Salt marshes
Disturbance
Wrack
Vegetation
Massachusetts

Marais maritimes
Perturbation
Laisses
Végétation
Massachusetts

Effects of wrack accumulation on salt marsh vegetation

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ABSTRACT

A major source of disturbance in New England salt marshes is the local accumulation of wrack, composed primarily of *Spartina alterniflora* and *Zostera marina*. Mats of wrack accumulate throughout the marsh, killing or damaging the plants beneath them. This study examines the formation of disturbance patches, their distribution in the vegetation and their subsequent successional development. Experimental placement of mats of wrack reveals that the zones of the marsh differ little in their sensitivity to this form of disturbance. However, the dominant grass species differ in their response to disturbance. The overall vegetation of the marsh reflects the pattern of disturbance in space and time as well as the successional development which occurs within individual patches.

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RÉSUMÉ

Effets de l'accumulation de laisses sur la végétation de marais maritimes

Une des sources principales de perturbation des marais maritimes de la côte atlantique d'Amérique du Nord est l'accumulation locale de laisses, composées principalement de *Spartina alterniflora* et de *Zostera marina*. Les tapis de laisses peuvent s'accumuler en tout endroit des marais, détruisant ou altérant les plantes qu'ils recouvrent. Dans cette étude, on examine la formation des taches de perturbation, leur distribution dans la végétation, les successions qui caractérisent leur évolution dans le temps. Des expériences de dépôt de laisses montrent que les différentes zones du marais varient peu dans leur sensibilité à la perturbation ; par contre, les espèces dominantes de graminées diffèrent dans leur réponse. La végétation de l'ensemble du marais porte la marque à la fois de la distribution de ces perturbations dans l'espace et dans le temps et des successions au sein de chacune des taches perturbées.

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INTRODUCTION

Salt marshes in New England are subject to a variety of natural and manmade disturbances. One of the most obvious forms of natural disturbance is the accumulation on the marsh surface of mats of plant debris, especially *Spartina alterniflora* and *Zostera marina*. In the United States, such mats are referred to in general as " wrack ", although European usage restricts that term to mats of brown algae. Such disturbance could result in the formation of pannes (Beeftink, 1979 ; Chapman, 1940 ; Miller, Egler, 1950 ; Pethick, 1974 ; Redfield, 1972), but this has not been confirmed.

This paper is an initial report on an ongoing study designed to measure the effects of wrack disturbance on the structure of salt marsh plant communities. We will

consider here the short-term effects of wrack accumulation on vegetation and the relation between wrack accumulation and panne formation.

METHODS AND MATERIALS

Site description

In our experiments, we distinguished four vegetation zones : high marsh, mid marsh, low marsh and creek banks. The high marsh includes areas dominated by *Spartina patens* and *Distichilis spicata*. The mid marsh is dominated by *S. patens* and short *S. alterniflora*. The low marsh is almost exclusively covered by short *S. alterniflora*. The creek bank includes the areas adjacent to tidal creeks which are dominated by tall *S. alterniflora*. The short and tall designations for *S. alterniflora* refer to ecophenotypes, a " tall form " with thick stems, wide leaves, a height of 1-3 m, and low density and a " short form " with narrow leaves, a height of 10-40 cm, and high density.

Our experiments have been conducted in Great Sippewissett Salt Marsh, Cape Cod, Massachusetts, a site that has received substantial study. The area is flooded twice daily from Buzzards Bay with a maximum tidal excursion of 1.7 m. The 50 ha marsh includes nearly equal amounts of each of the four vegetation zones (Valiela, Teal, 1979).

Manipulation of wrack

The effects of wrack accumulation on vegetation were assessed by experiments in which wrack was placed on quadrats for various periods of time. Within each of the four zones, 242 × 2 m quadrats were established in May 1981. Twenty of these were covered with 5-10 cm of naturally occurring wrack (composed primarily of *S. alterniflora*) collected nearby; the remaining four quadrats served as controls. The wrack was removed from four replicate quadrats in each zone after 1, 2, 4, 6, and 12 months to assess the effects of the duration of wrack coverage.

During the 1982 growing season we surveyed the quadrats using the point-contact method (Pielou, 1974). In each quadrat we recorded the first species intercepted by a vertical line through each of 80 regularly spaced points. The percent cover of a given species was calculated as the percentage of the points that contacted that species.

To measure the change in community composition, we calculated the Euclidean distance between the experimental and control plots. The distance is given by

$$D = \sum_{i=1}^{k} (\Delta x_i)^2 ,$$

where k is the number of species and Δx_i is the difference in cover of the ith species between the experimental and control quadrats. D measures the distance between the quadrats in the k-dimensional space whose axes are the percent cover of each species; it measures the dissimilarity of the control and treated quadrats (bare area was treated as a species in these calculations).

In addition to the experimental manipulations, we surveyed a section of the marsh, recording species cover, presence of wrack, and tidal innundation in 1/4 m^2 quadrats arranged on regularly spaced transects. The sample quadrats were classified by marsh zone, as designated above. We also designated quadrats as pannes, if the plant cover was less than 50 or there was significant algal mat development. These data provide a measure of distribution of wrack and pannes in the form of relative frequency of occurrence.

RESULTS AND DISCUSSION

The effect of wrack on community composition (Fig. 1) increases rapidly with the duration of cover, up to 4-6 months. Increasing the disturbance period beyond this has little effect. There is little difference between the zones, but some suggestion that the low and mid marsh are more sensitive than the other zones.

The cover of *Spartina alterniflora*, the most ubiquitous species in the marsh, is decreased by wrack cover (Fig. 2). The effect varies from zone to zone, being greatest in the low marsh and least in the high marsh.

The amount of bare area in undisturbed plots varies from about 40 in creek banks to only 5 in the high marsh. Wrack coverage increases bare area in the following year (Fig. 3); the effect is least in the high marsh.

The difference between species in their response to disturbance is best illustrated by the high marsh data where three grass species are common (Fig. 4). *S. patens* shows a rapid decline in cover with 4 months of wrack cover. On the other hand, *S. alterniflora* and *D. spicata* show only a slight change even after 12 months of disturbance. Thus, the change in composition of the

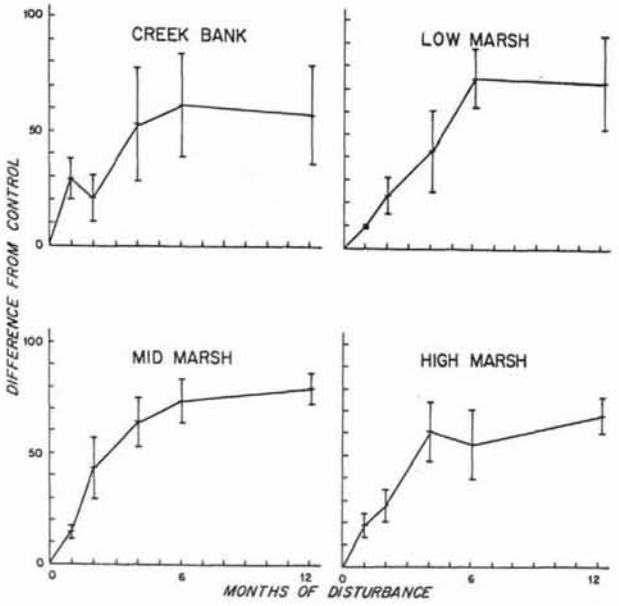

Figure 1

Difference in species composition between control and disturbed quadrats in four marsh zones. Difference is measured as Euclidean distance.

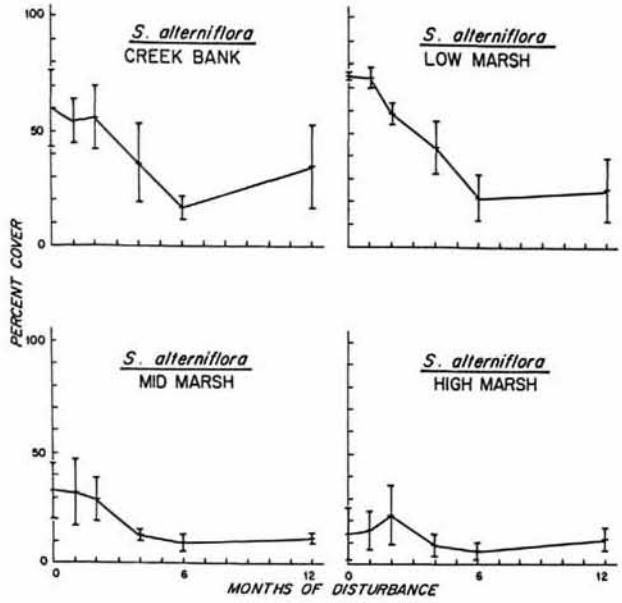

Figure 2

Percent cover of Spartina alterniflora *in four marsh zones as a function of disturbance duration.*

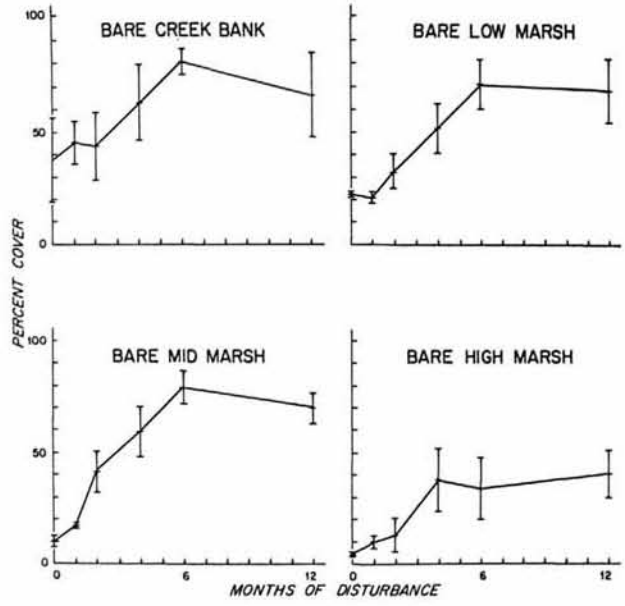

Figure 3

Percent bare ground in four marsh zones as a function of disturbance duration.

high marsh plots is primarily due to the loss of *S. patens* cover and a concurrent increase in bare ground.

The current composition of these plots reflects the resistance of species to wrack disturbance. Continued observation will provide a description of short-term succession in the salt marsh, determined by colonization, demographic characteristics, and species interactions.

The relationship of disturbance patches to pannes has been the focus of considerable conjecture. Pannes are slight depressions which generally have increased soil salinity and distinct vegetation associations. Plants

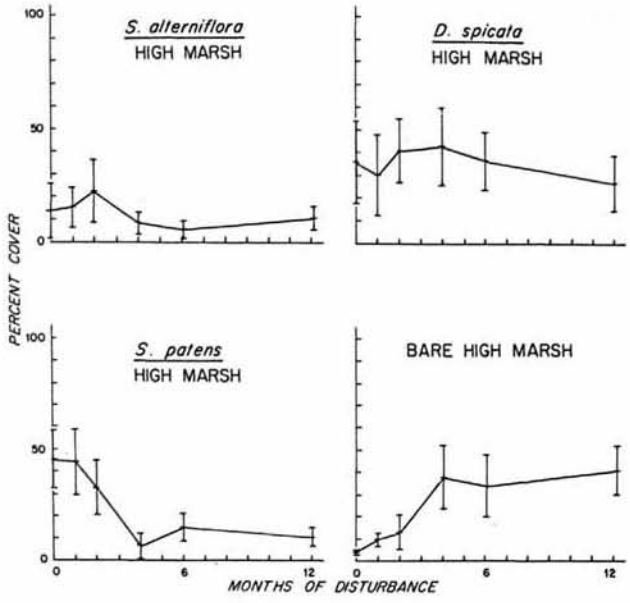

Figure 4

Percent cover of three grass species and bare ground in high marsh as a function of disturbance duration.

growing in pannes are often much less dense than in the surrounding vegetation and stunted in growth. In some parts of the marsh a thick algal mat may develop under the sparse plant cover. Miller and Egler (1950) identified several plant associations as typical of pannes and pools, emphasizing their importance in species diversity. They list six hypotheses, including wrack accumulation, for panne formation. They propose that erosion would increase following the death of the vegetation, forming a slight depression in the soil surface. Repeated evaporation of salt water from this depression would increase the surface soil salinity, commonly cited as the cause of the stunted, sparse growth of plants in pannes.

We surveyed a section of the marsh in order to establish the relationship of wrack and panne distribution within the vegetation zones. The distributions do overlap (Table), but much of the wrack occurs in higher zones than the pannes. This suggests either that the distribution of wrack in 1982 is atypical, that pannes are not in fact produced by wrack, or that the distribution of pannes reflects the distribution of wrack as modified by the sensitivity of the different zones of the marsh. The suggestion of lower sensitivity of the high marsh vegetation supports the last possibility.

Table

Frequency of wrack and panne occurrence in four salt marsh vegetation zones in a central section of Great Sippewissett Marsh, Cape Cod, Massachusetts.

	Percent frequency	
	Wrack	Pannes
Creek Bank	3.4	< 1
Low Marsh	3.4	12.8
Mid Marsh	17.5	16.7
High Marsh	15.8	< 1

CONCLUSIONS

We have shown that wrack cover can cause a change in salt marsh vegetation. Continued observations will determine whether some of the disturbance patches remain as pannes or are rapidly changed back to their initial composition. The dominant grass species respond differently from each other to wrack accumulation. Furthermore, the most ubiquitous species, *S. alterniflora* responded less intensely to disturbance at higher elevations than at lower elevations.

Acknowledgements

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