Plum Island Ecosystems (PIE)

We have been investigating the ecology of Plum Island Sound estuary since the late 1980s with support primarily from the National Science Foundation (NSF). Research greatly expanded in 1992 with support from the NSF Land Margin Ecosystems Research program. The site became part of the NSF Long-Term Ecological Research (LTER) network in 1998. The Plum Island project is one of 4 LTERs that studies the effects of terrestrial and oceanic drivers on ecosystems at the land-sea interface.

The Plum Island Ecosystems (PIE) LTER is an integrated research, education and outreach program. The overall goal is to be able to predict the long-term effects of human activities on land, climate change, and sea level rise on the health of estuaries. While our studies are focused on a single system, this system can be considered a model for what is happening in estuaries worldwide. We seek to apply our ecological knowledge of how this system works to help in the management and development of policy that protects the natural resources of this and other estuaries in the U.S coastal zone.

Site Description and Characteristics The coupled watersheds and estuary of Plum Island Sound are in northeastern Massachusetts in the Boston metropolitan region. The Ipswich River (400 km^2) and Parker River (200 km^2) basins lie entirely within the Seaboard Lowland section of the New England physiographic province. Shallow soils, glacial till and bedrock outcrops are dominant geological features formed during the last ice age. Low relief of the basin is responsible for one of its main characteristics, a large expanse of wetlands.

The climate is humid with an average annual (1961-1990) air temperature of 10°C, ranging from -4°C in January to 22°C in July. Precipitation is distributed uniformly throughout the year, with an annual average of 1188 mm. Snowfall accounts for about 8% of total annual precipitation. On an annual basis, the amounts of precipitation leaving the basin as either ET or streamflow are similar in proportion (~45%), while net diversions leaving the basin account for the remaining portion (~10%). While precipitation does not display seasonality, there is a distinct seasonality in streamflow, driven by the strong seasonal climatological forcing on snowmelt and ET. Average monthly streamflow ranges from 107 mm in March to 8 mm in September, while monthly ET ranges from 7 mm in December to 103 mm in July.

Boston bedroom communities have been encroaching along the southern portion of the watershed for several decades and population growth accelerated in the 1990s at rates common in the 1950s and 1960s. The rate of suburban sprawl is second only to Atlanta in the US. The total population of the basis was estimated about 200,000 in 2001 (328 people km^{-1}). Watershed land use composition in 2001 was approximately 46% forest, 34% urban/suburban, 10%

agriculture and 10% wetland/water.

The Plum Island Sound estuary (60 km^2) is a coastal plain, bar-built estuary with extensive areas of productive, tidal marshes (~40 km^2) in the cold-temperate Acadian biogeographic Province. The tidal range is 2.9 m and exceeds 4 m during spring tides. Mean annual sea level has been increasing about 2.8 mm yr^{-1} over the past 75 years. The estuary contains salt marsh, dominated by smooth cordgrass (*Spartina alterniflora*) and marsh hay (*Spartina patens*), fresh marsh, dominated by cattail (*Typha*), intertidal flats and open water tidal creeks and bays. In general the species diversity is low in the Acadian Province, with the number of fish species being half that south of Cape Cod in the Virginian Province. The degree of endemism is very high, being 25% for fishes and 30-40% for mollusks. A number of molluscan and algal species found in the Acadian region are arctic or boreal. Twenty-eight species of fish have been recorded in the brackish to marine areas and another 10 from the freshwater portions. Typical species in the marine portion are: Atlantic silversides, winter flounder, blueback herring, alewife, smelt, mummichog, sticklebacks, menhaden, pipefish and sculpin. Fiddler crabs, which are so common in salt marshes further south, are completely missing from the Acadian Province with no known ecological analog replacing them. Plum Island Sound estuary supports extremely productive commercial and recreational soft-shell clam and striped bass fisheries.

The shallow water estuary (1.6 m) is vertically well-mixed, with residence times ranging from < 1 day in the sound to several weeks in the upper estuary when freshwater discharge is low. Salinities range from 0 psu to 32 ppt and are also controlled by freshwater discharge. The estuary is meso-eutrophic with chlorophyll *a* concentrations typically less than 10 mg m^{-3}, but occasionally exceeding 70 mg m^{-3} in the upper estuary when residence times are long. Oxygen concentrations are typically undersaturated, which is indicative of the system being net heterotrophic and dependent on allochthonous organic matter inputs from the watershed and adjacent tidal marshes.

Research Focus Research focuses on how several aspects of global change influence organic matter and inorganic nutrient biogeochemistry and estuarine foodwebs. We are studying how inputs of organic matter and nutrients from land, ocean and marshes interact with the external drivers (climate, land use, river discharge, sea level) to determine the spatial patterns of estuarine productivity and trophic structure.

The project uses a combination of approaches to address research questions and hypotheses: 1) short- and long-term "core" measurements 2) short and long-term experiments, 3) comparative ecosystem studies and 4) modeling. The research integrates estuarine biogeochemistry with studies of food webs and population biology of all trophic levels. The PIE LTER data and information system provides a centralized network of information and data related to the Plum Island Sound Estuarine Ecosystem and its watersheds. The centralized network provides researchers associated with PIE-LTER access to common information and data in addition to centralized long-term storage. Data and information are easily accessible to PIE-LTER scientists, local, regional, state partners and the broader scientific community.