EFFECTS OF STREAM CHANNELIZATION ON AVIAN DIVERSITY AND DENSITY IN PIEDMONT VIRGINIA[1]

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ABSTRACT

Species diversity and density for game and non-game birds were studied during winter and summer, 1975 on three streams in the Virginia Piedmont which were channelized 2, 5, and 9 years prior to field work. Three study sites, each 1 hectare in size, were located along streams in secondary succession bottomland hardwood communities. Indices were calculated for bird species diversity (BSD) and foliage height diversity (FHD) using the Shannon-Weaver information theory formula. To further assess any differences in either diversity or density among the three sites the following variables were also examined: the number of breeding birds per hectare, the mean number of birds observed per hour, and the average number of bird species seen per day. Results indicated that BSD and FHD increased from the 2-year-old to 9-year-old channelized streams. A significant increase was observed in avian diversity and density through progressive successional stages of the channelized streams. Breeding birds per hectare was positively correlated with percent shrub cover. Stream channelization was found to be a disruptive process which sets back plant community succession, resulting in lower avian diversity and density.

INTRODUCTION

With the continual development of watersheds, many stream alterations are currently being made that may adversely affect avian populations. One of the techniques most often used for flood control is stream channelization.

Stream channelization includes those activities which straighten, widen, and deepen an existing stream channel. Trees and shrubs are often removed from both sides of the stream (the width of disturbance varying from 5 m to 50 m) while the dredging spoils are piled on the banks to be smoothed into levees.

Stream channelization has been used extensively throughout the U. S. as a means for flood control by state and local drainage districts, the Army Corps of Engineers, and by the Soil Conservation Service (SCS) under Public Law 566. By 1972 more than 12,000 kilometers of streams in 40 states had been altered, 20,000 more kilometers were scheduled for channelization, and yet another 280,000 kilometers of stream modification were declared necessary for future flood protection by the SCS (Madson 1972). Furthermore, approximately 70 percent of the projects under construction or approval are in the Southeastern states (Gillette 1972).

Recently, many popular articles and published papers have appeared both locally and nationally concerning the detrimental effects of stream channelization in general (Emerson 1971, Barstow 1971, Allen 1970) and on fish populations (Bayless et al. 1964, Cederholm 1972).

Unfortunately very little is known about the effects of stream alteration upon avian populations. New (1972) conducted a qualitative study in Indiana and concluded that stream channelization does reduce non-game bird populations and also alters the species composition of the avian community. Recent quantitative studies made in the Southwest (Carothers et al. 1974, Carothers and Johnson 1975) have demonstrated that certain water salvage and flood control management practices have

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devastating effects on avian productivity. Bonnema (1972) estimated an annual loss of 12,000 ducks and 8,000 pheasant in the Ten Mile Creek Watershed in Central Minnesota due to the drainage of 1,900 wetland hectares.

The purpose of this study was to determine the effects, if any, of stream channelization upon the riparian avian populations (game and non-game) due to the alteration of the streamside vegetation. To our knowledge this paper presents the first quantitative analysis of the effects of stream modification upon non-game birds in the Southeastern region.

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MATERIALS AND METHODS

Study Area

The study area is located in the Roanoke Creek (tributary to the Roanoke River) Watershed. The Roanoke Creek Watershed, consisting of 57,400 hectares, lies in the eastern half of Charlotte County, Virginia, which is one of the most intensively channelized areas in Southern Virginia. Charlotte County is situated in the Piedmont Plateau, an ancient peneplain which lies between the Blue Ridge Mountains and the Eastern Coastal Plain and extends from Pennsylvania to Alabama. The topography is gently rolling to rolling with steep breaks adjacent to the floodplain. The drainage pattern is dendritic.

The upland soils are nearly all well drained, possessing a fine sandy loam or clay loam surface layer. The main soil series are Cecil and Appling. Soil types of the floodplain are primarily silt loams, fine sandy loams, or clay loams of the Chewacla-Wehadkee series. Drainage of the bottomland soils ranges from well drained to poorly drained with considerable mixing in both texture and drainage (USDA 1974).

All study sites are located in secondary succession bottomland hardwood communities, the main forest type being river birch—sycamore (Oosting 1942). Major plant species of the area include: river birch *(Betula niger)*, black willow *(Salix niger)*, sycamore *(Platanus occidentalis)*, winged elm *(Ulmus alata)*, green ash *(Fraxinus pennsylvanica)*, honeysuckle *(Lonicera japonica)*, smartweed *(Polygonum* spp.), bramble-bush *(Rubus* spp.), aster *(Aster* spp.) and goldenrod *(Solidago* spp.). Oosting (1942) provides a detailed analysis of the plant communities of the Piedmont.

Three major streams, each representing a different age since channelization, were selected within the Roanoke Creek drainage system. All study sites were chosen for their similar physiographic features. Recovery age or the time since channelization for each stream was as follows: Spring Creek (Site 1) — 2 years; Twitty's Creek (Site 2) — 5 years; and Horsepen Creek (Site 3) — 9 years.

Birds

Two different techniques were used to gather avian population data. The first technique, bird transect counts (Emlen 1971), was made in each channelized area to obtain a relative index of bird use for each site. Data were not obtained during the spring migration period in order to restrict our relative index of use primarily to resident birds. Each station was divided into three permanently marked transects (parallel to the stream): one 12m wide x 50m long transect (bordered by an agricultural field) on the field side of the stream and two 25m wide x 50m long transects (bordered by woods) on the forest side of the stream. At each station, data were recorded along the three transects for a total of 27 transect census hours (9 hours/transect) per site, or 81 transect census hours for all three study sites. All areas were sampled during equivalent early morning hours and the location, identification, and movements of birds were recorded.

The second technique used was the breeding bird census method. Breeding bird territories were located by plotting the activity of singing males (including any aggressive encounters) on 8½ x 11 inch scale maps of each station (modified spot-map method — Williams 1936, Kendeigh 1944). Most observations were made during the early morning hours of May and June 1975, which coincided with the peak breeding activities of birds in the study region. Systematic searches for nests were then conducted to find the actual nests. A total of 27 survey hours were tallied for each site. Data collected for nests included date found, species, height of vegetation selected for the nest, and the number of eggs and/or young found in the nests.

Bird species diversity (BSD) for each site was calculated using the Shannon and Weaver (1949) information theory formula, as a measure of biotic diversity as applied by MacArthur and MacArthur (1961, 1964) and Margalef (1958). Bird species diversity was calculated as follows (MacArthur 1964):

$$H' = -\sum_{i}^{S} P_i \log e \, P_i$$

in which P_i was the proportion of the total bird census belonging to the i^{th} species and S is the total number of species. H′ was used in order to facilitate comparisons with other works. Refer to Lloyd et al. (1968) and Pielou (1966a, 1966b) for discussions on the use of information theory as a measure of diversity.

Vegetation

Vegetation was measured in June 1975 immediately after the peak of the avian breeding season. Understory vegetation was measured in 2m x 2½m quadrats — 16 per station, 48 per site. Data collected included: identification, presence, and a count of each species occurring in each quadrat. The percent ground cover, the average height of the ground layer, the percent shrub cover, the average height of the shrub layer, and the percent canopy closure were also recorded for each plot. Canopy closure was estimated in each plot by making simultaneous photoelectric readings with two calibrated photographic exposure meters (De Vos and Mosby 1970). Each measurement was recorded as a percent:

$$\frac{\text{meter reading in full light} - \text{reading under canopy}}{\text{meter reading in full light}} \times 100 = \%\ \text{canopy closure.}$$

Overstory analysis (stems over 10.2cm diameter breast height, d.b.h.) was conducted along 6 randomly chosen transect lines. Each transect was divided into 5 – 2m x 10m quadrats or 30 quadrats per station, 90 per site. Data recorded included: identification, count, height, and d.b.h. for each tree encountered in the plots.

A Spiegel-relaskop was used to determine canopy height and a calibrated 6m pole was used to determine the height of the shrub and herb layers.

Vegetation was divided ocularly into three major strata for the area: herbs (<1m), shrub (1-4m), and tree (>4m). Presence or absence of vegetation within each vertical strata was then recorded in the center of each plot.

The number of points with vegetation present in each selected stratum was used to calculate foliage height diversity (FHD) — an index of plant species composition — using the previously mentioned Shannon-Weaver formula as used for BSD. P_i now refers to the proportion of the total in the i^{th} chosen layer (MacArthur and MacArthur 1961).

RESULTS AND DISCUSSION

Data on bird density and bird diversity for all three channelized sites are presented in Table 1. The data indicate that both avian diversity and avian density increased gradually from the two-year-old channelized stream.

To determine if the increases were statistically significant, three one-way analyses of variance (ANOVA) were performed on the following variables: 1) the number of breeding birds per hectare (the number of bird nests found); 2) the number of birds observed per hour on transects; and 3) the average number of bird species seen per day. Significant differences ($P < .01$) for site were detected in all three ANOVA tests, except for the comparison of mean number of breeding birds per hectare which was significant at the 0.10 level. Duncan's new multiple range tests (Sokal and Rolf 1969) were then performed to test for significant differences between specific means. Results were as follows:

1) Bird nests
   a) The mean number of breeding birds per hectare (bird nests found) on the 2-year-old channelized stream was signficantly lower than the mean number of nests found on the 9-year-old channelized stream;
2) Number of birds observed per hour
   a) The mean number of birds seen in the 2 and the 5-year-old channelized streams was significantly lower than the mean number of birds seen in the 9-year-old channelized streams)
3) Average number of bird species seen per day
   a) The mean number of species seen per day at both the 2 and the 5-year-old channelized streams was significantly lower than the mean number seen at the 9-year-old channelized stream.

Table 1. Avian density, avian diversity and foliage height diversity for all study sites, summer, 1975.

Site	Years since completion of channelization	Total bird species for transects	Total birds observed on transects	Number of breeding species	Breeding density (birds/ha)	Bird species diversity H' (B.S.D.)	Foliage height diversity (F.H.D.)
Spring Creek	2	26	114	6	6	1.748	0.791
Twitty's	5	25	115	8	9	2.025	0.813
Horsepen	9	37	215	10	13	2.342	0.944

Table 2. Percent ground cover, average height of ground layer, percent shrub cover, average height of shrub layer and percent canopy closure for each study site, Charlotte County, Virginia, summer 1975.

Site	Years since completion of channelization	Ground cover (percent)	Average height of ground layer (cm)	Shrub cover (percent)	Average height of shrub layer (cm)	Canopy closure (percent)
Spring Creek	2	62.46	34.46	28.90	84.06	36.25
Twitty's	5	44.94	50.10	46.29	146.67	58.25
Horsepen	9	18.67	29.17	35.83	162.81	74.20

Both indices of "bird usage" — number of birds observed per hour and the average number of species seen per day — indicated that the 2-year-old channelized site had a relatively low avian diversity and density while the other two sites had recovered significantly (both avian diversity and density had increased) after five years.

Breeding bird densities (6-13 pairs/ha or 240-525 pairs/100 acres) of this study are similar to bird density data from other studies in eastern North America (452-650 pairs/100 acres, 239 pairs/100 acres, Odum 1950, Johnston and Odum 1956, respectively). Karr (1968) dealing with strip-mining reported a maximum density of 12 pairs per hectare (489 pairs per 100 acres). Our higher densities may be due to the permanent water component (the stream) present at all sites which may act as an extra stratum either as an additional vertical or horizontal structural layer present within the community (Karr 1968). Furthermore, higher breeding densities may be the rule for all riparian communities. Carothers and Johnson (1975) reported breeding densities of up to 1059 pairs per 100 acres in a Southwest riparian community. Further investigations are needed to determine riparian densities across the country.

Figures 1, 2, and 3 show the relationship between bird nests found, number of birds observed per hour, and vegetative structure along bird transects for each channelized area.

Data on percent ground cover, average heights of ground layer, percent shrub cover, average height of shrub layer, and percent canopy closure for each site are presented in Table 2. There was a decrease in percent ground cover as the successional age increased. Both the height of ground layer and the percent shrub cover increased until between 5 and 9 years after channelization, at which time the newly developing canopy layer shaded the understory. Both the average height of the shrub layer and the percent canopy cover continued to increase as the recovery age of the streams increased. Multiple stepwise regression analysis was used to determine if any significant relationships existed between habitat variables (Table 2) and any bird population parameters. The number of breeding birds per hectare (the number of bird nests found) was positively correlated with percent shrub cover and negatively correlated with percent ground cover. These two variables explained 87% of the variation in the number of breeding birds found per hectare. The average heights of the ground layer and the shrub layer were both found to be positively correlated with birds seen per hour. These two variables accounted for 95% of the variation in the number of birds seen per hour.

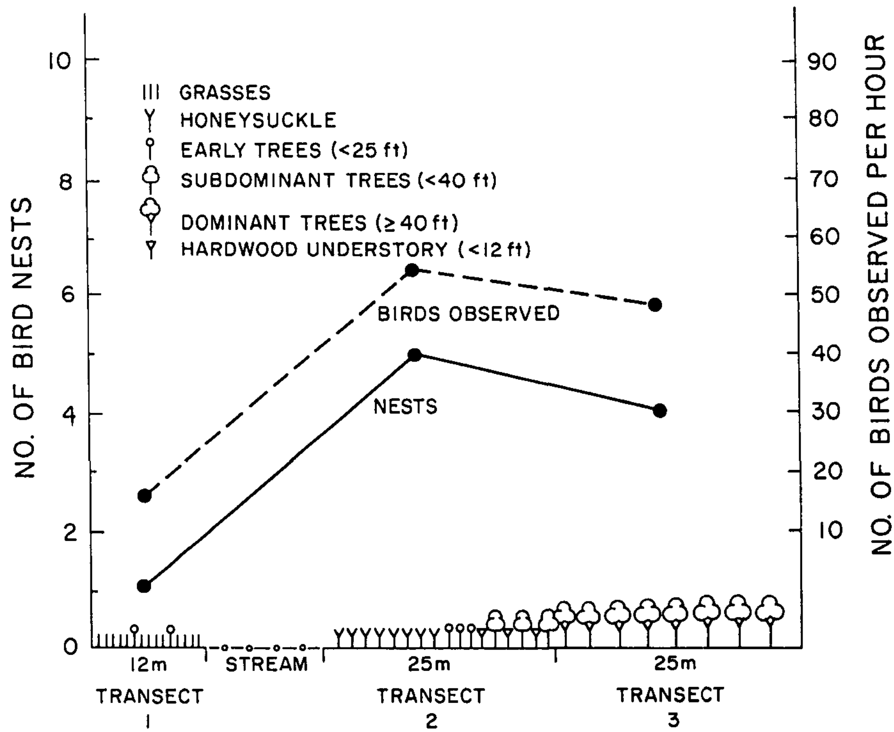

Figure 1. Number of birds observed per hour and the number of bird nests found on the 2-year-old channelized stream, January-June 1975, Charlotte County, Virginia.

Therefore, with an increase in understory development, a general increase in both species diversity and density may be expected. In previous studies, Hooper et al. (1973) and Gill et al. (1974) have stressed the importance of a moderate-to-dense understory among almost all stages of forest growth to assure reasonably large and diverse bird populations. We conclude that the 2-year-old channelized stream has a significantly lower number of bird nests compared to the 9-year-old stream due to the lack of understory or shrub growth and subsequently the lack of suitable nesting habitat. It is apparent from these observations and from Table 1 that our results do document a progressive trend toward an increase in the species composition and size of the bird populations from the 2-year-old channelized stream to the 9-year-old channelized stream.

A common concept used to condense community data into a single number is the index of species diversity. Various studies (Karr 1968, Willson 1974, Margalef 1968) have shown that bird species diversity (BSD) increases as the ecological age of an area increases. In addition, various studies have documented that a positive linear relationship exists between BSD and foliage height diversity (FHD) (MacArthur and MacArthur 1961, MacArthur 1964, Willson 1974, Karr 1968).

Our results indicate that BSD does progressively increase from the 2-year-old channelized stream to the 9-year-old channelized stream (Table 1). H′ values of BSD and FHD closely coincide with the values given by MacArthur and MacArthur (1961), and Kricher (1972, 1973). However, no attempt was made to obtain a regression equation, since there would be a maximum of three coordinates. When a comparison of avian diversity (BSD) and increasing ecological age for the present study is

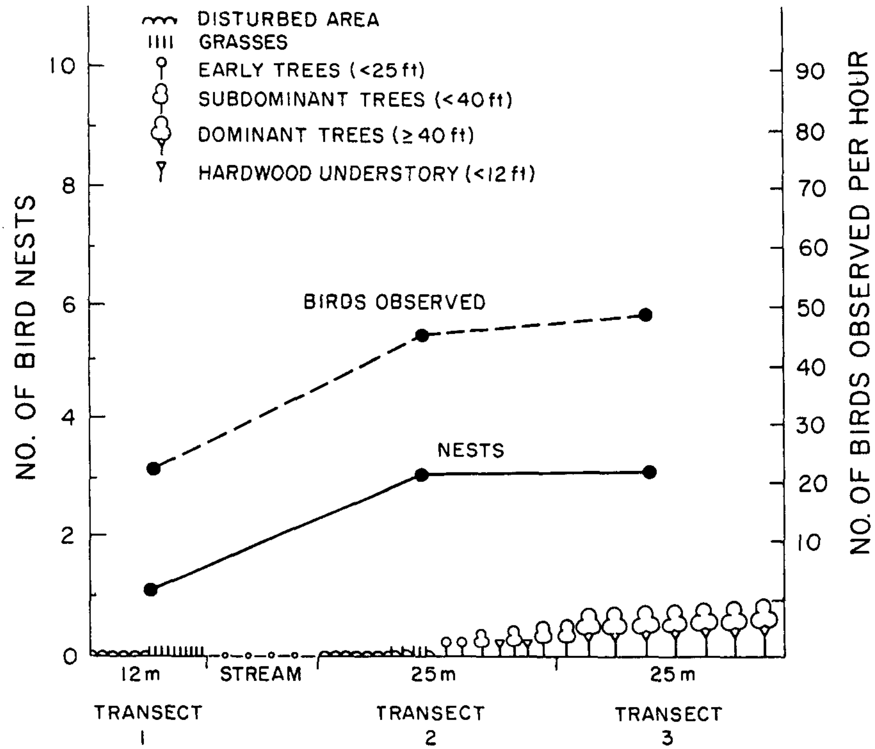

Figure 2. Number of birds observed per hour and the number of bird nests found on the 5-year-old channelized stream, January-June 1975. Charlotte County, Virginia.

made to two other Southeastern breeding bird population studies, a very similar trend is found in both the shape of the curves and respective BSD values (Figure 4).

A general increase in avian diversity and density through progressive successional stages toward climax vegetation has been documented by Saunders (1936) in New York, Odum (1950) in North Carolina, Johnston and Odum (1950) in Georgia, and Karr (1968) in Illinois. Therefore, we conclude that to an avian community, stream channelization is a disruptive process which removes most of the streamside vegetation, subsequently setting back the plant community to an early secondary seral stage in which bird species diversity and density will be significantly lower than in a similar undisturbed area.

The degree of changes within the avian community will depend on the magnitude of the habitat alteration and the particular community and substrate involved. In this study, a significant degree of recovery was observed after a period of 5-9 years following channelization.

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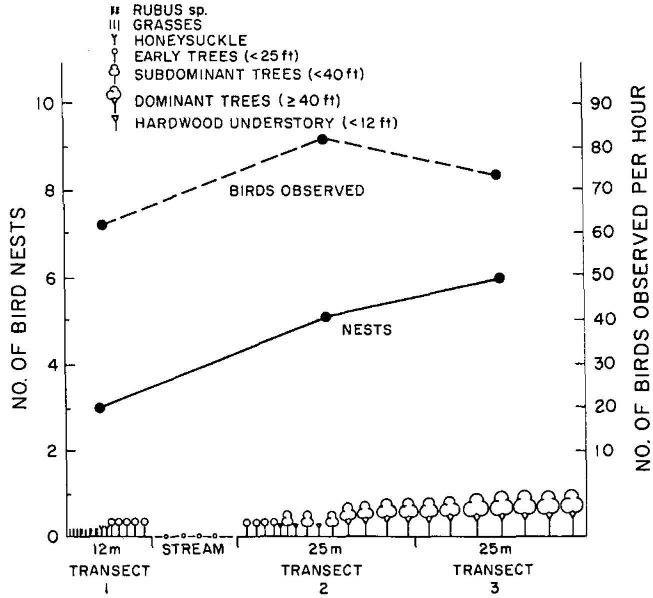

Figure 3. Number of birds observed per hour and the number of bird nests found on the 9-year-old channelized stream, January-June 1975, Charlotte County, Virginia.

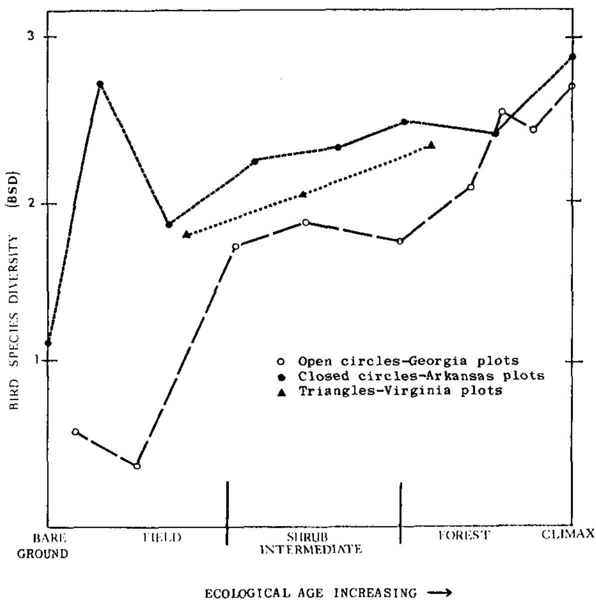

Figure 4. Comparisons of avian diversity (BSD) in various stages of plant succession in three Southeastern regions — Arkansas Ozarks, Georgia Piedmont, and the present study in the Virginia Piedmont. Linear sequence of plots as given in original papers (Shugart and James 1973, Johnston and Odum 1956). Linear sequence of Virginia plots from Table 2. Figure modified from Shugart and James (1973).

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THE ESTABLISHMENT OF *SCIRPUS OLNEYI* UNDER CONTROLLED WATER LEVELS AND SALINITIES

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ABSTRACT

From January 1973 to September 1974, a study was conducted at Rockefeller Refuge, Grand Chenier, Louisiana to determine the effects of irrigating *Scirpus olneyi* with various concentrations of salt water during drought periods. *Scirpus olneyi* was established in 12 one-tenth-acre impoundments and subjected to 6 water level and salinity treatments. Drying ponds for 1 and 3 months before the treatments were initiated had no measurable effects on culm density. The 20 ppt salinity treatments reduced culm density, but the 10 ppt salinity treatments and wet and dry controls had little or no effect on plant growth. The 6 experimental treatments had no effect on rhizome growth. Rhizome volume increased throughout the study.

INTRODUCTION

One of the most productive ecosystems in nature is the brackish marsh which totals 1,186,000 acres in Louisiana (St. Amant 1959; Chabreck 1972). The brackish marsh is an area where nutrients from saline water intergrade with fresh water to produce favorable conditions for plant growth. One of the major plant species in this marsh type is Olney bulrush *(Scirpus olneyi)*[a], a preferred food of muskrats *(Ondatra zibethicus)*[b] and snow geese *(Chen caerulescens)*. O'Neil (1949) stated that *S. olneyi* made up 80 percent of the muskrat's diet in brackish marsh in Louisiana during the time of his study. Harris and Webert (1962) found that the large culms and rhizomes of *S. olneyi* were utilized by nutria *(Myocastor coypus)* as food. Ross (1972) also concluded that *S. olneyi* was a preferred food of nutria.

Brackish marshes support a greater muskrat population than other marsh types, and O'Neil (1949) reported that 80 percent of the muskrats trapped in the coastal zone during the 1940's were harvested from brackish marsh areas. The 1945-46 trapping season produced 8,337,411 muskrats, while the 1973-1974 trapping season produced only 286,087 muskrats (Linscombe personal communication, Fur Division, Louisiana Wild Life and Fisheries Commission, Baton Rouge, Louisiana, 1975). The decline in the muskrat catch parallels the deterioration of the brackish marsh areas. Areas once dominated by Olney bulrush and leafy three-square *(Scirpus robustus)* are now dominated by closed stands of two climax species, marshhay cordgrass *(Spartina patens)* and saltmarsh grass *(Distichlis spicata)*. The later species are considered less valuable wildlife foods (St. Amant 1959).

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[a] Scientific nomenclature for plants follows Radford *et al.* (1968).
[b] Scientific nomenclature for animals follows Blair *et al.* (1968).