Metrics for Determining Hydrophytic Vegetation in Wetland Delineation: a Clarification on the Prevalence Index

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A recent publication and an article in *Wetland Science & Practice* (Lichvar and Gillrich 2014b, 2014a) discuss two metrics for determining if vegetation is hydrophytic for purposes of U.S. wetland delineations, the Prevalence Index (PI) and a proposed Hydrophytic Cover Index (HCI). Based on Wentworth et al. (1988), the PI is a weighted average of ordinal scores (1–5) for species in five wetland-indicator categories (defined in Table 1). Scores of 1–3 represent hydrophyte species, and the associated rule is that PI values ≤ 3.0 represent a positive determination for hydrophytic vegetation (U.S. Army Corps of Engineers 2010). The HCI uses a simple ratio of summed hydrophyte cover as a percentage of total cover; the proposed HCI rule is that HCI values > 50% represent a positive determination. The two papers note that the PI appears to give conflicting results in some cases, whereas the HCI has clear advantages in terms of simplicity and reliability. This is because the proposed HCI rule reflects the original conceptual definition of "hydrophytic vegetation" as having more than 50% representation of hydrophytic species (Environmental Laboratory 1987). However, the papers suggested that the PI scores over-weight non-hydrophyte[2] species, thus biasing the resulting index. That is not strictly the case. The purpose of this comment is to clarify the nature of the PI and to illustrate that the two indices are mathematical analogues with different emphasis.

Table 1 presents cover data for a field site (LW2) with 18 species (names omitted), including a FACU species ('P') with high percent cover. The math is presented in a form that makes the analogies more evident. The calculations show that the PI and HCI are both an average descriptive score that is weighted by cover. For the PI, the ordinal scores of all species are weighted by their respective covers, yielding an average score of 3.15. In the HCI, each species is, in effect, assigned an ordinal "score" of either 1 (hydrophyte) or 0 (non-hydrophyte), yielding an average score between 0 and 1 that represents a weighting of the 1s and 0s by the relative covers. In other words, the 5-rank scale is collapsed to a 2-rank scale with simpler mathematical properties. By excluding non-hydrophytic species, the HCI reduces to the simple metric of relative hydrophytic cover. If only species with PI scores of 1–3 are considered, their summed covers as a proportion of total cover would equal the value of the HCI (0.65, or 65%) — the equivalent of assigning a score of 1 or 0 to each species.

The conceptual intent of the Prevalence Index was to allow quantitative description of qualitative wetland-fidelity classes (OBL, FACW, etc.) for all species in a vegetation sample. Non-hydrophyte scores do not bias the PI, because the species scores are arbitrary ranks (not quantities) weighted by abundance[3]. As a weighted score, the PI is a descriptor of what indicator-class of species is predominant, on average (whether mainly FAC, mainly FACW, etc.). In contrast, the HCI is a descriptor of relative coverage for two rating classes (hydrophyte, non-hydrophyte), where one class "counts" and the other does not.

The site in Table 1 passes the HCI test but fails the PI test as it is currently applied for wetland delineation. This is not a flaw in the index, per se. Rather, the discrepancy arises from the prevalence-test *rule* which set the threshold value for hydrophytic determination at exactly 3.0. Thresholds are not inherent, but are chosen empirically (see National Research Council 1995, p. 129). In their original paper, Wentworth et al. (1988) noted that PI values within 0.5 units of the 3.0 threshold might also be indicative of hydrophytic vegetation (owing to the underlying variance of the estimate), but their point was not fully appreciated at the time. In very simplistic terms, the index can be thought of as having a mathematical "rounding" issue – as does any average value. For example, a vegetation sample consisting of many abundant FAC species plus a few low-cover FACU species is clearly hydrophytic, but it would have a PI slightly greater than 3.0. The PI is the average species "score", which implies a whole number. A PI of 3.05 or 3.15 is still basically 3 (FAC) when rounded. From that viewpoint, site LW2 could also pass the prevalence test.

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[2] Terms follow the usage of Lichvar and Gillrich (2014a, b)

[3] Any equal-interval scale could have served for the purpose. For example, the 5 wetland-indicator scores could have been 1, 3, 5, 7, and 9. Likewise, the ordinal scale could have been inverted (OBL = 5 to UPL = 1). In the first example, a prevalence-rule might require a PI less than or equal to 5 (the FAC score) for a positive determination; in the second example, a rule would require a PI > 3 (instead of < 3).

Table 1. Demonstration of conceptual analogy between the Prevalence Index (PI) and Hydrophytic Cover Index (HCI)

PI is an average score (from 1 to 5) weighted by species relative coverages

HCI is an average "score" (from 0 to 1) weighted by species relative coverages, where 1 = hydrophyte and 0 = not

Site	Species	Wetland-Indicator Rating†	PI score	Species percent cover (%)	PI score weighted by % cover		HCI Score	HCI score weighted by % cover
LW2	A	OBL	1	1.9	1.9		1	1.9
LW2	B	OBL	1	0.8	0.8		1	0.8
LW2	C	FACW	2	1.5	3.0		1	1.5
LW2	D	FACW	2	0.9	1.8		1	0.9
LW2	E	FACW	2	0.1	0.3		1	0.1
LW2	F	FACW	2	8.3	16.5		1	8.3
LW2	G	FACW	2	2.6	5.3		1	2.6
LW2	H	FACW	2	0.8	1.5		1	0.8
LW2	I	FAC	3	0.8	2.3		1	0.8
LW2	J	FAC	3	0.1	0.4		1	0.1
LW2	K	FAC	3	9.0	27.0		1	9.0
LW2	L	FAC	3	4.1	12.4		1	4.1
LW2	M	FAC	3	5.3	15.8		1	5.3
LW2	N	FAC	3	7.1	21.4		1	7.1
LW2	O	FAC	3	18.8	56.3		1	18.8
LW2	P	FACU	4	32.6	130.5		0	0.0
LW2	Q	FACU	4	0.4	1.5		0	0.0
LW2	R	UPL	5	0.1	0.6		0	0.0
Totals				95.0	298.9			61.9

† OBL = Obligate Wetland, FACW = Facultative Wetland, FAC = Facultative, FACU = Facultative Upland, UPL = Upland

Sum of cover-weighted PI scores (all species) = 298.9
Total cover (all species) = 95.0%
Cover of hydrophytes (P.I. scores '1–3' only) = 61.9%
Prevalence Index = (298.9/95.0) = 3.15

Cover of hydrophytes (= sum of cover-weighted HCI scores) = 61.9%
Total cover (all species) = 95.0%
Hydrophytic Cover Index = (61.9/95.0) = 0.65 (65%)

In hindsight, it appears that the decision to use a PI threshold value of 3.0 was somewhat conservative and thus could yield some ambiguous field determinations. Figure 1 illustrates this idea for a dataset of 63 field sites having a range of relative abundance of hydrophyte species, where PI and HCI values for each site are compared. Note that a PI threshold of 3.0 would essentially define hydrophytic vegetation as needing at least 60–65% relative hydrophytic cover (not 50%) for any positive determination. Conversely, nearly all sites with a PI of 3.2 or less would satisfy the HCI rule. This example suggests that a PI threshold of about 3.2–3.3 might give fewer incorrect determinations; however, it would be difficult to redefine a prevalence-test threshold without exploring a large sample of validation datasets, and impractical to work with a fractional threshold. As an alternative, the HCI is framed to be consistent with the original concept of hydrophytic vegetation (Environmental Laboratory 1987) as having more than 50% representation of hydrophytic species.

Like the PI, the HCI presents a few practical issues. A hypothetical sample with 50% OBL cover and 50% UPL cover (however improbable in the field) would have a PI of exactly 3.0 and an HCI of exactly 50%; that sample would pass the current PI rule but fail the HCI rule. A "rounding" question also remains: does an HCI of 50.1% satisfy the "greater than 50%" rule? Examining validation datasets (as in Figure 1) could help to clarify these issues.

In summary, the two indices emphasize different aspects of vegetation data. The HCI is a metric of species relative cover, whereas the PI is a metric of the "average" species type (i.e., OBL, FACW, FAC, FACU, or UPL). Note that the scatterplot in Figure 1 truncates as relative hydrophytic cover approaches 100%. This occurs because a site with 100% hydrophytic cover could have (hypothetically) all OBL species, or all FACW species, or all FAC species. The PI can distinguish those cases, while the HCI does not. As noted by Lichvar and Gillrich, the Hydrophytic Cover Index has advantages for wetland determination situations in being a direct metric of the relative coverage of hydrophytes, thus it is simpler to understand and apply

for yes/no decisions. The Prevalence Index describes which types of species are predominant, thus it may be useful as an index of species composition in evaluations of vegetation condition for ecological or monitoring studies. ■

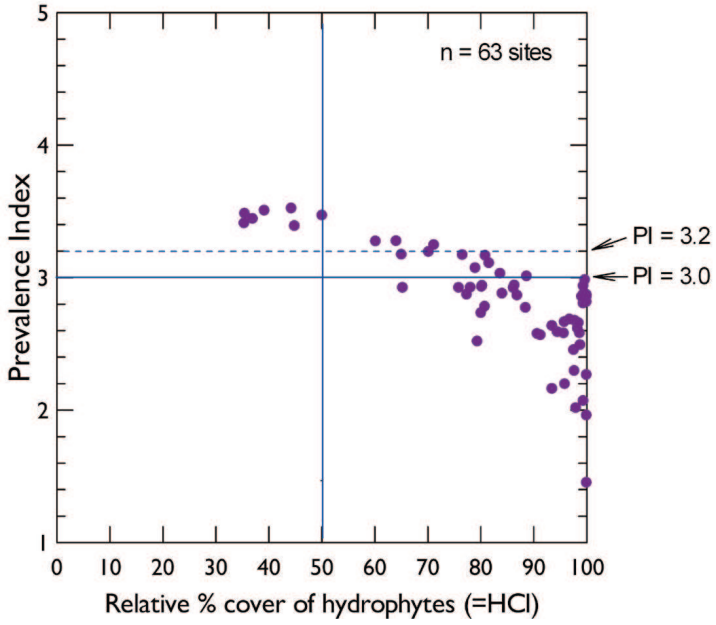

Figure 1. Values of the Prevalence Index vs. the Hydrophytic Cover Index for 63 field sites. Solid blue lines are the respective thresholds for defining hydrophytic vegetation (3.0 for the PI, 50% for the HCI); dotted blue line is for a PI threshold of 3.2. Ten sites with HCI $>$ 50% have a PI greater than 3.0, but only three have a PI greater than 3.2. All sites with HCI $\leq$ 50% have PI values $\geq$ 3.4.

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