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VEGETATIVE CHANGE ON SOUTH PADRE ISLAND, TEXAS, OVER TWENTY YEARS AND EVALUATION OF MULTISPECTRAL VIDEOGRAPHY IN DETERMINING VEGETATIVE COVER AND SPECIES IDENTITY

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ABSTRACT—A comparative vegetation analysis of an island-wide transect of South Padre Island, Texas, was conducted in 1997 using aerial multispectral digital videography and line intercept ground truth techniques to assess the usefulness of videography in estimating vegetative cover and species identifications. Ground truth data were used to assess vegetative change occurring in the 20 years since the report of Judd et al. (1977) on the vegetation of South Padre Island. Estimates of total cover by ground truth and remote sensing techniques were similar (2.45% difference) on South Padre Island. Thus, airborne multispectral digital videography is an effective technique for assessing changes in total vegetative cover of Texas barrier islands. This technique will be an effective tool for documenting changes in total cover on barrier islands due to natural perturbations such as hurricanes and human disturbances including vehicular traffic. Imagery obtained at altitudes of 200 m or greater did not permit discrimination of dominant species in each of an island's topographic zones. However, acquisition of imagery at a time of the year when dominant species are in specific phenological stages, such as flowering, and at a lower altitude may facilitate their recognition. Comparison of data from a single trans-island transect in 1997 with data from three trans-island transects and 18 transects across the foreshore, backshore, and primary dunes in 1977 suggests that there has been a marked decrease in species richness of the backshore and primary dune zones of South Padre Island. There also was a change in dominant species in the backshore zone. These changes in species richness and dominance may be largely attributable to vehicular traffic in these zones.

RESUMEN—Un análisis comparativo de la vegetación de un transecto transinsular de la isla South Padre en el estado de Texas fue realizado en 1997 usando videografía aérea multiesprectral digital y técnicas de validación de intercepción linear terrestre para evaluar la utilidad de la videografía en la estimación de la cobertura vegetal e identificación de especies. Los datos de estudios de validación terrestre fueron utilizados para evaluar el cambio vegetativo que ocurrió durante 20 años después del informe de Judd et al (1977) sobre la vegetación de la isla South Padre. Las estimaciones de la cobertura total mediante técnicas de validación terrestres y de medición remota fueron similares (2.45% de diferencia) en la isla South Padre. Por lo tanto, la videografía multiesprectral digital aérea se considera una técnica eficaz para evaluar cambios en la cobertura vegetal de las islas barrera de Texas. Esta técnica será una herramienta efectiva para documentar los cambios de cobertura total en las islas barrera debido a las perturbaciones naturales tales como huracanes y disturbios humanos como tráfico vehicular. Las imágenes obtenidas en altitudes de 200 metros o mayores no permitieron la discriminación de las especies dominantes de las varias zonas topográficas de una isla. Sin embargo, la adquisición de imágenes de una época del año en que las especies dominantes están en etapas fenológicas específicas, tales como la floración, y desde una altitud menor, puede facilitar su reconocimiento. Al comparar datos de un transecto transinsular de 1977 con los de tres transectos transinsulares y de 18 transectos correspondientes a la parte frontal, trasera, y de las dunas primarias de la isla en 1977, se sugiere que ha habido una marcada disminución en la riqueza de especies en la parte trasera y en la zona de dunas primarias de la isla South Padre. También hubo un cambio de especies dominantes en la zona trasera. Estos cambios en la riqueza y dominancia de especies pueden ser atribuidos en gran parte al tráfico vehicular en estas zonas.

The most conspicuous physiographic feature along the Gulf of Mexico coastline of Texas is a series of five barrier islands that enclose several shallow bay systems. Barrier islands provide most of the recreational beach areas of Texas, and they protect the coastline against water damage during tropical storms and hurricanes. Padre Island, the longest of these islands, extends 182 km southward from Corpus Christi to Brazos-Santiago Pass near Port Isabel. The island ranges from 0.5 to 7.8 km in width and is separated from the mainland by the Laguna Madre, a shallow lagoon with a maximum width of about 16 km. South Padre Island, 55 km long with an area of 16,200 ha, is separated from the northern two-thirds of the island by the Mansfield Channel.

The flora and vegetation of South Padre Island are relatively well known compared to other areas of the barrier island chain (Dahl et al., 1974; Judd et al., 1977; Lonard et al., 1978; Lonard and Judd, 1980; Judd and Sides, 1983; Judd and Lonard, 1987; Judd et al., 1989; Lonard et al., 1991; Lonard and Judd, 1997). Vegetation of the island differs from vegetation of other barrier islands of the northern Gulf of Mexico and Atlantic coasts (Judd et al., 1977; Stalter, 1993). No shrub or tree zones are present on South Padre Island. The vegetation is essentially one layered and nearly all species are herbaceous perennials (Judd et al., 1977).

Vegetation pattern on South Padre Island is the result of a variety of factors. Prevailing winds from the southeast laden with salt spray, periodic tropical storms, and hurricanes are important in determining species composition on the backshore and primary dune topographic facets (Oosting and Billings, 1942; Judd and Sides, 1983). Low annual precipitation accounts for the herbaceous and graminoid character of the vegetation in all topographic zones. Other important factors are intense solar radiation, periodic droughts, nature of the soil and its water content, level of the water table relative to the root zone, sand coverage, and human perturbations (Judd et al., 1977; Judd and Lonard, 1987; Judd et al., 1991).

The vegetation of South Padre Island occurs in distinct zones or belts that correspond to topographic facets (Judd et al., 1977). An idealized profile includes: 1) a foreshore devoid of rooted vegetation, 2) a backshore zone with embryonic dunes nearest the berm crest dominated by *Sesuvium portulacastrum* and a landward zone dominated by *Uniola paniculata,* 3) a primary dune ridge supporting *Ipomoea imperati* and *U. paniculata* as dominants, 4) a zone of secondary dunes and vegetated flats or a mosaic of both in which *Schizachyrium scoparium* is dominant, and 5) a tidal flat zone that is largely bare, but which supports halophytic vegetation in a narrow zone bordering the vegetated flats. A sixth zone, washovers, extends across these zones. Washovers are distinct in the primary dune and secondary dune and vegetated flats zones, but merge imperceptibly with the tidal flats (Judd et al., 1977).

Depressions that often support development of marsh communities occur frequently in the secondary dunes and vegetated flats topographic zone. These wetland plant communities are dominated by a combination of sedges and grasses including *Scirpus pungens, Spartina patens, Fimbristylis castanea, Fuirena simplex,* and *Rhynchospora colorata* (Judd et al., 1977).

Natural areas of the barrier island system are large and generally inaccessible to ground surveys. Remote sensing techniques including aerial photography and multispectral videography have been useful tools for classifying and mapping plant communities and for monitoring hurricane damage and human perturbations in the coastal zone of southern Texas (Everitt and Judd, 1989; Judd et al., 1989; Everitt et al., 1991; Lonard et al., 1991; Everitt et al., 1992; Judd et al., 1994; Everitt et al., 1996; Judd et al., 1997). However, no information is available on using multispectral videography for distinguishing and assessing natural vegetation in the various topographic zones on South Padre Island. Therefore, we sought to assess the usefulness of aerial multispectral digital videography in determining vegetative cover and species identity on South Padre Island and to assess vegetative change occurring in the 20 years since the report of Judd et al. (1977) on the vegetation of South Padre Island. This study will add to an understanding of the vegetation dynamics of South Padre Island, in particular, and to that of the barrier islands in the southern Gulf of Mexico, in general.

METHODS AND MATERIALS—The line intercept technique was used to provide ground truth information and to quantify vegetation abundance and distribution on South Padre Island at a location 16.3 km north of Brazos-Santiago Pass (Canfield, 1941; Judd et al., 1977). A 1,210-m transect, established perpendicular to the longitudinal axis of the island, extended from the Gulf of Mexico shoreline (GMS) to the Laguna Madre shoreline (LMS). The transect passed through five major topographic zones including the foreshore, backshore, primary dune ridge, secondary dunes and vegetated flats, and tidal flats, respectively (Judd et al., 1977). The transect was divided into 10-m intervals and data were recorded along the total length of each interval. Each species intercepted by the line was rated individually and scored without separation into strata. For each of the topographic facets, we recorded frequency and foliage cover and calculated from these data relative frequency, relative cover, and an importance value (IV) based on the sum of relative frequency and relative cover (Judd et al., 1977). Frequency of occurrence was used to describe the distribution of species along the transect, to assess the contact and overlap among species, and to reconcile ground truth data with data obtained from remote sensing methodology. Importance values were used to determine which species dominated a topographic zone. Vegetation sampling was conducted 13 May, 28 May, and 4 June 1997.

Imagery of the study site was obtained with a three-camera multispectral digital video imaging system (Everitt et al., 1995) on 14 May 1997 using a fixed-wing Aerocommander* aircraft. Imagery was taken between 1100 and 1300 h under sunny conditions. The system is comprised of three charge-coupled device video cameras and a computer equipped with an image digitizing board. The cameras are visible/near-infrared (NIR; 400 to 1100 nm) light sensitive. One camera had a NIR (845 to 857 nm) filter, one had a red (R; 625 to 635 nm) filter, and the other camera a yellow-green (YG; 555 to 565 nm) filter. The computer is a 486-DX50 system that has an RGB grabbing board (640 × 480 pixel resolution). The NIR, R, and YG image signals from the cameras are subjected to RGB inputs of the computer digitizing board, thus giving a color-infrared (CIR) composite digital image similar in color rendition to that of CIR film. The hard disk can store 1,000 CIR composite images. Video imagery of the study site was obtained at altitudes of approximately 200 and 2,440 m above ground level and provided horizontal ground pixel sizes of 0.22 and 2.6 m, respectively. Imagery was subjected to pixel line correction and image-to-image registration using a Pentium IBM compatible computer having Image Pro Plus and Adobe Photoshop Software. A mosaic was made of the study site using three images obtained at 200 m altitude. Adobe Photoshop software was used to make the mosaic. A line [1 pixel width (0.22 m)] was superimposed on the mosaic image denoting the location where the line transect was obtained. From the classified image, vegetative cover was quantified using Adobe Photoshop's magic wand tool, select/load selection, and image/histogram functions. Colored pixels representing vegetation were masked using the magic wand function. Subsequently, the select/load function was used to confirm selection of all vegetation pixels within the transect. Pixel quantifications were given in terms of percent vegetative cover and were displayed by the image/histogram function. Images presented here were photographed from a high resolution monitor.

* Trade names are included for the benefit of the reader and do not imply an endorsement of or a preference for the product listed by the United States Department of Agriculture.

RESULTS—Figure 1a depicts a trans-island video image of South Padre Island at approximately 2,400 m altitude above ground level, and Fig. 1b shows an image obtained at ca. 200 m above ground level. The line at the base of Fig. 1b shows the location of the line transect. The foreshore is the topographic zone affected by tidal amplitude and is littered by two bands of *Sargassum* and flotsam deposited at high tide that can be seen in Fig. 1b1. Rooted plants are absent in this zone.

The backshore topographic facet extends from the berm crest to the windward base of the primary dune system (60 to 100 m from GMS). Only three species, *Ipomoea pes-caprae, S. portulacastrum,* and *U. paniculata,* were present in this zone (Table 1). Total foliar cover obtained by the ground truth sampling technique along the transect was 7.56%, whereas computer classification along the transect line estimated 5.91% vegetative cover. *Sesuvium portulacastrum* occurred only in isolated patches 60 to 70 m from the GMS. *Uniola paniculata* and *I. pes-caprae* were present in foredunes near the seaward base of the primary dune

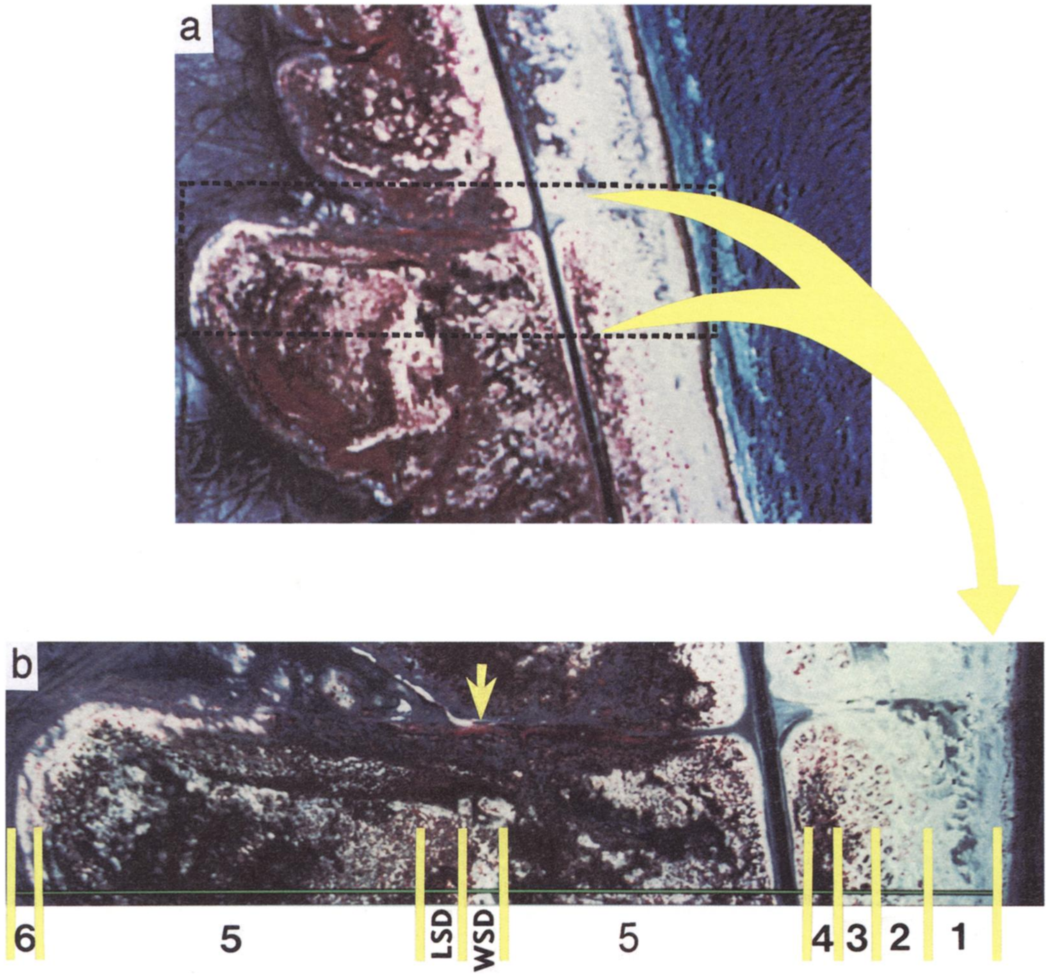

FIG. 1—Aerial color-infrared (CIR) video image (a) of the South Padre Island study site obtained at an altitude of 2,400 m. Print b depicts a CIR video mosaic (3 images) obtained at an altitude of 200 m of the area encompassed within the dashed line on print a. The line at the base of print b denotes the location of the line transect. The small arrow on print b shows an area dominated by wetland vegetation. Vertical yellow lines represent: 1) foreshore, 2) backshore, 3) windward slope of the primary dune complex, 4) leeward slope of the primary dune complex, 5) secondary dunes and vegetated flats, 6) transition zone between the secondary dunes and vegetated flats and the tidal flats, (WSD) windward slope of secondary dune, and (LSD) leeward slope of secondary dune.

TABLE 1—Frequency (%), relative frequency, cover (%), relative cover, and importance value (IV = relative frequency + relative cover) in the backshore zone on South Padre Island.

Species	Frequency (%)	Relative frequency	Cover (%)	Relative cover	IV
Ipomoea pes-caprae	50	50	1.83	24.2	74.2
Sesuvium portulacastrum	25	25	3.20	42.4	67.4
Uniola paniculata	25	25	2.53	33.4	58.4
Total cover			7.56		

TABLE 2—Frequency (%), relative frequency, cover (%), relative cover, and importance value (relative frequency + relative cover) on the windward and leeward slopes of the primary dune zone on South Padre Island.

Species	Frequency (%)	Relative frequency	Cover (%)	Relative cover	IV
Windward slope of primary dune					
Uniola paniculata	100	50	12.15	60.6	110.6
Ipomoea imperati	100	50	7.90	39.4	89.4
Total cover			20.05		
Leeward slope of primary dune					
Schizachyrium scoparium	100	20	13.20	26.5	46.5
Uniola paniculata	100	20	12.70	25.1	45.1
Oenothera drummondii	100	20	10.90	21.9	41.9
Heterotheca subaxillaris	50	10	9.05	18.2	28.2
Ipomoea imperati	50	10	3.70	7.4	17.4
Galactia canescens	50	10	0.25	0.5	10.5
Chamaecrista fasciculata	50	10	0.05	0.1	10.1
Total cover			49.85		

ridge (80 to 100 m from GMS), and the association is represented by a dull magenta image response (Fig. 1b2).

The most conspicuous topographic feature on South Padre Island is the primary dune complex. It extends from 100 to 140 m from the GMS. The vegetation of its windward and leeward surfaces were summarized separately because of the protection from salt spray deposition and sand scouring that the dune system affords to the leeward slopes of the dunes and consequently to the topographic zone protected in its lee (Table 2). The harsh environment of the windward slope supported only two species, *U. paniculata* and *I. imperati*, which are co-dominants (Fig. 1b3). Total vegetative cover obtained by the line intercept technique was 20.05%. In contrast, computer classification along the transect estimated 22.31% vegetative cover. The more protected leeward slope (Fig. 1b4) supports seven species (Table 2). *Uniola paniculata* and *I. imperati* occur on both dune slopes, and *S. scoparium, U. paniculata*, and *Oenothera drummondii* share dominance on the leeward slope. The percent cover value (49.85%), obtained by the field sampling technique, is 2.5 times greater on the leeward side of the primary dune than on the salt spray-influenced windward slope. Computer classification estimated 50.63% vegetative cover which is in close agreement to the ground truth technique. The greater plant cover has a dark reddish-brown image tone bordered by bare sand 123 m from the GMS (Fig. 1b4).

The broadest topographic zone on South Padre Island, extending from 140 to 670 m from GMS, comprises secondary dunes and vegetated flats. This facet typically is lower in elevation and subsequently is protected from environmental stresses by the primary dune system. Forty-seven species representing 19 families were present on the transect in this zone. *Schizachyrium scoparium*, which constituted 34.2% of the relative cover, was the dominant species (Table 3). Other important species included *Heterotheca subaxillaris, Paspalum monostachyum*, and *S. pungens* which had relative cover values of 11.9%, 8.3%, and 9.5%, respectively. *Schizachyrium scoparium* and *H. subaxillaris* were widely distributed in the zone. Frequency values for the two species were 98% and 69%. *Paspalum monostachyum* was noted initially on the transect 350 m from the GMS. It also occurred in all intervals between 440 and 640 m from GMS.

The secondary dunes and vegetated flats zone is interrupted by Park Road 100 at 180 to 190 m from GMS. The area adjacent to the highway on both the east and west margins is characterized by bare dry sand and low foliar cover. Isolated magenta patches represent small colonies of *H. subaxillaris* (Fig. 1b5). On the left side (west) of the highway, the secondary dunes and vegetated flats complex contin-

TABLE 3—Frequency (%), relative frequency, cover (%), relative cover, and importance value (relative frequency + relative cover) in the secondary dunes and vegetated flats zone on South Padre Island.

Species	Frequency (%)	Relative frequency	Cover (%)	Relative cover	IV
Schizachyrium scoparium	97.8	10.53	14.03	34.15	44.68
Heterotheca subaxillaris	68.9	7.42	4.90	11.94	19.36
Paspalum monostachyum	44.4	4.78	3.45	8.39	13.17
Scirpus pungens	33.3	3.59	3.92	9.54	13.13
Solidago sempervirens	51.1	5.50	1.44	3.49	8.99
Fimbristylis castanea	55.6	5.98	0.83	2.03	8.01
Chamaecrista fasciculata	42.2	4.55	0.83	2.02	6.57
Hedyotis nigricans	37.8	4.07	1.01	2.45	6.52
Galactia canescens	31.1	3.35	1.22	2.96	6.31
Uniola paniculata	35.6	3.83	0.91	2.22	6.05
Iva angustifolia	31.1	3.35	0.97	2.36	5.71
Polygala alba	40.0	4.31	0.28	0.67	4.98
Spartina patens	15.6	1.67	1.10	2.69	4.36
Croptilon rigidifolium	24.4	2.63	0.70	1.71	4.34
Fuirena simplex	11.1	1.20	1.16	2.82	4.02
Eragrostis secundiflora	22.2	2.39	0.63	1.53	3.92
Miscellaneous (31 species)	286.4	30.87	3.70	9.03	39.90
Total cover			41.08		

ues 190 m to the base of a large secondary dune. The zone is characterized by small, dry dune ridges with areas of exposed sand and shallow, moist swales which have a gray image tone (Fig. 1b5).

A brackish marsh with standing water was present at the windward base of a large secondary dune 360 to 380 m from GMS (Fig. 1b–WSD). It has a black tonal response fringed by a gray margin of wet sand. Vegetation of the marsh was essentially two-layered with *Bacopa monnieri* forming a dense, prostrate, stoloniferous mat. *Scirpus pungens* was the dominant species in the taller herbaceous overstory. *Fuirena simplex, R. colorata,* and *Solidago sempervirens* were other important species.

A prominent secondary dune (>10 m in height) was present in the secondary dune and vegetated flat complex 380 to 450 m from GMS (Fig. 1b–WSD, LSD). Vegetation of this conspicuous dune was analyzed separately so it could be compared to vegetation of the primary dune ridge. The dominant species on the windward slope was *S. scoparium* followed by *O. drummondii, H. subaxillaris,* and *Chamaecrista fasciculata* (Table 4). The windward slope that extends 50 m from the edge of the marsh to a relatively flat summit was conspicuous in the image due to the broad areas of exposed sand (Fig. 1b–WSD). Total vegetative cover obtained by the line intercept technique was 38.3%. In contrast, computer classification along the transect estimated 34.14% cover. The clear dominant on the steep but nearly stablized leeward face was the strongly rhizomatous *P. monostachyum.* The percent cover value (76.4%), obtained by the ground truth technique of the leeward face of the secondary dune was approximately twice that of the windward slope of the secondary dune (Table 4). Computer classification estimated 76.92% vegetative cover which is in close agreement to the line intercept technique. A dark reddish image tonal response characterizes the dense foliar coverage of the steep leeward slope (Fig. 1b–LSD).

The gently rolling topography of the secondary dunes and vegetated flats complex continues from 450 to 670 m from GMS. *Schizachyrium scoparium, H. subaxillaris,* and *P. monostachyum* were leading dominants on dune crests and well-drained sites, whereas *S. pungens, F. simplex, P. monostachyum, Iva angustifolia, R. colorata,* and *S. sempervirens* were important species in swales that appear black in the image (Fig. 1b5). Total foliar cover obtained by the line intercept technique in the 530-m broad belt of the secondary dunes and vegetated flats

TABLE 4—Frequency (%), relative frequency, cover (%), relative cover, and importance value (relative frequency + relative cover) in the windward and leeward slopes of a back-island secondary dune on South Padre Island.

Species	Frequency (%)	Relative frequency	Cover (%)	Relative cover	IV
Windward slope of secondary dune					
Schizachyrium scoparium	80	16	9.88	25.80	41.80
Oenothera drummondii	100	20	5.58	14.57	34.57
Heterotheca subaxillaris	60	12	7.20	18.80	30.80
Chamaecrista fasciculata	60	12	3.74	9.77	21.77
Physalis cinerascens	20	4	5.30	13.84	17.84
Indigofera miniata	20	4	2.58	6.74	10.74
Galactia canescens	40	8	0.86	2.25	10.25
Ipomoea imperati	40	8	0.20	0.52	8.52
Uniola paniculata	20	4	1.26	3.29	7.29
Panicum amarum	20	4	1.06	2.77	6.77
Croton punctatus	20	4	0.52	1.36	5.36
Euphorbia cordifolia	20	4	0.12	0.31	4.31
Total cover			38.30		
Leeward slope of secondary dune					
Paspalum monostachyum	100	20	39.30	51.44	71.44
Schizachyrium scoparium	100	20	14.75	19.31	39.31
Uniola paniculata	100	20	10.70	14.00	34.00
Physalis cinerascens	50	10	6.00	7.85	17.85
Heterotheca subaxillaris	50	10	4.60	6.02	16.02
Digitaria arenicola	50	10	0.95	1.24	11.24
Galactia canescens	50	10	0.10	0.13	10.13
Total cover			76.40		

complex was 41.08% (Table 3). Computer classification estimated 37% total cover.

A narrow transition zone 670 to 680 m from GMS was present between the secondary dunes and vegetated flats and the tidal flats (Fig. 1b6). Only three halophytic species, *S. patens, Salicornia bigelovii,* and *Suaeda linearis,* occurred here. *Spartina patens,* with a relative cover value of 96%, was the dominant species (Table 5). Total vegetative cover obtained by the line intercept technique was 18.5%, whereas computer classification estimated 17.7% vegetative cover in this narrow transition zone.

TABLE 5—Comparison of the relative importance of species occurring in the transition zone between the secondary dunes and vegetated flats and tidal flats on South Padre Island.

Species	Cover (%)	Relative cover
Spartina patens	17.8	96.2
Salicornia bigelovii	0.6	3.2
Suaeda linearis	0.1	0.5
Total cover	18.5	

Tidal flats extended as a broad, predominantly barren zone of sand with scattered patches of blue-green algae 680 to 1,210 m from GMS to LMS. Vehicular tracks are conspicuous features on the wet sand (Fig. 1b, upper left). Only one small stand of *S. bigelovii* (1 cm of foliage cover) was present on the margin of LMS. Approximately 100 m north of the transect, a small colony of juvenile *Avicennia germinans* plants occurred on the margin of a shallow inlet to the bay. Both species were present in an area outside the boundary of the video images of Fig. 1.

The solid, bright red area (see arrow) adjacent to an access road leading to the Laguna Madre from Park Road 100 represents a washover area dominated by two layers of herbaceous wetland vegetation. *Bacopa monnieri, Eleocharis obtusa,* and *Sporobolus virginicus* form a dense understory. The stoloniferous, matforming, *B. monnieri* which has planophile leaves apparently contributes heavily to the bright red image (Everitt et al., 1986). *Panicum amarum, S. pungens, F. simplex, S. sempervirens, Suaeda linearis,* and *S. bigelovii,* which comprise the taller layer, serve to effectively close the canopy (Fig. 1b).

Total foliar cover obtained by the field sampling technique along the transect across all topographic facets was 34.2%. In contrast, computer classification along the transect line estimated 31.75% vegetative cover, which is in close agreement to the ground sampling technique. Thus, remote sensing techniques coupled with computer image analysis may be an excellent means of rapidly determining total vegetative cover.

DISCUSSION—Aerial videography appears to have its greatest value in depicting the total cover of vegetation on Texas barrier islands. The estimate of total cover along the transect in Fig. 1 was only 2.45% lower than that obtained by vegetation analysis on the ground. Videography has less utility in discrimination of species, although Judd et al. (1994) showed that color-infrared aerial photography permitted discrimination of four of five species found in the backshore and primary dune zones of South Padre Island. This utility was facilitated by the patchy occurrence of vegetation in these topographic zones. It is far more difficult to discriminate species in the more densely vegetated secondary dunes and vegetated flats.

Judd et al. (1977) reported on three trans-island transects (i.e., from the gulf shoreline to the bay shoreline). These were at the ¼, ½, and ¾ positions relative to the length of the island. They also investigated 18 additional transects across the foreshore, backshore, and primary dunes because of the narrowness of these zones. These transects were positioned at 3.2 km intervals along the length of South Padre Island.

Judd et al. (1977) found eight species in the backshore zone, whereas we found only three species. Thus, in the 20 years since their study, species richness in the backshore zone has been markedly reduced. It is possible that the apparent species richness is spurious and due to small sample bias (i.e., one transect in 1997); however, Judd et al. (1977) reported that increasing the number of transects from three to 18 across the foreshore, backshore, and primary dune zone did not add significantly to species richness.

There was a marked change in dominant species in the backshore zone from 1977 to 1997. Judd et al. (1977) found that *S. portulacastrum* (IV = 70.0) and *U. paniculata* (IV = 71.9) were the dominant species. We found that *I. pes-caprae* (IV = 74.2) and *S. portulacastrum* (IV = 67.4) were the dominants in 1997. The importance of *U. paniculata* decreased from 71.9 in 1977 to 58.4 in 1997. In 1977 *I. pes-caprae* ranked fifth of eight species in importance with a value of 10.7. Thus, its abundance has increased greatly.

The decrease in species richness and the decrease in relative importance of *U. paniculata* may be caused by vehicular damage to vegetation and dunes of the backshore zone. The effect of vehicular traffic in the backshore zone of South Padre Island has not been quantified, but our subjective assessment over the years is that all-terrain vehicle (ATV) and dune buggy traffic has significantly decreased dune vegetation. In addition, two hurricanes (Allen in 1980 and Gilbert in 1988) have adversely affected vegetation cover and species richness (Judd and Sides, 1983; Judd et al., 1991). *Ipomoea pes-caprae* is a robust vine with rapid growth. Its increase in relative importance in the backshore zone may be related to its ability to recover more quickly following disturbance than can *U. paniculata.*

The windward slope of the primary dunes also showed a marked decrease in species richness from 1977 (six species) to 1997 (two species). The two dominant species were the same at both times (*U. paniculata* and *I. imperati* = *I. stolonifera* of 1977), but their positions of importance were reversed. *Uniola paniculata* was second in importance in 1977 and first in importance in 1997. The change in importance may reflect only site differences in relative abundance of the two species, whereas the decrease in species richness is probably due to vehicular traffic.

The leeward slope of the primary dunes exhibited a decrease in species richness from 1977 (11 species) to 1997 (seven species). In 1977, *I. stolonifera* (=*I. imperati*) was a clear dominant (IV = 81.0) with *U. paniculata* (IV = 31.6) and *S. scoparium* (IV = 30.1) of about equal secondary importance. In 1997 *S. scoparium* (IV = 46.5), *U. paniculata* (IV = 45.1), and *O. drummondii* (IV = 41.9) were all approximately equal in importance. In 1977 *O. drummondii* was seventh of 11 species in importance with a value of only 5.7. In 1997 *I. imperati* (=*I. stolonifera*) was fifth of seven species in importance with a value of 17.4. Apparently, the leeward slopes of the primary dunes have been adversely affected by vehicular traffic less than have the foredunes of the backshore zone and the windward faces of the primary dunes. This may be due to less vehicular traffic on the lee slopes. The abrupt slope makes driving hazardous and the looseness of the sand makes burial of ATVs and dune buggies probable.

Judd et al. (1977) did not list relative importance of species in the secondary dunes and vegetated flats zone. Rather, they compared vegetation of the entire trans-island transects because of the width of the secondary dunes and vegetated flats compared to other topographic zones. The greatest number of species encountered in any one of the three trans-island transects was 46. We found 47 species in the secondary dunes and vegetated flats zone alone in 1997. Thus, there has been no reduction in species richness in the secondary dunes and vegetated flats zone. *Schizachyrium scoparium* was the dominant species in the trans-island transects in 1977, and it was the dominant species of the secondary dunes and vegetated flats zone in 1997. The absence of change in species richness and dominant species probably reflects the relatively low impact of vehicular traffic in the secondary dunes and vegetated flats zone. Except for washover areas, there is little vehicular traffic in the secondary dunes and vegetated flats zone compared to the backshore and primary dune areas.

Tidal flats were largely barren in 1977 (Judd et al., 1977) and 1997. Species present were sparsely distributed salt tolerant taxa. Species richness of the windward face of the secondary dune was markedly greater (12 species) than that of the windward face of the primary dune (two species). This reflects the less harsh environment (less salt spray and sand scouring) and lower vehicular traffic. Species richness was identical (seven species) on the leeward slopes of the two dunes. Both of the dominant species of the windward face of the primary dune were present on the windward face of the secondary dune. *Schizachyrium scoparium* was the dominant species of the windward face of the secondary dune but was second in importance to *P. monostachyum* on the leeward slopes. The lower importance of *S. scoparium* on the leeward slopes may be due to the loose nature of the sand here and the high degree of sand coverage. *Paspalum monostachyum* is a taller, more robust grass that is more resistant to sand burial than is *S. scoparium*.

Dominant plants in the secondary dunes and vegetated flats on South Padre Island are similar to dominant species in relatively undisturbed upland grasslands in the Texas Coastal Sand Plain. The Coastal Sand Plain occurs northwest of South Padre Island in the portion of the Texas mainland bordered by Baffin Bay on the north and the Rio Grande Delta on the south (Diamond and Fulbright, 1990). Diamond and Fulbright (1990) report *S. scoparium* as the dominant species with *P. monostachyum* as a dominant species on moderately-drained flats and swales and *H. subaxillaris* as a leading dominant species on dune ridges and dry sand flats.

Videography is useful in delimiting topographic features, total vegetative cover and relative cover. It is less useful in species identification due to the presence of numerous grasses in the vegetation. For example, *P. monostachyum*, with its highly reduced leaf surface area and erectophile leaf orientation, is not easily detected in the imagery. Multispectral imagery obtained in mid-late October may have greater utility. The dominant species, *S. scoparium*, is in a peak flowering and fruiting phenophase during early autumn (Lonard and Judd, 1989) and it may exhibit a significant contrasting image response compared to other grasses and sedges.

Airborne videography appears to be a useful technique in monitoring perturbations resulting from storms and human activities (Judd et al., 1989; Judd et al., 1991; Lonard et al. 1991). Potential hurricane washover sites are readily discernible on images. The imagery is useful to a variety of resource managers and coastal zone planners. The technology will be particularly useful in monitoring recovery of vegetation following tropical storms and hurricanes. Field investigations that follow the recovery of nearshore vegetation provide a similar estimation of foliar cover (Judd and Sides, 1983), but such studies are time consuming and expensive.

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Literature Cited

CANFIELD, R. H. 1941. Application of the line interception method in range vegetation. Journal of Forestry 39:388–394.

DAHL, B. E., B. A. FALL, A. LOHSE, AND S. G. APPAN. 1974. Stabilization and reconstruction of Texas foredunes with vegetation. Gulf Universities Research Consortium 139:1–325.

DIAMOND, D. D., AND T. E. FULBRIGHT. 1990. Contemporary plant communities of upland grasslands of the Coastal Sand Plain, Texas. Southwestern Naturalist 35:385–392.

EVERITT, J. H., AND F. W. JUDD. 1989. Using remote sensing techniques to distinguish and monitor black mangrove (*Avicennia germinans*). Journal of Coastal Research 5:737–745.

EVERITT, J. H., D. E. ESCOBAR, AND F. W. JUDD. 1991. Evaluation of airborne video imagery for distinguishing black mangrove (*Avicennia germinans*) on the lower Texas gulf coast. Journal of Coastal Research 7:1169–1173.

EVERITT, J. H., A. J. RICHARDSON, AND P. R. NIXON. 1986. Canopy reflectance characteristics of succulent and nonsucculent rangeland plant species. Photogrammetric Engineering and Remote Sensing 52:1891–1897.

EVERITT, J. H., D. E. ESCOBAR, F. W. JUDD, AND M. R. DAVIS. 1992. Evaluation of SPOT satellite and airborne video imagery for distinguishing black mangrove (*Avicennia germinans*). In: Proceedings of the Thirteenth Biennial Workshop on Color Aerial Photography and Videography in the Plant Sciences. Orlando, Florida. Pp. 169–175.

EVERITT, J. H., F. W. JUDD, D. E. ESCOBAR, AND M. R. DAVIS. 1996. Integration of remote sensing and spatial information technologies for mapping black mangrove on the Texas Gulf Coast. Journal of Coastal Research 12:64–69.

EVERITT, J. H., D. E. ESCOBAR, I. CAVAZOS, J. R. NORIEGA, AND M. R. DAVIS. 1995. A three-camera multispectral digital video imaging system. Remote Sensing of the Environment 54:333–337.

JUDD, F. W., AND R. I. LONARD. 1987. Disturbance and community development. In: Proceedings of the Fifth International Symposium on Coastal and Ocean Management, Coastal Zone '87. American Society of Civil Engineering. Seattle, Washington. Pp. 1731–1745.

JUDD, F. W., AND S. L. SIDES. 1983. The effect of Hurricane Allen on the near-shore vegetation of South Padre Island. Southwestern Naturalist 28: 365–369.

JUDD, F. W., R. I. LONARD, AND S. L. SIDES. 1977. The vegetation of South Padre Island, Texas in relation to topography. Southwestern Naturalist 22: 31–48.

JUDD, F. W., R. I. LONARD, J. H. EVERITT, AND R. VILLARREAL. 1989. Effects of vehicular traffic in the secondary dunes and vegetated flats of South Padre Island, Texas. In: Proceedings of the Sixth International Symposium on Coastal and Ocean Management, Coastal Zone '89. American Society of Civil Engineers. Charleston, South Carolina. Pp. 4634–4645.

JUDD, F. W., R. I. LONARD, J. H. EVERITT, AND D. E. ESCOBAR. 1991. Resilience of seacoast bluestem barrier island communities. In: Proceedings of the Seventh International Symposium on Coastal and Ocean Management. American Society of Civil Engineers, Coastal Zone '91. Long Beach, California. Pp. 3513–3524.

JUDD, F. W., R. I. LONARD, J. H. EVERITT, D. E. ESCOBAR, AND M. R. DAVIS. 1997. Using multispectral videography to distinguish the pattern of zonation and plant species composition in brackish water marshes of the Rio Grande Delta. In: Proceedings of the Fourth International Conference for Marine and Coastal Environments. Environmental Research Institute of Michigan (ERIM). Ann Arbor, Michigan. Pp. II 621–II 629.

JUDD, F. W., R. I. LONARD, D. L. HOCKADAY, D. E. ESCOBAR, J. H. EVERITT, AND R. DAVIS. 1994. Remote sensing of nearshore vegetation, South Padre Island, Texas. In: Proceedings of the Second Thematic Conference on Remote Sensing for Marine and Coastal Environments. Volume 1, Needs, Solutions and Applications. Environmental Research Institute of Michigan (ERIM). Ann Arbor, Michigan. Pp. 581–589.

LONARD, R. I., AND F. W. JUDD. 1980. Phytogeography of South Padre Island, Texas. Southwestern Naturalist 25:313–322.

LONARD, R. I., AND F. W. JUDD. 1989. Phenology of native angiosperms of South Padre Island, Texas. In: Bragg, T., and J. Stubbendieck, editors. Proceedings of the Eleventh North American Prairie Conference, University of Nebraska Printing, Lincoln. Pp. 217–222.

LONARD, R. I., AND F. W. JUDD. 1997. The biological flora of coastal dunes and wetlands. *Sesuvium portulacastrum* (L.) L. Journal of Coastal Research 13:96–104.

LONARD, R. I., F. W. JUDD, AND S. L. SIDES. 1978. Annotated checklist of the flowering plants of South

Padre Island, Texas. Southwestern Naturalist 23: 497–510.

LONARD, R. I., F. W. JUDD, J. H. EVERITT, D. E. ESCOBAR, AND R. DAVIS. 1991. Roadside associated disturbance on coastal dunes. In: Proceedings of the Seventh International Symposium on Coastal and Ocean Management. American Society of Civil Engineers, Coastal Zone '91. Long Beach, California. Pp. 2823–2836.

OOSTING, H. J., AND W. B. BILLINGS. 1942. Factors effecting vegetational zonation on coastal dunes. Ecology 23:131–142.

STALTER, R. 1993. Dry coastal ecosystems of the Gulf Coast of the United States of America. In: van der Maarel, E. editor. Dry coastal ecosystems: Africa, America, Asia and Oceania. Elsevier, New York. Pp. 375–387.

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