1). This affected growth and development at these sites. The leaves were persistent into the winter at all sites.

Shingle oak can be recommended for acid to neutral sites in eastern Kansas and the Great Plains but may also be considered for certain long-term, maintained situations at more westerly locations. It is not widely available in the nursery trade, and no cultivars have been selected.

**Table 6. Relative mean stem diameter growth (cm, diameter in 1990/diameter at planting) of plants established in 1986.**

| Location | Legacy Maple | Caddo Maple | All Seasons Sug. Hack. | Shingle Oak | Evodia |
|---|---|---|---|---|---|
| Manhattan | 4.23 a[z] | 3.60 a | 5.59 a | 3.47 a | 14.17 a |
| Hays | 1.66 a | 1.32 b | 1.62 c | 2.21 a | 6.45 a |
| Colby | 2.75 a | 2.31 ab | - | - | - |
| Tribune | 2.60 a | 2.02 b | - | 2.24 a | 10.28 a |
| Garden City | 3.08 a | 1.61 b | 4.64 ab | 2.18 a | 17.67 a |
| Wichita | 2.75 a | 1.75 b | 2.60 bc | 2.89 a | 6.93 a |

[z] Mean separation by Tukey's HSD (.05). Means in columns followed by the same letter are not significantly different.

**Table 7. Mean foliage and overall quality (1= very poor and 5 = excellent for living trees at that site) of the 1986 statewide tree planting.**

| | Foliage Quality | | | | Overall Quality | | | |
|---|---|---|---|---|---|---|---|---|
| Location | 1986 | 1987 | 1988 | 1989 | 1986 | 1987 | 1988 | 1989 |
| | | | | **'Legacy' Sugar Maple** | | | | |
| Manhattan | 3.1 | 2.9 | 4.3 | 4.0 | 2.9 | 3.0 | 4.0 | 4.0 |
| Hays | 4.5 | 3.4 | 3.4 | 3.0 | 4.3 | 3.5 | 3.0 | 3.2 |
| Colby | 1.9 | 2.8 | 2.0 | 3.3 | 1.9 | 2.7 | 2.5 | 3.5 |
| Tribune | 2.5 | 3.0 | 3.0 | 3.0 | 2.8 | 3.0 | 3.0 | 3.5 |
| Garden City | 2.8 | 2.0 | 5.0 | 4.0 | 2.6 | 2.5 | 2.0 | 4.0 |
| Wichita | 3.4 | 4.0 | - | 4.5 | 3.5 | 4.0 | - | 4.5 |
| | | | | **Caddo Sugar Maple** | | | | |
| Manhattan | 4.2 | 4.5 | 4.6 | 4.1 | 4.2 | 5.0 | 4.7 | 4.9 |
| Hays | 5.0 | 4.3 | 3.4 | 3.6 | 4.9 | 4.5 | 3.8 | 4.1 |
| Colby | 2.1 | 3.5 | 3.4 | 3.0 | 2.3 | 3.7 | 4.0 | 4.0 |
| Tribune | 2.9 | 3.5 | 4.3 | 3.8 | 3.3 | 3.7 | 4.5 | 4.2 |
| Garden City | 3.9 | 2.8 | 3.6 | 3.4 | 3.8 | 3.1 | 3.7 | 3.7 |
| Wichita | 4.1 | 5.0 | - | 4.8 | 4.4 | 5.0 | - | 4.4 |
| | | | | **'All Seasons' Sugar Hackberry** | | | | |
| Manhattan | 4.7 | 4.3 | 4.4 | 3.6 | 5.0 | 4.5 | 4.0 | 4.4 |
| Hays | 5.0 | 3.5 | 3.3 | 3.0 | 4.7 | 4.0 | 4.0 | 4.0 |
| Garden City | 3.0 | 2.5 | 4.6 | 3.0 | 3.5 | 3.0 | 3.0 | 4.0 |
| Wichita | 4.5 | 4.6 | - | 3.3 | 4.6 | 3.8 | - | 4.1 |
| | | | | **Shingle Oak** | | | | |
| Manhattan | 4.3 | 2.5 | 3.0 | 1.8 | 4.5 | 3.2 | 2.6 | 2.1 |
| Hays | 5.0 | 4.2 | 3.1 | 2.4 | 5.0 | 4.5 | 3.6 | 2.8 |
| Colby | 1.7 | 3.0 | 3.0 | 3.0 | 1.7 | 2.5 | 3.0 | 2.8 |
| Tribune | 2.6 | 3.7 | 3.5 | 2.6 | 2.8 | 3.0 | 3.3 | 2.5 |
| Garden City | 3.6 | 2.9 | 2.3 | 2.5 | 4.0 | 2.5 | 2.3 | 3.2 |
| Wichita | 4.8 | 4.8 | - | 4.6 | 4.4 | 4.6 | - | 4.1 |
| | | | | **Evodia** | | | | |
| Manhattan | 5.0 | 5.0 | 5.0 | 5.0 | 4.7 | 4.4 | 4.8 | 3.8 |
| Hays | 3.6 | 4.5 | 4.0 | 3.7 | 3.8 | 4.2 | 2.7 | 3.2 |
| Tribune | 3.4 | 4.9 | 5.0 | 5.0 | 3.6 | 3.5 | 3.3 | 4.7 |
| Garden City | 4.9 | 3.8 | 5.0 | 4.9 | 4.6 | 4.5 | 5.0 | 4.6 |
| Wichita | 4.5 | 3.8 | - | 4.6 | 4.6 | 3.4 | - | 3.4 |

## Evodia

Evodia apparently sustained winter losses in years subsequent to its establishment. All trees were killed during the 1989-90 winter at Manhattan and Hays (Table 2). Only one plant survived in Garden City, and it was severely damaged. Plants were also damaged or killed at Wichita. This species was rated hardy to Arnold Arboretum Zone 5 or USDA Zone 6, but the winter of 1989-90 was exceptionally cold (Table 1). *Evodia hupehensis* is reportedly less hardy than *E. daniellii* (2). Although *E. daniellii* has not been evaluated in

our trials, it might be preferable to *E. hupehensis* for the colder regions of the central plains.

Evodia nearly doubled in size annually at Manhattan. Growth was less, but still noteworthy, at the other sites. Environmental differences between sites probably influenced differences in the relative growth rates.

The dark green, medium-textured, pinnately compound foliage of evodia was of very good to excellent quality at all sites (Tables 7 and 8). The overall quality of the plant was also good. It tended to grow rapidly, develop a low crown, and required pruning to maintain a "tree-like" appearance. It was not troubled by chlorosis, summer heat, insects, or disease in this study. Large white flowers were borne on current season's wood at an early age. It flowered in midsummer and produced an attractive and effective display.

Wyman (12) noted that its very close relative, *Evodia daniellii*, was comparatively weak-wooded and short-lived (15 to 40 years). Limbs of *E. hupehensis* were noted to be somewhat brittle during pruning in our study; however, no wind or ice damage was noted on these or older plants on the Kansas State University campus.

The species or its close relative (*E. daniellii*) would make useful, small (25 to 30 feet), summer-flowering trees. The Korean evodia (*E. daniellii*) is preferred and more available in the nursery trade. Its superior cold hardiness (2) would be a very desirable trait, based upon our experience with the Hupeh evodia.

**Table 8. Mean foliage and overall quality ratings (1 = very poor and 5 = excellent) of each species and site for the 1986 statewide tree planting. Ratings were transformed to normal scores by Tukey's transformation before repeated measures analysis.**

| Location | Legacy Maple | Caddo Maple | All Season S. Hackberry | Shingle Oak | Evodia |
|---|---|---|---|---|---|
| **Foliage Quality** | | | | | |
| Manhattan | 3.5 ab[z] | 4.4 ab | 4.2 a | 2.9 bc | 5.0 a |
| Hays | 3.7 ab | 4.1 b | 3.7 a | 3.6 b | 4.0 c |
| Colby | 2.4 c | 3.0 d | - | 2.5 c | 4.2 bc |
| Tribune | 2.8 bc | 3.6 c | - | 3.0 bc | 4.5 b |
| Garden City | 2.8 bc | 3.4 cd | 3.5 a | 2.8 bc | 4.6 ab |
| Wichita | 3.9 a | 4.6 a | 4.2 a | 4.7 a | 4.3 bc |
| **Overall Quality** | | | | | |
| Manhattan | 3.4 abc | 4.7 a | 4.4 a | 3.1 b | 4.4 ab |
| Hays | 3.6 ab | 4.3 ab | 4.2 a | 4.0 a | 3.5 c |
| Colby | 2.5 d | 3.4 c | - | 2.4 b | 4.0 bc |
| Tribune | 3.0 bcd | 3.9 b | - | 2.9 b | 3.7 c |
| Garden City | 2.7 cd | 3.6 c | 3.2 b | 3.0 b | 4.6 a |
| Wichita | 4.0 a | 4.6 a | 4.2 a | 4.4 a | 3.8 c |

[z] Mean separation by Tukey's HSD (.05). Means in columns followed bythe same letter are not significantly different.

## Summary

Our search for landscape plants with potential for use in relatively intemperate climates, like those found in Kansas, continues. Both quantitative growth data, as well as qualitative data, are important for plantsmen to decide whether or not a particular plant will fit their individual need(s). We have, thus, provided both types of data in this paper.

Based upon our results, we have drawn the following general conclusions. Caddo sugar maple had the best establishment and subsequent survival of all the test species. Although, it has relatively little of special interest for a sugar maple in moderate climes, we recommend it for more intemperate sites or where only little management is expected and that a superior quality tree is desired. Due to it's limited apparent winter hardiness, Evodia is not recommended for Kansas-like conditions. Even in Wichita, where it survived the winter, growth was relatively slow.

Generally, the other three species tested will probably require fairly high management for establishment in drier localities. Once established on these sites, however, they all appear to have a niche in the landscapes of the midwest.

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