SPECIES RICHNESS OF VEGETATIONAL AREAS OF TEXAS: A FIRST APPROXIMATION

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ABSTRACT

Using the *Atlas of the Vascular Plants of Texas* and the generally accepted vegetational area map of Texas, we analyzed the species richness of the different areas of Texas. We found that the vegetational areas are not equally rich and that richness does not correlate with primary productivity or size of area. Interestingly, the ratio of monocots to dicots is not the same in the eastern and western parts of the state. Other patterns also are apparent: Poaceae dominate the monocots in the west but not in the east; Cyperaceae are much more common in the east than in the west; Cactaceae are much more common in the west than in the east; Asteraceae and Fabaceae are about equal in both regions. We suggest that the traditional vegetational areas of Texas probably should be reassessed and perhaps a simpler vegetational map devised that is more congruent with current distributional information.

RESUMEN

Usando el *Atlas of the Vascular Plants of Texas* y el mapa generalmente aceptado de áreas de vegetación de Texas, se ha analizado la riqueza en especies de las diferentes áreas de Texas. Encontramos que las áreas de vegetación no son igual de ricas y que la riqueza no se correlaciona con la producción primaria o el tamaño del área. Es interesante que la relación de monocotiledóneas a dicotiledóneas no es la misma en las partes este y oeste del estado. Otros patrones son también aparentes: Las Poaceae dominan las monocotiledóneas en el oeste pero no en el este; las Cyperaceae son mucho más comunes en el este que en el oeste; las Cactaceae son mucho más comunes en el oeste que en el este; Las Asteraceae y Fabaceae son casi iguales en ambas regiones. Se sugiere que las áreas de vegetación tradicionales de Texas probablemente deberían reestudiarse y quizás elaborar un mapa de vegetación más simple que sea más congruente con la actual información sobre la distribución.

INTRODUCTION

It is well known that the different vegetational areas of Texas (sometimes called vegetational regions) are not equally rich in species. For example, Diggs et al. (2006) have indicated that, while east Texas has 3402 taxa, north central Texas has only 2376 taxa and that the Great Plains, although one-fifth the land mass of the United States, has only 3067 taxa. The latitudinal gradient in species richness is well known and is as true of plants as it is of animals, but little is understood about the factors determining species richness (Owen 1990; Thorne 1993; Ziv & Tsairi 2004; MacRoberts et al. 2007; Qian et al. 2007).

The Turner et al. (2003) *Atlas of the Vascular Plants of Texas* is primarily useful as a source of distributional information for individual species. However, it (and to a certain extent the Hatch et al. 1990 *Checklist of the Vascular Plants of Texas*) can be used, with caution, as data for other types of studies. In this paper, we use Turner et al. (2003) to determine the species richness of vegetational areas across Texas.

METHODS AND LIMITATIONS

The most often used vegetational areas map of Texas is shown in Figure 1 (Gould 1962, 1975; Correll & Johnston 1970; Jordan et al. 1984; Hatch et al. 1990; Telfair 1999; Turner et al. 2003; Diggs et al. 2006). Using the Turner et al. (2003) *Atlas*, we counted all species that occurred in each vegetational area. This was accomplished by drawing each area on a clear plastic sheet of transparency film the same size as the maps in the *Atlas* and overlaying the transparency on each of the approximately 5030 maps. If the species (dot) occurred within the vegetational area, it was counted as occurring in that area whether or not it was predominately found in another area. We did not question the validity of the traditional vegetational areas nor did we question the dots on the distribution maps in the *Atlas* but accepted them, recognizing that

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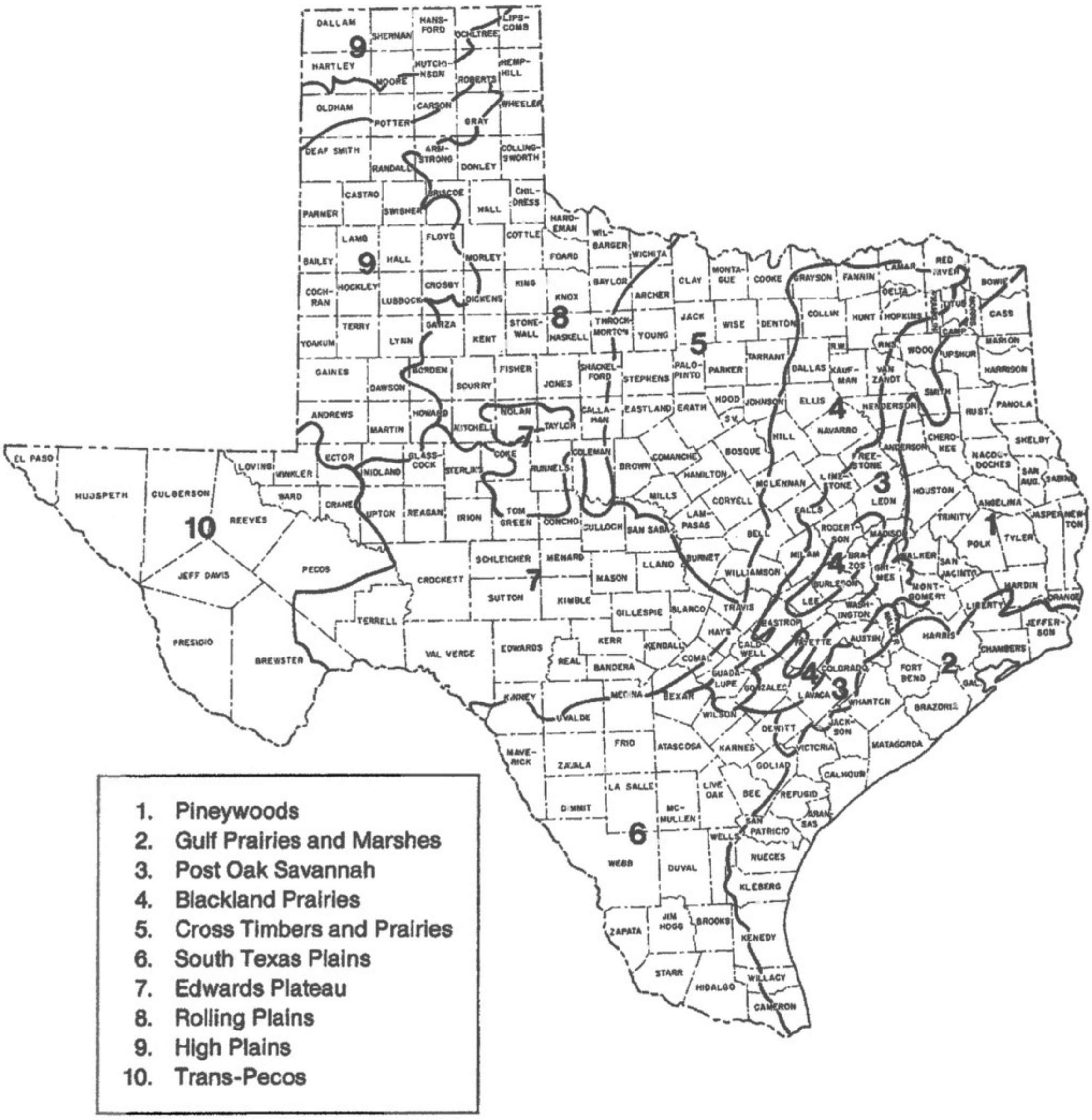

Fig. 1. Vegetational areas of Texas (from Hatch et al. 1990).

the distribution maps are incomplete and there are undoubtedly mistakes in them, and that the traditional vegetational areas are not universally accepted (MacRoberts & MacRoberts 2003a). We did not exclude non-native species but assumed, probably incorrectly, that they would be about equally frequent in each area; also recognizing that non-natives are part of the flora and are here to stay. We included data only at the species level. There are many sources of error in the data from uneven collecting (areas most heavily collected are near universities with herbaria) to the fact that Turner et al. (2003) "in positioning of dots within counties, if only a single collection was noted … usually placed the dot in the center of the county concerned (except in the Trans Pecos region….)." We, therefore, assigned species to areas conservatively: if a dot occurred on the vegetational area boundary we either checked with other sources (e.g., Hatch et al. 1990) to see if the problem could be resolved or counted it as occurring only in the areas already represented by the species. That is, we assumed that it was on the side of the county that was in the vegetational area already occupied. Thus, if an east Texas species occurred as far west as Travis County, and there was a single dot in the center of Travis County where the Edwards Plateau and the Blackland Prairies meet, then the species was not counted as occurring in the Edwards Plateau vegetational area but only in the area or areas to the east. We did not encounter many of these border problems, but to have an independent assessment of the accuracy of the Turner et al. (2003) maps, we compared them with the reported distribution of species in Hatch et al. (1990) where there is no ambiguity in vegetational area reported. For this comparison, we used the Pteridophytes and Gymnosperms in one sample and the Cyperaceae in another. We found a very strong positive correlation between the Turner et al. (2003) and Hatch et al. (1990) samples ($R^2 = 0.8648$ and $R^2 = 0.8023$, respectively), supporting our use of the Turner et al. (2003) data as satisfactory for the task at hand. In addition, the sample taken from the Turner *Atlas* is over 5000 species and ten vegetational areas, which is a substantial amount of data. We, therefore, do not believe that the problem of "dot placement" introduces a great deal of error as compared to other problems, such as uneven collecting among the different vegetational areas.

We looked at the distribution of several plant families (Poaceae, Cyperaceae, Asteraceae, Cactaceae, and Fabaceae) by vegetational area to see if any patterns of plant distribution were evident.

We used Owen and Schmidly's (1986) above-ground primary productivity (primary productivity index) data for Texas to see if this correlated with species richness. We averaged their data for each vegetational area to obtain a single figure for comparison with our richness numbers.

RESULTS AND DISCUSSION

The species area/vegetational area results are summarized in Table 1. Texas vegetational areas are not equally species rich. The Gulf Prairies and Marshes are the richest, the Trans-Pecos is second, and the Pineywoods is third. The High Plains are the least rich.

Species richness correlates only very weakly and negatively ($r_s = -0.3697$) with size of vegetational area. The Edwards Plateau ranked first in size but fourth in richness; the Rolling Plains ranked second in size but ninth in richness, and so on.

Species richness correlates only very weakly but positively ($r_s = 0.3455$) with primary productivity. Gulf Prairies and Marshes rank first in species richness but third in productivity. Trans-Pecos ranks second in species richness but tenth in productivity, and so on. These findings agree in general with those of Owen (1990), who found for mammals evidence contradictory to the hypothesis that greater productivity is associated with greater species richness. Samples at other scales than those used by Owen or ourselves might show different results, but this was not tested.

Breaking down the major figures somewhat, the monocot/dicot/Gymnosperm-Pteridophyte ratios fell into two groups across Texas. For the eastern parts of Texas, monocots varied between 29% and 30%, dicots between 67% and 69%, and Gymnosperms and Pteridophytes between 2% and 3%. For the western part of Texas, monocots varied between 19% and 24%, dicots between 74% and 77%, and Gymnosperms and Pteridophytes between 2% and 4%. There is a significant difference (chi square = 116, 3df, p = .00001) between these groups. Interesting here is that the number of grass species by vegetational area appears to be practically the same ranging from 11.2% for the Pineywoods to 16.6% for High Plains, with the others grouped closely between these (Table 2). However, when monocots alone are considered, grasses dominate the west Texas vegetational areas but do not dominate the east Texas vegetational areas. In the four easternmost areas of Texas, grasses constitute less than 50% (range 36.9% to 47.8%) of the monocot flora, but in the six westernmost areas, they constitute more than 50% (range 52.8% to 68.5%). Cyperaceae show the opposite trend (Table 3) and are much more common in the east than in the west. Asteraceae show only a mild trend toward being more common in west Texas than in east Texas (Table 4). Fabaceae show virtually no east-west trend (Table 5), but Cactaceae show a clear east-west trend (Table 6).

The reason for the differences in species richness among areas is not easily understood (Owen 1990; Withers et al. 1998; Qian et al. 2007; see also discussion in Diggs et al. 2006; MacRoberts & MacRoberts 2008 in press), but presumably a combination of complicated interrelated factors (elevation variation, precipitation and its seasonality, soil diversity, temperature extremes and averages, sunshine, geological

TABLE 1. Number and percentage of pteridophytes, gymnosperms, monocots, dicots, total species, area in millions of ha., and productivity of Texas vegetation areas. Area data from Hatch et al. (1990). Primary productivity index from Owen and Schmidly (1986).

Vegetation region	Ptero. & Gymno.	Monocots	Dicots	Total	Area	Productivity
Gulf Prairies & Marshes	43 (2%)	667 (29%)	1607 (69%)	2317	4.1	1905
Trans-Pecos	95 (4%)	411 (19%)	1688 (77%)	2194	7.3	295
Pineywoods	58 (3%)	655 (30%)	1440 (67%)	2153	6.4	2161
Edwards Plateau	70 (3%)	482 (23%)	1535 (74%)	2087	10.3	906
Blackland Prairie	41 (2%)	582 (29%)	1391 (69%)	2014	5.1	1848
Post Oak Savanna	38 (2%)	567 (30%)	1258 (68%)	1863	2.8	1981
Cross Timbers	38 (2%)	420 (24%)	1271 (74%)	1729	6.2	1397
South Texas Plains	28 (2%)	353 (23%)	1169 (75%)	1550	8.5	948
Rolling Plains	19 (2%)	284 (24%)	902 (75%)	1205	9.7	794
High Plains	19 (2%)	216 (24%)	658 (74%)	893	7.9	529

TABLE 2. Number and percentage of Poaceae by vegetational area.

Vegetational Area	Number of species	Percentage of total species in area	Percentage of monocots only
Pineywoods	242	11.2	36.9
Gulf Prairies & Marshes	319	13.8	47.8
Blackland Prairies	277	13.8	47.6
Post Oak Savannah	246	13.2	43.3
Edwards Plateau	263	12.6	54.6
Cross Timbers	222	12.8	52.8
South Texas Plains	224	14.5	63.4
Trans-Pecos	254	11.6	61.8
Rolling Plains	168	13.9	59.2
High Plains	148	16.6	68.5

TABLE 3. Number and percentage of Cyperaceae by vegetational area.

Vegetational Area	Number of species	Percentage of total species in area	Percentage of monocots only
Pineywoods	205	9.5	31.3
Gulf Prairies & Marshes	168	7.3	25.2
Blackland Prairies	164	8.1	28.2
Post Oak Savannah	163	8.7	28.7
Edwards Plateau	93	4.4	19.3
Cross Timbers	90	5.2	21.4
South Texas Plains	58	3.7	16.4
Trans-Pecos	57	2.6	13.9
Rolling Plains	52	4.3	18.3
High Plains	32	3.6	14.8

complexity, etc.) is responsible, none of which is easy to measure. Intuitively, it would seem that areas with relatively high seasonal temperatures and rainfall, e.g., the Pineywoods, would have high species richness. At the same time, the environmentally diverse Trans-Pecos, with its great topographical relief and diverse habitats that range from deserts to wooded mountain slopes, also would support a high number of species. Areas with moderate to low habitat diversity, moderate to low rainfall, and intermediate temperatures might be expected to have fewer species.

Table 4. Number and percentage of Asteraceae by vegetational area.

Vegetational Area	Number of species	Percentage of total species in area	Percentage of dicots only
Pineywoods	248	11.5	17.2
Gulf Prairies & Marshes	265	11.4	16.5
Blackland Prairies	255	12.7	18.3
Post Oak Savannah	226	12.1	18.0
Edwards Plateau	178	13.3	18.1
Cross Timbers	235	13.6	18.4
South Texas Plains	210	13.5	18.0
Trans-Pecos	327	14.9	19.3
Rolling Plains	179	14.8	19.8
High Plains	146	16.3	22.2

Table 5. Number and percentage of Fabaceae by vegetational area.

Vegetational Area	Number of species	Percentage of total species in area	Percentage of dicots only
Pineywoods	162	7.5	11.3
Gulf Prairies & Marshes	167	7.2	10.4
Blackland Prairies	154	7.6	11.1
Post Oak Savannah	149	7.9	11.8
Edwards Plateau	164	7.9	10.7
Cross Timbers	147	8.5	11.5
South Texas Plains	137	8.8	11.7
Trans-Pecos	159	7.2	9.4
Rolling Plains	106	8.7	11.6
High Plains	74	8.2	11.2

Table 6. Number and percentage of Cactaceae by vegetational area.

Vegetational Area	Number of species	Percentage of total species in area	Percentage of dicots only
Pineywoods	5	0.2	0.3
Gulf Prairies & Marshes	17	0.7	1.1
Blackland Prairies	8	0.4	0.6
Post Oak Savannah	7	0.4	0.6
Edwards Plateau	45	2.2	2.9
Cross Timbers	18	1.0	1.4
South Texas Plains	30	2.5	3.3
Trans-Pecos	75	3.4	4.4
Rolling Plains	18	1.5	2.0
High Plains	14	1.6	2.1

In the course of this work we recognized that plant species do not appear to pay much attention to vegetational area boundaries. The vast majority of species are not confined to any one area but spill out into adjacent areas. Thus, the most often used Texas vegetational area map (Figure 1), and its many derivatives and modifications, does not appear to be very accurate; it is probably no more accurate than any of the ecoregional maps so far produced (see MacRoberts & MacRoberts 2003a for a discussion of various vegetational schemes for the West Gulf Coastal Plain). For example, east Texas, although it is almost always mapped as several vegetational areas, has no floristic breaks (MacRoberts & MacRoberts 2003b). The Pineywoods grades into Post Oak Savannah, which in turn grades into Blackland Prairie, and southward into the Coastal Prairies and Marshes. These regions share 98% of their flora (MacRoberts & MacRoberts 2004). Only a few areas in Texas might be true breaks, one such being the southeastern part of the Edwards Plateau where the Balcones Escarpment seems to be a floristic barrier. However, the Edwards Plateau grades northward into the Cross Timbers, Rolling Plains, and High Plains, and westward into the Trans-Pecos. The main floristic break in Texas is right down the middle of the state in a 300 km wide ecotone between about 96° and 99° W longitude (MacRoberts & MacRoberts 2003b, see also McLaughlin 2007). Consequently, we believe that it is time to re-think vegetational area mapping for Texas in light of the extensive collecting that has occurred over the past half-century and to use the total flora as a basis for establishing vegetational areas.

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