



Reply to Giri and Long: Freeze-mediated expansion of mangroves does not depend on whether expansion is emergence or reemergence

Giri and Long (1) agree with our conclusion (2) that the expansion of mangroves from 1984 to 2011 near their range limit on the Atlantic coast of Florida is a threshold response to fewer days below -4°C . However, they suggest that our conclusions would have been “substantially different” had we included one additional year of data in the analyses, that we needed more information about the historical range of mangroves, and that we did not sufficiently rule out other factors. These suggestions reflect a basic misunderstanding of our methods and interpretation (2).

Our conclusions do not change whether this 28-y expansion represents an emergence or reemergence of mangroves. We used 1984 as the starting point for our study because it was the first year for which Landsat 5 Thematic Mapper (TM) imagery was available. Landsat 4 TM collected imagery in 1982 and 1983, but a regional analysis was precluded because the majority of the Florida coastline was obscured by clouds in those images (<http://earthexplorer.usgs.gov>). Had we been able to include imagery from 1983 and earlier, assuming other areas showed losses similar to the single location depicted figure 1 of Giri and Long (1), this would provide further evidence of the importance of cold events. The important conclusion of Cavanaugh et al. (2) is not whether mangroves are, or are not, recovering from a previous disturbance near their northern range limit, but that the areal extent of mangroves within their range is controlled by the frequency of days colder than -4°C .

The other processes that Giri and Long mention (erosion, land subsidence, and aggradation) may affect mangroves locally but do not explain the regional increase we observed.

We did not claim, as stated by Giri and Long (1), that “mangrove expansion is evident beyond the northern boundary” of the historic range. Rather, we examined changes in the areal extent of mangroves within their contemporary range, as defined by Spalding et al. (3), arguably the most comprehensive assessment of the contemporary distribution of mangroves in Florida and worldwide. Thus, we did not address whether mangroves moved beyond the northern boundary of their historic range in Florida, and this issue has no bearing on the conclusion that mangrove expansion is associated with decreases in the frequency of days colder than -4°C . Giri and Long (1) are correct that Landsat may not detect small incipient mangrove patches, but this only reinforces the fact that our estimates of mangrove expansion within their current range are conservative.

A more fundamental question raised by the criticism of Giri and Long is what sets the absolute range limit of mangroves? Our results support the hypothesis that the northern range limit in Florida is set by the intensity and frequency of cold days, a conclusion also reached by other recent work (4). However, factors controlling the range limits of mangroves in other parts of the world may be heterogeneous, as these limits vary widely in latitude, sea surface

temperature, air temperature, species composition, and other regional factors (5).

Kyle C. Cavanaugh^{a,b,1}, James R. Kellner^b, Alexander J. Forde^c, Daniel S. Gruner^d, John D. Parker^a, Wilfrid Rodriguez^a, and Ilka C. Feller^a

^aSmithsonian Environmental Research Center, Smithsonian Institution, Edgewater, MD 21037; ^bDepartment of Ecology and Evolutionary Biology, Brown University, Providence, RI 02912; ^cGraduate Program in Behavior, Ecology, Evolution, and Systematics, University of Maryland, College Park, MD 20742; and ^dDepartment of Entomology, University of Maryland, College Park, MD 20742

1 Giri CP, Long J (2014) Mangrove reemergence in the northernmost range limit of eastern Florida. *Proc Natl Acad Sci USA* 111:E1447–E1448.

2 Cavanaugh KC, et al. (2014) Poleward expansion of mangroves is a threshold response to decreased frequency of extreme cold events. *Proc Natl Acad Sci USA* 111(2):723–727.

3 Spalding M, Kainuma M, Collins L (2010) *World Atlas of Mangroves* (Earthscan, New York).

4 Osland MJ, Enwright N, Day RH, Doyle TW (2013) Winter climate change and coastal wetland foundation species: salt marshes vs. mangrove forests in the southeastern United States. *Glob Change Biol* 19(5):1482–1494.

5 Quisthoudt K, et al. (2012) Temperature variation among mangrove latitudinal range limits worldwide. *Trees (Berl)* 26(6):1919–1931.

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The authors declare no conflict of interest.

¹To whom correspondence should be addressed. E-mail: cavanaughk@si.edu.