Belowground Resilience to Freeze Damage in the Texas Gulf Coast Marsh-Mangrove Ecotone

Anna R. Armitage[1] *and Steven C. Pennings*[2]
[1]Texas A&M University at Galveston, Galveston, TX, USA
[2]University of Houston, Houston, TX, USA

Climate change forecasts predict increasing frequency and severity of disturbances such as hurricanes, droughts, and severe cold snaps. Biodiversity-ecosystem function (BEF) theory suggests that speciose systems may be more resilient to disturbance impacts, exhibiting faster recovery than low diversity communities. In coastal wetlands, recovery potential is closely linked to persistence of living belowground tissue. We leveraged a unique opportunity to examine this relationship by assessing the role of species diversity on belowground resilience following a strong cold snap on the Texas Gulf Coast (USA) in 2021. The study system was a long-term experiment in the marsh-mangrove ecotone that had maintained varying levels of plant diversity in ten large (24 m x 42 m) study plots since 2012, ranging from Avicennia germinans (black mangrove) monocultures to relatively speciose marsh-mangrove mixtures. Prior to the cold snap, plots with more than 35% mangrove cover had relatively low Simpson's diversity index scores ($1\text{-}D \leq 0.4$), reflecting mangrove dominance over a more speciose marsh assemblage. During a cold snap in February 2021, temperature minima were below -7°C for several hours, causing extensive (>90%) mangrove mortality. Four growing seasons (fall 2024) after the cold snap, we collected belowground biomass samples from five vegetation states within each plot: living Avicennia, living Spartina alterniflora, living Batis maritima, dead Avicennia, and bare ground. We separated live and dead root tissue based on texture, color, and buoyancy. There was 10x more living root biomass in samples from living vegetation states (Avicennia, Spartina, or Batis) than in bare vegetation samples. Samples from dead Avicennia had half as much living root biomass as those from living Avicennia. The living roots found in stands of dead Avicennia likely represented ingrowth from neighboring patches of Spartina or Batis. We extrapolated relative plot-level belowground biomass based on the coverage of each vegetation state in each 24 x 42 m plot. At this larger scale, the ratio of live:dead root biomass was strongly positively related to pre-freeze plant diversity levels, where plots that had been previously dominated by mangroves had very little living root tissue after the freeze. Only the two highest diversity plots had more living than dead root material, indicating relatively low root mortality in those high diversity assemblages. These results suggest that belowground biomass is not resilient to freeze damage, particularly in low-diversity assemblages. In areas with extensive Avicennia pre-freeze cover and post-freeze mortality, belowground biomass decomposition may lead to widespread subsidence and carbon loss. However, areas with higher pre-freeze plant diversity may be at somewhat lower risk of submergence and irreversible habitat loss.