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**DIVERSITY OF VASCULAR PLANTS
AND INTENSITY OF PLANT COLLECTING IN NEBRASKA**

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ABSTRACT

A computerized database of Nebraska's flora has been made from specimens in 20 herbaria. Almost 1,900 species of native and escaped-alien vascular plants have been collected in the state since the mid-1800s. The flora of some counties is very well known but that of many counties, especially southwestern and Sandhills counties, is poorly collected. More than 800 species (nearly 100% of the species that are likely to occur) have been collected from each of Cherry, Douglas, Lancaster, and Richardson counties, but fewer than 150 species are known from Fillmore and McPherson counties, less than 25% of the potential number species to be found there. Collectively, the state's floristic list is approaching completeness, although that condition has yet to be reached for many counties individually. Most newly found species are non-natives and are often weedy and of temporary occurrence at a given site; few new state records can be made of native species but many such records are possible from counties. The Asteraceae and Poaceae have the most species in many habitats, and some rich habitats contain as many as two-thirds of Nebraska's plant families. No native species is known to be extirpated from the state, but many natives are reduced to a few isolated populations.

† † †

Nebraska's large area ($77,355 \text{ mi}^2 = 200,350 \text{ km}^2$, 14th largest of the 48 contiguous states) but low population have made it one of the last states to be botanically explored in detail. Even today, not all native species have been collected from many Nebraska counties, including some of the more populous eastern ones. Some southwestern and Sandhills counties are very poorly sampled. Nevertheless, intensive collecting efforts from the 1970s into the 1990s suggest that most—perhaps 98%—of the state's native vascular plant species are known from at least one station in the state and that further collections will be mostly of the same species elsewhere in the state, of newly invading alien species, or of native species whose ranges barely enter

the state's borders. Today, most new state records are of non-native (mostly Eurasian) species that are extending their ranges or are chance accidental introductions, and many added site-records are being made of species already known from at least one station in the state. Here we present a summary of Nebraska's floristic list as it is known to date. We give species-totals for the entire state, for counties, and for a few smaller areas that have been extensively inventoried.

Many of Nebraska's native species are in steep decline and others have already disappeared from large parts of the state and are precariously confined to small and isolated areas. Of course, many species have always been rare and are even more so today than 150 years ago. Agriculture, urbanization, and road construction have been the major factors in eliminating the native flora over much of the state, and the arrival of hundreds of species of alien plants, many of them now serious weeds, has had strongly deleterious effects by displacing native species.

It has been only in the final decades of the 20th Century that widespread public interest has developed in preserving the state's native biota, as evidenced by the formation or rejuvenation of various conservation organizations and government agencies with preservation and restoration missions. Few voices for preservation were raised from the beginnings of the massive agrarian plowing of the native prairie in the 19th Century until the late 20th Century, but it is almost too late for at least the tallgrass and mixed-grass prairies because they are more than 95% gone. The Sandhills and shortgrass prairies have fared better, as have the upland forests of the Pine Ridge and Niobrara and Missouri river valleys, but there is almost no undisturbed vegetation anywhere in Nebraska.

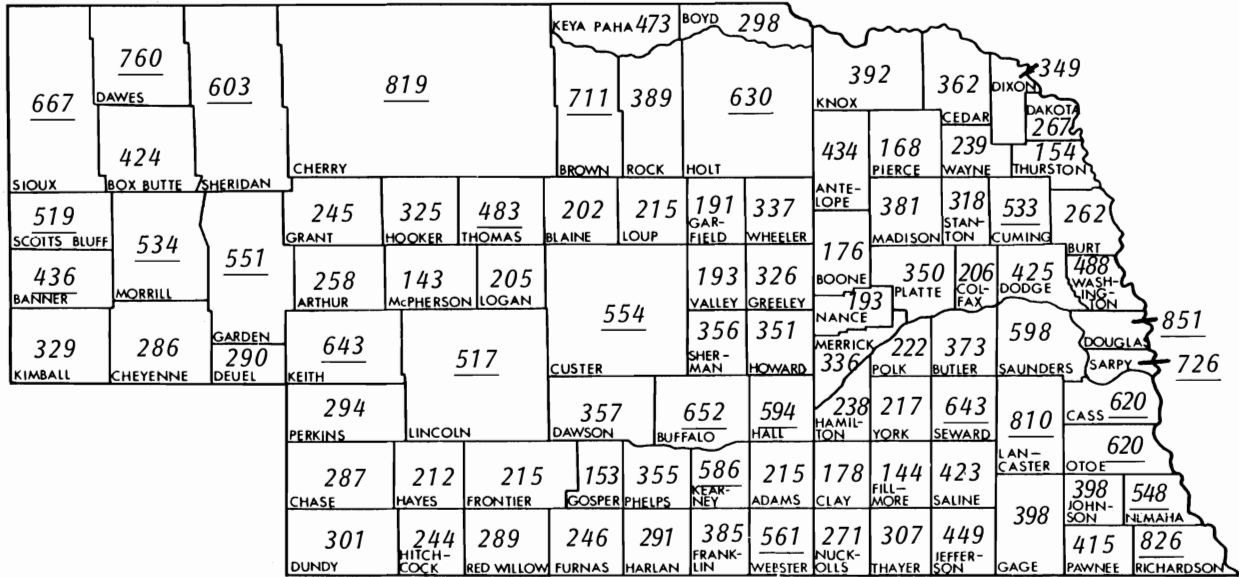


Figure 1. Map of Nebraska with counties named. The number of species collected from each county in the past 130 years is given. Well-collected counties whose floras are estimated to be at least 90% known are shown with underscored figures.

PUBLISHED TREATMENTS OF NEBRASKA'S FLORA

Early published reports of plants in the state are those of explorers Lewis and Clark in 1803–6, Nuttall and Bradbury in 1808, Frémont in the 1840s, and the Warren Expedition in 1857 (Clements, 1894). Among the early attempts to list Nebraska's complete flora are Samuel Aughey's error-ridden *Catalogue of the Flora of Nebraska* (1876) and H. J. Webber's *A Catalogue of the Flora of Nebraska* (1890).

A number of books included all species of vascular plants known in Nebraska at the time of publication: Britton and Brown's *An Illustrated Flora of the Northern United States, Canada, and the British Possessions* (1895, 1913); Niels Frederick Petersen's *Flora of Nebraska* (1912, 1923); Per Axel Rydberg's *Flora of the Prairies and Plains of Central North America* (1932); John Mack Winter's *An Analysis of the Flowering Plants of Nebraska* (1936); and the Great Plains Flora Association's *Atlas of the Flora of the Great Plains* (1977) and *Flora of the Great Plains* (1986). A series called *Flora of Nebraska* was started by the University of Nebraska Botanical Seminar in the late 1800s but never finished, and only one volume, Rosales (1895), included vascular plants. Other books covered the eastern or western parts of the state: Rydberg's *Flora of the Rocky Mountains and Adjacent Plains* (1917, 1922) covered western Nebraska, and Fernald's *Gray's Manual of Botany* (1950) included extreme eastern Nebraska. Neither Gleason's *The New Britton and Brown Illustrated Flora of the Northeastern United States and*

Adjacent Canada (1952) nor its derivative, Gleason and Cronquist's *Manual of Vascular Plants of Northeastern United States and Adjacent Canada* (1963, 1991), included Nebraska.

Most native and most escaped alien species of trees in Nebraska were described and mapped in Raymond J. Pool's *Handbook of Nebraska Trees* (1919, 1929, 1951, reprinted 1961) and mapped in Little's *Atlas of United States Trees*, volumes 1 (1971), 3 (1976), and 4 (1977), and the trees are also covered in numerous books on American trees. Curiously, two Asiatic trees that have escaped from cultivation and are now super-abundant and weedy over large areas of the state—white mulberry (*Morus alba*) and Siberian elm (*Ulmus pumila*)—were not mentioned by Pool (1919 *et seq.*), while Winter (1936) noted only that white mulberry “occasionally escapes” and Siberian elm is “widely planted”, and Petersen (1923) stated that white mulberry “sometimes escapes” but he didn’t mention Siberian elm. Thus, it is likely that these two trees became weedy after Pool’s, Petersen’s, and Winter’s books were published. The Siberian elm is now hybridizing with the native red elm (*Ulmus rubra*) and the hybrids are more common in some southeastern Nebraska sites than red elm, which is afflicted with Dutch elm disease.

Local studies in the state have produced numerous floristic lists for counties and other areas; a detailed listing of such publications from 1804 through 1985 is presented by Kantak and Churchill (1986). Additional floristic and monographic publications since 1985 further expand our knowledge of the state's flora (Beightol

and Bragg, 1993; Boettcher et al., 1993; Churchill et al., 1988; Garabrandt, 1988; Gilbert, 1989; Goodnight-Krager, 1993; Kantak and Churchill, 1993; Kaul, 1989, 1992; Kaul and Rolfsmeier, 1987, 1993; Kaul et al., 1988, 1991; Nagel and Kolstad, 1987; Patrick, 1986; Phillips Hardy, 1991; Rolfsmeier, 1988, 1989, 1991, 1993; Rolfsmeier et al., 1987, 1988, 1991; Rothenberger, 1987, 1994; Sutherland and Kaul, 1986; Sutherland and Rolfsmeier, 1989).

Despite all these publications, fieldwork continues to reveal species newly discovered in the state as well as more in-state distributional records of species already known here. Thus, our database is in continual revision to accommodate the new findings and to incorporate changing nomenclatural and taxonomic concepts.

Almost 1,900 species of native and alien vascular plants growing wild (outside cultivation) have been collected in Nebraska in the past 150 years. Only a few collections were made in the first half of the 19th Century, but the second half produced the first large collections. 20th-Century collecting intensity varied greatly, with the first and last thirds of the Century producing the most records and only a few persons actively doing extensive field work in the middle third. The most populous counties and those with colleges and universities have been particularly well-collected, but other counties have attracted collectors—Banner, Cherry, Cuming, Richardson, and Thomas counties, for example—and thorough collections have been made from various local areas such as remnant virgin tallgrass prairies, forests of the Missouri and Niobrara valleys, and a few prairies in the Sandhills and Platte Valley.

METHODS

We have prepared a computerized database of every species and well-marked subspecies or variety of Nebraska vascular plants represented in at least one of 20 herbaria by at least one specimen or reliably reported in scientific literature that cites voucher specimens. Thus, we have tried to verify all species reported in the publications noted above by finding or collecting at least one voucher specimen or by accepting vouchered reports from the literature. The Nebraska herbaria (standard international identifier code given where assigned) we consulted are those of the University of Nebraska—Lincoln (NEB) and the University of Nebraska at Omaha (OMA) and at Kearney; Chadron (CSCN) and Wayne state colleges, Cedar Point Biological Station, Doane College, Bridgeport High School, Crescent Lake Wildlife Refuge, and Nebraska Wesleyan University. We have also seen all Nebraska specimens at Fort Hays State University, Kansas; University of Kansas, Lawrence (KANU); Kansas State University, Manhattan (KSC); South Dakota State University, Brookings (SDC);

University of South Dakota, Vermillion (SDU); and University of Wyoming, Laramie (RM). For some groups, we have seen Nebraska-collected specimens in the herbaria of the Missouri Botanical Garden, St. Louis (MO), the New York Botanical Garden (NY), and various private collections.

In our database we mostly follow the nomenclature of the *Flora of the Great Plains* (Great Plains Flora Association, 1986), but we have often accepted interpretations and nomenclature from more recent publications. Insofar as it has become available, we have considered the nomenclature of *Flora of North America* (1993 *et seq.*), but most volumes have yet to appear.

Our list includes hundreds of additions, corrections, and deletions in the lists of Nebraska species that can be made from the *Atlas of the Flora of the Great Plains* and the *Flora of the Great Plains*. Those books were developed from databases made 20 and 10 years ago, respectively, and in succeeding years we made special efforts to document new and dubiously reported species for Nebraska and to correct errors in the books.

We entered our species-records into the database by county of collection because the county is the only collection site give for many voucher specimens, especially the older ones. Furthermore, Nebraska's counties form a rather uniform grid, except for four very large ones (Cherry, Custer, Holt, and Lincoln counties), and county-by-county dot-distribution maps give a rather precise overview of the species' actual distributions.

OBSERVATIONS AND DISCUSSION

Collecting intensity

Figure 1 and Table 1 show the number of species of native and escaped alien species of vascular plants that have been collected from each county. The unevenness of botanical exploration and collecting intensity is immediately evident, but county-by-county figures are not always comparable, even for adjacent counties. Intensively collected counties are indicated in Table 1 as those whose list of known species is estimated to be at least 95% complete, i.e., few species (especially native ones) are likely yet to be discovered in them. Such counties are well-known either because they have been the subject of intensive collecting by one or a few persons (i.e., Banner County by Phillips Hardy [1991]; Cuming by Churchill [1977, 1979]; Dawes by Urbatsch and Eddy [1973] and others; Keith by Sutherland and Rolfsmeier [1989]; Richardson by Reynolds [1942] with further collections by Shildneck [Koelling, 1994] and others; and Seward County by Rolfsmeier [1987]) or because they have been collected in repeatedly by numerous persons over many years (i.e., Buffalo, Cherry,

Table 1. Rank-order of all 93 Nebraska counties, showing numbers of species of native and escaped-alien vascular plants that have been collected in each county through 1994. These numbers are mapped in Fig. 1. Counties named in boldface are estimated to have at least 90% of their species collected as of 1994.

County	Species	County	Species	County	Species
Douglas	851	Antelope	434	Red Willow	289
Richardson	826	Dodge	425	Chase	287
Cherry	819	Box Butte	424	Cheyenne	286
Lancaster	810	Saline	423	Nuckolls	271
Dawes	760	Pawnee	415	Dakota	267
Sarpy	726	Gage	398	Burt	262
Brown	711	Johnson	398	Arthur	258
Sioux	667	Knox	392	Furnas	246
Buffalo	652	Rock	389	Grant	245
Keith	643	Franklin	385	Hitchcock	244
Seward	643	Madison	381	Wayne	239
Holt	630	Butler	373	Hamilton	238
Cass	620	Cedar	362	Polk	222
Otoe	620	Dawson	357	York	217
Sheridan	603	Sherman	356	Adams	215
Saunders	598	Phelps	355	Frontier	215
Hall	594	Howard	351	Loup	215
Kearney	586	Platte	350	Hayes	212
Webster	561	Dixon	349	Colfax	206
Custer	554	Wheeler	337	Logan	205
Garden	551	Merrick	336	Blaine	202
Nemaha	548	Kimball	329	Nance	193
Morrill	534	Greeley	326	Valley	193
Cuming	533	Hooker	325	Garfield	191
Scotts Bluff	519	Stanton	318	Clay	178
Lincoln	517	Thayer	307	Boone	176
Washington	488	Dundy	301	Pierce	168
Thomas	483	Boyd	298	Thurston	154
Keya Paha	473	Perkins	294	Gosper	153
Jefferson	449	Harlan	291	Fillmore	144
Banner	436	Deuel	290	McPherson	143

Douglas, Lancaster, Sarpy, Thomas, and Webster counties).

Undercollected and well-collected counties are sometimes adjacent. For example, Gage County, with only 398 species collected, has fewer than half the number of collected species than adjacent Lancaster County (810 species), yet the two counties are of similar size and include similar habitats and vegetation and are thus likely to have floras of similar size. Saunders County (598 species collected) lies between similar-sized Lancaster County (810 species) and half-its-size Douglas County (851 species) and one-third-its-size Sarpy County (726 species); no doubt more than a hundred (perhaps 200) species remain to be verified in Saunders County. These disparities can be explained by the presence of the University of Nebraska–Lincoln in Lancaster County, with collecting by numerous professional botanists as well as students beginning in that

county in the 1870s and continuing to the present, and by the University of Nebraska at Omaha in Douglas County, where collectors have been active since the 1960s. Dawes and Buffalo counties are the sites of Chadron State College and the University of Nebraska at Kearney, respectively, and collecting activity by students and faculty members from those institutions has likewise been vigorous there.

Data for most counties, however, have accumulated slowly over the past 130 years with the addition here of a species or two, there of a small collection from time to time, and occasionally by the contribution of a sizable collection gathered to substantiate a research project or environmental report. Thus, while an individual specimen or small collection may seem insignificant, the cumulative effect is considerable over the years.

The Sandhills (ca 23,000 mi²/59,800 km²) have been

Table 2. Species-richness of vascular plants in various habitats in Nebraska.

County	Habitat	Area (ha/ac)	Fam- ilies	Species	Aster- aceae	Poaceae
Saunders	Oak forest ¹	4.8/12	54	152	42	38
Butler	Oak forest ¹	6.4/16	55	152	25	24
Washington, Sarpy	Oak forest ²	644/1590	100	597	79	92
Otoe	Oak forest ¹	22/55	53	212	21	21
Lancaster	Tallgrass ³	10/25	24	75		
		5.7/14	30	79		
		13.7/34	25	72		
Lancaster	Tallgrass ⁴	97/240	57	392	68	61
Seward	Tallgrass ¹	2.8/7	35	116	34	15
Douglas & Sarpy	Tallgrass ⁵	53/131		217	58	39
Buffalo	Tallgrass ⁶	324/800		273	50	67
Hall	Tallgrass ⁶	827/2100		317		
Webster	Mixed-grass on loess hills ⁷	258/640	58	239	42	44
Arthur	Mixed-grass on sandhills ⁸	518/1280	42	205	42	36
Garden, Morrill, Scotts Bluff	Alkali wetlands ⁹	1257/3112	48	231	38	45
Scotts Bluff	Alkali wetland ¹		35	162	30	28
Saunders	Salt marsh ¹	43/106	42	168	35	30

¹Rolfmeier, 1991; ²Garabrandt, 1988; ³Goodnight-Krager, 1993; ⁴Kaul and Rolfmeier, 1987; ⁵Boettcher et al., 1993; ⁶Nagel and Kolstad, 1987; ⁷Rothenberger, 1994; ⁸Rolfmeier, unpub.; ⁹Rolfmeier, 1993.

very unevenly collected. The earliest extensive collecting was by Rydberg (1895), who found 485 species in three Sandhills counties, and by Jared Smith and Roscoe Pound (1893), who *walked* 300 miles across the Sandhills in 1892 and collected more than 200 species. Pool (1914) reported the flora and vegetation in detail, and Kaul (1990) summarized the current state of knowledge. Cherry (819 species collected, but most are from non-Sandhills habitats of the Niobrara Valley) and Thomas (483 species) counties have attracted collectors for more than a century, and Arthur County (258 species) has recently seen activity by botanists, but McPherson County is represented in herbaria by only 143 species, far fewer than it actually has. Our data show 753 species collected from sandy soils in the Sandhills, of which only 78 are escaped alien species, but further

collecting is likely to reveal at least 50 species more. The Sandhills have a rich flora for an area of deep, dune-forming sands, even though the size of its flora is approached by several eastern-Nebraska counties of much smaller size (Fig. 1, Table 1).

Species-richness and family-richness

Various vegetation types, especially tallgrass prairie, have been thoroughly sampled in parts of the state and some data are given in Table 2, which shows species-richness in various habitats. The data were gathered from areas of differing size and from various admixtures of adjacent vegetation zones and so are not directly comparable on a per-unit-area basis, but they provide clues to numbers of species in defined areas of some of the state's major vegetation zones. These data

suggest that tallgrass prairie is more species-rich than mixed-grass prairie and somewhat less rich than undisturbed oak forests, but verification will require further field work in defined areas.

Species-richness in the upland oak forests bordering the Missouri River floodplain in Nebraska was presented by Aikman and Gilly (1948), Kaul et al. (1988), and Rolfsmeier (1989). Generally, the number of species of woody plants and herbaceous understory plants decreases markedly upriver from Richardson to Cherry counties, and some understory species of the eastern North American deciduous forest are replaced upriver by those of western North America.

Richness of vascular-plant families is surprisingly high in some areas (Table 2). For example, 100—nearly three-fourths of Nebraska's 136 families—are known from just 644 ha/1590 ac in Washington and Sarpy county oak forests (Neale Woods and Fontenelle Forest, including some small prairies and marshes within the forests). Much smaller oak forests in Saunders, Butler, and Otoe counties have 40% of the state's families in them. Grasslands probably have lower family-richness than oak forests in Nebraska, judging from the few data in Table 2, but definitive comparative studies are yet to be done. Nevertheless, 57 families (42%) are present in a single Webster County section (258 ha/640 ac) of mixed-grass prairie on loess having some wooded riparian habitat, and the same number are present in a loess-glacial till Lancaster County tallgrass prairie only about one-third its size, while 42 families (30% of the state's total) are in two sections (518 ha/1280 ac) in Arthur County sandhills. These few data suggest that family-density in grasslands is highest in tallgrass prairie, lower in mixed-grass on heavy (loess) soil, and lower yet in mixed-grass on loose sand, but more and better-defined samples are needed to substantiate that. There are no data on family-density in the shortgrass prairies of the Nebraska Panhandle.

Although Nebraska's saline and alkaline soils appear, at first view, to be poor in species and families, the data summarized in Table 2 suggest otherwise. One-fourth to nearly one-third of the state's families have been collected from areas as small as 43 ha/106 ac. However, extremely saline/alkaline areas are nearly devoid of vegetation.

Species-richness of aquatic vascular plants was studied in 44 Sandhills lakes by Ray Thomson in 1915 (his data were published by McAtee in 1941); submersed plants comprised 1 to 17 species in each lake, but emergents were usually more species-rich. Donald Mahoney (1977) correlated water chemistry with species-richness of aquatic plants in eight Sandhills and

seven non-Sandhills lakes. He found that species-richness was significantly inversely correlated with alkalinity, solids, and total hardness of the water, but there was no correlation with surface or vegetation areas of the lakes. Erickson and Leslie (1987) found correlations of soils and vegetation in Sandhills and Rainwater Basin wetlands. They recorded 214 species of vascular plants from 17 Sandhills lakes and marshes and 64 from six Federal Waterfowl Protection areas in the Rainwater Basins.

Representation of families is, of course, uneven in any habitat, and many families are represented in the state by only a few species that are not common anywhere in Nebraska. Two families—Asteraceae and Poaceae—are the most species-rich (and often have the most individuals) in many Nebraska terrestrial habitats, and their proportional representation is shown in Table 2. The sedges and their relatives (Cyperaceae), are species-rich in grassland, aquatic, and forest habitats, and other families, such as Polygonaceae and Brassicaceae, are well-represented in some habitats.

ACKNOWLEDGMENTS

The data presented here result from collective efforts of hundreds of persons in the 19th and 20th centuries. Their specimens are preserved in herbaria and provide tangible evidence of Nebraska's flora. The Research Council of the University of Nebraska-Lincoln has provided funds to the first author for more than 20 years in support of field work for collecting specimens and of herbarium and library work to compile our database. Curators of most herbaria have been encouraging and helpful. The reviewers of our manuscript, Ronald L. McGregor and Craig Freeman, University of Kansas and David M. Sutherland, University of Nebraska at Omaha, have made valuable suggestions and have given useful information in the process.

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