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Invasive alien woody plants of the Orange Free State

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Keywords: alien, Grassland Biome, invasive plants (woody), Nama-Karoo Biome, Orange Free State, roadside survey, Savanna Biome

ABSTRACT

The frequency and abundance of invasive alien woody plants were recorded along roadsides and at watercourse crossings in 66% (151/230) of the quarter degree squares in the study area. The survey yielded 64 species of which the most prominent (in order of prominence) in streambank habitats were: *Salix babylonica*, *Populus* × *canescens*, *Acacia dealbata* and *Salix fragilis* (fide R.D. Meikle pers. comm.). The most prominent species (in order of prominence) in roadside and veld habitats were: *Opuntia ficus-indica*, *Prunus persica*, *Eucalyptus* spp., *Rosa eglanteria*, *Pyracantha angustifolia* and *Acacia dealbata*.

Little invasion was recorded for most of the province. The greatest intensity of invasion was recorded along the perennial rivers and rocky hillsides in the moist grassland of the eastern mountain region bordering on Lesotho and Natal.

UITTREKSEL

Die frekwensie en volopheid van uitheemse houtagtige indringerplante is langs paaie en by oorgange oor waterlope in 66% (151/230) van die kwartgradevierkante in die studiegebied aangeteken. Daar is 64 spesies aangetref waarvan die vernaamste (in volgorde van belangrikheid) langs stroomoewers *Salix babylonica*, *Populus* × *canescens*, *Acacia dealbata* en *Salix fragilis* (fide R.D. Meikle pers. meded.) was. Die vernaamste spesies (in volgorde van belangrikheid) langs paaie en in veldhabitats was *Opuntia ficus-indica*, *Prunus persica*, *Eucalyptus* spp., *Rosa eglanteria*, *Pyracantha angustifolia* en *Acacia dealbata*.

Daar was min indringing in die grootste deel van die provinsie. Die ergste indringing is langs standhoudende riviere en op rotsagtige heuwels in die vogtige grasveld van die oostelike berggebied langs die Lesotho- en Natalse grense aangetref.

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INTRODUCTION

Survey history and objectives

This study of the Orange Free State (OFS) is the third of eight regional surveys which together are designed to reflect invasion by woody alien plants in the Republic of South Africa as a whole. Surveys have been completed for the Transvaal (Henderson & Musil 1984) and Natal (Henderson 1989). The north-eastern OFS was surveyed concurrently with north-western Natal in February 1987. The remainder of the OFS was surveyed during October 1987, October 1988 and November 1988.

The objectives of the survey are: to produce a checklist of the major invasive alien woody plants of streambank, roadside and veld habitats in the study area; to determine the pattern of alien woody invasion as a whole and for individual species; to attempt to relate distribution to environmental factors and to determine which are the most prominent and potentially important invaders.

The study area

The OFS occupies an area of 127 993 km² (Department of Foreign Affairs and Information 1983). It lies between latitudes 26° and 31°S and longitudes 24° and 30°E (Figure 1). It is situated on the central plateau of South Africa and consists largely of open rolling plains

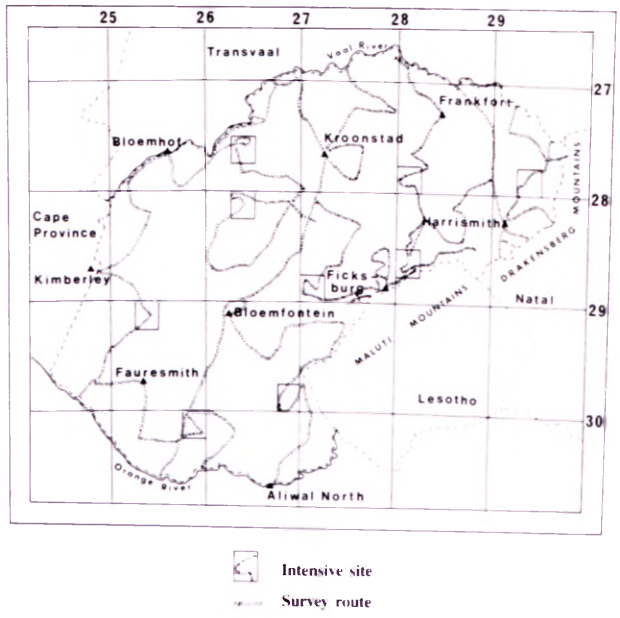


FIGURE 1.—The study area, survey routes and intensive sites.

interrupted at irregular intervals by low rocky hills. The general altitude above sea level varies from 1 000 m in the west to 2 000 m in the east. Near the borders of Lesotho and Natal the landscape becomes more undulating and high peaks up to 3 000 m occur along the Maluti and Drakensberg Mountains near the junction of the OFS, Lesotho and Natal borders.

Rain falls mainly in summer, the mean annual rainfall more or less coinciding with altitude. It averages only 250–380 mm in the west and increases gradually to 635–760 mm in the east with 890 mm or more near the Natal border (King 1951).

Summer temperatures are generally high, sometimes exceeding 38°C during mid-summer. The resultant high rate of evaporation causes a moisture deficit in virtually all regions of the province, so that perennial streams and continuously moist soils occur only in very limited areas of the high rainfall eastern districts (Roberts 1968). Periods of drought frequently occur in the spring and early summer (Van Rensburg 1975).

Winters are cold and dry, except in the mountainous eastern regions where mist and snow are common winter phenomena (Roberts 1968). Frost is moderate to severe over the entire province (Poynton 1972). Mean daily minimum temperatures for July range from less than −2,5°C to about 2,5°C (Schulze & McGee 1978). The highest frequency of below-freezing minimum temperatures occurs in the eastern Drakensberg region (Tyson 1986).

There are three biomes in the study area. These are Grassland, Nama-Karoo and Savanna (Rutherford & Westfall 1986) (Figure 2). Thirteen Acocks Veld Types (Acocks 1988) occur in the study area and have been grouped into four veld type categories for the purposes of this survey. These are temperate grassland, and moist subtropical and transitional grassland in the Grassland Biome; false karoo in the Nama-Karoo Biome; and Kalahari thornveld in the Savanna Biome (Table 1 and Figure 2).

Temperate grassland occupies the greatest area in the OFS. Indigenous woody species are scarce, being confined to occasional rocky hills. Moist subtropical grassland is situated in the high rainfall mountain region adjacent to the borders with Natal and northern Lesotho. Patches of indigenous forest occur in valleys and on sheltered mountain slopes. Transitional grassland links the temperate and moist subtropical grasslands in the highest and wettest parts of the OFS. It is undulating and broken country with indigenous scrub occurring on hillsides and ravine forests occurring in deep mountain valleys. Transitional and moist subtropical grassland have been combined here since they provide similar environmental conditions for the growth of woody species, which are the subject of this survey. Kalahari thornveld is limited to the extreme north-western portion of the province and is characterized by an open *Acacia* savanna, with a sparse ground cover of semi-arid grasses. False karoo occupies the western and south-western arid regions and is generally regarded as an induced formation resulting from the degradation and desertification of the original grassland (Acocks 1988). It is characterized by a sparse population of dwarf shrubs and mostly annual grasses. Trees and shrubs grow on the many low rocky hills.

METHOD

Sampling method

The method used in this survey was the same as that used in Natal (Henderson 1989). The presence and abundance of all naturalized alien trees and large shrubs were recorded for each veld type category, habitat type (roadsides and adjoining veld, and streambanks) and quarter

TABLE 1.—Veld type categories in the study area and the equivalent Acocks Veld Type groupings and Veld Type numbers

Veld type category*	Acocks Veld Type grouping	Acocks Veld Type No.
Temperate grassland	VI. Pure Grassveld Types	48, 49, 50, 51, 53, 58
Moist subtropical and transitional grassland	V. Temperate and Transitional Forest and Scrub Types	44
	VI. Pure Grassveld Types (transitional between Acocks 44 and Acocks 53 and Acocks 44 and Acocks 48)	54 56
Kalahari thornveld	III. Tropical Bush and Savanna Types	16
False karoo	IVA. False Karoo Types	35, 36, 41

* according to Henderson.

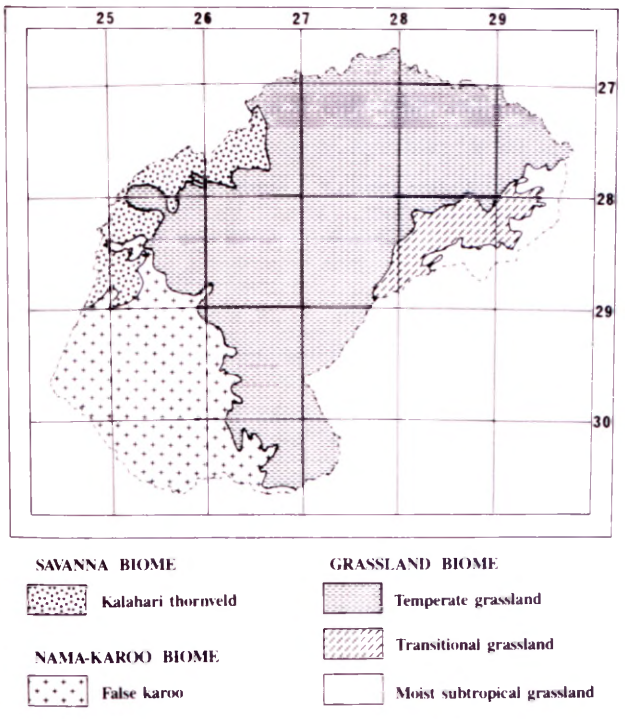


FIGURE 2.—The biomes and broad veld type categories in the study area, after Rutherford & Westfall (1986) and Acocks (1988).

degree square traversed by road. No naturalized climbers were seen in this survey. Although the objective of the survey was to record woody species, other large non-woody and succulent species were included rather than lose valuable information.

Recordings of roadside and veld invaders were made from a moving vehicle whereas recordings of streambank invaders were made while stationary at watercourse crossings. Abundance estimates of roadside and veld invaders were based on frequency of encounter within road transects of five to ten kilometres in length. Abundance estimates of streambank invaders were based on estimates at specific sites.

The width of road transects and length of watercourses scanned for invaders varied according to local conditions. Usually no more than 50 m of veld and 100 m of streambank habitat were scanned on either side of the road for invaders. Species occurring beyond these ranges and along watercourses which were not crossed were recorded as present in the given habitat type and veld type category but were not included within the formal recordings.

Nine quarter degree squares were selected, using a combination of systematic and subjective methods, for more intensive surveying (Figure 1). Initial site selection was systematic and on a country-wide basis, the sites being situated approximately two degree squares apart along each line of latitude and longitude. This ensured an even spread of sites through the whole country and through each biome. Further sites were subjectively selected to incorporate representative parts of each veld type category and geographical subregion in the study area. The intensive sites may also be used at a later date for a quick resurvey of the study area to assess any changes that may have taken place. In each of the nine sites abundance recordings of roadside and veld invaders were made along a total road length of approximately 30 km (six transects each five km long). Recordings were made at virtually all watercourse crossings. Herbarium specimens of all invader species which were flowering or fruiting, were collected.

Survey routes and road transects were plotted on 1:250 000 maps (general survey area) and 1:50 000 maps (intensive sites) before a field trip was undertaken. Wherever possible two or more road transects were plotted per quarter degree square. As in the Natal survey (Henderson 1989) road transects usually were not contiguous but were separated by a distance of between five and ten kilometres. Road transects along national roads and other routes with heavy traffic were kept to a minimum. Recordings were made at most bridges over watercourses but some were omitted because of time constraints and traffic considerations.

Abundance ratings

The abundance ratings for roadside and veld habitats and streambank habitats are given in Table 2. Henderson (1989) recommended that the abundance scale for streambank habitats be revised or replaced with a cover-abundance scale. Most of the field work for this survey had already been completed when this recommendation was made. The old abundance scale was therefore retained in this survey but will be replaced by a cover-abundance scale in further surveys.

Sampling level achieved

The sampling level achieved in this survey was 66% (151 of the total 230 quarter degree squares) at an average of 29 km travelled per square. An average of 18 km of road transects were sampled per quarter degree square for abundance estimates of roadside and veld invaders.

The veld type coverage in terms of quarter degree squares and road transects sampled, kilometres travelled and watercourse recordings made, is given in Table 3.

Data treatment—formulae used

Frequency

The percentage frequency of occurrence of a species x in veld type category y was calculated as follows:

$$\text{frequency} = \frac{\text{no. of watercourse recordings/road transects in veld type y having species x}}{\text{total no. of watercourse recordings/road transects in veld type y}} \times 100$$

All frequencies were expressed as percentages, even though some sample sizes were less than 100. This was done to facilitate comparisons with other similar statistics, and the error terms associated with these estimates should be borne in mind.

Prominence value

The prominence value is a combined measure of a species' frequency and abundance relative to that of all other species, within a particular vegetation category.

TABLE 2.—Abundance ratings

Rating	Roadsides and veld	No. *	Streambanks	Rating
9	A virtually continuous, almost pure stand	1000+	A virtually continuous, almost pure stand	7
8	The commonest species in a generally continuous tree or shrub layer	500–999	The commonest species in a generally continuous tree or shrub layer	6
7	Less abundant than above but greater than 20 individuals or groups per km	200–499		
6	10–20 individuals or groups per km	100–199		
5	5–10 individuals or groups per km	50–99	1 of the 2 or 3 commonest species in a generally continuous tree or shrub layer	5
4	2–5 individuals or groups per km	20–49	1 of the 4–6 commonest species in a generally continuous tree or shrub layer	4
3	± 1 individual or group per km	5–19	1 of the 7–11 commonest species in a generally continuous tree or shrub layer	3
2	Less abundant than above but more than 1 individual or group per 5 km	2–4	Less abundant than above but more than 1 individual present	2
1	± 1 plant or group per 5–10 km	1	1 plant in a sample	1

* Approximate numbers of individuals/groups per 10 km transect.

It has been derived from Curtis' Importance Value (Mueller-Dombois & Ellenberg 1974) and was first described by Henderson (1989).

In streambank habitats the prominence value for a species x in veld type category y was calculated as follows:

$$\text{prominence value} = \frac{\text{frequency of species x in veld type y scoring an abundance rating of 5, 6 or 7}}{\text{sum frequency of all species in veld type y scoring abundance ratings of 5, 6 or 7}} \times 100 + \frac{\text{frequency of species x in veld type y}}{\text{sum frequency of all species in veld type y}} \times 100$$

The selection of abundance rating 5 as the cut-off point is arbitrary but one at which a species can be regarded as locally prominent (see definition in Table 2). A formula using all abundance ratings would be preferable if each rating could be converted to an absolute value.

In roadside and veld habitats the prominence value for a species x in veld type category y was calculated as follows:

$$\text{prominence value} = \frac{\text{total abundance* of species x in veld type y}}{\text{sum of the abundances* of all species in veld type y}} \times 100 + \frac{\text{frequency of species x in veld type y}}{\text{sum frequency of all species in veld type y}} \times 100$$

* each abundance rating was expressed in numbers of individuals or groups recorded per transect (see Table 2). To be both conservative and consistent the minimum number was used in each instance, e.g. an abundance rating of 5 over ten kilometres = 50 and an abundance rating of 5 over five kilometres = 25.

** mean no. of individuals or groups per 10 km converted to rating (see Table 2).

Mean species abundance rating in roadside and veld habitats (see Table 7)

The mean abundance rating** of a species x in veld type category y was calculated as follows:

$$\text{mean no. of individuals or groups per 10 km} = \frac{\text{total no. of individuals or groups of species x in veld type y}}{\text{total distance along which species x was rated in veld type y}} \times 10$$

Mean abundance of invaders per km in roadside and veld habitats (see Table 5 and Figure 5)

The mean abundance of invaders per kilometre in veld type category y/quarter degree square z was calculated as follows:

$$\text{mean abundance} = \frac{\text{total abundance* of all species in veld type y/quarter degree square z}}{\text{total kilometres rated for abundance estimates in veld type y/quarter degree square z}}$$

RESULTS

The survey yielded 64 naturalized alien species. These species are listed in the Appendix together with a further six species which were obtained from specimen labels in the National Herbarium. All these species with the possible exception of *Nicotiana glauca* have been cultivated in the OFS and have spread spontaneously from gardens and plantations into the surrounding countryside. The distributions and high abundance areas of 30 of the most prominent species are given in Figures 6 & 7.

The streambank habitat

The whole study area

Three hundred and ninety watercourse crossings were sampled in which 42 species were recorded, with up to

TABLE 3.—Sampling coverage in each veld type category, Biome and the study area

Veld type category† and Biome‡	¼ degree squares	Road transects	Distance (km)*	Watercourse recordings
Grassland Biome	109	201	1 757	323
Temperate grassland†	92	160	1 416	223
Moist subtropical and transitional grassland†	21	41	341	100
Nama-Karoo Biome				
False karoo†	31	41	364	49
Savanna Biome				
Kalahari thornveld†	18	32	258	18
Study area	151	274	2 379	390

* This represents the distance along which abundance recordings were made. Total distance along which observations were made is approximately one and a half times that given; † according to Henderson; ‡ according to Rutherford & Westfall 1986.

TABLE 4.—Statistics for streambanks in each veld type category, Biome and the study area

Veld type category† and Biome‡	Total no. of spp.	Average no. of spp./crossing	Max. no. of spp./crossing	% crossings heavily invaded*	% crossings invaded**
Grassland Biome	39	1,6	12	19,5	79,6
Temperate grassland†	37	1,4	12	9,4	75,3
Moist subtropical and transitional grassland†	21	2,1	7	42,0	89,0
Nama-Karoo Biome					
False karoo†	13	0,7	9	0,0	38,8
Savanna Biome					
Kalahari thornveld†	3	0,4	2	0,0	33,3
Study area	42	1,5	12	16,2	72,3

* one or more species scored an abundance rating of 5 or more; ** invaders present; † according to Henderson; ‡ according to Rutherford & Westfall 1986.

TABLE 5.—Statistics for roadside and veld habitats in each veld type category, Biome and the study area

Veld type category† and Biome‡	Total no. of spp.	Average no. of spp./ ¼° sq.	Max. no. of spp./ ¼° sq.	% transects invaded	% transects heavily invaded*	Mean abundance of invaders per km**
Grassland Biome	55	6,4	21	91,5	3,5	1,2
Temperate grassland†	48	5,7	17	90,6	1,3	0,8
Moist subtropical and transitional grassland†	38	8,6	21	95,1	12,2	2,9
Nama-Karoo Biome						
False karoo†	26	4,0	10	95,1	0,0	0,4
Savanna Biome						
Kalahari thornveld†	13	2,9	6	75,0	0,0	0,3
Study area	58	5,7	21	90,1	2,6	1,0

* one or more species scored an abundance rating of 5 or more; ** see data treatment-formulae used; † according to Henderson; ‡ according to Rutherford & Westfall 1986.

12 species in one sample. Invaders were present at 72,3% of all crossings and 16,2% of all crossings were heavily invaded (Table 4).

Analysis according to veld type

The greatest intensity of invasion was recorded in moist subtropical and transitional grassland. Half the total number of species and two-thirds (42/63) of all heavily invaded watercourse crossings were recorded in this relatively small area. There was a progressive decrease in the intensity of invasion from east to west with the least invasion occurring in Kalahari thornveld.

Analysis according to species

Frequency

Salix babylonica was the most frequently recorded invader in all veld type categories and the whole study area (62,8%). It was most frequent in moist subtropical and transitional grassland where it was recorded at 76% of all watercourse crossings (Table 6).

TABLE 6. — Alien species occurring in streambank habitats

Biome‡ and veld type category†	Grassland Biome									Nama-Karoo Biome			Savanna Biome			Total study area		
	Temperate grassland†			Moist subtropical and transitional grassland†			Total			False karoo†			Kalahari thornveld†					
No. watercourse crossings	223			100			323			49			18			390		
	F	I	P	F	I	P	F	I	P	F	I	P	F	I	P	F	I	P
Acacia																		
baileyana	*			*			*									*		
dealbata	0,4		0,3	20,0	11,0	33,2	6,5	3,4	19,2							5,4	2,8	18,8
decurrens				1,0		0,5	0,3		0,2							0,3		0,2
Agave																		
americana	1,8		1,2				1,2		0,7	6,1		8,3				1,8		1,2
Ailanthus																		
altissima	*						*			*						*		
Arundo																		
donax	1,8		1,2				1,2		0,7	12,2		16,7				2,6		1,8
Cortaderia																		
sp.	*						*									*		
Cotoneaster																		
sp.				1,0		0,5	0,3		0,2							0,3		0,2
Cupressus																		
arizonica	1,3		0,9	3,0		1,5	1,9		1,2							1,5		1,0
sp.	0,4		0,3				0,3		0,2							0,3		0,2
Eucalyptus																		
tereticornis	0,4		0,3				0,3		0,2							0,3		0,2
spp.	6,3		4,2	*			4,3		2,6	2,0		2,7	16,7		37,5	4,6		3,1
Fraxinus																		
americana	0,4		0,3				0,3		0,2							0,3		0,2
Gleditsia																		
triacanthos	3,1		2,1	*			2,2		1,3	2,0		2,7				2,1		1,4
Juniperus																		
spp.	3,1		2,1	1,0		0,5	2,5		1,5							2,1		1,3
Ligustrum																		
sp.	0,4		0,3				0,3		0,2							0,3		0,2
Melia																		
azedarach	1,8		1,2				1,2		0,7							1,0		0,7
Morus																		
alba	2,7		1,8				1,9		1,2							1,5		1,0
Nicotiana																		
glauca										2,0		2,7				0,3		0,2
Opuntia																		
ficus-indica	3,1		2,1	*			2,2		1,4	*						1,8		1,2
sp. cf. *robusta* cultivars	0,9		0,6				0,6		0,4							0,5		0,3

F = % frequency of occurrence; I = % crossings heavily invaded; P = prominence value; * species occurring in the given category but not included in a formal recording at a watercourse crossing; † according to Henderson; ‡ according to Rutherford & Westfall 1986.

TABLE 6.—Alien species occurring in streambank habitats (continued)

Biome‡ and veld type category†	Grassland Biome									Nama-Karoo Biome			Savanna Biome			Total study area		
	Temperate grassland†			Moist subtropical and transitional grassland†			Total			False karoo†			Kalahari thornveld†					
No. watercourse crossings	223			100			323			49			18			390		
	F	I	P	F	I	P	F	I	P	F	I	P	F	I	P	F	I	P
Pinus																		
elliottii	0,4		0,3				0,3		0,2							0,3		0,2
spp.	0,4		0,3	*			0,3		0,2							0,3		0,2
Populus																		
× *canescens*	12,6		8,5	33,0	7,0	31,6	18,9	2,2	21,5	6,1		8,3	5,6		12,6	16,7	1,8	21,1
nigra	4,5		3,0	3,0		1,5	4,0		2,4	8,2		11,2				4,4		3,0
spp.	9,4		6,3				6,5		4,0	4,1		5,6				5,9		4,0
Prosopis																		
sp. cf. *glandulosa*	0,9		0,6				0,6		0,4							0,5		0,3
Prunus																		
armeniaca	0,4		0,3	1,0		0,5	0,6		0,4							0,5		0,3
persica	3,1		2,1	14,0		7,2	6,5		4,0							5,4		3,7
Pyracantha																		
angustifolia	3,6		2,4	13,0		6,7	6,5		4,0							5,4		3,7
Quercus																		
robur	0,4		0,3	*			0,3		0,2							0,3		0,2
Robinia																		
pseudoacacia	4,0	0,4	6,4	4,0		2,1	4,0	0,3	3,8							3,3	0,3	3,9
Rosa																		
eglanteria	4,0		2,7	6,0		3,1	4,6		2,8							3,8		2,6
Salix																		
babylonica	70,4	9,9	139,8	76,0	23,0	87,1	72,1	13,9	106,3	16,3		22,3	22,2		49,9	62,8	11,5	104,9
fragilis (fide R.D. Meikle pers. comm.)	3,1	0,4	5,8	17,0	6,0	21,3	7,4	2,2	14,4							6,2	1,8	13,9
Schinus																		
molle										12,2		16,7				1,5		1,0
Sesbania																		
punicea	1,8		1,2	1,0	1,0	2,6	1,5	0,3	2,3							1,3	0,3	2,5
Sophora																		
sp. cf. *davidii*	0,4		0,3				0,3		0,2							0,3		0,2
Tamarix																		
chinensis	1,3		0,9				0,9		0,5	2,0		2,7				1,0		0,7
Yucca																		
sp. cf. *aloifolia*	0,4		0,3				0,3		0,2							0,3		0,2

F = % frequency of occurrence; I = % crossings heavily invaded; P = prominence value; * species occurring in the given category but not included in a formal recording at a watercourse crossing; † according to Henderson; ‡ according to Rutherford & Westfall 1986.

TABLE 7.—Alien species occurring in roadside and veld habitats

Biome‡ and veld type category†	Grassland Biome									Nama-Karoo Biome			Savanna Biome			Total study area		
	Temperate grassland†			Moist subtropical and transitional grassland†			Total			False karoo†			Kalahari thornveld†					
No. road transects	160			41			201			41			32			274		
	F	A	P	F	A	P	F	A	P	F	A	P	F	A	P	F	A	P
Acacia																		
baileyana	1,3	1,0	0,6	10,0	2,0	2,9	3,0	2,0	1,4							2,2	2,0	1,2
cultriformis	*						*									*		
dealbata	8,8	2,0	7,0	65,9	3,0	32,9	20,4	3,0	17,6							15,0	3,0	15,4
decurrens				4,9	1,0	1,2	1,0	1,0	0,4							0,7	1,0	0,3
mearnsii	*			7,3	3,0	2,5	1,5	3,0	1,0							1,1	3,0	0,8
Agave																		
americana	5,6	1,0	3,0	*			4,5	1,0	1,9	36,6	1,0	28,2	12,5	1,0	16,7	10,2	1,0	5,1
Ailanthus																		
altissima	1,3	1,0	0,6	2,4	1,0	0,6	1,5	1,0	0,6				*			1,1	1,0	0,5
Arundo																		
donax	2,5	1,0	1,2				2,0	1,0	0,8	2,4	2,0	1,6	3,1	1,0	3,8	2,2	1,0	1,0
Atriplex																		
sp.													*			*		
Caesalpinia																		
gilliesii	*						*			*			*			*		
Cedrus																		
deodara	*			2,4	1,0	0,6	0,5	1,0	0,2							0,4	1,0	0,2
Cereus																		
peruvianus	*						*						3,1	1,0	3,8	0,4	1,0	0,2
Cotoneaster																		
pannosus				2,4	2,0	0,7	0,5	2,0	0,2							0,4	2,0	0,2
sp.	1,3	1,0	0,7	2,4	2,0	0,6	1,5	1,0	0,6							1,1	1,0	0,5
Crataegus																		
× *lavallei*	*			2,4	1,0	0,6	0,5	1,0	0,2							0,4	1,0	0,2
Cupressus																		
arizonica	8,1	1,0	4,5	26,8	2,0	7,9	11,9	2,0	5,7	4,9	1,0	3,3				9,5	2,0	5,2
spp.	0,6	1,0	0,3	9,8	1,0	2,4	2,5	1,0	1,0							1,8	1,0	0,9
Cydonia																		
oblonga	*						*			2,4	1,0	1,6				0,4	1,0	0,2
Eucalyptus																		
spp.	44,4	2,0	30,7	58,5	2,0	17,2	47,3	2,0	25,1	9,8	1,0	7,2	3,1	1,0	3,8	36,5	2,0	22,4
Fraxinus																		
americana	1,3	1,0	0,7				1,0	1,0	0,4	9,8	1,0	7,2				2,2	1,0	1,1
Gleditsia																		
triacanthos	23,1	1,0	13,3	17,0	2,0	4,6	21,9	1,0	10,0	4,9	2,0	3,9	6,3	1,0	9,1	17,5	1,0	9,3
Juniperus																		
spp.	3,8	2,0	4,0	4,9	2,0	1,7	4,0	2,0	2,7							2,9	2,0	2,4

F = % frequency of occurrence; A = mean abundance rating; P = prominence value; * species occurring in the given category but not included in a formal recording in a road transect; † according to Henderson; ‡ according to Rutherford & Westfall 1986.

TABLE 7.—Alien species occurring in roadside and veld habitats (continued)

Biome‡ and veld type category†	Grassland Biome									Nama-Karoo Biome			Savanna Biome			Total study area		
	Temperate grassland‡			Moist subtropical and transitional grassland‡			Total			False karoo†			Kalahari thornveld†					
No. road transects	160			41			201			41			32			274		
	F	A	P	F	A	P	F	A	P	F	A	P	F	A	P	F	A	P
Malus																		
pumila	0,6	1,0	0,3	4,9	2,0	1,2	1,5	1,0	0,6							1,1	1,0	0,5
Melia																		
azedarach	8,1	1,0	4,2	2,4	1,0	0,6	7,0	1,0	2,9	12,2	1,0	10,6	12,5	1,0	16,7	8,4	1,0	4,2
Morus																		
alba	1,3	1,0	0,6	2,4	1,0	0,6	1,5	1,0	0,6							1,1	1,0	0,5
Nicotiana																		
glauca	0,6	2,0	0,4				0,5	2,0	0,2	2,4	1,0	1,6				0,7	1,0	0,4
Opuntia																		
ficus-indica	43,1	2,0	30,9	17,0	1,0	4,4	37,8	2,0	20,4	43,9	1,0	35,6	46,9	2,0	95,6	39,8	2,0	24,7
imbricata	1,3	1,0	0,7				1,0	1,0	0,4	2,4	1,0	1,6				1,1	1,0	0,5
sp. cf. *robusta* cultivars	19,4	2,0	14,4	*			15,4	2,0	8,7	34,1	1,0	29,0	18,8	1,0	23,2	18,6	2,0	11,3
Pinus																		
elliottii	5,6	2,0	3,9	7,3	2,0	1,8	6,0	2,0	3,1							4,4	2,0	2,6
patula				2,4	1,0	0,6	0,5	1,0	0,2							0,4	1,0	0,2
sp. cf. *halepensis*										4,9	1,0	3,3				0,7	1,0	0,3
sp. cf. *uncinata*				*			*									*		
spp.	0,6	1,0	0,3	26,8	2,0	8,8	6,0	2,0	3,5	*						4,4	2,0	1,7
Populus																		
× *canescens*	8,8	1,0	4,4	19,5	2,0	5,2	10,9	1,0	4,6	2,4	1,0	1,6				8,4	1,0	4,1
nigra	3,1	1,0	1,6	9,8	2,0	2,6	4,5	1,0	2,0	2,4	1,0	1,6				3,6	1,0	1,8
spp.	3,1	1,0	1,5	7,3	2,0	2,2	4,0	1,0	1,8	*						2,9	1,0	1,5
Prosopis																		
spp.	5,0	2,0	3,2				4,0	2,0	2,0	17,1	2,0	26,8	15,6	2,0	27,1	7,3	2,0	5,0
Prunus																		
armeniaca	0,6	2,0	0,3	7,3	1,0	1,7	2,0	1,0	0,8	2,4	1,0	1,6				1,8	1,0	0,8
persica	33,8	2,0	24,1	65,9	3,0	29,7	40,3	2,0	26,6	9,8	1,0	7,2				31,0	2,0	23,7
Punica																		
granatum	*						*			4,9	1,0	3,3				0,7	1,0	0,3
Pyracantha																		
angustifolia	15,0	3,0	15,9	51,2	3,0	24,7	21,9	3,0	19,1	*						16,1	3,0	16,7
fortuneana	*			*			*									*		
rogersiana	1,9	1,0	1,1				1,5	1,0	0,7							1,1	1,0	0,6
sp.	0,6	1,0	0,3				0,5	1,0	0,2							0,4	1,0	0,2
Pyrus																		
sp.				*			*									*		
Quercus																		
robur				*			*									*		

F = % frequency of occurrence; A = mean abundance rating; P = prominence value; * species occurring in the given category but not included in a formal recording in a road transect; † according to Henderson; ‡ according to Rutherford & Westfall 1986.

TABLE 7.—Alien species occurring in roadside and veld habitats (continued)

Biome‡ and veld type category†	Grassland Biome									Nama-Karoo Biome			Savanna Biome			Total study area		
	Temperate grassland†			Moist subtropical and transitional grassland†			Total			False karoo†			Kalahari thornveld†					
No. road transects	160			41			201			41			32			274		
	F	A	P	F	A	P	F	A	P	F	A	P	F	A	P	F	A	P
Robinia pseudoacacia	7,5	1,0	4,1	9,8	3,0	6,2	8,0	2,0	5,2							5,8	2,0	4,4
Rosa eglanteria	15,0	3,0	18,0	53,7	3,0	33,0	22,9	3,0	24,2							16,8	3,0	21,2
Rubus sp.	0,6	2,0	0,4				0,5	2,0	0,2							0,4	2,0	0,2
Schinus molle	2,5	1,0	1,4				2,0	1,0	0,9	26,8	1,0	21,6	*			5,5	1,0	2,9
Sesbania punicea	*			2,4	1,0	0,6	0,5	1,0	0,2							0,4	1,0	0,2
Tamarix chinensis	1,3	2,0	1,0				1,0	2,0	0,6	*						0,7	2,0	0,5
Trichocereus sp.	*						*									*		
Yucca sp. cf. *aloifolia*				*			*			2,4	1,0	1,6				0,4	1,0	0,2

F = % frequency of occurrence; A = mean abundance rating; P = prominence value; * species occurring in the given category but not included in a formal recording in a road transect; † according to Henderson; ‡ according to Rutherford & Westfall 1986.

Populus × *canescens* was the next most frequent invader in the study area (16,7%) and was also most frequently recorded in moist subtropical and transitional grassland (33,0%). *P.* × *canescens* and *S. babylonica* were the only species to be recorded at more than 10% of all watercourse crossings in the study area.

Other species which were recorded at more than 10% of crossings in a veld type category were: *Acacia dealbata*, *Salix fragilis*, *Prunus persica* and *Pyracantha angustifolia* in moist subtropical and transitional grassland, and *Arundo donax* and *Schinus molle* in false karoo (Table 6).

Prominence

Salix babylonica was by far the most prominent riverine invader in the study area with a prominence value of 104,9 out of a combined total for all species of 200 (Table 6). It was also the most prominent invader in each of the veld type categories. *Populus* × *canescens*, *Acacia dealbata* and *Salix fragilis* were less prominent but all formed continuous stands along riverbanks in parts of moist subtropical and transitional grassland.

Roadside and veld habitats

The whole study area

One hundred and fifty one quarter degree squares and 274 road transects were sampled in which 58 species were recorded. Up to 21 species were recorded per quarter degree square. Naturalized species were recorded in 90,1% of all transects sampled but only 2,6% of all transects were heavily invaded (Table 5).

Analysis according to veld type

The greatest intensity of invasion was recorded in moist subtropical and transitional grassland (Table 5). Two-thirds of the total number of species were recorded here as well as most (5/7) of the heavily invaded transects. There was a progressive decrease in the intensity of invasion from the grassland types in the east to the savanna and karoo types in the west.

Analysis according to species

Frequency

The most frequently recorded species in the study area were *Opuntia ficus-indica* (39,8%), *Eucalyptus* spp. (36,5%) and *Prunus persica* (31,0%). *Opuntia* sp. cf. *robusta* cultivars, *Gleditsia triacanthos*, *Rosa eglanteria*, *Pyracantha angustifolia* and *Acacia dealbata* were recorded in more than 10% of all road transects (Table 7).

The highest percentage frequencies were recorded in moist subtropical and transitional grassland where *Acacia dealbata*, *Prunus persica*, *Eucalyptus* spp., *Rosa eglanteria* and *Pyracantha angustifolia* were recorded in more than 50% of all transects (Table 7).

Prominence

Opuntia ficus-indica scored the highest prominence value of 24,7 in the study area and in each veld type category with the exception of moist subtropical and transitional grassland where *Acacia dealbata* and *Rosa eglanteria* were the most prominent species (Table 7).

Only three species scored abundance ratings of 5 or more in road transects (Table 2) and these were *Acacia dealbata*, *Rosa eglanteria* and *Pyracantha angustifolia*. Species which were occasionally abundant in isolated localities were *Opuntia* sp. cf. *robusta* cultivars, *O. ficus-indica*, *Cupressus arizonica*, *Prunus persica* and *Juniperus* spp.

Patterns of invasion

Alien species are naturalized in streambank, roadside and veld habitats throughout the province. However, the greatest intensity of invasion in terms of species diversity and abundance of invaders was recorded in the eastern mountain region bordering on Lesotho and Natal (Figures 3, 4 & 5). Within this zone the most invasion was recorded in the Harrismith, Ficksburg, Fouriesburg and Golden Gate Districts.

A comparison of Figures 3 & 4, indicating the severity of invasion in streambank and roadside and veld habitats respectively, shows similar patterns except that in the north-eastern region there is more severe invasion of the streambank habitat than of roadside and veld habitats. This pattern of streambank invasion is mainly the result of *Salix babylonica* invasions.

DISCUSSION

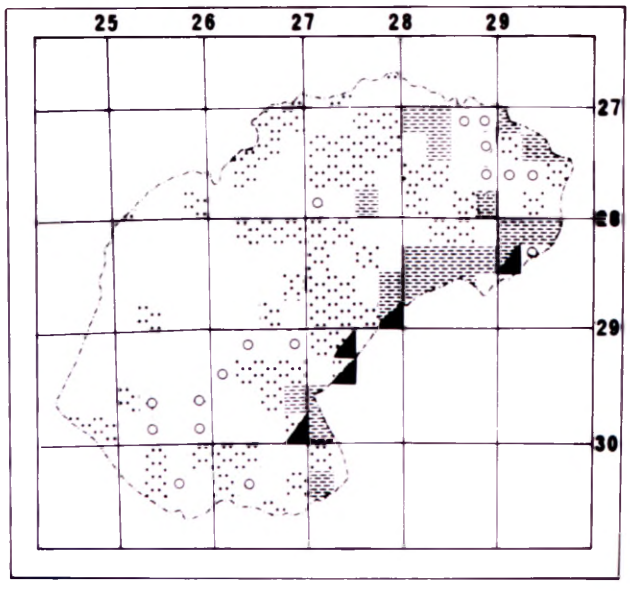
Indigenous versus alien species composition

Only 184 indigenous species of trees and shrubs were documented for the OFS by Venter & Joubert (1984). Alien species therefore constitute approximately one third (70/254) of the total (indigenous and naturalized) tree and shrub species of the province.

Indigenous species belong to 58 families, the Anacardiaceae being the largest with a total of 21 species, 19 of which are *Rhus* species. Naturalized alien species belong to 19 families, the largest being the Rosaceae with 16 species. Alien species of Rosaceae outnumber the indigenous species by at least three to one. Eleven families are represented by only alien species. The largest families which are alien to South Africa are the Pinaceae and Cactaceae (i.e. assuming that *Rhipsalis baccifera* is an early introduction and not indigenous).

Only two indigenous species, *Podocarpus latifolius* (family Podocarpaceae) and the very rare *Widdringtonia nodiflora* (family Cupressaceae) belong to the Gymnospermae whereas naturalized alien Gymnosperms number nine or more species. These alien species belong to the families Pinaceae (six or more species) and Cupressaceae (three or more species).

Alien species of the family Salicaceae account for most riverine invasion in the OFS. Only one indigenous species,



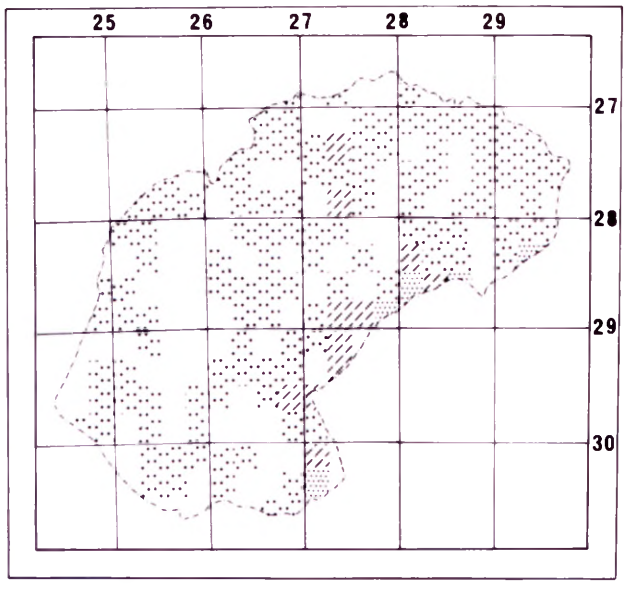
10 or more species per quarter degree square

1 or more river crossings heavily invaded

1 or more river crossings invaded

1 or more rivers invaded, but no formal recordings

FIGURE 3.—Invasion in streambank habitats in terms of the intensity of invasion of watercourse crossings and species diversity per quarter degree square.



Mean abundance per km:

less than 2 individuals/groups

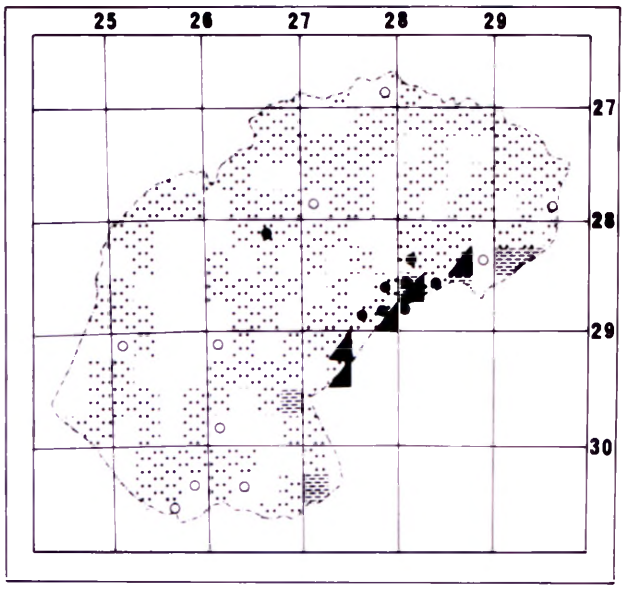
2–4 5–8

FIGURE 5.—Invasion in roadside and veld habitats in terms of the mean abundance of invaders per kilometre in each quarter degree square.

Salix mucronata, is represented in this family (Immelman 1987) but alien species number five or more.

Prominent and potentially important species

Salix babylonica, the weeping willow, is the most widespread riverine invader in the OFS. It forms continuous stands, some stretching for many kilometres, along the major perennial watercourses, particularly the Caledon, Wilge and Vaal Rivers. Although it has been planted at dams and along rivers for ornament, shade, fodder and erosion control its wide distribution along watercourses is most likely due to self (vegetative) propagation and dispersal by floodwaters. It is probable that *S. fragilis* is propagated and dispersed in the same manner (Henderson in prep.).



15 or more species per quarter degree square

1 or more road transects heavily invaded

1 or more road transects invaded

1 or more species locally abundant

1 or more species invasive, but no formal recordings

FIGURE 4.—Invasion in roadside and veld habitats in terms of the intensity of invasion of road transects and species diversity per quarter degree square.

There has been some confusion regarding the identity of *Salix fragilis* (fide R.D. Meikle pers. comm.). It appears that the same species was incorrectly referred to as *S. lasiandra* by Henderson (1989). This matter will be dealt with in a paper on invasive *Salix* species in South Africa (Henderson in prep.).

Salix fragilis is less widespread than *S. babylonica* but also forms pure stands which can stretch for several kilometres, for example along the Wilge River near Harrismith. Although aesthetically pleasing and possessing many beneficial qualities, the *Salix* species pose a potential threat to the conservation of indigenous riparian species and may alter the hydrology of the watercourses they invade (Henderson in prep.).

There is no information available on water usage by the alien *Salix* species, nor any other alien riparian species, in South Africa (C. Bruwer 1989, Hydrological Research Institute, pers. comm.; and D. Versfeld 1989, Jonkershoek FRC, pers. comm.). This aspect of alien invasion needs urgent attention. Rivers in many parts of South Africa have been heavily invaded by alien woody species (Macdonald *et al.* 1986) and although stream flow is expected to be diminished, there is no evidence. *S. babylonica* and *S. fragilis*, which flourish along perennial rivers in the important water catchment areas of the

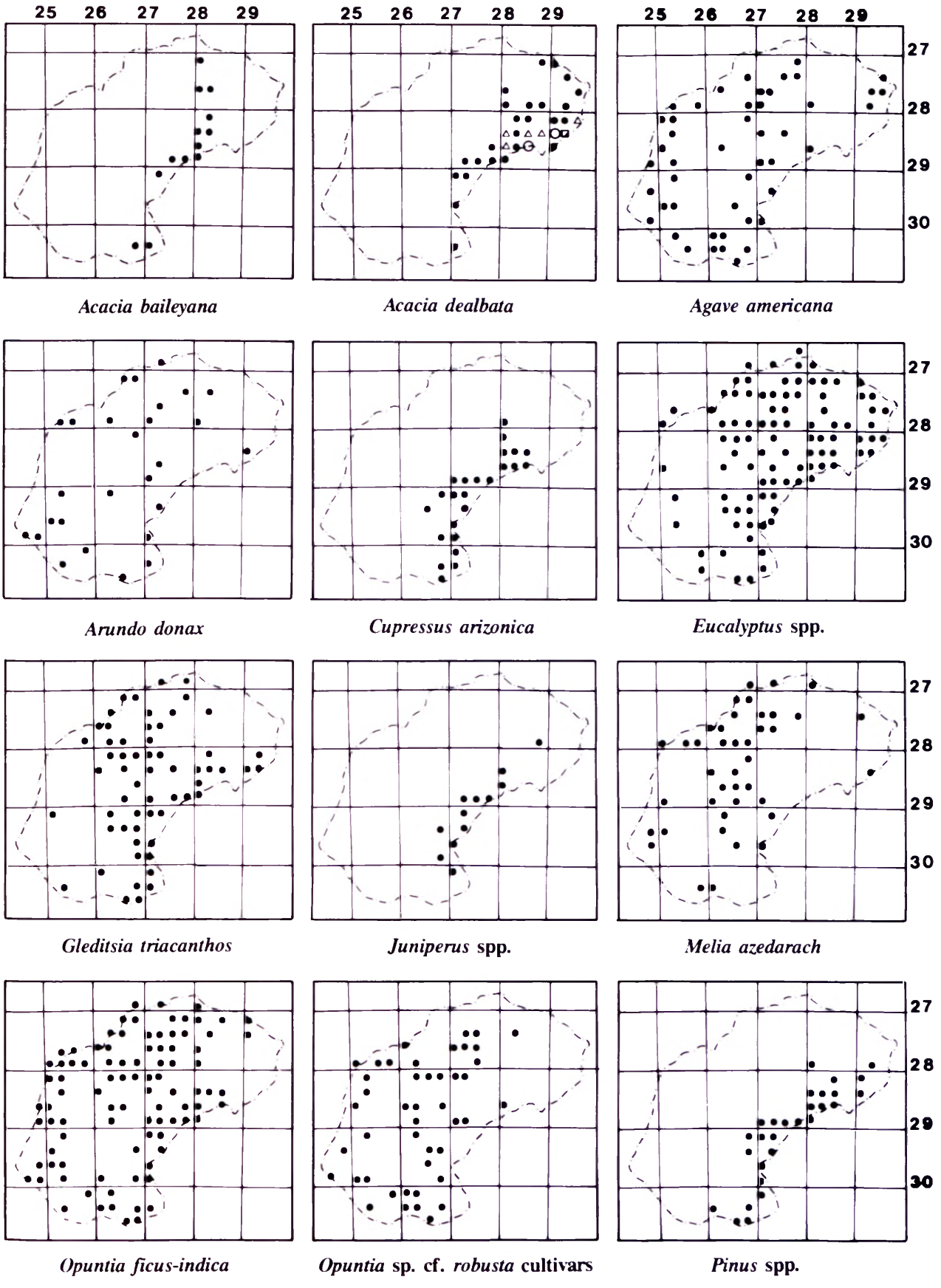


FIGURE 6.—Distribution of the most prominent species. Highest abundance rating of 4 or less: ●. Highest abundance rating of 5 or more: roadside and veld habitats, □; streambank habitats, △; streambank, roadside and veld habitats, ○.

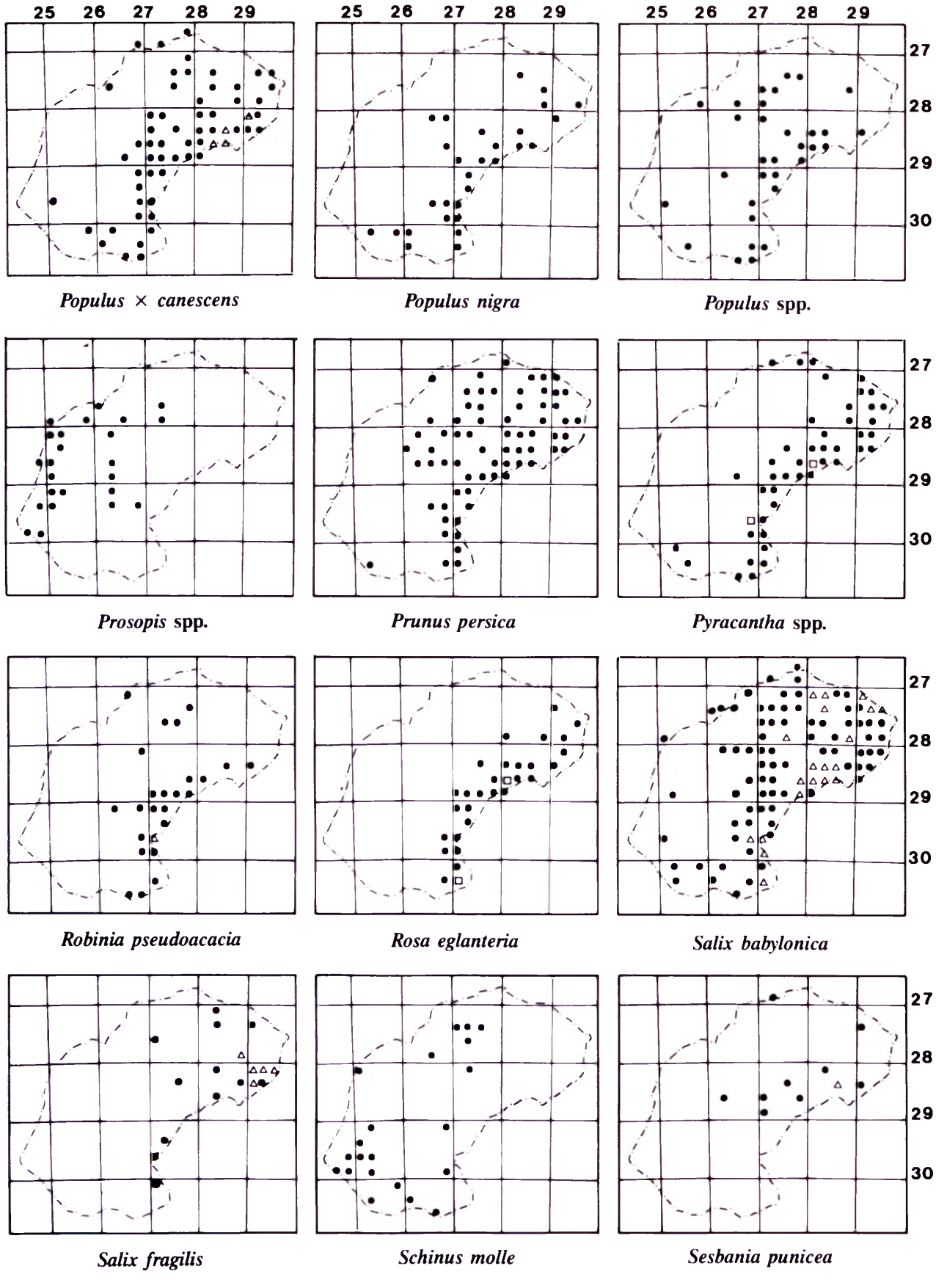


FIGURE 7.—Distribution of the most prominent species. Highest abundance rating of 4 or less: ●. Highest abundance rating of 5 or more: roadside and veld habitats, □; streambank habitats, △; streambank, roadside and veld habitats, ○.

central interior highlands (Henderson in prep.), might be significant water users in these parts. Their effects on stream flow would be most noticeable during times of drought. There is some evidence that deciduous species, like the *Salix* species, have greater water demands than evergreen species in spring (D.B. Versfeld pers. comm.) when water supplies are usually at their lowest.

Populus × *canescens* and *Acacia dealbata* form dense stands in places along watercourses. *P.* × *canescens* has a limited ability to spread as it only propagates vegetatively, but its profuse suckering enables it to form very dense stands. *A. dealbata* in contrast produces vast quantities of seed which is efficiently dispersed down watercourses enabling it to spread far afield; it could therefore become an important invader along the Caledon River. It is most invasive in moist subtropical and transitional grassland but has the potential to invade watercourses throughout the grassland areas and it may even penetrate the drier areas, as it has done in the Transvaal (Henderson & Musil 1984) and Natal (Henderson 1989). Its seed is relatively immobile out of water but may be dispersed in soil by road-building activities. It was sometimes recorded along roadsides for stretches of several kilometres.

Robinia pseudoacacia is a potentially important riverine invader as it can form dense suckering stands along watercourses. Its marked tendency to sucker has been used to advantage for the reclamation of dongas (Poynton 1973). It can also propagate from seed. According to Ridley (1930) its pods are very light and wind dispersed, shedding seed as they travel.

Rosa eglanteria, *Acacia dealbata*, *Pyracantha angustifolia* and *Prunus persica* are the most prominent invaders of veld habitats in the eastern OFS. *Rosa* and *Pyracantha* spp. are potentially the most important invaders of hillside scrub and surrounding grasslands in this region.

R. eglanteria and *P. angustifolia* are most invasive in the Fouriesburg, Clarens and Ficksburg Districts but are naturalized and locally abundant in the entire eastern region stretching from the Transvaal border in the north to the Cape border in the south. They are particularly abundant along rocky outcrops but also occur along dongas, fence lines and in open grassland. They are a potential threat to the conservation of indigenous woody species, many of which are confined to rocky outcrops. They may also pose a threat to grazing lands by replacing valuable grasses with impenetrable woody thickets.

Both *R. eglanteria* and *P. angustifolia* produce an abundance of brightly coloured fleshy fruits which are most likely to be dispersed by birds but possibly also by mammals. *R. eglanteria* which is a principle weed in New Zealand (Holm *et al.* 1979) is largely spread by horses in that country and is known to be eaten by cattle and goats in Tasmania (Ridley 1930).

Prunus persica, another member of the Rosaceae is widespread but appears to have a more limited ability to spread. It is usually confined to roadsides, railway lines, disturbed ground around habitation and at bridges over rivers which suggests that its distribution is largely determined by the dispersal of its seed by humans. Its fruit may also be dispersed by crows. Many large-seeded fruits, including those of *Prunus* spp. are known to be dispersed by crows (Ridley 1930).

Several gymnosperms are locally prominent on rocky outcrops in the eastern OFS. These include *Cupressus arizonica*, *Juniperus* sp. cf. *pinchotii*, *J. virginiana* and *Pinus elliottii*. *Juniperus* berries are eaten by many species of birds as well as small mammals throughout their native range in the northern hemisphere (Ridley 1930) and it is therefore likely that they are being dispersed in a similar manner in the OFS. *C. arizonica* and *P. elliottii* seeds are dispersed by wind. All these species are likely to be confined to rocky outcrops, ridges and dongas where they will receive some protection from fire.

Opuntia ficus-indica is one of the most widespread species in the OFS but occurs only as widely scattered plants. Its present distribution and abundance in South Africa is to a large extent controlled by introduced cactophagous insects (Zimmermann *et al.* 1986). It is therefore unlikely to become more abundant in the OFS. *Opuntia* sp. cf. *robusta* cultivars are also widespread but not abundant.

Eucalyptus spp. have been planted throughout the OFS for shade and shelter. Natural spread is usually confined to the immediate vicinity of plantings but watercourses might provide suitable conditions for their spread further afield. They were recorded along riverbanks and also on islands within perennial rivers. Some *Eucalyptus* spp. have been described by Brown & Gubb (1986) as moderately to highly invasive in many seminatural and natural habitats including riverine systems in the more arid regions to the west of the OFS.

Prosopis spp. are potentially important invaders of false karoo. These species are highly invasive in the arid northwestern Cape where they have infested more than 200 000 ha of land (Harding 1987). They are limited to areas with shallow ground water which are also the most fertile in these arid regions (Harding 1987).

Relation of invasion to environmental factors

There is a general trend for more invasion in terms of species diversity and abundance of invaders with increasing moisture availability from the dry savanna and karoo veld types in the west to the moist grassland types in the east. The most invasion occurs in the moist eastern mountain region bordering on Lesotho and Natal. Here invasion occurs along the perennial rivers and in terrestrial habitats particularly where rocky ridges and ravines afford some protection against fire and frost. Approximately 62% of the total alien species were recorded here. It has been estimated by extrapolation from Venter & Joubert (1984) that approximately 59% of indigenous woody species also occur in the moist eastern mountain region.

The large representation of alien Rosaceae (about 23% of the total alien species) may be partly explained in terms of minimum temperature requirements for seed germination. Many of the Rosaceae require stratification to terminate seed dormancy. This requirement may limit the distribution of species of *Rubus*, *Rosa*, *Pyracantha* and *Cotoneaster* to regions where winter temperatures fall

below 5°C (Dean *et al.* 1986). The whole of the OFS experiences minimum winter temperatures of below 5°C and the extreme eastern regions bordering on Lesotho and Natal, where the alien Rosaceae are most prominent, experience the highest frequencies of below-freezing minimum temperatures (Tyson 1986).

Watercourses have played an important role in the dispersal of several species. *Salix babylonica* and *Acacia dealbata* are good examples. There are no records of *S. babylonica* setting seed in South Africa. It spreads vegetatively from branches torn off by floodwaters and deposited downstream (Poynton 1973). *A. dealbata*, in contrast, produces vast quantities of rather immobile seeds. These seeds however are easily washed downstream enabling it to spread far from plantings. Stream flow also promotes the spread of suckering species such as *Populus* × *canescens*, which sends up a multitude of suckers when its roots become exposed, as well as *P. nigra* and *Robinia pseudo-acacia*.

Animals, particularly birds and mammals, may be important dispersal agents for many species. Seeds destined for being swallowed by animals are mainly those in a pulpy pericarp, being either drupaceous or baccate (Ridley 1930). A large proportion (47%) of the naturalized alien woody species in the OFS have fruits that are either drupes or berries. This includes all the species belonging to the Rosaceae. *Rosa eglanteria* and *Pyracantha angustifolia* are most noticeable as invaders of rocky hillside scrub in the eastern OFS. This vegetation type provides food, nesting sites and shelter for large numbers of birds and small mammals (Scheepers 1975).

CONCLUSION

Alien woody invasion is not expected to become a problem in the greater part of the OFS. The intensity of invasion is expected to increase the most in the moist grasslands in the eastern mountain region bordering on Lesotho and Natal. Here the spread of *Acacia dealbata*, *Rosa eglanteria* and *Pyracantha angustifolia* needs to be controlled. In the western drier regions fewer species are expected to become troublesome. The streambank habitat however could be threatened by alien invaders such as *Prosopis* and *Eucalyptus* spp.

Acacia dealbata appears to be the most aggressive invader species in terms of its ability to spread far from plantings and to produce a large number of individuals in a given area. It threatens the whole of the eastern mountain region and especially the perennial rivers. *Salix babylonica* is the most widespread riverine invader in the province and is particularly abundant along rivers in the important water catchment areas. Water usage by this species and other alien riparian species needs to be investigated.

ACKNOWLEDGEMENTS

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APPENDIX

The following is a species checklist of all naturalized alien trees and shrubs recorded during the survey as well as a few additional species cited on National Herbarium specimen labels (PRE). Some non-woody species are included.

Acacia
baileyana F.J. Muell., Bailey's wattle
cultriformis A. Cunn., knife-leaved wattle
dealbata Link, silver wattle
decurrens (J.C. Wendl.) Willd., green wattle
mearnsii De Wild., black wattle
Agave americana L., century plant
Ailanthus altissima (Mill.) Swingle, tree-of-heaven
Arundo donax L., giant reed
Atriplex sp.
Caesalpinia gilliesii (Wallich. ex Hook.) Benth., bird-of-paradise
Cedrus deodara (D. Don) G. Don, deodar
Cereus peruvianus (L.) Mill., queen of the night
Cestrum laevigatum Schlechtd. (PRE), inkberry
Cortaderia sp., pampas grass
Cotoneaster
franchetii Bois. (PRE), orange cotoneaster
pannosus Franch.
sp., cotoneaster
Crataegus
× *lavallei* Herincq, Lavallee thorn
monogyna Jacq. (PRE), English hawthorn
Cupressus
arizonica Greene
var. *glabra* (Sudw.) Little, smooth-barked Arizona cypress
var. *montana* (Wiggins) Little, Arizona cypress
spp., cypresses
Cydonia oblonga Mill., common quince
Cytisus scoparius (L.) Link (PRE), Scotch broom
Eucalyptus
tereticornis Sm., forest red gum
spp., gums
Fraxinus americana L., American ash
Gleditsia triacanthos L., honey locust
Juniperus spp. (*J. virginiana* L., red cedar; cf. *J. pinchotii* Sudw., redberry juniper and possibly other species)
Ligustrum sp., privet
Malus pumila Mill. var. *paradisiaca* (Medic.) C.K. Schneid., paradise apple
Melia azedarach L., syringa
Morus alba L., white mulberry
Nicotiana glauca R.C. Grah., wild tobacco
Opuntia
ficus-indica (L.) Mill., sweet prickly pear
imbricata (Haw.) DC., chain-link cactus
spinulifera Salm-Dyck (PRE), large round-leaved prickly pear
sp. cf. *robusta* cultivars, spineless prickly pears
Pinus
elliottii Engelm., slash pine
patula Schlechtd. & Cham., patula pine
? taeda L., loblolly pine
sp. cf. *P. halepensis* Mill., aleppo pine
sp. *cf. P. uncinata* Mill. ex Mirb.
spp., pines
Populus
× *canescens* (Ait.) J.E. Sm., grey poplar
nigra L. var. *italica* Muenchh., Lombardy poplar
spp. (cf. *P. deltoides* Bartr. ex Marsh., match poplar and possibly *P. wislizenii* Sarg., valley match poplar)
Prosopis spp. (*P. glandulosa* Torr. var. *glandulosa*, mesquite; cf. *P. glandulosa* Torr. var. *torreyana*, mesquite; *P. velutina* Wooton (PRE), velvet mesquite)
Prunus
armeniaca L., common apricot
persica (L.) Batsch., peach
Punica granatum L., pomegranate
Pyracantha
angustifolia (Franch.) C.K. Schneid., yellow firethorn
fortuneana (Maxim.) H.L. Li
rogersiana (A.B. Jacks.) Bean
Pyrus sp., pear tree
Quercus robur L., English oak
Robinia pseudoacacia L., black locust
Rosa eglanteria L., eglantine
Rubus sp., bramble
Salix
babylonica L., weeping willow
fragilis L. (fide R.D. Meikle, pers. comm.), basket willow
Schinus molle L., pepper tree
Sesbania punicea (Cav.) Benth., red sesbania
Sophora sp. cf. *S. davidii* (Franch.) Skeels
Tamarix chinensis Lour., Chinese tamarisk
Trichocereus sp.
Yucca sp. cf. *Y. aloifolia* L., Spanish bayonet