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DISAGREEMENTS BETWEEN PLOT-BASED PREVALENCE INDICES AND DOMINANCE RATIOS IN EVALUATIONS OF WETLAND VEGETATION

James S. Wakeley and Robert W. Lichvar
Environmental Laboratory
U.S. Army Engineer Waterways Experiment Station
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

Abstract: Methods for wetland identification and delineation require the investigator to determine whether vegetation is hydrophytic. Two widely used techniques for making hydrophytic vegetation decisions involve dominance ratios (i.e., the percentage of dominant species that are rated obligate (OBL), facultative wetland (FACW), and facultative (FAC)) and prevalence indices (i.e., the weighted-average wetland indicator status of all plants present). We sampled 338 vegetation plots on sites throughout the United States and calculated the dominance ratio and a plot-based prevalence index for each plot. We found that hydrophytic vegetation decisions based on the two methods disagreed on 16% of field plots. Analysis of simulated plot data (n = 80,000) indicated that frequencies of disagreement increase as vegetation complexity (i.e., number of strata and number of species per stratum) increases. We conclude that the two methods for hydrophytic vegetation decisions disagree too often to be considered equivalent. Additional studies are needed in different biogeographic regions and plant community types to determine the conditions under which prevalence indices, dominance ratios, or some other treatment of vegetation data provide more reliable indicators of wetland vegetation.

Key Words: Hydrophytic vegetation, prevalence index, dominance ratio, wetland delineation

INTRODUCTION

Decisions about whether or not a plant community is hydrophytic are central to wetland identification and delineation (Environmental Laboratory 1987, Federal Interagency Committee for Wetland Delineation 1989, Soil Conservation Service 1994). Two procedures for making hydrophytic vegetation determinations are widely used. The first, which we call the dominance ratio, is based on the wetland indicator status (Reed 1988) of dominant species in the plant community. The second, called the prevalence index, is a weighted-average indicator status for all species present in a sample from the community. The Federal Interagency Committee for Wetland Delineation (1989) presented the two approaches as alternative hydrophytic vegetation criteria. However, the two methods can produce different results and, therefore, potentially different jurisdictional decisions.

In a review of current wetland delineation methods, the National Research Council (1995:129) identified the need for studies that compare the use of prevalence indices and dominance ratios on the same sites in a variety of wetland situations. In this study, we used actual field data from sites throughout the United States and computer simulation of vegetation plot data to compare outcomes of the two methods. Our objectives were (1) to determine frequencies of disagreement between methods and (2) to evaluate the effects of vegetation complexity (i.e., number of strata and number of species per stratum) on those frequencies.

METHODS

Data Collection

We compiled data collected during previous studies at eight sites: Fort Richardson, AK; Edwards Air Force Base, CA; Puna and South Hilo Districts, HI; Department of Energy Paducah Site, KY; Waterways Experiment Station, MS; Picatinny Arsenal, NJ; Tobyhanna Army Depot, PA; and Dugway Proving Grounds, UT. Hereafter, we refer to these sites by their respective states. Data were gathered from 1993 through 1995 as part of projects to characterize, inventory, or map wetlands at each site. As wetland delineation was not the purpose of these studies, plots were placed in areas that were judged to be either wetland or upland. Environments were highly varied, including deserts, rain forest, boreal, and humid temperate areas. Plant community types varied from herbaceous to shrub to forested, and more than one type was present at most sites. Sample sizes at each site were small in keeping with the limited objectives of those projects. Samples were not necessarily representative of all cover types available at each site, nor were they intended to reflect overall conditions in the state or biogeographic region in which the site was located. We use these data only to explore the consequences of different mathematical treatments of the data on hydrophytic vegetation decisions and not to make comparisons among regions or community types.

Samples from AK were taken mainly in June and July 1995 and included primarily forested habitats with canopies dominated by *Picea mariana* (P. Mill.) B. S. P., *P. glauca* (Moench) Voss, *Populus balsamifera* L., or *Betula papyrifera* Marsh. and shrublands dominated by *Picea* spp., *Alnus* spp., and *Salix* spp. Samples from CA were gathered from February to April 1995 and were taken in and around playas in the Mojave Desert; dominant species included *Atriplex confertifolia* (Torr. & Frem.) S. Wats., *Distichlis spicata* (L.) Greene, and *Kochia californica* S. Wats. Data from HI were gathered in October 1993 mainly in rain forests dominated by *Metrosideros polymorpha* Gaud. and *Cibotium glaucum* (J.E. Smith) Hook. & Arn., and a herbaceous wetland dominated by *Eleocharis calva* Torr. and *Andropogon virginicus* L. Sampling in KY occurred in February 1996; samples were taken mainly in forests dominated by *Quercus falcata* Michx., *Liquidambar styraciflua* L., *Acer rubrum* L., and *Ulmus americana* L. Plots in MS were sampled in June 1994 in forests dominated by *Q. falcata* and *Q. nigra* L., and in herbaceous openings dominated by *Stenotaphrum secundatum* (Walt.) Kuntze, *Agropyron repens* (L.) Beauv., and *Alternanthera philoxeroides* (Mart.) Griseb. NJ samples were taken mainly in October and November 1993 from forests dominated by *Acer rubrum, Prunus serotina* Ehrh., and *Betula* spp. and openings dominated by *Solidago* spp. and *Spiraea latifolia* (Ait.) Borkh. Samples from PA, gathered in April and May 1995, were mainly taken in forests with canopies dominated by *Acer saccharum* Marsh., *A. rubrum,* and *Tsuga canadensis* (L.) Carr. Those in UT were gathered in December 1994 in shrub and herbaceous communities dominated by *Allenrolfea occidentalis* (S. Wats.) Kuntze, *Distichlis stricta* (Torr.) Rydb., and *Atriplex* spp.

Vegetation data were collected within 10 × 10 m plots established at representative locations within selected plant communities. Percent cover of each species present in a plot was estimated visually in each of four potential strata: herbs (all herbaceous plants and woody plants <1 m tall), saplings/shrubs (woody plants >1 m tall and <7.5 cm in diameter at breast height [dbh]), trees (woody plants >7.5 cm dbh), and woody vines (climbing vines >1 m tall) (Environmental Laboratory 1987). All cover estimates were made by one of the authors (RWL). Data were recorded generally in 10% increments for abundant species (>20% coverage) and 5% increments for less abundant species, except when intermediate values were used to distinguish species with visually different coverage. In the analysis, we used actual percent cover estimates and did not categorize the data by cover classes (e.g., Daubenmire 1959). Species with estimated cover of <1% were not included in calculations.

Data Analyses

On each plot, we identified dominant species by the "50/20 rule;" that is, the dominant species in each stratum were the most abundant species, either individually or cumulatively totaled, that comprised >50% of the total coverage in that stratum, plus any individual species that was at least 20% of the total coverage in the stratum (Federal Interagency Committee for Wetland Delineation 1989). Dominants were identified separately in each stratum; therefore, the same plant species might be dominant in more than one stratum. The list of dominants was then combined across strata within a plot so that a species that was dominant in more than one stratum was counted more than once in the total. Vegetation on a plot was deemed to be hydrophytic by the dominance ratio if >50% of dominant species across all strata combined were rated obligate (OBL), facultative wetland (FACW), or facultative (FAC) on the appropriate regional list of plant species that occur in wetlands (Reed 1988). We followed the Corps of Engineers Wetlands Delineation Manual (Environmental Laboratory 1987) (hereafter called the 1987 Manual) and counted "facultative minus" (FAC−) species among the facultative upland (FACU) and upland (UPL) species.

We calculated a plot-based prevalence index for each plot as the weighted-average wetland indicator status (I) (where $I_{OBL} = 1$, $I_{FACW} = 2$, $I_{FAC} = 3$, $I_{FACU} = 4$, and $I_{UPL} = 5$) of all plant species in the plot, where weights were equal to percent cover values (Wentworth et al. 1988) and species were counted in each stratum where they were present. Thus, if a species was present at 10% areal cover in one stratum and 40% in another, both values were used in calculating the prevalence index. Prevalence indices were calculated with the following formula: $PI = (I_{OBL}A_{OBL} + I_{FACW}A_{FACW} + I_{FAC}A_{FAC} + I_{FACU}A_{FACU} + I_{UPL}A_{UPL})/(A_{OBL} + A_{FACW} + A_{FAC} + A_{FACU} + A_{UPL})$, where A_{OBL} = total percent cover of OBL plants across all strata, A_{FACW} = total percent cover of FACW plants across all strata, etc. "Plus" and "minus" designations were not considered (e.g., FAC− and FAC+ species were both

Table 1. Comparison of hydrophytic vegetation decisions (Yes or No) based on dominance ratios (DR) and plot-based prevalence indices (PI) for actual field samples.

				Agreements (%)			Disagreements (%)		
Site Location	Number of Plots	DR = Yes (%)	PI = Yes (%)	DR = Yes PI = Yes	DR = No PI = No	Total	DR = Yes PI = No	DR = No PI = Yes	Total
AK	76	84.2	76.3	72.4	11.8	84.2	11.8	4.0	15.8
CA	38	44.7	39.5	36.8	52.6	89.4	7.9	2.6	10.5
HI	24	41.7	12.5	4.2	50.0	54.2	37.5	8.3	45.8
KY	64	65.6	70.3	57.8	21.9	79.7	7.8	12.5	20.3
MS	21	95.2	85.7	81.0	0.0	81.0	14.3	4.8	19.1
NJ	35	88.6	85.7	85.7	11.4	97.1	2.9	0.0	2.9
PA	58	84.5	81.0	79.3	13.8	93.1	5.2	1.7	6.9
UT	22	63.6	86.4	63.6	13.6	77.2	0.0	22.7	22.7
All sites	338	73.1	69.5	63.3	20.7	84.0	9.8	6.2	16.0

treated as FAC) (Federal Interagency Committee for Wetland Delineation 1989).

Our method for determining prevalence indices differed from that of the Federal Interagency Committee for Wetland Delineation (1989), which is based on frequencies of occurrence of plant species determined by point-intercept sampling along three 60-m transects. Our approach had the advantage of being plot-oriented and thus was similar to the sampling method used in the 1987 Manual, in which plant sampling is focused around a central soil pit. Our method for calculating prevalence indices used the same data sets as those used in calculating dominance ratios, and therefore, results of the two methods were directly comparable. Disagreements were due to fundamental differences in mathematical treatment of the data and not to differences in sampling methods. We concluded that vegetation was hydrophytic if the prevalence index was <3.0 (Federal Interagency Committee for Wetland Delineation 1989, Soil Conservation Service 1994).

Computer Simulation

We used computer simulation of large numbers of vegetation plots to evaluate trends in the frequency of disagreement between the two hydrophytic vegetation methods in relation to vegetation complexity by comparing outcomes of simulations involving different numbers of strata and species per stratum. Simulated cases involved either one or three strata, each containing 3, 5, 9, or 15 species per stratum. We used the uniform random number function (RANUNI) of PC-SAS software (SAS Institute, Inc. 1988) to generate hypothetical percent cover values for each plant species present in a stratum. Cover values in each stratum summed to 100%; this had no influence on single-stratum cases but resulted in equal weighting of strata in three-stratum cases.

A numerical wetland indicator status (1, 2, 3, 4, or 5) was randomly assigned to each species. Examination of the 12 regional lists of Reed (1988) revealed that overall frequencies of each indicator category were not appreciably different. OBL species ranged from 19–39% (mean 30%) of listed species across the 12 regions, FACW species ranged from 17–30% (mean 26%), FAC species ranged from 18–37% (mean 24%), and FACU species ranged from 13–28% (mean 21%). In the simulations, each indicator status including UPL was assigned with equal probability and no "+" or "−" modifiers were used. Whether or not these initial conditions were totally realistic was not an issue, as the simulations were used only to evaluate trends in frequency of disagreements with increasing vegetation complexity. Selection of dominant species, calculation of dominance ratios and prevalence indices, and hydrophytic vegetation determinations were done using the same procedures applied to field data. A single simulation consisted of 10,000 hypothetical plots for each combination of number of strata (i.e., 1 or 3) and number of species (i.e., 3, 5, 9, or 15 per stratum).

RESULTS

Field Data

Hydrophytic vegetation determinations based on dominance ratios and prevalence indices disagreed on 16.0% of actual field plots (n = 338) (Table 1). Over all plots, slightly more disagreements were due to a positive determination based on dominance ratio and a negative determination based on prevalence index, rather than the reverse. Results varied considerably among sites. The particularly high frequency of disagreement for HI plots was due mainly to the frequent occurrence of FAC dominants in communities that contained mostly "drier" subordinate species.

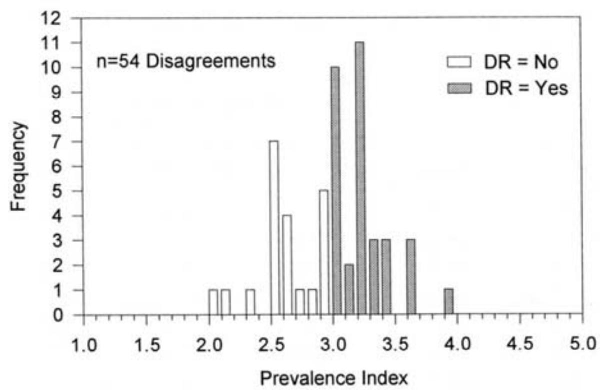

Figure 1. Frequency of disagreement between hydrophytic vegetation determinations (Yes or No) based on dominance ratios (DR) and plot-based prevalence indices in relation to the magnitude of the prevalence index, derived from actual field data from sites across the United States.

Over all 338 plots, prevalence indices averaged 2.65 (SD = 0.80) and ranged from 1.0 to 5.0. For plots on which the two vegetation methods disagreed, prevalence indices averaged 3.01 (SD = 0.39) and ranged from 2.01 to 3.92, although most were between 2.5 and 3.7 (Figure 1).

Some representative examples of plots on which vegetation methods disagreed are given in Table 2. In Table 2a, only two species were dominant (one FACU and the other OBL) in a single-stratum situation; thus, the dominance ratio was exactly 50%, indicating a borderline non-hydrophytic community. However, most of the areal cover was of species rated OBL, FACW, or FAC and the prevalence index (PI = 2.01) indicated strongly hydrophytic conditions. In contrast, the single-stratum example in Table 2b produced three dominants (two FACW and one UPL) and a hydrophytic community based on dominance ratio (DR = 67%). However, the majority of the coverage was of UPL plants and the prevalence index (PI = 3.67) indicated non-hydrophytic conditions.

In Table 2c, dominant species were identified and combined across three strata (a FACW herb, a FACW− shrub, and a FACU− tree) and the dominance ratio (DR = 67%) indicated hydrophytic conditions. However, the tree stratum as a whole contained drier species than the other two strata, and the greater areal coverage of trees resulted in a PI = 3.25 (non-hydrophytic). Such differences between strata may indicate that wetness conditions at the site have changed since the overstory was established.

Table 2d illustrates the situation in which most of the species (19 of 25) present on a very diverse plot are ignored in a hydrophytic vegetation decision based on dominance. In this case, a prevalence index based on all species (PI = 3.12) indicates non-hydrophytic conditions whereas the dominance ratio (DR = 67%) indicates hydrophytic vegetation.

Some evidence from field plots suggested that frequencies of disagreement between the two methods were higher on plots containing larger numbers of species or strata. For example, the frequency of disagreement was 13.3% on plots containing 1 to 5 species (n = 90), 16.4% on plots containing 6 to 10 species (n = 110), 13.3% on plots containing 11 to 15 species (n = 75), and 23.8% on plots containing 16 to 27 species (n = 63). Similarly, there was 15.0% disagreement on plots having only one vegetation stratum (n = 60), 12.9% on plots with two strata (n = 132), 18.8% on plots with three strata (n = 117), and 24.1% on plots with four strata (n = 29). However, interpretation of these results was complicated by the fact that plots containing fewer species or strata tended to be at different sites than those containing many species or strata, and seasonal timing of sampling affected the number of species detected on plots. Therefore, we used computer simulation to evaluate the effects of increasing vegetation complexity while controlling other potential sources of variation.

Simulations

Overall, vegetation determinations disagreed on 24.2% (n = 80,000) of simulated plots, but there was a clear trend of increasing disagreement as vegetation complexity increased. For cases involving a single stratum, frequency of disagreement increased from 18.5 to 25.6% as the number of species present increased from 3 to 15 (Table 3). Most of the disagreements were due to a positive hydrophytic vegetation decision based on dominance ratio and a negative decision based on prevalence index, but this was reversed when the number of species was small.

Frequencies of disagreement were greater for cases involving three strata rather than one (Table 3). Again, disagreements increased as the number of species per stratum increased. Disagreements involving a positive conclusion based on dominance ratio and negative conclusion based on prevalence index (18.0 to 27.9%) were far more common than the reverse (3.1 to 4.7%).

The five indicator status categories were assigned to plant species with equal probability in the simulations, and the average indicator status was 3.0. Therefore, it was not surprising that the proportion of plots that was hydrophytic based on the prevalence index was approximately 50% in all simulations (Table 3). However, the proportion that was hydrophytic based on dominance ratio increased from 47 to 75% as the number of species and number of strata increased. Therefore, increasing frequencies of disagreement between the two vegetation methods as vegetation complexity increased were mainly due to an increase in the proportion of plots accepted as hydrophytic based on dominance ratios.

For simulated single-stratum plots on which the two vegetation methods disagreed, prevalence indices ranged from 1.61 to 4.06, although most were between 2.5 and 3.5 (Figure 2). The spread in prevalence indices for the disagreements narrowed as the number of species increased, paralleling the trend for all prevalence indices (agreements and disagreements) combined. For example, simulated plots containing three species (n = 10,000) had prevalence indices that averaged 3.00 (SD = 0.92) and ranged from 1.0 to 5.0. For plots containing 15 species (n = 10,000), prevalence indices averaged 3.00 (SD = 0.42) and ranged from 1.45 to 4.53.

DISCUSSION

Hydrophytic vegetation decisions based on dominance ratios and prevalence indices agreed on 84% of actual sampling plots. Considering the very different mathematical treatment of field data under the two methods, this level of agreement could be considered very good. In this paper, however, we focus on the disagreements because these can potentially lead to different decisions concerning the presence or extent of jurisdictional wetlands on a site.

Average frequencies of disagreement between dominance ratios and prevalence indices were greater for simulated vegetation data than for actual data. One reason may be that random generation of vegetation data may have produced some ecologically unlikely combinations of species and the potential for more contradictory hydrophytic vegetation decisions. However, our actual field data also may be biased in that they were taken mainly to characterize the mapped wetland and upland communities present on the sites rather than to delineate boundaries. Therefore, sampling tended to avoid transitional areas and may have led to fewer disagreements between vegetation methods than might be expected in more typical wetland-delineation exercises.

Analysis of plot data from sites across the United States suggested that frequencies of disagreement between the two methods may be higher on plots containing larger numbers of species or strata. However, that conclusion was arguable because of other factors that could have affected field results, including differences in wetland types and plant species studied, different biogeographic regions where sites were located, variations in seasonal timing of plant sampling, and use of different regional lists of plant indicator status. Therefore, computer simulations of vegetation plot data were used to study the effects of changes in vegetation complexity while controlling unwanted sources of variation. Simulations revealed that frequencies of disagreement between hydrophytic vegetation methods increase as the number of strata and number of species per stratum increase. This result suggests that disagreements might be more frequent in relatively diverse forested habitats than in single-stratum herbaceous or less diverse forest communities.

Sources of Disagreement

There are several differences in the way data are treated in the two vegetation methods that can produce disagreements in hydrophytic vegetation decisions. First, the dominance-ratio approach ignores non-dominant species and their wetland indicator value entirely. Second, after dominant species are selected, their relative abundances are ignored. Thus, a dominant species that has 25% coverage is given equal weight in the dominance ratio to another species with 80% coverage. Third, the two methods give very different emphasis to FAC species. Consider, for example, a single stratum containing three FAC species each with 30% coverage. All three species are dominants by the 50/20 rule, and all are rated FAC or wetter. Therefore, the dominance ratio is 100% and the community appears to be strongly hydrophytic. However, the prevalence index is 3.0, which is marginally non-hydrophytic. The example in Table 2d shows further how the presence of FAC dominants can produce disagreements between the two methods.

A number of the disagreements we encountered were associated with small numbers of dominants that produced dominance ratios of exactly 50%. Consider, for example, a single stratum with three species—a FAC species at 40% coverage, a FACU species at 20%, and an OBL species at 10%. Only the FAC and FACU species are dominants, producing a dominance ratio of 50% (1/2) and a negative hydrophytic vegetation decision. However, the prevalence index is 2.63 (hydrophytic). Several (6 of 10) such disagreements in our data set could have been resolved by selecting one more dominant to break the tie.

In our analysis, we applied what we considered to be the most commonly used forms of the two vegetation methods. Many variations exist or could be suggested that might bring the two methods into better agreement. Alternatives mentioned in various delineation manuals include arbitrary selection of exactly three dominants per stratum; ignoring FAC species (i.e., "FAC-neutral" tests); dropping the "+" and "−" modifiers in calculating dominance ratios; and defining additional strata for vegetation sampling (Environmental Laboratory 1987, Federal Interagency Committee for Wetland Delineation 1989, Soil Con-

Table 2. Examples of actual plot samples that resulted in disagreements between hydrophytic vegetation decisions based on dominance ratios (DR) and plot-based prevalence indices (PI).

Species	Stratum	Indicator Status (*I*)	Percent Cover (*A*)	Product (*I* × *A*)	Dominant Species
A. Treeless Bog, Puna District, HI, 15 October 1993, Plot Q1 (Wet Meadow)					
Andropogon virginicus L.	Herb	FACU (4)	40	160	Yes
Cuphea carthagenensis (Jacq.) J.F. Macbr.	Herb	FAC (3)	1	3	No
Eleocharis calva Torr.	Herb	OBL (1)	80	80	Yes
Hydrocotyle verticillata Thunb.	Herb	OBL (1)	3	3	No
Juncus planifolius R. Br.	Herb	FACW (2)	30	60	No
Paspalum urvillei Steud.	Herb	FAC (3)	2	6	No
Rhynchospora caduca Elliott	Herb	FACW (2)	5	10	No
Sacciolepis indica (L.) Chase	Herb	FAC+ (3)	2	6	No
Total			163	328	
			DR = 1/2 = 50% (Not Hydrophytic)		
			PI = 328/163 = 2.01 (Hydrophytic)		
B. Edwards Air Force Base, CA, 25 April 1995, Plot 19 (Desert Clay Pan)					
Atriplex confertifolia (Torr. & Frem.) Wats.	Herb	UPL (5)	20	100	Yes
Bromus tectorum L.	Herb	UPL (5)	5	25	No
Distichlis spicata (L.) Greene	Herb	FACW (2)	10	20	Yes
Kochia californica S. Wats.	Herb	FACW (2)	10	20	Yes
Total			45	165	
			DR = 2/3 = 67% (Hydrophytic)		
			PI = 165/45 = 3.67 (Not hydrophytic)		
C. Tobyhanna Army Depot, PA, 3 May 1995, Plot 43 (Hardwood Forest)					
Coptis trifolia (L.) Salisb.	Herb	FACW (2)	2	4	No
Osmunda cinnamomea L.	Herb	FACW (2)	20	40	Yes
Vaccinium corymbosum L.	Shrub	FACW− (2)	30	60	Yes
Acer saccharum Marshall	Tree	FACU− (4)	70	280	Yes
Betula alleghaniensis Britton	Tree	FAC (3)	5	15	No
Fagus grandifolia Ehrh.	Tree	FACU (4)	8	32	No
Tsuga canadensis (L.) Carriere	Tree	FACU (4)	10	40	No
Total			145	471	
			DR = 2/3 = 67% (Hydrophytic)		
			PI = 471/145 = 3.25 (Not hydrophytic)		
D. Fort Richardson, AK, 14 July 1995, Plot 51 (Subalpine Meadow)					
Angelica lucida L.	Herb	FACU (4)	5	20	No
Calamagrostis canadensis (Michx.) Beauv.	Herb	FAC (3)	55	165	Yes
Delphinium glaucum S. Wats.	Herb	FACW (2)	4	8	No
Epilobium angustifolium L.	Herb	FACU (4)	2	8	No
Equisetum arvense L.	Herb	FACU (4)	5	20	No
Geranium pusillum L.	Herb	UPL (5)	10	50	Yes
Luzula parviflora (Ehrh.) Desv.	Herb	FAC (3)	3	9	No
Mertensia paniculata (Ait.) G. Don	Herb	FACU (4)	4	16	No
Petasites sagittatus (Banks ex Pursh) Gray	Herb	FAC (3)	2	6	No
Poa leptocoma Trin.	Herb	FAC (3)	5	15	No
Polemonium acutiflorum Willd. ex Roem. & J. A. Schultes	Herb	FAC (3)	1	3	No
Rubus arcticus L.	Herb	FAC (3)	3	9	No
Rubus chamaemorus L.	Herb	FACW (2)	1	2	No
Rumex arcticus Trautv.	Herb	FACW (2)	3	6	No
Sanguisorba canadensis L.	Herb	FACW (2)	6	12	No
Senecio triangularis Hook.	Herb	FACW (2)	3	6	No
Smilacina stellata (L.) Desf.	Herb	FAC (3)	2	6	No
Valeriana capitata Pallas ex Link	Herb	FAC (3)	8	24	Yes

Table 2. Continued

Species	Stratum	Indicator Status (*I*)	Percent Cover (*A*)	Product (*I* × *A*)	Dominant Species
Veratrum viride Ait.	Herb	FACU (4)	8	32	Yes
Betula glandulosa Michx.	Shrub	FAC (3)	5	15	No
Picea glauca (Moench) Voss	Shrub	FACU (4)	2	8	No
Salix glauca L.	Shrub	FAC (3)	15	45	Yes
Salix planifolia Pursh	Shrub	FACW (2)	10	20	Yes
Tsuga mertensiana (Bong.) Carriere	Shrub	FAC (3)	2	6	No
Viburnum edule (Michx.) Raf.	Shrub	FACU (4)	1	4	No
Total			165	515	
			DR = 4/6 = 67% (Hydrophytic)		
			PI = 515/165 = 3.12 (Not hydrophytic)		

servation Service 1994). The National Research Council (1995) also recommended that additional methods be evaluated. Some additional possibilities include modifying the 50/20 rule for selecting dominants to account for a larger proportion of the vegetation that is present on a plot; considering the relative abundance of dominant species in calculating a dominance ratio rather than treating all dominants as equal; increasing the weight placed on OBL and UPL species in the decision; assigning intermediate numerical status to species with "+" or "−" modifiers; or changing the threshold values for either the dominance ratio (50%) or prevalence index (3.0). Evaluating these various alternatives was beyond the scope of our study.

Plot-based Prevalence Indices

Our method for calculating the prevalence index parallels that of the Federal Interagency Committee for Wetland Delineation (1989) but adapts the method for use with vegetation plot data of the type required by the 1987 Corps Manual, which is the current federal standard for wetland delineation. For consistency between methods and across strata, we used percent cover as the abundance measure for all species and recorded coverage of each species by stratum. Thus, species present in more than one stratum were given added weight in the prevalence index, just as they are in the dominance ratio.

We used visually estimated percent cover values to calculate plot-based prevalence indices rather than the approach described by the Federal Interagency Committee for Wetland Delineation (1989), which uses the frequency of "hits" on each species derived from point-intercept sampling of 100 points spaced at 0.6-m intervals along each of three 60-m transects within the area of interest (generally a soil map unit). We devised the plot-based approach to be consistent with sampling methods recommended in the 1987 Manual, in which the vegetation plot surrounds a central soil pit, and to eliminate the effects of different field methods and different sampling areas on hydrophytic vegetation decisions. Thus, the disagreements we noted were due

Table 3. Comparison of hydrophytic vegetation decisions (Yes or No) based on dominance ratios (DR) and prevalence indices (PI) for simulated cases (n = 10,000 for each combination of number of species and number of strata).

Number of Species per Stratum	DR = Yes (%)	PI = Yes (%)	Agreements (%) DR = Yes PI = Yes	Agreements (%) DR = No PI = No	Agreements (%) Total	Disagreements (%) DR = Yes PI = No	Disagreements (%) DR = No PI = Yes	Disagreements (%) Total
				Single Stratum				
3	47.1	49.4	39.0	42.5	81.5	8.1	10.4	18.5
5	50.8	50.1	40.3	39.4	79.7	10.5	9.8	20.3
9	58.4	49.6	42.1	34.1	76.2	16.2	7.5	23.7
15	62.9	50.1	43.7	30.7	74.4	19.2	6.4	25.6
				Three Strata				
3	63.0	49.5	45.0	32.6	77.6	18.0	4.5	22.5
5	65.1	49.4	45.1	30.6	75.7	20.0	4.3	24.3
9	67.9	49.9	45.2	27.4	72.6	22.8	4.7	27.5
15	75.2	50.4	47.3	21.7	69.0	27.9	3.1	31.1

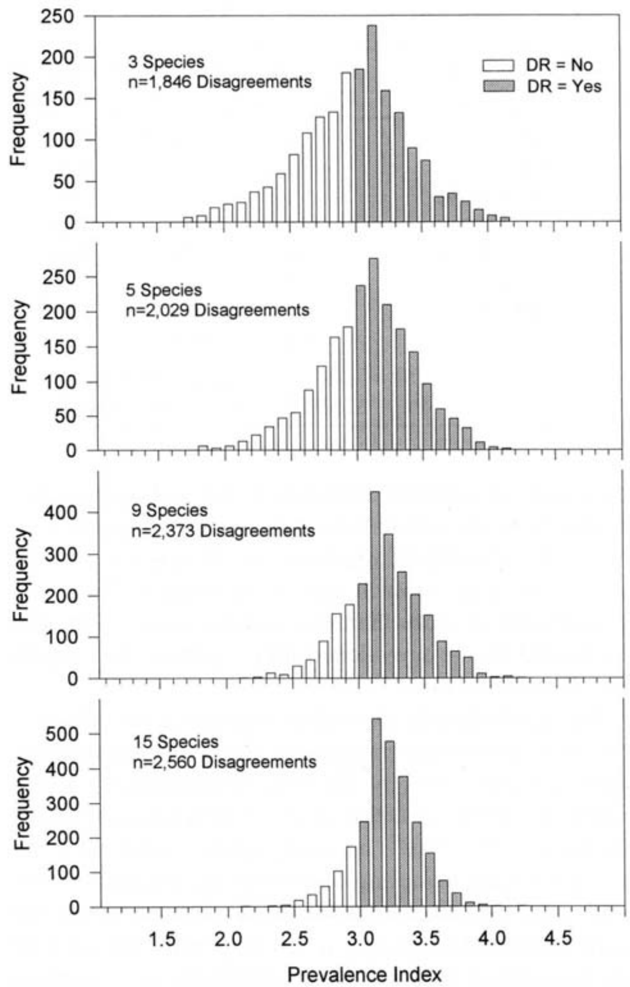

Figure 2. Frequencies of disagreement between hydrophytic vegetation determinations (Yes or No) based on dominance ratios (DR) and plot-based prevalence indices in relation to the magnitude of the prevalence index, derived from simulations of single-stratum cases involving 3, 5, 9, and 15 species.

solely to differences in mathematical treatment of the data under the two hydrophytic vegetation criteria.

Quadrat sampling and point-intercept (frequency) sampling are alternative ways to measure vegetation coverage. Mueller-Dombois and Ellenberg (1974:73) describe point sampling as a special case of quadrat sampling, in which the quadrat is reduced to a point and hits are recorded with sharpened pins or sighting devices directed either downward or upward into the canopy. Used in this way, frequency is a measure of cover (Mueller-Dombois and Ellenberg 1974, Hays et al. 1981, Bonham 1989). Therefore, our method for determining the prevalence index simply substituted direct estimates of plant cover for frequencies. Daubenmire (1959) considered plot-based methods to be superior to frequencies for measuring vegetation cover and composition, particularly for the less abundant species in the community, although he used smaller plots than ours (approximately 0.1 m^2). Visual estimates of percent cover are more difficult to make in larger plots. Plot-based estimates of canopy coverage are readily applied to both low-growing species and tree canopies; however, they can be difficult to apply accurately to plants whose height is near the investigator's eye level.

Reliability of Vegetation Indicators

Disagreements between prevalence indices and dominance ratios are too frequent to consider these two methods to be equivalent. The dominance-ratio approach has the practical advantage that only the dominant plant species must be identified in the field. For most routine wetland delineations that must be done quickly by investigators who sometimes have limited plant identification skills, this advantage is critical. On the other hand, potentially valuable information about the plant community is lost when only dominant species are considered. In contrast, the prevalence index is a more community-oriented approach that takes into account the presence and relative abundance of all species in the sample, not just a few dominants. Weighted-average methods, such as the prevalence index, have strong support in the ecological literature (Gauch 1982, Wentworth et al. 1988).

During the 1980s, the U. S. Fish and Wildlife Service sponsored 12 studies in 11 states that determined weighted-average vegetation scores for plant communities growing on soil units representing wetlands, wetland transition zones, and uplands in each study area (Segelquist et al. 1990). In general, there was a strong correspondence between hydrophytic vegetation and the presence of a hydric soil. However, studies by Segelquist et al. (1990) and others (e.g., Carter et al. 1988, Wentworth et al. 1988, Scott et al. 1989, Josselyn et al. 1990, Golet et al. 1993, Carter et al. 1994) indicate that wetland determinations need to consider soil and hydrology information when the vegetation index is either slightly higher or lower than 3.0. Based on a review of all existing studies, the National Research Council (1995:147) concluded that "indexes for predominance of hydrophytic vegetation clearly separate hydrophytic from nonhydrophytic vegetation only when index values deviate substantially from the threshold; lands with hydrophyte dominance near 50% or a prevalence index near 3.0 cannot be assessed confidently without strong reliance on other indicators."

Studies involving direct comparisons of prevalence indices and dominance ratios on the same sites are rare, particularly in relation to data on soils or hydrology. Wakeley et al. (1996) analyzed vegetation and determined hydric soil status on rain forest subplots (1 m^2) in Hawaii. They found that hydrophytic vegetation decisions based on prevalence indices agreed with hydric soil determinations more often than did decisions based on dominance ratios. On forested sites in north-central Florida, hydrophytic vegetation decisions based on the two methods agreed well with each other and with measured wetland hydrology in obvious wetland and non-wetland communities; however, results in transitional pine flatwoods communities were inconsistent (Davis et al. 1996). Additional studies are needed that compare outcomes of the two vegetation methods in relation to hydric soil determinations or presence of measured wetland hydrology in other biogeographic regions and plant community types to determine whether prevalence indices or dominance ratios are more reliable indicators of wetland conditions.

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