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Adapting the floristic quality assessment index to indicate anthropogenic disturbance in central Pennsylvania wetlands

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Abstract

The floristic quality assessment index (FQAI) is an evaluation procedure that uses measures of ecological conservatism (expressed numerically as a coefficient of conservatism or *C* value) and richness of the native plant community to derive a score (*I*) that is an estimate of habitat quality. We evaluated the ability of the FQAI to indicate the level of anthropogenic disturbance in headwater wetlands in the Ridge and Valley physiographic province of central Pennsylvania. *I* scores were highly correlated with disturbance, with scores generally decreasing with increasing levels of disturbance. However, we found that *I* did not equally characterize sites with differing species richness. *I* scores were higher for sites with greater intrinsic native species, regardless of other influences on floristic quality. To eliminate sensitivity to species richness, we evaluated sites using mean conservatism values ($\bar{C}$) and a variant of the *I* score (adjusted FQAI, hereafter cited as I') that considered both the contribution of non-native species and the intrinsic low species richness of high quality forested wetlands. $\bar{C}$ values were more highly correlated with disturbance than *I* scores; however, site assessments based on $\bar{C}$ values alone were misleading. I' scores were also more highly correlated with disturbance than *I* scores and were robust to differences in native species richness. Therefore, we offer I' as an improved formulation of the index that, in addition to serving as a useful condition assessment tool, addresses two problematic issues that have plagued the FQAI since its conception: the overwhelming influence of the species richness multiplier and the role of non-native species in floristic assessment.
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Keywords: Biological indicator; Condition assessment; Headwater wetland; Ridge and Valley physiographic province; Floristic quality assessment index (FQAI); Species richness

1. Introduction

Under Section 305(b) of the Clean Water Act, state regulatory agencies and tribal entities are required to develop water quality standards for their aquatic systems and monitor these systems routinely for compliance. While stream monitoring programs are

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generally well established, similar initiatives for wetlands have been slow to emerge, primarily due to a scarcity of rapid and effective condition assessment methods. Although many states are moving toward developing standards for wetlands, there is concern that traditional monitoring programs will be largely inadequate. This is because these programs rely largely on levels of chemical constituents as indicators of impairment (Danielson, 1998) and chemical indicators are poorly suited to detect the types of stressors that typically impact wetlands, including non-point source runoff, changes in land use (alteration and fragmentation), invasion by non-native species, and hydrologic modifications (Karr and Chu, 1999; Danielson, 1998). Recently, there has been increased interest in developing biological criteria for wetland assessment (Carlisle et al., 1999; U.S. E.P.A., 2002; Mack, 2004). As biological monitoring becomes more widespread, there will be a concomitant need for assessment tools that can rapidly and effectively evaluate condition.

One assessment tool that may prove useful in measuring condition is the floristic quality assessment index (FQAI) developed by Swink and Wilhelm (1979, 1994). The FQAI uses measures of ecological conservatism and richness of the native plant community to derive an estimate of habitat quality (referred to as *I*). In the method, ecological conservatism is expressed numerically as a coefficient of conservatism or *C* value. Conservatism values range from 0 to 10 and are assigned a priori based on an individual plant species' fidelity to specific habitat types and its tolerance to both natural and anthropogenic disturbance (Taft et al., 1997; Andreas et al., 2004). In general, plants that are widespread with broad tolerances (generalist species) are given lower values than plants with more narrow distributions and tolerances (conservative species). As originally conceived, non-native species were assigned zero and not used to compute the index, however more recent studies have suggested the inclusion of non-natives as an alternative to the traditional approach (Fennessy et al., 1998a,b; Lopez and Fennessy, 2002; Rooney and Rogers, 2002; Bernthal, 2003; Andreas et al., 2004; Rothrock, 2004). Once devised, conservatism values are averaged and used to weight species richness. The FQAI, therefore, can be conceptualized as a variation on more conventional weighted averaging techniques (Andreas et al., 2004).

The FQAI was first proposed in the late 1970s as a method for assessing habitat quality in the Chicago area (Swink and Wilhelm, 1979). Since the mid-1990s, regionalized versions of the method have been developed for Missouri (Ladd, 1993), northern Ohio (Andreas et al., 2004), southern Ontario (Oldham et al., 1995), Michigan (Herman et al., 1997), Illinois (Taft et al., 1997), North Dakota (Northern Great Plains Floristic Quality Assessment Panel, 2001), Wisconsin (Bernthal, 2003), and Indiana (Rothrock, 2004). Some of these early studies provided anecdotal evidence to suggest that the FQAI may be a good predictor of condition and more recent studies have explored its utility in this regard. Studies from Ohio have demonstrated a strong correlation between *I* scores and relative disturbance rank for riparian and depressional wetlands (Fennessy et al., 1998b; Lopez and Fennessy, 2002) and emergent, scrub-shrub, and forested wetlands (Mack, 2004). Francis et al. (2000) tested the FQAI in deciduous woodlands in southern Ontario and reported a slight decrease in scores with increasing disturbance.

We evaluated the FQAI as a tool for characterizing disturbance among headwater wetlands in the Ridge and Valley physiographic province of central Pennsylvania. The Ridge and Valley encompasses 13,080 km^2 in Pennsylvania. There are 17,403 stream kilometers of which 13,089 or 75% are first and second order (Environmental Resources Research Institute, 1998). Headwater wetlands are defined as wetlands associated with first and second order streams, and therefore comprise a significant portion of the wetland resource.

Urbanization and agriculture are the primary types of anthropogenic, landscape-level disturbances affecting wetlands in the region (Cole et al., 1997). These activities degrade wetland systems by increasing sediment and nutrient inputs and altering hydrologic patterns. Plant community composition has been shown to respond to these stressors in predictable ways (Taft et al., 1997). For example, a decrease in both species richness (Jurik et al., 1994; Dittmar and Neely, 1999) and diversity (Dittmar and Neely, 1999) has been reported in response to sedimentation, while nutrient enrichment favors more tolerant non-native or weedy native species (Hobbs and Huenneke, 1992). Because the FQAI combines measures of richness with individual plant tolerances, the index should be

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