Technical Publication SJ 87-6

The Effects of Off-road Vehicle Traffic on Vegetation of the Floodplain of the Upper St. Johns River

by

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August 1986

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

The vegetation of frequently traveled trails of tracked off-road vehicles (TORVs), of infrequently traveled trails, and of untraveled areas was examined to ascertain the effects of TORV traffic through the three major communities of the floodplain: maidencane wet prairie, sawgrass wet prairie, and tree island. In these communities, areas infrequently and frequently traveled by TORVs had higher within-habitat species diversity (alpha diversity), as measured by species richness (total number of species) and species density (number of species per sample), and a lower abundance of dominant species than did untraveled areas. In tree island and sawgrass prairie, the physiognomy of traveled areas was also markedly different from that of untraveled areas. These effects persisted through the growing season (May - September). It appears that TORV traffic will eventually reduce floral and faunal species diversity by progressively reducing the acreage of tree islands and sawgrass prairie. Because of this effect, and other potentially detrimental effects that cannot be predicted, it is suggested that TORV use should be prohibited in tree islands and sawgrass prairies and in buffer zones around these communities.

INTRODUCTION

In Florida, airboats and various types of wheeled and tracked vehicles are used for recreation in wetlands (Duever, Carlson, and Riopelle, 1981). Use of these vehicles causes visable damage to vegetation, but the long-term and cumulative effects of such damage have received little rigorous examination. Without such study, it is difficult to assess the ecological significance of the visable effects of off-road vehicle traffic.

Previous studies indicate that the rate of recovery of wetland vegetation from damage caused by off-road vehicle traffic is inversely related to the severity of the initial damage. The Florida Game and Freshwater Fish Commission (FGFFC) examined the effects of tracked off-road vehicles (TORVs) on communities dominated by sawgrass (Cladium jamaicense Crantz) in the Florida Everglades (Schemnitz, 1972). They found an average recovery rate from mild damage by halftracks of 48 percent within five months. Duever, Carlson, and Riopelle (1981), however, found little or no recovery within ten months from moderate to severe track vehicle damage in peat marshes dominated by sawgrass in the Big Cypress National Preserve. After six years there was still visable damage (Duever, Riopelle, and McCollom, 1986). Sikora, Sikora, and Turner (1983) also observed persistent damage from use of TORVs and wheeled off-road vehicles in the coastal marshes of Louisiana.

In the floodplain wetlands of the Upper St. Johns River Basin (Figure 1), the use of TORVs has been allowed for more than ten years. They have been used during the deer hunting seasons so that traffic has been limited to November and December. The trails of TORVs are visable in aerial photographs taken after the hunting season (Figure 2a). These photographs indicate that a large portion of the marsh is affected by TORV traffic. TORV operators believe that the effects of vehicle operation on the vegetation are reversed in the subsequent growing season; a contention partly supported by aerial photographs taken just before the hunting season (Figure 2b). Photographs, however, may not detect changes in the species composition which do not affect community physiognomy. Moreover, pre-season aerial surveillance indicates sustained damage in two major communities of the floodplain: sawgrass prairie and tree island.

Management of these wetlands is the responsibility of the St. Johns River Water Management District (SJRWMD) and, because of the visable effects of TORV use, the Governing Board of the SJRWMD requested a more detailed analysis of these effects on the ecological status of the marsh. Thus, this study was designed to elucidate the effects of both frequent and infrequent TORV traffic on the major plant communities of the marsh. The validity of two null hypotheses was examined: 1) TORV traffic does not alter the structure (species composition, species diversity, and physiognomy) of floodplain plant communities, and 2) TORV traffic alters plant community structure, but the effects are reversed

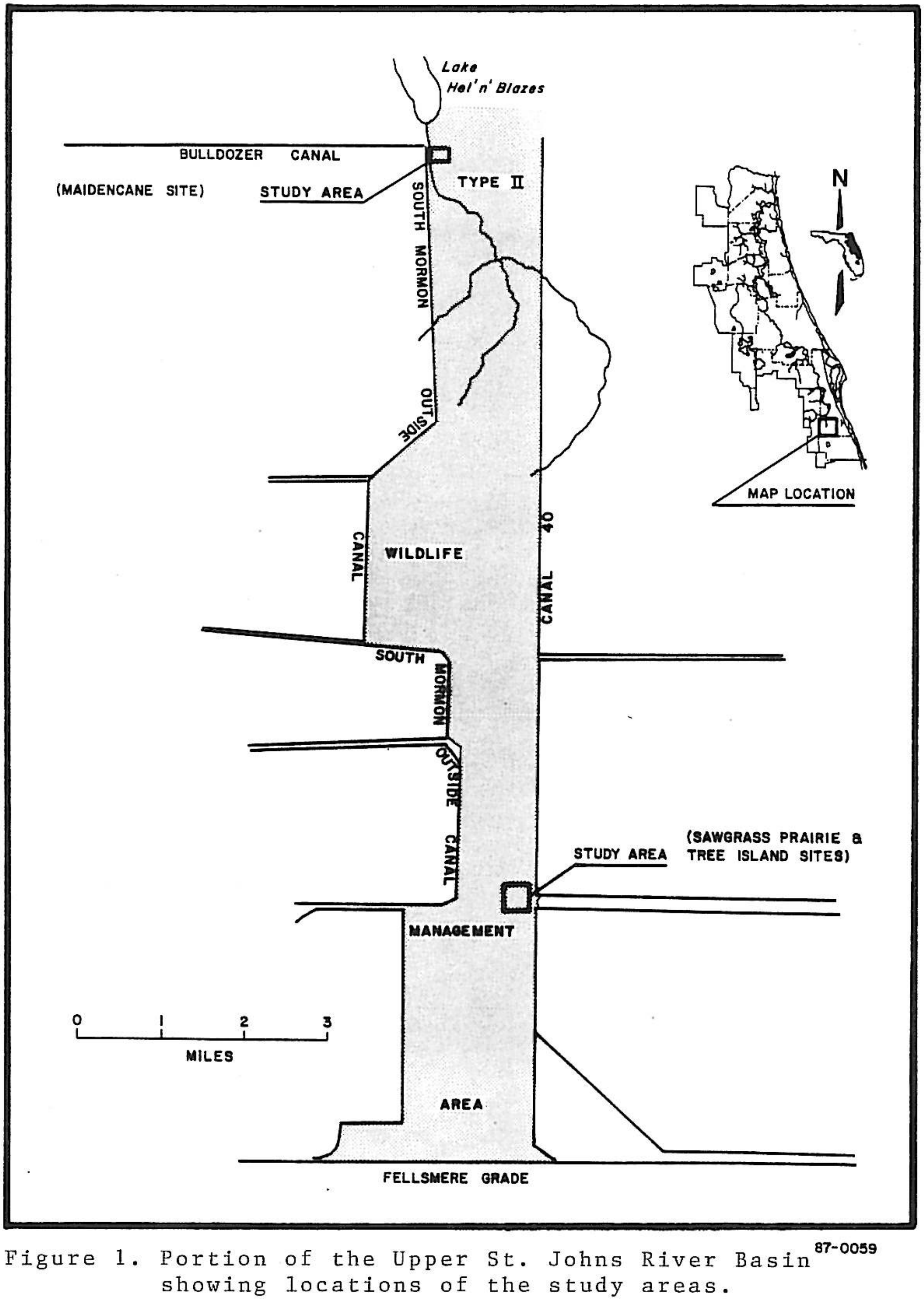
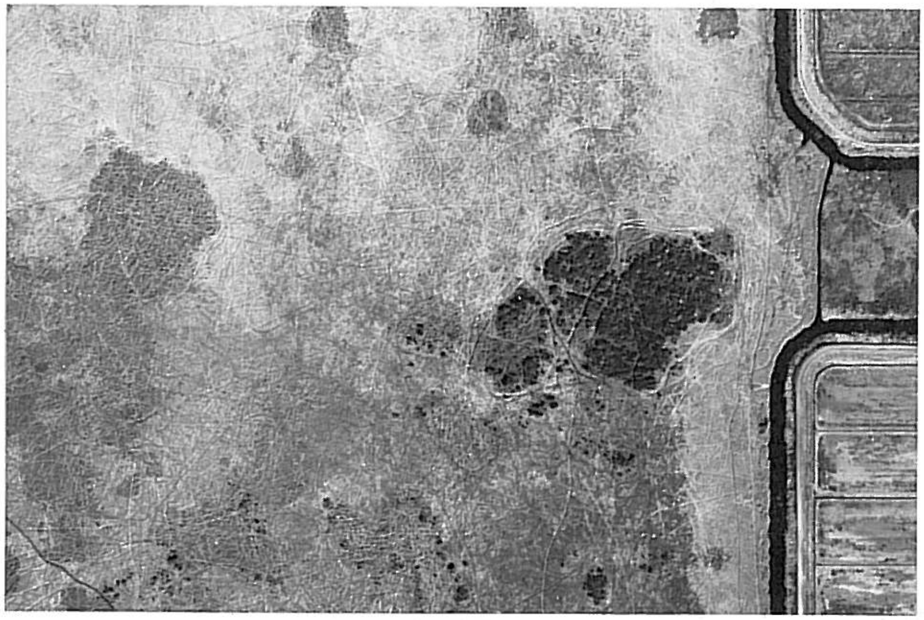
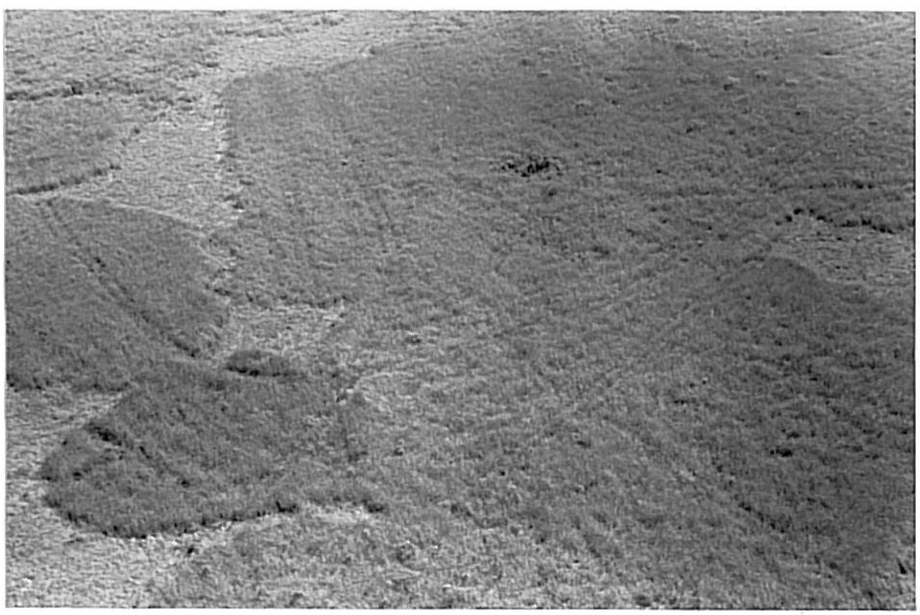


Figure 1. Portion of the Upper St. Johns River Basin showing locations of the study areas.



(a)



(b)

Figure 2. Aerial photographs of (a) the study area and adjacent marsh after hunting season (January, 1986) and (b) sawgrass and maidencane prairie before hunting season (October, 1981).

during the subsequent growing season. This study indicates that these hypotheses should be rejected and that TORV use, as currently regulated, will have long-term, detrimental effects.

METHODS

The St. Johns River begins as a chain of shallow lakes lying within a broad, herbaceous marsh in east-central Florida (Figure 1). The study site was within the marsh just south of the point at which the river channel begins. There, the marsh has been affected by partial drainage, resulting in a progressive reduction in frequency of flooding (Figure 3); by a high frequency of severe fires, causing destruction of the peat soil (Figure 4); and by airboat and TORV traffic (Figure 5). The major plant communities are graminoid, wet prairie dominated by *Panicum hemitomon* Schultes (maidencane prairie); graminoid, wet prairie dominated by *C. jamaicense* (sawgrass prairie); and tree island dominated by *Myrica cerifera* L. (tree island).

Within each of these communities sites were selected where three levels of TORV traffic had occurred in close proximity. These levels consisted of no traffic; short-term or infrequent traffic; and long-term or frequent (within- and among-years) traffic. Short-term sites were areas where a TORV had made one to several passes in the previous year; two track marks were clearly visable, each being roughly equal in width to the width of a TORV track. Long-term sites were areas used by TORVs year after year. In these areas, track marks were much less obvious due to extensive damage to vegetation between the tracks.

A station was delineated for each level of traffic within each community (total of nine stations) and each station was

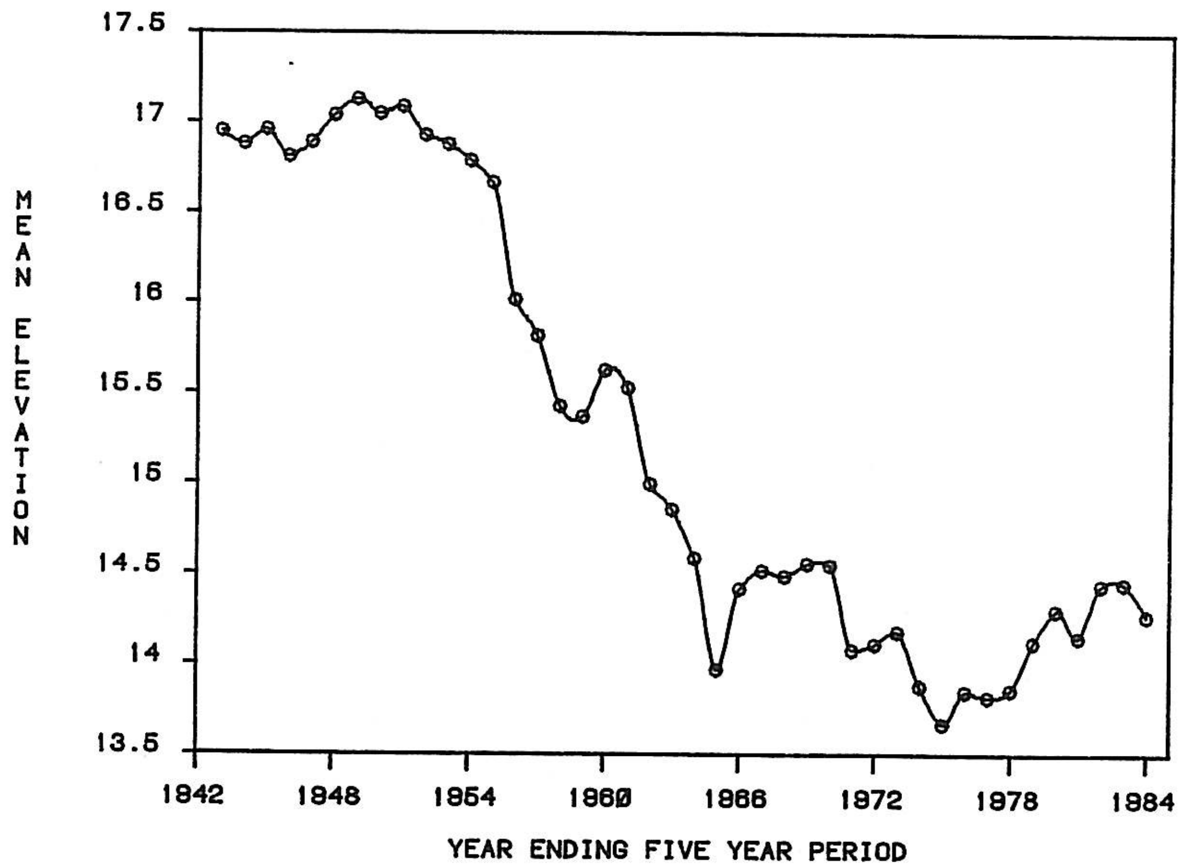


Figure 3. Five-year moving average of surface water elevations in the St. Johns River at U.S. 192; approximately six miles north of the northern study area and fourteen miles north of the southern study area.

Figure 4. Effects of a peat fire in the Upper St. Johns River Marsh.

(a)

(b)

Figure 5. Photographs of (a) an airboat trail and (b) the trail of a tracked off-road vehicle in the Upper St. Johns River Marsh.

sampled at three times during the growing season (May, July, and September). The dimensions of the stations were 2.6 m by 10.0 m, 2.6 m by 19.0 m, and 2.6 m by 38.0 m in maidencane prairie, sawgrass prairie, and tree island, respectively. Previous studies of TORV impacts examined their effects only within the ruts made by the tracks. This study assessed effects both within and between the ruts. This was deemed necessary because the major areal effects of TORV traffic occur between the tracks.

At each station, the abundance of each species was estimated according to a modified Braun-Blanquet cover-abundance scale (Table 1). From these data, the species composition and species richness (total number of species) was determined. In addition, the frequency of occurrence of each species and the mean species density (number of species per unit area) were determined by identifying all species which occurred in each of ten, randomly located quadrats within each station. The quadrats were squares of 0.25 m^2 in the maidencane prairie and of 1.0 m^2 in the sawgrass prairie and the tree island. The sampling locations for these quadrats were selected by considering the two dimensions of each station as cartesian coordinates marked at 0.1 m intervals. Random number pairs indicating the sampling locations were generated by a computer program, written by the second author, which utilized the random number generator of a Prime 750 computer (Prime Computer, Inc., 1977).

Table 1. Cover-abundance scale (modified from the Braun-Blanquet scale presented by Muller-Dombois and Ellenberg, 1974) used for assessing the prevalence of each species.

Description	Rank
8	cover greater than 75 percent
7	cover 50 to 75 percent
6	cover 25 to 50 percent
5	cover 5 to 25 percent
4	numerous, with cover below 5 percent
3	few, with cover below 5 percent
2	solitary, with cover below 5 percent
1	present in stand but not in releve

RESULTS

Species diversity, as indicated by both species richness and species density, was higher in traveled (treatment) stations than in untraveled (control) stations in all three communities (Figures 6 and 7). Furthermore, in the maidencane prairie and the sawgrass prairie, diversity was consistently highest in the frequently traveled station. In the tree island, diversity was somewhat lower in the frequently traveled station than in the infrequently traveled station in May and September but, overall, diversity was similar in the two treatment stations. The differences in diversity between the control station and the treatment stations remained throughout the growing season.

The higher diversity of treatment stations stemmed from the addition of ruderal (*sensu* Grime, 1979) species to the species suite of the control stations rather than from a substitution of species. Thus, with the exception of one instance (*Spartina bakeri* in the tree island), species present in control stations were also present in the relevant treatment stations (Tables 2 - 4). Several of the dominant species of the control stations, however, were less dominant (in terms of frequency, abundance, or both) in the treatment stations (Figures 8 - 10).

This pattern - the addition of ruderals and the decline of dominants - is most simply illustrated by the maidencane prairie. Here, eight of the nine species found occurred only in the treatment stations (Table 2). One of these, *Polygonum punctatum*,

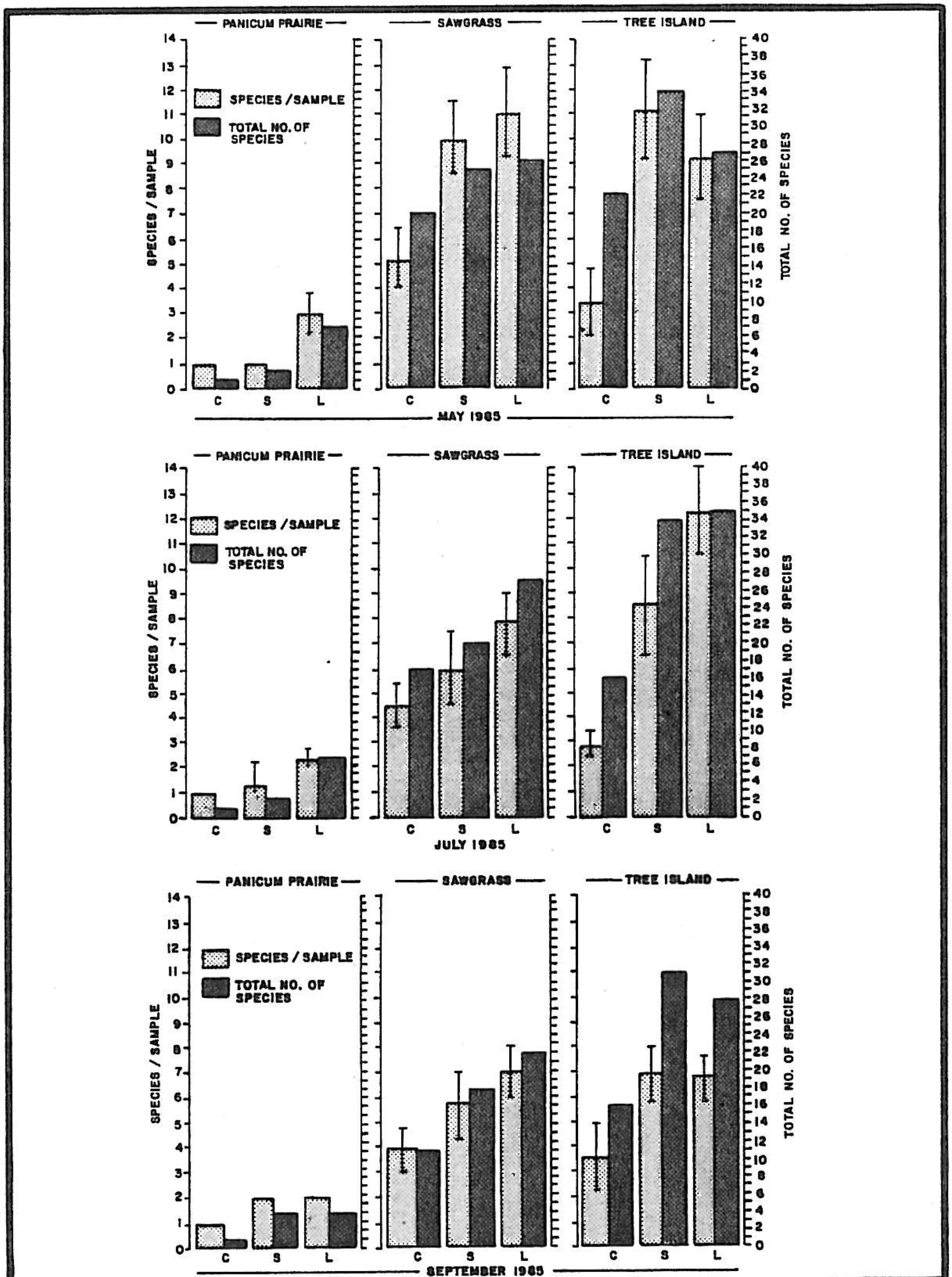


Figure 6. Total number of species and mean species density (species/sample) for each treatment in each community in May, July, and September 1985. The brackets indicate the 95% confidence intervals for means of species density.

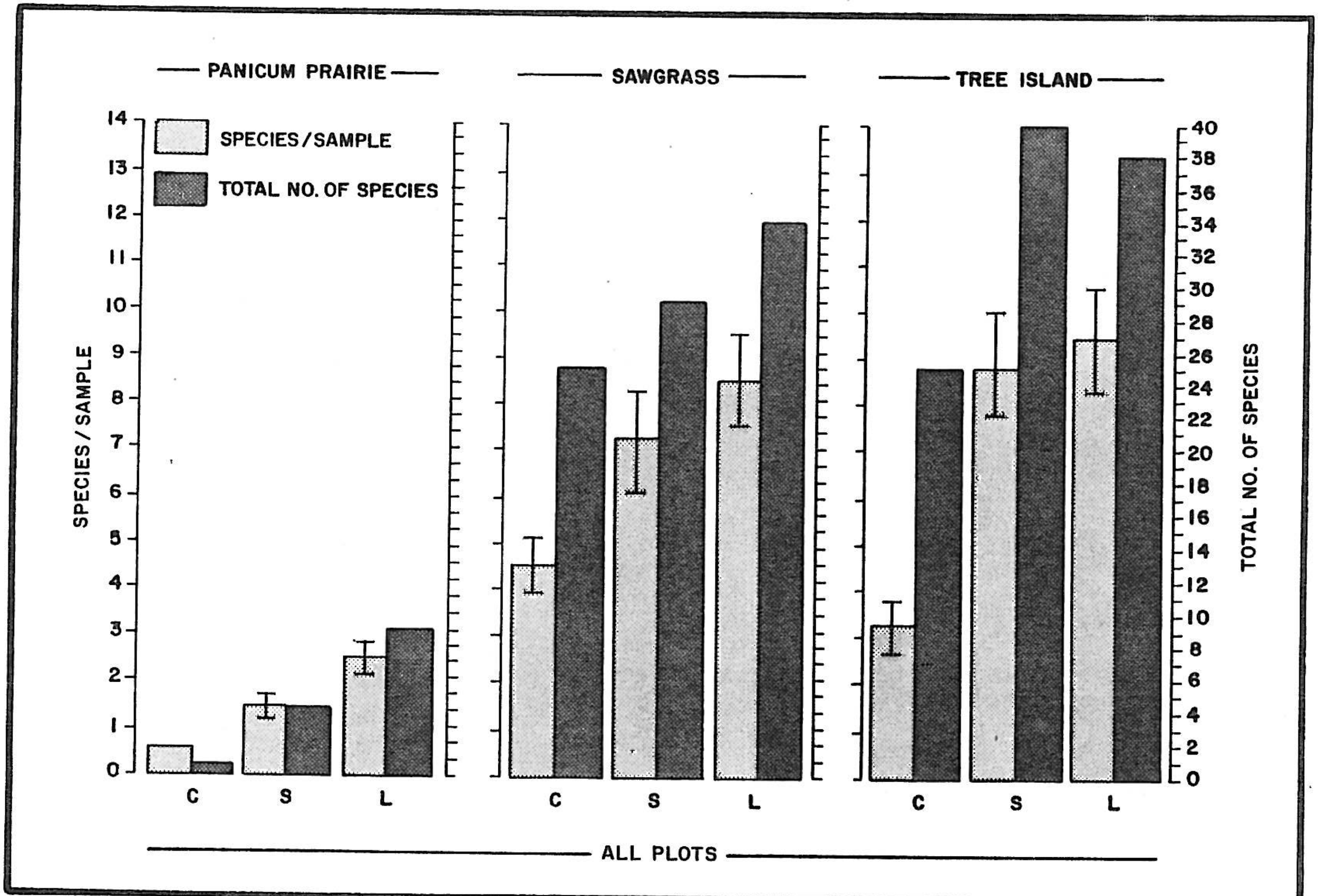


Figure 7. Total number of species and mean species density (species/sample) over the three sampling periods for each treatment in each community. The brackets indicate the 95% confidence for means of species density.

Table 2. Frequency of occurrence for each species encountered in the maidencance wet prairie. The maximum frequency within each treatment is 30, the maximum overall is 90.

Species	Treatment Long-term	Short-term	Control	Overall
Panicum hemitomon	30	30	30	90
Polygonum punctatum	20	13	--	33
Kosteletzkya virginica	01	--	--	01
Ptilimnium capillaceum	01	--	--	01
Erechtites hieracifolia	01	--	--	01
Echinochloa walteri	46	--	--	00
Eupatorium capillifolium	00	--	--	00
Setaria magna	00	00	--	00
Amaranthus australis	00	00	--	00

Table 3. Frequency of occurrence for each species encountered in the sawgrass wet prairie. The maximum frequency within each treatment is 30, the maximum overall is 90.

Species	Treatment Long-term	Short-term	Control	Overall
Boehmeria cylindrica	26	30	29	85
Cladium jamaicense	25	37	30	82
Aster elliottii	29	14	18	61
Osmunda regalis	09	13	23	45
Eupatorium capillifolium	23	17	01	41
Polygonum punctatum	01	21	02	24
Erechtites hieracifolia	10	12	02	24
Panicum hemitomon	15	08	01	24
Thelypteris palustris	08	14	01	23
Androgpogon sp.	20	--	--	20
Sambucus canadensis	--	10	07	17
Lachnanthes caroliniana	17	--	--	17
Osmunda cinnamomea	09	06	00	15
Sagittaria lancifolia	05	03	06	14
Ptilimnium capillaceum	09	04	01	14
Amaranthus australis	08	04	--	12
Lythrum alatum	07	02	02	11
Hydrocotyle umbellata	07	04	--	11
Setaria magna	02	06	--	08
Poaceae	05	01	00	06
Panicum dichotomum	06	00	--	06
Solidago fistulosa	01	03	00	04
Yellow aster	02	01	--	03
Cyperaceae (immature)	--	02	--	02
Cyperus haspan	01	01	00	02
shrub (outside)	--	--	01	01
Pontederia cordata	--	--	01	01
Acer rubrum	--	--	01	01
Baccharis halimifolia	--	--	01	01
Asclepias incarnata	01	00	--	01
Peltandra virginica	00	00	01	01
Dichromena colorata	01	00	--	01
Rhynchospora microcephala	01	--	--	01
Triadenum virginicum	01	--	00	01
Cephalanthus occidentalis	00	00	01	01
Pluchea rosea	--	00	--	00
Sacciolepis striata	00	--	--	00
Mitreola petiolata	02	--	--	00
Diodia virginiana	00	--	--	00
Mikania scandens	01	06	00	00
Psilocarya nitens	00	--	--	00

Table 4. Frequency of occurrence for each species encountered in the tree island. The maximum frequency within each treatment is 30, the maximum overall is 90.

Species	Treatment Long-term	 Short-term	 Control	 Overall
Lachnanthes caroliniana	29	22	08	59
Panicum hemitomon	30	25	04	59
Boehmeria cylindrica	15	30	08	53
Osmunda regalis	09	15	24	48
Aster elliottii	14	21	01	36
Thelypteris palustris	18	13	04	35
Cephalanthus occidentalis	19	04	08	31
Triadenum virginicum	12	16	--	28
Eupatorium capillifolium	17	11	00	28
Erechtites hieracifolia	14	13	00	27
Myrica cerifera	01	07	16	24
Cladium jamaicense	--	11	07	18
Cyperus haspan	05	12	--	17
Osmunda cinnomomea	06	07	04	17
Peltandra virginica	07	08	02	17
Poaceae (immature)	14	02	00	16
Panicum dichotomum	07	03	02	12
Polygonum punctatum	07	02	01	10
Dichromena colorata	05	04	--	09
Mitreola petiolata	07	01	--	08
Hydrocotyle umbellata	05	03	00	08
Cyperaceae (immature)	07	--	--	07
Rhynchospora microcephala	04	03	--	07
Eleocharis sp.	--	06	--	06
Rhynchospora odorata	06	00	--	06
Pontederia cordata	01	05	--	06
Lythrum alatum	03	03	--	06
Baccharis halimifolia	03	02	01	06
Ptilimnium capillaceum	02	02	--	04
Ilex cassine	--	03	--	03
Sacciolepis striata	02	01	--	03
Spartina bakeri	--	--	02	02
Solidago fistulosa	--	02	--	02
Crinum americanum	--	02	--	02
Mikania scandens	00	01	01	02
Androgpogon sp.	00	02	--	02
Acer rubrum	00	00	02	02
Pluchea rosea	--	--	01	01
Sambucus canadensis	--	--	01	01
Scleria reticularis	--	01	--	01
Asclepias incarnata	--	01	00	01

Table 4. (Continued)

Species	Treatment Long- term	 Short- term	 Control	 Overall
Pluchea oderata	01	00	--	01
Rhynchospora corniculata	00	01	--	01
Crenate vine	--	--	00	00
Sagittaria lancifolia	--	00	--	00
Kosteletykya virginica	00	--	--	00
Setaria magna	00	--	--	00
Senecio glabellus	00	--	--	00
Ludwigia repens	00	--	--	00
Psilocarya nitens	00	--	--	00

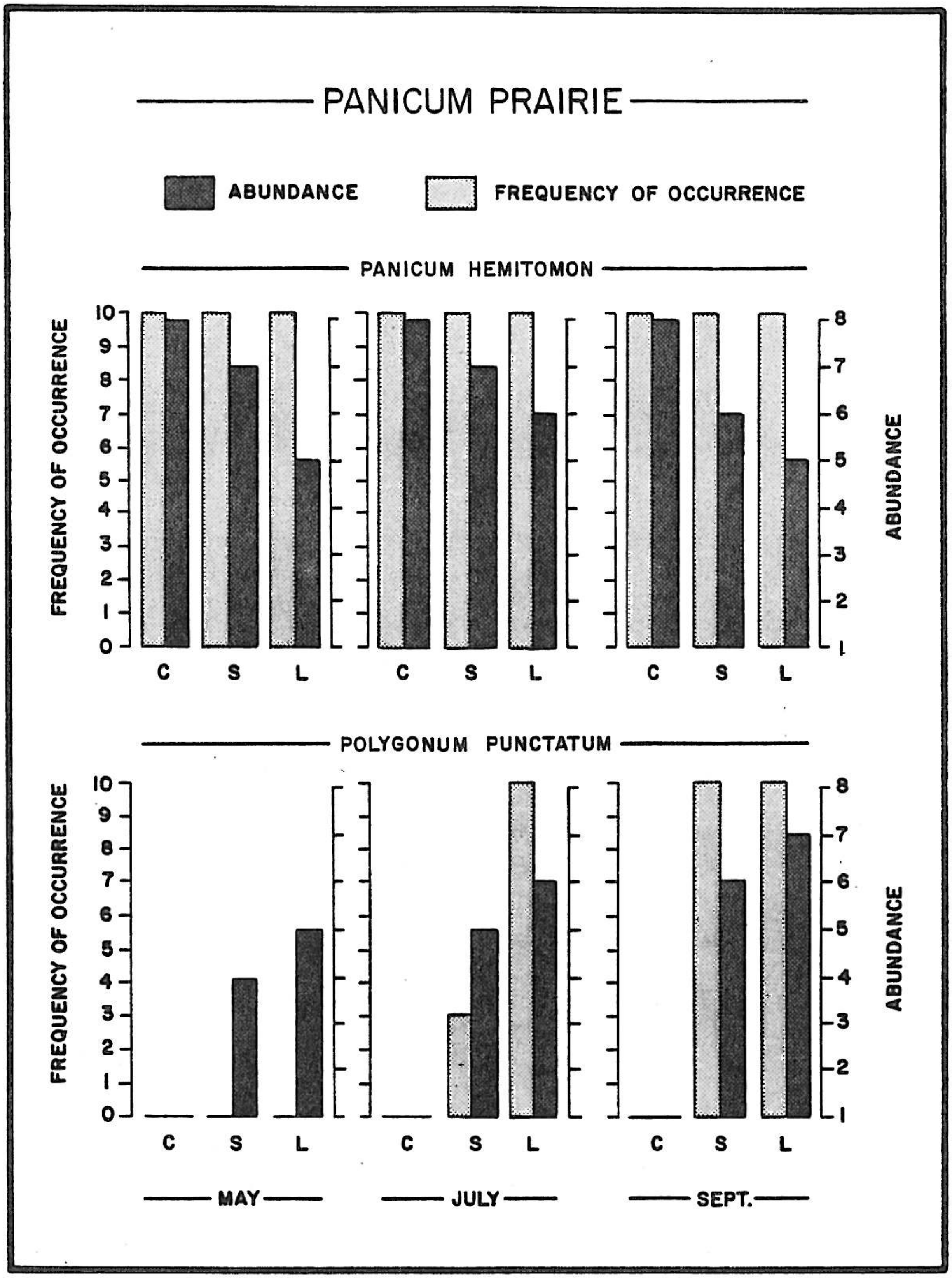
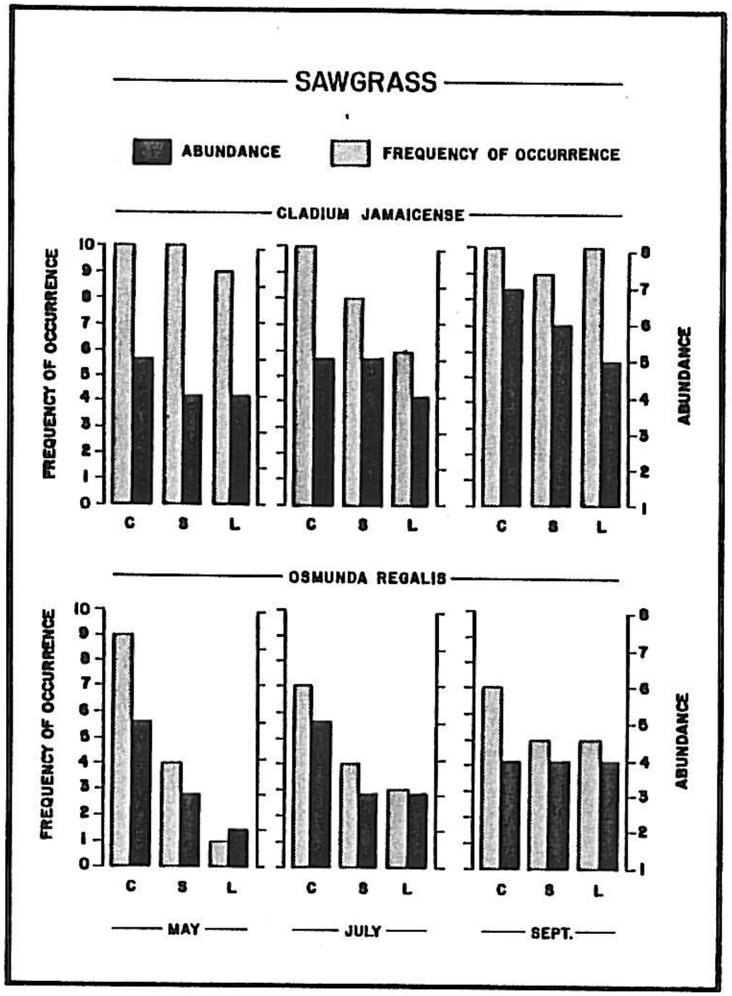


Figure 8. Variation in abundance (modified Braun-Blanquet Scale) and frequency of occurrence in each treatment for each sampling period for Panicum hemitomon and Polygonum punctatum in the maidencane prairie.



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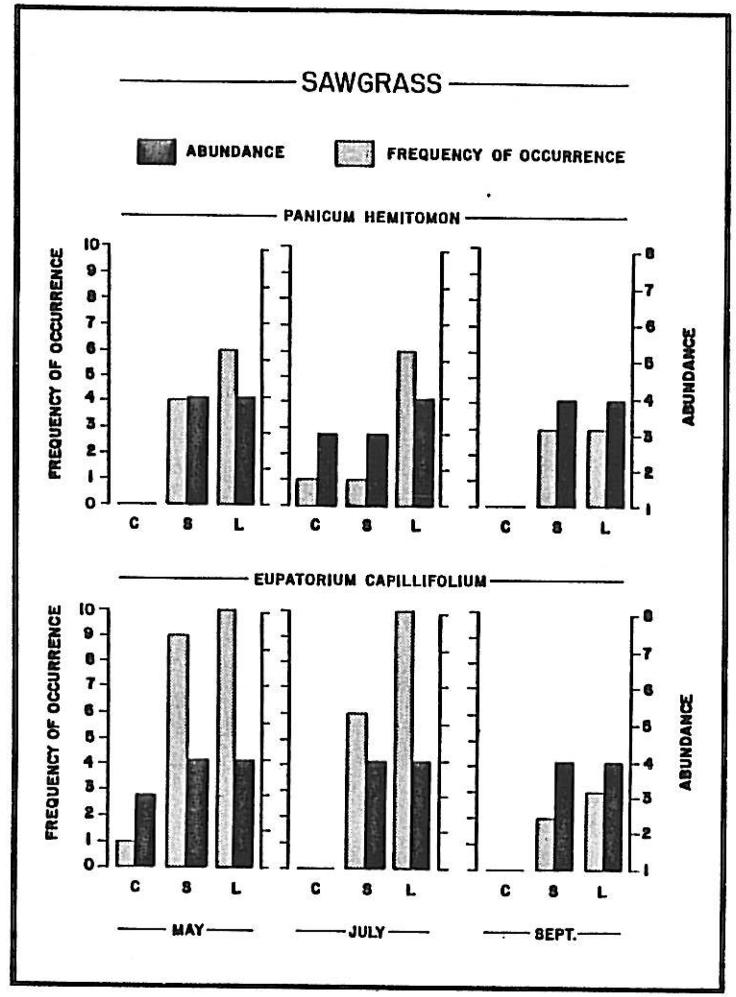
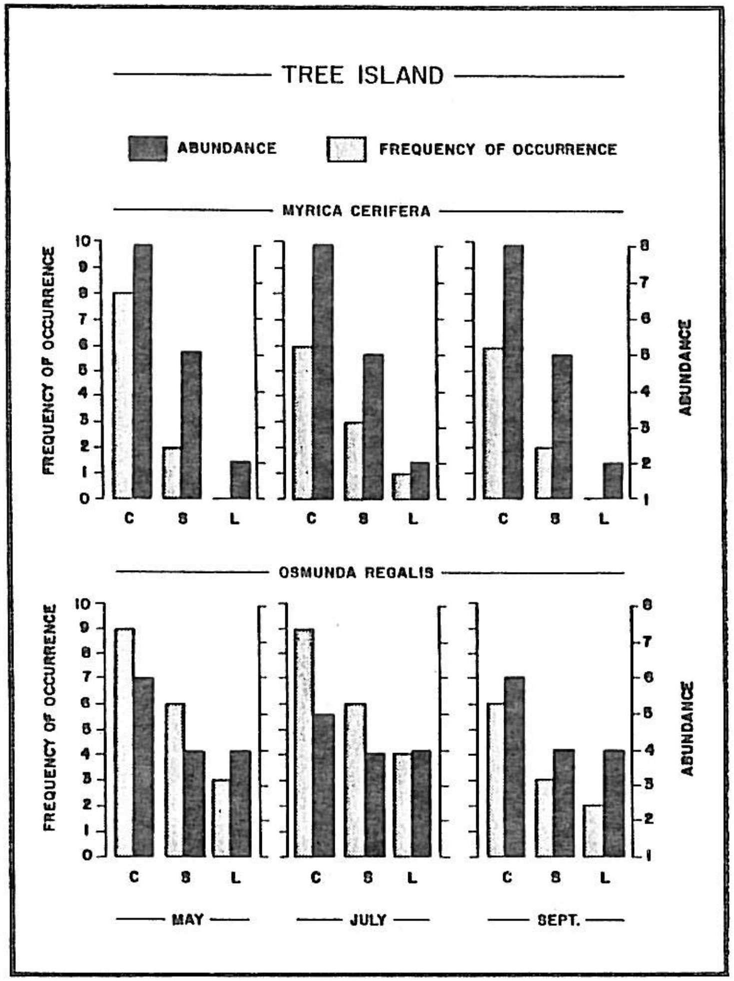


(b)

Figure 9. Variation in abundance (modified Braun-Blanquet Scale) and frequency of occurrence in each treatment for each sampling period for a) Cladium jamaicense and Osmunda regalis and for b) Panicum hemitomon and Eupatorium capillifolium in the Sawgrass Prairie.



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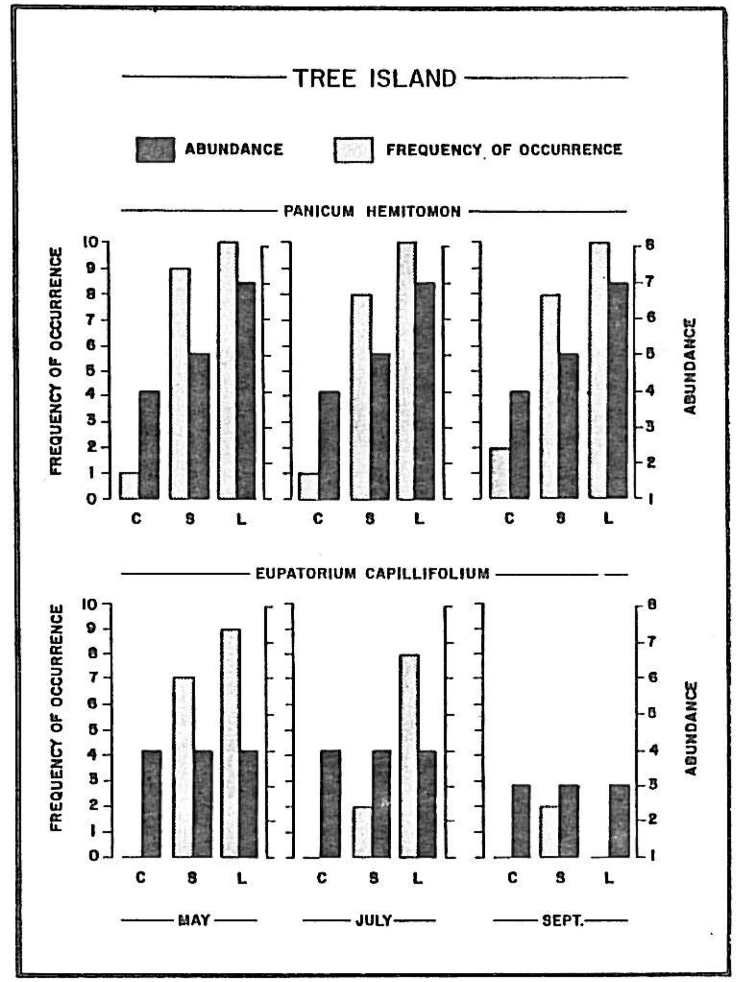

(b)

Figure 10. Variation in abundance (modified Bran-Blanquet Scale) and frequency of occurrence in each treatment for each sampling period for a) <u>Myrica cerifera</u> and <u>Osmunda regalis</u> and for b) <u>Panicum hemitomon</u> and <u>Eupatorium capillifolium</u> in the Tree Island.

became abundant in the treatment stations. Panicum hemitomon, the dominant species of the control station, however, was much less abundant in the treatments than in the control throughout the growing season (Figure 8). Similar patterns in species diversity and composition occurred in the sawgrass prairie (Table 3, Figure 9) and the tree island (Table 4, Figure 10): in treatment stations the abundances of dominant, perennial species, such as Cladium jamaicense, Osmunda regalis, and Myrica cerifera, were relatively low while the abundances of more ruderal species, such as Panicum hemitomon, Eupatorium capillifolium, and Lachnanthes caroliniana, were relatively high. In these two communities, however, the change in species composition also altered community physiognomy.

In the control stations of the sawgrass prairie and tree island, vegetation structure was complex due to the presence of overstory species, primarily C. jamaicense and M. cerifera, respectively. This structural complexity was markedly reduced in the frequently trafficked stations and noticeably reduced in the infrequently trafficked stations due to destruction of the overstory. These changes in community physiognomy were reflected in an increase in the abundances of understory herbs (eg. P. hemitomon and Eupatorium capillifolium) (Figures 9 and 10).

DISCUSSION

The persistent effects of TORV traffic observed require rejection of each null hypothesis and acceptance of the respective alternative hypotheses: 1) TORV traffic alters the structure of floodplain plant communities, and 2) the effects of TORV traffic are not reversed during the subsequent growing season. Thus, this study, and others (loc. cit.), demonstrates that operation of TORVs alters wetland vegetation and that the effects are long-lasting. But are the vegetational effects sufficiently detrimental to warrent restriction of TORV use? In order to answer this question, the management objectives for the marsh must be considered.

The wetlands of the Upper St. Johns River Basin are integral components of a semi-structural water management plan for the river's upper basin. This plan, to be implemented by the U. S. Army Corps of Engineers and locally sponsored by the St. Johns River Water Management District, is designed to control floods and augment the water supply in a fashion which enhances the region's ecological value. The ecological objectives of the plan are to increase the acreage of wetland habitat, by reconnecting drained wetlands to the floodplain, and to increase the quality of wetland habitat, by managing water levels (Brooks and Lowe, 1984). With respect to the latter objective, TORV traffic causes unmanaged vegetation succession and could frustrate efforts to manage the wetland habitat.

The primary long-term effect of TORV traffic on the wetland habitat is a dramatic alteration of the community structure of tree islands and sawgrass prairies. The alteration of these communities is so profound it is, perhaps, more appropriate to speak of local elimination rather than alteration. This is accompanied by an increase in plant species diversity. We believe, however, that the increase in plant diversity of impacted areas will be transient and will be followed by a decline in diversity to a level below that of unimpacted areas. This is supported by the following considerations.

The species diversity of sawgrass prairies and tree islands is high relative to that of maidencane prairies. The basis for this is the diversity of microclimates and the structural complexity conferred upon the former communities by their overstory species. With destruction of the overstory the diversity of microhabitats will decline. This will ultimately cause a decline in plant species diversity, but it is not unexpected that there could be a temporary increase in diversity. First, because destruction of the overstory temporarily allows the colonization of species rare or uncommon in undisturbed areas of the marsh, where dominance is typically high and they are competitively excluded. As the abundance of the new dominant species increases, diversity will decline. The most probable new dominant species would be Panicum hemitomon, and, as shown in Figure 7, the diversity of maidencane prairie is much lower than that of tree islands or sawgrass prairies. Second, the impacted areas were corridors through the natural vegetation. Thus, edge effects contributed significantly to the species list. As the width of impacted corridors increases, these edge effects will diminish and diversity will decline.

Theoretical support for this reasoning is given by the general literature of vegetation ecology which indicates that low levels of disturbance increase species diversity while high levels decrease diversity (Grime, 1979; Armesto and Pickett, 1985). Empirical support is given by aerial photographs which show that sawgrass prairie and tree island have both been replaced by maidencane prairie at the southerly study site. Fire is another possible agent of these changes, but there appears to have been no recent fires of sufficient intensity to eliminate these communities.

Many secondary effects of TORV traffic would stem from the effects on the vegetation. The habitat value of an area depends heavily upon its vegetation because the character of the vegetation determines the quantity and quality of primary production and markedly influences habitat structural complexity. The rate and nature of primary production sets upper limits on production at higher levels and, therefore, on the population densities of fish and wildlife. Theory, and a growing body of data, indicates that the rate of primary production may also limit species diversity (Brown, 1981). The structural complexity of the vegetation is also positively correlated with animal species diversity (Hutchinson, 1959; Simpson, 1964; Willson, 1974; Erdelen, 1984).

The effects of TORV traffic on the rates of primary production are unknown, but it is apparent that it reduces the structural diversity of both tree islands and sawgrass prairies. Consequently, although plant species diversity temporarily increases, due to the addition of ruderal species, animal diversity in impacted areas would be expected to decline. These considerations indicate that TORVs can not be operated in sawgrass communities or tree islands without jeopardizing both floral and faunal diversity.

Alteration of the flora and fauna of a wetland probably changes many of its other characteristics such as water quality, hydrological roughness, the rate of evapotranspiration, and the rates of production of game species and other species of concern (eg. endangered species, such as the snail kite, and nuisance species, such as mosquitoes). These effects have not been assessed and cannot be predicted, but it is likely that some of them would be undesireable. For example, preliminary research indicates that communities dominated by maidencane are very good breeding sites for mosquitoes in comparison to other types of marsh vegetation (Morris and Callahan, unpublished).

From a management perspective it seems prudent, therefore, to prohibit TORV operation in sawgrass and tree island communities. Further, in order to allow for natural expansion of these communities, and to protect their adjacent, natural ecotones, TORVs should be excluded from a buffer zone around them. In maidencane prairie, TORV operation does not dramatically alter the character of the vegetation and, therefore, would not be expected to significantly affect ecological processes. Here, the recreational benefits of TORV use may outweigh any concomitant ecological harm. Since most of the marsh open to TORV use is maidencane prairie, exclusion of vehicles from sawgrass prairies and tree islands, and from buffer zones around these communities, should not be inordinately restrictive.

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