RESEARCH PAPERS

AN OVERLOOKED ECOLOGICAL WEB

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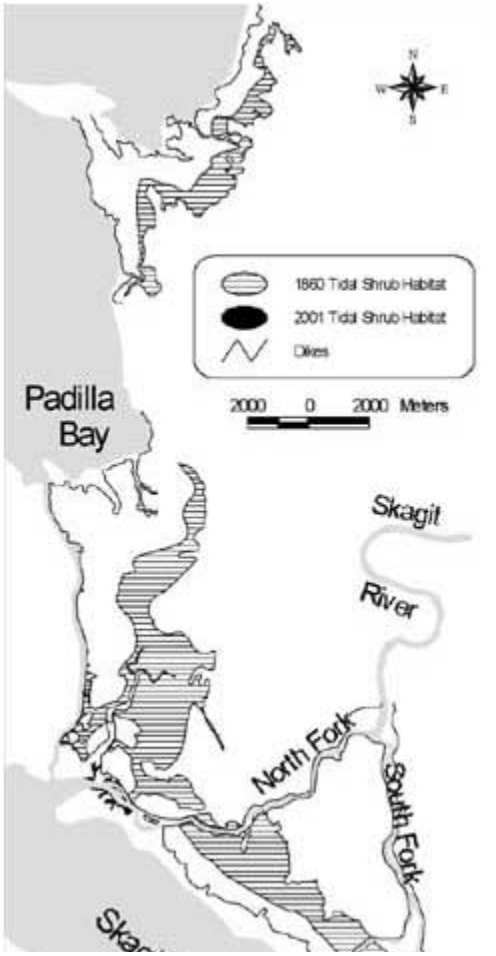
Sweetgale, Beaver, Salmon, and Large Woody Debris in the Skagit River Tidal Marshes:

The phrase "estuarine tidal marsh" generally evokes a pastoral image of tidally flooded meadows of grasses, sedges, rushes, and occasional wildflowers. However, there is another type of tidal marsh that is frequently overlooked-estuarine scrub-shrub wetlands. Shrub-dominated tidal marshes were historically very common, comprising 33% of the estuarine tidal wetlands in the Skagit delta, 35% in the Stillaguamish, and 70% in the Snohomish (Collins 2000). Today less than 6% of this habitat remains in the Skagit delta (mostly in the South Fork delta; **Figure 1**), and virtually none remains in the Stillaguamish and Snohomish deltas. These extensive losses are probably representative of other historically large regional estuarine marshes such as the Duwamish (Seattle), Puyallup (Tacoma), and Fraser (Vancouver, BC) deltas.



Most habitat loss in the Skagit delta occurred soon after Euro-American settlement in the 1870s. Tidal scrub-shrub wetlands were easier to clear than forests and easier to dike and drain than the lower elevation tidal meadows. In fact, early records show that the former shrub-lands were more expensive

than forested lands because of the comparative difficulty in developing forest land for agriculture (Collins 2000).

Figure 1.
Historical (-1860) and current (2001) distribution of estuarine tidal scrub-shrub wetland in the Skagit delta. (Modified from Collins et al. 2001)

Because rapid and extensive loss of estuarine shrub habitat occurred long ago, few people are aware this habitat ever existed, or whether it was ecologically significant. Should we be concerned about this habitat loss? Did this vegetation community play a role in the estuarine ecology of juvenile salmonids? The Skagit System Cooperative (SSC) is currently doing research to answer these and related questions.

Today the most common estuarine shrub is sweetgale (**Figure 2**), followed by willows, black twinberry, and wild rose. Sweetgale is unique among these shrubs, and all other estuarine plants in the Skagit delta, in being able to convert atmospheric nitrogen into nitrate, an important plant nutrient. This process is called nitrogen fixation.

Herbivores are nitrogen limited compared to carnivores, because plants are a poor source of nitrogen compared to protein-rich animals. Because nitrogen-fixing plants have relatively high concentrations of nitrogen in their tissues, they are a preferred food for herbivores. This is why horses and cattle prefer clover or alfalfa, which are both nitrogen-fixing plants. Thus, sweetgale may play an important role in estuarine foodwebs. It may be a preferred food for insects that feed on its leaves. When the leaves fall in the autumn, insects such as midge larvae (chironomids) and crustaceans such as scuds (amphipods) and pillbugs (isopods) may preferentially feed on the decomposing leaves. Midge larvae and scuds are common food items for juvenile salmonids in estuarine marshes, so sweetgale may be an important part of the salmonid food web in the estuary. A study is currently underway at the SSC to compare decomposition rates of three dominant plant species - sweetgale, Lyngby's sedge, and cattail-in the South Fork tidal marshes, and to compare colonization rates and abundance of insects and crustaceans that feed on the decomposing vegetation.

Sweetgale may also affect salmon by affecting the distribution of beaver in the estuary. Most people, even some beaver researchers, are unaware that beaver can be found in estuarine tidal marshes when the salinity is less than 10 parts per thousand (seawater is typically 30-35 ppt, while freshwater is less than 0.5 ppt). An ongoing SSC study is showing that beaver are common in the Skagit River tidal marshes (where the salinity is typically less than 5 ppt), and preliminary evidence indicates that beaver are strongly associated with sweetgale habitat.

In small tidal channels (less than 7 feet wide), beaver build small dams (less than 2 feet tall) that pond water at low tide, but are completely flooded at high tide. The apparent function of the dams is to pond sufficient water in the channels at low tide so that the beaver can still swim in the channels. Without dams the channels would go dry at low tide. These beaver ponds are full of small fish at low tide-juvenile salmon and sticklebacks. Without the ponds the fish would be forced into larger, wider, and deeper tidal channels that don't go dry at low tide. There they would be vulnerable to predators such as great blue herons and large fish. These predators are not found in the beaver ponds. Great blue herons are kept out by the sweetgale thickets

that border and hang over the channels, sometimes completely covering the channels.

Figure 2.
Close-up of sweetgale (Myrica gale).

In contrast, tidal channels that are located in cattail and sedge habitat never contain beaver ponds. Some ponds are formed by slumping banks, or trapped logs, but ponds in these channels are less common and smaller than those in channels found in sweetgale habitat. Furthermore, because great blue herons are not obstructed by shrubs, the herons are commonly found feeding on fish in these channels. Thus, sweetgale may indirectly benefit juvenile salmon by affecting the dam building by estuarine beavers and providing low tide refuges from predation.

Estuarine vegetation is usually found in distinct bands that parallel the shoreline. These bands are the result of a gradient of flooding and salinity stress experienced by plants in the estuary. For example, eelgrass is found in subtidal and very low intertidal areas. Low intertidal areas in the South Fork delta are occupied by American threesquare; higher intertidal areas are dominated by Lyngby's sedge, then by cattails; and at the highest elevations shrubs dominate the intertidal zone.

Sweetgale is found in a half-mile wide band between sedge and cattails at lower elevations and other shrubs like black twinberry, willow, wild rose, and spirea at higher elevations. At lower elevations sweetgale cannot tolerate tidal flooding to the extent that sedges and cattail can, and at higher elevations other, taller shrubs outcompete sweetgale for sunlight. Thus sweetgale is squeezed between two constraints on its estuarine distribution-physical stress at lower elevations and competition at higher elevations.

Sweetgale's intertidal distribution would be narrower were it not for the presence of large logs (large woody debris-LWD) in the tidal marsh. Logs are common in the South Fork tidal marsh and they allow sweetgale to expand its distribution into the lower elevation marsh by providing sweetgale with small elevated "island-logs" upon which to grow above a critical flooding threshold (**Figure 3**). SSC research shows that in the low-elevation marsh sweetgale grows exclusively on logs; the larger the log the greater the chance that sweetgale is growing on it (**Figure 4**). As elevation increases the proportion of sweetgale growing on logs declines steadily, but this proportion is always much greater than that expected by random growth on logs and soil, i.e., the proportion of log surface area to marsh surface area. This pattern indicates that as sediment accumulates in the marsh over the course of many floods, individual sweetgale shrubs spread by runners from logs to the elevated adjacent marsh surface and grow into dense thickets. Eventually, the original log islands are either buried by sediment or decompose, so that sweetgale appears to the casual observer to have no association with logs. Further increases in marsh elevation, allow other woody species to colonize the marsh

Figure 3.
Near high tide at the lower distributional limit of estuarine shrubs in the South Fork tidal marsh. Small sweetgale shrub growing on a log in the foreground. Larger, linear patch of sweetgale growing on a log in the background.

and compete with sweetgale.

Other shrubs and trees in the tidal marsh are also usually found growing on large logs, and generally these logs are even larger than those on which sweetgale grows (**Figure 5**). Where do these logs come from? It's unlikely that spruce trees growing in the tidal marsh are significant sources of estuarine wood. Although spruce is the largest and most abundant tree in the South Fork tidal marsh, it is sparsely distributed and it does not grow as large or as quickly as in other habitats. A sample of thirty spruce growing in the South Fork tidal marsh had a mean diameter at breast height (DBH) of only 35 cm and a maximum diameter of 61 cm.

In contrast to the size of living spruce, the average size of a log supporting sweetgale was 62 cm, and the average size of a "nurse-log" supporting a spruce tree was 120 cm. Other shrubs and trees in the tidal marsh also grow on logs that on average are much larger than the largest live spruce in the tidal marsh. Thus, large logs that are important in supporting estuarine shrub habitat must come from outside the estuarine marsh-from coastal or riverine forests. This implies that management of river margins (riparian zones) has potentially significant consequences for vegetation composition of estuarine tidal marshes and for the ecological functions (e.g., production of invertebrate prey for juvenile salmon, habitat for beaver and refuge from predators for juvenile salmon) provided by that vegetation.

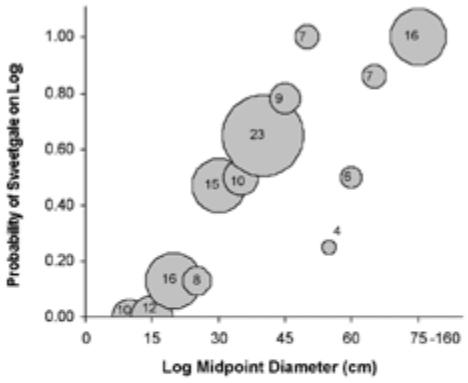


Figure 4.
The probability that Sweetgale is growing on a log increases in proportion to the size of the log. Bubble size and label represent the sample size of logs of a given size class. Logs over 75 cm diameter were grouped because all were colonized by Sweetgale.

The riparian zones most likely to contribute large fallen trees to the estuary would normally have been those of the lower Skagit River. However, riparian forests in this area are a small fraction of their historical extent (Collins 2000). Furthermore, dikes and riprap have hardened the river channel, preventing channel migration and bank undercutting, thereby reducing treefall from the riparian forests. Low recruitment of large wood to the estuary may have long-term consequences for the sustainability of estuarine shrubs and trees.

Current SSC research shows that South Fork delta distributary channels and blind tidal channels can migrate dramatically over time, so that established marsh vegetation can be eroded away, while new marsh is created by vegetation colonizing newly deposited sediments. Without a sufficient supply of large wood to the estuary to facilitate shrub colonization of new marshland, established shrub habitat will eventually be lost to channel migration without being replaced.

In summary, SSC research suggests that we need to more closely examine the ecology of an often neglected habitat-tidal shrublands, and we need to be more cognizant of the ecological connection between riparian zone management of the lower Skagit River and the long-term sustainability of estuarine vegetation and its ecological functions. Due

to the extensive loss of this vegetation type and its ecological functions, consideration should be given to restoring estuarine scrub-shrub habitat where appropriate.

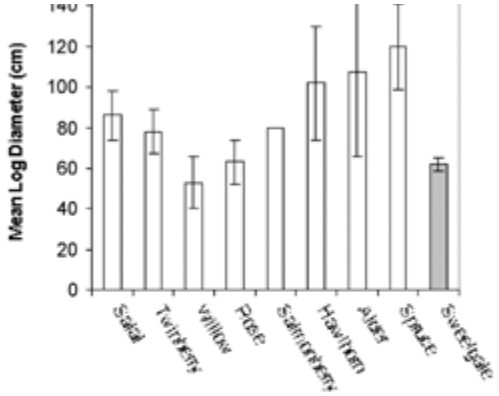


Figure 5.
Mean size of logs colonized by shrubs and trees in the South Fork tidal marsh. Most species grow on logs much larger than those colonized by sweetgale. The exceptions, willow and wild rose, were found at higher elevations and at low frequencies. Error bars represent sample variability.

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