



Woody Plants of Tamaulipan Thorn Scrub: Morphology, Wood Anatomy and Ecophysiology

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Abstract

During last three to four years we studied various aspects of woody plant species in Forest Science School, Universidad de Nuevo Leon, UANL, Mexico. The present study describes salient characteristics of habitat, leaf morphology, wood anatomy, wood density and few eco-physiological traits of major woody plant species of Tamaulipan Thornscrub, at Linares, Northeastern Mexico. This will serve as guide to know about all these traits for the students, researchers and foresters to unveil the various aspects of these woody species of high economic importance and ecological importance.

Keywords: Woody plants; Tamaulipan thornscrub; Characterization; Morphology; Wood anatomy; Ecophysiology

Introduction

Woody plant species occupy predominant vegetation in a forest ecosystem. There exists a wide diversity in species, form and abundance of each species in the forest. They vary widely in type of branching pattern and intensity, tree crown architecture, leaf canopy architecture, leaf size, form, texture, anatomy and various eco-physiological traits such as leaf traits, leaf epicuticular wax, leaf pigments and leaf nutrients etc. This present attempt is to give salient results of investigation on various aspects of Tamaulipan Thorn Scrub at Linares, Northeastern Mexico as model to study biology of woody plants in other geographical regions [1].

Methodology

Following standard protocols we studied various aspects of woody plant species on various morphological traits such as leaf traits, anatomy of leaves and wood, and eco-physiological traits such as epicuticular wax, pigments, leaf nutrients explained in the book by Maiti et al. [2]. We mention here salient results of few of these aspects.

Results

The following woody species are included in the study (Table 1).

Common name	Scientific name	Family	Type
Huajillo	<i>Acacia berlandieri</i> Benth.	Fabaceae	tree
Huizache	<i>Acacia farnesiana</i> (L) Willd.	Fabaceae	tree
Uña de gato	<i>Acacia gregii</i> var. <i>wrightii</i> Benth.	Fabaceae	tree
Chaparro prieto	<i>Acacia rigidula</i> Benth.	Fabaceae	tree
Huizache chino	<i>Acacia schaffneri</i> (S. Watson)	Fabaceae	tree
Barreta china	<i>Amyris madrensis</i> S. Watson.	Rutaceae	tree
Barretilla	<i>Amyris texana</i> (Buckley) P. Wilson	Rutaceae	shrub
Palo amarillo	<i>Berberis chococo</i> Schlecht.	Berberidaceae	tree
Oreja de ratón	<i>Bernardia myricifolia</i> (G. Scheele) S. Watson	Euphorbiaceae	shrub
Hierba. del potro	<i>Caesalpinia mexicana</i> A. Gray.	Fabaceae	tree
Palo blanco	<i>Celtis laevigata</i> Willd.	Ulmaceae	tree

Granjeno	<i>Celtis pallida</i> Torrey	Ulmaceae	shrub
Brasil	<i>Condalia hoockeri</i> M.C. Johnst.	Rhamnaceae	tree
Anacahuíta	<i>Cordia boissieri</i> A.L.D.C.	Boraginaceae	tree
Salvia	<i>Croton suaveolens</i> Presl.	Euphorbiaceae	shrub
Chapote manzano	<i>Diospyros palmeri</i> Eastw.	Ebenaceae	tree
Chapote prieto	<i>Diospyros texana</i> Scheele.	Ebenaceae	tree
Ebano	<i>Ebenopsis ebano</i> (Berland.) Barneby & J.W. Grimes. Briton et Rose.	Fabaceae	tree
Anacua	<i>Ehretia anacua</i> (Teran & Berland.) I.M. Johnst.	Boraginaceae	tree
Varadulce	<i>Eysenhardtia texana</i> Scheele	Fabaceae	tree
Panalero	<i>Foresteria angustifolia</i> Torr.	Oleaceae	shrub
Guayacan	<i>Guaiacum angustifolium</i> Engelm.	Zygophyllaceae	shrub
Tatalencho	<i>Gymnosperma glutinosum</i> (K. Sprengel) C. Lessing.	Asteraceae	shrub
Tenaza	<i>Havardia pallens</i> (Benth.) Britton & Rose	Fabaceae	tree
Barreta	<i>Helietta parvifolia</i> (A. Gray) Benth.	Rutaceae	tree
Coyotillo	<i>Karwinskia humboltiana</i> (Schult.) Zucc.	Rhamnaceae	shrub
Lantana	<i>Lantana macropoda</i> Torr.	Verbenaceae	shrub
Leucaena	<i>Leucaena leucocephala</i> (J. de Lamark) H.C. de Wit	Fabaceae	tree
Cenizo	<i>Leucophyllum frutescens</i> (Berland.) I.M. Johnst.	Scrophulariaceae	shrub
Retama	<i>Parkinsonia aculeata</i> L.	Fabaceae	tree
palo verde	<i>Parkinsonia texana</i> (A. Gray) S. Watson	Fabaceae	tree
Mesquite	<i>Prosopis laevigata</i> (Humb. & Bonpl. Ex Willd.) M.C. Johnst.	Fabaceae	tree
Encino	<i>Quercus virginiana</i> P. Miller	Fagaceae	tree
Sauce	<i>Salix lasiolepis</i> Benth.	Salicaceae	tree
Chapote amarillo	<i>Sargentia gregii</i> S. Watson	Rutaceae	tree
Coma	<i>Sideroxylon celastrinum</i> (Kunth) T.D. Penn.	Sapotaceae	tree
Colima	<i>Zanthoxylum fagara</i> (L.) Sarg.	Rutaceae	tree

Table 1: List of woody plant species in Tamaulipan Thorn Scrub at Linares, Northeastern Mexico. Here in is mentioned a brief account of these aspects.

Morpho-physiological characteristics of 36 woody plant species

We mention here salient aspects of available results on morphology, wood anatomy and ecophysiological traits of woody species of Tamaulipan Thorn Scrub at Linares, Northeastern Mexico (N.B. Only data available are included in some of the species studied) [3].

Acacia berlandieri Benth. (Fam. Fabaceae, Common name; Huajillo)

General description: Tree 4-5 m in height, shows ramification from the base with many stems, leaf canopy open.

Morphology: Leaves compound, bipinnate of 30 to 50 pairs. Flowering November to March, flowers white, pod with five to 10 seeds.

Habit: Tamaulipan Thorn Scrub.

Branching pattern and crown architecture: Pseudo monopodial, crown irregular.

Leaf morphology: Leaf compound, very small, deep green in color, petiolate, bipinnate, opposite, margin smooth, leaf surface plain, very much soft, texture smooth and very much thin. Dimensions of leaf parameter are shown in Table 2.

Species	Leaf type	Specific leaf area SLA (cm ² .g ⁻¹)	Leaf length (cm)	Leaf breadth (cm)	Petiole length (cm)	Leaf area (cm ²)	Leaf dry weight (g)
<i>Acacia berlandieri</i>	Compound	99.796 ± 28.96	15.608 ± 3.041	9.848 ± 2.124	1.978 ± 0.603	50.579 ± 18.094	0.521 ± 0.155
<i>Acacia farnesiana</i>	compound	108.843 ± 21.56	3.832 ± 1.061	3.12 ± 0.753	0.84 ± 0.236	3.677 ± 1.838	0.035 ± 0.017
<i>Acacia greggii</i> var. <i>wrightii</i>	Compound	98.97 ± 22.455	2.624 ± 0.509	3.266 ± 0.532	0.934 ± 0.179	3.35 ± 0.851	0.034 ± 0.008
<i>Acacia rigidula</i>	compound	95.309 ± 22.101	2.95 ± 0.622	3.936 ± 0.931	0.588 ± 0.184	4.836 ± 1.605	0.052 ± 0.018
<i>Acacia schaffneri</i>	Compound	72.658 ± 24.948	4.882 ± 6.682	3.478 ± 0.608	0.612 ± 0.396	4.611 ± 2.197	0.066 ± 0.027
<i>Amyris madrensis</i>	Compound	59.546 ± 7.8	7.732 ± 0.942	4.306 ± 0.41	1.522 ± 0.341	17.090 ± 3.261	0.295 ± 0.079
<i>Amyris texana</i>	Compound	138.919 ± 27.34	4.858 ± 1.624	6.548 ± 0.945	1.83 ± 0.424	12.213 ± 2.652	0.099 ± 0.075
<i>Berberis chococo</i>	Compound	74.060 ± 5.255	16.05 ± 2.293	8.386 ± 1.575	5.514 ± 1.297	51.574 ± 20.073	0.694 ± 0.257
<i>Bernardia myricifolia</i>	Simple	117.980 ± 28.42	2.968 ± 0.470	1.848 ± 0.325	0.486 ± 0.109	4.050 ± 1.245	0.047 ± 0.076
<i>Caesalpinia mexicana</i>	Compound	132.919 ± 32.288	15.69 ± 3.235	15.582 ± 2.258	4.172 ± 0.781	109.18 ± 30.995	0.837 ± 0.211
<i>Celtis laevigata</i>	Simple	149.331 ± 39.169	8.26 ± 0.944	4.188 ± 0.573	1.058 ± 0.23	24.268 ± 5.624	0.176 ± 0.068
<i>Celtis pallida</i>	Simple	171.338 ± 29.263	4.182 ± 0.881	2.51 ± 0.489	0.36 ± 0.083	7.884 ± 2.782	0.046 ± 0.016
<i>Condalia hoockeri</i>	Simple	199.191 ± 51.946	3.098 ± 0.35	1.85 ± 0.268	0.362 ± 0.107	3.283 ± 1.069	0.017 ± 0.005
<i>Cordia boissieri</i>	Simple	162.027 ± 28.524	14.98 ± 1.801	8.612 ± 1.933	3.042 ± 0.616	97.479 ± 21.859	0.624 ± 0.179
<i>Croton suaveolens</i>	Simple	122.738 ± 14.910	5.832 ± 0.939	2.342 ± 0.334	1.172 ± 0.238	10.704 ± 3.444	0.087 ± 0.024
<i>Diospyros palmeri</i>	Simple	152.306 ± 22.239	5.246 ± 0.575	2.758 ± 0.455	0.348 ± 0.702	10.103 ± 2.329	0.068 ± 0.020
<i>Diospyros texana</i>	Simple	151.358 ± 35.414	2.888 ± 0.353	1.326 ± 0.251	0.184 ± 0.055	2.956 ± 0.766	0.026 ± 0.033
<i>Ebenopsis ebano</i>	Compound	158.784 ± 29.129	4.626 ± 0.803	4.444 ± 0.807	1.128 ± 0.433	13.124 ± 4.019	0.084 ± 0.026
<i>Ehretia anacua</i>	Simple	125.487 ± 26.579	7.692 ± 1.033	4.114 ± 0.901	0.658 ± 0.143	21.981 ± 7.887	0.183 ± 0.085
<i>Eysenhardtia polystachya</i>	Compound	112.428 ± 17.575	4.614 ± 0.877	1.25 ± 0.301	0.622 ± 0.189	3.180 ± 1.232	0.0285 ± 0.010
<i>Forestiera angustifolia</i>	Simple	140.201 ± 32.583	2.778 ± 0.356	0.652 ± 0.198	0.122 ± 0.042	1.334 ± 0.379	0.010 ± 0.003
<i>Guaiacum angustifolium</i>	Compound	96.376 ± 18.987	3.866 ± 0.647	2.908 ± 0.361	0.75 ± 0.202	4.026 ± 1.210	0.043 ± 0.014
<i>Gymnosperma glutinosum</i>	Simple	186.996 ± 31.838	16.052 ± 2.355	2.856 ± 0.515	0.436 ± 0.218	24.988 ± 7.139	0.135 ± 0.038
<i>Harvardia pallens</i>	Compound	137.918 ± 18.269	7.87 ± 1.755	7.882 ± 1.389	2.508 ± 0.561	26.649 ± 7.797	0.198 ± 0.063
<i>Helietta parvifolia</i>	Compound	105.825 ± 25.186	4.326 ± 0.637	5.028 ± 0.951	1.484 ± 0.264	11.002 ± 3.577	0.104 ± 0.02
<i>Karwinskia humboldtiana</i>	Simple	183.398 ± 42.321	6.59 ± 1.095	3.084 ± 0.514	0.702 ± 0.115	15.923 ± 4.606	0.088 ± 0.023
<i>Lantana macropoda</i>	Simple	124.681 ± 24.62	3.352 ± 0.651	1.348 ± 1.287	0.304 ± 0.101	2.293 ± 0.667	0.019 ± 0.006
<i>Leucaena leucocephala</i>	Compound	150.015 ± 37.736	17.856 ± 2.792	13.436 ± 1.539	3.65 ± 0.671	94.742 ± 20.221	0.679 ± 0.250
<i>Leucophyllum frutescens</i>	Simple	115.556 ± 19.688	2.74 ± 0.371	1.22 ± 0.165	0.156 ± 0.067	2.172 ± 0.373	0.0208 ± 0.014
<i>Parkinsonia aculeata</i>	Compound	64.532 ± 11.104	33.556 ± 5.318	1.05 ± 0.276	0.828 ± 0.295	10.182 ± 3.615	0.156 ± 0.038
<i>Parkinsonia texana</i>	Compound	146.532 ± 24.932	1.972 ± 0.589	2.994 ± 0.62	0.79 ± 0.341	2.351 ± 1.127	0.016 ± 0.007
<i>Prosopis laevigata</i>	Compound	81.999 ± 15.928	8.83 ± 1.767	6.126 ± 1.634	3.522 ± 0.979	14.704 ± 4.812	0.183 ± 0.060
<i>Quercus virginiana</i>	Simple	73.229 ± 11.667	6.208 ± 0.75	2.346 ± 0.402	0.67 ± 0.203	10.73 ± 2.176	0.150 ± 0.04
<i>Salix lasiolepis</i>	Simple	108.730 ± 7.764	9.534 ± 1.273	0.848 ± 0.149	0.594 ± 0.100	5.939 ± 1.424	0.055 ± 0.013
<i>Sargentia greggii</i>	Compound	100.934 ± 24.427	11.086 ± 1.756	13.674 ± 2.545	3.622 ± 0.844	66.761 ± 19.537	0.701 ± 0.22

<i>Sideroxylon celastrinum</i>	Simple	127.756 ± 40.104	3.068 ± 0.426	1.328 ± 0.359	0.21 ± 0.097	2.757 ± 0.929	0.025 ± 0.016
<i>Zanthoxylum fagara</i>	Compound	160.202 ± 34.205	5.992 ± 1.96	3.15 ± 0.973	1.414 ± 0.327	6.91 ± 3.46	0.044 ± 0.021

Table 2: Leaf traits (n=5).

Anatomy: Pores diffuse porous, mostly solitary, few in groups of 2 or 3, not numerous, contains gummy substance. Non-uniform in size. Pores oval in shape, mostly large, some are very small. Axial parenchyma confluent. Apotracheal parenchyma in the form of broad band, scalariform, marginal parenchyma is visible. Vessels broad, very short, broad, truncated with straight perforation plate, pits oval in

shape, alternate in arrangement, evolutionarily more advanced. Fiber cell broad lumened but thick walled. Wood tissue is loose with thin walled Fiber cells, profuse parenchyma seem to soft.

Ecophysiology: Leaf traits (Table 2) and pigments (Table 3).

Plant species	Epicuticular wax $\mu\text{g}/\text{cm}^2$	chl a mg g^{-1} fw	chl b mg g^{-1} fw	carotenoid mg g^{-1} fw	chl (a+b) mg g^{-1} fw	chl (a/b) mg g^{-1} fw	chl (a+b)/ car mg g^{-1} fw
<i>Acacia berlandieri</i>	63.41 ± 15.48	0.557 ± 0.168	0.102 ± 0.018	0.161 ± 0.057	0.659 ± 0.165	5.729 ± 2.556	4.208 ± 0.505
<i>Acacia farnesiana</i>	441.85 ± 179.20	1.057 ± 0.129	0.233 ± 0.031	0.290 ± 0.035	1.290 ± 0.153	4.566 ± 0.392	4.458 ± 0.238
<i>Acacia greggii</i> var. <i>wrightii</i>	129.67 ± 19.78	1.037 ± 0.432	0.289 ± 0.102	0.256 ± 0.110	1.326 ± 0.515	3.753 ± 0.964	5.433 ± 1.302
<i>Acacia rigidula</i>	27.58 ± 7.49	1.093 ± 0.067	0.266 ± 0.032	0.276 ± 0.022	1.359 ± 0.096	4.143 ± 0.277	4.933 ± 0.140
<i>Acacia schaffneri</i>	134.08 ± 35.51	1.025 ± 0.327	0.265 ± 0.075	0.266 ± 0.056	1.289 ± 0.399	3.860 ± 0.374	4.731 ± 0.610
<i>Amyris madreensis</i>	126.34 ± 34.69	0.829 ± 0.172	0.174 ± 0.072	0.193 ± 0.057	1.003 ± 0.214	5.441 ± 2.105	5.384 ± 0.968
<i>Amyris texana</i>	5.98 ± 6.37	1.166 ± 0.300	0.34 ± 0.073	0.438 ± 0.074	1.506 ± 0.371	3.400 ± 0.320	3.391 ± 0.307
<i>Berberis chococo</i>	119.51 ± 40.77	0.786 ± 0.347	0.287 ± 0.118	0.585 ± 0.228	1.073 ± 0.443	2.812 ± 0.728	1.824 ± 0.262
<i>Bernardia myricifolia</i>	353.33 ± 135.52	0.810 ± 0.22	0.217 ± 0.049	0.219 ± 0.031	1.027 ± 0.268	3.696 ± 0.229	4.621 ± 0.684
<i>Caesalpinia mexicana</i>	42.93 ± 5.09	0.852 ± 0.357	0.215 ± 0.075	0.219 ± 0.042	1.067 ± 0.431	3.784 ± 0.689	4.702 ± 1.392
<i>Celtis laevigata</i>	28.65 ± 11.35	0.868 ± 0.301	0.222 ± 0.059	0.243 ± 0.054	1.091 ± 0.359	3.779 ± 0.606	4.376 ± 0.917
<i>Celtis pallida</i>	92.62 ± 49.29	0.752 ± 0.118	0.184 ± 0.029	0.177 ± 0.024	0.936 ± 0.147	4.099 ± 0.158	5.265 ± 0.151
<i>Condalia hoockeri</i>	38.72 ± 20.13	0.700 ± 0.166	0.218 ± 0.030	0.212 ± 0.025	0.918 ± 0.193	3.172 ± 0.496	4.336 ± 0.763
<i>Cordia boissieri</i>	96.45 ± 24.21	0.862 ± 0.151	0.196 ± 0.035	0.197 ± 0.041	1.058 ± 0.178	4.434 ± 0.519	5.420 ± 0.230
<i>Croton suaveolens</i>	62.97 ± 11.03	0.589 ± 0.107	0.140 ± 0.022	0.162 ± 0.036	0.728 ± 0.128	4.198 ± 0.288	4.571 ± 0.526
<i>Diospyros palmeri</i>	150.49 ± 34.54	1.153 ± 0.290	0.336 ± 0.068	0.433 ± 0.070	1.489 ± 0.355	3.400 ± 0.320	3.391 ± 0.307
<i>Diospyros texana</i>	698.26 ± 122.52	1.113 ± 0.186	0.240 ± 0.086	0.317 ± 0.060	1.354 ± 0.216	6.075 ± 4.086	4.415 ± 0.974
<i>Ebenopsis ebano</i>	50.13 ± 12.45	1.755 ± 0.035	0.398 ± 0.017	0.425 ± 0.017	2.153 ± 0.045	4.420 ± 0.168	5.078 ± 0.210
<i>Ehretia anacua</i>	15.38 ± 2.80	0.854 ± 0.188	0.257 ± 0.050	0.238 ± 0.033	1.111 ± 0.237	3.303 ± 0.174	4.603 ± 0.471
<i>Eysenhardtia polystachya</i>	138.49 ± 32.32	1.112 ± 0.279	0.306 ± 0.085	0.284 ± 0.057	1.418 ± 0.317	3.802 ± 0.986	4.99 ± 0.404
<i>Forestiera angustifolia</i>	572.76 ± 306.70	0.598 ± 0.157	0.081 ± 0.010	0.194 ± 0.038	0.679 ± 0.162	7.353 ± 1.631	3.477 ± 0.213
<i>Guaiacum angustifolium</i>	69.52 ± 39.67	1.000 ± 0.101	0.230 ± 0.036	0.225 ± 0.022	1.230 ± 0.130	4.394 ± 0.404	5.457 ± 0.106
<i>Gymnosperma glutinosum</i>	57.08 ± 13.89	1.228 ± 0.139	0.299 ± 0.040	0.330 ± 0.029	1.528 ± 0.174	4.118 ± 0.285	4.621 ± 0.264
<i>Harvardia pallens</i>	77.35 ± 35.57	1.051 ± 0.318	0.266 ± 0.093	0.269 ± 0.044	1.318 ± 0.404	3.992 ± 0.448	4.793 ± 1.013
<i>Helietta parvifolia</i>	117.21 ± 36.51	0.721 ± 0.132	0.161 ± 0.031	0.159 ± 0.026	0.881 ± 0.162	4.492 ± 0.132	5.515 ± 0.144

<i>Karwinskia humboldtiana</i>	12.21 ± 5.15	1.034 ± 0.221	0.305 ± 0.071	0.290 ± 0.041	1.339 ± 0.288	3.417 ± 0.369	4.617 ± 0.799
<i>Lantana macropoda</i>	268.00 ± 68.40	0.575 ± 0.099	0.165 ± 0.045	0.181 ± 0.031	0.740 ± 0.141	3.572 ± 0.473	4.117 ± 0.524
<i>Leucaena leucocephala</i>	64.44 ± 12.54	1.403 ± 0.115	0.284 ± 0.049	0.314 ± 0.019	1.687 ± 0.160	5.024 ± 0.536	5.364 ± 0.239
<i>Leucophyllum frutescens</i>	361.17 ± 57.34	0.581 ± 0.126	0.139 ± 0.028	0.165 ± 0.026	0.720 ± 0.154	4.165 ± 0.166	4.328 ± 0.355
<i>Parkinsonia aculeata</i>	174.08 ± 45.52	0.850 ± 0.226	0.363 ± 0.148	0.153 ± 0.035	1.212 ± 0.364	2.490 ± 0.492	7.921 ± 1.495
<i>Parkinsonia texana</i>	239.93 ± 100.62	1.240 ± 0.174	0.257 ± 0.041	0.275 ± 0.041	1.497 ± 0.211	4.845 ± 0.309	5.464 ± 0.254
<i>Prosopis laevigata</i>	94.92 ± 15.11	0.703 ± 0.047	0.138 ± 0.020	0.189 ± 0.012	0.840 ± 0.066	5.177 ± 0.468	4.445 ± 0.325
<i>Quercus virginiana</i>	145.54 ± 84.24	0.799 ± 0.196	0.186 ± 0.082	0.227 ± 0.063	0.985 ± 0.255	4.854 ± 1.724	4.441 ± 1.053
<i>Salix lasiolepis</i>	50.65 ± 13.53	1.162 ± 0.114	0.165 ± 0.045	0.281 ± 0.017	1.327 ± 0.155	7.580 ± 2.067	4.733 ± 0.502
<i>Sargentia gregii</i>	48.39 ± 12.88	1.047 ± 0.145	0.291 ± 0.043	0.236 ± 0.026	1.338 ± 0.186	3.604 ± 0.149	5.646 ± 0.303
<i>Sideroxylon celastrinum</i>	147.584 ± 35.59	1.025 ± 0.144	0.294 ± 0.049	0.256 ± 0.049	1.319 ± 0.138	3.596 ± 0.797	5.286 ± 0.840
<i>Zanthoxylum fagara</i>	58.20 ± 11.80	1.049 ± 0.187	0.286 ± 0.062	0.292 ± 0.049	1.336 ± 0.249	3.706 ± 0.211	4.590 ± 0.618

Table 3: Pigment contents in leaf (n=5).

Epicuticular wax (Table 3) and leaf nutrients (macro, micro, proteins, Carbon, etc.) (Table 4).

Species	Leaf macro-nutrient contents							Leaf micronutrient contents		
	(mg g ⁻¹ dw)			(%)				(µg g ⁻¹ dw)		
	K	Mg	P	Proteina	C	N	C:N	Cu	Fe	Zn
<i>Acacia berlandieri</i>	0.78 ± 0.08	2.69 ± 0.41	6.80 ± 2.10	23.88	49.18 ± 1.25	3.82 ± 0.14	12.88 ± 8.89	3.52 ± 0.62	73.46 ± 8.01	15.08 ± 3.61
<i>Acacia farnesiana</i>	1.54 ± 0.11	0.22 ± 0.17	34.72 ± 2.20	21.31	46.17 ± 2.63	3.41 ± 0.18	13.54 ± 14.61	24.62 ± 1.11	259.76 ± 2.66	15.47 ± 0.83
<i>Acacia gregii</i> var. <i>wrightii</i>	1.22 ± 0.19	3.03 ± 1.23	20.5 ± 3.41	24.75	36.59 ± 1.11	3.96 ± 0.18	9.25 ± 6.22	8.11 ± 2.97	99.04 ± 23.21	28.14 ± 2.29
<i>Acacia rigidula</i>	1.25 ± 0.14	0.43 ± 0.09	38.75 ± 0.55	16.25	48.23 ± 1.56	2.60 ± 0.22	18.58 ± 6.96	7.09 ± 0.36	252.33 ± 3.04	10.23 ± 1.16
<i>Acacia schaffneri</i>	1.44 ± 0.22	1.72 ± 1.17	19.86 ± 1.77	27	39.52 ± 0.99	4.32 ± 0.16	9.15 ± 6.19	3.18 ± 0.94	138.93 ± 32.25	44.6 ± 5.71
<i>Amyris madreensis</i>	0.88 ± 0.05	1.55 ± 0.54	23.07 ± 1.63	13.44	38.06 ± 1.89	2.15 ± 0.14	17.69 ± 13.85	8.16 ± 1.21	125.13 ± 43.75	30.94 ± 3.97
<i>Amyris texana</i>	1.09 ± 0.08	2.67 ± 0.36	19.56 ± 4.79	23.25	38.06 ± 1.89	3.72 ± 0.33	12.79 ± 5.65	9.18 ± 1.17	99.88 ± 31.75	17.40 ± 1.24
<i>Berberis chococo</i>	0.90 ± 0.05	2.35 ± 0.86	12.42 ± 2.06	15.19	36.91 ± 1.25	2.43 ± 0.19	15.17 ± 6.71	5.12 ± 0.38	58.79 ± 13.95	50.68 ± 9.41
<i>Bernardia myricifolia</i>	1.09 ± 0.10	3.61 ± 0.38	11.54 ± 1.18	26.31	42.69 ± 1.13	4.21 ± 0.49	10.13 ± 2.30	8.03 ± 0.85	139.73 ± 24.69	16.17 ± 0.93
<i>Caesalpinia mexicana</i>	1.29 ± 0.23	1.20 ± 0.12	13.32 ± 1.88	18.19	41.12 ± 1.96	2.91 ± 0.38	14.13 ± 5.16	4.55 ± 0.96	48.47 ± 19.26	17.36 ± 5.74
<i>Celtis laevigata</i>	1.57 ± 0.23	2.19 ± 0.27	20.67 ± 3.28	18.81	39.45 ± 0.51	3.01 ± 0.18	13.13 ± 2.78	8.88 ± 2.09	254.09 ± 40.44	42.28 ± 5.49

<i>Celtis pallida</i>	1.24 0.18	±	3.20 0.25	±	42.60 0.90	±	25.75	38.66 0.88	±	4.12 0.67	±	9.38 ± 1.32	25.98 1.04	±	276.89 ± 5.70	12.42 ± 0.29
<i>Condalia hoockeri</i>	0.89 0.06	±	6.50 0.84	±	25.76 3.33	±	19.13	30.07 2.81	±	3.06 0.41	±	9.83 ± 6.85	5.02 ± 0.39		73.79 ± 18.44	11.54 ± 3.41
<i>Cordia boissieri</i>	1.42 0.12	±	2.72 0.31	±	45.58 1.65	±	20.5	43.43 1.20	±	3.28 0.09	±	13.23 13.38	30.71 0.55	±	280.55 ± 8.46	51.87 ± 1.80
<i>Croton suaveolens</i>	2.43 0.14	±	0.22 0.09	±	75.62 3.67	±	14.56	45.17 0.35	±	2.33 0.53	±	20.16 ± 0.67	26.87 1.66	±	229.13 24.25	34.55 ± 4.11
<i>Diospyros palmeri</i>	0.96 0.06	±	2.84 0.92	±	18.13 1.60	±	13.56	37.59 1.72	±	2.17 0.12	±	17.36 14.33	5.36 ± 1.13		92.96 ± 14.59	18.58 ± 5.90
<i>Diospyros texana</i>	0.98 0.08	±	2.59 0.55	±	36.55 2.26	±	11.81	40.79 1.46	±	1.89 0.06	±	21.58 24.33	2.80 ± 0.16		72.47 ± 22.66	41.45 ± 4.03
<i>Ebenopsis ebano</i>	0.90 0.03	±	2.88 0.25	±	14.06 1.27	±	24.13	37.57 1.21	±	3.86 0.20	±	9.73 ± 6.05	8.85 ± 2.14		130.60 94.49	17.21 ± 3.81
<i>Ehretia anacua</i>	1.12 0.06	±	9.45 0.37	±	16.72 1.18	±	15.25	34.09 2.51	±	2.44 0.10	±	13.97 25.10	12.62 0.79	±	68.90 ± 5.82	40.07 ± 5.31
<i>Eysenhardtia polystachya</i>	1.84 0.22	±	2.22 0.24	±	16.43 2.54	±	25.37	36.26 0.58	±	4.06 0.27	±	8.94 ± 2.15	16.16 2.92	±	82.86 ± 10.47	51.39 ± 10.66
<i>Forestiera angustifolia</i>	0.89 0.06	±	1.27 0.35	±	28.32 3.61	±	18.75	49.47 0.43	±	3.00 0.41	±	16.47 ± 1.04	4.03 ± 0.39		70.10 ± 11.86	48.56 ± 6.13
<i>Guaiacum angustifolium</i>	0.80 0.18	±	4.10 0.87	±	12.69 1.32	±	18.13	41.89 3.56	±	2.90 0.42	±	14.44 ± 8.48	3.99 ± 2.07		83.30 ± 6.70	20.59 ± 4.08
<i>Gymnosperma glutinosum</i>	1.40 0.04	±	1.90 0.13	±	21.49 3.31	±	36.81	46.19 1.04	±	5.89 0.29	±	7.85 ± 3.54	8.93 ± 2.40		167.40 13.81	12.16 ± 1.64
<i>Harvardia pallens</i>	1.11 ± 0.11		3.15 0.68	±	22.86 2.52	±	18.56	43.49 1.24	±	2.97 0.15	±	14.64 ± 8.27	3.51 ± 0.46		109.87 10.53	29.57 ± 6.38
<i>Helietta parvifolia</i>	1.01 0.12	±	5.17 0.45	±	21.48 1.83	±	15.19	31.13 1.03	±	2.43 0.25	±	12.84 ± 4.16	9.11 ± 2.21		72.94 ± 4.97	37.55 ± 9.07
<i>Karwinskia humboldtiana</i>	1.05 0.12	±	1.31 0.37	±	16.41 2.28	±	17.75	31.35 0.70	±	2.84 0.10	±	11.03 ± 6.91	5.86 ± 0.75		70.41 ± 12.17	13.19 ± 1.61
<i>Lantana macropoda</i>	1.37 0.06	±	3.71 0.31	±	26.04 2.04	±	27.69	42.91 3.74	±	4.43 0.39	±	9.68 ± 9.53	13.00 0.22	±	145.81 48.14	28.29 ± 4.72
<i>Leucaena leucocephala</i>	0.98 0.05	±	2.60 0.38	±	14.21 2.03	±	23.63	43.16 1.98	±	3.78 0.50	±	11.42 ± 3.96	6.03 ± 0.41		77.59 ± 2.20	11.06 ± 1.12
<i>Leucophyllum frutescens</i>	0.8 ± 0.10		2.69 0.28	±	13.69 3.10	±	14.06	49.97 0.94	±	2.25 0.27	±	22.17 ± 3.51	6.45 ± 0.79		118.12 15.44	27.23 ± 3.79
<i>Parkinsonia aculeata</i>	1.56 0.35	±	5.29 1.82	±	24.93 2.81	±	19	36.63 3.25	±	3.04 0.41	±	12.05 ± 7.93	7.44 ± 2.20		165.63 69.17	51.66 ± 8.09
<i>Parkinsonia texana</i>	1.10 ± 0.11		2.95 0.87	±	14.5 ± 6.07		25.06	43.41 3.44	±	4.01 0.30	±	10.83 11.47	5.97 ± 1.50		96.08 ± 24.65	25.29 ± 5.86
<i>Prosopis laevigata</i>	1.65 0.29	±	2.88 1.12	±	34.04 2.03	±	24.06	41.64 0.71	±	3.85 0.21	±	10.83 ± 3.38	5.17 ± 1.53		128.92 41.18	48.47 ± 11.71
<i>Quercus virginiana</i>	0.91 0.07	±	2.60 1.34	±	15.04 1.37	±	12.25	43.02 2.38	±	1.96 0.18	±	21.95 13.22	3.63 ± 0.50		66.32 ± 13.19	39.25 ± 3.88
<i>Salix lasiolepis</i>	1.51 0.09	±	2.34 1.18	±	23.57 1.54	±	12.87	33.37 4.58	±	2.06 0.50	±	16.24 ± 9.16	8.49 ± 0.52		95.49 ± 13.15	144.86 12.77
<i>Sargentia gregii</i>	0.78 0.04	±	2.45 0.19	±	13.19 3.84	±	11.94	44.07 1.22	±	1.91 0.45	±	23.13 ± 2.71	4.79 ± 0.47		87.80 ± 18.23	14.48 ± 0.94

<i>Sideroxylon celastrinum</i>	0.09 0.78	±	0.68 0.13	±	33.02 1.30	±	15.13	49.25 1.56	±	2.42 0.36	±	20.35 ± 4.38	25.24 1.50	±	249.00 15.03	±	14.10 ± 7.38
<i>Zanthoxylum fagara</i>	0.99 0.13	±	2.80 0.46	±	14.77 2.51	±	18.63	40.35 3.15	±	2.98 0.90	±	13.56 ± 3.50	15.66 3.17	±	112.80 22.32	±	18.92 ± 2.80

Table 4: Leaf nutrients (n=5).

Acacia farnesiana (L) Wild. (Fam. Fabaceae, Common name; Huizache)

General description: Tree 6-7 m in height, leaf canopy semi-close.

Morphology: Leaves compound, bipinnate of 10 to 15 leaflets. Flowering February to March, flower shining yellowish in color, fruit brown- reddish in color, pod of purple to black in color.

Habit: Tamaulipan Thorn Scrub.

Branching pattern and crown architecture: Pseudomonopodial, crown globose. Branching density high, leaf canopy semiclose.

Leaf morphology: Leaves compound, very small, green in color, leaf petiolate, bipinnate, opposite, margin smooth, leaf surface plain, very much thin and soft.

Anatomy: Wood semi-ring porous, vessels sparsely scattered, mostly solitary, round to oval in shape, few in radial groups of 2 or 3, very small to medium in size, non-uniform in size in cross section. Axial parenchyma paratracheal to confluent. Apotracheal parenchyma in the form of broad and long band, scalariform, marginal parenchyma, broad band of scalariform parenchyma visible. Medium in length, very broad in breadth more or less with little inclined simple perforation plates, pits round, small, very close, alternate in arrangement. Wood possesses dense contents [4,5]. Wood tissue compact with medially thick walled fiber cells but with profuse parenchymatous tissue, seem to be medially soft. The Fiber cell with broad lumen and thin cell wall could be suitable for paper pulp (Figure 1).



Figure 1: *Acacia farnesiana*.

Ecophysiology: Leaf traits (Table 2), pigments (Table 3), epicuticular wax (Table 3) and leaf nutrients (macro, micro, proteins, Carbon etc. (Table 4).

Acacia greggii A. Gray var. *wrightii* (G. Bentham). (Fam. Fabaceae, Common name; Uña de Gato).

General description: Tree spiny, 4-5 m in height, leaf canopy semi-close. Morphology: Leaves compound, bipinnate of 10 to 18 pairs of leaflets. Flowering March to May, flower yellowish in color, pod of brown color.

Habitat: Tamaulipan Thorn Scrub.

Leaf morphology: Leaf compound, very small, deep green in color, petiolate, bipinnate, leaves opposite, leaf surface plain, soft, thick and waxy texture.

Anatomy: Wood diffuse porous, vessels medium in number, many are large, few small, mostly solitary, non-uniform, round to oval in shape, few in radial groups of 2 to 3 cells, mostly big in size, non-uniform in size in cross-section. Axial parenchyma confluent to aliform. Apotracheal in form of broad and short band, scalariform, compact. Vessels short and broad, truncated to little inclined simple perforation plate, pits small, round, very close, alternate in arrangement. Wood compact with thick walled Fiber, seem to be hard wood (Figure 2).

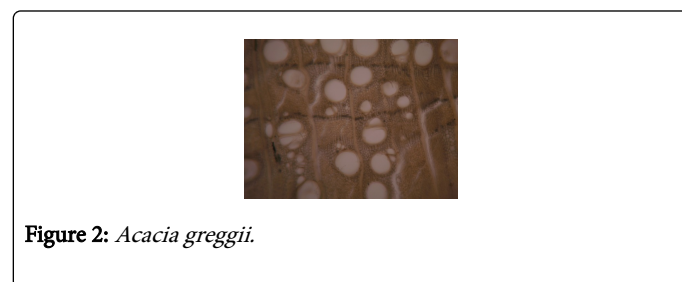


Figure 2: *Acacia greggii*.

Wood anatomy: *Acacia wrightii* pores diffuse porous, mostly solitary, few in groups of 2 or 3, numerous, non-uniform in size. Pores oval in shape, mostly medium in size large, some are very small. Axial parenchyma confluent. Apotracheal parenchyma in the form of broad band, scalariform, Vessels truncated, broad, short, more or less with straight perforation plates, pits elongated scalariform alternate in arrangement. Medullary rays wavy. Ray cells stratified, multilayered, stratified. Vessels medium in breadth, truncated with straight perforation plate, pits oval in shape, alternate in arrangement.

Wood density: 0.896 (g/cm³) (average of 10), medium hard.

Ecophysiology: Leaf traits (Table 2), pigments (Table 2), epicuticular wax (Table 2) and leaf nutrients (macro, micro, proteins, Carbon, etc.) (Table 3)

Acacia rigidula Benth (Fam. Fabaceae, Common name; Chaparro Prieto)

General description: Spiny tree ramified forming various stems, 4-5 m in height.

Morphology: Leaves compound bipinnate with four pair of leaflets. Flowering February to July, flower yellow in color, but in some case white, fruit brown red in color, the pod black.

Habit: Tamaulipan Thorn Scrub.

Branching pattern and crown architecture: Pseudomonopodial, crown irregular, branching density medium.

Leaf morphology: Leaves compound, very small, deep green in color, petiolate, bipinnate, opposite, margin smooth, surface plain, soft, texture smooth and thick.

Anatomy: Wood semi-ring porous, vessels not numerous, mostly solitary, round to oval in shape, mostly in radial groups of 2 or 3, medium in size, narrow non uniform in size in cross section. Axial parenchyma confluent aciform [6-8]. Apotracheal parenchyma not distinct, but the presence of tangential band of sclerenchyma distinct. Vessels short, very much broad more or less with little inclined simple perforation plates, pits elongated, very close, alternate in arrangement. Fiber cells thick walled, narrow lumened. Wood tissue is compact with thick walled Fiber, suitable for strong furniture (Figure 3).



Figure 3: *Acacia rigidula*.

Wood density: (0.976 g/cm³), wood hard

Ecophysiology: Leaf traits (Table 2), pigments (Table 3), epicuticular wax (Table 3) and leaf nutrients (macro, micro, proteins, Carbon etc.) (Table 4)

Acacia schaffneri S. Watson. (Fam. Fabaceae; common name; Huizache Chino)

General description: Tree spiny, 3-4 m in height, leaf canopy open.

Morphology: Leaves compound, bipinnate of 10 to 15 pairs of leaflets. Flowering in spring. Flowers yellowish in color, fruit dark red in color, pod black.

Habitat: Tamaulipan Thorn Scrub.

Branching pattern and crown architecture: Pseudomopodial, crown irregular, branching density high, leaf canopy close,

Leaf morphology: Leaves compound, very small, deep green in color, bipinnate, margin smooth, petiolate and texture smooth, very much soft and thin.

Anatomy: Wood density 1.096 (g/cm³) (average of 10), wood is very hard.

Ecophysiology: Leaf traits (Table 2), pigments (Table 3), epicuticular wax (Table 3) and leaf nutrients (macro, micro, proteins, Carbon etc.) (Table 3).

Amyris madrensis S. Watson. (Fam. Rutaceae, Common name, Barreta China)

General description: Tree, ramified, 3-4 m in height, leaf canopy semi close.

Morphology: Leaves compound, pinnate of five to nine pairs of leaflets. Flowering at end of spring, flowers green in color to white, fruit a drupe of one seed.

Habitat: Submontane scrubland

Leaf Morphology: Leaves compound, medium size, green color, petiolate, imparipinnate, margin smooth, leaf surface plain, texture waxy and shining.

Anatomy: Wood semiring porous, vessels numerous, narrow, few solitary, many in radial group of several vessels, non-uniform in size, mostly small. Axial parenchyma paratracheal [9-11]. Apotracheal parenchyma in the form of long narrow band, scalariform, marginal parenchyma is not distinct. Vessels medium in length, slightly inclined simple perforation plates, pits round, oval, alternate in arrangement. Wood tissue is compact with thin walled Fiber cells, profuse vessels, seem to be hard. Fiber cells broad lumened and thin walled. Wood is hard for fabrication of furniture, this may be suitable for paper pulp (Figure 4).



Figure 4: *Amyris madrensis*.

Wood density: 1.016 (g/cm³), (average of 10) wood very hard

Ecophysiology: Leaf traits (Table 2), pigments (Table 3), epicuticular wax (Table 3) and leaf nutrients (macro, micro, proteins, Carbon etc.) (Table 4).

Amyris texana (Buckley) P. Wilson. (Fam. Fabaceae, Common name; Barretilla)

General description: Shrub, ramified, aromatic, 1-2 m in height, leaf canopy semi-close.

Morphology: Leaves compound, trifoliolate leaflets elliptic to oval in dentate margin. Flowering end of spring, flower white greenish in color, fruit one drupe of only one seeds.

Habitat: Tamaulipan Thorn Scrub.

Branching pattern and crown architecture: Sympodial, crown irregular, branching density medium to high; canopy close.

Leaf morphology: Leaves compound, medium in size, deep green in color, petiolate, trifoliolate, margin serrated, texture smooth, very much soft, little thick, leaf surface plain, waxy and very much shining.

Anatomy: Wood density: (0.863 g/cm³), medium hard.

Ecophysiology: Leaf traits (Table 2), pigments (Table 3), epicuticular wax (Table 3) and leaf nutrients (macro, micro, proteins, Carbon etc.) (Table 4).

Berberis choco Schlecht. (Fam. Berberidaceae, Common name. Palo Amarillo)

General description: Tree 3-4 m in height, leaf canopy open.

Morphology: Leaves compound, oblong to elliptic with five to nine leaflets. Flowers yellow, fruit ovoid with two to four seeds reddish-brown color.

Habitat: Tamaulipan Thorn Scrub.

Leaf morphology: Leaves compound, large size, light green in color, petiolate, imparripinnate in shape, margin smooth, leaf little thick, texture smooth, waxy and shining.

Anatomy: *Berberis chococo* Wood semiring porous, vessels numerous, arranged in longitudinal groups, very narrow in diameter, round to oval in shape. Axial parenchyma confluent aliform. Apotracheal parenchyma in the form of long medially broad band, scalariform, not clearly distinct, marginal parenchyma not distinct. Vessels medium in length and breadth with inclined simple perforation plate pits small, round, alternate in arrangement. Wood tissue is compact with medially thick walled Fiber cells, profuse vessels, seem to be medially hard [12,13]. Fibers medially thick walled and medium broad lumened (Figure 5).



Figure 5: *Berberis chococo*.

Wood density 0.961 (g/cm³) (average of 10), wood hard

Ecophysiology: Leaf traits (Table 2), pigments (Table 2), epicuticular wax (Table 2) and leaf nutrients (macro, micro, proteins, Carbon etc.) (Table 4).

Bernardia myricifolia (G. Scheele) S. Watson. (Fam. Euphorbiaceae, Common name; Oreja de Ratón)

General description: Shrub, highly branched, 2-2.5 m in height, leaf canopy closed.

Morphology: Leaf simple, elliptic with dented margin and presence of pubescence. Flowering end of spring, flower male and female separate on different plant, fruit one capsule of only three seeds [14].

Habitat: Tamaulipan Thorn Scrub.

Branching pattern and crown architecture: Sympodial, irregular, branching density high, leaf canopy close.

Anatomy: Wood semiring porous, vessels moderate in numbers mostly solitary, round to oval in shape, on uniform in size, mostly large. Axial parenchyma confluent to aciform. Apotracheal parenchyma in the form of broad band, scalariform. Vessels long, narrow with inclined simple perforation plate, slightly broad, more or less with straight simple perforation plates, pits elongated scalariform alternate in arrangement. Wood tissue is medially compact with medially thick walled. Wood is semi-hard for fabrication of furniture; this may be suitable for paper pulp (Figure 6).

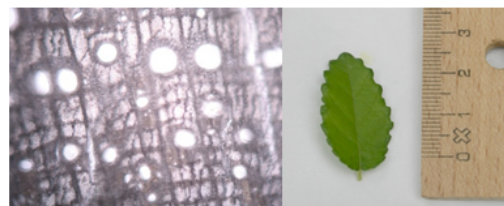


Figure 6: *Bernardia myricifolia*.

Wood density: 0.975 (g/cm³) (average of 10), wood hard

Ecophysiology: Leaf traits (Table 2), pigments (Table 3), epicuticular wax (Table 3) and leaf nutrients (macro, micro, proteins, Carbon etc.) (Table 4)

Caesalpinia mexicana A. Gray. (Fam. Fabaceae, Common name: Hierba del Potro)

General description: Tree 4 m in height, leaf canopy open.

Morphology: Leaves compound, compound, oval with 4 to 5 pairs of leaflets. Flowering February to July, flowers yellowish in color, fruit a pod of brown color. Leaf compound, bipinnate, large size of dark Green color, petiolate, margin smooth, texture smooth, leaf surface plain, soft and little thick, leaf surface waxy and shining.

Habitat: Tamaulipan Thorn Scrub.

Branching pattern and crown architecture: Sympodial, irregular, pseudomonopodial, irregular, branching density medium.

Anatomy: Wood diffuse porous, vessels sparse, mostly solitary, in radial bands of 2-3 cells, round to oval in shape, mostly big and non-uniform in size, small to medium in cross section. Axial parenchyma confluent aliform. Apotracheal parenchyma in the form of short to broad band, scalariform, marginal and terminal parenchyma visible. Vessels short, broad with inclined perforation plates, pits elliptical, very close, opposite to alternate in arrangement. Wood contains dense exudates. Wood tissue loose with profuse parenchyma and with medially thin walled Fiber cells. Wood seems to be soft. Fiber cells with broad lumen and medium thick cell wall could be suitable for paper pulp (Figure 7).



Figure 7: *Caesalpinia mexicana*.

Wood density: 0.692 (g/cm³), (average of 10) wood very soft

Ecophysiology: Leaf traits (Table 2), pigments (Table 3), epicuticular wax (Table 3) and leaf nutrients (macro, micro, proteins, Carbon etc.) (Table 4)

Carbon fixation (carbon sequestration)

Celtis laevigata Wild. (Fam. Ulmaceae, Common name: Palo Blanco)

General description: Tree 7-8 in height, leaf canopy semi close.

Morphology: Leaves simple, oval with entire margin or dented. Flowering March to April, flower small and greenish in color, fruit a drupe of one seed.

Habitat: Tamaulipan Thorn Scrub.

Branching pattern and crown architecture: Pseudomonopodial, crown globose.

Leaf Morphology: Leaf simple, large size, green color, petiolate, lanceolate in shape, margin slightly serrated, leaf surface plain, soft, little thick, texture velvety and little waxy.

Anatomy: Wood semi-ring porous, vessels not numerous in number, mostly solitary, very few in multiples of 3 cells or more, round to oval in shape, mostly big in size, non-uniform in size in cross section. Axial parenchyma paratracheal, vasicentric. Apotracheal parenchyma in the form of long narrow to broad, scalariform, marginal and terminal parenchyma visible. Vessels short, very much broad with inclined simple perforation plates, pits round, small, very close, alternate in arrangement. Wood contains dense materials [15-17]. Wood tissue not compact with medially thin walled Fiber cells and profuse parenchyma. Wood seems to be medially soft. Fiber cells with broad lumen and medium thick cell wall could be suitable for paper pulp (Figure 8).

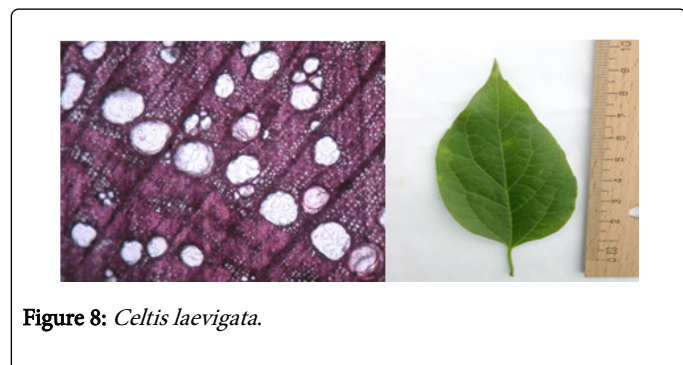


Figure 8: *Celtis laevigata*.

Wood density: 0.717 g/cm³, (average of 10) wood soft

Ecophysiology: Leaf traits (Table 2), pigments (Table 3), epicuticular wax (Table 3) and leaf nutrients (macro, micro, proteins, Carbon, etc.) (Table 4)

Celtis pallida Torrey. (Fam. Ulmaceae, Common name; Granjeno)

General description: Spiny shrub 3 m in height, leaf canopy open.

Morphology: Leaves simple, oval, softly dented in margins. Flowering in spring, flowers monogamous or polygamous of brown color, fruit a drupe of one seed of yellow to orange color.

Habitat: Tamaulipan Thorn Scrub.

Branching pattern and crown architecture: Pseudomonopodial, crown irregular

Leaf Morphology: Leaves simple, very small, of clear green colour, petiolate, oval in shape, texture slightly rough, leaves soft and thin.

Anatomy: Wood semi-ring porous, vessels numerous mostly in radial rows of 2 to 3 cells, few solitary, round to oval in shape, small to

medium in size, non-uniform in size in cross section. Axial parenchyma paratracheal, Apotracheal parenchyma in the form of long narrow to broad, scalariform, marginal parenchyma visible. Vessels short, very much broad with inclined simple perforation plates, pits round, small, very close, alternate in arrangement. Wood possesses dense contents. Wood tissue compact with medially thick walled Fiber cells and profuse parenchyma. Wood seems to be semi-hard. Fiber cells with broad lumen and medium cell wall thickness could be suitable for paper pulp (Figure 9).

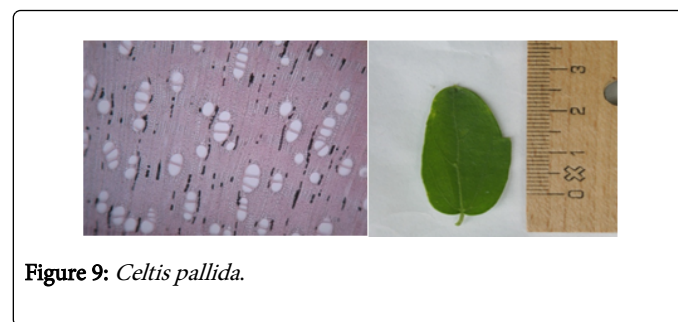


Figure 9: *Celtis pallida*.

Wood density: 0.776 g/cm³, (average of 10) wood soft.

Ecophysiology: Leaf traits (Table 2), pigments (Table 3), epicuticular wax (Table 3) and leaf nutrients (macro, micro, proteins, Carbon, etc.) (Table 4).

Condalia hoockeri M.C. Johnst. (Fam. Rhamnaceae Common name; Brasil)

General description: Spiny tree 4 m in height, leaf canopy open.

Morphology: Leaves simple, oval with entire margin. Flowering summer, flowers green and the fruit drupe black.

Habitat: Tamaulipan Thorn Scrub.

Branching pattern and crown architecture: Pseudomonopodial, crown irregular

Leaf Morphology: Leaves very small, simple of clear green color, petiolate, ovate in shape, margin entire, smooth, texture smooth, soft, surface waxy and shining, leaves thin. Leaf simple, medium size, petiolate of dark green color, elliptic in shape, margin smooth, leaf texture pubescent, soft, leaf surface plain and thick.

Anatomy: Wood diffuse porous, vessels sparse, mostly solitary, very few in radial bands of 2-3 cells, round to oval in shape, large to small in size. Mostly big in size, non-uniform in size in cross-section. Axial parenchyma confluent aliform. Apotracheal parenchyma in the form of short to broad band, scalariform [18]. Vessels short, broad with truncated simple perforation plates, pits reticulate to scalariform. Wood tissue compact with medially thick walled Fiber cells. Wood seems to be semi-hard. Fiber cells with thick cell wall and narrow lumen could impart strength and suitable for strong furniture (Figure 10).

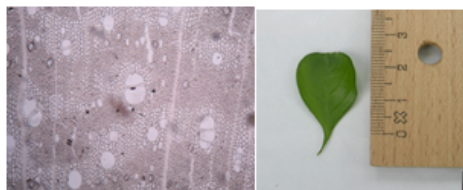


Figure 10: *Condalia hookeri*.

Wood density: 0.856 g/cm³, (average of 10) wood medium hard

Ecophysiology: Leaf traits (Table 2), pigments (Table 3), epicuticular wax (Table 3) and leaf nutrients (macro, micro, proteins, Carbon, etc.) (Table 4)

Cordia boissieri ALDC (Fam. Boraginaceae, Common name: Anacahuíta)

General description: Tree 2-4 m in height, leaf canopy open.

Morphology: Leaves simple with dens pubescence, oval to ovalate in shape with entire margin. Flowering throughout the year, flowers white and the fruit drupe white to yellow green.

Habitat: Tamaulipan Thorn Scrub.

Branching pattern and crown architecture: Pseudopodial, crown globose, branching pattern high, leaf canopy semi close.

Anatomy: Wood diffuse porous, vessels numerous, many are large, few small, mostly solitary, non-uniform, round to oval in shape, few in radial groups of 2 or 3, few very small in size, non-uniform in size in cross section. Axial parenchyma confluent aciform. Apotracheal scattered around vessels region loose. Vessels short and broad, truncated to little inclined simple perforation plate inclined, pits elliptical, very close, alternate in arrangement. Wood tissue is loose, with profuse parenchyma, seem to be soft. Fiber cells broad lumened with medially thick cell wall. May be used for paper pulp (Figure 11).

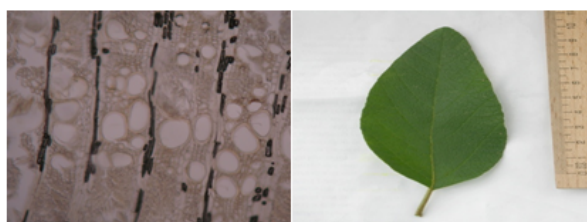


Figure 11: *Cordia boissieri*.

Wood density: 0.625 g/cm³, (average of 10) wood very soft

Ecophysiology: Leaf traits (Table 2), pigments (Table 3), epicuticular wax (Table 3) and leaf nutrients (macro, micro, proteins, Carbon etc.) (Table 4)

Croton suaveolens Presl. (Fam. Euphorbiaceae, Common name: Salvia)

General description: Shrub 2 m in height, leaf canopy closed.

Morphology: Leaves simple, petiolate, and elliptic to oval-elliptic with entire margin. Flowers arranged in racemes, flowers white to yellowish, fruit a capsule, which separate in three parts.

Habitat: Tamaulipan Thorn Scrub.

Branching pattern and crown architecture: Sympodial, crown irregular, branching density low.

Leaf morphology: Leaves, simple, medium in size of whitish green color, margin entire, elliptic in shape, surface ubescent, leaf surface plain, thick.

Wood density: 0.912 g/cm³, (average of 10) wood hard

Ecophysiology: Pigments (Table 3), epicuticular wax (Table 3), leaf nutrients (macro, micro, proteins, Carbon etc.) (Table 4) and carbon fixation (carbon sequestration)

Diospyros palmeri Eastw. (Fam. Ebenaceae, Common name; Chapote Manzano)

General description: Tree 4-5 m in height, leaf canopy closed.

Morphology: Leaves simple, oblong-obovate and petiolate with entire margin. Flowers White in color to greenish, fruit berry of brown color to black [19].

Habitat: Tamaulipan Thorn Scrub.

Branching pattern and crown architecture: Pseudomonopodial, crown globose, Branching density medium, leaf canopy semi close,

Leaf morphology: Leaf simple, medium size, very deep green in color, petiole very small, ovate in form, margin smooth, leaf surface very smooth, plain, soft, thick, curved, texture highly waxy and very much shining.

Anatomy: Wood diffuse porous, vessels sparse, mostly solitary, very few in gropus, very narrow in diameter, round to oval in shape. Axial parenchyma paratracheal confluent. Apotracheal parenchyma. Vessels medium in length and breadth with inclined simple prefratio plate pits small, round, alternate in arrangement. Wood tissue loose with profuse parenchyma and thin walled Fiber cells, profuse, seem to be soft wood.

Wood density: 0.726 g/cm³, (average of 10) wood soft

Ecophysiology: Leaf traits (Table 2), pigments (Table 3), epicuticular wax (Table 3) and leaf nutrients (macro, micro, proteins, Carbon etc.) (Table 4)

Diospyros texana Scheele. (Fam. Ebenaceae, Common name; Chapote Prieto)

General description: Tree 6-7 m in height. Leaf canopy closed.

Morphology: Leaves simple with entire margin and present pubescence. Flowering February to June, flowers white, fruit a berry with 3 to 8 seeds.

Habitat: Tamaulipan Thorn Scrub.

Branching pattern and crown architecture: Pseudomonopodial, crown globose

Leaf morphology: Leaf simple, very small, deep green in color, petiolate, ovate in shape, margin smooth, leaf surface plain and soft, texture slightly pubescent and thick.

Anatomy

Wood density: 0.642 g/cm³ (average of 10), wood very soft.

Ecophysiology: Leaf traits (Table 2), pigments (Table 3), epicuticular wax (Table 3) and leaf nutrients (macro, micro, proteins, Carbon etc.) (Table 4)

Ebenopsis ebano (Berland) Barneby & Grimes JW. Britton Et Rose. (Fam. Fabaceae, Common name; Ebano)

General description: Tree 6-7 m in height, leaf canopy open.

Morphology: Leaves compound, bipinnate with 3 to 6 pairs of leaflets. Flowering April to July, occasionally in November, fruit a legume of dark brown to black color.

Habitat: Tamaulipan Thorn Scrub.

Branching pattern and crown architecture: Pseudomonopodial, crown irregular, branching density high, leaf canopy semi close.

Leaf Morphology: Leaves compound, petiolate, petiole small, leaf of dark green colour. Leaf margin smooth, leaves paripinnate, opposite, texture smooth, little thick, surface straight and covered with wax.

Anatomy: Wood diffuse porous, semi-ring porous, mostly solitary, round to oval in shape, few in radial groups of 2 or 3, very small in size, narrow, non-uniform in size in cross section. Axial parenchyma confluent aciform. Apotracheal parenchyma in the form of narrow band, scalariform [20]. Vessels medium in length and breadth, more or less with little inclined simple perforation plates, very close, small, alternate in arrangement. Fiber cells broad lumened, thin walled, suitable for paper pulp. Wood tissue is compact with medially thick walled Fiber, suitable for strong furniture (Figure 12).

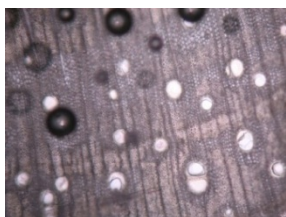


Figure 12: *Ebenopsis ebano*.

Wood density: 0.909 g/cm³, (average of 10) wood very soft

Ecophysiology: Leaf traits (Table 2), pigments (Table 3), epicuticular wax (Table 3) and leaf nutrients (macro, micro, proteins, Carbon etc.) (Table 4)

Ehretia anacua (Teran & Berland.) I.M. Johnst. (Fam. Boraginaceae, Common name; Anacua)

General description: Tree 5-7 m in height, leaf canopy closed.

Morphology: Leaves simple, elliptic to ovate with entire to dented margin. Flowering June to October, flowers white in color, fruit a drupe of yellow or orange.

Habitat: Tamaulipan Thorn Scrub.

Branching pattern and crown architecture: Pseudomonopodial, crown irregular, branching density high, leaf canopy close.

Leaf morphology: Leaf simple, large size, deep green in color, petiolate, elliptic in form, margin smooth, leaf surface rough, texture velvet, leaf thick and waxy.

Anatomy: Wood diffuse porous, vessels sparse in numbers mostly in pore multiples, round to oval in shape, few non-uniform in size, very small. Axial parenchyma confluent aciform. Apotracheal parenchyma in the form of narrow non-scalariform. Vessels short to medium in length, broad, more or less with straight simple perforation plates, pits round, alternate in arrangement. Medullary ray cells stratified, multilayered, stratified, pits scalariform, evolutionary slightly advanced. Wood tissue is loose with profuse parenchyma, seem to be soft (Figure 13).



Figure 13: *Ehretia anacua*.

Wood density: 0.823 (g/cm³), (average of 10), wood medium hard

Ecophysiology: Leaf traits (Table 2), pigments (Table 3), epicuticular wax (Table 3) and leaf nutrients (macro, micro, proteins, Carbon etc.) (Table 4)

Eysenhardtia texana Scheele. (Fam. Fabaceae, Common name; Vara Dulce)

General description: Tree 3-4 m in height, leaf canopy open.

Morphology: Leaves compound, pinnate with 15 to 50 leaflets. Flowering April to September, flowers white, fruit a legume of green to brown color.

Habitat: Tamaulipan Thorn Scrub.

Branching pattern: Monopodial, crown architecture irregular.

Leaf morphology: Leaves compound, small of dark green color, texture smooth, soft, leaf surface smooth.

Anatomy: Wood semi-ring to ring porous, vessels numerous, mostly isolated. Few in radial bands of 2 or more cells, vessel round to oval in shape, non-uniform in size in cross section. Axial parenchyma paratracheal. Apotracheal parenchyma in the form of long tiers, scalariform. Vessels medium in length, broad with inclined to truncated, simple perforation plates, pits round, very close, small, alternate in arrangement. Fiber cells broad lumened and thick walled. Wood tissue is compact with medially thick walled Fiber cells, seem to be medially hard (Figure 14).

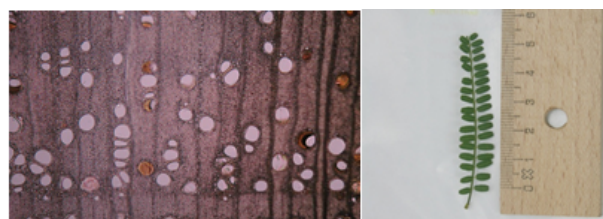


Figure 14: *Eysenhardtia texana*.

Wood density: 0.910 (g/cm³) (average of 10), wood hard

Ecophysiology: Leaf traits (Table 2), pigments (Table 3), epicuticular wax (Table 3) and leaf nutrients (macro, micro, proteins, Carbon etc.) (Table 4)

Foresteria angustifolia Torr. (Fam. Oleaceae, Common name; Panalero)

General description: Shrub 2-3 m in height, leaf canopy closed.

Morphology: Leaves simple with entire margin. Flowering in summer to spring, flowers green in color, male and female flowers in separate plant, fruit a drupe of brown color with only one seed.

Habitat: Tamaulipan Thorn Scrub.

Branching pattern and crown architecture: Sympodial, crown irregular, branching density high, leaf canopy close.

Leaf morphology: Leaves: Leaf simple, small, green color with small petiole, Leaves elliptic, margin entire. The blade is in the form of ellipses and has a smooth margin. Texture smooth, leaf surface plain and slightly waxy, leaf thin.

Anatomy: Wood semi-ring porous, vessels numerous, mostly in radial bands of 2 or few of 3 vessels, pores solitary, round to oval in shape, few in radial groups of 2 or 3, very small in size, narrow, non-uniform in size in cross section. Axial parenchyma paratracheal. Apotracheal parenchyma in the form of long tiers, scalariform. Vessels short and broad, more or less with little inclined simple perforation plates, pits round, very close, small, alternate in arrangement [5]. Wood tissue is compact with medially thick walled Fiber cells, seem to be medially hard. Fiber cells thin walled, broad lumened, suitable for paper pulp (Figure 15).

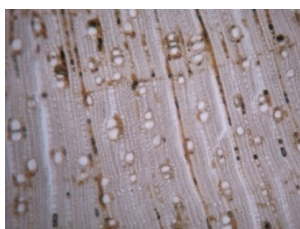


Figure 15: *Foresteria angustifolia*.

Wood density: 0.633 (g/cm³), (average of 10) wood very soft

Ecophysiology: Leaf traits (Table 2), pigments (Table 3), epicuticular wax (Table 3) and leaf nutrients (macro, micro, proteins, Carbon etc.) (Table 4)

Guaiacum angustifolium Engelm. (Fam. Zygophyllaceae, Common name; Guayacan)

General description: Shrub 2-3 m in height, leaf canopy open.

Morphology: Leaves compounds, pinnate of 4 to 8 leaflets with entire margin. Flowering in March to April, flowers of violet to purple color, fruit a capsule of brown color with one to three seeds of red to orange color.

Habitat: Tamaulipan Thorn Scrub.

Branching pattern and crown architecture: Monopodial, crown irregular.

Leaf morphology: Leaves compound, very small, deep green in color, petiolate, opposite, paripinnate, margin smooth, leaf surface smooth, plain, very much soft, thin and little waxy.

Anatomy: Wood diffuse porous, vessels numerous, narrow, mostly isolated. Few in radial bands of 2, vessel round to oval in shape, non-uniform in size in cross section, narrow vessels. Axial parenchyma confluent aciform. Apotracheal parenchyma in the form of short bands, scalariform [18]. Vessels medially long, not narrow inclined to truncated, with simple perforation plates, pits round, very close, small, alternate in arrangement. Wood tissue is compact with medially thick walled Fiber cells, seem to be semi-hard. Fiber cells medially thick walled but broad lumened, may be suitable for paper pulp (Figure 16).

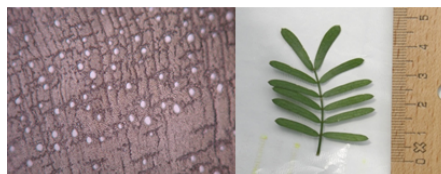


Figure 16: *Guaiacum angustifolium*.

Ecophysiology: Leaf traits (Table 2), pigments (Table 3), epicuticular wax (Table 3) and leaf nutrients (macro, micro, proteins, Carbon, etc.) (Table 4)

Gymnosperma glutinosum (K. Sprengel) C. Lessing. (Fam. Astraceae. Common name. Tatalencho)

General description: Shrub 1.5-2 m in height, leaf canopy open.

Morphology: Leaves simple with entire margin. Flowering in summer to fall, flowers of yellow, the fruit an achene.

Habitat: Tamaulipan Thorn Scrub.

Branching pattern and crown architecture: Monopodial, crown irregular, branching density low, leaf canopy semi close.

Wood density: 0.942 (g/cm³), (average of 10), wood hard

Ecophysiology: Leaf traits (Table 2), pigments (Table 2), epicuticular wax (Table 2) and leaf nutrients (macro, micro, proteins, Carbon etc.) (Table 4)

Havardia pallens (Benth.) Britton & Rose. (Fam. Fabaceae, Common name; Tenaza)

General description: Tree 4-5 m in height, leaf canopy closed.

Morphology: Leaves compound, bipinnate with seven to 20 pairs of leaflets. Flowering in May to August, flowers white in color, fruit a legume of brown color.

Habitat: Tamaulipan Thorn Scrub.

Branching pattern and crown architecture: Sympodial, irregular, branching density low.

Leaf morphology: Leaves compound, large size of dark green color, petiolate, opposite, bipinnate, margin smooth, texture smooth, plain, soft and thin.

Anatomy: Wood semi-ring porous, vessels sparsely scattered, mostly solitary, round to oval in shape, few in radial groups of 2 or 3, very small in size, non-uniform in size in cross section, medium in size [12].

Axial parenchyma paratracheal vascicentric. Apotracheal parenchyma in the form of broad and long band, scalariform. Vessels medium in length, broad in breadth more or less with little inclined simple perforation plates, pits elliptical, scalariform, very close, big, alternate in arrangement. Medullary rays narrow, traverse throughout the cross section, evolutionary slightly less advanced. Wood tissue is compact with medially thick walled Fiber cells but with profuse parenchymatous tissue, seem to be medially hard (Figure 17).



Figure 17: *Havardia pallens*.

Wood density: 0.766 (g/cm³), (average of 10) wood soft

Ecophysiology: Leaf traits (Table 2), pigments (Table 3), epicuticular wax (Table 3) and leaf nutrients (macro, micro, proteins, Carbon etc.) (Table 4)

Helietta parvifolia (A. Gray) Benth. (Fam. Rutaceae, Common name; Barreta)

General description: Tree aromatic of 4-5 m in height, leaf canopy closed.

Morphology: Leaves compound, trifoliate with entire margin. Flowering in spring, flowers white to green in color, the fruit three to four samara like carpels.

Habitat: Tamaulipan Thorn Scrub.

Branching pattern and tree crown architecture: Pseudomonopodial and irregular crown architecture, branching density medium, leaf canopy semi close.

Leaf morphology: Leaf compound of medium size, deep green in color, petiolate trifoliate, margin smooth, texture smooth, soft, very thick, leaf surface very much waxy and shining.

Anatomy: Wood diffuse porous, vessels numerous, very narrow, mostly isolated. Vessels round to oval in shape, non-uniform in size in cross section, distributed in the form of stars. Axial parenchyma paratracheal. Apotracheal parenchyma diffuse. Medullary rays not distinct. Vessels medium in length, narrow, mostly inclined to simple perforation plates, pits round, very close, small, alternate in arrangement. Wood tissue compact with medially thick walled Fiber cells, seem to be medially hard (Figure 18).

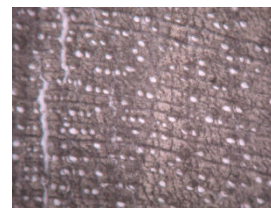


Figure 18: *Helietta parvifolia*.

Wood density: 0.999 (g/cm³), (average of 10) wood very hard

Ecophysiology: Leaf traits (Table 2), pigments (Table 3), epicuticular wax (Table 3) and leaf nutrients (macro, micro, proteins, Carbon etc.) (Table 4)

Karwinskia humboltiana (Schult.) Zucc. (Fam. Rhamnaceae, Common name; Coyotillo)

General description: Shrub of 2-2.5 m in height, leaf canopy closed.

Morphology: Leaves simple elliptic to oblong with entire margins. Flowering in summer-fall, flowers green color, the fruit drupe of brown to black.

Habitat: Tamaulipan Thorn Scrub.

Branching pattern and crown architecture: Sympodial, crown globose, branching density medium to low, leaf canopy open.

Leaf morphology: Leaves simple, medium in size of dark green color, petiolate, margin smooth, oval in shape, texture thick, smooth.

Anatomy: Wood diffuse porous, vessels numerous, very narrow, mostly isolated. Vessel round to oval in shape, non-uniform in size in cross section, distributed in the form of stars. Axial parenchyma paratracheal. Apotracheal parenchyma diffuse. Medullary rays not distinct. Vessels medium in length, narrow, mostly inclined to simple perforation plates, pits round, very close, small, alternate in arrangement [20]. Wood tissue compact with medially thick walled Fiber cells, seem to be medially hard (Figure 19).

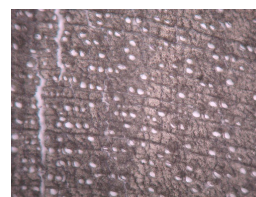


Figure 19: *Karwinskia humboltiana*.

Wood density: 0.884 (g/cm³), (average of 10) wood medium hard

Ecophysiology: Leaf traits (Table 2), pigments (Table 3), epicuticular wax (Table 3) and leaf nutrients (macro, micro, proteins, Carbon etc.) (Table 4)

Lantana macropoda Torr. (Fam. Verbenaceae, Common name; Lantana)

General description: Shrub of 1 m in height, leaf canopy closed.

Leaves simple ovate with dented margins. Flowering in February to May, flowers white color, the fruit a drupe.

Habitat: Tamaulipan Thorn Scrub, branching density low

Wood density: 0.821 (g/cm³), (average of 10) wood medium hard

Ecophysiology: Leaf traits (Table 2), pigments (Table 3), epicuticular wax (Table 3) and leaf nutrients (macro, micro, proteins, Carbon etc.) (Table 4)

Leucaena leucocephala (J. de Lamark) H.C. de Wit. (Fam. Fabaceae, Common name; Leucaena)

General description: Tree of 5-6 m in height, leaf canopy semi closed.

Morphology: Leaves compound, bipinnate with 11 to 17 pairs of leaflets. Flowering in May to June, flowers white color, the fruit legume of brown color.

Habitat: Tamaulipan Thorn Scrub.

Branching pattern and crown architecture: Monopodial, crown irregular.

Leaf morphology: Leaves compound, large size, deep Green in color, petiolate, opposite, bipinnate, margin smooth, leaf thin, leaf surface slightly waxy.

Anatomy: Wood ring porous, vessels sparse mostly solitary, few in radial band of 2-3 cells, round to oval in shape, non-uniform in size, small to big in cross section. Axial parenchyma paratracheal, vascicentric [8]. Apotracheal parenchyma in the form of short to broad band, scalariform. Vessels medium in size, medium in breadth with slightly inclined perforation plates, pits round, small, alternate in arrangement. Wood tissue not compact with medially thin walled Fiber cells. Wood seems to be soft. Fiber cell medially thick walled, broad lumened, suitable for paper pulp (Figure 20).



Figure 20: *Leucaena leucocephala*.

Wood density: 0.679 (g/cm³), average of 10) wood soft

Ecophysiology: Leaf traits (Table 2), pigments (Table 2 and 3), epicuticular wax (Table 3) and leaf nutrients (macro, micro, proteins, Carbon etc.) (Table 4)

Leucophyllum frutescens (J. Berlandier) I.M. Johnston. (Fam. Scrophulariaceae, Common name; Cenizo)

General description: Shrub of 2-2.5 m in height, leaf canopy closed.

Morphology: Leaves simple, elliptic to obovate with entire margins. Flowering throughout the year, flowers violet or pink to white color, the fruit a capsule of brown color.

Habitat: Tamaulipan Thorn Scrub.

Branching pattern and crown architecture: Sympodial, crown globose, Branching density medium, leaf canopy open.

Leaf morphology: Leaves simple, large size of whitish green color, margin smooth, elliptic in shape, slightly pubescent, very soft, little thick.

Anatomy: Wood ring porous, vessels sparse mostly solitary, few in radial band of 2-3 cells, round to oval in shape, non-uniform in size, small to big in cross section. Axial parenchyma paratracheal, vascicentric. Apotracheal parenchyma in the form of short to broad band, scalariform. Vessels medium in size, medium in breadth with slightly inclined perforation plates, pits round, small, alternate in arrangement. Wood tissue not compact with medially thin walled Fiber cells. Wood seems to be soft. Fiber cell medially thick walled, broad lumened, suitable for paper pulp (Figure 21).

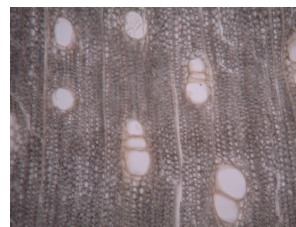


Figure 21: *Leucophyllum frutescens*.

Wood density: 0.786 (g/cm³) (average of 10), wood soft

Eco-physiology: Leaf traits (Table 2), pigments (Table 3), epicuticular wax (Table 3) and leaf nutrients (macro, micro, proteins, Carbon etc.) (Table 4)

Parkinsonia aculeata L. (Fam. Fabaceae, Common name; Retama)

General description: Tree of 5-7 m in height, leaf canopy open.

Morphology: Leaves compound, bipinnate with numerous pairs of leaflets. Flowering in spring-fall, flowers yellow color, the fruit a legume of brown color.

Habitat: Tamaulipan Thorn Scrub.

Leaf morphology: Leaves compound, small, deep green in color, petiolate, bipinnate, margin smooth, opposite, leaf surface smooth, plain, soft and very much thin, leaf surface thin, plain, soft, texture little waxy.

Wood density: 0.756 (g/cm³), (average of 10), wood soft

Ecophysiology: Pigments, epicuticular wax, leaf nutrients (macro, micro, proteins, Carbon etc.) and carbon fixation (carbon sequestration).

Parkinsonia texana (A. Gray) S. Watson. var. macrum. I.M. Johnston. (Fam. Fabaceae, Common name; Palo Verde)

General description: Tree spiny, 7-8 m in height, with green bark, leaf canopy open.

Morphology: Leaves compound, bipinnate of 2 to 3 pairs of leaflets. Flowering June to July, flowers yellowish arranged in raceme, the fruit legume dark brown with one to five seeds.

Habitat: Tamaulipan Thorn Scrub.

Branching pattern and crown architecture: Pseudomonopodial, crown globose.

Anatomy: Wood semi-ring porous, vessels sparse, mostly solitary or very few in radial rows of 2 cells, round to oval in shape, very small to medium in size, non-uniform in size in cross section. Axial parenchyma paratracheal, vasicentric. Apotracheal parenchyma in the form of narrow to broad, scalariform [3]. Vessels short, broad with inclined simple perforation plates, pits round, small, very close, alternate in arrangement. Wood tissue compact with medially thick walled Fiber cells and profuse parenchyma. Wood seems to be semi-hard. Fiber cell broad lumened, thin walled, suitable for paper pulp (Figure 22).



Figure 22: *Parkinsonia texana*.

Wood density: 0.756 (g/cm³), (average of 10), wood soft,

Ecophysiology: Leaf traits (Table 2), pigments (Table 3), epicuticular wax (Table 3) and leaf nutrients (macro, micro, proteins, Carbon etc.) (Table 4)

Prosopis laevigata (Humb. & Bonpl. Ex Willd.) M.C. Johnst. (Fam. Fabaceae, Common name; Mezquite)

General description: Tree of 7-8 m in height, leaf canopy semi open.

Morphology: Leaves compound, petiolate with 10 to 20 pairs of leaflets. Flowering in February to March and finally in April of May, flowers yellow color, the fruit legume brown to reddish color.

Habitat: Tamaulipan Thorn Scrub.

Branching pattern and crown architecture: Pseudomonopodial, crown globose

Anatomy: Wood ring porous, vessels infrequent, mostly solitary, round to oval in shape, few in radial groups of 2 or 3, non-uniform in size, some are big in cross section. Axial parenchyma confluent. Apotracheal parenchyma in the form of broad band, scalariform. Vessels longer, slightly broad, more or less with little inclined simple perforation plates, pits elongated elliptical, alternate in arrangement. Wood tissue is compact with medially thick walled Fiber cells, seem to be medially hard. Fiber cells with pointed apex, lumen broad with medium thick cell wall. Could be suitable for paper pulp (Figure 23).



Figure 23: *Prosopis laevigata*.

Wood density: 0.953 (g/cm³), average of 10 wood hard.

Ecophysiology: Leaf traits (Table 2), pigments (Table 3), epicuticular wax (Table 3) and leaf nutrients (macro, micro, proteins, Carbon, etc.) (Table 4).

Quercus virginiana P. Miller. (Fam. Fagaceae, Common name, Encino)

General description: Tree of 8-9 m in height, leaf canopy semi open.

Morphology: Leaves simple with entire dented margins. Flowering in spring, flowers yellow, the fruit an acorn brown color.

Habitat: Temperate woodland.

Leaf morphology: Leaf simple, medium size, deep green color, petiolate, elliptic in shape, margin dentate, leaf surface slightly wavy and rigid, texture smooth, and thick, waxy and shiny.

Wood density: 0.961 (g/cm³), (average of 10), wood hard.

Retama sphaerocarpa (L.) Boi, wood hard.

Leaf morphology: Leaves compound, large size, clear green in color, linear in shape, petiolate, leaf surface plain, texture smooth and waxy.

Anatomy: Wood diffuse porous, vessels infrequent, few solitary, few in a multiple of 2 to 3 vessels, round to oval in shape, non-uniform in size. Axial parenchyma confluent. Apotracheal parenchyma diffuse. Vessels broad, medium in length, more or less with little inclined simple perforation plates, pits round to elliptical, alternate in arrangement. Wood tissue is not compact with profuse parenchyma probably leading to soft wood (Figure 24).

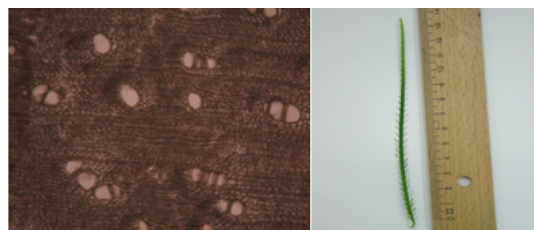


Figure 24: *Retama sphaerocarpa*.

Salix lasiolepis Benth. (Fam. Salicaceae, Common name; Sauce)

General description: Tree of 10 m in height, leaf canopy semi close.

Morphology: Leaves simple, erect linear to lanceolate with entire margins. Flowering in March, flowers green to yellowish color, the fruit capsule.

Habitat: Riparian Area.

Leaf morphology: Leaf simple, medium size, deep green in color, lanceolate in shape, margin smooth, petiolate, surface is smooth, petiolate and waxy.

Anatomy: Wood diffuse porous to semi-ring porous, vessels, numerous, mostly solitary, very few in multiple of 2-3 cells, round to oval in shape, non-uniform in size, small to medium in cross section. Axial parenchyma paratracheal, vascicentric. Apotracheal parenchyma in the form of short to broad band, scalariform. Vessels medium, broad with inclined perforation plates, pits round, small, alternate in arrangement [16-18]. Wood tissue not compact with medially thin walled Fiber cells. Wood seems to be soft. Fiber cells with broad lumen and medium thick cell wall could be suitable for paper pulp (Figure 25).



Figure 25: *Salix lasiolepis*.

Wood density: 0.625 (g/cm³), (average of 10) wood very soft.

Ecophysiology: Leaf traits (Table 2), pigments (Table 3), epicuticular wax (Table 3) and Leaf nutrients (macro, micro, proteins, Carbon etc.) (Table 4)

Sargentia gregii S. Watson. (Fam. Rutaceae, Common name; Chapote Amarillo)

General description: Tree of 4-5 m in height, leaf canopy close.

Morphology: Leaves compound, aromatic, alternate with entire margins. Flowers green yellowish color, the fruit a drupe yellow shining.

Habitat: Tamaulipan Thorn Scrub.

Branching pattern and crown architecture: Pseudomonopodial, crown globose, branching density high, leaf canopy close.

Leaf morphology: Leaves compound, large size, deep green in color, peltate, trifoliate, margin smooth, texture waxy and shining, leaf surface plain, smooth, rigid and thick.

Anatomy: Wood diffuse porous, vessels numerous, mostly in radial bands of 2-3 cells, very few in multiples, round to oval in shape, mostly big in size, non-uniform in size. Axial parenchyma confluent aliform. Apotracheal parenchyma in the form of short to broad band, scalariform. Vessels short, broad with inclined perforation plates, pits round to elliptical, very close, opposite in arrangement. Medullary rays narrow but intersected by wood tissue. Wood contains dense materials. Wood tissue medially compact with medially thick walled Fiber cells. Wood seems to be semi-hard. Fiber cell wall thick, lumens narrow (Figure 26).

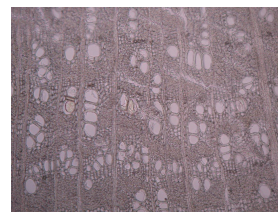


Figure 26: *Sargentia gregii*.

Wood density: 0.929 (g/cm³), (average of 10) wood hard

Ecophysiology: Leaf traits (Table 2), pigments (Table 3), epicuticular wax (Table 3) and leaf nutrients (macro, micro, proteins, Carbon etc.) (Table 4)

Sideroxylon celastrinum (K. Kunth) T.D. Pennigton. [Syn. *Bumelia celastrina* K. Kunth]. (Fam. Sapotaceae, Common name; Coma)

General description: Tree of 4-5 m in height, leaf canopy semi close.

Morphology: Leaves simple, oblanceolate to obovate or elliptic with entire margins. Flowering in May to November, flowers white greenish color, the fruit drupe blue or black color.

Habitat: Tamaulipan Thorn Scrub.

Branching pattern and crown architecture: Pseudomonopodial, crown globose.

Leaf morphology: Leaves simple, small size, deep green in color, petiolate, spatulate in shape, margin smooth, leaf surface smooth, soft and very thick, leaf surface waxy and shining.

Anatomy: Wood semi-ring porous, vessels numerous present scattered like stars spaced from another groups, mostly solitary, round to oval in shape, few in radial groups of 2 or 3, very small in size, narrow, non-uniform in size in cross section. Axial parenchyma confluent. Apotracheal parenchyma in the form of broad band, scalariform, marginal parenchyma, broad band of scalariform parenchyma visible [10]. Vessels longer, medium in breadth more or less with little inclined simple perforation plates, very close, small, and alternate in arrangement. Wood tissue is compact with medially thick walled Fiber cells but with profuse parenchymatous tissue, seem to be medially hard. Fiber cell medially thick walled, medium broad lumened (Figure 27).

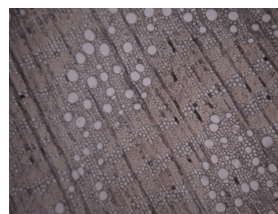


Figure 27: *Sideroxylon celastrinum*.

Ecophysiology: Leaf traits (Table 2), pigments (Table 3), epicuticular wax (Table 3) and leaf nutrients (macro, micro, proteins, Carbon etc.) (Table 4)

Zanthoxylum fagara (L.) Sarg. (Fam. Rutaceae, Common name; Colima)

General description: Tree spiny of 3-4 m in height, leaf canopy close.

Morphology: Leaves compound aromatic, old-pinnate with five to 13 leaflets, with dented margins. Flowering in winter-fall, flowers green yellowish color, the fruit a capsule of brown color.

Habitat: Tamaulipan Thorn Scrub.

Branching pattern and crown architecture: Branching density medium, leaf canopy semi close.

Leaf morphology: Leaves compound, medium in size of dark green color, petiolate, imparinate, margin smooth, texture smooth, plain, little thick, leaf surface waxy and shining.

Anatomy: Wood semiring porous, vessels moderate in numbers mostly solitary, round to oval in shape, few in radial groups of 2 or 3, non-uniform in size, mostly small. Axial parenchyma paratracheal confluent. Apotracheal parenchyma in the form of broad band, scalariform. Vessels longer, slightly broad, more or less with straight simple perforation plates, pits elongated scalariform alternate in arrangement. Medullary ray cells stratified, multilayered, stratified, pits scalariform, evolutionary slightly less advanced. Wood tissue is compact with medially thick walled Fiber cells, profuse vessels, seem to be medially hard. The apex of Fiber cells is pointed to round, the lumen is somewhat broad, the cell wall is thin, but little lignified. Wood is semi-hard for fabrication of furniture; this may be suitable for paper pulp (Figure 28).



Figure 28: *Zanthoxylum fagara*.

Wood density: 0.661 (g/cm³), (average of 10), wood soft

Ecophysiology: Leaf traits (Table 2), pigments (Table 3), epicuticular wax (Table 3), leaf nutrients (macro, micro, proteins, Carbon etc.) (Table 4) and carbon fixation (carbon sequestration)

Conclusions

A study on morphology, wood anatomy and eco-physiological traits of more than 30 woody species at Linares, Northeastern Mexico reveals that there exists a large variability in habit, branching pattern, leaf morphology, wood anatomy and eco-physiological traits which help in the co-existence and adaptation of these species in xeric environments in summer and cool season. There exists a large variability in branching pattern among woody species which act as solar panel in the capture of solar radiation for photosynthesis and plant productivity.

With respect to leaf traits, the species vary in size, form and shape of leaves. There exists a large variability in leaf area, leaf specific area and dry weight of leaves. The large variations in wood anatomical traits such vessel size, distribution, compactness of wood tissue could be related to the taxonomic delimitation of the species, adaptation of the

species to xeric conditions in summer and cool season and also could be related to the quality and utility of timbers. Most of the species possess narrow vessels which have been well documented in the literature to protect vessels against cavitation and embolism in summers and winter season in Mediterranean regions similar to the conditions of Northeastern Mexico. A large variability exists in Wood density among species which could be related to Wood anatomical features. In the previous chapters we mention that the absence of and low frequency of stomata in the upper leaf surface and sunken nature of stomata could be related to adaptation to drought. Besides the presence of thick cuticle, trichome density and compact palisade cells are considered adapted to drought conditions in literatures. Concerted research inputs need to be directed in this aspect.

Similarly, there are large variations in pigments contents (chlorophyll a, b, and total) and epicuticular wax, which also help in the growth, development and the productivity of the adaptation of the species in their adverse environments prevailing in summer and winter season. In addition there exists a large variability in leaf nutrient contents (macro and micronutrients), protein, carbon sequestration which help in the productivity and adaptation of the woody species in their environments. Woody species with high capacity of carbon sequestration could be planted in carbon polluted areas to reduce carbon dioxide load from the atmosphere. Woody species with high leaf nutrients could serve as important sources of nutrients for grazing wild animals.

We selected eco-physiologically efficient woody species for different traits:

- Various eco-physiological traits mentioned below contribute to the productivity and adaptation of woody plants in the ecosystem.
- Leaf area (cm²): *Caesalpinia mexicana* (109.18), *Cordia boissieri* (97.47), *Leucaena leucocephala* (94.74), *Sargentia greggii* (66.76), *Berberis chococo* (51.57), *Acacia berlandieri* (50.58).
- Leaf specific area (cm²/g¹): *Condalia hoockeri* (199.19), *Karwinskia humboldtiana* (183.39), *Cordia boissieri* (162.09), *Zanthophyllum fragara* (160.20), *Gymnospermum glutinosum* (186.99).
- Dry weight (g): *Caesalpinia mexicana* (0.837), *Sargentia greggii* (0.701), *Berberis chococo* (0.694), *Leucaena leucocephala* (0.679), *Cordia boissieri* (0.624).
- Wood density (g/cm³): *Acacia shaffneri* (1.09), *Amyris madrensis* (1.01), *Hellieta parvifolia* (0.99), *Acacia rigidula* (0.97), *Quercus virginiana* (0.96), *Ebenopsis ebano* (0.91).
- *Epicuticular wax* (µg/cm²): *Diospyros texana* (698.26), *Acacia farnesiana* (441.85), *Sideroxylon celastrinum* (147.58), *Forestiera angustifolia* (572.76), *Bernardia myricifolia* (353.33).

Leaf pigments (in mg g⁻¹ fw):

Leaf pigments help in the capture of solar energy and photosynthesis and plant productivity.

Chlorophyll a: *Ebenopsis ebano* (1.755), *Croton suaveolens* (0.589), *Amyris texana* (1.66), *Leucaena leucocephala* (1.403), *Gymnosperma glutinosum* (1.228).

Chlorophyll b: *Ebenopsis ebano* (0.398), *Amyris texana* (0.34), *Eysenhardtia polystachya* (0.306), *Parkinsonia aculeata* (0.363), *Diospyros palmeri* (0.336).

Chlorophyll total (Chl a+b): *Ebenopsis ebano* (2.153), *Leucaena leucocephala* (1.687), *Gynosperma glutinosum* (1.528), *Amyrys texana*, (1.506), *Parkinsonia texana* (1.497).

Carotenoids: *Berberis chococo* (0.585), *Diospyros palmeri* (0.433), *Gynosperma glutinosum* (0.330), *Amyrys texana* (0.438), *Ebenopsis ebano* (0.425).

Leaf nutrients (mg g⁻¹ dw):

Leaf nutrients contribute to the physiological functions of trees and also serve as sources of nutrients for ruminants.

Cu: *Cordia boissieri* (30.71), *Croton suaveolens* (26.87), *Celtis pallida* (25.98), *Sideroxylon celastrinum* (25.24), *Acacia farnesiana* (24.62).

Fe: *Acacia farnesiana* (259.76), *Acacia rigidula* (252.33), *Sideroxylon celastrinum* (249.00), *Croton suaveolens* (229.13), *Celtis laevigata* (254.09).

Zn: *Salix lasiolepis* (144.86), *Cordia boissieri* (51.87), *Parkinsonia aculeata* (51.66), *Eysenhardtia polystachya* (51.39), *Berberis chococo* (50.68), *Prosopis laevigata* (48.47).

K: *Croton suaveolens* (75.62), *Cordia boissieri* (45.58), *Celtis pallida* (42.60), *Acacia rigidula* (38.75), *Diospyros texana* (36.55).

Mg: *Ehretia anacua* (9.45), *Condalia hookeri* (6.50), *Parkinsonia aculeata* (5.29), *Helietta parvifolia* (5.17), *Quercus virginiana* (2.60).

P: *Croton suaveolens* (2.43), *Eysenhardtia polystachya* (1.84), *Prosopis laevigata* (1.65), *Celtis laevigata* (1.57), *Parkinsonia aculeata* (1.56).

% Protein: *Gynosperma glutinosum* (36.81), *Diospyros texana* (11.81), *Sideroxylon celastrinum* (15.13), *Celtis pallida* (25.75), *Ebenopsis ebano* (24.13), *Cordia boissieri* (20.5).

% C: *Leucophyllum frutescens* (49.97), *Forestiera angustifolia* (49.47), *Sideroxylon celastrinum* (49.25), *Acacia berlandieri* (49.18), *Acacia rigidula* (48.23), *Sargentia greggii* (44.07), *Cordia boissieri* (44.43).

% N: *Gynosperma glutinosum* (5.89), *Sideroxylon celastrinum* (2.42), *Celtis pallida* (4.12), *Acacia berlandieri* (3.82), *Diospyros texana* (1.89).

C/N ratio: *Sargentia greggii* (23.13), *Quercus virginiana* (21.95), *Croton suaveolens* (20.16), *Diospyros palmeri* (17.36), *Sideroxylon celastrinum* (20.35).

In the context of wide diversity in morpho-anatomical and eco-physiological traits there is a necessity of inter-disciplinary research inputs to unveil the mystery of co-existence and adaptation of the Woody species in xeric and cool environments in Northeastern Mexico. The detailed aspects of these phenomenon features are well explained in the book, Applied Biology of Woody Plants.

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