Scaling protection and restoration of natural infrastructure to reduce flood impacts and enhance resilience

By

Shannon E. Cunniff

Director, Coastal Resilience, Environmental Defense Fund, 1875 Connecticut Avenue NW, Washington, DC 20009

ABSTRACT

Restoring natural infrastructure offers much promise as a means to reduce both flood hazard and exposure to complement and supplement other flood damage reduction strategies. Interest increased in flood risk reduction methods using natural and nature-based features, in part, because of increased recognition that such could provide both flood risk reduction and other benefits, such as water quality uplift, community recreational space, and fish and wildlife habitat. Recent flood disasters and the rising costs of disaster response and recovery have triggered policy shifts toward economically efficient investments that enhance greater community resilience. While natural infrastructure is becoming more widely recognized as a tactic for building community and ecological resilience to erosion and flooding, it remains underutilized. Actions to aid consideration of natural infrastructure and scale up its use are presented.

ADDITIONAL KEYWORDS: Flood resilience, natural infrastructure, ecosystem functions, risk reduction.

Urban, industrial, and agricultural expansion into riparian and coastal floodplains occurring concurrently with aging and inadequate infrastructure networks has amplified our vulnerability to floods. As a result, the cost of storm events is rising; from 2015 through 2018, the United States experienced eight flooding disasters that each exceeded $1 billion and collectively cost $25 billion (NCEI 2019). Buchanan *et al.* (2017) estimated, based on probabilistic relative sea level projections and fixed storm frequency, a 40-fold increase in the expected annual number of local 100-year floods for U.S. coastal locations by 2050. Climatology-hydrodynamic modeling that takes into account both sea level rise and changes in tropical cyclones frequency and intensity, found that the historical 100-year flood level would occur annually in the northeast and mid-Atlantic states and every 1-30 years in southeast Atlantic and Gulf of Mexico regions in the late 21st century (Marsooli *et al.* 2019).

Reducing the damages from flooding requires managing the hazard (i.e. flood waters), reducing exposure (i.e. people and infrastructure present in flood hazard areas) and lowering vulnerability (susceptibility to the damaging effects of a hazard). Reducing flood risk by relying on traditional flood "control" structures, building codes, and insurance has met with mixed success at best as demonstrated by the devastation and economic impact of significant flooding in areas beyond identified 100-year floodplains (e.g. widespread winter flooding in the Midwest, 2015; Baton Rouge, 2016; and Houston, 2017) and repetitive flooding events of known flood hazard areas (e.g. Princeville and Kingston, North Carolina; Des Moines, Iowa; and Ellicott City, Maryland). The nation's approach to flood risk is insufficient and can be improved. Given increasing flood risk, the nation needs to adopt a far more concerted and multifaceted approach that simultaneously addresses hazard, exposure, and vulnerability to reduce the socio-economic impacts of floods and improve resiliency when floods do occur.

Restoring natural infrastructure may be the key missing tactic for reducing both flood hazard and exposure to complement and supplement other flood damage reduction approaches. (For simplicity, this paper includes natural features, nature-based processes, and green infrastructure under the rubric of "natural infrastructure"). Along the nation's seaboard, development, leveed rivers, declining water quality, and erosion from rapidly rising seas led to deterioration and loss of features including marshes, mangroves, barrier islands, dunes, and reefs (see Alexander *et al.* 2012, Feagin *et al.* 2005, Polidoro *et al.* 2010, Dahl 2011, NOAA 2017 for information on causes and trends of habitat loss). Habitat deterioration and loss means loss of key ecosystem services. Losing these "first lines of defense" has increased exposure to riparian floods and coastal waves, storm surge, and king tide flooding. Therefore, reversing habitat loss by restoring natural infrastructure is a way to reduce the effects of flood-intensifying conditions associated with climate change (e.g. more intense precipitation, higher waves, accelerated coastal erosion) and mitigate effects of expanded urbanization of floodplains (see Figure 1). Protecting and restoring natural infrastructure can lessen the human impacts on hydrology and the environment by combatting erosion, promoting water storage and infiltration, attenuating flood peaks, dampening wave heights and dissipating wave energy (NAS 2014; Spalding *et al.* 2014; Cunniff and Schwartz 2015; and Nilsson *et al.* 2018) and thus reduce flood damages. Natural infrastructure also offers other advantages, such as recreational space, water quality improvement, and fish and wildlife habitat to yield solutions that improve community quality of life on a daily basis and not just when a storm occurs.

NATURAL INFRASTRUCTURE FUNCTIONS

Flood height is one of the most critical determinants of the economic cost of a flood (Williams *et al.* 2012) and inches can make a big difference; therefore, natural infrastructure techniques that aid holding water on lands upstream of developed areas or on less-developed floodplains can reduce flood damages. Well-managed forests and agricultural land using sustainable practices, such as cover crops, can absorb more precipitation and slow surface flow to reduce downstream flood height and flood speed (Nilsson *et al.* 2018). This is due to several factors: areas with greater foliar cover and leaf litter cover intercept and slow precipitation hitting the soil, reducing the rate of overland flow, reducing erosion, and together with healthy soils increas-