Wetland and Riparian Restoration: Taking A Broader View

Contributed Papers and Selected Abstracts
Society for Ecological Restoration
International Conference, September 14-16, 1995,
Seattle, Washington

Editors: Keith B. Macdonald
Fred Weinmann

Published by
U.S. Environmental Protection Agency
Region 10
Seattle, Washington
1997

Salmon River Salt Marsh Restoration in Oregon: 1978-1995

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Abstract: **The U.S. Forest Service initiated the Salmon River estuary salt marsh restoration in 1978 by removing dikes from a 22 ha pasture. In 1987, a nearby 58 ha pasture was likewise returned to tidal circulation. Vegetation composition, biomass, elevation, sediment accretion, salinity, and substrate texture have been monitored for 15 years since 1978. Adjacent natural salt marshes serve as research controls. Species composition changed rapidly after dike breaching. Pasture species, killed by saltwater, were displaced initially by annual marsh colonizers (*Cotula coronopifolia* and *Spergularia marina*). After 4 years, regionally common native species (*Carex lyngbyei*, *Salicornia virginica* and *Distichlis spicata*) began to replace the annuals and today dominate the restored marshes. Reestablished low marsh differs in species composition from the high marsh controls. Diked pasture elevations were ca. 35 cm lower than adjacent control marsh elevations, caused by subsidence. Subsided restored surfaces increased in elevation at a greater rate than control elevations. Sediment-clogged pasture creeks deepened 20-60 cm upon tidal reconnection. Substrate in the restored marsh accreted ca. 4 cm per decade. Estimated above ground primary productivity based on biomass measurement of the pasture was comparable to that of natural salt marsh controls (ca. 1,200 g/m2/yr) and to other Pacific Northwest high salt marshes. Restored marsh productivity was much greater (2,300 g/m2/yr) than controls. Restoration trends differ between the two restored units. The 58 ha unit lacked an intact drainage system characteristic of the 22 ha unit and surface ponding retarded restoration. The U.S. Forest Service restoration goal was to return diked pasture to its presettlement condition. Restoration was successful in reestablishing apparently functioning salt marshes that are integrated into the estuary; however, long term prospects for complete restoration to pristine conditions are more problematic.**

Introduction

Popular, government and academic interest in wetland and riparian ecosystem restoration has burgeoned in the past decade as we become more cognizant of the enormous losses and degradation of these critically valuable biotic systems (NRC 1992, Mitsch and Gosselink 1993, National Academy of Sciences 1995). Small in proportion to the earth's other impaired and impoverished landscapes, wetlands and riparian systems are recognized as having over arching importance in regulating climate, maintaining water quality, stabilizing hydrologic regimes, and providing crucial wildlife habitat (Mitsch and Gosselink 1993).

Despite the fervor and concern over wetland restoration, there have been few large scale wetland restoration projects conducted over an extended period of time. As the preferred compensatory mitigation strategy, wetland restoration projects have typically been on privately owned land, small in extent and poorly planned, executed and monitored (Kusler and Kentula 1990).

When Congress designated the Cascade Head Scenic Research Area (CHSRA) in 1974 (P.L. 93-535), a unique opportunity arose to restore and monitor a substantial salt marsh area on public land along the north central Oregon coast. The U.S. Forest Service, which administers the specially designated CHSRA, was directed by Congress to restore "*. . . the Salmon River estuary and its associated wetlands to a functioning estuarine system free from the influences of man . . . . to its condition prior to the existing diking and agricultural use*" (U.S. Forest Service 1976). About 75 percent of the Salmon River salt marshes had been diked to create pasture, mostly in the early 1960s. Conversion of coastal marshes has been common in Oregon where of the state's original salt marsh area, about 46 percent has been diked or filled since the early 19th century; most conversion has been to pasturage (Boulé and Bierly 1987). Besides accomplishing the Forest Service's goal of returning pasture to near-natural estuarine conditions, restoration of the Salmon River salt marshes by dike breaching serves

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as a long-term demonstration project that should be helpful to wetland managers in planning other coastal restoration programs and projects.

Study Site and Objectives

The Salmon River project consists of two units restored by dike removal, (1) a 21 ha pasture on the north shore was returned to tidal circulation in 1978, and (2) an additional 63 ha of pasture on the south shore were restored in 1987. For comparison, both restored pastures were selected so that they are flanked by relatively intact natural salt marshes that served as "controls" (Figure 1). Restoration was deliberate but passive in that dikes were breached allowing reestablishment of tidal circulation without planting, seeding or surface grading. Together with graduate students, I monitored these restoration sites for 17 and 8 years respectively. Throughout the remainder of the paper I refer to the north shore site as "Mitchell Marsh" and the south shore as "Y-Marsh."

I address four objectives: (1) will salt marsh vegetation reestablish in the absence of planting or seeding; (2) is it possible to restore a diked pasture to original high marsh conditions; (3) what is the rate of restoration; and (4) is the pattern of restoration similar in Mitchell Marsh and Y-Marsh?

Diane Mitchell initiated the north shore study in 1978 and established 115 one-meter square plots along 20 transects in the restored and control units. At each plot she sampled vegetation cover, biomass and elevation before and after dike removal in 1978 and 1979 respectively (Mitchell 1981). Together with Mitchell and Janet Morlan, I continued sampling vegetation cover in 1980, 1981, 1982, 1984, 1988, and 1993. Additionally, I sampled interstitial soil salinity, soil texture, soil organic matter, and accretion above a sand layer placed on the pasture surface in 1978. Mitchell also sampled elevations across 47 cross-sections along 8 marsh creeks. With Morlan, I completely resampled the restored marsh in 1988, 10 years after dike breaching (Morlan 1991, Frenkel and Morlan 1991).

On the south shore in the Y-Marsh, I established 57-meter-square plots along 6 transects and sampled vegetation cover in 1987 prior to dike breaching and again in 1988, 1990, 1991, 1992, 1993, and 1995. I surveyed plot elevations in 1988.

Salt Marsh Reestablishment

Composition and productivity

Upon dike removal, saline (30 to 10 ppt) tides flooded the pasture, stressing upland plants, and within a year, killing them. Detached litter and dead plants prevailed for several years after dike breaching. Change in selected species composition is shown in Figure 2 for Mitchell Marsh from pasture in 1978 to extensive low salt marsh in 1993. We considered three species groups: upland species (e.g., *Holcus lanatus* and *Ranunculus repens*) that were killed immediately; residual species (e.g., *Agrostis alba* and *Potentilla pacifica*) that diminished in cover; and both ephemeral and persistent colonizing species (e.g., *Carex lyngbyei, Cotula coronopifolia, Distichlis spicata* and *Salicornia virginica*) that invaded and increased in cover. Bare ground increased to a maximum the second year after dike breaching after litter was washed away, and diminished rapidly thereafter. Six years after restoration, two low marsh assemblages dominated the Mitchell site, an extensive brackish *Carex lyngbyei* community and a more limited *Salicornia virginica-Distichlis spicata* community in more saline areas.

A similar pattern of reestablishment occurred on the more recently restored Y-Marsh, except that bare ground and litter dominated and persisted for several years after dike removal. Colonization by salt marsh species was slow and initially characterized by annual ephemeral species (*Cotula coronopifolia, Puccinelia pumila* and *Spergularia marina*). By 1993, two assemblages were prominent, a *Deschampsia cespitosa* community and a *Salicornia virginica-Distichlis spicata* community.

During the same interval, species composition in the relatively intact control sites on both the Mitchell Marsh and Y-Marsh changed very little (Figure 3).

I estimated above ground net primary productivity from sorted biomass in the Mitchell Marsh following the method of Kibby et al. (1980). Pasture productivity was similar to that of the control high marsh in 1978, about 1000 g/m^2-yr. After dike breaching, biomass at first diminished and then gradually increased to 2300 g/m^2-yr in 1988, more than double the value of either the intact high marsh or the pasture.

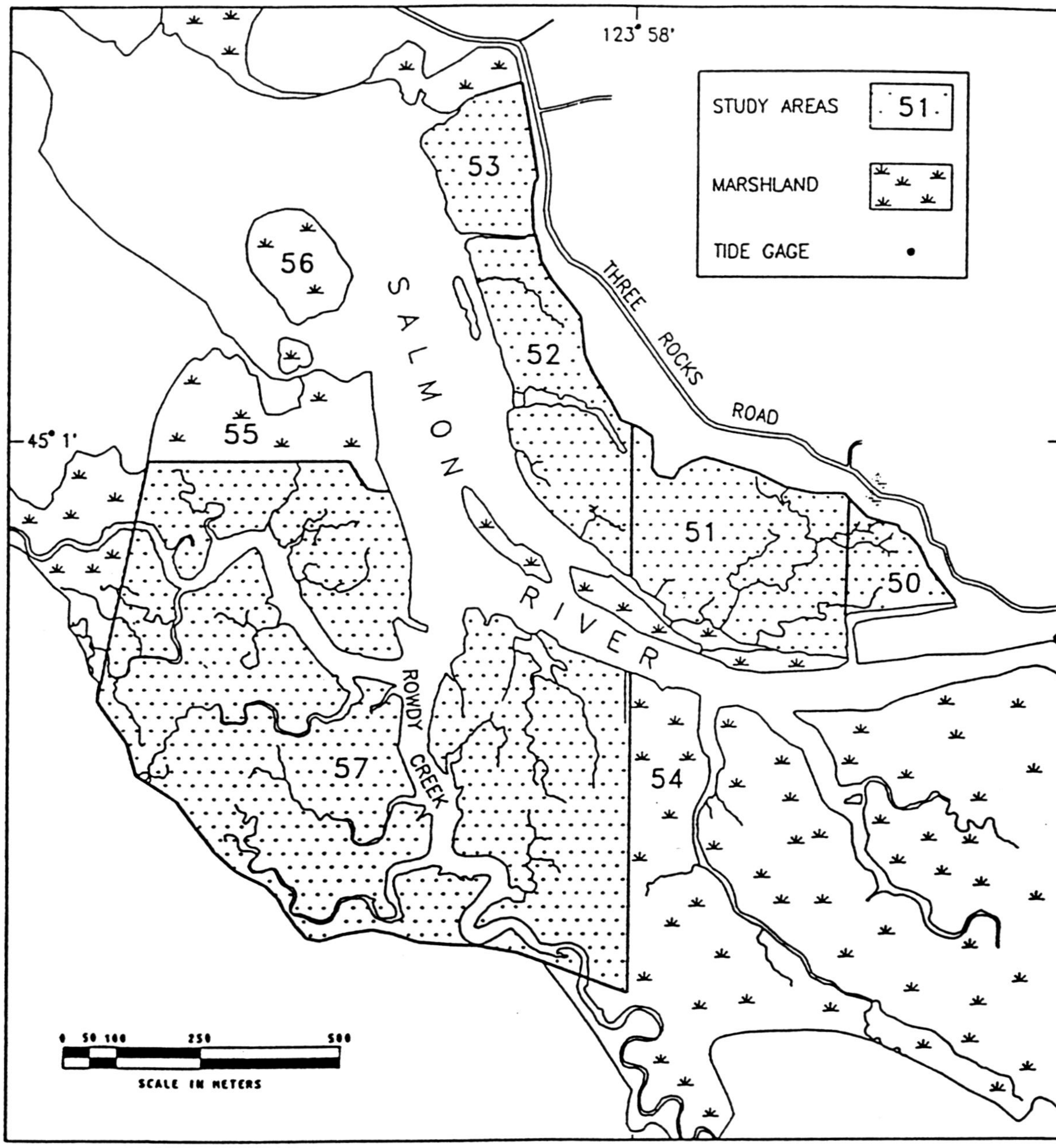

Figure 1. Location of restoration and control area in the Salmon River estuary. Mitchell Marsh: Restoration area 51 and 52, Control area 50 and 53; Y-Marsh: Restoration area 57, Control area 54.

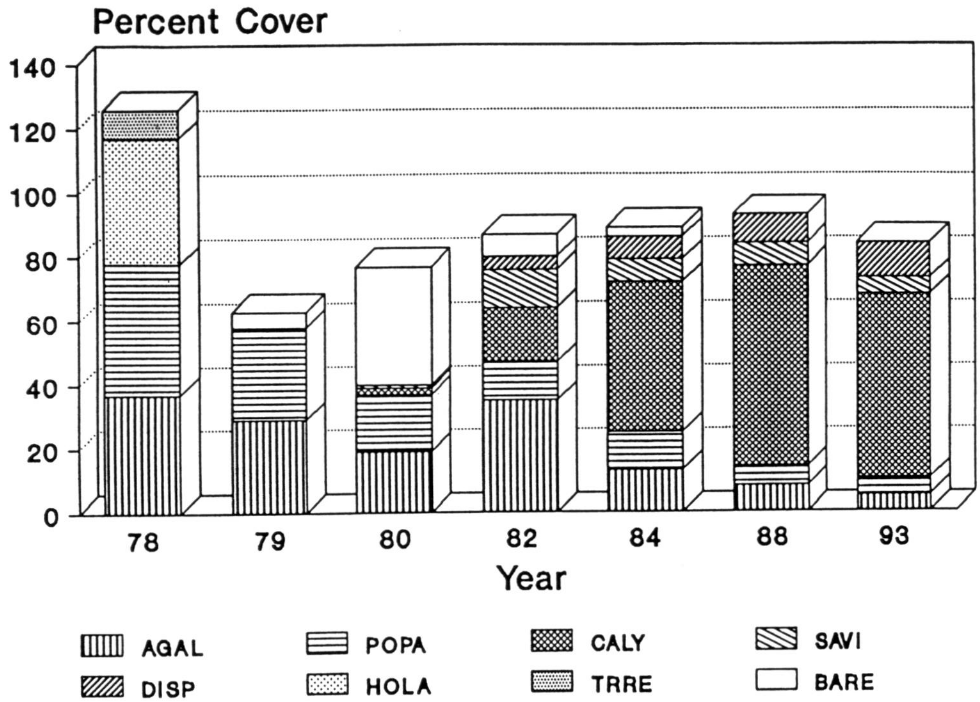

Figure 2. Change in percent cover of principal plant species in the Mitchell Marsh restoration site, 1978-1993 in the Salmon River estuary.
AGAL = *Agrostis alba*, POPA = *Potentilla pacifica*, CALY = *Carex lyngbyei*,
SAVI = *Salicornia virginica*, DISP = *Distichlis spicata*, HOLA = *Holcus lanatus*,
TRRE = *Trifolium repens*, and BARE = surface not vegetated by vascular plants.

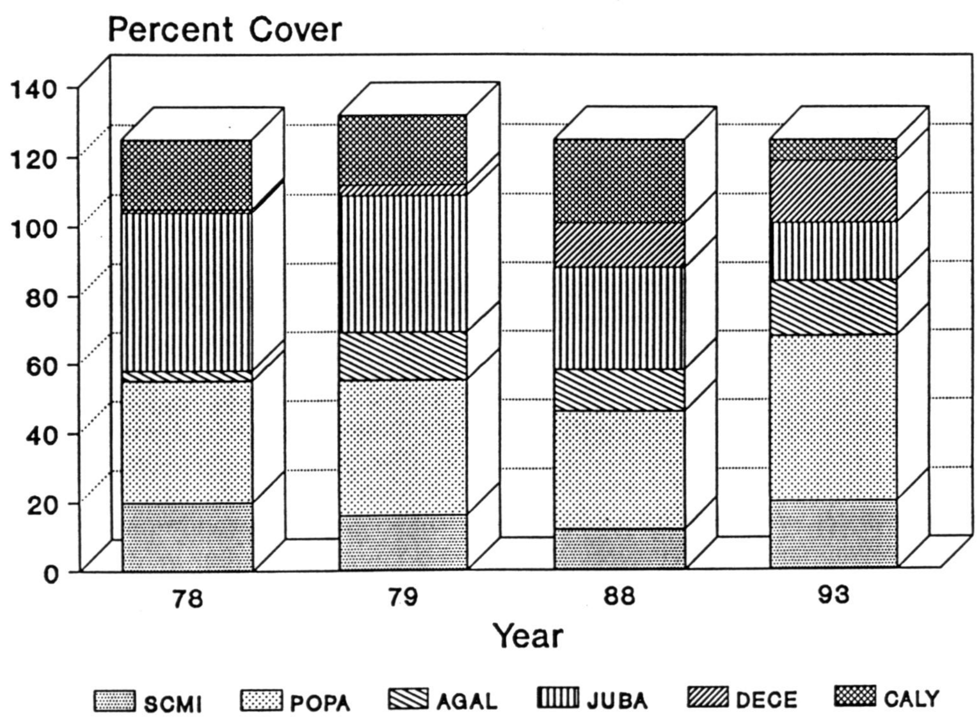

Figure 3. Change in percent cover of principal plant species in the Mitchell Marsh control site, 1978-1988 in the Salmon River estuary.
SCMI = *Scirpus microcarpus*, POPA = *Potentilla pacifica*, AGAL = *Agrostis alba*,
JUBA = *Juncus balticus*, DECE = *Deschampsia cespitosa*, and CALY = *Carex lyngbyei*.

Environmental Change

By environmental change I refer to variation in controls that affect marsh restoration including, surface elevation that determines tidal inundation, creek development, sediment accretion, salinity, soil texture, and soil aeration.

During the 17 years that Mitchell Marsh was diked (1961-1978), the original marsh surface subsided 30-35 cm due to loss of buoyancy, oxidation and trampling, while the flanking control marsh surface did not subside (Figure 4). A similar pattern of subsidence occurred on the Y-Dike side that was diked for 27 years prior to dike removal; however the Y-Marsh site was generally about 20 cm lower than the Mitchell Marsh (Figure 4). Upon reestablishment of tidal exchange, the subsided pasture surface increased in elevation at a greater rate than the control marsh surface.

With dike removal, tides again began to flush inactive, clogged tidal creeks. Creeks deepened and narrowed due to erosion, but also because of sedimentation along marsh levees (Figure 5). Marsh creeks show greatest deepening low in the marsh where tidal flushing was greatest, and least deepening at creek heads. In the Y-Marsh, the original tidal creek pattern had been severely altered during the diking period. In places creeks were obliterated leading to ponding and anaerobiosis. Elsewhere the basic creek pattern remained and creeks deepened.

Creek reestablishment was critical to marsh restoration. It is by creeks that sediments and nutrients are exchanged with the estuary. It is by creeks that saline water enters and drives compositional change, and, it is by creeks that anaerobic toxics are removed and aeration enhanced.

Discussion

Salt marsh vegetation was fully restored to Mitchell Marsh and the Y-Marsh within about eight years without planting, seeding, or grading. The only necessary manipulation was dike removal which reestablished tidal exchange.

Composition of restored marsh vegetation, however, is very different now from that prevailing prior to diking and pasture creation in the early 1960s. Based on relatively unaltered natural salt marshes flanking the restored sites, I assumed that pre-dike composition was typical of high marsh with dominance of *Juncus balticus, Deschampsia cespitosa*, and *Potentilla pacifica*. Because the pasture surface subsided 30-40 cm during the diked period, upon return of estuarine circulation, low marsh characterizes the restored sites and strongly reflects salinity and soil texture conditions. Today, an expanse of almost pure *Carex lyngbyei* marks the more brackish and finer textured substrates. Where conditions are more marine, with higher salinities and sandier substrates, *Salicornia virginica* and *Distichlis spicata* dominate.

Above ground net primary productivity in the restored Mitchell Marsh is almost twice that of the pasture and typical high marsh. Enhanced productivity probably reflects released resources and increased tidally born nutrients. Since reestablishment of salt marsh is akin to primary succession, it is not surprising to observe high net productivity (Odum 1969).

To restore high marsh, surface elevations would need to be increased at least 30 cm. Accretion rates are greater in the restored sites (ca. 5 cm per decade) than in adjacent controls (ca. 1-2 cm per decade). Accretion rates, however, are more diminished in high marsh than in lower areas near the river; therefore, I estimate that it would take at least 80 to 100 years to change from a low to high salt marsh.

Drainage and soil aeration also control salt marsh restoration. When marshes are diked, natural drainage patterns disintegrate and are altered by reduced flow, sedimentation, livestock trampling of creek banks, and grading. For high marsh reestablishment, an efficient integrated creek system must redevelop. In Mitchell Marsh, where the creek system was subdued but not destroyed, restoration proceeded fairly rapidly. In the Y-Marsh, surface grading had destroyed the original creek system and drainage was poor. Marsh vegetation restoration was retarded.

Poor drainage and low surface elevations in the Y-Marsh led to persistent ponding which created extreme anaerobic conditions. These were accentuated by the accumulation of dead pasture litter that was not removed by tidal water. After dike breaching, extensive patches of algal mat dominated the Y-Marsh for about four to five years. Vascular plants tolerating these conditions included ephemeral *Cotula coronopifolia, Puccinelia pumila, Spergularia marina*, and *Triglochin coccinea*. More typical salt marsh species were found along creek margins or where soil aeration was greater. Gradually, soil aeration increased, algal mats broke up, and ephemeral

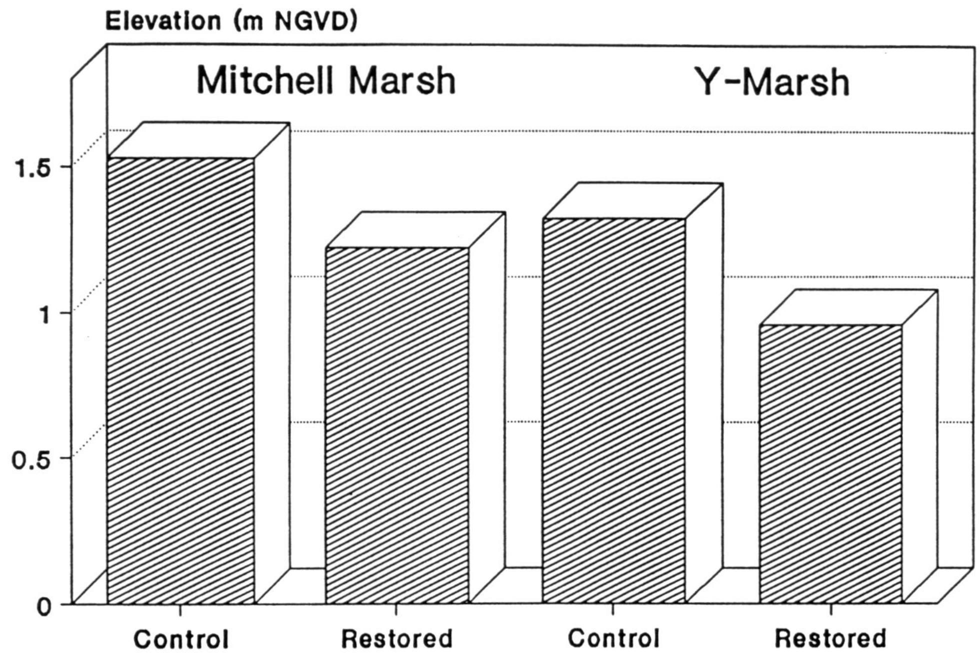

Figure 4. Elevation distribution 1988 of the restoration site and controls in Mitchell Marsh and Y-Marsh in the Salmon River estuary.

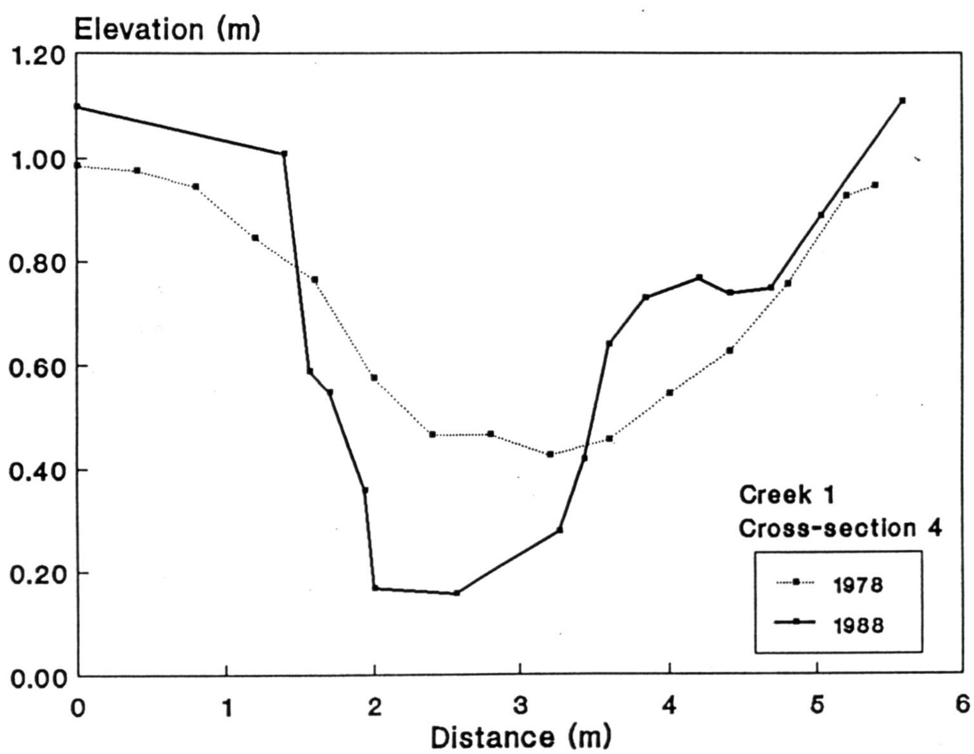

Figure 5. Elevation across a typical marsh creek cross-section in the Mitchell Marsh restoration site in 1978 and 1988 showing creek deepening associated with reestablished tidal circulation.

species have begun to be replaced by common regional salt marsh species.

Conclusions

I addressed four objectives. First, after dike removal, typical salt marsh vegetation reestablished in the course of about eight years in the absence of planting and seeding. Although I did not measure marsh function directly, species composition, enhanced productivity, presence of salmonids in marsh creeks (C. Simenstad pers. comm., June 30, 1993), and abundant waterfowl provide evidence of a functioning marsh.

Second, because the diked pasture subsided 30-40 cm relative to the original high marsh, low salt marsh vegetation prevailed after dike breaching. It is unlikely that original salt marsh conditions will be restored within 100 years, if then.

Third, rates of restoration as measured by vegetation composition vary greatly. Under favorable conditions, Mitchell Marsh returned to low marsh within about six years after which composition changed very slowly. In the Y-Marsh, where surface drainage had been severely altered causing ponding and anaerobiosis, marsh vegetation took about eight years to reestablish and even then was changing annually.

Fourth, the pattern of restoration was quite different in Mitchell Marsh than in the Y-Marsh. Although surface subsidence was the same in the two restored areas, initial elevation, drainage and anaerobiosis were strikingly different. Under anaerobic conditions prevailing in the Y-Marsh, restoration of vascular plants was retarded, algal mats covered large areas, annual ephemeral plants dominated for several years before more characteristic marsh plants became established.

Despite these differences in restoration pattern and rate, the Salmon River salt marsh restoration is a success. The project demonstrates that one of the best opportunities to stem the national and regional loss of coastal wetlands is to return agriculturally diked coastal wetlands to natural salt marsh through dike removal. This opportunity is particularly advantageous on large tracts of public land. It is under these circumstances that restoration can be carefully planned and monitored over decades.

Acknowledgements

The Salmon River estuary research project could not have taken place without the careful meticulous field and analytical work of Diane Mitchell and Janet Morlan, for this I am especially grateful. I also wish to acknowledge funding assistance from the U.S. Forest Service and U.S. Environmental Protection Agency, Region 10.

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