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Editorial: Environmental threats to the state of Florida—climate change and beyond: volume II

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Editorial on the Research Topic
Environmental threats to the state of Florida—climate change and beyond: volume II

As discussed in the editorial to Volume I of this series on environmental impacts on the State of Florida, global-scale human alteration of natural ecosystems has an ancient legacy (Gilliam, 2021). Especially in the temperate zone, evidence is widespread of anthropogenic change in natural ecosystems going back several millennia, often with effects persisting even to the present time (Gilliam, 2016). Human occupation by indigenous people of what is now Florida extends back to >12,000 years BCE (Hine, 2013; Milanich, 2017), yet anthropogenic activities in the past two centuries, and their environmental consequences (e.g., climate change, large scale hydrologic alteration), dwarf these ancient land-use legacies, in spite of their long-lived nature.

Also discussed in the Volume I editorial were numerous facets of the unique susceptibility of Florida to the effects of climate change. Superimposed on all of these is a large and rapidly growing human population with a heavy reliance on both marine and terrestrial ecosystems, all increasingly vulnerable to effects of climate change. These challenges are not unique to Florida, as many ecosystems worldwide are exposed to the cumulative effects of multiple stressors that degrade the resources and services provided by natural environments (Crain et al., 2008; Zimmerman et al., 2008). As of the U.S. Census Bureau's Vintage 2022 population estimates, Florida—the third populous in the U.S. as it is—has the highest population growth rate (nearly 2%) in the country. The last time that happened (in 1957) was due to the intersection of technology and societal change, including the 1950's nascent wide-spread use of air conditioning, along with the population growth peak following World War II known as the Baby Boom. From 1900 to the present, Florida's population growth has been exponential (Figure 1). The current rate of 1.9% suggests that the state's population of 22.2 million persons may double within ~40 yr.

Volume II of this Research Topic addresses widely-varied issues with direct or indirect links to climate change and all serious threats to aquatic and terrestrial ecosystems of great importance to Florida. These include urbanization of estuaries leading to critical habitat destruction, phytoplankton dynamics of inner continental shelf waters potentially affected by terrestrial nutrients, saltwater intrusion effects on species of palms, effects of oil spills on marine microbes, release of nutrients from legacy mining, alteration in seagrass and oyster

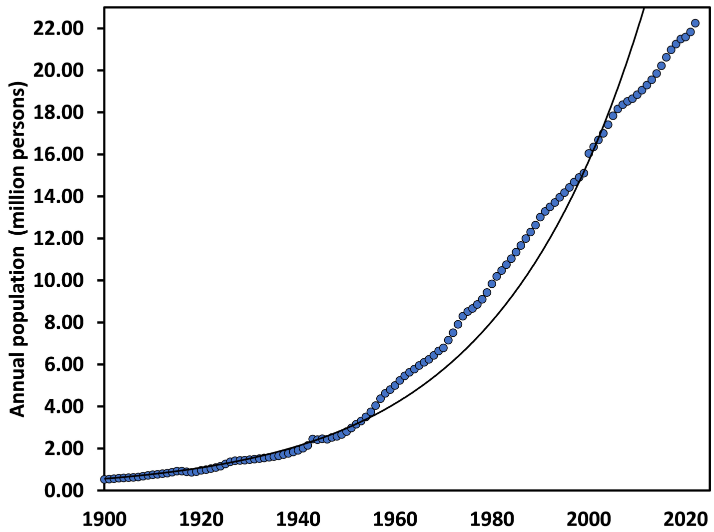

FIGURE 1
Annual population of Florida, 1900—2022. Curve is an exponential fit, r^2 =0.99. Data taken from www.census.gov.

habitat, and the increasingly ubiquitous nature of microplastics in marine and estuarine ecosystems.

In many cases, anthropogenic alterations of natural ecosystems call for attempts to restore them. Beck et al. established both short-term targets and long-term goals for restoration in an urban estuary within the Tampa Bay watershed. Although results have been inconsistent, they appropriately developed a novel approach for restoration that accommodates sea-level rise, climate change, and watershed development. Phytoplankton comprise the essential autotrophs of aquatic ecosystems, and are highly sensitive to cultural eutrophication. Stelling et al. examined biomass/composition of phytoplankton of waters of the inner continental shelf off Cape Canaveral on the Atlantic coast of Florida. They found notable seasonal dynamics, with chlorophyll *a* increasing 4-fold from summer to fall, which was ascribed to seasonal changes in wind patterns. With climate change-driven sea level rise, saltwater intrusion becomes an increasing threat to terrestrial ecosystems. Khoddamzadeh et al. used a factorial design to quantify the effect of saltwater intrusion on four species of palms. Although all species exhibited declines in health indicators (e.g., growth and nitrogen uptake) with increasing salinity, there was notable interspecific variation. Although oil spills are not a new phenomenon, the 2010 Deepwater Horizon oil spill in the Gulf of Mexico was the largest on record. Brock et al. examined temporal dynamics of marine microbes with nearshore samples taken from Pensacola Beach, FL, and subjected to a standard oil exposure protocol. They found pronounced temporal variability, much of which was related to temperature. Aware that chemical composition—and related photoreactivity—varies among different sources of crude oil, Headrick et al. examined the effects of oils of contrasting composition on marine microbes. They found that microbial responses in Florida waters to oil spills were highly dependent on the source of the oil and solar conditions on the surface at the time and location of the spill, ultimately affecting the potential for bioremediation. The results from both Brock et al. and Headrick et al. have implications for understanding the dynamics of oil spills on surface waters that originated from spills in deep waters. A regrettably unavoidable consequence of phosphorus mining in Florida is the creation of reservoirs for the retention of mining waste slurries. Morrison et al. investigated the effects of the April 2021 infrastructure failure at Piney Point, a retired reservoir that released phosphorus-laden water into Tampa Bay, and the potential risk such a release has in exacerbating blooms of red tide organisms, such as the dinoflagellate, *Karenia brevis*. This study also demonstrated that the spatial extent of the wastewater release was much farther than expected, with Piney Point water identified by stable isotope analysis at a control site over 48 kilometers outside of Tampa Bay. Croteau et al. used historical data (1985—2020) to assess climate change mediated alteration in seagrass and oyster habitats. They reported patterns of increased temperature and decreased streamflow across sites in the eastern Gulf Coastal Plain. Such results have important implications for restoration and management of seagrass and oyster habitat and underscore the importance of understanding climatic and hydrologic dynamics. A topic of increasing popular interest, is the ubiquitous nature of plastics in marine and estuarine ecosystems. Gowans and Suida conducted the first-ever study on the ingestion of plastics by manatees within the order *Sirenia*, a large marine mammal commonly found in Tampa Bay, FL. Necropsies performed of 26 manatees found macro-and micro-plastic ingestion in 26.9% and 73.1% of individuals, respectively, indicating that plastic consumption by manatees is common. In sharp size contrast, Fibbe et al. studied microplastic ingestion by copepods, an important primary consumer in marine and estuarine ecosystems.

The two-year study comprised 14 sampling dates at seven sites within Tampa Bay examining gut contents of *Acartia tonsa*. Although there were no clear spatial or temporal trends, ingestion of microplastics by copepods was commonly observed.

What should be clear from the articles in Volume II of this Research Topic is the wide diversity in environmental threats. Although some may be unique to Florida, most are globally relevant. Based on the various impacts discussed in this volume, ecosystem restoration is warranted in many cases (see Beck et al.). A challenge implicit in any restoration project, however, is to determine a desirable endpoint that constitutes success, and climate change creates an ecological 'moving target.' This reminds us of the venerable quote from plant ecologist, Henry Chandler Cowles (Cowles, 1899), that ecological change is "… a variable approaching a variable, not a constant." The collective empirical evidence provided by these studies could not be clearer as a clarion call for action to reverse the trends of all factors driving climate change, especially through the further and wide-spread development of non-fossil fuel sources of energy. Use of fossil fuels is an undeniable legacy of our past, and we must do what we can to keep it thus—a part of our past, but not our future.

Author contributions

FG: Writing – original draft, Writing – review & editing. MM: Writing – review & editing. MB: Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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