Succession in Ecological Education

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Abstract

As complex and dynamic systems, wetlands offer the opportunity to investigate and incorporate the ecological concept of succession in educational settings. For example, the well-known, classic hydrosere concept is illustrated in numerous ecology and life-science textbooks. In this chapter, the drawbacks of using the hydrosere successional concept are assessed, and two examples of using wetlands to illustrate the process of succession for educational purposes are described. In each case, the premise and approach is that students best "learn ecology by doing ecology."

Keywords

Education · Succession · Wetlands

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Introduction

As complex and dynamic systems, wetlands offer the opportunity to investigate and incorporate the ecological concept of succession in educational settings. For example, the well-known, classic hydrosere concept is illustrated in numerous ecology and life-science textbooks. In this article, the drawbacks of using the hydrosere successional concept are assessed, and two examples of using wetlands to illustrate the process of succession for educational purposes are described. In each case, the premise and approach is that students best "learn ecology by doing ecology" (Gibson et al. 1999).

Be Careful Using the Classic Hydrosere Succession Concept as a Teaching Tool

The classic hydrosere model of succession, where infilling of a lake or pond through time leads to a "climax" forest community, has a long history and is reproduced in many textbooks as a good example to teach the concepts of primary succession. However, numerous exceptions to this classic sequence of hydrosere succession have been observed, and forest communities often do not represent a final, stable community. Infilling of basins with organic matter does occur (i.e., terrestrialization), but succession is rarely unidirectional, and does not result in mature upland or mesic "climax" forests replacing earlier successional bog stages (Klinger 1996). Instead, for understanding wetland succession, a Gleasonian approach based upon species life histories is more appropriate (Van der Valk 1981; Middleton 1999). The fallacy of using the Clementsian model in teaching successional concepts was outlined by Gibson (1996) who advocated a more probabilistic, hierarchical approach.

The Olentangy River Wetland Research Park and EARTH University's Tropical Wetland Project

Two riverine wetlands constructed by William Mitsch and colleagues at Ohio State University provide examples of ecosystem-scale systems that can be used for conservation education and research in a successional wetland setting (Mitsch et al. 2008; Mitsch et al. 2012). The Olentangy River Wetland Research Park (ORWRP) is a pair of 1 ha flow-through-created riverine wetland basins established in 1994. One basin was planted with 13 native species of macrophytes; the other was unplanted and allowed to colonize naturally (Mitsch et al. 2012). After 15 years, the planted basin had higher plant community diversity and lower primary production than the unplanted basin. In addition to monitoring vegetation, soil development, water quality changes, and carbon and nitrogen dynamics, the faculty at The Ohio State University developed at least 35 courses taking advantage of the successional dynamics at the ORWRP (http://swamp.osu.edu/Academics/academic_courses.html). Similarly, a swamp palm (*Raphia taedigera*

Mart.) forest in La Reserva Wetland at EARTH University, Costa Rica, is one of several natural and constructed wetlands (112 ha in size), which has been developed as a campus research wetland since 2005 (Mitsch et al. 2008). In addition to improving effluent water quality of an animal farm, dairy plant, landfill, and banana plantation, studies on these wetlands have been integrated into the educational curriculum at EARTH University for over 14 years. As the constructed wetlands change in plant composition and structure over time, they offer opportunities to teach successional theory.

Integrating Wetland Succession into Undergraduate Life Science Courses

To incorporate the "learning ecology by doing ecology" concept, a set of experimental plots were established in a postagricultural bottomland forest in southern Illinois (Gibson et al. 1999, 2005) (Fig. 1). Mowing and rototilling, fertilizer addition, and herbivore exclusion treatments allowed a test of the effects of disturbance as defined by mowing and rototilling, and deer browsing and resource availability on secondary succession in this wetland habitat (Mathis 2001). One hundred and forty-four 5 × 5 m plots in 16 15 × 15 m blocks were established

Fig. 1 Aerial view of experimental research plots in a postagricultural bottomland habitat in southern Illinois. The plots contrasted mowing and fertilizer treatments. Twelve of the 16 blocks excluded large herbivores. Undergraduate ecology laboratory classes tested the initial- versus relay-floristics models. Each of the square blocks is 15 × 15 m and contained nine 5 × 5 m plots assigned to mowing (control, mowed annually, mowed and rototilled annually) and fertilizer (control, fertilizer every 5 years, and annual fertilizer application) treatments (Photo by David Gibson)

Fig. 2 Undergraduate students counting tree seedlings in the bottomland hardwood forest secondary succession plots (Photo by D. J. Gibson)

following plowing of the abandoned agricultural field in 1996, with experimental treatments and data collection maintained through 2002 (http://www.plantbiology.siu.edu/long-term/). A second set of plots with similar mowing and fertilizer treatments, but without herbivore exclusion, were established during the same time period in a nearby upland area (Gibson et al. 2005).

These plots were used as a context for inquiry-based undergraduate ecology laboratories to test the basic tenets of succession, including an evaluation of relay versus initial floristics, seedling growth experiments (Barko et al. 2004), and predator-prey relationships (Oyler et al. 1999), and for individual undergraduate research projects (Rice et al. 1999). Such plots could also be used for teacher training of inquiry methods for K-12 education. Evaluations showed that these laboratories were educationally effective in meeting our objectives (Bhattacharyya 1999).

Undergraduates were able to test relay versus initial floristics (i.e., contrasting sequential versus early species establishment) in these plots by noting the number of trees established in disturbed (mowed) versus undisturbed (unmowed control) plots (Fig. 2). Before collecting these data, students were asked to conduct a preproject assessment consisting of a multiple choice sentence stem and a concept map (Box 1) to evaluate their knowledge of succession prior to the exercise. After collecting data on tree density, the students were asked to repeat the assessment in light of the data that they had collected and their field experience (Fig. 3). After this field exercise, the students were introduced to the concepts of relay versus initial floristics and generally found that their observations supported the latter and that their knowledge and understanding of succession had improved (Bhattacharyya 1999).

Box 1 Pre- and Postproject Assessment

Student demonstrates their understanding of the concepts related to succession after the field exercise by completing the sentence stem (1) or drawing a concept map (2) as directed below.

1. Sentence Stem:

   Circle one of the following.
   After the farmer stops cultivating a field, trees come into abandoned fields: 25 years, 10 years, 3 years, 1 year, right away.

2. Concept Map:

   Draw a concept map of succession including the following terms (plus additional terms you think are necessary):
   Plant types: tree seeds, tree seedlings, grass seeds, grass seedlings, mature forest
   Changes: cutting, mowing, dispersal

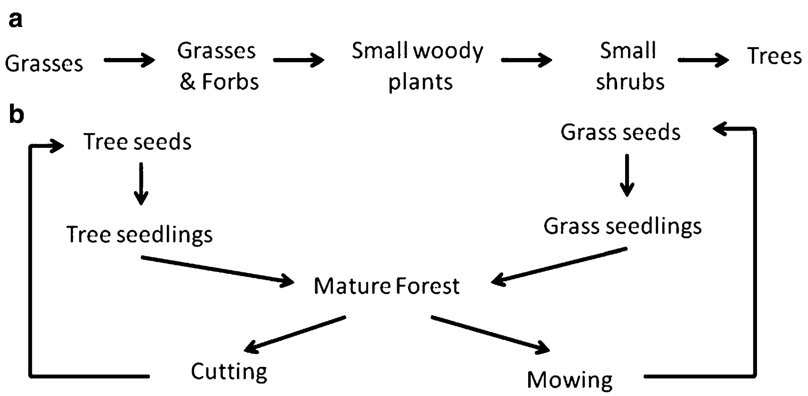

Fig. 3 Sample of student's concept maps illustrating their understanding of the process of secondary succession in bottomland hardwood forest. a) Low-scoring concept map, b) high-scoring concept map (Redrawn from Bhattacharyya 1999)

Future Challenges

Successional wetlands provide a setting to place educational opportunities into current ecological theory. However, it is necessary to avoid Clementsian successional ideas in which a predictable sequence of species changes leads to a “climax” community. There are limitations and caveats for using space-for-time substitutions (i.e., chronosequences where sites of different times since disturbance are compared instead of following a site continuously through time since disturbance) (Neiring 1994; Johnson and Miyanishi 2008; Walker et al. 2010) and spatial belting within wetlands as representations of temporal succession (Neiring 1987). Successional wetlands allow field-based laboratory classes to be developed based on using inquiry-based learning. This pedagogical approach can also be used to alleviate negative adult perceptions of these habitats that arise from the view that they are undesirable, dangerous places (Anderson and Moss 1993).

In addition to the examples cited here, some online education sources focused on using wetland systems are provided in Box 2.

Box 2 Online Educational Resources for Wetland Education

1. Ducks Unlimited’s Teacher’s Guide to Wetland Activities (http://www.greenwing.org/dueducator/teachersguide_educator.html) and Conservation Lesson plans (http://www.greenwing.org/dueducator/lesson_plans.html).
2. WOW! The Wonders of Wetlands (http://www.wetland.org/education_wow.htm).
3. EPA Wetlands Education (http://water.epa.gov/type/wetlands/outreach/education_index.cfm).
4. Environmental Concern Inc. is a 501(c)3 public not-for-profit Corporation that is dedicated to working with all aspects of wetlands (http://www.wetland.org/index.htm).

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