"Examining Succession in a Mangrove Community at Walsingham Pond"

Katherine Raber

Excerpt

As the only halophytic (i.e., salt-loving) tree species, mangroves thrive in a stressful habitat with high wave energy, high salt concentrations, a dearth of oxygen, and acidic soil (Nybakken 2001). Counterintuitively, the mangal—while such a seemingly inhospitable environment—is a highly productive ecological sere (i.e., transition zone) between the marine and terrestrial worlds (Chen & Twilley 1998). Dotting less than 75% of all tropical coastlines (Nybakken 2001), mangroves—even with their diminished global range—have an average annual productivity almost equal to that of the tropical rainforests (Gould, personal communication), at approximately 218±72 teragrams of carbon per year (Zablocki et al. 2011). The mangal provides other ecosystem services as well, including the provision of nursery and refuge spaces for marine-based organisms as well as defense from coastal erosion due to its dynamic root structure (Duke et al. 1998; Nybakken 2001; Olds et al. 2013).

The roots are the diagnostic feature of mangroves—their morphologies (i.e., structure) help determine the zonation, or physical segregation, of the species in the same wetland (Nybakken 2001). In Bermuda, there are only three halo-tolerant species: *Rhizophora mangle* (i.e., red mangrove), *Avicennia germinans* (i.e., black mangrove), and *Conocarpus erectus* (i.e., buttonwood). These three species' seedlings floated to the island, arriving approximately 3000 years ago on the Gulf Stream as the global rate of sea level rise began to decrease (Ellison 1996). *R. mangle* uses its distinctive prop roots to attenuate the intensity of incoming waves, as this species is most commonly found beneath the low tide line (Ellison & Farnsworth 1993; Duke et al. 1998). Constantly inundated, *R. mangle* invests in its prop roots in order to clear the height of breaking waves and obtain atmospheric oxygen via lenticels along the exterior of its roots

(Gould, personal communication). This species also bulk sequesters extra salts that cannot be prefiltered from the water into sacrificial leaves that will be sloughed off. Found above the low tide line is *A. germinans*, which uses strawlike pneumatophores to access much-needed atmospheric oxygen. Its salt strategy utilizes pumps located at the surface of leaves for salt excretion. Finally, *C. erectus* is the rearguard in a mangal, as it is found above the high tide line without a highly specialized root system. However, it, too, can pump salt from the base of its leaves.

Mangals not only protect shorelines but even accrete sediment (Ellison 1993; Zablocki et al. 2011; Olds et al. 2013); thus, these habitats are one of inherent change. Ecologists classify habitats on a gradient of succession where species invade and replace others due to a combination of tolerance, facilitation, and competition (Nybakken 2001). In primary succession, a naïve substrate comes to support other organisms like mangroves as they change the soil conditions. Secondary succession occurs with the disturbance of an area: the mangroves themselves may be removed; however, the soil is still there for the later growth of any species. In either event, pioneer species are the first to enter the area, giving way to more competitive, climax species over time.

Any mangal could be one of four types of communities (Gould, personal communication). It could be a climax community where the adults are efficiently replaced by their juvenile conspecifics (i.e., the younger generation of the same species) growing mono-specifically, or exclusively, beneath the understory. Then again, it could also be in a state of successional flux. It might move to the climax state via space-limited competition, or it could be in a state of eternal succession as the land and its species composition “march out to the sea” as new sediments are accumulated along the shoreline. The final option for this community is that disturbances constantly reset its successional stage, giving it a dynamism that is lacking in the other three communities.

Knowledge of the ecological state of a mangal is crucial to predicting its future state as well as how best to protect it both now and in the long run. A good measure for the successional state of a community is its ratio of adult to juvenile conspecifics (Ellison & Farnsworth 1993; Chen & Twilly 1998; Sousa et al. 2003; Salmo et al. 2013). Only those plant species with seedlings tolerant of their parents' shade will come to dominate the climax community. Thus, a climax community will be theoretically mono-specific within a certain species guild (i.e., a group of species that utilize the same resources in a similar fashion). A common question associated with community structure is: what factors produce it? If these factors are abiotic (i.e., nonliving) or nutrient based, then the community is "bottom-up" or resource limited; on the other hand, a "top-down" design means that predation and competition determine the species composition (Nybakken 2001).

My lab group and I wished to determine the successional state of a mangal-surrounded ocean hole on the eastern side of the island of Bermuda known as Walsingham Pond. We hypothesized that any observation of zonation patterns in this habitat would imply a successional state. Previous studies impute the power of measuring organic matter and chemical compound concentrations of the soil (Salmo et al. 2013), gas exchange rates (Zablocki et al. 2011), salt levels (Chen & Twilley 1998), or light intensity (Ellison & Farnsworth 1993) as the parameter(s) most indicative of zonation. However, we proposed that substrate moisture, percentage of dissolved oxygen, and pH levels would most influence mangrove distributions due to the physiological differences among the native species. Using the understory seedling bank methodology (Ellison & Farnsworth 1993; Chen & Twilly 1998; Sousa et al. 2003; Salmo et al. 2013), we judged that we would find a greater proportion of *R. mangle* propagules under both the *R. mangle* and *A. germinans* canopies. This is because *R. mangle* propagules are more shade tolerant than the seedlings of *A. germinans* (Ellison & Farnsworth 1993). If this were the case, then we might potentially deduce the successional state of the mangal at Walsingham Pond.

Armed with that knowledge, one may also prognosticate the future characteristics of Walsingham Pond and better predict the effects of outside forces such as climate change on the structure of this unique community. With the mangal acting as the lynchpin that ties together the terrestrial and marine worlds over both time and space, it is imperative to detail its organization and typical route of succession, especially in relation to its functioning in the natural world. Only then will we better know what ecosystem services will be lost with a mangal's alteration or destruction.

Fellow Commentary

Lekha Kanchinadam

Katherine Raber’s lab report, “Examining Succession in a Mangrove Community at Walsingham Pond,” introduces the reader to a fascinating character: the mangrove, the only salt-loving tree species in the world, which not only manages to thrive in a seemingly “inhospitable” ocean shore ecosystem but is also a crucially helpful force in its ecosystem, providing refuge for other species and defending against coastal erosion. The way Katherine describes it, the mangrove sounds like a superhero of a tree.

Katherine’s introduction works hard to *motivate* her lab group’s experiment and hypothesis. In the process of setting up a motive, however, Katherine covers other important ground: she describes the mangrove, focusing on the characteristics that make mangroves important to their ecosystem. Their ability to defend against ocean erosion, for example, is because they facilitate the accumulation of sediment. This characteristic is directly linked to the next layer of motive: because they accumulate sediment, mangroves are responsible for changing their ecosystem. This means that mangrove habitats “are one of inherent change.” These inherently changing ecosystems have been categorized by ecologists into “succession states”—another key term and motivator for Katherine’s experiment. She describes the possible succession states and the communities that result from their changing.

This issue of succession communities is the next level of motive: ecologists know that if they can identify a mangrove ecosystem’s succession state, they can “better predict the effects of outside forces such as climate change” on the community. This is an important piece of information, and Katherine’s goal in this experiment is to find it out for a specific mangrove community, the one at Walsingham Pond.

By explaining what she’s doing (investigating what succession state the mangroves are in) and why (because it’s helpful information to protect and conserve the ecosystem), Katherine also gives us the key terms and background information we need to understand the rest of her group’s experiment. It’s an informative path to the end of her introduction, where she also presents her group’s methodology in tackling this experiment.

Katherine’s discussion of methodology is another example of clever double duty. She briefly reviews the literature and explains that other scientists have used other methods to discover mangrove succession states. However, her group will use a different method from most other scientists. Thus, her experiment is motivated by differentiating from the scholarly discourse in method, not only in content.

Katherine’s introduction is highly motivated and also engaging. In other words, she writes with her audience in mind. Her explanations of scientific phenomena are easy to follow and she uses short parenthetical explanations to clarify certain bits of jargon—depending on where she presents or shares this paper, she could easily change these details to cater to a more or less expert audience. I was particularly taken by the efficacy of her word choice. Phrases and words such as “counterintuitively…” “however…” and “not only… but” are simple and inconspicuous but instantly help the reader follow the logic of her argument. Katherine’s introduction should be helpful for the science writer as well as the nonscience writer—enjoy!