SOME EFFECTS OF GRID SYSTEM MOSQUITO CONTROL DITCHING ON SALT MARSH BIOTA IN DELAWARE [1]

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ABSTRACT. The effects of grid system mosquito control ditching on salt marsh phanerogams, salt marsh snails (*Melampus bidentatus*), and two species of fiddler crabs (*Uca minax* and *Uca pugnax*) were investigated over a two-year period (1973–1974) in Kent and Sussex Counties, Delaware. Reports of research conducted from 1936 to 1946 on one of the present study areas had indicated that ditching caused deleterious changes in the plant community structure. However, channel dredging in the nearby Mispillion River in 1933 and 1935 may have had an appreciable influence on the plant succession reported in these earlier studies. Vegetational cover typing of the area shows that the 1974 plant community structure is similar to what it was prior to ditching in 1936.

Random quadrat sampling showed the densities of *Uca* and *Melampus* to be significantly greater ($P<0.05$) on a ditched marsh as compared to an adjacent unditched marsh.

INTRODUCTION

Historically, there has been a conflict between mosquito control and wildlife management agencies over the effect of grid system mosquito control ditching on the wildlife inhabiting or utilizing the tidewater marshes of Delaware. An early study conducted by Stearns et al. (1940) found such ditching to be detrimental to muskrats and their associated food plants. Cottam and associates, (Cottam et al., 1938; Bourn and Cottam, 1950; Cottam and Bourn, 1952) reported that ditching lowers water tables, with subsequent adverse effects upon salt marsh grasses and certain groups of invertebrates. Other workers, such as Headlee (1939) and Travis et al. (1954), discounted the ill effects of ditching.

To evaluate the effects of grid system ditching on salt marsh biota, Bourn and Cottam (1950) conducted research during a 12-year period on 2 marshes located in Kent County, Delaware. A series of 5 vegetational cover maps was prepared for one of these marshes in the 10-year period following ditching in 1936. This cover typing illustrated a succession from a *Spartina alterniflora* Loisel dominated marsh to an area dominated by *Baccharis halimifolia* L. and *Iva frutescens* L. Bourn and Cottam (1950) also found reduced invertebrate populations, particularly molluscs and crustaceans, in a ditched marsh as compared to an unditched marsh. Inasmuch as *S. alterniflora* is a major source of nutrients to estuarine organisms via its decomposition to detritus (Teal, 1962; Odum and de la Cruz, 1967), and because salt marsh invertebrates are food items for many forms of wildlife, the implications put upon mosquito control ditching by Bourn and Cottam (1950) are serious and far reaching. This is particularly true as their report has been accepted as the classical reference in its field and is cited in notable salt marsh review references (Chapman, 1960; Daiber, 1972; Ranwell, 1972).

Bourn and Cottam (1950) implied that as long as ditches on their study area remained open to tidal ebb and flood, the shrubs *Baccharis* and *Iva* would continue to dominate. However, in 1973, a preliminary observation of the Bourn and Cottam study area revealed that *S. alterniflora* dominated even though the ditches were still in good operating condition. This observation was in disagreement with

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[1] Misc. paper No. 740, University of Delaware Agricultural Experiment Station. This research was supported by a grant from the Delaware Department of Natural Resources and Environmental Control, Division of Fish and Wildlife, Mosquito Control Section.

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Bourn and Cottam's prediction, and provided the incentive for a study to re-examine the biological effects of grid system ditching on Delaware salt marshes.

The purpose of the research reported here was to begin such a study, and the 2 major objectives were: (1) to map the vegetation currently existing on the marsh previously studied by Bourn and Cottam (1950) and compare this to cover maps presented in their report, and (2) to determine and compare the density of fiddler crabs (*Uca* spp.) and salt marsh snails (*Melampus bidentatus* Say) on a ditched marsh and an unditched marsh.

METHODS

Description of Study Area. Two areas of marsh were selected for this study. The first, Mispillion River-East (MRE), is approximately 190 hectares (470 acres) in size and borders the north shore of the Mispillion River in Kent County, Delaware. The range between daily mean low and high water is ca. 1.22 m (4.0 ft.), and salinity ranges from 5–25 parts per thousand (o/oo). The orginal ditching of the area was done in 1935–1936 by Civilian Conservation Corps relief labor. Eighty-four major ditches were excavated in a "herring bone" pattern and spaced approximately 46 m (150 ft.) apart. According to the Delaware Mosquito Commission, these ditches received no maintenance from 1936 to 1966, when they were cleaned of sediment and debris (A. Wheatley, pers. comm.). This marsh was chosen for study because it is the one studied by Bourn and Cottam (1950) to determine the response of salt marsh vegetation to ditching.

The second marsh studied, Mispillion River-West (MRW), is located on the south shore of the Mispillion River in Sussex County, Delaware, ca. 1000 m (3281 ft.) upstream from MRE. The tidal range is similar to that of MRE, and salinity ranges from 5–20 o/oo. The area is ca. 103 hectares (253 acres) in size, of which 51 ha (125 a) have been ditched and 52 ha (128 a) remain in a semi-natural, unditched condition. The ditches were originally excavated in the mid-1930's and renovated in the mid-1960's. The dominant vegetation on both the ditched and unditched sections of this area is short form *S. alterniflora*. *B. halimifolia* and *I. frutescens* are common on spoil piles adjacent to the ditches, but are rare on the unditched section.

Cover typing. To evaluate the long-term effects of mosquito control ditching on phanerogams, a detailed vegetational cover map of the MRE area, as it exists today, was needed for comparison with those maps prepared for the area in 1936, 1938, 1939, 1941, and 1946, by Bourn and Cottam (1950). The marsh borders, ditches, and other significant features of the area were traced from a 1968 aerial photograph obtained from the U.S.D.A. Soil Conservation Service. Cover detailing was completed by ground reconnaissance and by the use of a 1972 infrared aerial photograph.

A modified acreage grid (Forestry Suppliers, Inc., Jackson, Miss.) was used to determine the percent composition of each major vegetation type depicted in all the maps compared in this study. Because of similarities in habitat requirements *B. halimifolia* and *I. frutescens* were treated as one vegetation type. The same was done for *Spartina patens* (Aiton) and *Distichlis spicata* (L.).

Uca—Melampus sampling. Sampling for fiddler crabs (*Uca minax* (LeConte) and *Uca pugnax* (Smith)) and salt marsh snails (*M. bidentatus*) was carried out in the ditched and unditched sections of the MRW study area during August, 1974. The area was gridded into 250 plots, each one being 61 m (200 ft.) square. Of these, 80 (40 in the ditched and 40 in the unditched sections) were selected for sampling by use of a table of random numbers. Within each plot so selected, the approximate center was estimated, and from this point the location of a 0.25 m^2 quadrat was determined by random toss (Fig. 1). All vegetation within the quadrat was cut

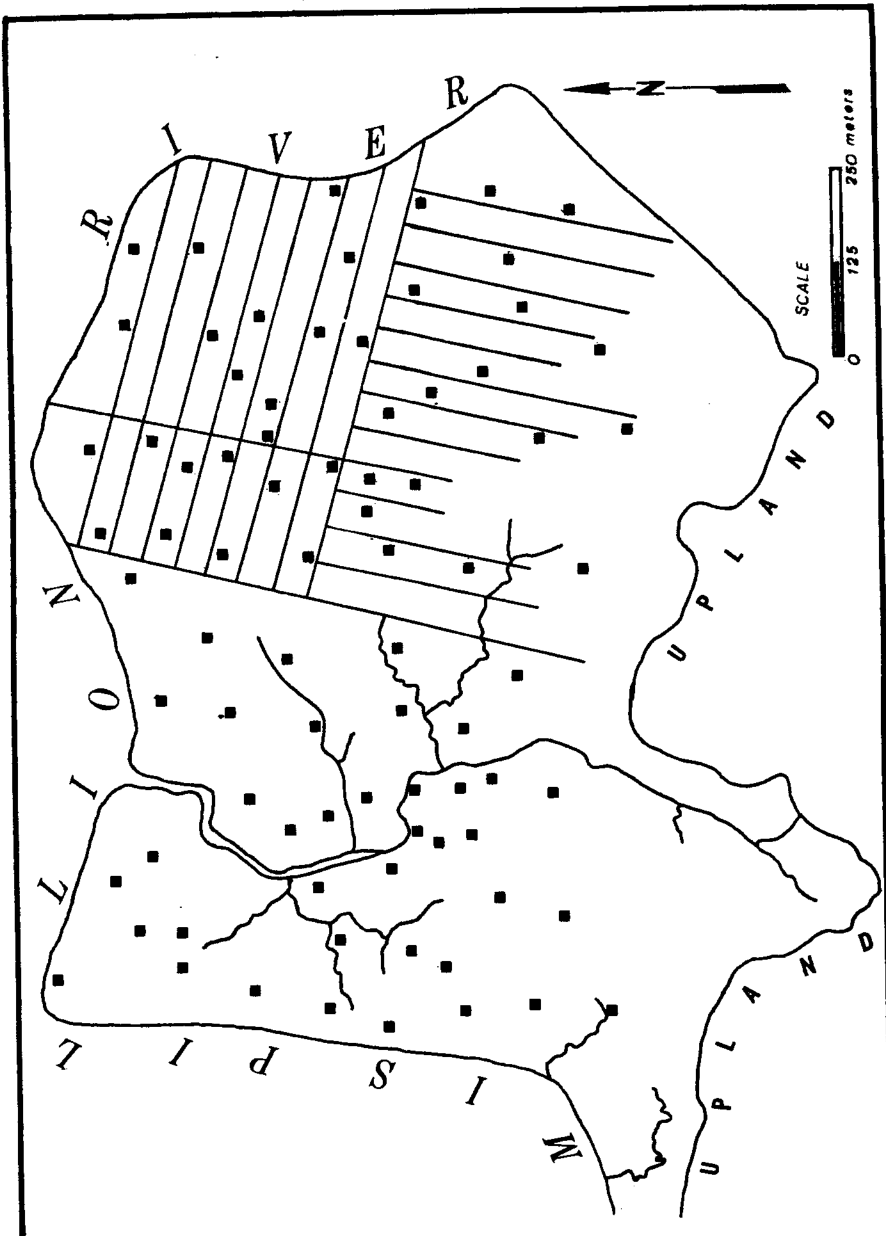

Figure 1. Uca - Melampus sampling points in the MRW study area - August, 1974.

to near ground level and, after a careful check for *Melampus* which might be clinging to the plants, removed. A direct count was made of *Melampus* within the quadrat. An index of *Uca* density was derived by counting the crab burrows within the quadrat which showed signs of habitation.

RESULTS

VEGETATION ANALYSIS. The chronological summary of plant succession on the MRE study area from 1936–1974 is presented in Table 1. No data are given for the vegetation of the area prior to ditching because the map presented by Bourn and Cottam (1950) to depict the pre-ditch vegetation is not sufficiently detailed for analysis. However, the 1936 vegetation data are assumed to be the same as the pre-ditch data, since ditching was not completed on the area until April, 1936.

The five species of phanerogams which underwent the most change in percent coverage from 1936–1974 were *S. alterniflora* (short form), *S. patens, D. spicata, B. halimifolia,* and *I. frutescens* (Fig. 2). The data presented for 1936–1946 represent the results of the study by Bourn and Cottam (1950), and will be discussed first. *S. alterniflora* covered 62% of the MRE area in 1936. However, by 1938, this species covered only 36% of the area. The decrease in the growth of *S. alterniflora* began to stabilize in 1939 and in 1941 a small increase in coverage was noted. The trend of expansion of *S. alterniflora* continued in 1946. *S. patens* and *D. spicata* steadily decreased in coverage from 1936–1946; going from a collective coverage of 31% in 1936 to slightly more than 6% in 1946. *B. halimifolia* and *I. frutescens* continually increased in coverage from 1936–1946, and collectively covered 50% of the area in 1946.

By 1974, the plant community structure had changed markedly. *S. alterniflora* (short form) was clearly the dominant species, and had a coverage 11% greater than in 1936. *B. halimifolia* and *I. frutescens* had decreased appreciably in coverage since 1946, with most of the 1974 growth confined to the headland borders and spoil piles. *S. patens* and *D. spicata* had increased in coverage only slightly since 1946.

Uca—Melampus SAMPLING. The percent

Table 1. Plant community structure of the Mispillion River—East study area from 1936–1974.[a]

Species	% Composition 1936	1938	1939	1941	1946	1974
Spartina alterniflora	62	36	32.1	36	40	73
Spartina patens &/or *Distichlis spicata*	31	30	23.4	18	6.3	11
Baccharis halimifolia &/or *Iva frutescens*	5	22.4	39.3	39	50	14
Salicornia spp.	0.9	tr[b]	tr	tr	tr	tr
Typha angustifolia	0.6	0.1	0.2	0.3	1	tr
Scirpus robustus	0.3	0	0	tr	0	tr
Pluchea camphorata	0.2	7.6	2.8	0.2	0	tr
Aster subulatus	0	3.9	1.8	4.1	0.7	0
Solidago sempervirens	0	0	0.2	0.1	0.4	tr
Erechtites hieracifolia	0	0	0.2	1.3	0	0
Atriplex spp.	0	0	0	tr	0	0
Spartina cynosuroides	0	0	0	0	tr	0.1
Scirpus olneyi	0	0	0	0.8	1	0.4
Typha latifolia	0	0	0	0	tr	tr
Phragmites communis	0	0	0	0	0	0.9

[a] Data presented for the period 1936–1946 were excerpted from maps presented by Bourn and Cottam (1950); 1974 data from the map prepared for this study.
[b] Trace (tr) less than 0.1 percent.

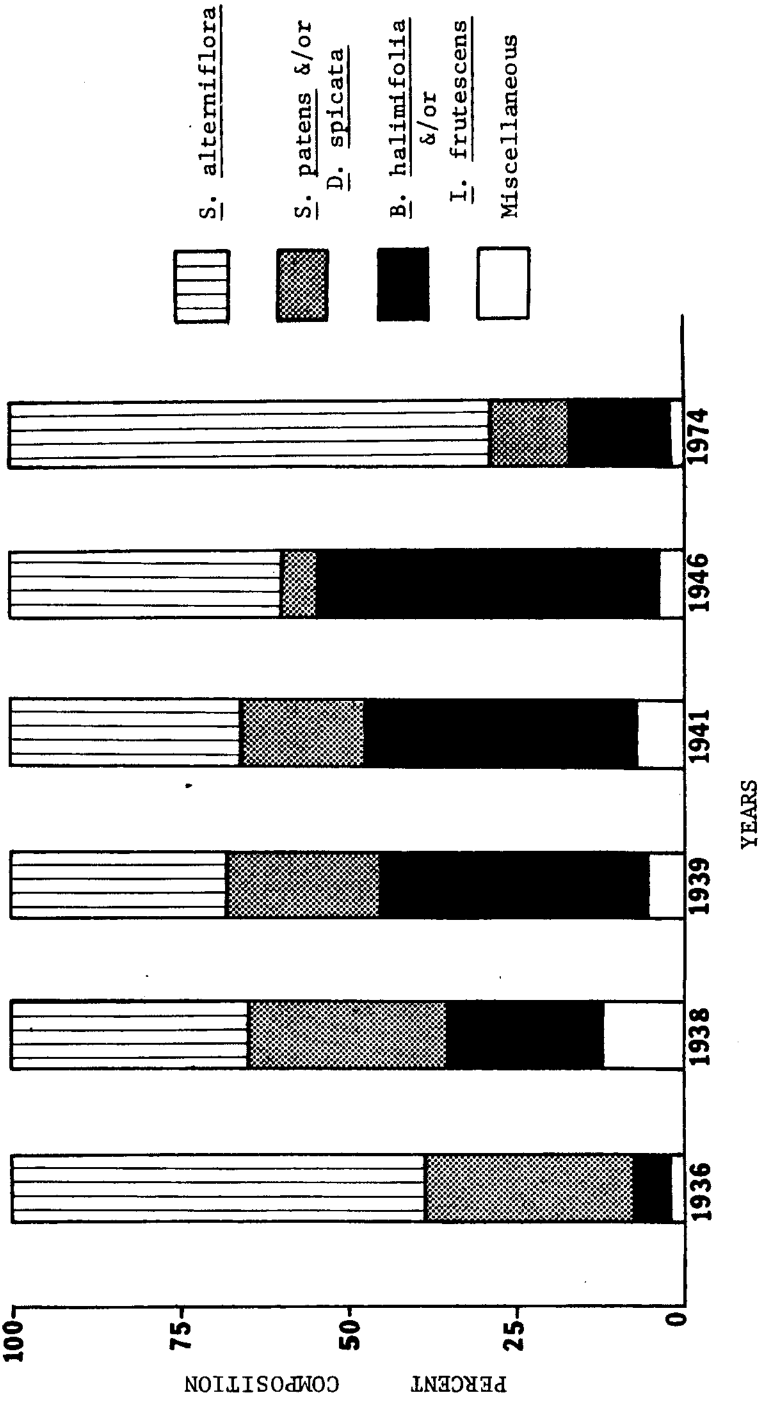

Figure 2. Percent composition of the major vascular vegetation types on the MRE study area - 1936-1974.

occurrence and mean density of *Uca* spp. burrows and *Melampus* on the ditched and unditched sections of the MRW study area are presented in Table 2. Student's t test (Steel and Torrie, 1960) shows that the means of both *Uca* and *Melampus* were significantly greater ($P<0.05$) on the ditched area as compared to the unditched area. The values of the 40 quadrats on the ditched area showed a range of 0–500 active *Uca* burrows/m^2. The unditched area showed a range of 0–192 *Uca* burrows/m^2. The highest density of *Uca* burrows (principally *U. pugnax*) was found within 5 m (16.6 ft.) of the creek and ditch banks, and decreased inversely with the distance away from these areas. *M. bidentatus* had a range of 0–1,116 animals/m^2 on the ditched area. The unditched area showed a range of 0–524 *Melampus*/m^2. *Melampus* displayed a clumped distribution, with few individuals found within 5 m of a ditch or creek bank.

DISCUSSION

VEGETATION. The period from 1936–1946 shows a plant succession somewhat analogous to that predicted by Kerwin and Pedigo (1971), Chapman (1960), and Miller and Egler (1950); i.e., from a low marsh characterized by *S. alterniflora,* to a high marsh dominated by shrubs and upland associated plants; viz., *B. halimifolia* and *I. frutescens*. However, the rate at which this succession occurred was faster than would be expected on an undisturbed marsh. Bourn and Cottam (1950) attributed this increased rate of succession solely to the effect of the ditches, which, they felt, drained the marsh. However, data exist which support the argument that the ditches alone were not responsible for the vegetational changes.

The Mispillion River was formerly an important route of commerce. Because of this, a navigation project was adopted as early as 1879 to clear the river of shoals and provide for a depth sufficient for commercial vessels to navigate from Delaware Bay to Milford, Delaware. The original project was completed in 1889 and subsequently modified in 1919, 1937, and 1954. The Annual Reports of the Chief of Engineers, U.S. Army, for 1933, 1934, 1935, 1938, and 1939, give the following information concerning maintenance dredging in the Mispillion River to meet project requirements:

1933—23,286 yd^3 of sediment removed from the entrance channel from Delaware Bay to the mouth of the Mispillion River.
571 yd^3 of sediment dredged from the river bed.

1935—31,106 yd^3 of sediment removed from the channel entrance.
38,494 yd^3 of sediment dredged from the river bed.

1937—34,415 yd^3 of sediment dredged from the channel entrance.

1938—4,009 yd^3 of material dredged from the river bed.

1939—Construction of a 3,500 ft extension of the north jetty completed at the river mouth.

Rude (1928) reported that dredging

Table 2. A comparison of some population characteristics of *Uca* spp. and *Melampus bidentatus* on the ditched and unditched sections of the Mispillion River—West Study area, 1974.

Section	*Uca*[a]			*Melampus*[b]		
	Percent Occurrence	Mean no./m^2	Standard Deviation	Percent Occurrence	Mean no./m^2	Standard Deviation
Ditched	85	108	132	72.5	213.1	266
Unditched	70	25.6	38	80	93	122

[a] Data based on number of active burrows per sample area.
[b] Data based on actual animals present per sample area.

can lead to a lowering of the mean low tide level because the deepening and widening of the channel, and the removal of shoals, creates a greater cross-sectional area of river bed to accommodate the volume of water present at any given time. Therefore, it is possible that the dredging which took place in 1933–35 could have drained the marsh, by lowering the mean low water level, before ditching began. However, due to an absence of tide record data for the Mispillion River during the time in question, it is not possible to confirm or refute this hypothesis. Ditching may have acted synergistically with dredging to reduce the growth of *S. alterniflora* and promote *Baccharis* and *Iva,* but there is insufficient data to support the argument of Bourn and Cottam (1950) that ditching alone changed the vegetational character of the marsh.

The dominance of *S. alterniflora* on the MRE study area in 1974 can be attributed to 2 major factors. The first of these is a lack of dredging, with its subsequent effect upon the tidal regime, in the Mispillion River since 1964. Secondly, sea level has been rising in relation to the coast of Delaware at the rate of 0.15 m (½ ft.) per century for the past 3000 years (Kraft, 1971). A rise in sea level will allow 2 phenomena to occur: (1) water tables in the marshes will be raised, and (2) there will be a decrease in elevation above mean sea level, providing for increased frequency of tidal inundation. Both factors would enhance the growth of *S. alterniflora* (Adams, 1963; Chapman, 1940). Clogged ditches cannot account for the dominance of *S. alterniflora,* because they were renovated in 1966 and remain in good operating condition.

Recent work in New Jersey indicates that ditching enhances the biomass production of *S. alterniflora* because of increased tidal inundation (pers. comm. with J. Shisler, Department of Entomology and Economic Zoology, Rutgers University, New Brunswick, New Jersey). A similar study in North Carolina suggests that ditches may increase the productivity of ditchside *Juncus roemerianus* Scheele (Kuenzler and Marshall, 1973). If tidal water is the main source of nutrients for a salt marsh (Blum, 1968), it would seem logical that ditching, by providing for an increased frequency of tidal inundation, would have a beneficial effect upon plants growing near the ditch banks.

Uca—Melampus study. The mean densities of *Uca* on the ditched and unditched sections of the MRW study area were considerably greater than the mean density of 14.35 *U. minax* burrows/m^2 reported by Kerwin (1971) for a Virginia marsh and the 2.7 *U. pugnax* burrows/m^2 reported by Nixon and Oviatt (1973) for a Rhode Island marsh. Ferrigno et al. (1969) found a maximum mean density of 46.26 *Uca* burrows/m^2 in the tall form *S. alterniflora* zone of New Jersey marshes, which is greater than the burrow density on the unditched section of the MRW area, but less than that found on the ditched section.

Our finding that the density of *Uca* spp. is greater on a ditched marsh as compared to an unditched area is supported by a similar finding by Ferrigno (1970) in a study of the effects of "quality ditching" in New Jersey (for an explanation of quality ditching see Ferrigno and Jobbins, 1968). Based upon the results of the study reported here and the report by Ferrigno (1970), we hypothesize that ditching is beneficial to *Uca.* This is probably due to the increased edge-effect produced by ditching which is similar to that provided by natural tidal creeks with which certain *Uca* species, particularly *U. pugnax,* are intimately associated (Teal, 1958).

Relatively few quantitative studies have been conducted on the abundance of *Melampus.* Ferrigno et al. (1969) found a maximum mean density of 468 *Melampus*/m^2 in a New Jersey marsh, which is greater than the densities found in either the ditched or unditched sections of the MRW study area. However, Kerwin (1972) in Virginia and Nixon and Oviatt (1973) in Rhode Island reported mean densities of only 7.2 *Melampus*/m^2 and

6.8 *Melampus*/m² respectively.

The results of this study tentatively suggest that ditching is beneficial to *M. bidentatus,* however, Ferrigno (1970) found considerably lower densities of *Melampus* on a ditched marsh as compared to an unditched marsh. Daiber, (1972) also reported that ditching will decrease the number of *Melampus* on an area subjected to such management. The discrepancies between our study and the reports of Ferrigno and Daiber probably reflect variations in the marshes under study. The factors governing the distribution of *Melampus* are largely unknown, except that they are most numerous above the high tide line (Hausman, 1932), and are most commonly associated with *S. patens, D. spicata,* and short form *S. alterniflora* (Kerwin, 1972). Due to these conflicting findings and the lack of knowledge of specific habitat requirements we must state that the effect of ditching on *Melampus* is uncertain.

CONCLUSIONS

Since the 1930's, several authors, particularly those with wildlife-related interests, have contended that grid system mosquito control ditching responsible for a rapid succession from a low marsh characterized by the growth of *S. alterniflora* to an area dominated by upland associated plant species, and drastic declines in the populations of invertebrates which are important in terrestrial and aquatic food chains. However, the results of the study reported here indicate that grid system ditching is not necessarily detrimental to native marsh grasses and invertebrates.

The possibility exists that the results of this study were biased because only 2 relatively small areas of marsh were studied. Also, the marshes under our study were ditched originally almost 40 years ago and, as such, have had time to stabilize to some extent. Perhaps the results of a similar study, but in a marsh which had been recently ditched, might be different. We suggest a continuation of basic studies on the effects of ditching in several marshes throughout Delaware. In particular need of study are the effects of ditching on water tables in the marshes and the comparative use of mosquito control ditches and natural tidal creeks by aquatic organism.

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