

Analysis of the streamside vegetation within the Hubbell Trading Post Historic Site, Apache County, Arizona

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February 2002

Abstract

Foliage-height density (FDH) of perennial vascular plants and percent cover of annual vascular plants were estimated for the riparian vegetation along Pueblo Colorado Wash within the boundaries of the Hubbell Trading Post National Historic Site, Apache County, Arizona. Data were recorded as a third repeat in a continuing assessment of changes in vegetation over time. Thirteen transects were measured in mid-August of 2001. There were few apparent differences in perennial vegetation between the summer of 1998 and the summer of 2001, except where additional efforts had undergone to eradicate the exotic shrubs *Elaeagnus angustifolius* (Russian-olive) and *Tamarix ramosissima* (salt-cedar). Within the streamside legs of the transects, two perennials, *Eleocharis parishii* (Parish spikerush) and *Equisetum arvensis* (common horsetail) were present in 1998 and absent in 2001. Conversely, within the bankside legs of the transects, three species of *Sporobolus*, *S. airoides* (alkali sacaton), *S. contractus* (spike dropseed), and *S. cryptandrus* (sand dropseed) were present in 2001 and not in 1998. In both 1998 and 2001, *Scirpus pungens* (common three-square) was the dominant herbaceous perennial and *Xanthium strumarium* (cocklebur) was the dominant annual, although the cover of *S. pungens* was much greater in 2001. Although speculations as to the cause of changes in vegetation are made, it is still premature to test hypotheses.

Introduction

The primary purpose of the latest measurement was to further assess changes in vascular riparian vegetation along Pueblo Colorado Wash of the Hubbell Trading Post Historic Site. Along most of the channel, attempts were made in spring of 1998 and 2000 to eradicate the exotic shrubs *Elaeagnus angustifolius* L. (Russian-olive) and *Tamarix ramosissima* Ledeb. (salt-cedar). It is the long-term goal of the U. S. Park Service to reestablish the channel vegetation to that which preceded its invasion by exotic species.

In order to estimate composition and structure of the present channel vegetation, foliage-height density or foliar-height density (FHD) by species of perennial vascular plants and percent cover by species of annual vascular plants were measured along bankside transects. Except for a single site, transects were paired, one on each side of the bank, six transects along the north bank and seven along the south bank. Both south-bank and north-bank transects were measured mid-summer 1998 and south-bank transects were remeasured early fall 1998. Thus, vegetation within the treated area was estimated before and after the period of highest average rainfall for central Arizona (Bulk 1985). In 2001, transects were measured in mid-August and, because of a lack of significant rainfall, were not remeasured in the fall.

Methods

Vegetation sampling

Vegetation sampling along both sides of Pueblo Colorado Wash was conducted 12 August 2001. Measurements were taken along thirteen 40m transects that had been established along the intermittent stream channel in 1998 (Table 1, Figure 1). The objectives of the transects were to estimate foliage-height density of perennial vegetation and cover of annuals. Foliage-height distribution was recorded as "hits" along vertical poles. In addition to providing a measure of vegetation structure, this method estimates total foliage-height density, which is simply the number of hits divided by the number of possible hits and vegetation volume (TVV) or the sum total of cubic decimeters within the transect's rectangular box ($40\text{m} \times 1\text{dm} \times \text{vegetation height } [\infty]$) that contain vegetation. My method is a modified version of the vertical-line intercept or foliage-height density of MacArthur & MacArthur (1961), MacArthur & Horn (1969) and vegetation volume of Mills et al. (1991). The resolution of 1dm by 1m cylinders is adequate for woody vegetation but rather coarse for herbaceous perennials. I chose foliage-height distribution estimation over the line intercept method because the latter estimates vegetation cover only and does not account for vegetation height or structure within the canopy. Also FHD or TVV correlates closely with breeding bird densities (Mills et al. 1991), which is a primary management concern for the Park.

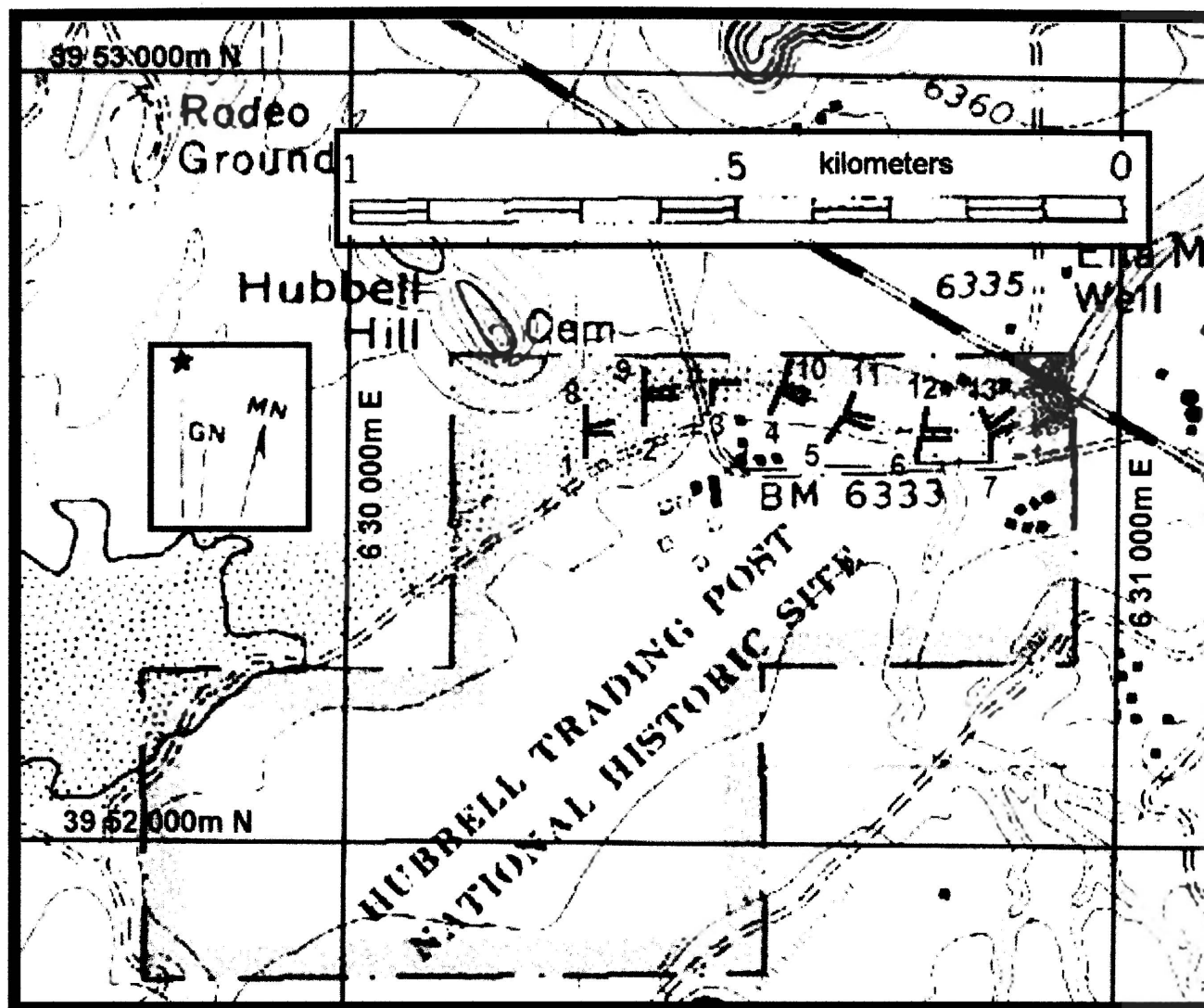


Figure 1. Map showing vegetation transects within the Hubbell Trading Post National Historic Site.

Table 1. Locations of transects (N/A = not available)					
transect number	UTM coordinates of transect at 00m (NAD 27, zone 12))	heading east of magnetic north from reference point	distance from reference point	reference point	UTM coordinates of reference points
1	06 30 323mE 39 52 505mN	25°	50m	1	06 30 394mE 39 52 470mN
2	06 30 382mE 39 52 572mN	297°	70.1m	2	06 30 439mE 39 52 530mN
3	06 30 472mE 39 52 596mN	355°	27.8m	3	06 30 471mE 39 52 570mN
4	06 30 550mE 39 52 588mN	358°	67.8m	4	06 30 554mE 39 52 507mN
5	06 30 635mE 39 52 562mN	321°	21.7m	5	06 30 647mE 39 52 541mN
6	06 30 720mE 39 52 544mN	296°	46.0m	6	06 30 757mE 39 52 514mN
7	06 30 814mE 39 52 534mN	259°	12.7m	7	N/A
8	06 30 280mE 39 52 528mN	N/A	N/A	N/A	N/A
9	06 30 347mE 39 52 602mN	N/A	N/A	N/A	N/A
10	06 30 560mE 39 52 627mN	N/A	N/A	N/A	N/A
11	06 30 646mE 39 52 604mN	N/A	N/A	N/A	N/A
12	06 30 731mE 39 52 580mN	N/A	N/A	N/A	N/A
13	06 30 813mE 39 52 574mN	N/A	N/A	N/A	N/A

The present analysis was modified from Mills et al. (1991) by recording "hits" of perennial vegetation along the vertical axes by meters instead of by decimeters. From a practical perspective, this facilitated an increase in the number of transects thereby enhancing statistical significance. MacArthur & Horn (1969) used a telephoto lens to measure vertical distances with an accuracy of approximately 0.5m.

Seven reference points were selected within the Park boundaries such that they were as evenly distributed as possible and easily relocated (Table 1). At least one photograph was taken of each with a reference placard placed at the point.

Starting points (00m) of transects were established non-randomly at ca. 100m increments along the channel without bias with respect to the condition of the vegetation. The transects were situated at least 40m from the Park boundary in order to avoid boundary effects. Starting points were marked with 0.5in rebar at a point 20m bankside from the water's edge or the outer edge of obligate wetland graminoids, such as *Eleocharis parishii* Britton (Parish spikerush) and *Scirpus pungens* Vahl (common three-square). The transects were directed perpendicular toward the stream channel for 20m, then, to the right along the channel edge regardless of sinuosity for an additional 20m. The bearing from the starting point to the turn was recorded as degrees east of magnetic north.

Measurements were taken every two meters along the transect beginning with meter two. A nine meter collapsible pole was set vertically and living perennial vegetation within 1dm of the pole was recorded in height increments of 1m. This was done by recording the acronym of the plant species that fell within a particular meter mark on the pole. Thus for each 40m transect, vegetation volume, according to species, was sampled within twenty cylinders with a radius of 1dm.

At each 2m point along each transect a 20cm by 50cm (0.1m²) Daubenmire Grid was laid on top of the herbaceous layer and the cover of annuals was estimated by counting the number of squares occupied. The cover was recorded as cover classes one through seven (1= <1%, 2= 1-5%, 3= 5-25%, 4= 25-50%, 5= 50-75%, 6= 75-95%, 7= 95-100%).

Results and discussion

The primary different in foliage-height density (FHD) between the summer of 1998 and the summer of 2001 is that between those areas that were not treated (weed-tree removal) by 1998 and were treated by 2001 (Table 2, Figure 2). The area around transect 10 was still not treated and that the FHD was nearly identical for the two years. There is also a marked difference of FHD for transect three between years in 1998 and 2001. The higher FHD in the 1998 data can be explained by the presence of a canopy of *Populus deltoides*, which is absent in 2001 (Figure 3). Apparently, meandering of the channel removed it from under the tree canopy by 2001. Meandering was also apparent by the changes in the length of the first leg of many transects (i.e., the distance from the 00m rebar and the channel's edge).

Changes in species composition are less easily explained. The most conspicuous difference within the streamside legs between 1998 and 2002 is the presence of both *Equisetum arvense* and *Eleocharis parishii* in 1998 and their complete absence in 2001 (Figure 4). In 2002, there was an increase in *Scirpus pungens*, which has very similar soil moisture requirements to *E. arvensis* and *E. parishii*. Competition for space is an important factor in plant composition of high-moisture soils (Stevens 1989) and, thus, the generally taller, more robust-stemmed *S. pungens* may simply be displacing the other two less-robust species. Sorrell et al. (2000) have found that the root anatomy as it affects aeration may be directly correlated to the distribution of species within wetlands. Van der Valk et al. (1994) reported a decline in plant diversity associated with an increase in water level within wetlands and thus the decrease in diversity within the Historic Site may indicate an overall increase in average water level because of channelization or some other, yet undocumented factor. The increase of *S. pungens* cover may also be occurring because of the lack of grazing pressure. Livestock were removed from the Historic Site in 1997 (Nancy Stone, pers. comm.). Reichenbacher (1984) found a direct correlation between the occurrence of a closely related species, *S. americana*, and the absence of livestock grazing along a riparian stream in Arizona.

There is a similar trend between the bank legs of the 1998 and 2001 transects but involving different species. In 2001, three *Sporobolus*, *S. airoides*, *S. contractus*, and *S. cryptandrus*, and two *Elymus*, *E. glauca* and *E. lanceolata* were recorded, which were absent from the 1998 data. Unlike the stream-side transects, however, there are no species that the *Sporobolus* and *Elymus* seem to be displacing. These species may simply be increasing because of the absence of grazing. Trends of a similar nature with these species have occurred along the Verde River, Arizona after cessation of grazing (unpublished data).

Apparently, there was a flush of *Populus deltoides* seedlings along the stream that were lost during a flood event prior to the fall 2001 sampling (Nancy Stone and Bill Zeedyk, pers. comm.). The seedlings of *P. deltoides* are well-adapted to the scouring of the sandbars in the spring caused by snow-melt flooding, followed by a gradual decrease in water levels in the summer (Fenner et al. 1984). Although minor flooding may augment the establishment of *P. deltoides* seedlings (Campbell & Green 1968), major flooding deters their long-term survival. For example, Irvine and West (1979) show that the oldest trees of *P. fremontii*, a closely related species, were located beyond the zone of usual flooding.

Average percent cover of annuals for each transect showed dramatic variation between the summer and fall sampling of 1998 (Table 3, Figure 5). This is easily explainable by the increase rainfall after the summer sampling. The somewhat intermediate values for August 2001 may simply reflect an intermediate amount of moisture. The great increase in annual cover for transects eight and nine in 2001 is probably correlated to the opening of the canopy following weed-tree eradication treatments. Increase in overstory density is generally correlated with a decrease in herbaceous cover and diversity (Berger & Klaus 2000). Transect ten was not treated and transects eleven through thirteen had a canopy of either *Populus* or residual *Tamarix*. Increases in annual cover for 2001 along transect four and five are more difficult to explain. In both cases, a native species was on the increase and their increased presence may reflect the absence of grazing as it was postulated for the increase in cover for certain perennial grasses (Table 3).

If there is an existing indication of what the mature riparian plant association will be within the Historic Site, it may be represented, in part, by the area near transect 13 (Figure 6). Here, the beginning of the transect, both in 1998 and in 2001, shows a somewhat tall canopy with an open understory, a condition typical of older deciduous forests (Aber 1979). With the continued exclusion of livestock that browse on tree seedlings (Rucks 1984) and the continued removal of competitive weed-tree species, native tree species will probably increase through time.

Table 2. Summary of vegetation type, canopy height, and foliage-height density (FHD) data for each transect by date.

Transect number	Vegetation association	Data								
		summer 1998			fall 1998			summer 2001		
		Maximum height (m)	Average height* (m)	FHD (m ³ /m ²)	Maximum height (m)	Average height (m)	FHD (m ³ /m ²)	Maximum height (M)	Average height (m)	FHD (m ³ /m ²)
1	<i>Eleocharis parishii</i>	1	0.15	0.15	1	0.50	0.6	1	0.6	0.65
2	<i>Scirpus pungens</i>	2	0.40	0.5	1	0.40	0.4	2	0.75	0.8
3	<i>Scirpus pungens</i>	10	0.95	1.25	11	1.40	1.65	1	0.55	0.55
4	<i>Pascopyrum smithii</i> → <i>Scirpus pungens</i>	1	0.20	0.2	1	0.40	0.6	1	0.55	0.55
5	<i>Pascopyrum smithii</i> → <i>Chrysothamnus nauseosus</i>	1	0.30	0.35	1	0.35	0.45	2	0.4	0.45
6	<i>Scirpus pungens</i>	1	0.35	0.55	1	0.45	0.7	1	0.3	0.3
7	<i>Chrysothamnus nauseosus</i> → <i>Scirpus pungens</i>	2	0.55	0.7	2	0.50	0.6	1	0.55	0.65
8	<i>Elaeagnus angustifolia</i> → <i>Scirpus pungens</i>	7	1.10	1.35	N/A	N/A	N/A	1	0.85	0.85
9	<i>Elaeagnus angustifolia</i> → <i>Scirpus pungens</i>	6	1.95	1.9	N/A	N/A	N/A	1	0.25	0.25
10	<i>Tamarix ramosissima</i>	7	1.85	1.25	N/A	N/A	N/A	7	1.9	1.35
11	<i>Elaeagnus angustifolia</i> → <i>Scirpus pungens</i>	5	1.80	1.7	N/A	N/A	N/A	4	1.0	0.9
12	<i>Populus deltoides</i>	12	2.25	1.8	N/A	N/A	N/A	13	2.3	1.25
13	<i>Populus deltoides</i>	12	1.65	1.8	N/A	N/A	N/A	12	1.65	1.2

*average height here is the sum of the maximum heights for all transect points divided by the number of points (20)

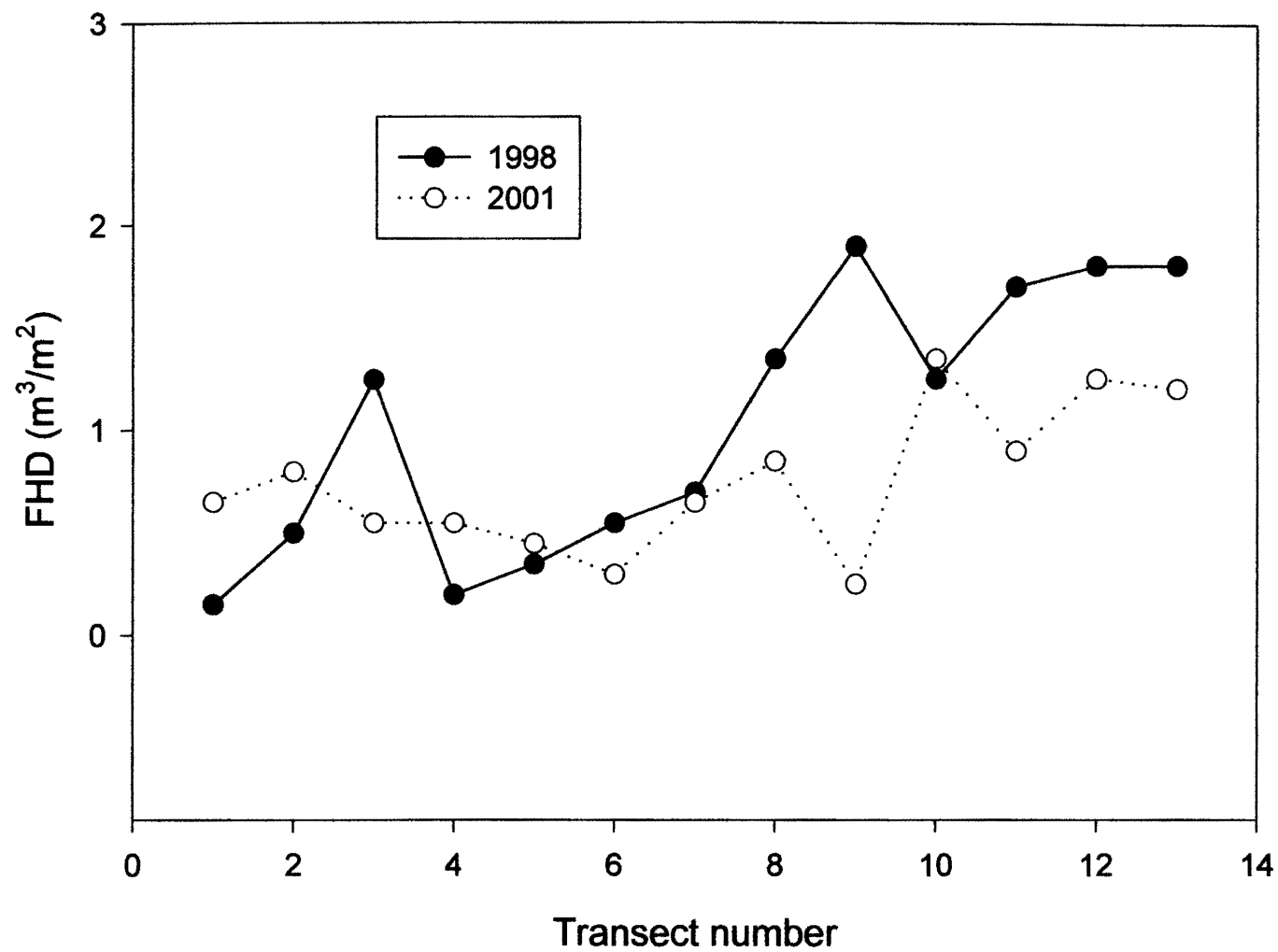


Figure 2. Comparison of FHD between summer 1988 and summer 2001 for each transect.

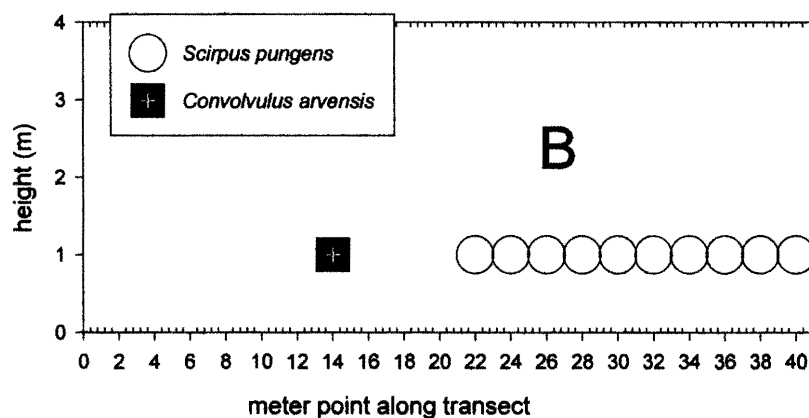
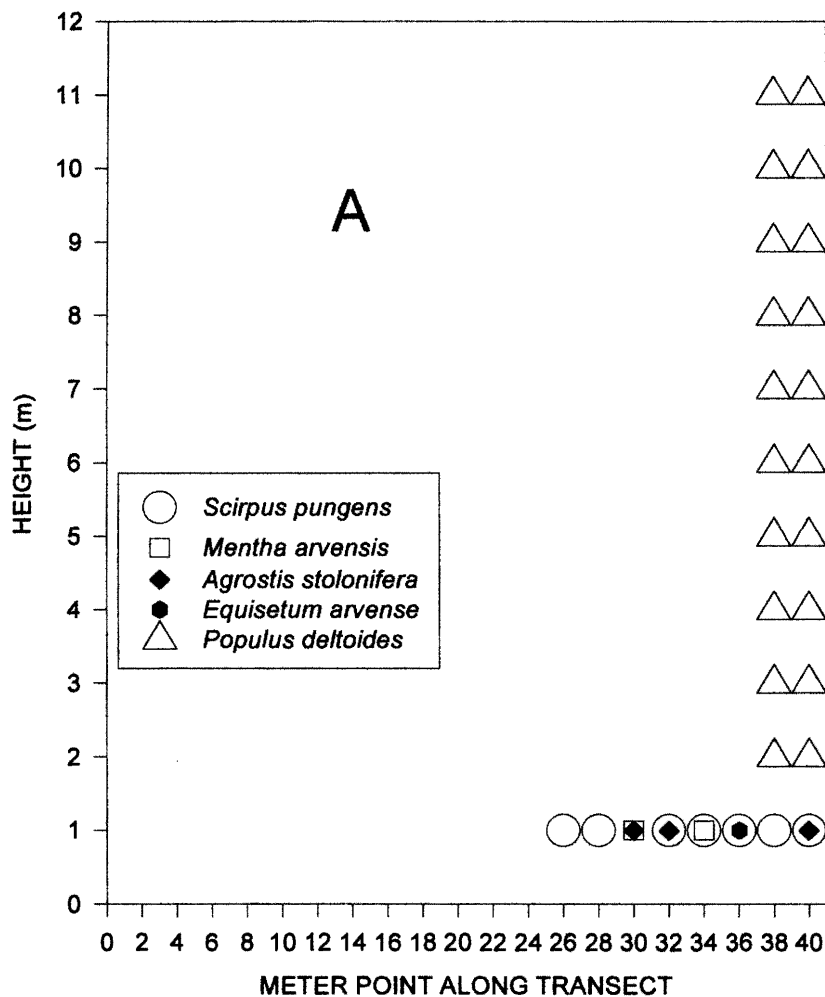


Figure 3. Comparison of foliage-height distributions (FHD) for transect three between years 1998 (A) and 2001 (B).

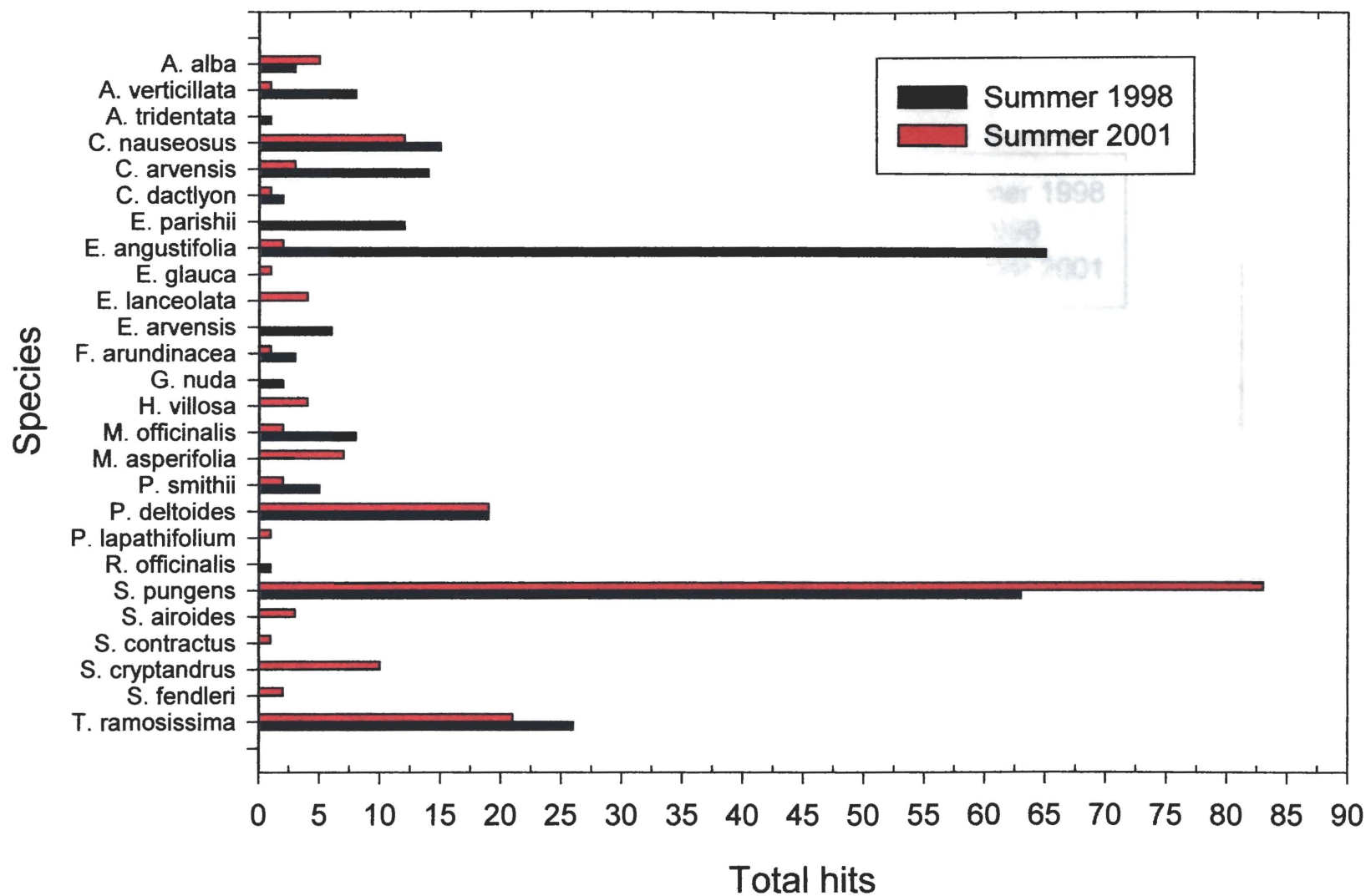


Figure 4. Total hits (FHD) for all transects, by species.

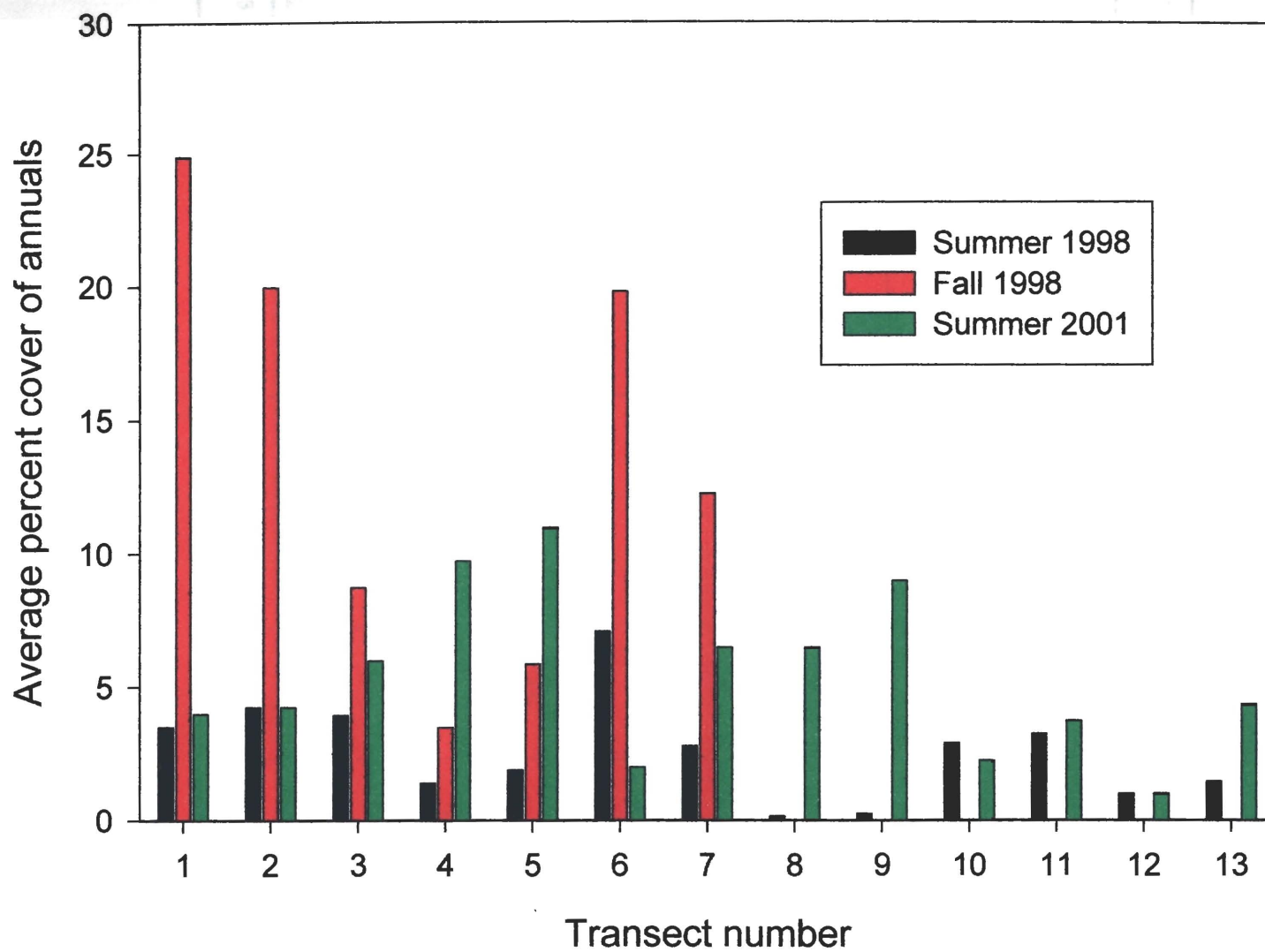
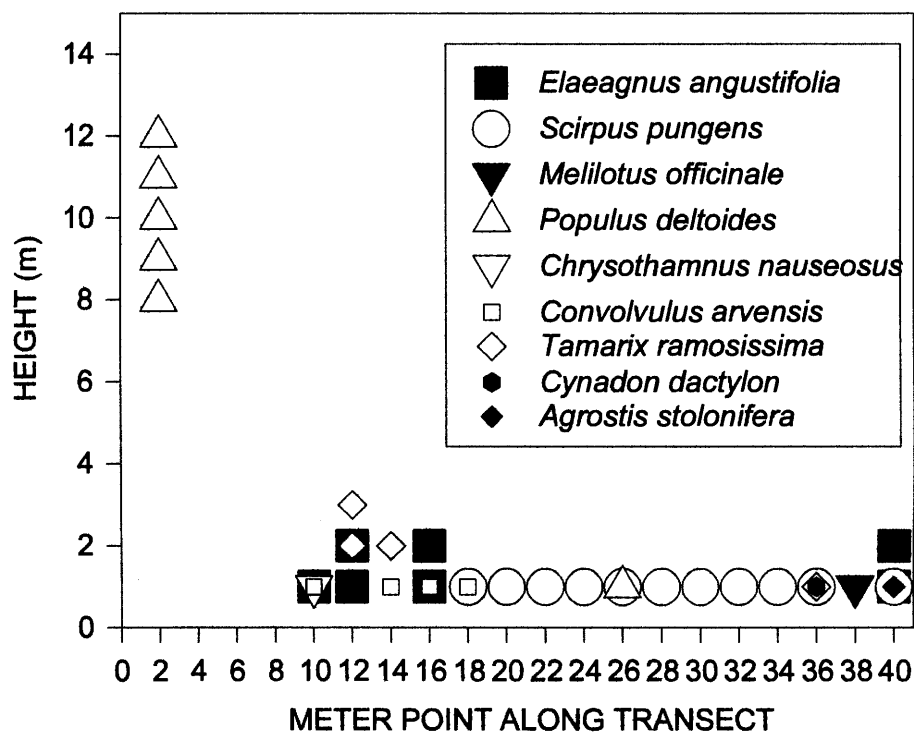


Figure 5. Average percent cover of annuals, by transect.

Table 3. Comparison among transects of overall average percent cover and annuals with the greatest cover.

Transect number	Summer 1998		Fall 1998		Summer 2001	
	Annuals with greatest cover	overall ave. % cover	Annuals with greatest cover	overall ave. % cover	Annuals with greatest cover	overall ave. % cover
1	<i>X. strumarium</i> , <i>A. palmeri</i>	3.5	<i>X. strumarium</i> , <i>P. oleracea</i>	24.9	<i>H. annua</i>	4
2	<i>X. strumarium</i> , <i>C. canadensis</i>	4.25	<i>X. strumarium</i> , <i>H. leporinum</i>	20.0	<i>X. strumarium</i> , <i>K. scoparia</i>	4.25
3	<i>X. strumarium</i>	3.95	<i>X. strumarium</i> , <i>H. leporinum</i>	8.75	<i>S. kali</i> , <i>K. scoparia</i>	6
4	<i>O. acanthium</i>	1.4	<i>X. strumarium</i> , <i>A. acanthicarpa</i>	3.5	<i>K. scoparia</i> , <i>P. aviculare</i>	9.75
5	<i>X. strumarium</i>	1.9	<i>B. rubens</i> , <i>P. major</i>	5.88	<i>C. texensis</i> , <i>S. kali</i>	11
6	<i>X. strumarium</i> , <i>S. kali</i>	7.1	<i>C. texensis</i> , <i>B. rubens</i> , <i>S. kali</i> , <i>X. strumarium</i>	19.88	<i>S. kali</i>	2
7	<i>X. strumarium</i> , <i>P. aviculare</i>	2.8	<i>B. rubens</i> , <i>P. aviculare</i>	12.3	<i>X. strumarium</i> , <i>E. crus-gali</i>	6.5
8	<i>M. minima</i>	0.15	n/a	n/a	<i>C. canadensis</i> , <i>X. strumarium</i>	6.5
9	<i>X. strumarium</i>	0.25	n/a	n/a	<i>S. kali</i> , <i>X. strumarium</i>	9
10	<i>K. scoparia</i> , <i>X. strumarium</i>	2.9	n/a	n/a	<i>K. scoparia</i>	2.25
11	<i>X. strumarium</i>	3.25	n/a	n/a	<i>C. canadensis</i> , <i>K. scoparia</i>	3.75
12	<i>X. strumarium</i>	1	n/a	n/a	<i>C. texensis</i>	1
13	<i>X. strumarium</i> , <i>C. glaucum</i>	1.45	n/a	n/a	<i>K. scoparia</i> , <i>P. monspeliensis</i>	4.35

1998



2001

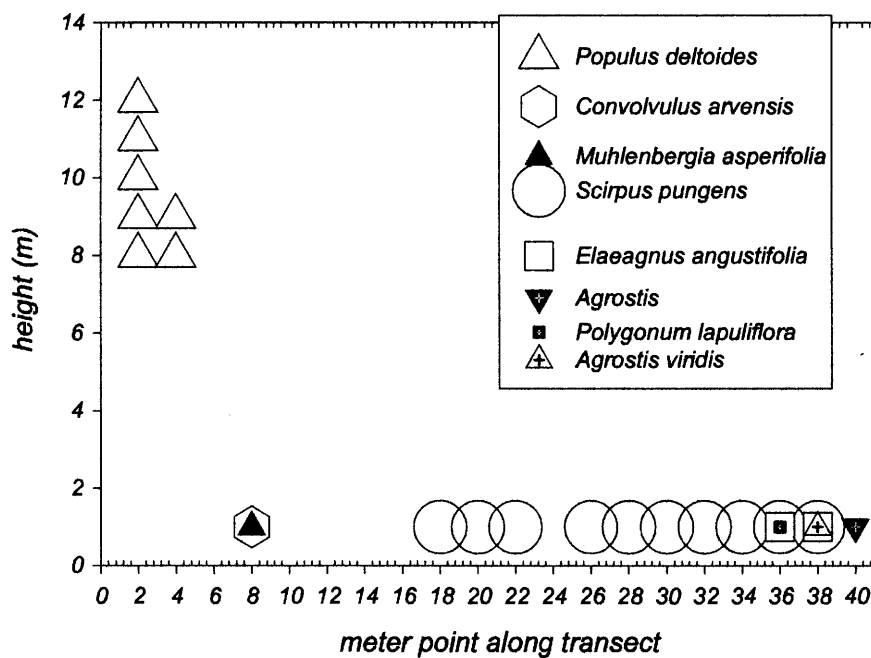


Figure 6. Foliage-height density graphs for transect 13, summer 1998 and summer 2001.

Conclusions

Most of the changes in vegetation between the summer of 1998 and the summer of 2001 are attributable to further weed-tree treatments along the north bank. Some of the vegetation changes may have been caused by the cessation of livestock grazing within the Historic Site. These changes, however, are still subtle and, if are truly in response to decreased herbivory, then they should become more dramatic with time. The increase of *Scirpus pungens* and associated decrease in *Eleocharis parishii* and *Equisetum arvense* remain enigmatic but may also be related to decreased herbivory.

It is still too early to suggest correlations between vegetation changes and environment factors or to suggest particular trends in the composition or structure of the vegetation within the Hubbell Trading Post Historic Site. It is also too early to speculate on how much time it may take to see these correlations and changes. In fact, the most remarkable aspect of the study to date is the lack of notable change along the stream. It is very possible that flooding events have set back the natural succession within the Historic Site and that restoration along a small section of stream may prove difficult because of the absence of similar management upstream. In this regard, the riparian community within the Historic Site may remain in a state of perpetual succession, a fate which has been proclaimed for other stream channels in semiarid region of Arizona (Campbell & Green 1968). At his point, however, all hypotheses remain tenuous and further sampling is necessary.

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