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A Comparison of the Forest Floras along the Des Moines and Missouri Rivers

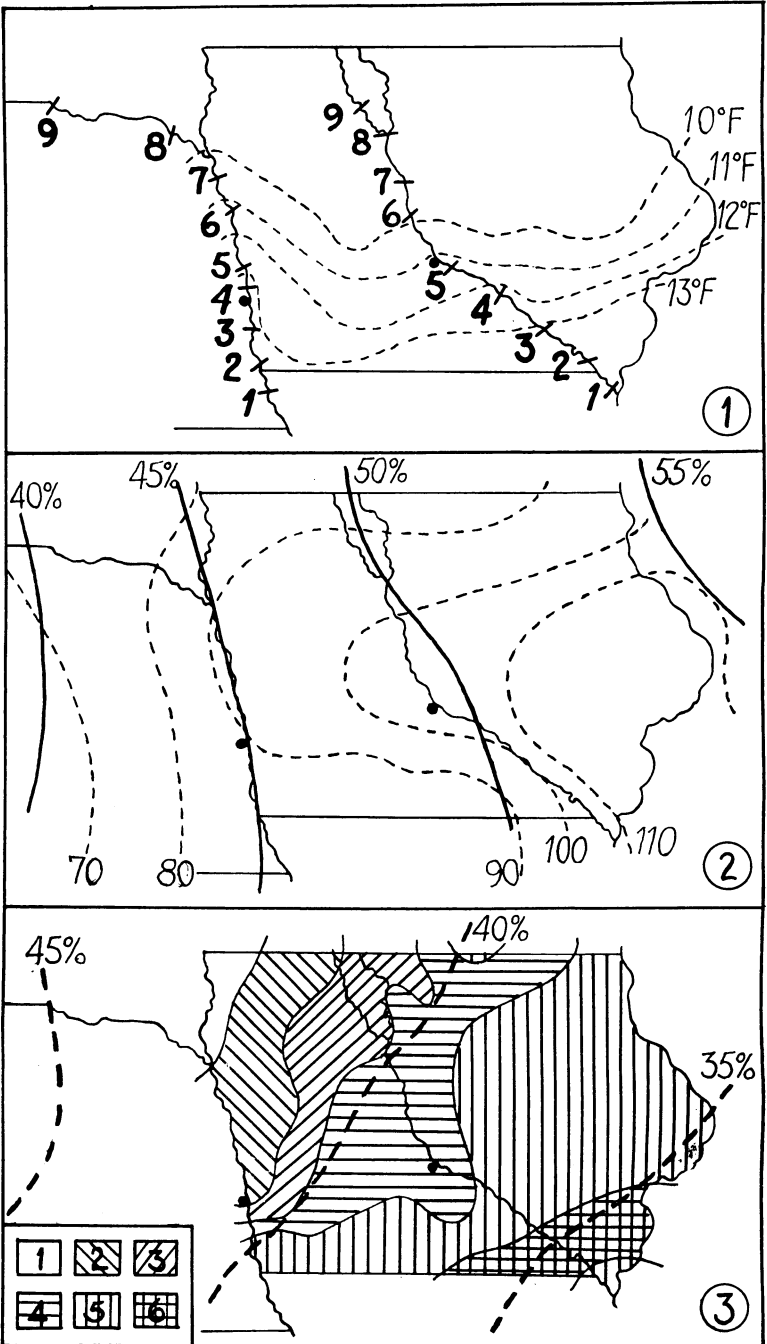
JOHN M. AIKMAN AND CHARLES L. GILLY

A cursory examination of the deciduous forest of eastern North America, at intervals from its center (14) in the Ohio river basin westward, discloses changes in the structure of the forest characterized chiefly by a reduction in number of species and in the abundance and size of the component trees. Beyond the Mississippi river in Iowa and eastern Nebraska the forest flora is concentrated chiefly along streams flowing diagonally southeastward. Bordering these streams the deciduous forest extends into the prairie.

The Des Moines river and the Missouri river, along the eastern boundary of Nebraska, constitute two almost parallel frontiers of woody plants separated by 150 to 200 miles originally covered chiefly by prairie. Although the Missouri river because of its size, age and depth of channel would probably have a better developed forest vegetation than the Des Moines river if in the same location as the Des Moines, forest communities are much better developed along the course of the latter stream apparently because of the increased proximity of its position to the center of the deciduous forest formation. The number, size and behavior of the woody plants of 9 transects (Fig. 1) of the same latitude along these streams have been compared and some factors affecting woody plant growth evaluated as possible causes of the differences apparent in matched forest communities on the two streams.

The investigation of the distribution of woody plants in Iowa and eastern Nebraska covers a period of more than a century. Comprehensive summaries of the pertinent literature of the prairie and of forest development in the prairie association of this portion of the Mississippi valley are available (1, 5, 12, 13, 16). More recent investigations of the vegetation and the plant growth factors of the region have been made (2, 3, 9, 10, 15, 16, 17). Nomenclature of the tree species is after Little (8) and that of the shrub species after Jones (6).

In an investigation of the distribution and structure of the forests of eastern Nebraska (1) about 40 transects along the Missouri river were located and studied. Nine of these transects have been selected for comparison with 9 transects along the Des Moines river (Fig. 1). Further investigation of these Missouri river transects on the eastern side of the river have been made. The transects to be compared are of the same latitude and are numbered in order from the mouth of the Des Moines river to its source with corresponding transects along the Missouri river on the eastern boundary of Nebraska.



COMPARISON OF FACTORS

Edaphic factors.

The Geology of the two stream courses is materially different with the exception of transects, 1 and 2 (4, 7). Along both rivers the upland soil in transects 1 and 2 except for some uneroded loessal deposits bordering the Missouri river, is Kansan drift with limited exposure of the underlying Nebraskan and occasional outcrops of underlying bed rock. These drift hill soils are quite heavy and clayey with a somewhat heavy subsoil containing gravel and a varying number of rounded glacial boulders. Soils of this origin, with a thin covering of loess except in erosion areas, extend along the Des Moines river in include transect 5 (Fig. 1).

The soil of the bluffs bordering the alluvial valleys in transects 3 to 8 in Nebraska is composed of loess material which forms a thick mantle over the underlying glacial till. The loess soil is fine-grained and has a less compact structure in exposures along stream banks. The soil in transect 9 is of high plains origin beyond the effect of glaciers and of outwash materials from these glaciers.

The Wisconsin drift sheet covers the Des Moines valley from its source to transect 6. Compared to the surface of the Kansas till, which has been deeply sculptured by the lower Des Moines river and its tributaries, the Wisconsin drift of the upper Des Moines valley still has smooth glacial topography. It has been modified so little by erosion that the almost unbroken surface of the drift, extending for miles back from the river, offers little protection to woody vegetation along the river and its tributaries. Although the gorge itself is deeply cut at transect 7 it is V-shaped and the eroded area extends for only a few feet back from the edge of the gorge.

An important factor affecting the development of forest vegetation on the bordering bluffs is the comparative degree of protection afforded by the depth to which the two rivers have been eroded and by the degree and aspect of slope of the resulting bluffs. The depth of the Des Moines valley below the surface of the uplands increases from about 50 feet at transect 9 to 250 feet at the moraine in transect 6. The depth is 170 feet at transect 4 and 220 feet at transect 1. The average width of the valley from transect 9 to transect 1 is slightly more than one mile. The average depth of the Missouri valley is 150 feet at transect 9 and has a more gradual reduction

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- Fig. 1. Location of transects.
 Average minimum January temperature.....
- Fig. 2. Average annual number of days with 0.01 inches of more precipitation.....
 Average minimum relative humidity in October.....
- Fig. 3. Percentage annual precipitation during 3 summer months.....
- | | |
|--|----------------|
| Normal annual precipitation in inches: | |
| 1—24-26 inches | 4—30-32 inches |
| 2—26-28 inches | 5—32-34 inches |
| 3—28-30 inches | 6—34-36 inches |

Table 1. Distribution by transects, of species of upland trees along the Des Moines and Missouri rivers.

Missouri River									Species	Des Moines River								
1	2	3	4	5	6	7	8	9		1	2	3	4	5	6	7	8	9
x	x	x	x	x	x	x	x	x	Malus ioensis	x	x	x	x	x	x	x	x	x
x	x	x	x	x	x	x	x	x	Crataegus calpodendron	x	x	x	x	x	x	x	x	x
x	x	x	x	x	x	x	x	x	Crataegus mollis	x	x	x	x	x	x	x	x	x
x	x	x	x	x	x	x	x	x	Quercus macrocarpa	x	x	x	x	x	x	x	x	x
x	x	x	x	x	x	x	x	x	Ostrya virginiana	x	x	x	x	x	x	x	x	x
x	x	x	x	x	x	x	x	x	Tilia americana	x	x	x	x	x	x	x	x	x
									Acer nigrum	x	x	x	x	x	x	x	x	x
x	x	x	x	x	x	x			Prunus serotina	x	x	x	x	x	x	x	x	x
x	x	x	x	x	x	x			Gymnocladus dioicus	x	x	x	x	x	x	x	x	x
x	x	x	x	x	x	x			Carya cordiformis	x	x	x	x	x	x	x	x	x
x	x	x	x	x	x	x			Quercus borealis	x	x	x	x	x	x	x	x	x
x	x	x	x	x	x				Prunus virginiana	x	x	x	x	x	x	x	x	x
									Crataegus punctata	x	x	x	x	x	x	x	x	x
x	x	x	x						Amelanchier canadensis	x	x	x	x	x	x	x	x	x
							x	x	Populus tremuloides	x	x	x	x	x	x	x	x	x
									Populus grandidentata	x	x	x	x	x	x	x	x	x
									Quercus alba	x	x	x	x	x	x	x	x	x
x	x	x	x	x					Carya ovata	x	x	x	x	x	x	x	x	x
x	x	x	x	x					Fraxinus americana	x	x	x	x	x	x			
x	x	x	x	x					Quercus velutina	x	x	x	x	x	x			
									Prunus pennsylvanica								x	x
									Crataegus margaretta	x	x	x	x	x	x			
x	x	x	x	x					Morus rubra	x	x	x	x	x	x			
x	x	x	x	x					Cercis canadensis	x	x	x	x	x	x			
x	x	x							Quercus muhlenbergii	x	x	x	x	x	x			
x	x								Aesculus glabra	x	x	x	x	x	x			
									Carpinus caroliniana								x	x
									Quercus bicolor	x	x	x	x	x				
									Quercus imbricaria	x	x	x	x					
									Crataegus crus-galli	x	x	x						
									Aesculus glabra arguta	x	x	x						
									Carya tomentosa	x	x	x						
x	x								Asimina triloba	x	x							
									Acer saccharophorum	x	x							
									Carya laciniata	x	x							
									Quercus marilandica	x	x							
									Quercus palustris	x	x							
									Quercus stellata	x								
									Fraxinus quadrangulata	x								

to 100 feet at transect 1. The width of the Missouri valley is greater, increasing from an average of about 5 miles at transect 9 to approximately 12 miles at transect 1. The greater width of the Missouri valley materially decreases protection from the prairie climate of the upland. This is compensated for however by the more irregular

topography of the Missouri river bluffs which offer protection to mesophytic species within ravines and narrow valleys removed from the surface of the bluff bordering the valley.

A comparison of the soil as to parent material and present development does not show sufficient difference between the two streams to account for greater ease of forest establishment in a given transect than in the transect of the same latitude on the other stream. Topographic differences would seem to favor the establishment of species in the transects along the Missouri river because of the greater age of the stream and more varied topography in all of the transects.

Climatic factors.

Average annual precipitation decreases from 36 inches in transect 1 on the Des Moines river to less than 24 inches in transect 9 on the Missouri river (Fig. 3). The degree of reduction is approximately the same from transect 1 to transect 9 on the two streams but precipitation is less in transects of comparable latitude on the Missouri than on the Des Moines river. A greater percentage of the annual precipitation occurs in the three summer months on the western stream (Fig. 3) and relative humidity is lower (Fig. 2). However, protection from extreme winter temperature seems to be more favorable in comparable transects on the Missouri river as compared to the Des Moines (Fig. 1). Rehder's climatic zone map, to indicate approximate hardiness of trees and shrubs, shows the same difference (11).

In general moisture conditions are more unfavorable on the western stream although the degree of protection as compared to the adjacent upland areas is slightly greater. Along the course of this stream woody plant species have become established in soils of less available moisture under conditions which materially increase their water requirement.

COMPARISON OF THE FOREST FLORAS

In comparing the forest communities of the two streams, no attempt is made to print complete herbarium lists of the woody plants credited to the locality. Only those plants found in the transects are included in the tables. Among the shrubs, several species of casual occurrence have been omitted. Even a superficial comparison of tree and shrub communities in transect 1 of the two streams shows that there is a much greater difference in the upland tree population, both as to number of species and as to development of individuals, than in the shrub or floodplain populations (Table 1, 2, 3). The shrub communities show the least difference in total number of species in the several transects of the two streams and the floodplain communities show the least difference in composition of the stands.

From transect 1 to transect 9, the numbers of upland tree species (Table 1) along the Des Moines river were 37, 33, 29, 27, 27, 27, 21,

Table 2. Distribution by transects, of species of shrubs and woody vines along the Des Moines and Missouri rivers.

Missouri River									Species	Des Moines River								
1	2	3	4	5	6	7	8	9		1	2	3	4	5	6	7	8	9
					x	x	x		<i>Physocarpus opulifolius</i>								x	x
									intermedius									
					x	x	x	x	<i>Sheperdia argentea</i>									x
					x	x	x	x	<i>Prunus melanocarpa</i>									
	x	x	x	x	x	x	x	x	<i>Symphoricarpos occidentalis</i>						x	x	x	x
x	x	x	x	x	x	x	x	x	<i>Rubus occidentalis</i>						x	x	x	x
x	x	x	x	x	x	x		x	<i>Rubus strigosus</i>						x	x	x	x
									<i>Lonicera dioica</i>					x	x	x	x	x
									<i>Ribes cynosbati</i>						x	x	x	x
					x	x			<i>Ribes americanum</i>						x	x	x	x
x	x		x						<i>Viburnum lentago</i>			x		x	x	x	x	x
x	x	x	x	x	x	x	x	x	<i>Rosa suffulta</i>			x	x	x	x	x	x	x
x	x	x	x	x	x	x	x	x	<i>Rhus glabra</i>			x	x	x	x	x	x	x
x	x	x	x	x	x	x	x	x	<i>Ceanothus ovatus pubescens</i>			x	x	x	x	x	x	x
x	x	x	x	x	x	x	x	x	<i>Amorpha canescens</i>			x	x	x	x	x	x	x
x	x	x	x	x	x	x	x	x	<i>Amorpha fruticosa</i>			x	x	x	x	x	x	x
x	x	x	x	x	x	x	x	x	<i>Menispermum canadense</i>			x	x		x	x	x	x
x	x	x	x	x	x	x	x	x	<i>Prunus americana</i>			x	x	x	x	x	x	x
x	x	x	x	x	x	x	x	x	<i>Sambucus canadensis</i>			x	x	x	x	x	x	x
x	x	x		x	x	x			<i>Smilax hispida</i>			x	x	x	x	x	x	x
x	x	x	x	x	x	x	x	x	<i>Celastrus scandens</i>			x	x	x	x	x	x	x
x	x	x	x	x	x	x	x	x	<i>Vitis riparia</i>			x	x	x	x	x	x	x
x	x	x	x	x	x	x	x	x	<i>Parthenocissus quinquefolia</i>			x	x	x	x	x	x	x
x	x	x	x	x	x			x	<i>Zanthoxylum americanum</i>			x	x	x	x	x	x	x
x	x	x	x	x	x	x	x	x	<i>Ribes missouriensis</i>			x	x	x	x	x	x	x
x	x	x	x	x	x	x	x	x	<i>Rhus radicans</i>			x	x	x	x	x	x	x
x	x	x	x	x	x	x	x	x	<i>Cornus drummondii</i>			x	x	x	x	x	x	x
x	x	x	x	x	x	x	x	x	<i>Cornus stolonifera</i>			x	x	x	x	x	x	x
x	x	x	x	x	x	x	x	x	<i>Cornus purpusi</i>			x	x	x	x	x	x	x
x	x	x	x			x	x	x	<i>Euonymus atropurpureus</i>			x	x	x	x	x	x	x
x	x	x	x	x	x				<i>Corylus americana</i>			x	x	x	x	x	x	x
x	x	x	x	x					<i>Ceanothus americanus</i>			x	x	x	x	x	x	
x	x	x	x						<i>Rubus allegheniensis</i>			x	x	x	x	x	x	x
x	x	x	x						<i>Staphylea trifolia</i>			x	x	x	x	x	x	x
									<i>Cornus racemosa</i>			x	x	x	x	x	x	x
									<i>Cornus alternifolia</i>			x	x	x	x	x	x	x
x	x	x	x	x	x	x			<i>Symphoricarpos orbiculatus</i>			x	x	x	x			
x	x	x	x						<i>Rhamnus lanceolata</i>			x	x	x	x	x		
x	x								<i>Cephalanthus occidentalis</i>			x	x	x	x	x		
x	x	x							<i>Hypericum prolificum</i>			x	x					
									<i>Smilax rotundifolia</i>			x	x	x	x	x		
									<i>Viburnum affine</i>							x	x	x
									<i>Rhus aromatica</i>			x	x	x				

18, 15 as compared to 20, 20, 18, 17, 16, 11, 11, 6, 7 in comparable transects on the Missouri river. In the same order the numbers of shrub species in the transects of the two streams were 31, 32, 29, 32, 33, 36, 34, 33, 32 and 30, 31, 29, 28, 24, 26, 27, 23, 24 (Table 2); the numbers of floodplain tree species were 18, 17, 18, 18, 19, 19, 18, 15, 14 and 13, 13, 14, 14, 12, 13, 12, 14, 13 (Table 3). Of a total of 39 species of upland trees the number found growing in every transect on the Des Moines river was 14 and on the Missouri was 6. Of a total of 42 species of shrubs and woody vines, numbers growing in every transect of the two streams were 21 and 15. Of a total of 20 species of floodplain trees the numbers were 13 and 11.

Three definite communities of woody plants are found on the uplands bordering the lower Des Moines river. They are in order of decreasing mesophytism: the maple-linden association (*Acer saccharophorum*, *Acer nigrum* and *Tilia americana* dominants); the oak-hickory associates (*Quercus borealis*, *Quercus alba*, *Quercus velutina*, *Quercus macrocarpa*, *Carya tomentosa*, *Carya ovata* and *Carya cordiformis* and other oaks and hickories the dominants); and the shrub associates (*Corylus americana*, *Cornus* sp., *Symphoricarpos* sp. and *Rhus glabra*, dominants).

The maple-linden association represents a transition from the beech-maple (*Fagus grandifolia* — *Acer saccharophorum*) climax with its center in southern Ohio to the linden consociation in eastern Nebraska. The oak-hickory associates is represented throughout the

Table 3. Distribution by transects, of species of floodplain trees along the Des Moines and Missouri Rivers.

Missouri River									Species	Des Moines River								
1	2	3	4	5	6	7	8	9		1	2	3	4	5	6	7	8	9
x	x	x	x	x	x	x	x	x	<i>Salix interior</i>	x	x	x	x	x	x	x	x	x
x	x	x	x	x	x	x	x	x	<i>Salix amygdaloides</i>	x	x	x	x	x	x	x	x	x
x	x	x	x	x	x	x	x	x	<i>Salix nigra</i>	x	x	x	x	x	x	x	x	x
x	x	x	x	x	x	x	x	x	<i>Populus deltoides</i>	x	x	x	x	x	x	x	x	x
x	x	x	x	x	x	x	x	x	<i>Acer negundo</i>	x	x	x	x	x	x	x	x	x
x	x	x	x	x	x	x	x	x	<i>Gleditsia triacanthos</i>	x	x	x	x	x	x	x	x	x
x	x	x	x	x	x	x	x	x	<i>Celtis occidentalis</i>	x	x	x	x	x	x	x	x	x
x	x	x	x	x	x	x	x	x	<i>Fraxinus lanceolata</i>	x	x	x	x	x	x	x	x	x
x	x	x	x	x	x	x	x	x	<i>Ulmus americana</i>	x	x	x	x	x	x	x	x	x
x	x	x	x	x	x	x	x	x	<i>Ulmus fulva</i>	x	x	x	x	x	x	x	x	x
x	x	x	x	x	x	x	x	x	<i>Juglans nigra</i>	x	x	x	x	x	x	x	x	x
x	x	x	x	x	x	x	x	x	<i>Acer saccharinum</i>	x	x	x	x	x	x	x	x	x
				x		x	x		<i>Salix mackenzieana</i>	x	x	x	x	x	x	x	x	x
									<i>Salix bebbiana</i>						x	x	x	x
									<i>Juglans cinerea</i>	x	x	x	x	x	x	x	x	x
						x	x		<i>Salix discolor</i>	x	x	x	x	x	x	x		
x	x	x	x						<i>Platanus occidentalis</i>	x	x	x	x	x	x	x		
									<i>Fraxinus nigra</i>					x	x	x	x	
									<i>Betula nigra</i>	x	x	x	x	x				
				x	x				<i>Ulmus thomasi</i>	x	x		x	x				

area but becomes greatly modified in the upper Missouri river transects because of the dropping out of species. The shrub associates shows a wide variety of dominants in various situations but throughout the area is best characterized by the mesic species *Corylus americana* and the xeric species *Rhus glabra*.

The maple-linden association.

A very evident and important structural difference found in comparing the three associations within transects of the same latitude is in the dominant species. In the climax association, *Tilia americana* is dominant in all of the transects on both rivers. It has associated with it in southeastern and central Iowa two species of maple which do not occur in any of the transects of eastern Nebraska. *Acer saccharophorum* and the linden are dominant in Des Moines river transect 1. *Acer saccharophorum* is present in transect 2 but is not a dominant because of lack of abundance. In transects 2 to 7 on the Des Moines river the black sugar maple, *Acer nigrum* is co-dominant with the linden. The maple-linden association in these transects is located in the most mesophytic situations; protected north and northeast slopes. In transects 8 and 9, linden alone is the dominant, forming consociations in the more mesophytic sites. Black maple is present but not in sufficient numbers to rank as a dominant (Table 1).

In the Missouri river transects *Tilia americana* forms consociations in the more mesophytic habitats. *Quercus borealis* of the oak-hickory associates is more closely associated with the linden in transects 1 to 7 than with the oak-hickory because of the absence of competition from the hard maple. An important factor contributing to the separation of the mesic red oak from the more xeric oaks and hickories is the absence from the Missouri river transects of *Quercus alba*, the most important dominant of the oak-hickory associates in central Iowa. However, in these 7 transects the linden and red oak are often represented by consociates (pure stands) with the linden occupying the sites of greater soil moisture. In all of the transects on both streams, *Ostrya virginiana* a sub-dominant because of size is closely associated with the linden. In transects 8 and 9, the linden occupies the more mesophytic situations as it does in transects 8 and 9 along the Des Moines river. In these transects on the Missouri river the strip of woodland is so narrow that often there is local zoning and a mixture of linden, ironwood, and burr oak of about equal size results.

The oak-hickory associates.

Another important difference in the structure of upland tree communities in transects of the same latitude on the two rivers is in number of species (Table 1). This is especially true of oak and hickory species. In transect 1, on the Des Moines river there are 13 species of the oaks and hickories: *Quercus borealis*, *Quercus imbr-*

caria, *Quercus bicolor*, *Quercus marilandica*, *Quercus palustris*, *Quercus alba*, *Quercus muhlenbergii*, *Quercus stellata*, *Quercus macrocarpa*, *Carya laciniata*, *Carya alba*, *Carya ovata* and *Carya cordiformis*. Of these species *Quercus palustris* and *Quercus bicolor* occur only on the upper flood plain and in the more moist situations of the bordering upland. In transect 2 *Quercus stellata* has dropped out. *Quercus palustris*, *Quercus marilandica* and *Carya laciniata* drop out in transect 3, *Carya alba* drops out in transect 4, *Quercus imbricaria* in transect 5 and *Quercus bicolor* in transect 6.

Along the Missouri river the oaks and hickories are represented in transect 1 by 6 species, *Quercus borealis*, *Quercus velutina*, *Quercus muhlenbergii*, *Quercus macrocarpa*, *Carya ovata* and *Carya cordiformis*, compared to 13 species in transect 1 on the Des Moines river. In transect 4 *Quercus muhlenbergii* has dropped out and the comparison is 5 to 8. The comparative numbers of oak and hickory species in the number 6 transects is 4 and 7 respectively and in number 8, 1 and 5. Besides species of oaks and hickories two other dominants of the oak-hickory associates on both streams are *Prunus serotina* and *Fraxinus americana*.

The oak-hickory communities on the two streams are also different in number of sub-dominants. There are 8 sub-dominants of the oak-hickory associates in the Des Moines river transects which are absent from all of the Missouri river transects. In order of appearance in the upper transects they are: transect 9, *Crataegus punctata*; transect 8, *Populus grandidentata*; transect 7, *Prunus pennsylvanica*; transect 6, *Crataegus margareta* and *Carpinus caroliniana*; transect 4, *Crataegus crus-galli*; transect 3, *Aesculus glabra arguta* and transect 1, *Fraxinus quadrangulata*.

There is a total of 18 species of upland trees occurring in one or more transects on the Des Moines river that do not occur in any transect on the Missouri river. Of all of the upland trees occurring along both rivers, 13 species appear in the communities of the Des Moines river in transects farther up the course of the river than in the transects of the Missouri river. No single upland tree species appears first on the Missouri river.

All of the floodplain species of ecological importance with the exception of *Acer saccharinum*, *Juglans cinerea*, *Platanus occidentalis*, *Fraxinus nigra* and *Betula nigra* are found as far up the Missouri river as they are on the Des Moines river. (Table 3). *Juglans cinerea*, *Fraxinus nigra* and *Betula nigra* are not found in any of the Missouri river transects. The amount of available soil moisture is more constant in the floodplains of the two streams than it is in the upland communities. This would seem to indicate that climatic factors are more important than the mechanics of distribution in determining the extent of distribution of tree species along streams in the prairie region. However, there may be some difference because of the fact that most of the upland species are distributed by means of animals and the floodplain species by means of wind and water.

The shrub associates.

There is less difference between the shrub associates in transects of the same latitude on the two rivers than there is in the tree associations. As to number of species there is a slight advantage in favor of the Des Moines transects but the Missouri river transects are more extensive and better developed (Table 2). Species present in Missouri river transects but absent from corresponding transects on the Des Moines river seem to be concentrated more in the upper transects while those present along the Des Moines and not along the Missouri seem to be concentrated in the lower transects.

In all of the transects on the two rivers, the shrub associates forms a tension zone between the oak-hickory associates and adjacent areas originally occupied by prairie. The more mesic components live under the trees and in proximity to them. The shrub species increase in xerophytism and decrease in shade tolerance from this inner border of the shrub to the outer border where shrub species must compete on almost even terms with grass species.

Corylus americana and *Rhus glabra* may be considered the dominants of the shrub associates for the entire region. *Corylus americana* has an important role in situations of greater soil moisture and reduced light while *Rhus glabra* competes on the outer border of a given shrub zone. For this reason communities of *Corylus americana* and its more mesic associates are more abundant and better developed in the eastern portion of the area studied and *Rhus glabra* and its associates are better developed in the western part of the area. The mesic shrubs are more prevalent in the eastern part of the range because the general climatic conditions are favorable for their growth on exposures and slopes which in the western part would be extremely xeric.

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