Vulnerability and Responses of American Samoa Mangroves to Relative Sea-Level Rise and Pacific Island Region Capacity-Building Priorities

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ABSTRACT

An assessment was made of American Samoa mangroves' vulnerability and predicted changes in position from sea-level rise. The study also evaluated capacity in the Pacific Islands region to assess mangrove vulnerability to climate change and institute adaptation measures. Of the outcomes from climate change, relative sea-level rise may be the greatest threat to mangroves. By 2100, mangrove losses from relative sea-level rise could be as high as 47 percent in American Samoa and 22 percent when extrapolating regionally, causing about a quarter of total predicted annual regional losses.

American Samoa mangrove vulnerability to sea-level rise was determined and future position was predicted through analyses of sea-level trends and projections, mangrove spatial change analysis, reconstruction and monitoring of sedimentation rates, and determination of potential migration areas. These analyses provided three categories of requisite information: (i) Observed and projected rate of change in sea-level relative to the mangrove sediment surface, determined from trends in relative sea-level through analysis of sea-level data from a local tide gauge and observations of trends in the elevation of mangrove sediment surfaces; (ii) observed and projected trends in mangrove seaward margin positions; and (iii) physiographic settings (slope of land upslope and location of obstacles along the landward margin).

Results indicate that American Samoa mangroves are not likely keeping pace with rising sea-level, both surface and subsurface process controls on sediment elevation are important factors, and a large proportion (16, 23 and 68 percent) of the landward margins of the three mangrove study sites are obstructed from natural landward migration with sea-level rise. Based on observed trends in sediment surface elevations and movement of two mangroves' seaward margins, these sites have likely not been keeping pace with relative sea-level rise, with an elevation deficit of about 2 mm a^{-1} at both sites. An embayment mangrove experienced sea-level rise relative to the mangrove sediment surface of 2.22 (± 2.22 95% CI) mm a^{-1} and a basin mangrove experienced 1.97 (± 0.32 95% CI) mm a^{-1}. At these sites, a highly significant positive correlation between the change in position of the seaward margins and change in relative sea-level suggests that rising sea-level relative to the mangrove surface caused the observed landward migration. Shoreline movement was not significantly correlated with changing sea-level at a third site, where development activities have likely been dominant factors

determining changes in mangrove position; vulnerability, based on observations of trends in sediment surface elevation, was not determined for this third site.

This study was the first to employ broad spatial coverage and a large number of sampling locations (330 sampling locations) to observe trends in the elevation of two mangroves' sediment surfaces, a necessary sampling design to adequately characterize mangrove sites, based upon previously documented high spatial variability in trends in mangroves' surface elevation. Both surface and subsurface processes exhibited large controls on sediment elevation, highlighting the need to monitor the full soil profile to accurately measure trends in mangrove surface elevation. Highly significant different mean changes in sediment surface elevation occurred for mangroves in different geomorphic settings (a difference of 3.4 [± 1.3 SE] mm a^{-1}, N = 1412, $P<0.007$), supporting the hypothesis that mangroves in an estuarine/drowned river valley composite geomorphic setting are more resistant to relative sea-level rise than embayment mangroves. Mean landward migration of the mangroves' seaward margins was 12 to 37 times the relative sea-level rise rate. This is the first documentation of significantly different mean sediment surface elevation change for mangroves in different geomorphic settings, and the first documentation of the relationship between the rate of seaward mangrove margin erosion and relative sea-level rise rate, information needed to develop reliable predictive elevation models for mangrove ecosystems. Changes in extreme high water levels and frequency were found to not pose an increasing threat to American Samoa mangroves beyond the effects from rising mean sea-level. This site-specific assessment supports the hypothesis that, in this region, which experiences large El Nino Southern Oscillation-related steric changes lasting several months to years, extreme high waters are likely to be related to mean sea-levels.

This was the first comprehensive assessment to determine both (i) whether the mangrove site's threshold for resistance to sea-level rise has been exceeded, and (ii) the site's capacity to naturally migrate landward in response to rising sea-level. This was the first study to select research methods suitable for employment in Pacific Small Island Developing States, considering both cost and staff abilities.

Results support instituting adaptation measures in American Samoa to reduce obstacles to landward mangrove migration with sea-level rise and to manage activities within catchments that affect mangrove elevation. Regionally, there is extremely low capacity to assess mangrove vulnerability to climate change and to institute adaptation measures. Regional adaptation priorities include coastal planning that facilitates mangrove migration with sea-level rise, better management of non-climate stressors, and identification of climate change impacts on mangroves through regional standardized monitoring.